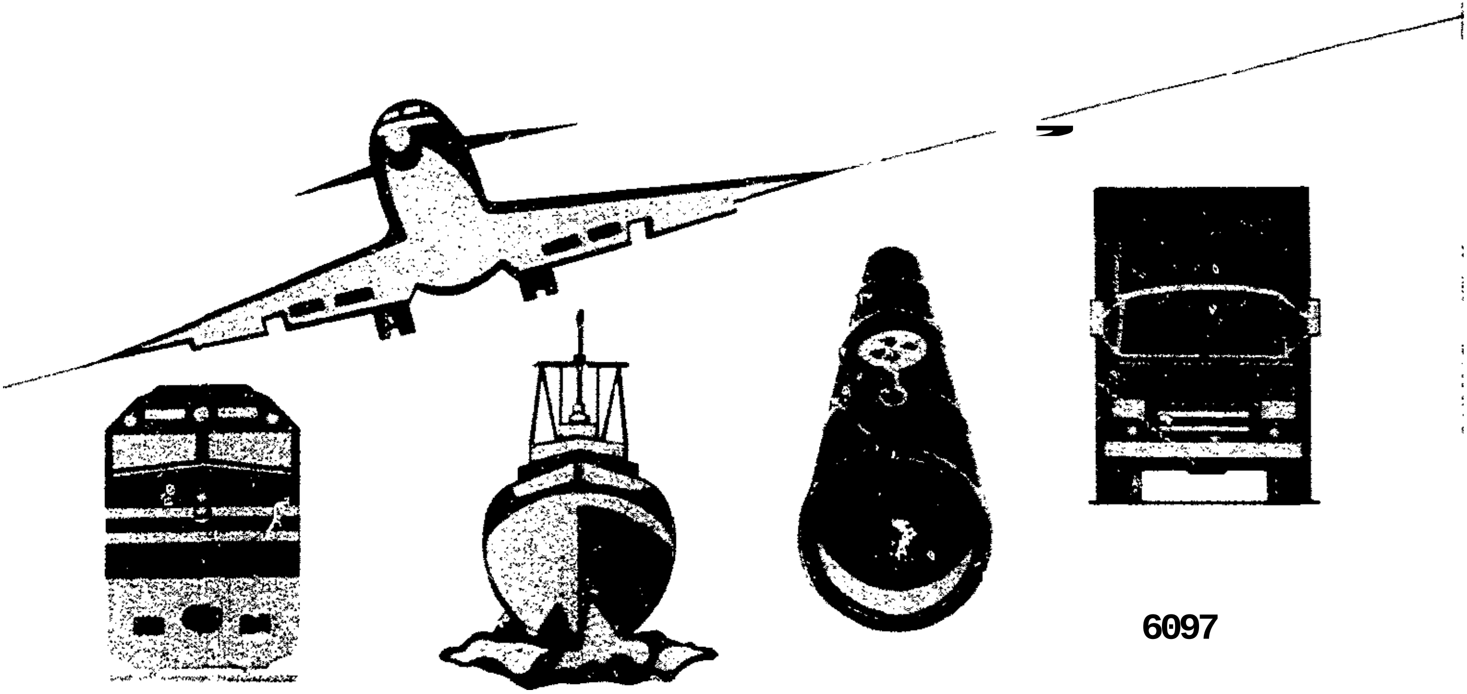
PB93-910406
NTSB/AAR-93/05

# NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

# AIRCRAFT ACCIDENT REPQRT

## MIDAIR COLLISION
## MITSUBISHI MU-28-60, N74FB, AND PIPER PA-32-301, N82419
## GREENWOOD MUNICIPAL AIRPORT
## GREENWOOD, INDIANA
## SEPTEMBER 11,1992



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## SEPTEMBER 11,1992

Adopted: September 13,1993
Notation 6097

Abstract: This report explains the midair collision of an MU-2 aircraft with a PA-32 aircraft about 2 miles northeast of the Greenwood Municipal Airport, Greenwood, Indiana, on September 11, 1992. Safety issues in the report focused on the deficiencies in the see-and-avoid concept as a primary means of collision avoidance, and the failure of pilots to fully utilize the air traffic control system by obtaining instrument flight rules clearances before takeoff. Recommendations concerning these issues were made to the federal Aviation Administration, the National Business Aircraft Association, the National Association of Flight instructors, the Experimental Aircraft Association, and the Aircraft Owners and Pilots Association.

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## EXECUTIVE SUMMARY

On September 11,1992, about 1457 central daylight time, a Mitsubishi MU-2B-60 (MU-2), N74FB, and a Piper PA-32-301 Saratoga (PA-32), N82419, collided at 2,100 feet mean sea level, approximately 2 miles northeast of the Greenwood Municipal Airport, Greenwood, Indiana. The PA-32 was descending from 2,500 feet en route to Greenwood Airport in accordance with visual flight rules. The MU-2, also operating under visual flight rules, was climbing out of the Greenwood Municipal Airport en route to Columbus, Ohio. The pilots of both airplanes and the four passengers aboard the MU-2 were fatally injured. The two other occupants of the PA-32 were seriously injured. Both airplanes were destroyed. The accident occurred in daylight visual meteorological conditions.

Prior to the collision, the PA-32 had been receiving air traffic control radar services from the Indianapolis Departure East/Satellite Controller. When the airplane was 3 miles north of the Greenwood Airport, radar services were terminated. Approximately 44 seconds later, the pilot of the MU-2 reported to the radar controller that he was "off Greenwood" in anticipation of receiving an instrument flight rules clearance. The radar controller issued a discrete beacon code, but the flight had not been identified on radar at the time of the collision.

The National Transportation Safety Board determines that the probable came of the accident was the inherent litations of the see-and-avoid concept of separation of aircraft operating under visual flight rules that precluded the pilots of the MU-2 and the PA-32 from recognizing a collision hazard and taking actions to avoid the midair collision. Contributing to the cause of the accident was the failure of the MU-2 pilot to use all of the air traffic control services available by not activating his instrument flight rules flight plan before takeoff. Also contributing to the cause of the accident was the failure of both pilots to follow recommended traffic pattern procedures, as recommended in the Airman's Information Manual, for airport arrivals and departures.

The major safety issues addressed by the report are the continuing problem of deficiencies in the see-and-avoid concept, as a primary means of collision avoidance, and the failure of pilots to fully utilize the air traffic control system by obtaining instrument flight rules clearances prior to becoming airborne, especially when operating in or near high density traffic areas.

As a result of this accident and others, safety recommendations addressing these issues were made to the Federal Aviation Administration, the National Business Aircraft Association, ;he National Association of Flight Instructors, the Experimental Aircraft Association, and the Aircraft Owners and Pilots Association.

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## 1. FACTUAL INFORMATION

### 1.1 History of Flight

On September 11, 1992, about 1457 central daylight time, a Mitsubishi MU-2B-60 (MU-2), N74FB, and a Piper PA-32-301 Saratoga, (PA-32), N82419, collided at 2,100 feet mean sea level (msl)[1] in southern Marion County, Indiana. The collision occurred approximately 2 miles northeast of the Greenwood Municipal Airport, Greenwood, Indiana. The PA-32 was descending from 2,500 feet en route to Greenwood Airport in accordance with visual flight rules (VFR). The MU-2, also operating under VFR, was clibing out of the Greenwood Municipal Airport en route to Columbus, Ohio. The pilots of both airplanes and the four passengers aboard the MU-2 were fatally injured. The two other occupants of the PA-32 were seriously injured. Both airplanes were destroyed. The accident occurred in daylight visual meteorological conditions (VMC).

About 1245 central daylight time? the PA-32, owned by Control Systems Engineering Inc., departed Eagle Creek Airport, which is located 7 miles west of Indianapolis, Indiana, for a landing at Greenwood Municipal Airport, Greenwood, Indiana, with an en route stop at Terry Airport, located about 14 miles northwest of Indianapolis, Indiana. On board the airplane was the pilot, a pilot-passenger, and the pilot's daughter. The investigation revealed that the purpose of the flight was to talk to the mechanic at Terry Airport, take aerial photos of the pilot's new office building and a remote job site, and provide flying practice for one

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[1] All altitudes are in msl. unless otherwise indicated.

[2] All times herein are Central Daylight Time (CDT), based on a 24-hour clock, unless otherwise noted.

or both of the qualified pilots on board. The new office building was located about 1 mile east of the collision. The pilot had departed under **VFR** and had not Ned a flight plan, which was not required. The flight was operated under Title 14 Code of Federal Regulations (CFR) Part 91.

The airplane was based at Eagle Creek Airport. According to the manager of the flight school to which the airplane was leased, the pilot flew 10 to 12 times a year. He and the pilot-passenger, who usually flew with **him,** had arrived at the airport about 1230 on the day of the accident. The pilot's **daughter** then arrived, and the three of them departed shortly thereafter.

According *to* a mechanic at Terry Airport, the PA-32 landed about 1330. The pilot toured the facility, asked him about an annual inspection that had been performed there on the airplane, and about possible **future** work. The mechanic stated that he had never met the pilot before **but** that he observed **him** to be in good health and in good spirits.

At 1445:17, the pilot of the PA-32 advised the Indianapolis Departure West/Satellite (DRW/Satellite) controller that he had departed Terry Airport and would land at Greenwood Airport.[3] The controller issued the airplane a discreet beacon code, radar identified the airplane, and instructed the pilot to climb and **maintain** *2,500* feet. At 1451:47, the controller transferred control of the airplane to the Indianapolis Departure East/Satellite (DRE/Satellite) controller. At 1451:58, the pilot **of** the PA-32 transmitted to the controller, "Indy Approach, eight *two* four one nine with you at two point five [2,500 feet] going *to* Greenwood [Airport]." Seven seconds later the DRE/Satellite controller replied, "Cherokee four one nine roger, maintain, **VFR, I'll** have on course for you in about five miles." This transmission was acknowledged by the pilot. Approximately 2 minutes later the controller advised, "...you may proceed on course to Greenwood, advise the airport in sight." This transmission was acknowledged by the pilot. At 1455:51, the controller stated, "Cessna four, Cherokee four one nine the airport twelve **to** one o'clock there and three miles." The pilot replied, "four one nine we have the airport." At 1455:57, the controller stated, "November four one nine, roger, surface winds at Indianapolis [Airport] zero two zero at eight, squawk VFR, radar service terminated, frequency change approved." At 1456:03, the pilot replied, "ah four one nine, thank you very much." There were no further communications with the pilot of the PA-32.

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[3] **The direct mute of flight from Terry Airport to Greenwood Airport put the airplane inside the airport radar service area (ARSA) which required the pilot to be in contact with air traffic control (ATC).**

On the morning of September 11, 1992, N74FB, a Mitsubishi MU-2B-60 (MU-2), departed from Huntingburg Airport, Huntingburg, Indiana, en route to Greenwood Municipal Airport. The airplane was owned by and registered to Solar Sources Inc., a coal mining company with offices in Indianapolis, Indiana, and was based in Huntingburg, Indiana. It arrived at the Greenwood Municipal Airport about 1400, where the pilot was observed about 1430 waiting in the lounge area of the local fixed base operator (FBO). Four passengers arrived shortly after 1430 and socialized for several minutes. One was observed using the telephone in the FBO's lounge for about 3 minutes. The pilot and the four passengers then walked out of the lounge area to board the MU-2. The airplane taxied out to the takeoff end of runway 36, and departed shortly thereafter. The pilot of the MU-2 had filed two instrument flight rules (IFR) flight plans with the Terre Haute Flight Service Station (FSS), Terre Haute, Indiana, at 1208. One was for the flight from Huntingburg, Indiana, to Greenwood, Indiana, with a departure time of 1300 and an arrival time of 1330. The other was for the flight from Greenwood. Indiana, to Columbus, Ohio, with a departure time of 1400 and an arrival time of 1445. The flight was operated under Title 14 CFR Part 91.

At 1456:41, the pilot of N74FB contacted the DRE/Satellite controller and stated, "Indy Approach, Mitsubishi seven four Foxtrot Bravo over." The DRE/Satellite controller replied, "Mitsubishi seven four Fox Bravo, Indy." Two seconds later, the pilot of N74FB transmitted, "Roger, I'm off the ground Greenwood [Airport] standing by for [IFR] clearance to Columbus [Airport]." At 1456:51, the DRE/Satellite controller stated, "Seven four Fox Bravo, roger, squawk four five six four and ident. Maintain, at or below five thousand." There were no further communications with the pilot.of the MU-2.

Witnesses told Safety Board investigators that there was little traffic landing or departing Greenwood Airport on the day of the accident, which was typical for that airport. They also stated that the MU-2 was the only high performance airplane that regularly operated out of Greenwood Airport. Witnesses who observed the airplanes prior to the collision said that the PA-32 was southbound, while the MU-2 was climbing and turning toward the east. They stated that the PA-32 struck.the MU-2's fuselage in the area of the empennage.

The airplanes collided about 1457 at an altitude of 2,100 feet (see figure 3 for plots of the radar data for both airplanes). The pilot-passenger on the PA-32 took control of the airplane and was able to make a controlled landing before the airplane struck ground obstacles, including three houses. Both airplanes came to rest in a residential area about 2 miles northeast of the Greenwood Municipal Airport. The five occupants of the MU-2 were killed. The pilot of the PA-32 was killed, and the other two occupants were seriously injured. Pieces of the MU-2's left horizontal stabilizer and elevator were recovered during the search of a cornfield west of where the major portion of the MU-2's tail section came to rest. The fuselage came to rest inverted about 1/4 mile east of the tail, while the PA-32 came to rest upright in the back yard of a local resident about 1 mile east of the MU-2. (See figure 1).

The collision occurred in daylight VMC at 39 degrees, 39 minutes and 22 seconds north latitude and 86 degrees, 03 minutes and 41 seconds west longitude.

## 1.2 Injuries to Persons

| Injuries | Crew | Passengers | Others | Total |
|---|---|---|---|---|
| Fatal | 2* | 4 | 0 | 6 |
| Serious | 1 | 1 | 0 | 2 |
| Minor/None | 0 | 0 | – | 0 |
| Total | 3 | 5 | 0 | 8 |

*Includes the pilots of both airplanes.

## 1.3 Damage to Aircraft

The MU-2 was destroyed by the collision, ground impact, and the postcrash fire; its value was estimated at $750,000. The PA-32 was destroyed by the postcrash fire shortly after ground impact. Its value was estimated at $85,000.

## 1.4 Other Damage

Debris from the two airplanes was scattered over a rectangular residential area approximately 1/2 by 1 mile in Southern Marion County, Indiana. Three houses located on Southern Lakes Drive were damaged when the fuselage of the MU-2 came to rest in their back yards and caught fire. The PA-32 struck the roofs of two houses on Dornock Drive causing minor damage. The airplane touched down in the back yard of one of those houses, and its left wing struck and destroyed a children's playhouse. The impact separated the outboard 4 feet of the left wing

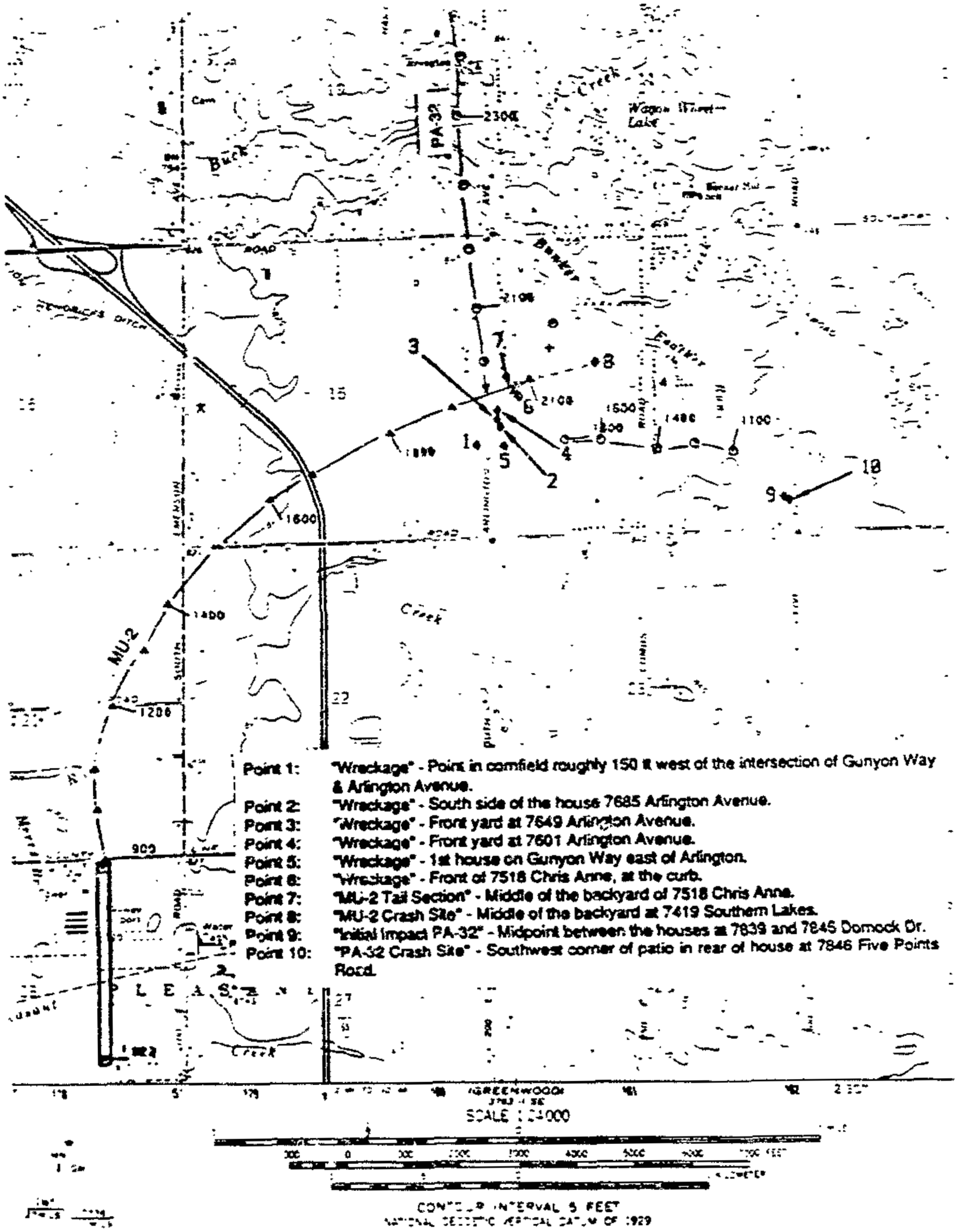


**Figure 1.**--Wreckage **plot.**

from the airplane. The airplane then slid through the fence at the rear of the yard and into the back yard of another house, coming to rest next to the rear of the house. A postcrash fire consumed the airplane and a major portion of the house. The fire caused minor damage to an adjoiniig house.

The estimated property damage to houses and other structures was $280,000.

## 1.5 Personnel Information

### 1.5.1 The Pilot of the PA-32

The 54-year-old pilot of the PA-32 was qualified in accordance with applicable regulations. He held a private pilot certificate for single-engine airplanes and an instrument rating. He began flying general aviation airplanes in 1969 and had logged in excess of 1,200 total hours, approximately 150 hours of which were in the PA-32. The pilot's training and certification records revealed that he had completed a biennial flight review on May 12, 1991, and that he had no history of flight safety violations or aircraft accidents. The pilot was familiar with the Indianapolis area. His activities in the days before the accident were routine, including his eating and resting habits.

The pilot held a valid third class medical certificate dated October 18, 1991, with the limitation "must wear corrective lenses while flying." His vision was shown on the form as: for distant vision, the right eye as 20/70 corrected to 20/30; the left eye as 20/30 corrected to 20/20; and the combined vision as 20/40 corrected to 20/20. For near vision, both eyes were listed as 20/100 with the right corrected to 20/20 and the left to 20/30. The combined vision was listed as 20/100 corrected to 20/20. He could wear either glasses or rontact lenses. It could not be determined if the pilot was wearing his glasses or contact lenses at the time of the collision. According to his wife, his health had not changed in the past year. He drank alcohol socially and did not take prescription medicine.

The pilot was involved in the ownership of Control Systems Engineering, the company that owned the PA-32. The company had recently purchased property approximately 3 miles from the Greenwood Municipal Airport. Part of the purpose of the flight was to take aerial photographs of this property with one passenger using a video camera and the other passenger using a still camera. The cameras were destroyed in the impact and postcrash fire.

Operation of the PA-32 does not require a second pilot; however, a qualified pilot was seated in the right front seat and had access to the flight controls. He was qualified in accordance with applicable regulations, and he held a private pilot certificate for single-engine airplanes and an instrument rating. He was employed as an engineer by Control Systems Engineering. A postaccident interview with his wife revealed that he was due to take a biennial flight check. Part of the purpose of the flight was to prepare for this test. As a result of the collision, the pilot-in-command was incapacitated, and the pilot-passenger assumed control of the PA-32 and made an emergency landing.

### 1.5.2 The Pilot of the MU-2

The 68-year-old pilot of the MU-2 was properly certificated and was adequately trained and experienced to conduct the flight He had been employed by Solar Sources, Inc., Greenwood, Indiana, a mining corporation that owned the MU-2 and a Piper Aztec as corporate airplanes. He had been its principal pilot for about 8 years.

The pilot was qualified in accordance with applicable regulations. He held a commercial pilot certificate with an instrument rating for single and multiengine airplanes. Additionally, he was certificated as an instrument flight instructor for both single and multiengine airplanes. He learned to fly in the U.S. Army-Air Force and had converted his military licenses to civilian iicenses. At the time of the accident, he had logged more than 19,000 hours of pilot time, of which about 9,000 hours were in the MU-2. The pilot's certification records revealed that he had completed a biennial flight review on July 10, 1992, and that he had been involved in two incidents: in 1980, an in-flight loss of all electrical power but successful airplane landing; and in 1984, a wheels-up landing.

The pilot held a valid second class medical certificate dated October 11, 1991. His vision shown on the medical application form was: far distant vision: the right eye as 20/20 corrected to 20/15, and the left eye as 20/30 corrected to 20/15; for near vision; both eyes as 20160 corrected to 20/25. fie wore glasses for an astigmatism and was seen wearing glasses at the Greenwood Flight Center before he departed on the accident flight. According to his wife, the pilot's health was excellent and had not changed in the past year. He exercised, did not smoke, drank alcohol only occasionally, and he did not take prescription medicine.

### 1.5.3 Air Traffic Controller

Radar Controller.--The controller who was working the DRE/Satellite position at the Indianapolis International Airport at the time of the accident was qualified to assume the responsibilities of his position. Examination of the controller training records did not reveal any deficiencies.

Supervisor.--The area supervisor was a full performance level controller, qualified in his assigned position.

Interviews with the controllers did not reveal any deficiencies in their knowledge of relevant air traffic control (ATC) procedures or policies.

## 1.6 Aircraft Information

The Piper ?A-32-301, N82419, was owned by Control Systems Engineering Inc. It was leased to and operated by R.A.F. Limited Flight School, Eagle Creek Airport, Indianapolis, Indiana. The airplane was certificated, equipped, and maintained in accordance with Federal Aviation Administration (FAA) regulations. A review of the airplane's maintenance records that were available revealed no discrepancies relevant to the circumstances of the accident flight. FAA records indicate that the airplane was issued a standard certificate of airworthiness on June 20, 1980.

At the time of the accident, the airplane had accumulated 2,416 hours of flight time. The engine, a Lycoming IO-540-K1G5, was rebuilt by an authorized repair station in June 1989, and had accumulated 976 hours since overhaul. The airplane was inspected in accordance with Federal Aviation Regulation *(FAR)* 91.409(b). The most recent inspection was an annual one completed on July 29, 199%. The airplane had flown 53 hours since that inspection. The PA-32 was painted gray with red and black trim markings and had an anti-collision light installed on the vertical stabilizer and strobe lights installed on the wing tips. It could not be determined whether the strobe lights were on at the time of the collision.

The MU-2B-60 (MU-2), N74FB, was owned and operated by Solar Sources, Inc., of Indianapolis, Indiana. The airplane was manufactured in August of 1980, and was issued a standard certificate of airworthiness on January 23, 1980, according to FAA records. It was powered by two Garrett TPE 331-10-511M engines. A review of the airplane's maintenance records revealed no outstanding discrepancies or deferred maintenance.

At the time of the accident, the airframe had accumulated 4,098 hours. Both of the engines were factory overhauled by the manufacturer in November 1990, and had accumulated 602 hours since that time. The airplane was inspected in accordance with an approved inspection program as required by 14 CFR 91.409(f)(4). The most recent inspection was a 150-hour check completed on May 29, 1992. The airplane had flown 76 hours since that inspection. The MU-2 was painted white with blue and silver trim markings and had strobe lights installed on both wing tip fuel tanks and the vertical stabilizer. During interviews with Safety Board investigators, the backup MU-2 pilot stated that it was the practice of the MU-2 pilot to use the strobe lights. However, the cockpit was so badly destroyed that switch position was not determined, and filament analysis on the strobe light bulbs was not performed.

## 1.7 Meteorological Information

At the time of the accident, the weather conditions in the Indianapolis area were high scattered clouds and excellent visibility. The weather observations at the Indianapolis International Airport, about 13 miles west-northwest of the accident location, were:

> Time--1450; Surface Aviation: 4,500 feet scattered; 25,000 feet scattered; visibility--15 miles; temperature--70 degrees F, dew point--49 degrees F; wind--020 degrees at 10 knots; altimeter--30.29 inches Hg.
>
> Time--1504, Special: 4,500 feet scattered; visibility--15 miles; temperature--68 degrees F, dew point--48 degrees F wind--050 degrees at 5 knots; altimeter--30.28 inches Hg.
>
> Time--1550; Surface Aviation: 4,500 feet scattered, visibility--15 miles; temperature--71 degrees F, dew point--47 degrees F; wind--340 degrees at 4 knots; altimeter--30.28 inches Hg.

The position of the sun relative to the accident site at the time of the accident was 230 degrees (true) in azimuth and 43 degrees in elevation.

## 1.8 Aids to Navigation

Not applicable.

## 1.9 Communications

Interviews with the controllers assigned to the Indianapolis Departure East/Satellite (DRE/Satellite) did not reveal any communications difficulties with either airplane.

The DRE/Satellite controller stated he was in communication with six to eight aircraft at the time of the accident. Based upon the number of aircraft on frequency and the. coordination required for an associated restricted military airspace, the controller judged his workload to be moderate at the time of the accident.

## 1.10 Aerodrome Information

Greenwood Municipal Airport is an uncontrolled airport approximately 12 miles southeast of Indianapolis International Airport, Indianapolis, Indiana. (See figure 2). The field elevation of the airport is 822 feet. The airport has one asphalt runway oriented on a north/south direction with runway headings of 180 degrees and 360 degrees. The runway is 3,462 feet long and 50 feet wide and has pilot-controlled low, medium, and high intensity runway lights. Runway 18 has a displaced threshold 465 feet south of its approach end. The airport is approximately 1.5 miles southeast of the Indianapolis ARSA.

The airport reported 42,400 aircraft operations for the year ending June 9, 1992.. This number included.operations for 7,208 air taxi aircraft, 24,168 general aviation locals (operations remaining in the local traffic pattern and to or from the airport and a practice area within a 20-mile radius of the airport), 10,600 general aviation itinerants (operations not classified as "local," including air carriers and air taxi aircraft), and 424 military aircraft. The airport, like many other U.S. airports without operating control towers, is equipped with one type of common traffic advisory frequency (CTAF) known as UNICOM, which operates on a frequency of 123.0 kHz.

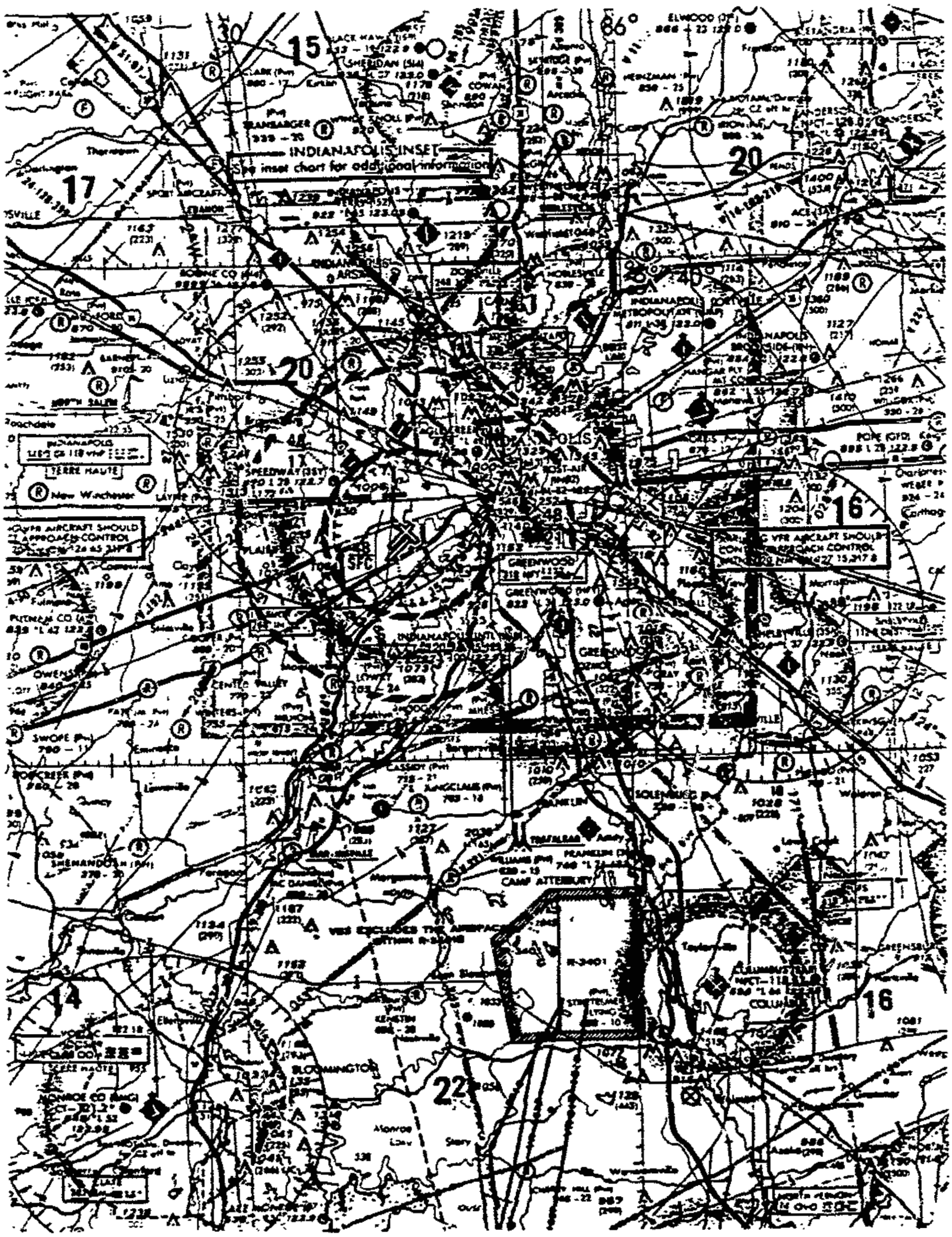


**Figure** 2.--Sectional chart of **ARSA** and Greenwood **Airport.**

The UNICOM is explained in the **Airman's** Information Manual *(AIM)* as a "nongovernmental air/ground radio communication station which may provide airport information at public use airports where no tower or Flight Service Station **(FSS)** exists. On pilot request, UNICOM stations may provide pilots with weather information, wind direction, the recommended runway or other necessary information" **This** and other CTAFs afford pilots a means to communicate their intentions and to obtain airport traffic information when operating to or from airports without operating control towers.

## 1.11 Flight Recorders

Cockpit voice recorders (CVRs) or **flight** data recorders (FDRs) were neither installed nor required in either airplane.

## 1.12 Wreckage and Impact Information

Wreckage and debris from the two airplanes were located at two main sites, approximately 4,200 feet apart, in a residential area of Franklin Township in **Marion** County, Indiana. One wreckage site contained the MU-2 fuselage, its wings, and engines. The empennage was found a few blocks east of the fuselage; the left horizontal stabilizer and elevator were found in a corn field east of the empennage. The other **main** wreckage site contained almost all of the wreckage **of** the **PA-32.**

### 1.12.1 The MU-2

After the collision, the MU-2 continued on a northeasterly heading and crashed inverted in the back yard of the house at 7419 Southern Lakes Drive. **A** postcrash fire consumed the airplane and caused property damage to three houses nearby.

The main portion of the empennage landed in the back yard of a house located about *2* blocks from the back yard of the house on Southern Lakes Drive where the MU-2 crashed. This piece of wreckage consisted of the empennage, vertical stabilizer with a portion of the rudder attached, the right horizontal stabilizer, and the right elevator.

The lower portion of the rudder, and the left horizontal stabilizer and elevator were found in a corn field about 150 feet west of the residential neighborhood. Small pieces of metal from the inboard portion of the left horizontal stabilizer and lower portion of the rudder were found in the yards of houses. The left elevator balance weight was found in a parkway adjacent to a driveway of a house. There was evidence of a propeller strike on the balance weight, and the weight was spattered with oil. There were three propeller slashes in the upper skin of the left horizontal stabilizer. The left horizontal stabilizer was crushed rearward in an accordion manner, from the deicing boot to the rear spar, and the leading edge was displaced upward. There was a transfer of gray paint onto the leading edge deice boot.

The lower portion of the rudder, near the lower hinge point, was twisted, torn, and covered with oil. The inboard section of the left elevator torque tube was crushed and had a semicircular depression. There were circular scratches and tears in the upper section of the vertical stabilizer and in the left side of the empennage forward of the horizontal stabilizer.

The MU-2, less the empennage, remained intact until the airplane struck the ground. The postcrash fire completely destroyed the cockpit, cabin and wings. Both engines were partially buried in the ground.

There were no recoverable cockpit instruments. The throttle quadrant was recovered from the cockpit wreckage. The power levers were full forward, and the condition levers were in their "takeoff-land" position. The landing gear, control handle, and flaps were in the "up" position. The flap jackscrews and switch were also in the "up" position.

Both engines showed evidence of producing power at ground impact. Both propellers had multiple bends and nicks. The first stage impellers of both engines showed rotational damage and bending opposite the direction of rotation. The left engine had metal spray on its igniter. The right engine had soil on its igniter.

### 1.12.2 The Piper PA-32

After the collision, the PA-32 continued a gradual descent in an easterly direction for almost 1 mile before it struck and caused minor damage to the roofs of two houses. It came to rest in the back yard of a third house. A postcrash fire consumed the airplane and a major portion of the house and caused minor damage to an adjoining house.

Some small pieces of debris from the airplane were found near the probable collision location. **A** belly stiffener from the right side of the fuselage immediately aft of the firewall was found next to the south side of a house in the neighborhood. The stiffener had black rubber transfer marks on it. Pieces of engine cowling were found in a vacant lot.

The propeller spinner was crushed and twisted around the propeller dome. There were blue paint transfers on the spinner, which was covered with oil and **dirt.** One propeller blade had separated in its hub, and had oil streaks on the blade root. All three propeller blades were missing sections 4 to 6 inches in length from their tips, **and** all three propeller blades had multiple nicks and bends. There were blue paint transfers on the blades and blue paint chips inside the propeller spinner.

The cockpit, cabin, right wing and inboard portion of the left wing were destroyed by fire. There was no recoverabie information or data from the cockpit instruments because they were also consumed in the fire. The **flaps** were verified to have been up by the position of the flap handle and the actuator bellcrank. The empennage with the stabilator, vertical stabilizer, and rudder did not burn but were damaged during the ground impact sequence.

## 1.13 Medical and Pathological Information

The postmortem examinations of the pilots of both airplanes were performed by the Indiana University School of Medicine, Department of Pathology, Forensic Division The examinations found no preexisting conditions that contributed to the accident. The carboxyhemoglobin level of the PA-32 pilot was measured at 5.2 percent of the total hemoglobin, and the cause of death of the pilot **of** the PA-32 was zttributed to smoke inhalation and bums. The pilot and passengers of the MU-2 died of multiple traumatic injuries sustained at ground impact following the collision. The autopsy of the pilot of the PA-32 revealed neither what incapacitated him following the collision nor why he did not exit the burning airplane following the ground impact sequence.

Toxicological tests were completed by the American Institute **of** Toxicology, Indianapolis, Indiana, on blood and urine samples obtained **from** the pilot of the PA-32. Tests on both samples were negative on a large drug screen, including ethanol and major drugs of abuse.

Toxicological testing was completed by the FAA's Civil Aeromedical Institute on liver and kidney samples obtained posthumously from the pilot **of** the MU-2. Tests on kidney fluid indicated no ethanol, and tests on liver fluid were negative for a drug screen that included major drugs of abuse.

The Safety Board requested that the FAA provide blood and urine samples from all **FAA** personnel who had handled either airplane involved in the collision. The air traffic controllers declined to provide specimens for such testing. The manager **of** the Great Lakes Air Traffic Control Division decided separately that urine samples were not applicable to the investigation, under the FAA's postaccident drug testing guidelines. Based on his determination that there were no performance problems involving air traffic controllers at the time of the **collision,** urine samples were not obtained from them

## 1.14 Fire

Although witnesses indicated that the PA-32 was trailing smoke or some kind of fluid after the collision, the postcrash f i i may have destroyed any evidence of an it-flight fire. The investigation did not find any evidence **of an** in-flight fire on either airplane.

The Franklin Township **Fire** Department, along with units from Perry Township, Beech Grove, and Warren Township, responded to the postcrash **fires** at both wreckage sites. All units were notified simultaneously at **1459.** The first units arrived about 1502 at the MU-2 site and about **1505** at the PA-32 site. The fires were considered under control at 1535 **and** 1545, respectively.

## 1.15 Survival Aspects

The passenger-pilot in the right front seat and the passenger in the rear cabin **of** the PA-32 survived the collision and exited the airplane after it came to rest in the back yard **of** a house. The pilot in the left seat was incapacitated during the collision **and** did not exit the airplane before the postcrash f i i enveloped the airplane and house.

Although the cockpit and cabin **of** the MU-2 were not compromised **during** the collision, the eirplane was uncontrollable. The pilot and passengers did not survive the impact with the ground.

## 1.16 Tests and Research

The Safety Board examined radar returns recorded by the Automated Radar Terminal System (ARTS IIIA) of the Indianapolis Terminal Radar Approach Control (TRACON). The Safety Board also examined the conspicuity of both airplanes and studied factors that would have affected the ability of each airplane pilot to see the other as viewed from each cockpit. A visibility study was conducted to determine the locations and sizes of the airplanes as they would have appeared in their respective binocular fields of vision, as defined by a single fixed-eye position.

### 1.16.1 Indianapolis TRACON

ARTS IIIA radar data recorded for the period from 1431 through 1458 on September 11, 1992, were obtained from the Indianapolis TRACON for evaluation by the Safety Board. Using the recorded radar data (see figure 3), ground track plots were made on an Indianapolis sectional chart to illustrate the track line histories of the airplanes.

Recorded radar data indicated that at 1444:51 an airplane associated with a "1200" beacon code, assumed to be the PA-32, was directly north of Terry Airport at an altitude of 1600 feet. At 1445:33, the radar target, assumed to be the PA-32, switched to a beacon code of "0301" and continued to track to the south. At 1456:04, a "1200" beacon code target, assumed to be the MU-2, was observed approximately over Greenwood Municipal Airport at 900 feet heading northeast. At 1456:08, the radar data indicated that the PA-32 switched beacon codes to "1200" and continued to track to the south at an altitude of 2,500 feet. At 1456:51, recorded radar data indicated a beacon target report of "4564," assumed to be the MU-2, at 1,900 feet northeast of the airport. At 145655.47, one "4564" (last recorded radar return) and one "1200" beacon target report were recorded in close proximity to each other at an altitude of 2,100 feet, 11.4 nautical miles southeast of Indianapolis International Airport, and 2 miles northeast of the Greerwood Airport.

Radar Only (RO)[4] data indicated one return near the two airplanes at 1457:00.19. A "1200" beacon target report, assumed to be the PA-32, continued to descend on a southeasterly track until reaching 1,100 feet at 1457:19.

[4] Target reports based on ATC radar primary returns nther than on mode A transponder beacon returns.

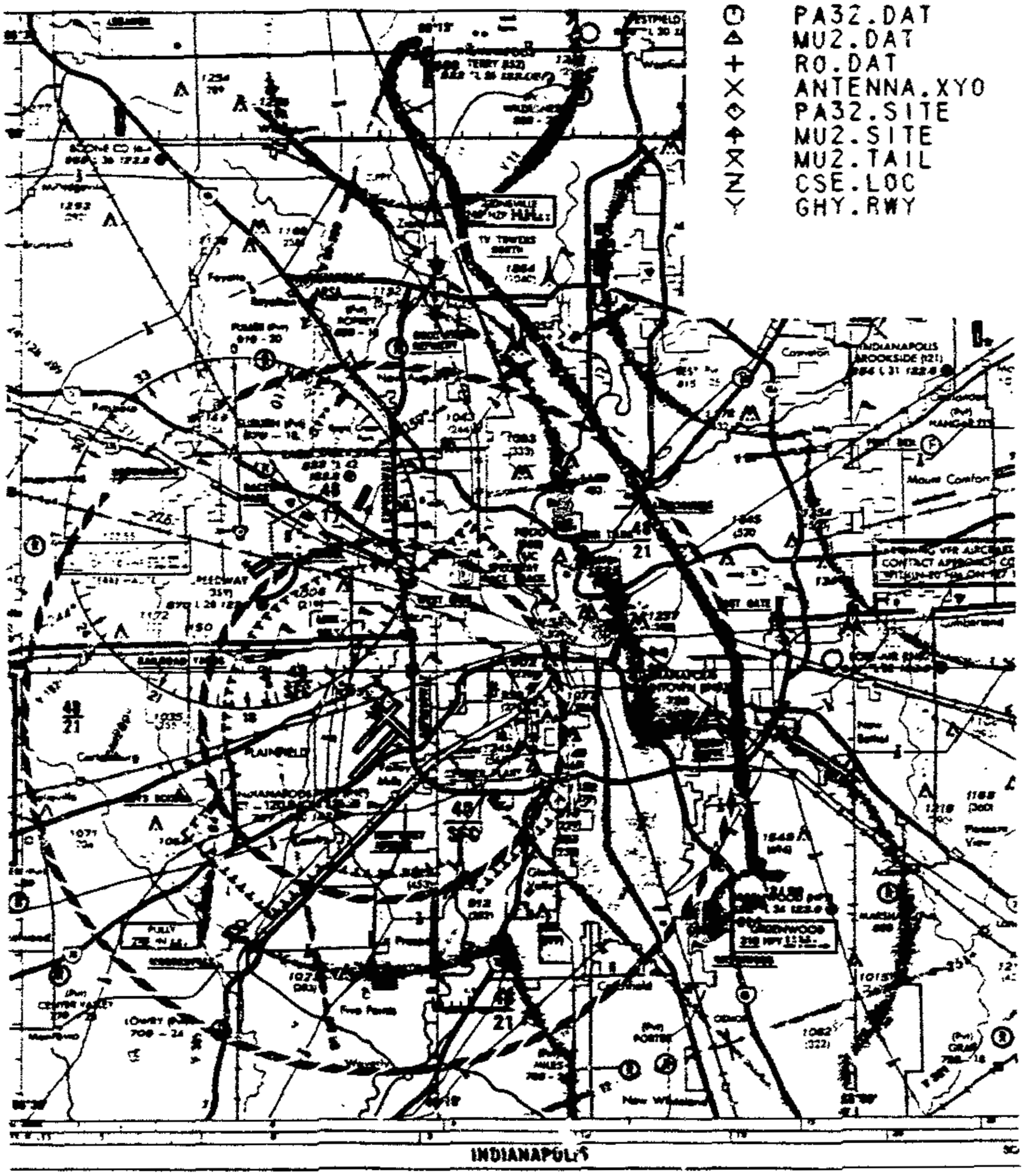


Figure 3.--Recorded radar ground track plots,

The Airport Surveillance Radar (ASR) magnetic tape data from the Indianapolis sensor were processed at the Safety Boards facilities. The beacon target reports for transponder codes 0301, 4564, and 1200, assumed to be associated with the PA-32 and N74FB between 1431:00 and 1458:00, were identified. Also obtained were the positions of the MU-2s fuselage and tail section, the PA-32, and the Control Systems Engineering building. The coordinates for runway 18/36 at Greenwood were supplied by the FAA. Indianapolis Terminal Control Area (TCA) location and dimensions were obtained from the St. Louis Aeronautical Sectional Chart. These data, along with the recorded radar data between 1431:00 and 1458:00, were scaled in nautical miles and plotted using the location of the Indianapolis sensor as the origin.

Plots of the data were overlaid onto the St. Louis Aeronautical Sectional chart (1:250000) and the U.S. Geological Survey Beech Grove, Indiana Quadrangle map (1:100000). Dialogue from the ATC transcript was correlated to the recorded radar data and position plot, along with an overlay of the ATC transmissions between the controllers and both airplanes.

### 1.16.2 Airplane Performance Calculations

The Safety Board examined the recorded radar data to determine the positions, altitudes, velocities, and flightpaths of both airplanes. The radar data indicated that the minimum separation occurred about 1456:53, the estimated time of the collision.

The last radar return recorded for the PA-32 before the collision was considered spurious and was not used. As a result, it was necessary to extrapolate the PA-32 radar data to approximate the collision point.

The smoothed and interpolated radar ground track coordinates were used as input data to a National Aeronautics and Space Administration (NASA) computer program entitled "MANAT." This program used position and time data to calculate performance parameters, such as air speed, ground speed, roll angle, pitch angle and vertical acceleration. The program also used wind and temperature data, as well as airplane-specific information. The abrupt maneuver made by the PA-32 just prior to the collision, as reported by the surviving occupants, would not have been detected by the radar data due to its sampling rate of 1/4.7 seconds.

The program revealed that during the last 11 seconds of recorded data prior to the collision, the average ground speed of the MU-2 was 168 knots, the average indicated air speed was 163 knots, the average magnetic heading was 066 degrees, and the average vertical velocity was +1,596 feet per minute. The recorded data for the PA-32 during this period indicated that during the same time, its average ground speed was 127 knots, indicated air speed was 118 knots, magnetic heading was 173.5 degrees, and average vertical velocity was -390 feet per minute. Figure 4 shows the radar track time histories of the airplanes as recorded by the Indianapolis ARTS IIIA.

### 1.16.3 Cockpit Visibility Study

A cockpit visibility study was conducted to determine the probable locations and sizes of the airplanes as they would have appeared in the windscreens of each airplane. To accomplish this, the viewing angle for both airplanes was calculated and plotted for their respective pilots' fields of vision. The calculations were based on flightpath, attitude time histories, and length and wingspan of the airplanes.

The raw ground track information presented in the radar study and extrapolated coordinates were used to calculate performance and probable locations of the airplanes. This task involved defining the limits of the respective fields of vision based on a single fixed eye position and determining if they had sufficient time to react and therefore to "see and avoid."

A binocular camera was used to photograph cockpits of two similar airplanes. The camera uses a continuous strip of film to produce a panoramic view of the window configuration. Horizontal and vertical grid lines in 5-degree increments are superimposed on the photographs. The resulting photographs show the outline of the cockpit windows as seen by a pilot rotating his head from side to side. Monocular obstructions within the window, such as windshield or door posts, are also defined by the photographs.[5]

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[5] Areas where objects can be seen with only one eye

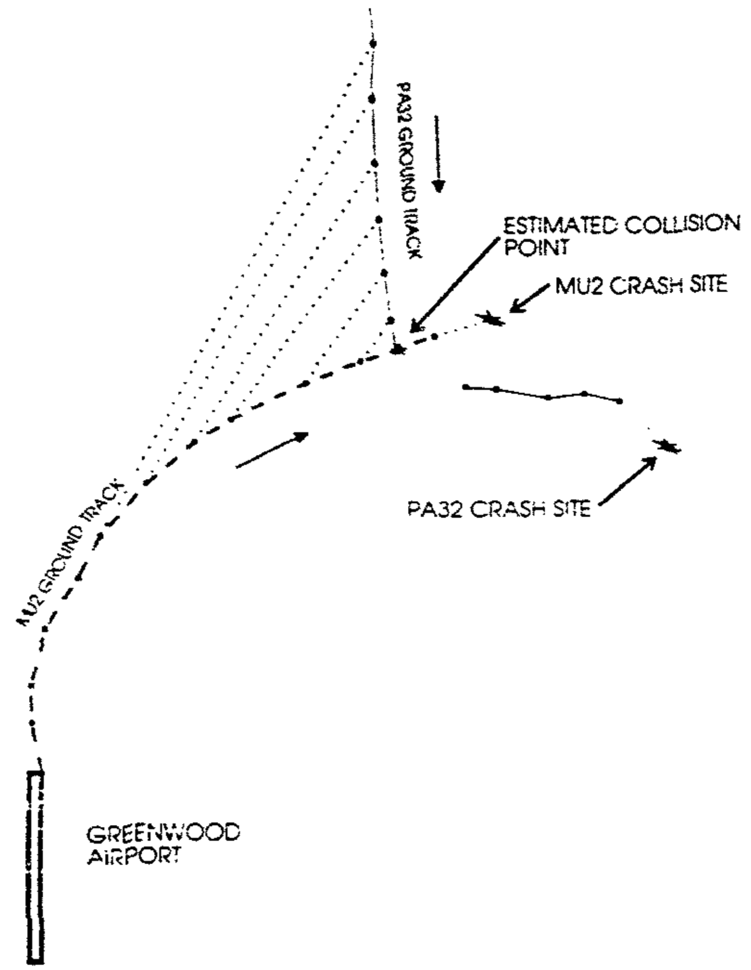


**Figure 4.--ATC radar track time histories.**

The binocular photographs were taken with the camera placed in the pilot's seat at the design eye reference point (DERP)[6] with the airplane on level ground. The view from the right front seat of the PA-32 was created by reversing the photographic image. The pilots involved in the accident were all of average height, so the use of the design eye reference point should have provided an appropriate approximation. The pilot of the PA-32 was 5 feet and 9 1/2 inches tall; the pilot-passenger of the PA-32 was 5 feet and 8 inches tall: and the pilot of the MU-2 was 5 feet and 11 inches tall.

The position time histories of the airplanes were superimposed on the photographs of the full field of vision for the pilots of both airplanes and the copilot's seat of the PA-32. This was accomplished by plotting the azimuth and elevation angles computed for the center of the target airplane on the respective crewmember's field of vision and, in the case of the PA-32, the passenger/copilot occupying the right cockpit seat. The positions of the target airplanes, as seen from the cockpit, were dispiaced as the airplanes' pitch and roll angles changed.

Based on the radar data, the collision was estimated to have occurred at 1456:53. Research has shown that, as a minimum, targets should subtend 0.2 degrees of arc to ensure accurate recognition[7] (see section 1.17.2 of this report). FAA Advisory Circular (AC) 90-48C, entitled Pilot's Role in collision Avoidance, utilized military data to document that the minimum time necessary to recognize a potential in-flight target and to successfully execute an evasive maneuver is 12.5 seconds. At 12.5 seconds prior to the collision, the time was 1456:41. Therefore. the figures were constructed to display the viewing angle time histories from 1456:28 to 1456:41 (13 seconds) for the PA-32 and from 1456:33 to 1456:41 (8 seconds) for the MU-2.

The cockpit visibility study revealed that:

> The **PA-31-** would have appeared below the hrrizontal zero eye reference plane, in the. lower left comer of the MU-2's windshield, clear of all obstructions from 1456:33 (20 seconds before the collision) to 1456:37. In the following 4 seconds. it could have

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[6] The design eye reference point is a single point established in accordance with provisions of Civil Aeronautics Manual (CAM) 4b.351-3. "Minimum Area of Visibility in the Flight Crew Compartment." 1955. from which the central viewing axis may be located.

[7] Morgan, C., Cook, J., Chapanis, A., and Lund, M., "Human Engineering Guide to Equipment Design," McGraw-Hill, New York, 1963.

appeared in the monocular field of view created by the left windshield post. After that, the 12.5 second window of opportunity **to** see and avoid was not available. (See MU-2 cockpit in appenaix *C)*.

The **MU-2,** as viewed by the pilot of the **PA-32,** was in the right windshield, immediately right of the center windshield post from 1456:28 (25 seconds before the collision) to 1456:41 (12 seconds before the collision). The MU-2's position in the windshield would have moved from just below the horizontal zero eye reference plane to just above the instrument panel during this time. The apparent downward movement of the Mu-2 in the PA-32's field of vision would have been caused by the airplanes' converging flightpaths. (See PA-32 cockpit in appendix C).

The MU-2, as viewed by the passenger-pilot of the PA-32, would have appeared in the monocular field of vision created by the right windshield post from 1456:28 (25 seconds before the collision) to 1456:41 (12 seconds before the collision). (See PA-32 copilot's view in appendix *C)*.

At an elevation angle of 43 degrees, the sun was not in the normal field of vision of the pilots of either airplane.

## 1.17 Additional Information

### 1.17.1 Survivor Interviews

Attempts were made by Safety Board investigators to interview both survivors, but, due **to** the serious and deteriorating nature of their medical conditions, interviews **were** not conducted. However. information was obtained by investigators **from** police. rescue personnel, and bystanders who spoke with the survivors.

The daughter stated to a police interviewer in the hospital that they had a camcorder aboard the airplane and that just before the collision, "we were getting ready to film the office.." Based on information obtained from both survivors, the pilot yelled a warning and tumed the airplane left before the collision; the pilot responded to questions just after the collision but stopped responding before the airplane reached the ground; and smoke and material on the windscreen after the collision eliminated forward visibility. No further information could be obtained.

### 1.17.1.1 Arrival and Departure Procedures at Greenwood Airport

Safety Board investigators interviewed two general aviation pilots and an airline captain who were familiar with operations at Greenwood Airport. They were asked to describe routine amval and departure procedures that they would use when runway 36 was in use.

The airline captain, who owned a twin-engine airplane that was based at Greenwood Airport, said that the airport used a pattern altitude of 1,000 feet agl and a left-hand traffic pattern for runway 36. Arriving from the northeast, a pilot would be expected to use a crosswind entry beyond the departure end of the runway. An overhead entry would also be acceptable. To depart to the northeast, a pilot would depart the pattern with a left 45-degree turn, clear the traffic pattern, and head in any desired direction as long as the pilot was careful not to violate the Indianapolis **ARSA.** The captain indicated that he did not see any problem with a right 45-degree departure but said that he would not use a left-hand pattern with three left turns and a midfield departure from downwind because he would feel too exposed to other traffic. He indicated that he was not aware of a published procedure for landing and departing at this airport.

The president of the R.A.F. Flight School at Eagle Creek Airport said that Greenwood Airport used a standard left-hand pattern at an altitude of 1,000 feet above ground level (agl). Arriving from the northeast, a pilot would be expected to make a standard crosswind entry between midfield and the end of the runway. Departing to the northeast, a pilot would fly straight out or use a left-hand pattern with three left turns and a midfield departure. A right 45-degree departure would be nonstandard, as would all right-hand departures.

An airplane mechanic at Terry Airport, who was a private pilot with 450 hours flight time and was working on an instrument rating, said that Greenwood Airport used a left-hand traffic pattern, at an altitude of 800 feet agl. Arriving from the northeast, a pilot would fly a crosswind entry midfield or over the end of the runway. For departure, the pilot would turn left over the field and depart midfield.

### 1.17.2 See and Avoid

The requirement for pilots to maintain an adequate outside scan to assure that they are able to "see and avoid" other aircraft is addressed by 14 CFR, Part 91.67, which states:

> When weather conditions permit, regardless of whether an operation is conducted under IFR or VFR, vigilance shall be maintained by each person operating an aircraft so as to see and avoid other aircraft, in compliance with this section.

Accordingly, the operation of a flight under IFR but in VMC does not relieve a pilot of the responsibility to see and avoid other aircraft. Further, the receipt of traffic advisories would not relieve participating VFR pilots of their responsibilities to see and avoid other traffic.

There are many physical, physiological, and psychological constraints that have been shown to reduce the human ability to exercise the required degree of vigilance. These limitations include target characteristics, size, color, task variables, such as workload and time at task, observer characteristics, such as age and fatigue, and environmental parameters, such as weather, clouds and glare.

Research data indicate that the human eye (with 20/20 vision) is capable of identifying letters of the alphabet if these letters subtend a visual angle[8] of at least 0.08 degree or 5 minutes of arc. Letters are considered highly discernible whereas target identificatim can be more complex. Humans are capable of detecting a target when it subtends about 12 minutes of arc, if the subject is alerted to search for the target.[9]

Reaction time after visual acquisition of a target is also a factor in avoiding a collision. FAA AC 90-48C provides data derived from the military on the time necessary for a pilot to recognize an in-flight target and to execute an evasive maneuver. AC 90-48C indicates that the total time required to see an object, to perceive the collision threat, and to begin to take evasive action is

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[8] An angle subtended at the eye by the viewed object. Visual angle is a function of both the size of the object measured perpendicularly 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.

[9] Van Cott, H. and Kinkade, R.. "Human Engineering Guide to Equipment Design," Revised Edition, American Institute for Research, Washington. D.C.. 1972.

12.5 seconds. About 6.4 seconds of the 12.5 seconds are required to complete the evasive maneuver after the collision threat is perceived. (See table 1.)

Table 1.--Reaction Time

| | Visual Acquisition (seconds) | Evasive Maneuver (seconds)* | Cumulative (seconds) |
|---|---|---|---|
| See object | 0.1 | | 0.1 |
| Recognize | 1.0 | | 1.1 |
| Perceive collision course | 5.0 | | 6.1 |
| Decision to turn left or right | | 4.0* | 10.1 |
| Muscular reaction | | 0.4* | 10.5 |
| Airplane lag time | — | 2.0* | 12.5 |
| Total | 6.1 | 6.4* | |

*Total reaction time.

Finally, there is a concept known as diffusion of responsibility, which describes a tendency on the part of pilots in some circumstances to relax their vigilance. A NASA study on near midair collisions indicated that an inappropriate sense of shared responsibility may occur when an airplane is under ATC radar control. That is, a pilot relegates a portion of his vigilance responsibility for seeing and avoiding to the controller. The study states, in part "If ASRS (Aviation Safety Reporting System) reports are representative, many pilots under radar control believe that they will be advised of traffic that represents a potential conflict and behave accordingly. They tend to relax their visual scan for other traffic until warned of its presence."[10]

This "diffusion of responsibility" is supported by the AIM, which states:

[10] Billings, C.. Grayson, R., Hecht, W.. and Curry, R., "A Study of Near Midair Collisions in U.S. Terminal Airspace," NASA Technical Memorandum 81225. 1980.

4-81. CLEARANCE

a, ....*An* ATC clearance means an authorization by ATC, for the purpose of preventing collision between known aircraft, for **an** aircraft to proceed under specified conditions within controlled airspace....

Pilot/Controller Glossary

AIR TRAFFIC CLEARANCE-An authorization by air traffic control, for the purpose of preventing collision between known aircraft,..

PILOT/CONTROLLER ROLES AND RESPONSIBILITIES

5-71. GENERAL

c. The air traffic controller is responsible to give first priority to the separation of aircraft....

e. The responsibilities **of** the pilot and the controller intentionally overlap in many areas, providing a degree of redundancy. Should one or the other fail in any manner, this overlapping responsibility is expected to compensate, in many cases, for failures that may affect safety.

None of these excerpts specify whether the aircraft are being operated under VFR or IFR. **The AIM** and Air Traffic Control Handbook 7110.65G prioritize controllers' separation responsibilities. Primary separation responsibility is IFR aircraft from **IFR**, secondary **is** IFR from **VFR**, and finally on a time available basis VFR from VFR.

### 1.17.3 ATC Procedures

The prescribed ATC procedures and phraseology for use by personnel providing ATC services are contained in the FAA Air Traffic Control Handbook 7110.65G. Chapter **2, "General** Control," Section 1, "General," paragraph ***2-2,*** lists the duty priority. **It** states, in part, "Give first priority to separating aircraft and **issuing** safety alerts...." Additionally, a paragraph 2-2 Note states, in part, "primary purpose of the ATC system is to prevent a collision between aircraft operating in the system...."

Air traffic controllers issue two different types of traffic advisories to alert pilots of other known or observed air traffic in their vicinity that in the judgment of the controller warrants the pilot's attention. The most commonly used advisory is the basic "traffic advisory," described in paragraph 2-21, "Traffic Advisories." This advisory may be based on visual observation, observation of radar-identified or unidentified aircraft targets, verbal reports from pilots, or other ATC facilities. The word "traffic" is used to provide the advisory from aircraft in miles, the direction the traffic is proceeding, and the type of aircraft and altitude, if known. Traffic advisories will be provided, as possible, depending on higher priority duties of the controller or other limitations, such as controller workload, radar limitations, traffic volume and radio frequency congestion. Traffic advisories do not relieve pilots of their responsibility to see and avoid other traffic.

The second and more urgent advisory is called a "safety advisory." Safety advisories are issued by controllers to aircraft under their control when in the controller's judgment, the aircraft is at an altitude that is in unsafe proximity to terrain, obstructions, or other aircraft. In the case of proximity to another aircraft, "traffic alert" is used to provide this advisory service, followed by an alternate course of action to the pilots, such as a turn or climb/descent. Paragraph 2-6, Note 1, states, in part, "The issuance of a safety advisory is a first priority once the controller observes and recognizes a situation such as unsafe aircraft proximity to terrain, obstacles, or other aircraft. While a controller cannot immediately see the development of every situation where a safety advisory must be issued, the controller must remain vigilant for such situations and issue a safety advisory when the situation is recognized."

The 18-minute transcript of the Indianapolis DRE/Satellite activities indicated that the controller issued three traffic advisories to airplanes other than *the two* involved in the collision. The traffic ranged from 1 mile to 5 miles ahead or to the right of the airplanes; in one case, the pilot acknowledged visual contact with the other aircraft. No "safety advisories" were issued during that time period.

Air Traffic Control Handbook 7110.65G, paragraph 4-87, "Communications Release" states: "If an IFR aircraft intends to land at an airport not served by a tower or FSS, approve a change to the advisory service frequency when you no longer require direct communications." A note to that paragraph adds:

"An expeditious change permits the aircraft to receive timely local airport traffic information...." Although the PA-32 was a VFR airplane, receiving VFR advisories, the pilot was issued a discreet transponder code (0301) to receive conflict alert information. When the pilot of the PA-32 reported Greenwood Airport in sight, the controller advised investigators that he saw no radar targets in the vicinity of the PA-32 and that radar service was terminated. He stated that he saw the transponder change from "0301" to "1200" (which now deactivated the conflict alert system) and that he no longer monitored the flightpath of the airplane.

Forty-four seconds after the release of the PA-32, the DRE/Satellite controller received a transmission from the pilot of the MU-2: "Indy Approach, Mitsubishi seven four Foxtrot Bravo over." At this time, the controlier was neither aware of the location of the airplane nor of the pilot's intentions; therefore, he had to request additional information. He responded, "Mitsubishi seven four Fox Bravo, Indy." At 1956:47, the pilot of the MU-2 indicated the departure airport location and that he was requesting an IFR clearance to Columbus. According to the Air Traffic Control Handbook 7110.65G, Chapter 5, "Radar," Section 3, "Radar Identification," paragraph 5-50, "Application," states: "Before you provide radar service, establish and maintain radar identification of the aircraft involved...." Paragraph 5-52, "Beacon Identification Methods" states, in part, "When using only Mode 3/A radar beacon to identify a target, use one of the following methods: Request the aircraft to activate the "IDENT" feature of the transponder and then observe the identification display. Phraseology: 'SQUAWK (code) AND IDENT."

As soon as the controller knew that the pilot was requesting his prefiled IFR clearance, the controller had to look away from the radar screen to the strip bay and locate the proper flight progress strip. He then had to confii the information on the strip and issue the correct discreet code to establish radar contact. The controller stated that he did not see a radar target (MU-2) depart from Greenwood Airport; therefore, he had to establish radar identification. It was during this process that the collision occurred. Radar contact had not yet been established; therefore, traffic could not have been issued.

The conflict alert program is designed to alert controllers to potentially hazardous traffic situations that require immediate attention or action. However, the program will only function if the airplanes involved are equipped with operating altitude encoding transponders, and the computer has identified each airplane with a given track or a correlated target. Since the MU-2's flight plan had not yet been entered into the computer and the PA-32 was an uncorrelated (untracked) target, the conflict alert system did not activate. If the Mu-2 pilot had received the transponder code before departure, the conflict alert would have activated because of the close proximity of the PA-32.

# 2. ANALYSIS

## 2.1 General

Both the PA-32 and the MU-2 were equipped and maintained in accordance with applicable rules and directives. There was no evidence that the airworthiness of either airplane contributed to the collision.

Weather would not have restricted the pilots' ability to see one another. The pilots of both airplanes were qualified for the flights, and there were no known medical problems that impeded their ability to avoid the collision.

The accident occurred outside the boundaries of the Indianapolis ARSA. Therefore, the applicable rules and the safety benefits associated with that protected airspace are not relevant to this accident.

The air traffic controller and his supervisor assigned to the Indianapolis International Airport, DRE/Satellite position, were qualified to perform their respective functions and to provide the required ATC services.

The collision occurred in airspace where ATC services were provided to IFR aircraft and traffic advisories were provided to VFR aircraft receiving flight-following services. However, VFR aircraft were authorized to operate in the airspace outside an ARSA without receiving ATC services, if they remained in VMC and operated under the see-and-avoid concept. Since VMC prevailed, it was appropriate for both airplanes to operate in the airspace where the collision occurred.

The Safety Board developed a cockpit visibility study to determine whether either pilot's view of the other airplane would have been obstructed. *Also,* collision geometry was examined to determine if either pilot took evasive action. The collision geometry was reconstructed from the physical evidence found in the wreckage of the airplanes and from ARTS IIIA radar data. The Safety Board also examined pilot and ATC procedures, and limitations of the see-and-avoid concept.

## 2.2 Cockpit Visibility Study

The cockpit visibility study showed that the PA-32 may have been visible to the pilot of the MU-2 for 8 seconds before the 12.5 seconds theoretically needed to identify and avoid a collision. For 4 of the 8 seconds, the PA-32 could have appeared unobstructed in the lower left comer of the MU-2's left windshield. The left windshield post could have limited the MU-2 pilot's view to a monocular view of the PA-3% for the last 4 seconds. This assumes that the pilot was sitting stationary at the DERP. However, if the pilot had moved his head forward to adjust his radios or flight controls, or to scan outside, he might have been able to see the PA-32 with both eyes. Any movement from the DERP, whether it is from the pilot moving in the cockpit or the pitch or roll movements of the airplane, would displace the targets accordingly.

The study showed that the MU-2, as viewed by the PA-32 pilot, would have beer! positioned in the right windshield of the PA-32, visible for 13 seconds before the 12.5 seconds theoretically needed to identify and avoid a collision, just to the right of the monocular field of vision created by the center windshield post. The pilot-passenger in the right front seat could have had a monocular field of vision of the MU-2 created by the right windshield post during the same period of time.

Because the sun was not in the normal field of view of either pilot, the sun should not have produced an abnormal glare on the windshield of either airplane, even though there was only a scattered layer of clouds in the area at the time of the accident.

The Safety Board believes that both pilots, along with the qualified pilot-passenger in the right seat of the PA-32, should have employed scanning techniques to detect potential collision threats. However, it is apparent that the scanning techniques employed did not result in timely identification of the collision threat. Both pilots had an unobstructed view of the other for a short time--4 to 8 seconds for the MU-2 pilot and 13 seconds for the PA-32 pilot--before the 12.5 seconds necessary to recognize the threat and take evasive action. Cockpit visibility, as indicated by the cockpit photographs, did not effectively explain why the pilots of each airplane did not see the other airplane in time to take evasive action.

The ability of pilots to detect other airplanes depends largely on the conspicuity of the other airplane, as determined by the airplane's motion, size, color and brightness, compared to the background against which it is observed.[11] Sadly, some of the most important factors for good conspicuity are missing in midair collision situations. When a pilot is on a direct collision course with another airplane (with both airplanes going straight), the other airplane appears to be stationary, fixed in the pilot's windscreen, and it does not move. It grows slowly, becoming conspicuously large only in the final brief period before collision when effective evasive action may not be possible.

These problems are reflected in the visibility study, which shows that even when the MU-2 was engaged in a turn, its motion in the windscreen of the PA-32 was relatively small (as was the PA-32s motion in the MU-2's windscreen). The MU-2 was painted predominantly white and the PA-32 predominantly gray. These colors, which are typical of the general aviation fleet, would not be particularly conspicuous to another pilot against typical backgrounds during the brief period that the airplanes appear large enough for color to be an important factor.

Both airplanes were equipped with strobe lights, which could be a useful factor for conspicuity even during the day, since they can impart a sense of motion to a midair target that would otherwise appear stationary. Because of the damage, it was not possible to determine whether the strobe lights on the MU-2 or the PA-32 were in use at the time of impact.

## 2.3 Analysis of the Collision Geometry

The collision geometry was determined using data from the radar data study. These data were consistent with the accounts of witnesses and the physical wreckage examined.

The collision geometry showed a closure rate of 234 knots between the two airplanes on a 038-218 degree magnetic bearing. For the Mu-2, the relative bearing of the other airplane was 30 degrees to the left of straight ahead; and for the

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[11] The Safety Board issued Safety Recommendation A-91-112 on the issue of conspicuity in its report on the February 1, 1991, runway collision of a USAir B-737 and a Skywest Fairchild Metroliner at the Los Angeles International airport (NTSB/AAR-91/08). This recommendation concerns the conspicuity of aircraft against airport surfaces at night and does not address the present accident situation.

PA-32, the other airplane was 45 degrees to the right. The collision angle was 105 degrees just before the collision. (See figure 5).

However, the collision angle at impact was very close to 90 degrees because the PA-32 made a steep bank to the left about 45 degrees just before the collision. This banking is supported by evidence that there was no contact between the left wings of either airplane. Examination revealed that there was contact between the belly of the PA-32 and the leading edge deicing boot of the MU-2's left horizontal stabilizer. The nose landing gear of the PA-32 made contact with the elevator torque tube of the MU-2. (See figure 6).

The collision occurred as the MU-2 ciimbed through 2,100 feet on a course of 070 degrees at a ground speed of 168 knots, climbing at approximately 1,200 feet per minute (fpm). The vertical component of this rate of climb was 12 knots, and the climb path was 4 degrees relative to the horizontal plane. The collision damage on the MU-2 was confined to the empennage. Most of the MU-2's structure forward of the empennage was consumed by a postimpact fire. However, on those pieces of structure that were not destroyed, there was no evidence of collision damage.

The radar data showed the PA-32 to be on a track of 174 degrees, at a ground speed of 127 knots, with a rate of descent of 390 fpm. The vertical component of this rate of descent is 3.9 knots, and the descent path is -2.1 degrees relative to the horizontal plane. The collision damage to the PA-32 involved the propeller, propeller spinner, engine cowling, and belly skin. The PA-32 structure was destroyed by the fire.

Since the plane of motion of the two airplanes was within 15 degrees of the horizontal, an accepted practice was used in solving this 3-dimensional relative motion problem. This practice dictates that if the plane of motion of the two aircraft is within 15 degrees of the horizontal or vertical planes, the problem is resolved by using either the horizontal or the vertical motion alone, as appropriate. This will introduce errors of less than 5 percent at a maximum value of 15 degrees. Since the motion of both airplanes was within 4 degrees and 1.5 degrees of the horizontal, the relative motion geometry was solved in the horizontal plane, and the resulting errors were considered negligible.

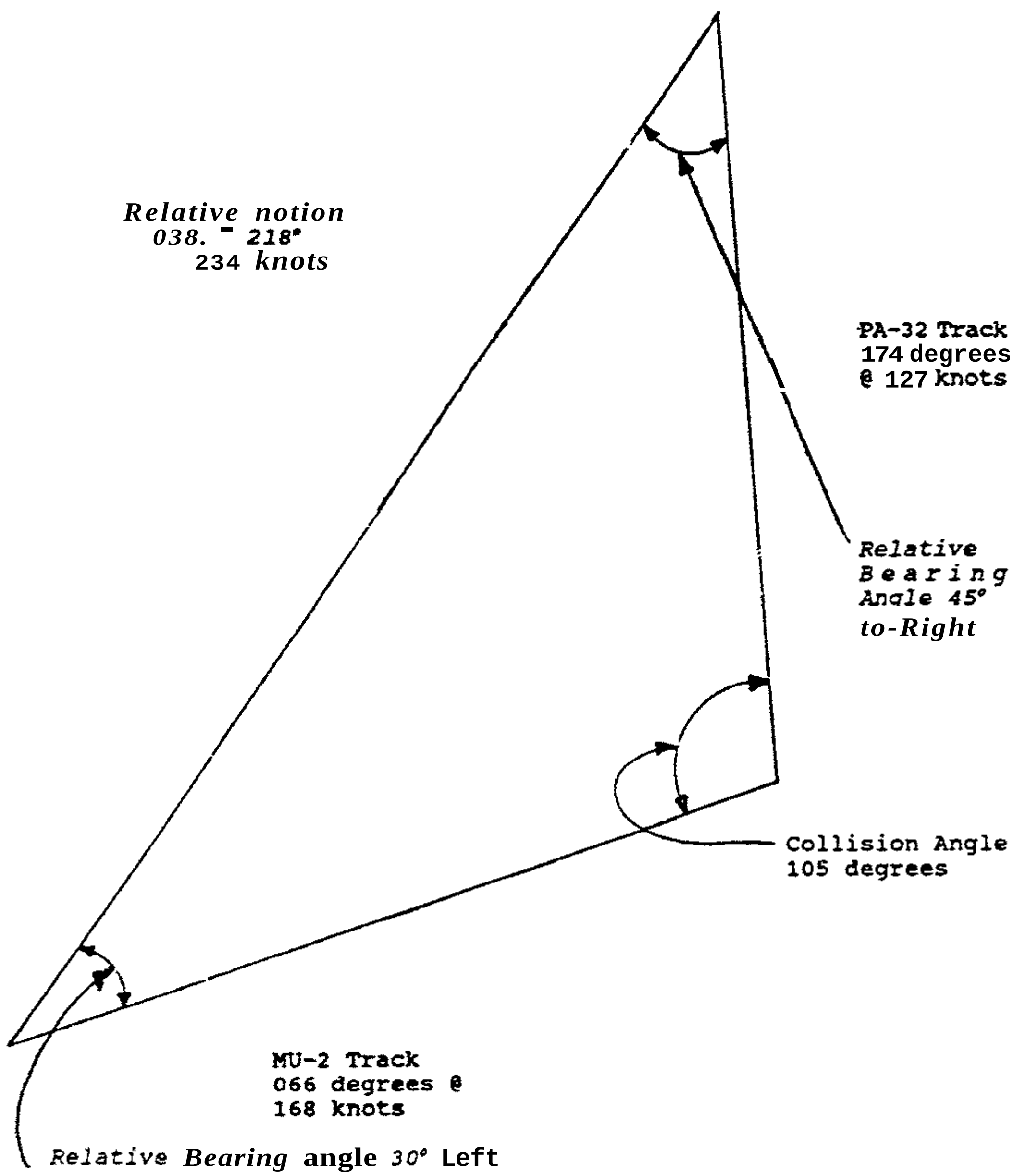



**Figure 5.--Triangular relationship of the airplanes at impact.**

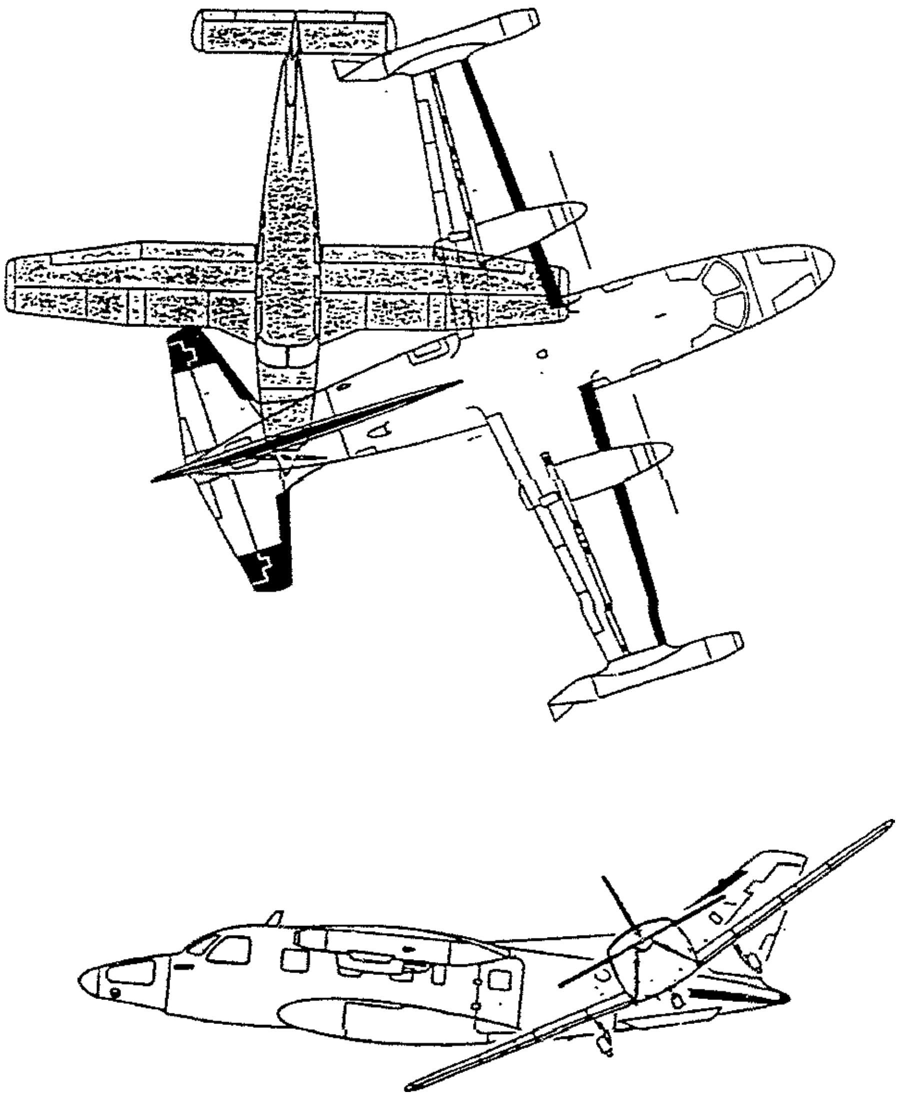


Figure 6.--Horizontal view and pfanview of the airplanes at impact.

It is probable that the MU-2 appeared suddenly and that the **PA-32** pilot made a reactive **turn** to the left just before impact. The absence of impact marks or damage on those portions of the MU-2 forward of the empennage indicate that the PA-32 passed behind the left wing of the MU-2 as it climbed and that it contacted the MU-2's empennage. The impact damage and the engine oil spray pattern on the PA-32 also indicated thdt the attitude of the PA-32 was nose high at the time of impact. The first contact between the two airplanes was one propeller blade of the PA-32 contacting the tip of the left horizontal stabilizer and elevator of the MU-2 and separating the balance weight from the elevator. The balance weight was of sufficient mass to separate that blade in the propeller, resulting in the weight being sprayed with oil from the hub of the PA-32's propeller assembly. There were *two* additional propeller strikes on the horizontal stabilizer before the stabilizer was crushed rearward during contact with the belly of the PA-32. There were black rubber transfer marks on the PA-32's belly stiffener, which had separated and was found near the probable area of the collision. There was also a gray paint transfer on the deice boot of the MU-2.

The propeller spinner of the PA-32 was driven into the vertical stabilizer of the MU-2 where the vertical spar joined the empennage. There was at least one propeller revolution before the empennage separated from the MU-2's *aft* fuselage joint, as evidenced by circular scrapes and cuts on the left side of the empennage. Blue paint transfer was found on all PA-32 propeller blades and the propeller spinner. The PA-32's oil-filled propeller dome was crushed when it contacted the MU-2, releasing a large amount of oil in the damaged area of the vertical stabilizer of the MU-2. The cowl of the PA-32 was also damaged in this sequence, and it separated from the airplane.

The propeller of the PA-32 separated the rudder from the MU-2 while the belly of the PA-32 separated the left horizontal stabilizer and left portion of the elevator of the MU-2. These pieces were recovered near the collision.

The empennage of the MU-2 broke away and fell to the ground. Without the empennage, the MU-2 was not controllable. The MU-2, with its engines set at climb power, assumed a nose-down attitude until it struck the ground inverted.

The PA-32, which did not sustain damage to its control surfaces but incurred some engine damage when the propeller cut through the tail **of** the MU-2, continued **to** the east in a shallow descent. The oil from the damaged propeller dome sprayed over the windscreen and impaired the visibility from the cockpit of the PA-32. No pieces of windscreen were found at the impact point, and fire destroyed any evidence of its condition. There was also smoke from oil spray on the engine and exhaust system that may have hindered visibility in the cockpit. With the loss of propeller oil pressure, the propeller blade; were driven to the low pitch stops by aerodynamic forces. In addition, the blade that was found loose in its hub would have caused some vibration during the remainder of the flight.

## 2.4 Airport Traffic Pattern Areas - Uncontrolled Airports

The MU-2 was departing the Greenwood Airport traffic pattern, and the PA-32 had announced landing intentions at Greerwood Airport immediately prior to the collision. 14 CFR Part 91, General Operation and Flight Rules, governs the VFR flight operations of both the MU-2 and PA-32. The airport did not have a control tower; and the pilots were required to comply with 14 CFR, Part 91.127, Operating On or In the Vicinity of an Airport: General Rules, which states, in part, the following:

> (a) Unless otherwise required by Part 93 of this chapter, each person operating an aircraft shall comply with the requirements of this section and, if applicable, of Part 91.129.
>
> (b) Each person operating an aircraft to or from an airport without an operating control tower shall-
>
> (1) In the case of an airplane approaching to land, make all turns of that airplane to the left...
>
> (3) In the case of an aircraft departing the airport, comply with any traffic patterns established for that airport in Part 93.

Greenwood Municipal Airport does not have a traffic pattern established in FAR Part 93, Special Air Rules and Airport Traffic Patterns. Further, FAR Part 91.127 does not include a traffic pattern altitude or a specified departure procedure.

AC 90-66, Recommended Standard Traffic Patterns for Airplane Operations at Uncontrolled Airports, which was published in February 1975, recommends a 1,000-foot agl traffic pattern. This specific recommendation is not contained in the text of the AIM; however, it is mentioned in the figures that depict traffic pattern operation. Four local pilots, including the MU-2 backup pilot, were interviewed by Safety Board investigators concerning the Greenwood traffic pattern altitude. Two of them chose 1,000 feet, one 800 feet, and the other 2,000 feet. The Airport/Facility Directory, published by the National Oceanic and Atmospheric Administration (NOAA), lists the traffic pattern altitude as 800 feet.

Guidance for traffic pattern operations at uncontrolled airports is found in the AIM. It is an FAA publication that is described as the "official guide to basic flight information." It is widely used and available to pilots. In the text of *AIM*, paragraph 4-54, it is stated that airport "traffic pattern altitudes for propeller driven aircraft generally extend from 600 feet to as high as 1.500 feet above the ground" and cautions pilots to be "alert for other aircraft."

Paragraph 4-54 also depicts a traffic pattern arrival procedure of entering the downwind leg at a 45-degree angle. The two departure procedures recommend that aircraft either aepart the traffic pattern by flying straight out or exiting with a 45-degree left turn beycnd the departure end of the runway, after reaching traffic pattern altitude.

A pilot attempting to enter a traffic pattern at an uncontrolled field must visually scan for other aircraft over a 900-foot range from 600 feet to 1,500 feet agl. Although the AC published in 1975 recommends a 1,000-foot pattern, the *AIM* guidance allows for a range of pattern altitudes. The AC's publication has been limited, but the AIM is published every 16 weeks, distributed by subscription, and reprinted in numerous forms by many aviation publishers. Unlike the AC, it is readily available and used by many general aviation pilots.

It should be noted that there is no requirement for pilots to follow these recommended procedures. According to his backup pilot, the pilot of the MU-2 had developed his own arrival and departure procedures at Greenwood Airport: Departing on runway 36, he would climb straight out 500 feet to 700 feet and then initiate a right turn, preventing inadvertent penetration into the Indianapolis ARSA and allowing for passenger comfort. During the accident flight, it also placed the airplane on a heading toward the destination of Columbus, Ohio.

The Greenwood Airport is located 2 miles from the southeast boundary of the Indianapolis ARSA, and, as such, the traffic pattern at the airport may not take into consideration the flight characteristics of high-performance turbopropeller aircraft that use the airport. Therefore, the Safety Board believes that the FAA should review entry and departure procedures at uncontrolled airports for high-performance airplanes that are separate from low-performance airplanes.

Like most uncontrolled airports, there are no specified VFR arrival or departure procedures for the Greenwood Airport. Four local pilots, including the MU-2 backup pilot, were interviewed concerning the arrival and departure procedures for the airport. These pilots produced four procedures, none of which resembled the procedures outlined in the AIM.

The AIM recommends arrival and departure procedures under a section entitled Airport Operations. In order to access the AIM guidelines concerning traffic pattern entries, the pilot must reference another section entitled ATC Clearances/Separations. In order to access the AIM-recommended traffic advisory practices, the pilot must reference yet another AIM section entitled Services Available to Pilots.

There is little regulation or guidance relating to arrival and departure procedures at uncontrolled airports. The little available guidance is difficult to access. Pilots do not adhere to the guidance, either because it does not address the parameters of their particular flight operation or because of a lack of knowledge. The Safety Board believes that more specific guidance should be made available to pilots to standardize traffic pattern operations at uncontrolled airports.

## 2.5 In-flight IFR Clearance Procedures

The weather, forecast conditions, and the requested altitude of 15,000 feet did not require the MU-2 pilot to file an IFR flight plan for the flight from Greenwood, Indiana, to Columbus, Ohio. With 19,000 hours and a flight frequency of 2 to 3 times per week, it is doubtful that the pilot of the MU-2 believed that filing an IFR flight plan was necessary to maintain his currency. It is more likely that the purpose of the IFR flight plan was to aid in traffic separation and to prevent inadvertent entry into airspace that required prior clearance.

The pilot filed the IFR flight plan for departure at 1400 and called for his clearance once he was airborne at 1456:47. The AIM, paragraph 5-11, states:

a. To prevent computer saturation in the en-route environment, parameters have been established to delete proposed departure flight plans which have not been activated. Most centers have this parameter set so as to delete these flight plans a minimum of 1 hour after the proposed departure time. To ensure that a flight plan remains active, pilots whose actual departure time will be delayed 1 hour or more beyond their filed departure time, are requested to notify ATC of their departure time.

b. Due to traffic saturation, control personnel frequently will be unable to accept these revisions via radio. It is recommended that you forward these revisions to the nearest FSS.

It is possible that the MU-2 pilot expedited his departure to obtain his clearance while airborne before he had to file his flight plan again. Nonetheless, airborne receipt of the IFR clearance increased the pilot's workload and could have distracted him from looking for traffic. It also delayed the controller's ability to identify the airplane by radar before the collision. The Safety Board believes that it would have been prudent for the pilot to have activated the IFR flight plan before takeoff so that controllers could have provided traffic advisories. Moreover, the pilot's attention would have been directed inside the cockpit at the time he received his clearance if he had written down the clearance and if he had dialed in his transponder code. Therefore, the pilot failed to take full advantage of the ATC services available. This failure contributed to the factors that led to the accident–

## 2.6 Corporate Aircraft Workload

The MU-2 pilot's departure procedure from runway 36 at Greenwood Municipal Airport did not follow the guidance in the AIM. He began a turn almost immediately after Woff. According to his backup pilot, as a consideration to his passengers' comfort, he brought the flaps up in a gradual rig..: turn as the MU-2 accelerated in the climb. As a consideration of his passengers' time, he called for the IFR clearance once they were underway.

In the approximately 60 seconds from liftoff to the collision, the MU-2 pilot would normally have had to perform man) duties. They include performing the after-takeoff checklist. making radio calls to UNICOM and to departure control, flying the airplane, raising the landing gear, raising the flaps, adjusting the transponder, and adjusting the engines and propellers.

The MU-2's average ground speed was computed at 168 knots. The closure rate between the two aircraft was calculated at 234 knots. Concerns about inadvertently flying into the ARSA, obtaining an IFR clearance, and considerations of passenger service resulted in a very high workload while the aircraft was traversing a relatively high traffic density environment. Consequently, the MU-2's pilot had less time available to scan for other aircraft that might have posed a threat to his airplane.

## 2.7 Operation Near an Airport

There was more than one objective for the flight of the PA-32. Just prior to the collision, the aircraft departed Terry Airport where the pilot of the PA-32 had discussed aircraft maintenance with a local mechanic. The pilot-passenger was due for a flight check and went along for the flight review. Additionally, cameras were aboard to photograph Control Systems Engineering's new property near Greenwood Airport and a remote job site.

During the PA-32 pilot's initial call to the Indianapolis ARSA, he indicated that his intention was to fly to Greenwood. His danghter, in the rear of the PA-32. indicated that the pilot intended to fly so that his passengers could take aerial photographs of the Control Systems Engineering property prior to landing at Greenwood. This property is located within 1 mile of where the two aircraft collided. The proximity of this property to the collision increases the likelihood that the pilot of the PA-32 was looking downward to facilitate the photography instead of scanning for other airplanes. Both passengers may have been involved with the photography, thereby limiting their ability to scan for other airplanes.

The AIM, paragraph 4-8 (c 2), Traffic Advisory Practices at Airports without Operating Control Towers, contains recommended traffic advisory practices. Pilots conducting other than arrival or departure operations in the vicinity of an airport are advised to monitor/communicate on the appropriate frequency within 10 miles of the airport. The PA-32 was equipped with two communications radios and an audio panel that would permit the monitoring of two frequencies simultaneously. Both the pilot and the pilot-passenger were wearing headsets at the time of the collision. It would have been possible for the PA-32 pilot to monitor both frequencies or to have his passenger-pilot monitor the UNICOM while he communicated with the ***ARSA.*** This would have been an especially good practice because they were operating near an airport for purposes other than takeoff and landing.

The Safety Board notes that the radar controller terminated radar services and advised the pilot that a frequency change was approved when the airplane was about 3 miles from the airport. The FAA *Air* Traffic Controller Handbook 7110.65G, *Air* Traffic Control, paragraph 7-107, stares, in part, "terminate ARSA service to aircraft landing at other than the primary airport a a sufficient distance from the airport to allow the pilot to change to the appropriate frequency for traffic and airport information." The timing of the change in communications was inconsistent with the AIM, which recommends that pilots initiate UNICOM communications approximately 10 miles from the airport. The Safety Board considered these factors but believes that the late communications changeover did not relieve the pilots of each airplane of their responsibility to see and avoid each other. Moreover, the pilot of the PA-32 should have utilized both radios when he was approaching Greenwood Airport.

## *2.8* **The See-and-Avoid** Concept

The responsibility to "see and avoid" other aircraft is assigned to the pilot by 14 CFR Part 91. Part 91, Subpart B - Right Rules, Section 91.113, states:

> §91.113 Right-of-way rules: Except water operations.
>
> (b) General...reg araless of whether an operation is conducted under instrument flight rules or visual flight rules. vigilance shall be maintained by each person operating an aircraft so as to see and avoid other aircraft.

This regulation also indicates which aircraft has the right of way in different situational parameters and in converging and approaching head on.

To interpret and facilitate the see-and-avoid concept, the FAA published AC 90-48C, Pilot's Role in Collision Avoidance. This AC reinforces the concept of pilot responsibility and instructs the pilot on how to scan for traffic. Unfortunately, the title of the AC does not adequately indicate the information contained therein. It *can* be found in the AIM but in a section not normally associated with traffic avoidance, under Chapter 8, Medical Facts for Pilots. it .

would be more readily utilized if it was moved to a section that pilots refer to for collision avoidance.

As referenced in section 1.17.2, See and Avoid, the AIM and the *Air Traffic Controller Handbook* 7110.65G prioritizes controllers' separation responsibilities. However, from the excerpts given in that section, it would be difficult for a pilot to discern that separation of VFR airplanes from IFR airplanes is given lower priority.

The Safety Board believes that the circumstances of this accident emphasize the limitation of the see-and-avoid concept of separation of aircraft operating under visual flight rules, especially in congested areas near airports. In this case, the pilots had extremely limited time to detect a threat and to take evasive actions. The existing regulations permit such operations, which have a small margin of safety for avoiding midair collisions; however, there are many recommended practices that would have provided a greater margin of safety. Therefore, the Safety Board concludes that the inherent limitations of the see-and-avoid concept are directly causal to this accident.

The FAA has placed emphasis on better pilot education concerning air space and has taken action against pilots who violate air space. However, there is a lack of emphasis on proper scanning techniques. Therefore, the Safety Board believes that the FAA should assume a more active role in ensuring that instructor pilots are informed, during training and biennial flight reviews, about the necessity for emphasizing scanning techniques.

## 2.9 Human Performance Analysis

Both pilots were familiar with their respective airplanes and with the Greenwood Airport. The pilot of the PA-32 had purchased the airplane several years ago and had logged about 150 hours of flight time in it. He was flying the airplane regularly and, according to his logbook, had last flown about 1 month before the collision. Since many of these flights involved practicing instrument approaches into Greenwood Airport, the pilot should have been familiar with the airport and its traffic pattern and procedures. The right seat passenger was also a pilot and had accompanied the pilot on many of these flights. The MU-2 pilot was an MU-2 check pilot who had completed more than 9,000 hours of flight time in the airplane and more than 250 checkouts of other pilots. He was a corporate pilot who flew the Mu-2 two or three times a week, and most trips originated out of

Greenwood Airport. **Thus,** there were no issues related to either pilot's **familiarity** with **their** airplanes or the airport area.

There is some reason to question the actions of the MU-2 pilot for not opening his flight plan on the ground and for electing a VFR right turn during departure. Moreover, it is **unknown** whether the PA-32 pilots adequately monitored the **UNICOM** frequency in advance of their arrival in the Greenwood area. Finally, there are grounds for concern about a lack **of** standard arrival and departure procedures a uncontrolled airports that have a mix of **high- and** low-performance **airplanes.** Beyond these considerations, however, the greatest area **of** attention would be in the **limitations of** the see-and-avoid concept **as** a means for ensuring **traffic** separation.

In its report on the midair collision of **a DC-9** and a PA-28 over Cerritos, California, on August 31, 1986,[12] the Safety Board concluded that a contributing factor in the accident was *"the* limitations of the see-and-avoid concept to ensure traffic separation under the conditions **of** the conflict." In a subsequent report on the **midair** collision of **an** Army U-21A airplane and a PA-31 at Independence, Missouri, on **January** *20,* 1987,[13] the Safety Board determined that "deficiencies **of** the see-and-avoid concept **as** a primary means of collision avoidance" was one **of three** probable causes of the accident. in both **reports,** the Safety Board's conclusions were based on a body of laboratory and in-flight studies **that** indicated ihe great difficulty of reliably seeing other airplanes when there **is no warning of** an impending collision and when the opposing airplane **is as** small **as** a PA-32 or **an** MU-2.

In the latter report, the Safety Board made the following recommendation to the **FAA:**

A-88-27

Expedite the development, certification, and production **of** various low-cost proximity warning and conflict detection systems **for use** aboard general aviation aircraft.

---

[12] Aircraft Accident Report--"Collision of Aeronaves de Mexico. S.A.. flight 498, a DC-9-32, XA-JED, and a Piper PA-28-181, N4891F, Cerritos, California. August 31, 1986." (NTSB/AAR-87/07)

[13] Aircraft Accident Report--"Midair Collision of U.S. *Army* U-21A, *Army* 1861. and Sachs Electric Company Piper PA-31-350. N60SE, Independence. Missouri. January 20, 1987." (NTSB/AAR-88/01)

On May 16, 1989, the Administrator of the FAA responded to the recommendation noting that the FAA had required that after February 5, 1995, the installation of traffic alert and collision avoidance system (TCAS) I equipment would be mandatory in a broad category of commuter aircraft to provide traffic advisory information On July 19, 1989, the Safety Board responded to the Administrator's letter noting that it strongly supported these efforts by the FAA but that they failed to meet the intent of the recommendation. The response stated that "the Safety Board had in mind a system which would be simple. affordable, and available for all light general aviation aircraft in 2 to 3 years." The Safety Board wanted the FAA to have an affordable system by the end of 1992, at the latest. The FAA response was classified "Open—Unacceptable Response-" The FAA responded further on May 25, 1993, stating that the Radio Technical Commission for Aeronautics, Inc., is revising Document No. DO-197, "Minimum operational Performance Standards for an Active Traffic Alert and Collision Avoidance System I," (Active TCAS I) to address commuter aircraft. This revision will become Document No. 197A and will provide for an active traffic alert and collision avoidance system for commuter aircraft. Passive TCAS systems for general aviation aircraft will remain in Document No. DO-197. B. F. Goodrich is developing a passive TCAS system for the Navy that will provide a low-cast system for the general aviation market.

The Safety Board replied on July 7,1993, stating that because the FAA could provide no estimate on a certification date for the passive TCAS being developed by B. F. Goodrich, the recommendation would continue to be held as "Open--Unacceptable Response." The Board urged the FAA to actively seek the rapid development of the general aviation type TCAS system.

The current accident again underscores the need for low-cost proximity warning and conflict detecrion systems for use aboard general aviation aircraft. It is now nearly 5 years since the Safety Boards recommendation was issued, and the FAA has yet to meet the intent of the recommendation. This accident involved qualified and experienced flightcrews, in a typical operational environment for general aviation with little traffic in the environment. Some form of TCAS warning of the presence of conflicting traffic may well have prevented the accident Therefore, it is appropriate to reiterate Safety Recommendation A-88-27.

Along with the limitations of the see-and-avoid concept mentioned in the conclusions of the midair collision on August 31, 1986, in Cerritos, California, the Safety Board issued Safety Recommendation A-87-98 to the FAA which urged the FAA to take expedited action to add VFR conflict alert (Mode-C Intruder) logic to ARTS as an interim measure until the implementation of the Advanced Automation System. The Safety Board considered this issue so important that it was included in the original "Most Wanted program, which was adopted on October 10, 1990. In response to Safety Recommendation A-87-98, on January 6, 1992, the Acting Administrator of the FAA responded that the FAA was continuing its efforts to install the Mode-C Intruder conflict alert logic. He stated that the fii site at the New York TRACQN was operational on July 3, 1991, and that it was anticipated that all remaining ARTS sites would be operational by late 1995.

The Safety Board believes that the FAA is accepting too great a risk by not aggressively pursuing the development and implementation of this program. Notwithstanding the fact that the Safety Board has classified the FAA's actions as "Open--Acceptable Response," it still believes that more can be done to expedite the process.

While the Safety Board is unable to determine with any certainty that the Mode-C Intruder program would have prevented this accident, it is conceivable that if such a program had been in operation, it could have generated an alert that would have directed the controller's attention to the radar scope. At that time, if the controller recognized the potential collision threat, an alert could have been issued that might have averted the collision. Therefore, the Safety Board believes that the FAA should continue to fully fund and expedite the development of the Mode-C Intruder program at all ARTS facilities.

# 3. CONCLUSIONS

## 3.1 Findings

1. Both pilots were properly certificated and qualified for their respective flights.

2. Both airplanes were properly maintained for their flights.

3. The airplanes collided at about a 105-degree angle, at an altitude of about 2,100 feet msl (about 1,300 feet agl) in visual meteorological conditions.

4. The collision took place just outside and *to* the east of the Indianapolis ARSA.

5. Both pilots were required to see and avoid the other airplane. There was evidence that the PA-32 attempted **to** turn away from the Mu-2 **just** prior to impact.

6. Each airplane was in the field of view of the pilot of the other airplane for at least 20 seconds prior to the collision.

7. The **MU-2** pilot was probably preoccupied with a heavy workload that detracted from his effective scanning.

8. The pilot and occupants of the PA-32 may have been focused on photographing activities **to an** extent that distracted them from effectively scanning for **traffic**.

9. Both airplanes were equipped with operating Mode-C transponders operating under VFR.

10. The controller terminated radar service to the PA-32 when the airplane was **3** miles north of Greenwood Municipal Airport.

11. The Mu-2 pilot elected not to obtain his IFR clearance on the ground but rather to ask for it after takeoff. This decision added to his workload during takeoff when, among other things, he was issued a transponder code just prior to being radar identified for an IFR clearance.

12. The Indianapolis Departure East/Satellite controller could not issue traffic to the MU-2 because the collision occurred before radar identification of the MU-2 was established.

13. There are no established standard entry or departure procedures for Greenwood Municipal Airport. The MU-2 pilot was not following published recommended guidance for takeoff from the airport.

14. The pilot of the PA-32 appeared not to have been following published recommended entry procedures to the airport.

## 3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the accident was the inherent limitations of the see-and-avoid concept of separation of aircraft operating under visual flight rules that precluded the pilots of the MU-2 and the PA-32 from recognizing a collision hazard and taking actions to avoid the midair collision. Contributing to the cause of the accident was the failure of the MU-2 pilot to use all of the air traffic control services available by not activating his instrument flight rules flight plan before takeoff. Also contributing to the cause of the accident was the failure of both pilots to follow recommended traffic pattern procedures, as recommended in the Airman's Information Manual, for airport arrivals and departures.

## 4. RECOMMENDATIONS

**As** a result **of** the investigation of this accident, the National Transportation Safety Board makes the following recommendations:

--to the Federal Aviation Administration:

Develop, publish, and disseminate **VFR** departure and arrival procedures for uncontrolled airports near Classes B, C, or D air space, irrespective of the provisions contained in Part 91 of the FARs. Consideration should be given to establishing entry and departure corridors for high-performance airplanes that are separate from low-performance airplanes at these uncontrolled airports. (Class 11, Priority Action) (A-93-127)

Revise the **Airman's** Information Manual to recommend that pilots departing in VMC, with intentions of obtaining IFR clearances, obtain ATC clearances prior to becoming airborne when two-way radio communication with ATC is available on the ground. (Class 11, Priority Action) (A-93-128)

Revise the **Airman's** Information Manual so that the information on scanning **for** other **aircraft** and the judgment aspects of collision avoidance *are* emphasized. Upon the next revision of the Right Training Handbook (AC 61-21A) and the Pilot's Handbook of Aeronautical Knowledge **(AC** 61-23B), include the information on scanning for other aircraft and the judgment aspects of collision avoidance. (Class II, **Priority** Action) (A-93-129)

Inform **flight** instructors about the necessity for emphasizing scanning techniques during training and biennial **flight** reviews. (Class 11, Priority Action) (A-93-130)

For the benefit of pilot awareness, revise language in the Airman's Information Manual **to** clearly reflect pilot responsibility in view of the limits of controller responsibility for separating IFR from VFR aircraft. (Class II, Priority Action) (A-93-131)

**--to** the National Business Aircraft Association, the National Association of Right Instructors, the Experimental Aircraft Association, and the Aircraft Owners and Pilots Association:

> Inform your members of the circumstances of this accident, and encourage them to institute the recommended practices discussed in the accident report, especially the need **for** flight instructors to emphasize scanning techniques during training and biennial flight reviews, and the need **for** pilots to clearly understand their responsibilities in view of the limits of controller responsibility for separating IFR from VFR aircraft. (Class II, Priority Action) **(A-93-132)**

In addition, the Safety Board reiterates the following safety recommendation to the Federal Aviation Administration:

> A-88-27
>
> Expedite the development, certification, and production of various low-cost proximity warning and conflict detection systems **for** use aboard general aviation aircraft.

**BY THE NATIONAL TRANSPORTATION SAFETY BOARD**

Carl W. Vogt
Chairman

Susan Coughlin
**Vice** Chairman

John K. Lauber
Member

John Hammerschmidt
Member

Christopher A. Hart
Member

**September 13,1993**

# 5. APPENDIXES

## APPENDIX A

## INVESTIGATION AND HEARING

### 1. Investigation

The Safety Boards North Central Regional Office (Chicago) was initially notified of the accident about 1500 central daylight time, September 11, 1992, and immediately responded to the accident scene. After more was learned about the accident, a team of three investigators departed Washington, D.C., early on September 12,1992. At later dates, four other investigators were assigned to the investigation to cover other aspects.

Parties to the investigation were the Federal Aviation Administration, Mitsubishi Heavy Industries America, Inc., Beechcraft Company, Allied-Signal Aerospace Company/Garrett Engine Division, the National Air Traffic Controllers Association, the Marion County Sheriffs Department, and the Indiana State Police.

### 2. Public Hearing

No public hearing was conducted, and depositions were not taken.

# APPENDIX B

## PERSONNEL INFORMATION

### Pilot William Robert Mullen

Mr. Mullen, 68, held a commercial pilot certificate No. 479083, issued on February 13, 1958, with airplane single and multiengine land privileges. He held a flight instructor certificate, last reissued on February 24, 1992, with ratings in single and multiengine land airplanes and instrument airplane. His most recent second class airman medical certificate, issued on October 11, 1991, contained the limitation that he must wear glasses for near and distant vision correction while exercising his airman's privileges.

Mr. Mullen's pilot records indicated that he had 19,743 hours total flight time with 19,248 hours as pilot-in-command. Witnesses indicated that more than 9,000 hours of that was in MU-2s. He had initially gained flying experience in the U.S. Army-Air Force where he had flown P-47s in World War II. Pilot Mullen qualified in the MU-2 while employed by Mooney Aircraft when the company had entered an export agreement to represent the MU-2 in the United States. He had served as an airplane salesman and check pilot/instructor qualifying more than 250 pilots in the MU-2 over the years. Logbook entries indicated that Mr. Mullen had flown 92 hours in the 90-day period before the accident, the majority of which had been in the accident airplane. He had completed a biennual flight review in the MU-2 on July 10,1992.

### Pilot William Paul Bennett

Pilot Bennett, 54, held a private pilot certificate for single engine airplanes and an instrument rating. He held a third class medical certificate, dated October 18, 1991, with the limitation that he must wear corrective lenses while flying.

Mr. Bennett began flying general aviation airplanes in 1969. A review of his logbooks indicated that he had 1,224 hours of flight time as of August 17, 1992, the last flight entered. Approximately 150 of those hours were logged in a PA-32. The number of hours Mr. Bennett flew in the 90-day period preceding the accident could not be determined because iogbook entries were incomplete.

**Passenger-Pilot Mark Robert Doucey**

Mr. Doucey held a private pilot certificate for single engine airplanes and an instrument rating. His third class medical certificate, dated July 3, 1992, had no limitations.

Mr. Doucey reported 412 hours of pilot time on his last medical examination form and zero hours in the past 6 months.

**Supervisory Air Traffic Controller James Michael Daugherty**

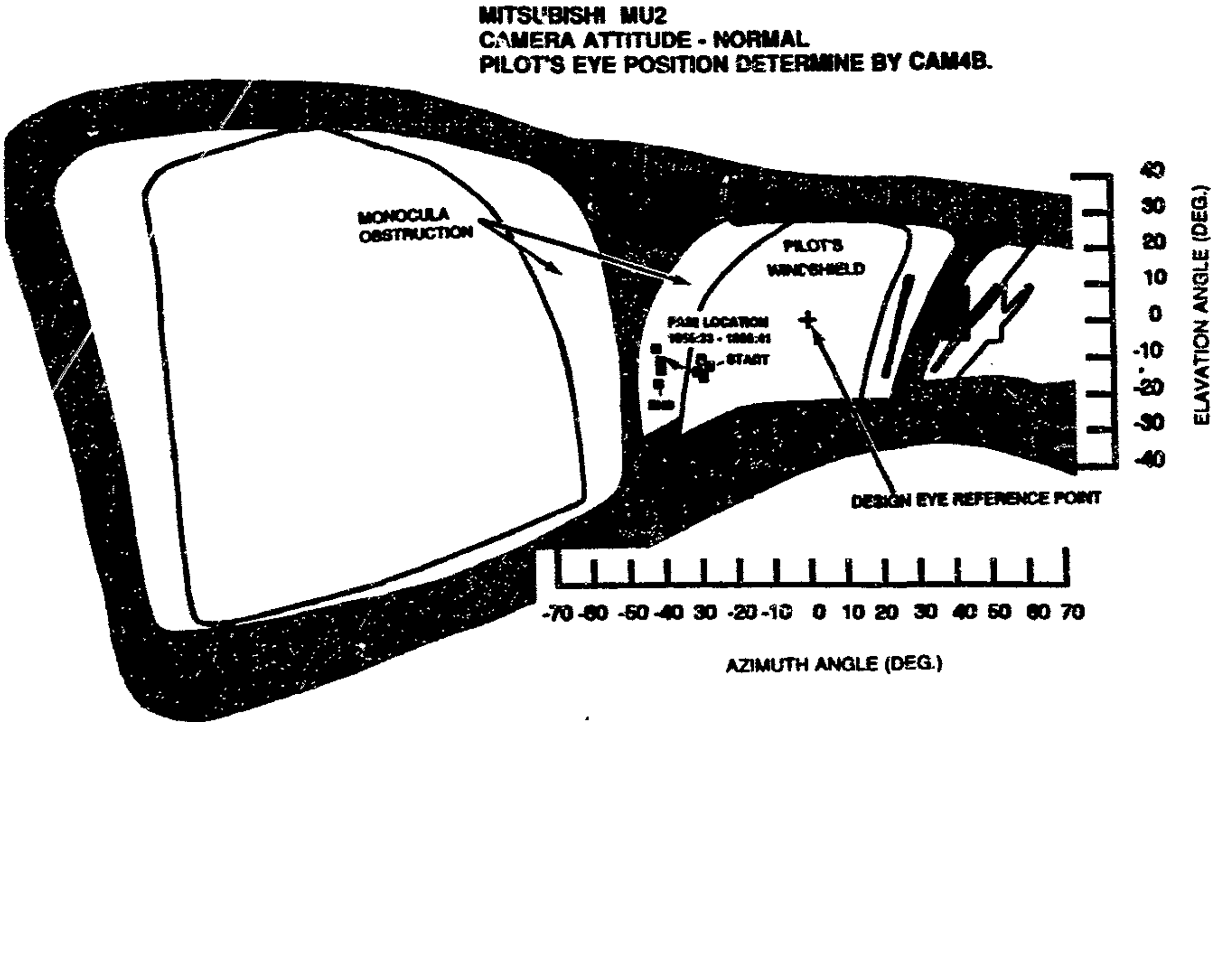
Mr. Daugherty, 40, was employed by the FAA on January 11, 1982. In November 1989, he transferred from Terre Haute, Indiana, to the Indianapolis International Airport. He has been a supervisor since May 1989. His most recent medical certificate was issued in December 1991.

**Departure East/Satellite Controller David Michael Fritz**

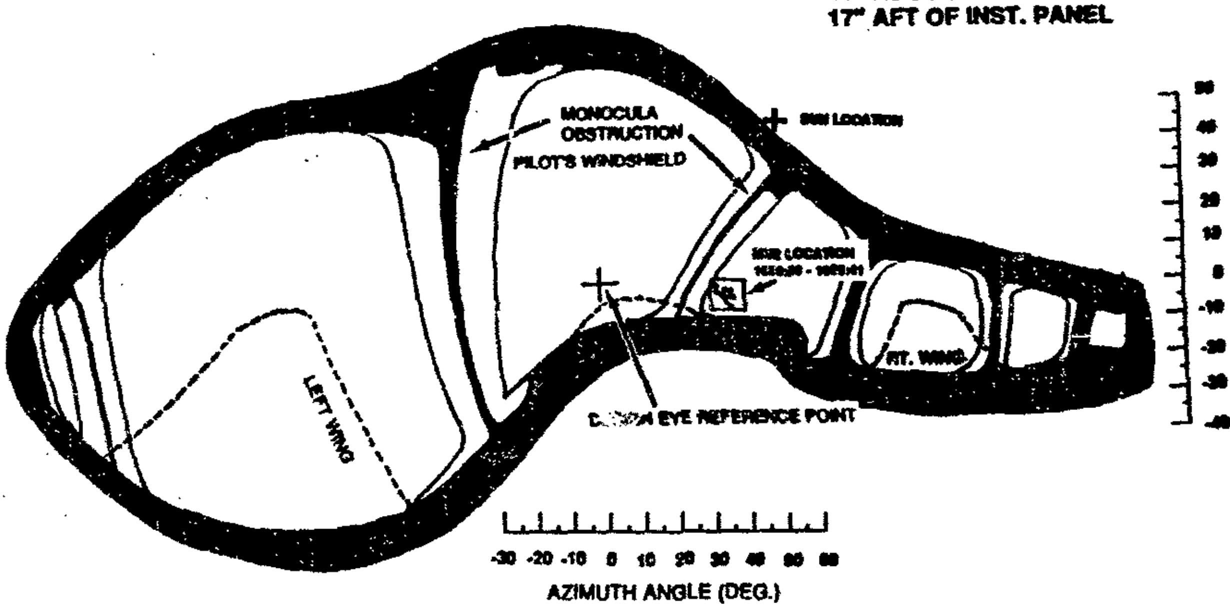
Mr. Fritz, 31, entered the FAA Academy on February 20, 1983. He transferred from the Greater Pittsburgh International Airport and arrived for duty at Indianapolis on January 15, 1989. Mr. Fritz became a certified Departure East controller on March 28, 1989, and upgraded to Full Performance Level on May 27, 1989. His immediate supervisor for the last 18 months was Mr. James Daugherty. His most recent medical certificate was issued in September 1992. He had 4 years of military ATC experience in a radar facility.

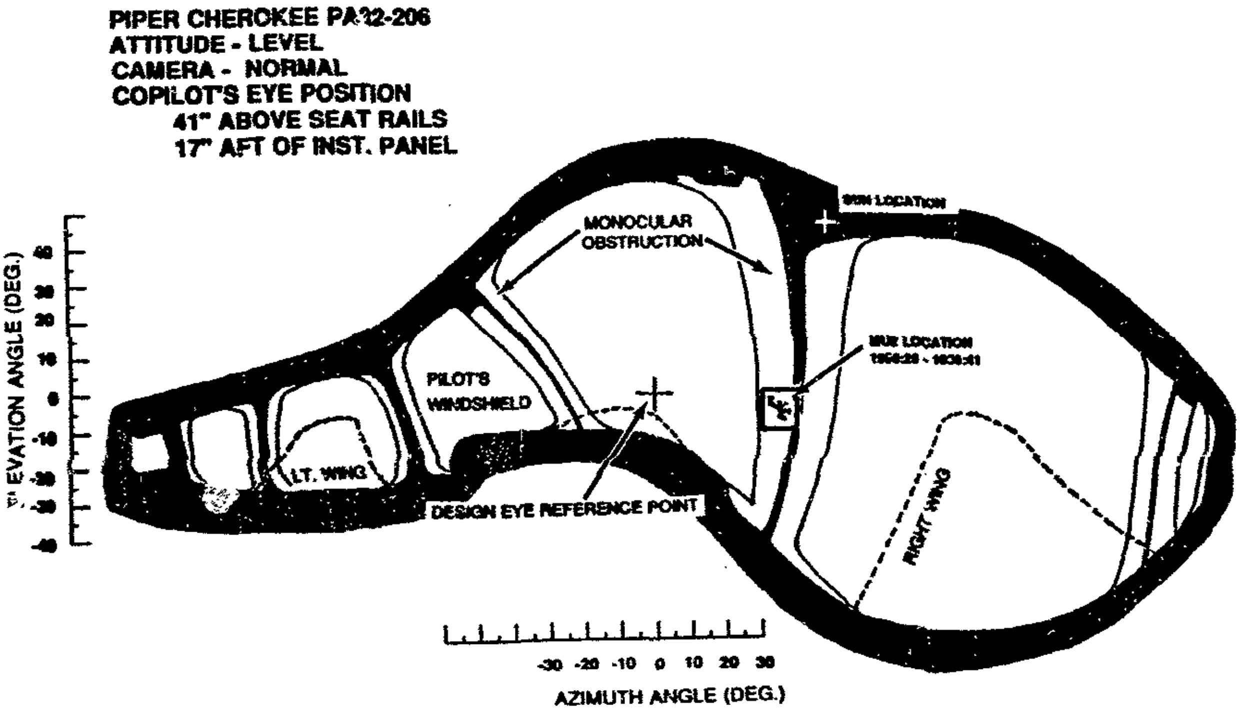
# APPENDIX C

## COCKPIT FIELD OF VISION PLOTS



PIPER CHEROKEE PA32-206
ATTITUDE - LEVEL
CAMERA - NORMAL
PILOT'S EYE POSITION
41" ABOVE SEAT RAILS
17" AFT OF INST. PANEL




PIPER CHEROKEE PA32-206
ATTITUDE - LEVEL
CAMERA - NORMAL
COPILOT'S EYE POSITION
41" ABOVE SEAT RAILS
17" AFT OF INST. PANEL
MONOCULAR OBSTRUCTION
PILOT'S WINDSHIELD
LT. WING
DESIGN EYE REFERENCE POINT
RIGHT WING
ELEVATION ANGLE (DEG.)
40
30
20
10
0
-10
-20
-30
-40
-30 -20 -10 0 10 20 30
AZIMUTH ANGLE (DEG.)

# APPENDIX D

# FAA ADVISORY CIRCULAR 90-48C
# PILOTS' ROLE IN COLLISION AVOIDANCE

US Department of Transportation
Federal Aviation Administration

## Advisory Circular

Subject: PILOTS' ROLE IN COLLISION AVOIDANCE

Date: 3/18/83
Initiated by: AFO-820

AC No: 90-48C
Change:

1. PURPOSE. This advisory circular is issued for the purpose of alerting all pilots to the potential hazards of midair collision and near midair collision, and to emphasize those basic problem areas related to the human causal factors where improvements in pilot education, operating practices, procedures, and improved scanning techniques are needed to reduce midair conflicts.

2. CANCELLATION. AC 90-48B, Pilots' Role in Collision Avoidance, dated 9/5/80 is canceled.

3. BACKGROUND.

a. From 1978 through October 1982 a total of 152 midair collisions (MAC) occurred in the United States resulting in 377 fatalities. Throughout this approximate 5-year time period the yearly statistics remained fairly constant, with a recorded high of 38 accidents in 1978 and a low of 25 in both 1980 and 1981. During this same time period there were 2,241 reported near midair collisions (NMAC). Statistics indicate that the majority of these midair collisions and near midair collisions, occurred in good weather and during the hours of daylight.

b. The FAA has introduced several significant programs designed to reduce the potential for midair and near midair collisions. This advisory circular is but one of those programs and is directed towards all pilots operating in the National Airspace System, with emphasis on the need for recognition of the human factors associated with midair conflicts.

4. ACTION. The following areas warrant special attention and continuing action on the part of all pilots to avoid the possibility of becoming involved in a midair conflict.

a. "See and Avoid" Concept.

(1) The flight rules prescribed in Part 91 of the Federal Aviation Regulations (FAR) set forth the concept of "See and Avoid." This concept requires that vigilance shall be maintained at all times, by each person operating an aircraft, regardless of whether the operation is conducted under Instrument Flight Rules (IFR) or Visual Flight Rules (VFR).

(2) Pilots should also keep in mind their responsibility for continuously maintaining a vigilant lookout regardless of the type of aircraft being flown. Remember that most MAC accidents and reported NMAC incidents occurred during good VFR weather conditions and during the hours of daylight.

b. Visual Scanning.

(1) Pilots should remain constantly alert to all traffic movement within their field of vision, as well as periodically scanning the entire visual field outside of their aircraft to ensure detection of conflicting traffic. Remember that the performance capabilities of many aircraft, in both speed and rates of climb/descent, result in high closure rates limiting the time available for detection, decision, and evasive action. (See the "Distance-Speed-Time" chart in Appendix 1.)

(2) The probability of spotting a potential collision threat increases with the time spent looking outside, but certain techniques may be used to increase the effectiveness of the scan time. The human eyes tend to focus somewhere, even in a featureless sky. In order to be most effective, the pilot should shift glances and refocus at intervals. Most pilots do this in the process of scanning the instrument panel, but it is also important to focus outside to set up the visual system for effective target acquisition.

(3) Pilots should also realize that their eyes may require several seconds to refocus when switching views between items in the cockpit and distant objects. Proper scanning requires the constant sharing of attention with other piloting tasks, thus it is easily degraded by such psychophysiological conditions such as fatigue, boredom, illness, anxiety, or preoccupation.

(4) Effective scanning is accomplished with a series of short, regularly-spaced eye movements that bring successive areas of the sky into the central visual field. Each movement should not exceed 10 degrees, and each area should be observed for at least 1 second to enable detection. Although horizontal back-and-forth eye movements seem preferred by most pilots, each pilot should develop a scanning pattern that is most comfortable and then adhere to it to assure optimum scanning.

(5) Peripheral vision can be most useful in spotting collision threats from other aircraft. Each time a scan is stopped and the eyes are refocused, the peripheral vision takes on more importance because it is through this element that movement is detected. Apparent movement is almost always the first perception of a collision threat and probably the most important, because it is the discovery of a threat that triggers the events leading to proper evasive action. It is essential to remember, however, that if another aircraft appears to have no relative motion, it is likely to be on a collision course with you. If the other aircraft shows no lateral or vertical motion, but is increasing in size, take immediate evasive action.

(6) Visual search at night depends almost entirely on peripheral vision. In order to perceive a very dim lighted object in a certain direction, the pilot should not look directly at the object, but scan the area adjacent to it. Short stops, of a few seconds, in each scan will help to detect the light and its movement.

(7) Lack of brightness and color contrast in daytime and conflicting ground lights at night increase the difficulty of detecting other aircraft.

(8) Pilots are reminded of the requirement to move one's head in order to

search around the physical obstructions, such as door and window posts. The doorpost can cover a considerable amount of sky, but a small head movement may uncover an area which might be concealing a threat.

c. Clearing Procedures.

(1) Pilots should:

(i) Prior to taxiing onto a runway or landing area for takeoff, scan the approach areas for possible landing traffic by maneuvering the aircraft to provide a clear view of such areas. It is important that this be accomplished even though a taxi or takeoff clearance has been received.

(ii) During climbs and descents in flight conditions which permit visual detection of other traffic, execute gentle banks left and right at a frequency which permits continuous visual scanning of the airspace about them.

(iii) Execute appropriate clearing procedures before all turns, abnormal maneuvers, or acrobatics.

d. Airspace, Flight Rules, and Operational Environment.

(1) Pilots should be aware of the type of airspace in which they intend to operate in order to comply with the flight rules applicable to that airspace. Aeronautical information concerning the National Airspace System is disseminated by three methods: aeronautical charts (primary); the Airman's Information Manual (AIM); and the Notices to Airmen (NOTAM) system. The general operating and flight rules governing the operation of aircraft within the United States are contained in Part 91 of the FAR.

(2) Pilots should:

(i) Use currently effective aeronautical charts for the route or area in which they intend to operate.

(ii) Note and understand the aeronautical legend and chart symbols related to airspace information depicted on aeronautical charts.

(iii) Develop a working knowledge of the various airspace segments, including the vertical and horizontal boundaries.

(iv) Develop a working knowledge of the specific flight rules (FAR 91) governing operation of aircraft within the various airspace segments.

(v) Use the AIM. The Basic Flight Information and ATC Procedures describe the airspace segments and the basic pilot responsibilities for operating in such airspace.

(vi) Contact the nearest FAA Flight Service Station for any pertinent NOTAMS pertaining to their area of operation.

(3) pilots should also be familiar with and exercise caution, in those operational environments where they may expect to find a high volume of traffic or special types of aircraft operation. These areas include Terminal Radar Service Areas (TRSA's), airport traffic patterns, particularly at airports without a control tower; airport traffic areas (below 3,000 feet above the surface within five statute miles of an airport with an operating control tower); terminal control areas; control zones, including any extensions; Federal airways; vicinity of VOR's; restricted areas: warning areas: alert areas: Military Operating Areas (MOA); intensive student jet training areas; military low—level high—speed training routes; instrument approach areas; and areas of high density jet arrival/departure routings, especially in the vicinity of major terminals and military bases.

e. Use of Communications Equipment and Air Traffic Advisory Services.

(1) One of the major factors contributing to the likelihood of NMAC incidents in terminal areas that have an operating air traffic control (ATC) system has been the mix of known arriving and departing aircraft with unknown traffic. The known aircraft are generally in radio contact with the controlling facility (local, approach, or departure control) and the other aircraft are neither in two-way radio contact nor identified by ATC at the time of the NMAC. This precludes ATC from issuing traffic advisory information to either aircraft.

(2) Although pilots should adhere to tne necessary communications requirements when operating VFR, they are also urged to take advantage of the air traffic advisory services available to VFR aircraft.

(3) Pilots should:

(i) Use the AIM.

(A) The basic AIM contains a section dealing with services available to pilots, including information on VFR advisory services, radar traffic information services for VFR pilots, and recommended traffic advisory p-actices at nontower airports.

(B) The airport/facility Cireccory contains a list of ail major airports showing the services available to pilots and the applicable communication frequencies.

(ii) Develop a working knowledge of those facilities providing traffic advisory services and the area in which they give these services.

(iii) Initiare radio contact with the appropriate terminal radar or nonradar facility when operating within the perimeters of the advertised service areas or within 15 miles of the fecility when m service area is specified.

(iv) when it is not practical to initiate radio Contact for traffic information, at least monitor the appropriate facility communication frequency, particularly when operating in or through arrival/departure mutes and instrument approach areas.

(v) Remember that controller observation of aircraft in the terminal area is often limited by distance, depth perception, aircraft conspicuity, and other normal visual acuity problems. Limitations of radar (when available), traffic volume, controller workload, unknown traffic, etc., may prevent the controller from providing timely traffic advisory information. Traffic advisories are secondary to the controllers' primary duties (which are separating aircraft under their control and issuing safety advisories when aware of safety conflicts). Therefore, the pilot is responsible for seeing and avoiding other traffic. Traffic advisories should be requested and used when available to assist the pilot to see and avoid other traffic by assisting, but not substituting in any way, the pilot's own visual scanning. It is important to remember that advisories which air traffic control may provide are not intended to lessen in any manner the pilot's obligation to properly scan to see and avoid traffic.

f. Airport Traffic Patterns.

(1) A significant number of midair collisions, as well as near midair collisions, have occurred within the traffic pattern environment.

(2) Pilots should:

(i) When operating at tower-controlled airports, maintain two-way radio contact with the tower while within the airport traffic area. Make every effort to see and properly avoid any aircraft pointed out by the tower, or any other aircraft which may be in the area and unknown to the tower.

(ii) When entering a known traffic pattern at a nontower airport, keep a sharp lookout for other aircraft in the pattern. Enter the pattern in level flight and allow plenty of spacing to avoid overtaking or cutting any aircraft out of the pattern.

(iii) When approaching an unfamiliar airport fly over or circle the airport at least 500 feet above traffic pattern altitude (usually at 2,000 feet or more above the surface) to observe the airport layout, any local traffic in the area, and the wind and traffic direction indicators. Never descend into the traffic pattern from directly above the airport.

(iv) Be particularly alert before turning to the base leg, final approach course, and during the final approach to landing. At nontower airports, avoid entering the traffic pattern on the base leg or from a straight-in approach to the landing runway.

(v) Compensate for blind spots due to aircraft design and flight attitude by moving your head or maneuvering the aircraft.

g. Flying In Formation.

(1) Several midair collisions have occurred which involved aircraft on the same mission, with each pilot aware of the other's presence.

(2) Pilots who are required, by the nature of their operations, to fly in pairs or in formation are cautioned to:

(i) Recognize the high statistical probability of their involvement in midair collisions.

(ii) Make sure that adequate preflight preparations are made and the procedures to be followed are understood by all pilots intending to participate in the mission.

(iii) Always keep the other aircraft in sight despite possible distraction and preoccupation with other mission requirements.

(iv) Avoid attempting formation flight without having obtained instruction and attained the skill necessary for conducting such operations.

h. Flight Instructors, Pilot Examiners, and Persons Acting As Safety Pilots.

(1) The importance of flight instructors training pilot applicants to devote maximum attention to collision avoidance while conducting flight operations in today's increasing air traffic environment cannot be overemphasized.

(2) Flight instructors should set an example by carefully observing all regulations and recognized safety practices, since students consciously and unconsciously imitate the flying habits of their instructors.

(3) Flight instructors and persons acting as safety pilots should:

(i) Guard against preoccupation during flight instruction to the exclusion of maintaining a constant vigilance for other traffic.

(ii) Be particularly alert during the conduct of simulated instrument flight where there is a tendency to "look inside."

(iii) Place special training emphasis on those basic problem areas of concern mentioned in this advisory circular where improvements in pilot education, operating practices, procedures, and techniques are needed to reduce midair conflicts.

(iv) Notify the control tower operator, at airports where a tower is manned, regarding student first solo flights.

(v) Explain the availability of and encourage the use of expanded radar services for arriving and departing aircraft at terminal airports where this service is available, as well as, the use of radar traffic advisory services for transiting terminal areas or flying between en-route points.

(vi) Understand and explain the limitations of radar that may frequently limit or prevent the issuance of radar advisories by air traffic controllers (refer to AIM).

(4) Pilot examiners should:

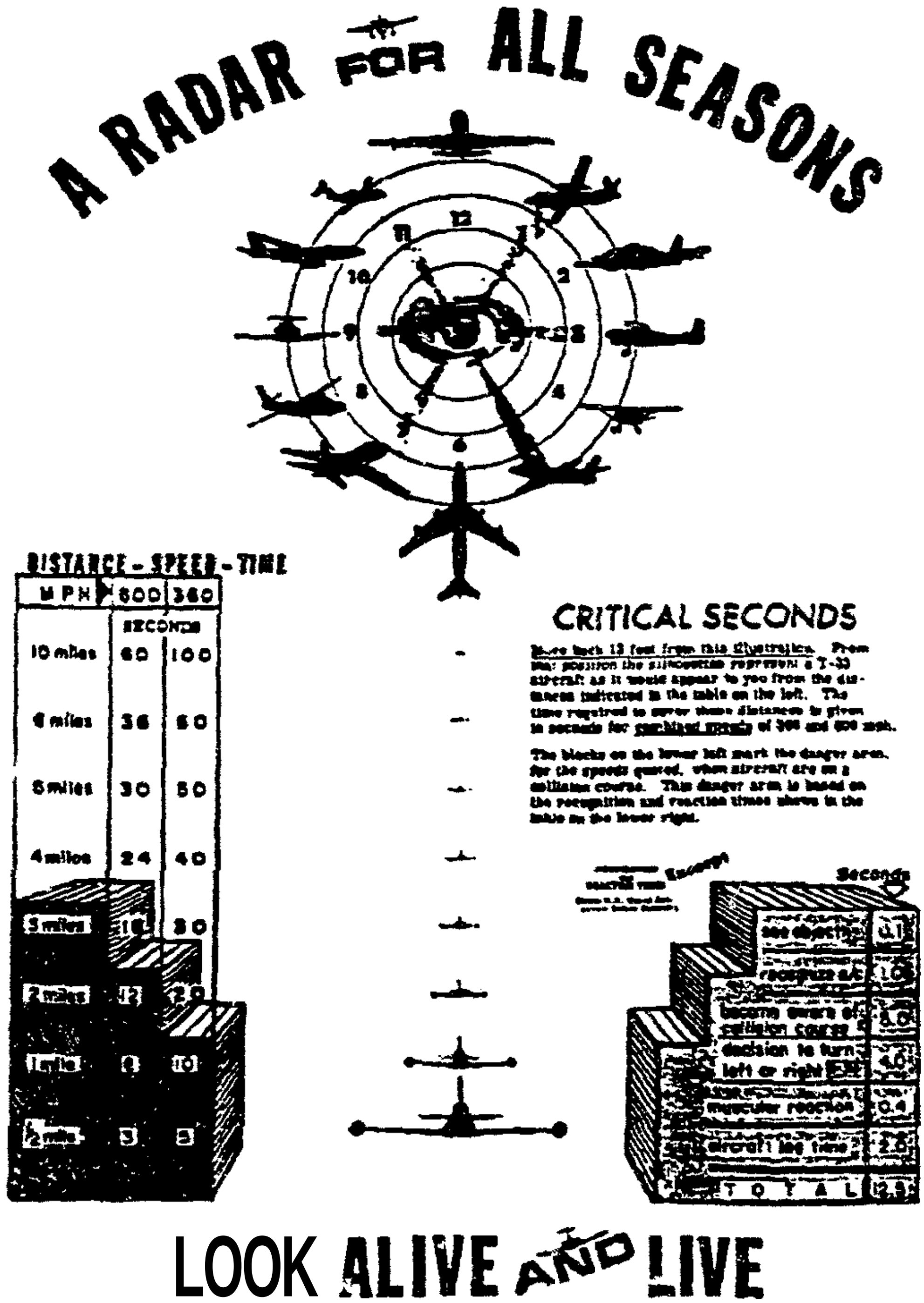
(i) During any flight test, direct attention to the applicant's vigilance of other air traffic and an adequate clearance of the area before performing any flight maneuver.

(ii) Direct attention to the applicant's knowledge of the airspace, available FAA air traffic services and facilities, essential rules, good operating practices, procedures, and techniques that are necessary to achieve high standards of air safety.

i. Scan Training. The Aircraft Owners and Pilots Association (AOPA) Air Safety Foundation has developed an excellent educational program designed to inform pilots on effective visual scan techniques. All pilots are encouraged to attend FAA/industry sponsored safety meetings which feature this program. The program, called "Take Two and See," is available on loan through the AOPA Air Safety Foundation, 7315 Wisconsin Avenue, Bethesda, Maryland 20814. For further information on the availability of this or any other Accident Prevention Program dealing with collision avoidance, interested persons may contact the Accident Prevention Specialist at any FAA General Aviation District Office or Flight Standards District Office.

Kenneth S Hunt

KENNETH S. HUNT
Director of Flight Operations


A RADAR FOR ALL SEASONS
12
1
2
3
4
6
7
8
9
10
11
DISTANCE - SPEED - TIME
MPH 600 360
SECONDS
10 miles 60 100
6 miles 36 60
5 miles 30 50
4 miles 24 40
3 miles 18 30
2 miles 12 20
1 mile 6 10
½ mile 3 5
CRITICAL SECONDS
Move back 13 feet from this illustration. From that position the silhouettes represent a T-33 aircraft as it would appear to you from the distances indicated in the table on the left. The time required to cover these distances is given in seconds for combined speeds of 360 and 600 mph.
The blocks on the lower left mark the danger area for the speeds quoted, when aircraft are on a collision course. This danger area is based on the recognition and reaction times shown in the table on the lower right.
Seconds
see object 0.1
recognize a/c 1.0
become aware of collision course 5.0
decision to turn left or right 4.0
muscular reaction 0.4
aircraft lag time 2.0
TOTAL 12.5
LOOK ALIVE AND LIVE

# APPENDIX E

# AIR TRAFFIC CONTROL TRANSCRIPT

U.S. Department of Transportation
Federal Aviation Administration

# Memorandum

Airport Traffic Control Tower
2951 Midfield Service Road
Indianapolis Int'l Airport
Indianapolis, Indiana 46241

Subject: INFORMATION: Transcription Concerning The Accident Involving N82419 Piper Saratoga and Mitsubishi N74FB on September 11, 1992 at 1957 UTC

Date: September 22, 1992

From: Air Traffic Manager
Indianapolis ATCT

Reply to Attn. of:

io

This transcription covers the time period froc September 11, 1992, 1947 UTC to September 11, 1992, 2005 UTC.

| Agencies making transmissions | Abbreviations |
|---|---|
| Indianapolis Radar Approach Control Departure Combined Satellite West | IND TRACON - W |
| Indianapolis Radar Approach Control Departure Combined Satellite East | IND TRACON - E |
| Indianapolis Approach Control Arrival Feeder West | IND TRACON - B |
| Indianapolis Tower Local Control | IND TOWER - LC |
| Terre Haute Approach Control | HUF TRACON |
| R3401 Officer | R3401 |
| Columbus Tower | BAK TOWER |
| Pipcr Saratoga November eight two four one nine | N82419 |
| Mitsubishi November seven four Forrrot Bravo | N74FB |
| Piper Twin Comanche November seven nine Bravo Alpha | N79BA |
| USAir four sixteen | USA416 |

Page 2

| | |
|---|---|
| Racer eight one flight | RACER81 |
| Bluestreak forty ninety-one | JIA4091 |
| Beechcraft Dutchess November six zero one Qight Uniform | N6018U |
| Cessna Skyhawk Novenber six Sin four two two | N66422 |
| Piper Twin Comanche November tight three six seven Yankee | N8367Y |
| Army King Air two three one three one | R23131 |
| Cessna Skyhawk November seven three eight nine five | N73895 |
| Blue Streak forty-two eighty-one | JIA4281 |
| Beechcraft Bonanza November five five zero Romeo Juliet | N550RJ |

I HEREBY CERTIFY that the following is a true transcription of the recorded conversations pertaining to the subject aircraft accident:

Robert D. Miller
Name

Quality Assurance Specialist
Indianapolis ATC Tower
Title

(1947)
(1948)

1948:42 IND TRACON - E — And Bonanza zero Romeo Juliet turn right heading one four zero vectors around traffic I'll have back on course for you in about four miles

| | | |
|---|---|---|
| 1948:49 | N550RJ | OK Romeo Julie: one four zero |
| 1948:54 | IND TRACON - E | November Dine Bravo Alpha no traffic observed between you and Greenwood squawk VFR radar service is terminated frequency change approved |
| 1948:59 | N79BA | Niner Bravo Alpha you have a good day nov |
| 1949:00 | IND TRACON - E | *(Good day) |
| 1950:07 | IND TRACON - E | November zero Romeo Juliet traffic at eleven o'clock and five miles northeast bound at nine thousand and it's a twin comanche |
| 1950:15 | N550RJ | OK eleven o'clock Romeo Juliet we're looking |
| 1950:17 | IND TRACON - E | '(Roger) |
| 1950:45 | R23131 | Approach Army uh tvo three one three one is vith you at one zero thousand and ve have Echo |
| 1950:50 | IND TRACON - E | Army two three one three one Indy Approach fly heading three four zero and expect vectors to the ILS runway five left final approach course |
| 1950:57 | R23131 | Roger three four zero for vectors ILS runvay five left |
| 1951:03 | IND TRACON - E | Bonanxa zero Romeo Juliet traffic is no longer a factor proceed on course |
| 1951:06 | N550RJ | Romeo Juliet thanks a lot |
| 1951:08 | IND TRACON - E | Roger |

| | | |
|---|---|---|
| 1951:09 | IND TRACON - W | East West |
| 1951:10 | IED TRACON - E | East |
| 1951:11 | IND TRACON - W | November four one niner flashing at you do you want to work do you nnt to uh uh take a point out he's going to Greenwood |
| 1951:15 | IND TRACON - E | I'll Just work hin |
| 1951:16 | IND TRACON - W | SC |
| 1951:17 | IND TRACON - E | *(FZ) |
| 1951:58 | N82419 | Indy Approach eight two four one nine with you at two point five going to Greenwood |
| 1952:05 | IND TRACON - E | Cherokee four one nine roger maintain uh VFR I'll have on course for you in about five miles |
| 1952:09 | N82419 | Four one nine roger |
| 1952:15 | IND TRACON - E | Twin Coeanche eight three six seven Yankee contact Indianapolis Center one two zero point six five |
| 1952:21 | N8367Y | Twenty sixty five so long |
| 1952:29 | IND TRACON - E | Army one three one traffic one o'clock two miles northwest bound • seven thirty seven descending to one one thousand |
| 1952:36 | R23131 | Uh one three one has him in sight |

| | | |
|---|---|---|
| 1952:38 | IND TRACON - E | Roger |
| 1952:41 | IND TRACON - E | Indy Approach |
| 1952:43 | R3401 | Yeah are you checking to see if the lines working |
| 1952:46 | IND TRACON - E | I I wasn't checking it no |
| 1952:48 | R3401 | Ok I can barely hear you but ah it is the end |
| 1952:51 | IND TRACON - E | OK |
| 1952:52 | R3401 | OK thank you |
| 1952:53 | IND TRACON - E | Alright |
| 1953:40 | IND TRACON - E | Ccssna eight nine five say your heading |
| 1953:46 | N73695 | (Unintelligible) |
| 1953:56 | IND TRACON - E | Cessna seven three eight niner five say your heading |
| 1953:57 | N73895 | (Unintelligible) |
| 1953:59 | IND TRACON - E | OK Cessna eight niner five I'm just getting modulation only |
| 1954:05 | N73895 | (Unintelligible) |
| 1954:07 | IND TRACON - E | I'm still not getting anything you've traffic at two o'clock and a mile uh southbound southeast bound squawking VFR altitude indicates three thousand |

| | | |
|---|---|---|
| 1952:38 | IND TRACON - E | Boges |
| 1952:41 | IND TRACON - E | Indy Approach |
| 1952:43 | R3401 | Yeah are you checking to see if the lines working |
| 1952:46 | IND TRACON - E | I I wasn't checking it no |
| 1952:48 | R3401 | Ok I can barely hear you hr ah it is the end |
| 1952:51 | IWD TRACON - E | OK |
| 1952:52 | R3401 | OK thank you |
| 1952:53 | IND TRACON - E | Nsight |
| 1953:40 | IND TRACON - E | Cessna eight nine five ray your heading |
| 1953:46 | N73695 | (Unintelligible) |
| 1953:56 | IND TRACON - E | Cersna seven three eight niner five say your hea [illegible] |
| 1953:57 | X73895 | (Unintelligible) |
| 1953:59 | IND TRACON - E | OK Cessna eight niner five I'm just getting modulation only |
| 1954:05 | N73895 | (Unintelligible) |
| 1954:07 | IND TRACON - E | I'm still not getting anything you've traffic at tw o'clock and a mile uh southbound southeast bound squawking VFR altitude indicate6 three thousand |

| | | |
|---|---|---|
| 19%:15 | N73895 | (Unintelligible) |
| 1954:19 | IND TRACON - E | Cherokee four one nine you may proceed on course to Greenwood advice the airport in sight |
| 1954:23 | N82419 | Ah four one nine roger on course to Greenwood |
| 1954:26 | JIA4281 | Departure bluestreaks forty-two eighty-one with you at two and a half |
| 1954:28 | IND TRACON - E | Bluestreak forty-two eighty-one indy Departure radar contact climb and maintain six thousand |
| 1954:32 | JIA4281 | We're climbing EO six thousand bluestreaks forty-two eighty-one |
| 1954:44 | IND TRACON - E | Bonanza five five zero Romeo Juliet contact Dayton Approach on one three four point four five |
| 1954:53 | N550RJ | Romeo Julie: will do |
| 1954:55 | IND TRACON - E | Army one three one contact Indy Approach one niner point three |
| 1954:58 | R23131 | One one nine point three for one three one good day |
| 1955:01 | IND TRACON - E | Good day |
| 1955:04 | IND TRACON - E | Bluestreak forty-two eighty-one turn right heading one niner zero |
| 1955:07 | JIA4281 | One nine zero on the heading bluestreaks forty-tvo eighty-one |

| | | |
|---|---|---|
| 1955:39 | IND TRACON - E | Bluestreak forty-tvo eighty-one turn right heading two zero zero intercept the DAWNN one climb and maintain one zero thousand |
| 1955:47 | JIA4281 | Uh *two* hundred **and** we're climbing to ten bluestreak forty-tvo eighty-one |
| 1955:51 | IND TRACOS - E | Cessna four er Cherokee four one nine the airport twelve to one o'clock there and three miles |
| 1955:55 | N82419 | Ah four one nine ve have the airport |
| 1455:57 | IND TRACON - E | November four one nine roger surface **winds** at Indianapolis zero two zero at eigh: squawk VFR radar service terminated frequency change approved |
| 1956:03 | N82419 | Ah four one nine thank **you** very much |
| 1956:05 | IND TRACON - E | **Roser** |
| 1956:22 | IND TRACON - E | **Indy** Approach |
| 1956:23 | R3401 | A squawk for racer eight **one** a flight of three |
| 1956:28 | IND TRACON - E | **I'll** have *to* call **you** back **on** tha: **I** guess |
| 1956:29 | R3401 | **OK** |
| 1956:31 | IND TRACON - E | Is he **is** he uh done with the IR six eighteen route et what **do** you **know** where he's going |
| 1956:35 | R3401 | **Ah** they'll be **going back** I think eo Terre Haute |
| 1956:37 | IND TRACON - E | Terre Haute **OK** I'll call **you** back |

| | | |
|---|---|---|
| 1956:39 | R3401 | |
| 1956:41 | N74FB | Indy Approach Mitsubishi seven four Foxtrot Bravo over |
| 1956:45 | IND TRACON - E | Mitsubishi seven Pour Fox Bravo Indy |
| 1956:47 | N74FB | Roger I'm off the ground Greenwood standing by for clearance to Columbus |
| 1956:51 | IND TRACON - E | Seven four Fox Bravo roger squawk four five six four and ident maintain uh at or below five thousand |
| 1957:01 | Unknown Source | (Unintelligible) |
| 1957:03 | ti66422 | Indy Approach ah Cessna six six four two two is with you at three thousand |
| 1957:09 | IND TRACON - E | Cessna four two two roger maintain VFR altimeter three zero tvo nine |
| 1957:14 | N66422 | Four two two |
| 1957:38 | IND TRACON - E | And Mitsubishi four Fox Bravo I didn't 'get rhe readback squawk four five six four and ident |
| 1957:59 | USA416 | Departure USAir feur sixteen passing one point five for five thousand |
| 1958:05 | IND TRACON - E | Hitsubishi seven four Fox Bravo Indy |
| 1958:12 | IND TRACON - E | USAir four sixteen Indy departure radar contact turn right heading one four zero climb and maintain er correction turn right herding zero niner zero climb and maintain six thousand |

| | | |
|---|---|---|
| 1958:20 | USA416 | Six thousand and right to ah zero nine zero USAir four sixteen |
| 1958:26 | IND TRACON - E | November seven four Fox Bravo Indy |
| 1958:45 | JIA4281 | You got higher fur forty-two eighty-one |
| 1958:48 | IND TRACON - E | Bluestreak forty-two eighty-one contact Indy Center one three two point two |
| 1958:51 | JIA4281 | Thirty two two good dag |
| 1958:55 | IND TRACON - E | November seven four Fox Bravo Indy |
| 1959:25 | RACER81 | Racer eight one check |
| 1959:30 | RACER81 | Indianapolis Racer eight one off of restricted area three four oh one for return to Hulman Field |
| 1959:37 | IND TRACON - E | Racer eight one roger squawk four two five seven and ident |
| 1959:46 | RACER81 | There's your parrot with the flash |
| 1959:52 | IND TRACON - E | USAir four sixteen climb and maintain six thousand |
| 1959:56 | USA416 | Yes sir uh six thousand USAir uh four sixteen |
| 2000:02 | IND TRACON - E | November four two tw uh Indy turn uh left heading one two zero and Im going to take you uh over top of Greenwood Airport |
| 2000:10 | N66422 | Uh one two zero on the heading for four two two *(please) |

| | | |
|---|---|---|
| 2000:14 | IND TRACON - E | November seven four Fox Bravo Indy |
| 2000:22 | W D TRACON - E | Terre Haute Indy Approach |
| 2000:28 | HUF IRACON | Hulman |
| 2000:29 | IND TRACON - E | Yeah I got Racer eight one about twelve miles northeast of Hoosier on a uh four two five seven code at thrity five hundred right now can X give you him on about a two forty heading at uh six thousand and then your control for a turn back tovards uh ierre Haute we're landing on fives and be's just going to be in the way righ: now |
| 2000:46 | HUF TRACON | Ok you want him on a uh what two seventy heading |
| 2000:49 | IND TRACON - E | No two seventy heading's no good righ: now how abou: a two forty heading for about |
| 2000:51 | HUF TRACON | Two forty and five's good |
| 2000:52 | IND TRACON - E | Five thousand |
| 2000:53 | HUF TRACON | Yeah |
| 2000:54 | IND TRACON - E | FZ |
| 2000:55 | IND TRACON - E | Do you want me to give hin a a clearance or what |
| 2000:57 | HUF IRACON | Tell you what can you give him six thousand and we'll take hin down when we can |
| 2000:59 | IND IRACON - E | I'll give him six thousand |

| | | |
|---|---|---|
| 2001:00 | HUF TRACON | Yeah we have a five thousand north of Bloomington |
| 2001:02 | IND TRACON - E | Two forty heading |
| 2001:03 | HUF TRACON | JL |
| 2001:04 | IND TRACON - E | FZ |
| 2001:05 | IND TRACON - E | Racer eight one climb and maintain six thousand and ah good rate up to six thousand turn left heading tvo one zero |
| 2001:12 | RACER81 | Racer eight one roger quickly to ah six thousand fee: we're out of three point five now tvo one oh the heading |
| 2001:17 | IND TRACON - E | Racer six one affirmative and you're cleared to the Terre Haute Airport via vectors to ah Terre Haute climb and maintain six thousand an2 there's traffic about ah niner miles northvest of ah Ierre Haute at five thousand descending |
| 2001:28 | RACER81 | OK I'm no contact on him and the call sign by the vay is Racer eight one six thousand feet two ten |
| 2001:34 | IND TRACON - E | Racer eight one roger |
| 2001:53 | IND TRACON - E | USAir four sixteen climb and maintain one zero thousand |
| 2001:55 | USA416 | One zero thousand USAir four sixteen |
| 2001:59 | IND TRACON - E | Facer eight one verify turning left to two one zero |
| 2002:01 | RACER81 | (Unintelligible) turning two one oh heading |

| | | |
|---|---|---|
| 2002:11 | IND TRACON - E | November seven four Fox Bravo Indy |
| 2002:14 | RACER81 | Racer eight one would like higher |
| 2002:16 | IND TRACON - E | Racer eight one it's going to be six thousand for a final ah due to traffic Racer eight one fly heading two three zero and ah contact Terre Haute Approach on two eight eight point ah one five twenty eight er two eight eight point one five |
| 2002:32 | RACER81 | Racer eight one go channel five |
| 2002:49 | IND TRACON - E | November four two two turn left heading zero nine zero |
| 2002:53 | N66422 | Zero nine zero four two two |
| 2002:59 | IND TRACON - E | USAir four sixteen contact Indy Center one two four point five two maintain ten thousand |
| 2003:05 | USA416 | Two four five two and ten thousand USAir four sixteen |
| 2003:10 | JIA4091 | Evening Indy Bluestreak forty ninety-one ten thousand Foxtrot |
| 2003:17 | IND TRACON - E | Is that Bluestreak forty ninety-one calling |
| 2003:19 | JIA4091 | That's affirmative |
| 2003:20 | IND TRACON - E | Bluestreak forty ninety-one fly heading two seven zero descend and maintain seven thousand expect vectors ILS five right |

| | | |
|---|---|---|
| 2003:25 | JIA4091 | Two seventy down to seven for five right Bluestreak forty ninety-one |
| 2003:43 | IND TRACON - E | And ah four two two advise Shelbyville in sight |
| 2003:45 | N66422 | Ah four two two's looking will advise |
| 2004:09 | IND TRACON - E | Indy |
| 2004:10 | BAK TOWER | Yes sir I'm sorry I wanted to verify ah were you notified that two eight eights finished vith the ILS |
| 2004:16 | IND TRACON - E | Ah no I wasn't but I know but that's fine |
| 2004:17 | BAY TOWER | Ok he's done |
| 2034:18 | IND TRACON - E | Alright FZ |
| 2004:19 | BAK TOWER | Thanks (unintelligible) |
| 2004:30 | N6018U | Indy Approach good afternoon ah November six zero one eight Uniform niner thousand |
| 2004:35 | IND TRACON - E | November six zero one eight Uniform Indy Approach fly ah heading zero three zero and expect vectors to the VOR final approach course at Brookside |

| | | |
|---|---|---|
| 2004:44 | N6018U | Alright zero three zero for ah vectors to the final approach course for one eight Uniform |
| (2005) | | |

"END OF TRANSCRIPT''

* This portion of the recording is not entirely clear but chis represents the best interpretation possible under the circucstances.

*U.S. G.P.O.:1993-300-644:80008