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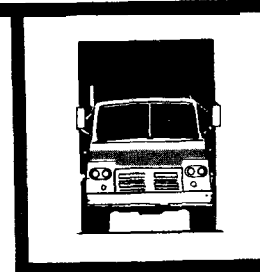
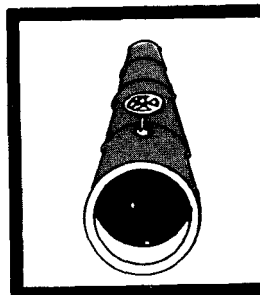
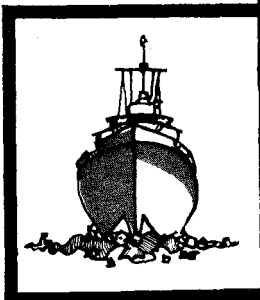
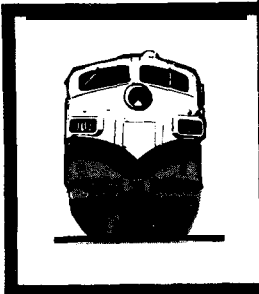
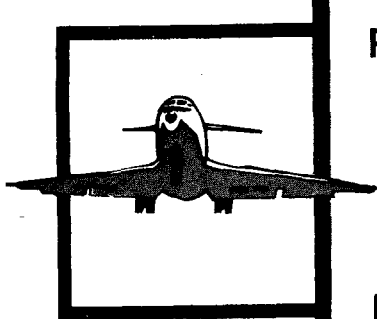
WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

MIDAIR COLLISION OF SKYWEST AIRLINES
SWEARINGEN METRO II, N163SW,
AND MOONEY M20, N6485U,
KEARNS, UTAH
JANUARY 15, 1987

NTSB/AAR-88/03

UNITED STATES GOVERNMENT





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16. Abstract On January 15, 1987, about 1252 mountain standard time, Skywest flight 1834, a Swearingen SA-226TC (METRO II), and a Mooney M20 collided in flight over Kearns, Utah, in visual meteorological conditions. The two pilots and six passengers aboard the METRO II and the two pilots aboard the Mooney were killed in the accident which occurred within the confines of the Salt Lake City airport radar service area The National Transportation Safety Board determines that the probable cause of this accident was lack of navigational vigilance by the Mooney instructor pilot which led to the unauthorized intrusion into the Salt Lake City airport radar service area. Contributing to the accident were the absence of a mode-C transponder on the Mooney airplane and the limitations of the air traffic control system to provide collision protection under the circumstances of this accident.			
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EXECUTIVE SUMMARY

On January 15, 1987, about 1252 mountain standard time, SkyWest flight 1834, a Swearingen SA-226TC (METRO II), and a Mooney M20 collided in flight over Kearns, Utah, in visual meteorological conditions. The two pilots and six passengers aboard the METRO II and the two pilots aboard the Mooney were killed in the accident which occurred within the confines of the Salt Lake city airport radar service area.

The issues examined in this report include the see-and-avoid concept as a means to prevent midair collisions, radar controller training and performance, pilot responsibilities to avoid controlled airspace until receiving proper clearance to enter, and overall Federal Aviation Administration responsibilities to provide collision protection for aircraft operating near major airports.

The National Transportation Safety Board determines that the probable cause of this accident was lack of navigational vigilance by the Mooney instructor pilot which led to the unauthorized intrusion into the Salt Lake City airport radar service area. Contributing to the accident were the absence of a mode-C transponder on the Mooney airplane and the limitations of the air traffic control system to provide collision protection under the circumstances of this accident.

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

MIDAIR COLLISION OF SKYWEST AIRLINES SWEARINGEN METRO II, N163SW, AND MOONEY M20, N6485U, KEARNS, UTAH JANUARY 15, 1987

1. INVESTIGATION

1.1 History of Flights

On January 15, 1987, at 1216 mountain standard time, SkyWest flight 1834, a Fairchild Swearingen SA-226TC (METRO II), registration N163SW, departed Pocatello, Idaho, on a regularly scheduled passenger flight to Salt Lake City, Utah (SLC). The flight was operating under the provisions of Title 14 Code of Federal Regulations Part 121 with two pilots and six passengers aboard. Flight 1834 was handed off from the SLC Air Route Traffic Control Center to the Bear Sector controller at the SLC Terminal Radar Approach Control (TRACON) for a left downwind arrival to SLC International Airport. At 1237:49, the Bear sector controller issued a heading of 100° to flight 1834 and advised the flight to expect vectors for a visual approach to runway 34L. (See Air Traffic Control Transcript in appendix C). During the next few minutes, flight 1834 was given further vectors and descent clearances, and at 1247:21, it was given a frequency change to the TRACON Final controller.

At 1250:28, after being cleared to descend to 7,000 feet mean sea level (msl), the Final controller advised, "SkyWest eight thirty four, traffic ten to nine o'clock, four miles, six thousand, Boeing seven, ah, thirty seven three hundred." Flight 1834 acknowledged, "SkyWest eight thirty four has the traffic." At 1250:35, the Final controller advised, "SkyWest eight thirty four, plan to follow that traffic, there's traffic south of him eleven o'clock, six miles north bound, [a] seven thirty seven out of seven thousand five hundred, for the right." Flight 1834 responded, "OK, we'll follow the first one, SkyWest eight thirty four." At 1250:44, the Final controller advised, "SkyWest eight thirty four, wait a minute, report the other one in sight." Flight 1834 responded, "We're looking for him."

At 1251:02, the Final controller transmitted, "SkyWest eight thirty four, ten o'clock four miles, seven thousand four hundred." Flight 1834 replied, "Eight thirty four, we're looking." The Final controller then issued instructions at 1251:15 for flight 1834 to make a left turn to 070°, and the flight acknowledged. At 1251:32, the Final controller transmitted, "SkyWest eight thirty four, traffic's ten to eleven o'clock, three miles." Flight 1834 did not acknowledge that transmission, and at 1251:43, the Final controller advised, "SkyWest eight thirty four, turn left heading zero five zero." The flight acknowledged and reported, "Still have no contact on that traffic." At 1251:50, the Final controller transmitted, "SkyWest eight thirty four, roger, turn further left heading three six zero."

Flight 1834 acknowledged and at 1251:58, an expletive was transmitted over the TRACON Final control frequency during a transmission from SkyWest flight 575. There were no further transmissions from flight 1834.

According to the UNICOM 1/ operator at SLC Municipal 2 Airport (SLC 2) about 1115 or 1120, a pilot in Mooney M20C, registration N6485U, operating under 14 CFR Part 91, called to inquire if the runway was clear. The Mooney was occupied by a private pilot in the left seat and an instructor pilot in the right seat. The UNICOM operator advised that the runway was clear, and a few minutes later, a pilot in the Mooney called for and was given an airport advisory. The UNICOM operator observed the Mooney taxi to runway 34 and take off about 1125 or 1130. The Mooney remained in the traffic pattern at SLC 2 performing touch-and-go landings. There were no other aircraft in the traffic pattern at the time.

The UNICOM operator stated that she last talked to the Mooney about 1145 to 1150 when a pilot called, "Final for 34." The UNICOM operator said that she observed the airplane perform a touch-and-go landing, but she did not observe the direction of departure of the airplane. There were no further known communications with the Mooney regarding departing the traffic pattern or any additional aspects of the flight.

According to recorded air traffic control (ATC) radar data, after the Mooney departed the SLC 2 traffic pattern at 1235, 2/ the airplane flew south and maneuvered about 25 miles south southeast of SLC International Airport before beginning a turn to the northwest. The airplane continued in a northwesterly direction until it was about 9 miles south of SLC International Airport where it began a gradual left turn until its target merged with the target of SkyWest flight 1834. The targets merged at 1257:58--the time the expletive was recorded on the ATC tape at the SLC TRACON.

The Final approach controller stated that he did observe a visual flight rules (VFR) target about 3 to 4 miles southwest of SLC 2 moving north to northwest when flight 1834 was on downwind. He said he had no more than normal cause to monitor the target. He also stated that it was not unusual to observe VFR targets in the pattern near SLC 2 during visual meteorological conditions. Other controllers at SLC TRACON also stated that it was not uncommon to observe numerous targets operating in the traffic pattern at SLC 2. The Final controller and other controllers added that they normally would observe the VFR targets near SLC 2 disappear from the radarscope and then reappear during practice touch-and-go landings.

The Final controller said that he did not recall seeing any VFR targets in the vicinity of SkyWest 1834 as it was turning toward final just before the collision. The Final controller stated that his workload was moderate, and all of his equipment was operating normally before the accident. In addition, the Local controller in the SLC tower stated that he did not observe the target of the Mooney on the tower Bright Radar Indicator Tower Equipment display.

There was no evidence that the Mooney pilots were in radio contact with any ATC facility at the time of the accident.

Several eyewitnesses were interviewed who observed the airplanes before and after the collision. Some of the witnesses stated that the nose of the METRO II pitched up just before impact.

1/ Unicorn is a nongovernment communications facility that may provide airport information at certain airports.

2/ The times recalled by the UNICOM operator were off by about 40 minutes as recorded by the SLC TRACON.

The witnesses stated that the METRO II was headed northeasterly and the Mooney was headed northwesterly just before impact. They stated that the METRO II had made a few left turns as it turned toward the northeast. In general, the eyewitnesses agreed that the two airplanes collided with the Mooney striking the METRO II's right forward fuselage area with its nose.

After the collision, both airplanes fell to the ground with wreckage scattered over 2 square miles in a residential section of Kearns, Utah. There was no fire. The collision occurred at 7,000 feet msl in daylight visual meteorological conditions. The coordinates of the center of the accident site were 40°39' 20" N and 112°00' 00" W.

1.2 Injuries

<u>Injuries</u>	<u>Crew</u>	<u>Passengers</u>	<u>Total</u>
Fatal	4	6	10
Serious	0	0	0
Minor	0	0	0
None	<u>0</u>	<u>0</u>	<u>0</u>
Total	4	6	10

1.3 Damage to Airplanes

Both airplanes were destroyed by the collision and ground impact. The estimated value of the Mooney was about \$22,000; the estimated value of the METRO II was \$900,000.

1.4 Other Damage

A school, several homes, automobiles, and public utilities were damaged by debris from the airplanes. An estimate of the ground damage was \$1.8 million according to insurance carriers.

1.5 Personnel Information

Controllers.--The air traffic controllers who provided ATC services to flight 1834 were qualified in accordance with current regulations. The examination of their training records did not reveal anything remarkable. Similarly, the investigation of the controllers' background and their activities 2 to 3 days before reporting for duty on January 15 did not reveal anything remarkable.

The Final controller, who had primary responsibility for the handling of flight 1834, was hired by the FM on August 23, 1981. He entered on duty at SLC on February 1, 1982, after completing radar training at the Federal Aviation Administration (FAA) ATC training facility at Oklahoma. The Final controller reached full performance level at the TRACON on August 16, 1983. He held a second-class medical certificate dated July 1986.

The Final controller was assigned the 0800 to 1600 shift and was on his third workday of a 5-day workweek at the time of the accident. He had not worked any overtime in the recent past.

METRO II.--The flightcrew of SkyWest flight 1834 was qualified in accordance with applicable company and FAA regulations (see appendix B). The examination of the training records and an investigation of the background of the flightcrew and their actions during the 2 to 3 days before the accident did not reveal any remarkable findings.

Mooney.--Both pilots aboard the Mooney were qualified in accordance with the applicable regulations (see appendix B). The instructor held a commercial pilot certificate, issued April 6, 1979, for single- and multiengine land and instrument airplane privileges. He also held a flight instructor certificate, the latest issuance of which was dated November 19, 1986, with the same aforementioned ratings and privileges. His second-class medical certificate, issued on November 13, 1986, contained the limitation that the holder shall possess correcting lenses for near vision while exercising the privileges of his airman certificate. He also possessed a waiver of demonstrated ability for high frequency hearing loss in his right ear.

A logbook with the last entry on December 26, 1986, indicated that the instructor had logged 1,331.9 hours as an instructor, 211.8 hours of dual flight hours, and 2,547.8 total flight hours.

The instructor pilot was a retired Army major and was employed as an interstate tractor-trailer driver for PIE Nationwide of Salt Lake City. His supervisor at PIE described him as a cautious driver.

At the time of the accident, the instructor owned a Piper PA-28 (Cherokee) based at SLC International Airport. He had previously owned another PA-28 which was substantially damaged while making an emergency landing near Hyampom, California. The accident occurred following fuel exhaustion on a crosscountry flight from Salt Lake City to Arcata, California. The instructor and his wife received minor injuries in that accident.

In November 1986, the instructor and his wife drove to Albuquerque, New Mexico, where he attended a 3-day flight instructor refresher course.

The wife of the instructor pilot did not know the purpose of the flight on the accident day. She did not know if the instructor had given the other pilot instrument flight training; however, she was aware that he had given him primary flight training. The instructor and the student were friends as well as flight training associates, and they flew together occasionally.

The instructor owned two types of vision restricting devices for instrument flight training--"foggles"^{3/} and a white hood. According to other students of this instructor, he preferred that his students use foggles. The instructor's wife located the hood at home after the accident in the instructor's personal possessions. The foggles were not located at that time, but, during an interview in April 1987, the widow said that both the hood and the foggles were in the instructor's personal possessions at home.

Most of the instructor's students who were interviewed were based at SLC International Airport where the instructor kept his airplane. They said that SLC 2 was used occasionally for takeoff and landing practice. According to the students, when departing runway 34 at SLC 2, the instructor urged his students to begin turning crosswind about 400 feet above the ground, which was generally obtained about 1/4 mile from the departure end of the runway.

^{3/} Foggles are a goggle-style vision restriction device used for instrument training.

One pilot, who had just recently begun instrument training with the instructor, stated that a few weeks before the accident, the instructor had used a "homemade" instrument approach during the training. This homemade instrument approach involved the use of an approach chart from Colorado. Although he could not recall the actual approach chart, he believed that it involved the use of two VORs. He said that the approach was commenced between and west of the SLC International Airport and the SLC 2. He could provide no further details.

The pilot receiving instruction held a private pilot certificate issued August 29, 1981, with ratings for airplane-single engine land. His flight instructor for his private pilot rating was the same instructor as for the accident flight. He held a third-class medical certificate issued August 29, 1985, with no restrictions. The private pilot had taken his instrument pilot written test on December 9, 1985; however, he did not achieve a passing grade. He took the written test again on January 13, 1986, and successfully completed it.

At the time of the accident, the private pilot had accumulated about 301.4 hours, of which 59 hours were dual. His flight log indicated that he had flown about 70 hours in a Cessna 172, about 157 hours in a Piper PA-22-160, and the remainder in the Mooney. On September 3, 1985, he had completed a biennial flight review given by the instructor involved in the accident. This was also the last recorded dual instruction. There were numerous entries in his logbook for the past 6 years indicating about 165 flights between SLC International Airport and SLC 2.

According to the private pilot's wife, he told her the night before the accident that he was going to begin his instrument flight training the next day. She also said that he took his checkbook with him which was his normal custom when he was receiving training.

1.6 Aircraft Information

The METRO II was owned and operated by SkyWest Airlines. Examination of the airplane's maintenance records revealed that it was equipped and maintained in accordance with applicable regulations and company procedures.

The airplane was painted overall white with the company paint scheme of horizontal yellow, orange, and red narrow stripes running the length of the fuselage. At the empennage, the stripes widened to about 18 inches as they turned vertically and ran up the vertical stabilizer. The name "SkyWest" was written in large red letters on the white vertical stabilizer.

The METRO II was equipped with navigation lights, three strobe lights (one on each wingtip and one on the tailcone), landing lights, logo lights, and a rotating beacon on the top of the vertical fin.

The Mooney reportedly was owned by the pilot occupying the left seat, and it was based at SLC2. The FAA records showed that the airplane was still registered to another person from Cheyenne, Wyoming. However, the widow of the private pilot stated that her husband had purchased the airplane in August 1986. No engine or airplane logbooks were located for the maintenance history of N6485V before October 2, 1986. However, a single logbook found in the airplane wreckage had entries for an annual inspection and a 100-hour inspection dated October 2, 1986, and a propeller overhaul for October 11, 1986. No maintenance records were found which indicated when the pitot-static system or altimeters were last inspected. The airplane was equipped with a transponder, but it did not have mode-C altitude reporting capability.

The Mooney was equipped with a strobe light, located under the center wing (belly) section, a rotating beacon, and navigation lights. A landing light was located in the lower right side of the nose cowl i ng.

The paint scheme of the Mooney was predominantly white with royal blue and powder blue stripes running the length of the fuselage. Blue stripes were also painted on the wing tips across the empennage and up the vertical stabilizer.

1.7 Meteorological Information

The 1251 surface weather observation for SLC International Airport showed scattered clouds at 7,000 feet above ground level (agl) with an estimated ceiling at 15,000 feet agl. The wind was 270° at 9 knots; visibility was unrestricted. A Significant Meteorological Information for severe turbulence and low-level windshear was in effect at the time of the accident.

According to the captain of the SkyWest flight 575 which was following the accident flight, there were no clouds, turbulence, or significant winds below 8,000 feet msl. He said that the flight visibility was greater than 10 miles. A helicopter pilot, who hovered over the accident site, stated that there was light with occasional moderate turbulence at 300 to 400 feet above the accident site. He said that the cloud bases were about 8,000 to 8,500 feet msl with flight visibility greater than 20 miles.

At the time of the accident, the sun's azimuth was 184° with the elevation at 28°. This would have placed the sun nearly behind the Mooney and the METRO II would have been pointed toward the sun before the left turns were begun.

1.8 Navigational Aids

There were no known navigational difficulties. However, during the course of the investigation, the Safety Board learned that general aviation pilots in the Salt Lake City area, including the instructor pilot aboard the accident flight, were using "homemade" instrument approaches for instrument flight training. In fact, some pilots alleged that the commercial radio beacon from station KSL, frequency 1160, located 5 miles west of SLC and 10 miles northwest of SLC 2 airports, had been used in the past to devise such an approach for SLC 2 airport.

FAA Bulletin No. 78-14, discusses the subject of "homemade/makeshift" instrument approaches and points out that such approaches cannot be used for purposes of meeting the requirements of instrument training and certification. However, it is not uncommon for instructor pilots to use such procedures during instrument training and such a practice is acceptable for basic training in instrument skills.

1.9 Communications

There were no known communications difficulties.

1.10 Aerodrome Information

1.10.1 Salt Lake City International

The airport (elevation 4,227 feet) is served by parallel runways 34L/16R on the west side of the airport, and runways 34R/16L and 32/14 on the east side of the airport. Runways 34L, 16L, and 16 R are served by instrument landing system (ILS) approaches.

For the 12 months preceding May 1, 1986, there were 257,541 flight operations at the airport of which 112,464 were air carriers, 50,600 were air taxis, 10,633 were general aviation local, 76,663 were general aviation itinerate, and 7,181 were military.

The airport is served by an airport radar service area (ARSA) which became effective May 8, 1986 (see figure 1). The FAA held a public meeting on January 15, 1986, at which time the implementation of the ARSA was discussed. General notices of the meeting were placed in local newspapers and aired on the radio. Final implementation of the ARSA was published in the Airman's Information Manual. On May 2, 1986, the accident prevention specialist at the SLC flight standards district office issued a Letter to Airmen that addressed the implementation of the ARSA. That letter was mailed to pilots and aviation-affiliated facilities in Utah using the FAA's airman's records facility in Oklahoma City, Oklahoma. In addition, from May 17, 1986, to January 15, 1987, the accident prevention specialist conducted 12 Aviation Safety Education Seminars in Utah. The topics addressed at virtually all of these seminars included ARSAs and midair collision avoidance. It was not determined if either of the Mooney pilots attended the seminars.

On October 15, 1986, the Utah Department of Transportation, Division of Aeronautics, held a meeting for licensed pilots in Blanding, Utah, on the subject of the SLC ARSA.

A past president of the Utah Pilots Association stated that he believed that the information regarding the implementation of the ARSA was well publicized by the FAA. He, as well as other pilots, recalled receiving a pamphlet from the FAA at their residences which described how to fly in the ARSA and included a photocopy of a sectional, chart depicting the ARSA.

The SLC ARSA airspace was implemented in a nonstandard configuration due to topography and operational airspace requirements (see figure 1). The 10-mile outer circle was truncated on the east side of the primary airport to accommodate the high terrain of the Wasatch mountain range. It also was modified in the southwest quadrant to accommodate the high terrain of the Oquirrh Mountains that border the western edge of the valley.

The vertical limits of the ARSA 5-mile circle extend from the surface to 8,200 feet. The 10-mile outer circle vertical limits extend from 5,400 feet to 8,200 feet. The exception of these limits is a "keyhole" in the south quadrant of the 10-mile outer circle that accommodates the users of SLC 2 airport and is used as the localizer course for the ILS to SLC International. The vertical limits for the "keyhole" area are from 5,800 feet to 8,200 feet.

Pilots operating within an ARSA must have two-way radio communication with the controlling facility, and they may not enter the ARSA without such communication.

1.10.2 Salt Lake City Municipal 2 Airport

SLC 2 is located 7 miles southwest of Salt Lake City and about 10 miles south southwest of SLC International Airport. The airport elevation is 4,608 feet, and the traffic pattern altitude, as published in the National Oceanic and Atmospheric Administration Airport Directory, is 5,408 feet. The airport is served by runway 16/34--a 6,100-foot long and 100-foot wide asphalt surface. Runway 34 uses a standard left pattern, and runway 16 uses a nonstandard right pattern. The airport's common traffic advisory frequency and UNICOM frequency is 122.7 MHz. The UNICOM is monitored by a fixed base operator (FBO) at the airport.

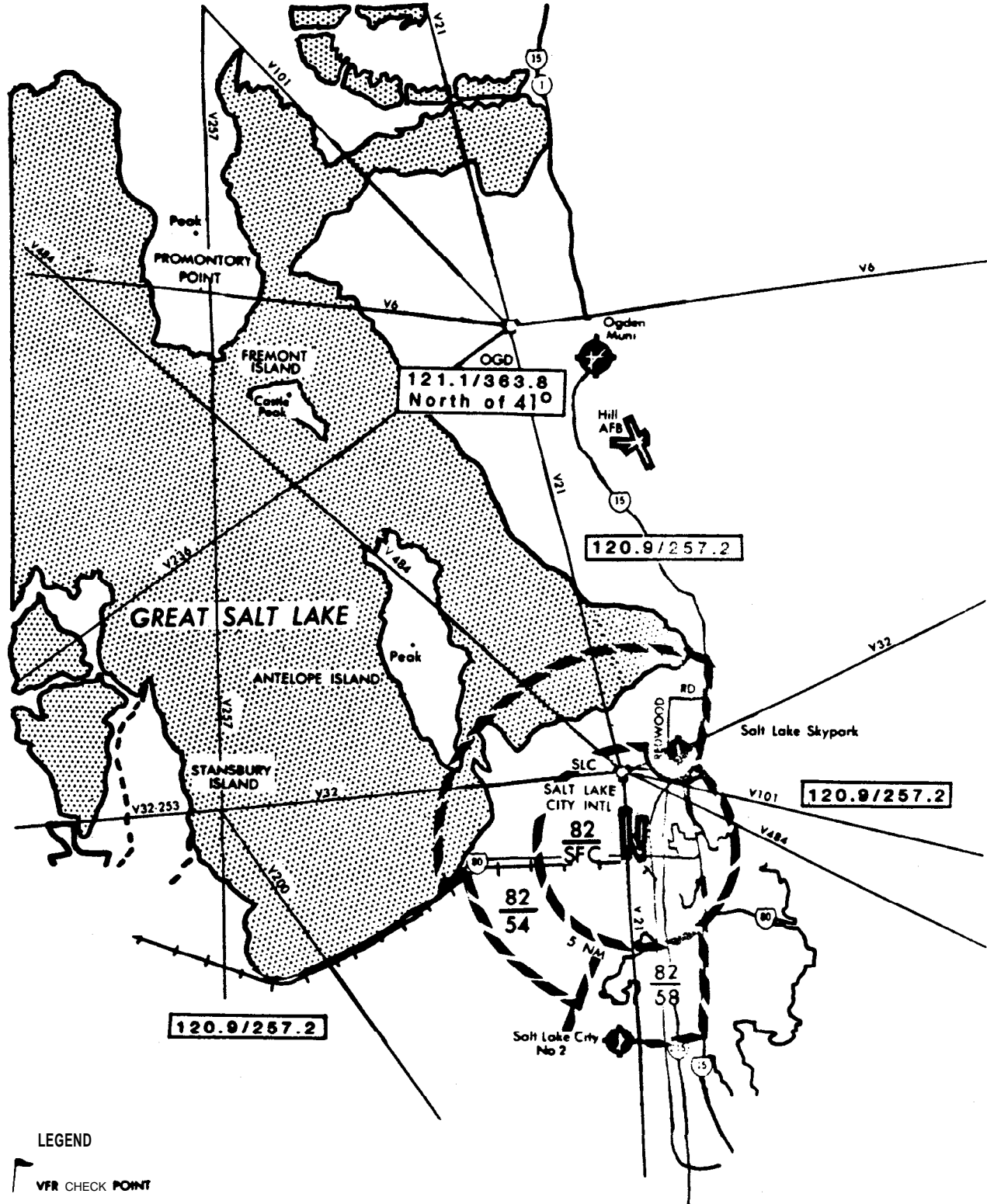
The airport master record for the 12 months preceding May 1, 1986, indicates that there were 78,274 flight operations at the airport, of which 46,787 were local general aviation, 5,756 were itinerate general aviation itinerent, 25,000 were military, and 731 were air taxi. The airport record dated May 21, 1986, showed that there were 212 single-engine aircraft, 3 multiengine aircraft, and 44 military (predominantly helicopters) aircraft based at the airport.

The FBO at SLC 2 provides aircraft servicing and flight training. In 1986, the FBO put about 300 students through some form of flight training--predominantly primary training. The FBO operates


AIRPORT RADAR SERVICE AREA

(NOT TO BE USED FOR NAVIGATION)

SALT LAKE CITY, UTAH SALT LAKE CITY INTERNATIONAL AIRPORT FIELD ELEV. 4227' MSL



LEGEND

-  VFR CHECK POINT
-  ARSA
- ALTITUDES ARE MSL
- BEARINGS ARE MAGNETIC

Prepared by the
 FEDERAL AVIATION ADMINISTRATION
 Cartographic Standards Section
 ATO-259

Figure 1-- Salt Lake City ARSA.

13 airplanes, 11 of which are used for flight training. Most of the airplanes (less than 10 percent) operated by the FBO were not mode-C equipped, nor were they equipped with strobe lights.'

The practice areas used by pilots operating out of SLC 2 are the area northwest of SLC International Airport, west of Antelope Island, and the area 5 to 19 miles southwest of SLC 2.

1 .11 Flight Recorders

Neither airplane was equipped nor were they required to be equipped with flight data recorders or cockpit voice recorders.

1 .12 Wreckage and Impact Information

The major portions of both airplanes fell into roughly a 6- by 8-block area of a predominately residential section of Kearns, Utah. The wreckage area was located about 2 miles north of SLC 2 and about 8 miles south of SLC International Airport.

Major portions of the METRO II were generally aligned on a magnetic heading of about 060°, along a path that was about 4,565 feet long. The METRO II was generally separated into six major sections--each wing, with the engines and propellers attached, the forward fuselage, the aft fuselage broken into two pieces, and the empennage. Evidence of the collision was noted in both wing root areas, the wing carry-through structure, the forward and aft fuselage belly, the right side of the empennage, and on both propellers.

The entire empennage of the METRO II was located about 800 feet east northeast of the initial wreckage. Cabin materials and passenger seats from the METRO II were also located in this area. Continuing easterly from the METRO II empennage, the entire right wing with the engine attached was found in the back yard of a residence. The major portion of the left wing was found about three houses east of this location with the engine and propeller attached. It came to rest in the midst of a residence that was destroyed in the accident.

The Mooney wreckage path began about the same point as did the METRO II and was generally aligned along a 025°-heading for about 3,400 feet. The Mooney was almost totally disintegrated as a result of the collision and inflight breakup. Portions of the nose section, cabin, wings, wing center section, aft fuselage, empennage, and the engine were found scattered throughout the wreckage area. The first major piece of the Mooney wreckage was a 51-inch outboard section of the left wing located adjacent to the right aft fuselage panel of the METRO II. A portion of the left wing spar from the Mooney was also found in this area.

1 .13 Medical and Pathological Information

The Utah State Medical Examiner's Office performed autopsies on the pilots from both airplanes. No preexisting disease or other incapacitating conditions were identified. The cause of death of all airplane occupants was attributed to multiple severe impact injuries.

Toxicological tests conducted on the remains of the pilots were negative for alcohol and drugs. Urinalysis of samples submitted by the final controller was negative for drugs and alcohol.

1.14 Fire

There was no inflight or postimpact fire.

1.15 Survival Aspects

This was a nonsurvivable accident because the occupiable spaces of the airplanes were destroyed by the collision and ground impact forces. No persons on the ground were injured.

1.16 Tests and Research

1.16.1 Metro and Mooney Lights

The strobe light located on the lower fuselage of the Mooney was removed and tested after the accident. The light and its power supply were undamaged but did not operate when tested. After replacing a defective transistor, the unit operated normally. The position lights, landing light, and rotating beacon were not recovered.

Both wing strobe light power supplies from the Metro II were removed and tested with satisfactory results. The right wing strobe bulb was found operational; the left bulb was destroyed by the impact.

1.16.2 Mooney Avionics

The King Model KT76 transponder face plate and switchboard of the Mooney had separated and were not recovered. The unit had sustained substantial impact damage and could not be tested.

The digits displayed on the automatic direction finder (ADF) (manufacturer not determined) control head were 042. The selector switch was positioned to "ADF" and the needle was indicating 225". The compass card was positioned so that the 150°-index was at the 12 o'clock position. The unit had sustained substantial damage.

The No. 1 NAV/COM, King Model KX175B, had sustained substantial damage and the panel face plate was missing. A teardown and inspection of the unit at the manufacturer's showed that the NAV portion appeared to be channelled to 117.75 MHz, and the COMM portion appeared to be channelled between 124.67 and 124.70 MHz.

The No. 2 NAV/COMM, King KX175, NAV frequency displayed was 109.8 MHz. The selector switch was in the "off" position. The COMM frequency displayed was 122.7 MHz, and the selector switch was in the "on" position.

1.16.3 Radar Retrack

On April 3, 1987, the radar data recorded by the SLC TRACON's computer was entered into the FAA's retrack program computer at Atlantic City, New Jersey.

The retrack program approximated what the final controller would have observed on his radarscope except that no primary or secondary targets were depicted and the radar video map was not displayed. Only alphanumeric data were displayed on the radarscope. The alphanumeric character size and spacing for the retrack program were adjusted to a scale which approximated what was in use at the SLC TRACON at the time of the accident. Leader line lengths were set at approximately 1/4 inch which was the length being used by the Final controller according to his statement.

The retrack program was run from 1240 until 1255. Beginning at the start of the run, a triangle target, which depicted a VFR non-mode-C aircraft, was observed approximately 25 miles south southeast of SLC. This was the only nontagged VFR target that was displayed during the retrack program and the only target that merged with the target of SkyWest 1834. The VFR target

maneuvered in this general area and subsequently made a turn to the northwest. The target continued to track to the northwest until, at 1250:47, it flew nearly directly over SLC 2. The target moved parallel to runway 34 at SLC 2, and at 1251:30, about 1 mile north of the airport, a gradual left turn was noted until the target merged with the target of SkyWest 1834 at 1251:58.

At 1250:19, the retrack program showed that the data block representing Western 612 (WA612), a Boeing 737, was inbound to runway 34 right at SLC from the south. The data block for WA612 was offset to the southwest, which would have occurred as a normal function of the "quad" offset program ^{4/} used at the SLC TRACON. As the target of WA612 proceeded northbound toward SLC, at 1250:32, the data block for WA612 overlapped and obscured the target of the VFR aircraft (the Mooney). As each airplane continued on its respective course, the data block of WA612, which contained an "A" within the data block to denote arrival status, moved concurrently (overlapped) with the depicted triangle of the VFR target. In fact, the VFR target symbology and the top portion of the "A" appeared to blend into one entity. Varying degrees of obscuration continued for about 38 seconds, until the VFR target became visible again at 1251:10. At 1251:38, the data block of WA612 was observed to offset again to the northeast and then offset to the southwest at approximately 1251:44. After the VFR target became visible at 1251:10, it remained so for about 48 seconds, until it merged with the target of SkyWest 1834 and disappeared from the scope at 1251:58.

1.16.4 Radar Flight Check

On January 18, 1987, an FAA flight check Saberliner and a Mooney 201 were used to flight check the SLC TRACON ASR8 radar and to establish the vertical limits of the radar coverage near SLC 2. The Saberliner flew along the approximate flightpath and altitudes of the METRO II from the handoff to the Final controller to the point of the collision. Primary and secondary radar returns were observed during the entire flight. The Saberliner also flew at 7,000 feet from the south of SLC 2 along the approximate flightpath of the Mooney. Again, primary and secondary radar returns were observed the entire time.

Another flight check was flown from the south with the Saberliner descending to a low approach at SLC runway 34. Primary and secondary radar returns were observed until the airplane descended below about 4,700 feet inbound. The radar returns reappeared at 5,100 feet after the low approach.

The test flight Mooney 201 was flown with its mode-C transponder on for two flights. The first flight approached SLC 2 from about 6 miles south at 5,400 feet (SLC 2 traffic pattern altitude) along the approximate track of the Mooney involved in the accident. A touch-and-go landing was executed on runway 34 at SLC 2 and primary and secondary radar returns were observed until the airplane descended below 4,700 feet south of the runway and then reappeared about 4,500 feet after the landing. The Mooney was then flown along the track of the accident airplane at 7,000 feet over SLC 2 where it turned slightly to the left and tracked to the point of the collision. Again, primary and secondary radar returns were observed the entire time.

^{4/} Quad Offset Program--a local software modification program that determines the offset direction of all arrival FDB by their geographical positions at the time they are acquired by the ARTS computer. The "offset" is intended to prevent overlap of FDB of other aircraft, not for untracked targets.

The last two flights flown in the Mooney 201 were with the transponder set to code 1200 with the mode C off. The first flight was from about 6 miles south of SLC 2 at 7,000 feet to the point of collision. Both primary and secondary radar returns were observed. The second flight was also from the south at 7,000 feet with a descent to a touch-and-go landing at SLC 2, then it climbed toward the collision point. Primary and secondary returns were observed until the descent through 4,800 feet, and they reappeared again as the airplane climbed back through 4,825 feet. The airplane reached only 5,325 feet at the point of the collision.

According to the controllers and supervisors at the SLC TRACON, the radar controls and adjustments for the flight check were the same as those in use at the time of the accident. The same radarscope and positions were used during the flight check as were in use at the time of the accident.

1.16.5 Airplane Performance and Cockpit Visibility

Automated Radar Terminal System (ARTS IIIA) recorded radar data from the SLC TRACON were used to reconstruct the flight tracks of the accident airplanes. (See figure 2.) A computer program calculated the performance of each airplane and depicted its track. The program uses recorded radar data, aerodynamic coefficients and wingloading for the airplanes, and winds and temperatures aloft. Mode-C altitude information for the Mooney was not available, nor was a discrete beacon code assigned. The altitude values shown for the METRO II are from its mode-C altitude information recorded at the TRACON.

Using the flight track reconstruction, a cockpit visibility study was conducted to determine the location of each airplane with respect to the field of vision of the pilots in the other airplane.

A binocular camera, which simulates the binocular vision of humans, was used by the FAA Technical Center to photograph the cockpit windows of both airplane types. The airplanes were positioned level on the ramp. The camera was placed at the design eye reference point.

Appendix D contains figures that depict the probable positions of the other airplanes relative to the pilots' viewing positions. The plots indicate where the opposing airplane would appear in the windscreen of the viewing airplane. Because no altitude information was available for the Mooney, two sets of plots were developed; one for the Mooney climbing, the other was level at 7,000 feet. The plotted time histories show only the opposing airplane's center, therefore, the plots are not representative of their size and shape. The chronological order of the data points can be determined from the timing reference and the arrowheads that show the direction of movement.

The ability of the human eye to perform visual identifications of letters that subtend 5 minutes of arc, defines 20-20 vision as measured by the Snellen eye chart. Letters are considered to be highly discriminable, whereas target identification may be quite complex. Research has shown that "when the visual angle subtended by the largest dimension of the target is smaller than 12 minutes, there is an increase in relative search-to-identification time, and an increase in the numbers of errors in identification." These and other research data indicate that targets should subtend, as a minimum, 12 minutes of arc (0.29, to ensure reasonably accurate identification." ^{5/}

^{5/} Baker, C.A. and Grether, W.J., "Visual Presentation of Information: in Human Engineering Guide to Equipment Design," Eds., Morgan, Cook, Chapanis, & Lund; McGraw-Hill, 1963, pp. 67-68.

According to the aircraft performance calculations based on the radar data, the image of the Mooney did not subtend a 0.2° arc to the pilots of the METRO II until about 14 seconds before impact. The METRO II subtended the 0.2° arc to the Mooney pilots about 27 seconds before impact.

1.17 Additional Information

1.17.1 SkyWest Flight Operational Procedures and Training

SkyWest Airlines was not required to and did not have a formal course of programmed instruction on collision avoidance and outside visual scan training. However, the airline's director of operations and personnel involved with the ground training program stated that collision avoidance and sterile cockpit procedures are addressed in the training and are a part of the airline's operational procedures. According to the airline's director of operations, the inflight checklists are designed to be completed as much as possible at the higher altitudes. All company paper work is designed to be accomplished before takeoff, at cruise altitudes, or after landing. The airline's ground training instructors include in their training syllabus articles on crew coordination and proper cockpit management.

The Sky West Operations Manual and checklists contain items related to collision avoidance. For example, item 4 of the Engine Start Check directs the flightcrew to turn on the rotating beacon. Item 9 of the Climb Check directs the flightcrew to activate the strobe lights. Item 5 on the Before Landing Check directs/reminds the flightcrew to check for traffic. The checklists are read by the nonflying pilot to allow the flying pilot to remain vigilant for traffic.

SkyWest's standard operating procedures for the METRO II require a climb speed of 180 knots. This speed allows the pilot better visibility over the nose than the 160-knot airspeed recommended by the manufacturer. The airline also has issued to its pilots numerous articles pertaining to collision avoidance and has made National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System (ASRS) forms available to their flightcrews for reporting near-midair occurrences.

Based on the manner in which the pilots of flight 1834 were trained and the customary SLC arrival procedures, the following procedures would be considered routine. Beginning at a position north of SLC, the flying pilot would request the Descent Checklist before initiating a descent from cruise altitude. The Descent Checklist, read by the nonflying pilot, would be accomplished in about 1 or 2 minutes. The normal arrival procedures into SLC, when using runway 34, is a vector for downwind west of the airport, normally at an altitude of 8,000 feet msl or above. SkyWest flightcrews normally maintain a speed of more than 200 knots due to numerous arrivals of jet airplanes. ATC normally issues a descent to 7,000 feet when the airplane is south of SLC. Flightcrews usually expect a turn to base leg for the ILS somewhere between 12 and 15 miles south of the SLC VOR. During visual meteorological conditions, if other traffic is ahead of the flight on the approach, ATC will issue a clearance to follow that traffic and to report the traffic in sight for a visual approach. On base leg, the airspeed can vary from over 200 to 120 knots depending on ATC requests.

The Approach Checklist would be requested by the flying pilot on base leg and would be completed by challenge and response in approximately 30 seconds. The items on the Approach Checklist are 1. Nose Wheel Steering, 2. Ice Protection, 3. Landing Lights, 4. Fuel X-Flow, 5. Boost Pumps, and 6. Brakes. Once the Approach Checklist is completed, the flightcrew would have all navigational aids set up for the approach. The workload now would consist of completing the Before Landing Checklist, communications with ATC, and looking for traffic.

At a point about 2 miles west of the localizer centerline, approach control normally would issue a left turn to a northerly heading to intercept the localizer. A frequency change from approach control to tower occurs either at the outer marker during instrument conditions or on base leg if on a visual approach.

The Before Landing Checklist is initiated at the final approach fix and must be completed before a 2-mile final. The Before Landing Checklist consists of: 1. Ignition, 2. Flaps, 3. Landing Gear, 4. Prop Sync and Speed Levers, and 5. Landing Clearance (Traffic Checked).

1.1.7.2 Radar Controller Training

As part of the investigation of this accident, the Safety Board examined the FAA's training programs for terminal radar controllers. Investigators visited the FAA ATC Academy in Oklahoma City, Oklahoma, April 6 through 9, 1987, and the SLC TRACON on April 10, 1987, to review the training curricula and to interview management and training personnel.

At the time of the midair collision in Kearns, Utah, the National Air Traffic Screen, Placement, and Training Program (NATSPT) was being used to screen candidates in the entrance phase of controller training. On the average, approximately 60 percent of the students successfully complete this first screen. The Radar Training Facility (RTF) courses (en route and terminal) were also operating as screening devices, however, between 89 and 99 percent of the students successfully completed these screens.

Managers and staff from the RTF and from the Human Resources Research Branch (of the Civil Aeromedical Institute) expressed the opinion that there was no longer a need to use the RTF courses to screen controllers since the NATSPT had proved to be an effective tool in selecting the students with the best aptitude for becoming controllers. Furthermore, as long as the RTF courses were designated as screens, the course material could not easily be modified to reflect air traffic environmental changes.

Safety Board investigators observed that in the terminal laboratory simulation problems (29 problems given over 12 days) none of the problems included actual depictions of primary or secondary targets, and none included VFR targets without mode-C-altitude encoding which penetrated terminal airspace (ARSA or TCAs). All VFR targets were mode C and did not penetrate the ARSAs or TCAs until given approval by the trainee.

The chief of the Radar Training Section advised the Safety Board that the RTF personnel were not aware of the circumstances of recent midair collisions. He stated that he had not received any direction to change existing programs as a result of the recent accidents. He also informed the Safety Board that a training proposal for the terminal course had been forwarded to FAA headquarters on August 12, 1986, which discussed modifying the program to eliminate the screening process of the RTF portion of training.

On October 5, 1987, the FAA decided to change the status of the RTF courses from a screening format to a training format. This change was effective February 16, 1988, for the terminal course, and February 26, 1988, for the en route course. As soon as the hardware and software improvements are available, the courses will be modified to include minimum safe altitude warning conflict alert, and mode-C intruders in the laboratory problems. The equipment modernization phase is already in the procurement phase. The software improvements are expected to be completed by June 1990. Until these modifications are completed, ARSA/TCA intruders will not be included in the RTF simulation problems.

The radar training course used at the SLC TRACON was derived from the FAA Terminal Instructional Program Guide which provides guidance for establishing facility training programs. The SLC TRACON uses an electronic target generator (ETG) to provide realistic training for radar controllers. At the time of the Kearns, Utah, accident, the ETG had 39 scenarios in varying degrees of complexity, however, VFR mode-C intruders were not incorporated into any ETG scenarios. The SLC TRACON management stated that the need to provide such training "had not been identified

before the accident.” Subsequent to the Safety Board’s visit on April 10, 1987, ARSA intruders were included in ETG scenarios.

Facility records revealed that the Final controller had received briefings on the implementation of the ARSA and procedures for ARSA's during February, March, April, July, August, and October 1986. A special briefing was provided during May 1986, before the ARSA becoming effective. During April 1986, the Final controller had received a briefing on safety alerts that had been mandated by the Northwest Mountain Region of the FAA.

A review of the Final controller’s records and interviews revealed that he entered on duty August 23, 1981, and successfully completed Indoctrination, Fundamentals of Air Traffic Control, Control Tower Operation, and the Nonradar Air Traffic Control course. He was enrolled in the Radar Air Traffic Control course when it was undergoing validation processes in 1981. Consequently, the course was 240 hours long rather than the 136-hour course currently offered. He was given a passing mark on the course, and he received a 92 on the Radar Test examination.

The Final controller completed Terminal Qualification at SLC International Airport, between February 1, 1982, and August 16, 1983; he received passing grades in all phases. He received an exceptional rating in his most recent performance appraisal.

2. ANALYSIS

2.1 General

The METRO II was equipped, maintained, and operated in accordance with applicable regulations. It was not possible to verify the maintenance history of the Mooney because the records could not be found. Nevertheless, there was no evidence that an airworthiness problem with either airplane had a bearing on the accident.

The strobe light on the lower fuselage of the Mooney was probably inoperative at the time of the accident because of a defective transistor. However, the forward face of the light was painted black to prevent pilot disorientation while in flight, and therefore, even if it had been operational, it most likely would not have been visible to the pilots of the METRO II. It could not be determined whether the METRO II strobe lights were on and functioning at the time of the accident; however, SkyWest procedures and the integrity of the components available for examination suggest that its strobe lights probably were on. Similarly, the preimpact operation of the METRO II's landing lights could not be conclusively established, although the SkyWest procedures dictate that they be turned on during the Approach portion of the checklist. However, the landing light mechanisms were found with evidence that they were in the retracted position at impact.

The pilots of each airplane were qualified for the flights, and there were no known physiological conditions that would have impeded the pilots' ability to avoid the accident.

It could not be determined which pilot was manipulating the controls of the Mooney at the time of the accident; however, because this was most likely an instructional flight, it is reasonable to conclude that the private pilot occupying the left seat was probably flying and the instructor was providing training.

According to the personnel acquainted with the pilots of the METRO II, the voice recorded on the the SLC approach control frequency was that of the captain. Consequently, based on the company policy that the nonflying pilot handle radio calls, it was concluded that the first officer was flying.

The accident occurred in visual meteorological conditions, so weather was not considered a factor. The location of the sun should not have been a factor for the pilots of either airplane because there was a high, overcast sky. However, the hazy sky and the snow-covered terrain probably adversely affected the pilots' ability to see other aircraft. In fact, the METRO II pilots' inability to sight the B-737 approaching SLC International Airport, despite several advisories by the Final controller, indicates the difficulties encountered in acquiring targets. The B-737 was much larger than the Mooney, but it also was silhouetted against the snow-covered terrain.

The Safety Board examined the possibility that the "nonstandard" design of the ARSA or lack of pilot awareness by pilots of its design and use were factors in the accident. It was determined that the implementation of the ARSA included considerable and adequate dissemination of information to pilots by the FAA and the Utah Pilots Association. The design of the ARSA, although nonstandard because of unique terrain features, was not considered a factor in the accident. Moreover, the Mooney pilots had flown often in the local area since the ARSA was established and should have been aware of the ARSA's boundaries.

The Safety Board examined the radar data and wreckage to determine the collision impact angles and to assess the pilots' ability to "see and avoid" the collision. The Safety Board also examined the actions of the pilots of both airplanes and the actions of the ATC controllers involved in the handling of the METRO II to determine if their actions contributed to the cause of the

accident. Lastly, the Safety Board examined the overall ATC system factors, including radar controller training, which may have led or contributed to the cause of the accident.

2.2 Collision Geometry

The physical evidence from both airplanes provided a relatively complete collision reconstruction. Two separate methods were used to derive the relative headings and speeds of the airplanes at impact. One method was based on the propeller slashes from the METRO II's left propeller on the Mooney's right wingtip, and the second method involved a vector analysis based on the relative direction of scratches on each airplane as a result of the collision. The results of these two separate analyses agree within 7°.

Since the radar data show that both airplanes were in left turns for a time before the collision, preimpact convergence angles and a closure vector were not established in this analysis for possible collision avoidance purposes, because such calculations presume a constant heading and unaccelerated flight. Additionally, precollision flightpath and convergence-angle estimates based on the collision evidence were not possible because it could not be determined whether the Mooney was climbing or level before the collision. Also, eyewitness statements and the expletive transmitted by the METRO II's captain indicated an evasive maneuver was initiated by the METRO II just before the collision. The evasive maneuver further negated preimpact flightpath estimates based on the final collision geometry.

However, the horizontal and vertical collision angles at the moment of impact, as well as the closure vector and closure rate relative to each airplane at the moment of impact, were calculated. Using these calculations and certain known facts, such as witness statements and airplane performance histories and capabilities, helped to develop a likely collision scenario.

In general, the analysis showed that the airplanes collided at an angle of 117°, at a relative bank angle of 46°, and at a relative vertical angle of 36°. The calculated collision angle of 117° agrees within 7° with the relative headings of both airplanes. This difference is probably the result of the effects of winds at altitude or tolerances in measurements of scratch and propeller slash marks. Moreover, the closure rate between the two airplanes was calculated to have been 272 knots, or 461 feet per second, at the time of impact.

A precollision situation that could account for the evidence of an evasive maneuver by the METRO II and that would also take into account the physical evidence and expected performance of the two airplanes would place the Mooney in a constant altitude left bank of about 15° and the METRO II in a left bank of about 30° with a 24°-nose up pitch attitude at the time of impact.

2.3 See and Avoid

Both airplanes were required by Federal Aviation Regulations to “see-and-avoid” each other even though although SkyWest 1834 was being provided radar service and traffic advisories by ATC. These services do not relieve a flightcrew of the responsibility to maintain visual separation from other aircraft in visual conditions.

According to the visibility study conducted by the Safety Board, the Mooney would have been visible to both METRO II pilots in their binocular vision field had the Mooney been climbing. If the Mooney had been level, it would have been visible in the binocular vision field almost entirely until the last few seconds when it would have moved into their monocular vision field. The study also showed that there was sufficient but limited time for the METRO II pilots to have seen the Mooney in time to take evasive action. However, in spite of the “physical” capability of the METRO II pilots to have seen the Mooney in sufficient time to have evaded it before the collision, the circumstances

before the collision limited their ability to do so. That is, the flightcrew of the METRO II was busy with cockpit duties, including the approach checklist, in preparation for landing, and they were actively looking for a Boeing 737, which had been called to their attention by the air traffic controller. The Boeing 737 was in the 10 to 11 o'clock position, while the Mooney would have been to their right, away from the area they were scanning. Consequently, the attention of the METRO II crew was diverted away from the Mooney and they were less likely to see it.

In addition, the poor contrast of other airplanes in the overcast and hazy sky conditions and the snow-covered ground made target acquisition difficult. Nevertheless, the METRO II flightcrew apparently did sight the Mooney just before the collision; however, they did not do so in sufficient time to assess the threat and take evasive action. Therefore, the Safety Board concludes that the failure of the METRO II pilots to see the Mooney in sufficient time to avoid the collision was understandable, especially since they were not advised of the threat and would not necessarily be expecting such traffic. They were concentrating their scan toward the area of the Boeing 737 because they needed to see it and advise the air traffic controller so they could continue their approach. Although the failure of the METRO II pilots to see the Mooney in time to avoid the collision was an element in the accident circumstances, the Safety Board believes that the pilots of the METRO II may not have had as great an opportunity to see the Mooney as the Mooney pilots would have had to see the METRO II.

Likewise, according to the visibility study, the ability of the Mooney pilots to have seen the METRO II and to have taken evasive action before the collision was similarly limited, but should have been better than that of the METRO II pilots. The same environmental conditions cited above adversely affected their ability to acquire targets; however, there were no apparent factors that should have distracted them from an adequate traffic scan, other than the possibility of the private pilot wearing a vision restricting device. While it was not determined whether the private pilot was wearing a vision restricting device, it would not have been unusual for him to have been using one since this probably was an instrument training flight. If he was wearing such a device, he would not have been able to see conflicting traffic. This would have placed all responsibility for collision avoidance on the instructor to scan for traffic in his role as safety pilot.

The visibility study showed that there was sufficient time for the Mooney pilots to have sighted the METRO II; however, the Mooney's cockpit structures may have obscured partially or completely the target of the METRO II. The instructor had a better chance of sighting the METRO II, assuming the Mooney was in a climb, before it disappeared below the windscreen. When the Mooney was in level flight, the instructor had several seconds to sight the METRO II, but during some of this time, the target would have been in his monocular field of vision, and therefore, more difficult to acquire.

Although both airplanes were operating in a "see and avoid" environment, the Mooney pilots were not receiving ATC services, even though their airplane was within the ARSA. This should have heightened the vigilance of the pilots, especially the instructor pilot who was performing duties of a safety pilot. The Mooney pilots certainly should have been aware of the potential for other aircraft flying in the vicinity of the arrival pattern at SLC International Airport.

In summary, the Safety Board concludes that the ability of the pilots of either airplane to have seen the other airplane in sufficient time to avoid the collision was marginal. However, the Mooney pilots, primarily the instructor pilot had a better capability to see the METRO II and avoid the collision. Therefore, in spite of the limitations of the see and avoid concept, the Safety Board concludes that the failure of the instructor pilot to see and avoid the other airplane was a factor in the accident.

The Safety Board has cited the limitations of the see and avoid concept as causal and contributing in other midair collision accidents. ^{6/} The Safety Board believes that the reliance on pilots to see and avoid other aircraft in an ATC controlled environment, especially with high density traffic and high closure speeds, is unacceptable, and it has urged the FAA to institute more positive and viable measures for traffic separation.

Of course, the Safety Board recognizes that the intent of the ARSA at SLC was to provide protection and traffic separation for participating airplanes operating within its confines. Therefore, the Safety Board evaluated the reasons for the intrusion into the ARSA by the Mooney without the required radio communications.

2.4 ARSA Intrusion

The evidence was inconclusive as to why the Mooney intruded into the ARSA. Pilot incapacitation was not considered a factor nor was the experience level of the pilots considered a factor since they were sufficiently experienced and knowledgeable about ARSA procedures to have avoided the ARSA. Further, the design of the ARSA, although nonstandard, was not considered a factor, because the pilots were familiar with its location and the definitive boundaries near SLC 2. Consequently, the Safety Board tried to determine whether the intrusion was intentional or inadvertent.

Based on the background and experience of the Mooney pilots, the Safety Board concludes that the intrusion into the ARSA was not intentional. There is no reasonable rationale that could explain why the pilots would knowingly enter the ARSA without following the prescribed radio procedures. They both knew how to operate legally within the ARSA and how to operate outside of it if necessary. Consequently, the Safety Board concludes that the intrusion into the ARSA was probably inadvertent and was one of the elements in the cause of the accident.

When the timing of the passage of the boundary of the ARSA and the time of the accident are considered (about 1 minute), it is reasonable to assume that a short period elapsed during the flight to the northwest, during which the Mooney pilots were distracted and neither pilot realized that they had entered the ARSA. One or both pilots may have recognized their error in the last few seconds and may have initiated a left turn to exit the ARSA. However, the left turn observed on the radar track also could have been part of a planned practice instrument maneuver.

One explanation for their distraction involves the possibility that the pilots of the Mooney were flying a practice instrument procedure using the KSL commercial radio station or some other navigational aid. It is understandable that for this flight, the instructor pilot may have been demonstrating or may have had the other pilot practice tracking of a navigational aid because the private pilot was preparing for his instrument rating.

The ground track of the Mooney indicates a nearly direct track from the southeast to SLC 2. When the airplane reached the airport, it paralleled the runway, and about 1 mile north of the

^{6/} Aircraft Accident Report--"Midair Collision of U.S. Army U-21 A, Army 18061, and Sachs Electric Company Piper PA-31-350, N60SE, Independence, Missouri, January 20, 1987"(NTSB/AAR-88/01); "Midair Collision of Wings West Airlines Beech C-99 (N63990) and Aesthetec, Inc., Rockwell Commander 112TCB N1125M Near San Luis Obispo, California, August 24, 1985" (NTSB/AAR-85/07); "Midair Collision Between Nabisco Brands, Inc., DA50 N784b, and Air Pegasus, Corporation, PA28, N1977H, Teterboro, New Jersey" (NTSB/AAR-87/05).

airport, it made a slight left turn directly toward the KSL radio station. The relatively straight line tracks of the airplane suggests that a tracking exercise was in progress. If they were flying an instrument training exercise, it is possible that the pilots failed to recognize that they had overflowed SLC 2 and that they had entered the ARSA.

However, the configuration of the navigational equipment in the Mooney could neither support nor confirm a conclusion that it was setup for such a procedure. Further, the lack of evidence precludes the Safety Board from concluding that an instrument training exercise was being flown, and therefore, caused the illegal entry into the ARSA. However, regardless of what caused the entry into the ARSA, the instructor pilot certainly should have been vigilant over the navigational status of the airplane, including its ground track and altitude. Because the Mooney pilots were not in radio contact with ATC and were operating under VFR, the instructor had the responsibility to ensure proper navigation by means of pilotage (reference to terrain features) or by reference to navigational aids. The fact that the airplane intruded into the ARSA confirms that he failed to do so.

In conclusion, the Safety Board determined that the intrusion into the ARSA was inadvertent. The intrusion was causal to the accident because neither of the METRO II pilots nor the Final controller were expecting an aircraft operating at 7,000 feet within the ARSA without radio contact. The pilots in the Mooney had the responsibility to remain clear of the ARSA. Consequently, their failure to do so was causal to the accident.

2.5 ATC Procedures and Controller Actions

The actions of the Bear Sector controller were not considered causal, because the potential conflict was not evident when he transferred flight 1834 to the Final controller. The Local controller also did not play any part in the cause of the accident because a transfer of communications with the flight to his area of responsibility had not been accomplished.

Because the targets of both accident airplanes were found to have been displayed on the Final controller's radarscope, the Safety Board evaluated the procedures at the SLC TRACON and the actions of the Final controller to determine why no traffic advisories regarding the Mooney's target were issued to the METRO II flightcrew.

The Final controller had first priority responsibility for separation of flight 1834 from other instrument flight rules (IFR) traffic and to provide additional services, including traffic advisories for other traffic. He was fulfilling part of that responsibility during the sequence of events leading up to the accident by continually giving radar vectors to flight 1834 to separate it from two Boeing-737's approaching SLC International Airport. However, both of those airplanes were ARSA participants and were displaying full data block (FDB) radar returns with altitude information. The Mooney was not mode-C equipped and was not an "associated" tracked target, so it was not displaying a limited data block (LDB) or an FDB. That is, all beacon targets are "tracked" within the ARTS IIIA system; however, only those targets which are designated as "associated" are displayed as tracked targets.

Tracking data, such as data blocks, are suppressed for nonassociated tracks, such as for the Mooney, and these radar targets appear to the radar controller as "untracked" target reports, along with primary and secondary targets.

The Final controller stated that pilots were having difficulty seeing other aircraft but they were not having difficulty seeing the airport. He said that controllers at SLC are accustomed to observing non-mode-C targets operating in and near the traffic pattern at SLC 2, presumably below the ARSA. The SLC TRACON controllers have an understandable expectation that such targets are not within the ARSA airspace if they are not in radio contact. They stated that they routinely observe VFR targets appear on the radar as aircraft depart SLC 2 in a climb, and they observe these targets

routinely disappear during descent to landing. In this case, the Mooney target was very near the position of the “normal” SLC 2 traffic pattern. At the same time, the Final controller was busy resolving potential conflicts with the aircraft landing at SLC International Airport. Compounding the situation was the fact that the radar symbol (triangle) depicting the Mooney was obscured by a data tag for part of the time available for the controller to notice the symbol and to provide traffic advisories.

The Safety Board believes that the overlapping of the Mooney’s target by the data block from the Boeing 737 may have contributed to the Final controller’s failure to note the Mooney’s target and his subsequent failure to provide a traffic advisory to the METRO II. When the Mooney’s target became unobscured (about 48 seconds before the collision), it was nearly directly over SLC 2. At that time, a non-mode-C target in the vicinity of SLC 2 would not have been of concern to the Final controller. Moreover, the absence of the Mooney’s target before that time could have been perceived as an aircraft that had descended for a landing at SLC 2--a routine occurrence.

In fact, the Final controller stated that he recalled seeing a non-mode-C target 3 to 4 miles south of SLC 2 moving toward SLC 2 while he was handling the METRO II, but he had no more than normal cause to monitor it. He said he did not see any VFR targets in the vicinity of the METRO II before the collision, and he had no reason to believe that the target he had noted earlier was the airplane later involved in the accident. However, during the several seconds after the Mooney’s target passed to the north of SLC 2, the Final controller was busy providing traffic advisories to the METRO II as part of his duties. Since the Mooney was not in radio contact with him, if he did notice the Mooney target in the seconds before the collision, he may have subconsciously dismissed it as being in the traffic pattern at SLC 2 and below the ARSA as it was supposed to be. The fact that the Mooney’s target was obscured during the same time that normal traffic at SLC 2 disappears from the radarscope may have reinforced this situation.

In conclusion, the Safety Board believes that the Final controller’s failure to detect the traffic conflict and to provide conflict advisories was an element in the events that led to the accident, but the controller’s performance is not considered causal to the accident because of the circumstances of the conflict.

The Safety Board also examined the Final controller’s training specifically and terminal radar controller training in general to determine whether training was a factor in the accident. Regarding the Final controller, it was concluded that his training and experience were more than sufficient to prepare him to perform his tasks properly. He had been a full performance level controller since 1983 and had worked with the SLC ARSA since its implementation in May 1986. Therefore, although he probably had not received formal training with regard to ARSA intruders in the past during his initial (RTF) training at the Academy and during ETG training at the facility, his on-the-job experience was sufficient to have made him aware of the potential for such intruders. Consequently, the lack of formal training for ARSA intruders is not considered a factor in this accident, although it is a deficiency in the radar controller training program that should be corrected.

Despite the fact that the Academy RTF was considered a screen versus true training, the Safety Board is concerned that radar training in the RTF scenarios did not include ARSA (or TCA) intruders. Similarly, the lack of “real world” training in the facility ETG training also concerns the Safety Board. The Safety Board believes that initial radar controller training, including screening programs, should include scenarios involving aircraft that violate “expected” controlled airspace standards so that controllers will be prepared for such contingencies.

The implementation of automated redundancies to assist controllers in their duties is several years from total implementation. In the meantime, the Safety Board believes that initial radar training, on-the-job training, and recurrent training should include “real world” scenarios to

properly prepare controllers. The Safety Board believes that the FAA's failure to require "real world" training for radar controllers regarding ARSA (and TCA) intruders indicates a deficiency in the ATC system that should have been identified and corrected before this accident. The fact that the SLC 2 traffic pattern was so close to the final approach path to SLC and the possibility that pilots would violate the ARSA should have been identified, and procedures and training should have been provided to cope with this problem. This system deficiency suggests a lack of a proactive quality assurance program within the FAA air traffic service.

The apparent widespread number of TCA and ARSA intruders identified in the recent past and the number of near-midair collision reports should have prompted a systematic analysis by the FAA to develop accident prevention measures. For example, NASA ASRS reports for SLC during the months before the accident revealed several occurrences of pilots reporting VFR intruders in the SLC ARSA during vectors to land at SLC. In some of those instances, the location and circumstances were virtually identical to the location and circumstances of this accident.

The Safety Board believes that a thorough review of this matter by the FAA before the accident should have identified the potential for air traffic controllers to overlook untracked non-mode-C aircraft in the area north of SLC 2. If the FAA had conducted such a review, the need for special training or procedures would have been apparent. In fact, a specific requirement that operations out of SLC 2 be mode-C equipped could have been derived. Consequently, the Safety Board concludes that the lack of an aggressive quality assurance effort by the FAA was an element that indirectly set the stage for this accident to occur.

The present ATC system is not adequate to assure collision protection between aircraft participating in the system (generally flights operating in accordance with IFR) and nonparticipating aircraft (operating under VFR) in busy terminal areas. The ATC system must be enhanced to provide air traffic controllers with an automated (computerized) warning system to assist them in avoiding midair collisions. The system should alert controllers to an impending traffic conflict in sufficient time so that they could take appropriate action to eliminate the collision threat.

The Safety Board believes that controllers have and will continue to overlook conflicts between IFR and VFR aircraft because of distraction, workload, and prioritizing of their duties. As long as the avoidance of collision between IFR and VFR aircraft depends on perfect human performance, i.e., vigilance and alertness of controllers and pilots, the potential for midair collisions will continue.

The Safety Board believes that the FAA should expand the capabilities of its ARTS computers to include a conflict alert feature to warn controllers of an impending conflict between IFR aircraft and mode-C transponder-equipped VFR aircraft. The Safety Board understands that the computer software logic has already been developed for this feature but is not presently used because of computer processing limitations. The Safety Board has issued Safety Recommendation A-87-98 to the FAA urging it to procure additional processing capacity for these ARTS IIIA equipped terminal facilities and then add the VFR conflict alert (mode-C intruder) feature to the system. The FAA's most recent response to this recommendation, dated March 11, 1988, stated that it was conducting a 30-day technical and operational review to determine if this conflict alert feature can be added to the terminal ATC facilities.

The Safety Board believes that the facts and circumstances of this accident illustrate the need to provide controllers with an automated warning system to assist them in preventing a midair collision between IFR and VFR aircraft. The final radar controller stated that if he had seen a VFR aircraft in the vicinity of the SkyWest aircraft, he would have alerted it through a traffic advisory or a safety alert. He stated further that he did not perceive any VFR traffic near the METRO II just before the collision. The Safety Board believes that the controller was concentrating on achieving the requisite IFR separation between the METRO II and the Mooney and was not conscious of the impending

conflict between the two airplanes. The Safety Board believes that if the mode-C conflict alert feature had been available to the controller and the Mooney had been equipped with a mode-C altitude encoding transponder, the controller's awareness may have been heightened and this midair collision accident may have been prevented. Therefore, the Safety Board concludes that the absence of this automated warning system was a contributing factor to the accident.

2.6 Corrective Actions

On July 27, 1987, in a letter to the FAA, the Safety Board issued Safety Recommendations A-87-96 through -98 and reiterated Safety Recommendations A-85-64 and -65 regarding improvements needed to reduce the potential for midair collisions in the ATC system. These recommendations were prompted by four midair collisions in which at least one airplane was being operated under IFR by a pilot who was communicating directly with an ATC terminal radar control facility. ^{7/} Section 4. Recommendations, of this report contains the specific recommendations, the FAA's reply, and the Safety Board's evaluation of the FAA's reply to these recommendations.

The facts and circumstances of those four accidents, as well as other investigations of controller operational errors, raised concerns about the limitations of the see and avoid concept of collision avoidance; the effectiveness of ATC terminal radar controllers to detect and prevent conflicts between participating and nonparticipating aircraft near airports served by TCAs and ARSAs; and future needs and developments to prevent midair collisions.

As part of its support for these recommendations, the Safety Board concluded that except in those environments where all aircraft are known to a controller, are under radar control, and are subject to the ATC system conflict alert feature, the prevention of midair collisions depends entirely on human performance. Collision avoidance primarily depends on the pilot's ability to see and avoid other aircraft--a concept with significant limitations. Further, collision avoidance between ATC system participating aircraft under radar control and nonparticipating aircraft is also contingent on the human performance of the controllers. The Safety Board believes that the four midair collisions are evidence that a system that relies on perfect human performance, without automated backup, does not provide a sufficient level of safety.

The Safety Board believes that air carrier airplanes should be protected from collision with each other and with general aviation airplanes and that such protection should be automated and redundant. Consequently, the rapid development and installation of airborne collision avoidance equipment, the requirements for mode-C reporting equipment for all aircraft near airports served by TCAs and ARSAs, and the development and installation of VFR mode-C intruder conflict alert logic in TRACON ARTS computers is necessary to provide automated redundancy in the ATC system.

^{7/} Aircraft Accident Report--"Collision of Aeronaves de Mexico, S.A., McDonnell Douglas DC-9-32, XA-JED, and Piper PA-28-181, N4891F, Cerritos, California, August 31, 1986 (NTSB/AAR-87/07); "Midair Collision of SkyWest Airlines Swearingen METRO II, N163SW, and Mooney M20, N6485U, Kearns, Utah, January 15, 1987" (NTSB/AAR-88/03); "Midair Collision of U.S. Army Beech U-21A, Army 18061, and Sachs Electric Company Piper PA-31-350, N60SE, Independence, Missouri, January 20, 1987" (NTSB/AAR-88/01); and "Midair Collision of Cessna 340A, N8716K, and North American SNJ-4, N711SQ, Orlando, Florida, May 1, 1987" (NTSB/AAR-88/02).

Further, as a result of its report of the Independence, Missouri, midair collision, on January 20, 1987, 8/ the Safety Board issued Recommendations A-88-25 and 26) regarding controller training and collision detection equipment for general aviation aircraft. The FAA has not yet had time to reply to these recommendations. Specifically, the Safety Board is concerned that as a result of their training, and possible operational experience, some radar controllers may be focusing an inordinate amount of attention to targets identified by FDBs to the exclusion of other targets representing VFR aircraft depicted by LDBs, and primary and secondary radar returns.

The Safety Board's examination of the FAA ATC training programs for radar controllers and a review of daily operational practices shows an emphasis on separation of FDB IFR traffic, and when VFR traffic is introduced in the training scenario, it is always represented by an LDB with mode-C altitude information displayed. Because ARTS tracking systems superimpose computer-generated alphanumeric symbology over primary and secondary radar information on the radarscopes, tracking and distinguishing IFR from VFR (nonparticipating) aircraft using the ARTS information is easier than using the primary and secondary targets. The fact that FDBs provide more information than LDBs, and because radar controllers generally control (separate) traffic that is identified by FDBs, there is a possibility that other targets might be overlooked by controllers.

If this type of oversight is occurring in the ATC system as suggested by these accidents, the FAA should identify possible training deficiencies and make appropriate improvements in controller training as recommended in Safety Recommendation A-88-26, until the development and implementation of the automated redundancy systems recommended earlier to backup the human element in the system.

8/ Aircraft Accident Report--"Midair Collision of U.S. Army Beech U-21A, Army 18061, and Sachs Electric Company Piper PA-31-350, N60SE, Independence, Missouri, January 20, 1987" (NTSB/AAR-88/01)

3. CONCLUSIONS

3.1 Findings

1. The collision occurred within the SLC ARSA about 7,000 feet above sea level in visual meteorological conditions.
2. The Mooney was flown into the ARSA without the proper clearance from the SLC TRACON.
3. Both flightcrews were operating in the “see and avoid” environment-
4. The METRO pilot made an evasive maneuver shortly before impact, but it was too late to avoid the collision.
5. Given the absence of mode-C, the Mooney was in a location that could easily have been interpreted by the air traffic controller as an aircraft operating in the traffic pattern at SLC 2.
6. The radar target for the Mooney was obscured for about 38 seconds by the data block from another airplane, but it emerged and was not obscured for 48 seconds before the collision.
7. The final controller did not issue traffic advisories regarding the Mooney to the METRO crew because he did not see the target of the Mooney.
8. The flight instructor in the Mooney did not maintain sufficient vigilance to assure that his airplane remained clear of the ARSA.
9. Radar controller training at the FAA ATC Academy and at the SLC TRACON did not include nonmode -C intruders as part of the RTF or ETG scenarios.
10. The FAA failed to identify potential hazardous conditions at SLC that indirectly set the stage for air traffic controllers to overlook ARSA intruders.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was lack of navigational vigilance by the Mooney instructor pilot which led to the unauthorized intrusion into the Salt Lake City airport radar service area. Contributing to the accident were the absence of a mode-C transponder on the Mooney airplane and the limitations of the air traffic control system to provide collision protection under the circumstances of this accident.

4. RECOMMENDATIONS

In a letter to the FAA dated July 27, 1987, the Safety Board reiterated the following recommendations:

A-85-64

Expedite the development, operational evaluation, and final certification of the Traffic Alert and Collision Avoidance System for installation and use in certificated air carrier aircraft.

A-85-65

Amend 14 CFR Parts 121 and 135 to require the installation and use of Traffic Alert and Collision Avoidance System equipment in certificated air carrier aircraft when it becomes available for operational use.

These recommendations were originally issued following an investigation of a midair collision on August 24, 1984, near San Luis Obispo, California. 9/

On December 15, 1987, the FAA responded to these recommendations citing the Notice of Proposed Rulemaking (NPRM) No. 87-8, docket No. 25355, "Traffic Alert and Collision Avoidance Systems," published in the Federal Register on August 26, 1987. On January 11, 1988, the Safety Board commented on the NPRM and on February 8, 1988, the Safety Board classified these two recommendations "Open--Acceptable Action" pending completion of the rulemaking initiative.

On July 27, 1987, the Safety Board also issued three recommendations to the FAA as a result of an investigation of a midair collision on August 31, 1986, in Cerritos, California. 10/

A-87-96

Implement procedures to track, identify, and take appropriate enforcement action against pilots who intrude into Airport Radar Areas without the required Air Traffic Control communications.

A-87-97

Require transponder equipment with mode-C altitude reporting for operations around all Terminal Control Areas and within an Airport Radar Service Area after a specified date compatible with implementation of Traffic Alert and Collision Avoidance System requirements for air carrier aircraft.

9/ Aircraft Accident Report--"Midair Collision of Wings West Airlines Beech C-99 (N63990) and Aesthetec, Inc., Rockwell Commander 112TC N112SM, Near San Luis Obispo, California, August 24, 1985" (NTSB/AAR-85/07).

10/ Aircraft Accident Report--"Collision of Aeronaves de Mexico, S.A., McDonnell Douglas DC-9-32, XA-JED, and Piper PA-28-181, N4891 F, Cerritos, California, August 31, 1986" (NTSB/AAR-87/07).

A-87-98

Take expedited action to add visual flight rules conflict alert (mode-C intruder) logic Automated Radar Terminal System systems as an interim measure to the ultimate implementation of the Advanced Automation System.

On October 19, 1987, the FAA responded to these recommendations. In response to Safety Recommendation A-87-96, the FAA issued General Notice N7210.301, Controlled Area Intrusions, and incorporated the provisions of this notice in Change 3 to Handbook 7210.3H, Facility Operation and Administration. This handbook change tasks the facility manager to provide guidance in facility directives for the tracking and identification of aircraft that enter airport traffic areas, airport radar service areas, or terminal control areas without authorization.

To address the terminal control area violators, Compliance and Enforcement Bulletin No. 86-2 was issued on March 9, 1987, directing that the suspension of airmen certificates should not be less than 60 days. The bulletin further directs that civil penalty action should be used only where suspension is precluded or in limited instances where a civil penalty (\$1,000) shall be sought.

In response to Safety Recommendation A-87-97, the FAA published a NPRM, Docket No. 25304, Notice No. 87-7, in the Federal Register (FR) on June 16, 1987. This NPRM proposes to revise the regulations concerning mode-C equipment requirements for operating in and around terminal control areas.

Finally, in response to Safety Recommendation A-87-98, the FAA determined that the VFR conflict alert (mode-C intruder) logic cannot be added to the ARTS IIIA until the Advanced Automation System (AAS) is implemented. The ARTS IIIA is operating at maximum timing and capacity and cannot, in its present configuration, accommodate additional enhancement without state-of-the-art equipment to increase both timing and capacity. Therefore, additional enhancements cannot be added until the implementation of the AAS.

More recently, on February 12, 1988, the FAA published Notice 88-2, Docket No. 25531, FR 4306, entitled "Transponder with Automatic Altitude Reporting Capability Requirement and Controlled Airspace Common Floor." This notice proposes to require all aircraft to be equipped with a transponder with automatic altitude reporting (mode-C) when operating in terminal airspace where ATC radar service is provided. This notice also would require that all aircraft, when operating higher than 6,000 feet above the surface in controlled U.S. airspace be similarly equipped.

The Safety Board is currently assessing the impact of these actions on aviation safety. A status will be assigned to each recommendation when that assessment is complete.

On February 25, 1988, the Safety Board issued two recommendations to the FAA following an investigation of a midair collision on January 20, 1987, in Independence, Missouri. 11/

11/ Aircraft Accident Report--Midair Collision of U.S. Army Beech U-21A, Army 18061. and Sachs Electric Company Piper PA-31-350, N60SE, Independence, Missouri, January 20, 1987" (NTSB/AAR-88/01)

A-08-25

Incorporate formal training on the dangers of the low-workload environment at all levels of air traffic controller training.

A-88-26

Establish an ad hoc task force, including controller and human performance expertise, to evaluate the extent to which radar air traffic controllers are dependent on FDB radar symbology to carry out their duties and to make appropriate improvements in initial and recurrent radar training to rectify such deficiencies.

The FAA has not yet had time to respond to these recommendations.

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

Review and revise as necessary the Air Traffic Control Academy and facility terminal radar training programs to include "real world" aspects, such as visual flight rules intruders, into the radar training facility and the electronic target generator scenarios. (Class II, Priority Action) (A-88-46)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ **JIM BURNETT**
Chairman

/s/ **JAMES L. KOLSTAD**
Vice Chairman

/s/ **JOHN K. LAUBER**
Member

/s/ **JOSEPH T. NALL**
Member

March 15, 1988

JIM BURNETT, Chairman, filed the following dissenting statement regarding probable cause and contributing factors.

The National Transportation Safety Board determines that the probable cause of this accident was lack of navigational vigilance by the Mooney instructor pilot which led to the unauthorized intrusion into the Salt Lake City airport radar service area and his failure to maintain see and avoid vigilance. Contributing to the accident were the absence of a mode-C transponder on the Mooney airplane and the limitations of the air traffic control system to provide collision protection under the circumstances of this accident.

JAMES L. KOLSTAD, Vice Chairman, filed the following concurring and dissenting statement regarding probable cause and contributing factors.

I concur that the probable cause of this accident was the lack of navigational vigilance by the Mooney instructor pilot which led to the unauthorized intrusion into the Salt Lake City airport radar

service area and believe the absence of a mode-C transponder on the Mooney contributed to the accident. However, I respectfully dissent from the view that the ATC system was a contributing factor and believe that the probable cause is deficient in not citing each crew's failure to see and avoid the other. All pilots have a duty, in visual meteorological conditions, to "see and avoid." The operations of the SkyWest crew in a controlled environment did not relieve them of that responsibility. Air traffic control cannot be expected to call every VFR target in a crowded visual meteorological conditions terminal environment. To expect air traffic to do so is reasonable in today's air traffic environment, since ARSA and TCA intruders may not always have mode-C. Moreover, the Safety Board determined that both crews had adequate time to see and avoid each other.

Consequently, I believe that the probable cause should be stated as follows:

The National Transportation Safety Board determines that the probable cause of this accident was lack of navigational vigilance by the Mooney instructor pilot which led to the unauthorized intrusion into the Salt Lake City airport radar service area. Contributing to the accident were the absence of a mode-C transponder on the Mooney airplane and the failure of the SkyWest crew to see and avoid the Mooney.

JOHN K. LAUBER, Member, filed the following concurring statement regarding probable cause.

I concur that the lack of navigational vigilance by the Mooney instructor pilot led to the unauthorized intrusion into the Salt Lake City airport radar service area which resulted in the mid-air collision. Because I believe that the absence of mode-C altitude information directly and adversely affected the controller's ability to perceive the Mooney target which should have been visible on his radar screen, I concur in citing this factor as contributory.

With regard to the role of the ATC system, I think it is important to cite its limitations in providing collision protection under the circumstances of this accident. In my view, the primary, overriding function of ATC should be the prevention of collisions between aircraft receiving air traffic services and all other aircraft. In this accident and in several others we have investigated, radar information indicating the presence of an "intruder" aircraft was available to a controller who was in communication with the aircraft receiving ATC services, yet no traffic was "called" because the controller did not perceive the merging targets.

In this situation, the controller, and because of his actions, the SkyWest crew, were occupied with trying to get visual separation on another aircraft approaching the parallel runway at SLC--aircraft which never presented a collision threat to SkyWest--during a significant period of time when the Mooney and the SkyWest aircraft were on a collision course. These actions were in accordance with existing ATC procedures and directives, which in effect give priority to the maintenance of legal separation between "IFR" aircraft (i.e., to the avoidance of an operational error) over "additional services," which include traffic advisories on "nonparticipating" aircraft. Task priorities have a direct effect on controllers' perceptions, and I believe, explain, in part, why this controller (and others in other accidents) did not "see" the merging targets. For these reasons, I think we need to explore ways to change these priorities and to augment controllers' abilities to deal with these changes through technology such as VFR mode-C intruder programs.

"See and avoid" is the cornerstone of collision avoidance in nearly all low-altitude airspace in nearly all weather--without it our aviation system could not function as we know it. However, fundamental limitations of the human visual system dictate some inherent limitations of "see and avoid" in certain circumstances. One such set of circumstances is when an aircraft is in radar airspace, and is receiving radar services which include traffic advisories. Certain expectancies develop under these circumstances--expectancies which directly affect the behavior of the people involved. I find it

not at all surprising that the SkyWest crew did not “see and avoid” the Mooney given that target size and relative motion did not favor detection and recognition of a collision threat until a very short time before the collision took place and given that their attention was directed to searching for the traffic from which they (and the controller) needed “legal” separation. Under such circumstances, I believe citing failure to “see and avoid” as causal or contributory would misdirect our attention from more fundamental system failures, and for these reasons I did not support the inclusion of “see and avoid” in the probable cause. However, this also points up the need to augment pilots’ abilities to “see and avoid” through such technology as TCAS.

JOSEPH, T. NALL, Member, filed the following concurring and dissenting statement regarding probable cause.

I concur in part and dissent in part with my colleagues finding of probable cause for the following reasons:

The primary means of collision avoidance at the location of this accident between aircraft receiving ATC services (participating) and aircraft not receiving ATC services (nonparticipating) is the designation of airspace known as the Salt Lake City airport radar service area (ARSA). The ARSA is designed to segregate participating from nonparticipating aircraft by requiring two-way radio communication with ATC prior to entering the ARSA. The SW-4 was a participating aircraft, the Mooney 20 was not. Had the safety pilot of the Mooney 20 complied with current regulations and ensured that the Mooney 20 remained outside of the ARSA, this collision would not have occurred. Therefore, the intrusion into the ARSA by the Mooney 20 negated the collision protection afforded by the ARSA regulations and must be considered a causal factor in this accident.

Once the Mooney 20 had intruded into the ARSA airspace, FAR 91.67 became the primary means of collision avoidance. The evidence of record indicates that both flightcrews were operating in visual meteorological conditions (VMC). FAR 91.67(a) requires each person operating an aircraft in VMC to maintain vigilance so as to see and avoid other aircraft. FAR 91.67(c) further provides specific reference to converging aircraft and states that the aircraft to the other’s right has the right-of-way.

The evidence of record indicates that the Mooney 20 was approaching the SW-4 from the right and that it would have been primarily within both of the SW-4 pilot’s normal binocular vision viewing area. Further, the evidence indicates that the targets of both airplanes would have subtended at least to a 2°-arc, which has been usually deemed necessary for detection and recognition, in sufficient time for the flightcrews to react. Therefore, I believe both flightcrews had the ability and obligation to see and avoid each other in the VMC that prevailed and their failure to do so must be considered a causal factor in this accident.

I believe the intrusion into the ARSA and the failure of both flightcrews to see and avoid each other are primary in determining the probable cause of this accident.

Additionally, two other elements have been cited as causal by my colleagues: the absence of mode-C equipment on the Mooney and the limitations of the ATC system to provide collision protection under the circumstances of this accident.

The operation of the Mooney 20 airplane through the airspace adjacent to or within the Salt Lake City ARSA did not require, either by regulation or operational necessity, the carriage of mode-C. Given the testimony of the SLC controller that he had not seen the Mooney 20 target, my colleagues conclude that had mode-C been present, the SLC controller may have seen the target and perceived a conflict. Not only is there no evidence to substantiate this, but there is evidence that other controllers saw and referred to the Mooney 20 as traffic for other aircraft. The absence of

mode-C equipment on the Mooney does not represent a deficiency in the operation of that aircraft, and therefore, should not be considered as contributing to this accident.

With regard to the performance of the ATC system, the FAA ATC handbook, Order 7110.65, paragraph 2-21, defines the responsibilities of the air traffic controller with respect to the issuance of traffic advisories. It states: "... issue traffic advisories to all aircraft (IFR or VFR) on your frequency when in your judgment their proximity diminish to less than the applicable separation minima." In the case of aircraft operating within an ARSA, the separation minima between IFR and VFR require either 500 feet vertical separation or establishment of visual separation. It can be argued that the SLC approach controller believed that the Mooney 20 was not within the confines of the ARSA, and therefore, assumed that adequate vertical separation existed from the SW-4. However, the SLC controller stated that he had not seen the Mooney 20 target, and thus there was no need to provide a traffic advisory to the SW-4. Given that the primary function of the ATC system is collision avoidance, it is incumbent on the controller to be aware of potential collisions and to provide traffic advisories and safety alerts when appropriate. It is also clear that the performance of this function is often mitigated by the priorities associated with the application of ATC separation criteria which commands a high task priority. Therefore, I concur with my colleagues that the present limitations of the ATC system, which does not possess significant automated collision avoidance redundancy and places a higher emphasis on maintaining separation standards than detecting an impending collision, contributed to the circumstances of this accident.

5. APPENDIXES

APPENDIX A

INVESTIGATION AND HEARING

1. Investiaation

The Safety Board was notified of the accident about 1515 eastern standard time on January 15, 1987, and immediately dispatched investigators from Washington, D.C. to the accident site. Investigation groups led by Safety Board investigators were organized for operations, air traffic control, METRO II airworthiness, Mooney airworthiness, and survival factors.

Parties to the investigation were the FAA, SkyWest Airlines, Aircraft Owners and Pilots Association, and Fairchild Aircraft.

2. Public Hearing

No public hearing or depositions were held.



APPENDIX B
PERSONNEL INFORMATION

METRO I

Captain Michael D. Gambrill, date of birth May 6, 1948, held airline transport pilot certificate No. 1755445, issued December 22, 1985, with the ratings and limitations of airplane multi-engine land--SA-227, commercial privileges, airplane single-engine land. His first-class medical certificate, issued December 10, 1986, imposed not restrictions.

Captain Gambrill was hired by SkyWest Airlines as a first officer on SA-226/227 airplanes on July 1, 1984. He was upgraded to captain on December 22, 1985. At the time of the accident, he had accrued a total flight time of about 3,885 hours, of which about 1,863 hours were in the SA-226/227 airplanes.

In the 90 days, 30 days, and 24 hours before the accident, Captain Gambrill had flown about 230 hours, 71 hours, and 2 hours 42 minutes, respectively. His duty time was 7 hours before the accident. His rest time during the 24 hours before the accident was about 17 hours. Duty times for the previous 90, 60, and 30 days were 496 hours, 324 hours, and 157 hours, respectively.

On August 21, 1986, Captain Gambrill had completed a Part 135 proficiency check in the SA-226/227 airplane. His last ground school training in the airplane was completed on October 14, 1986.

First Officer Walter F. Ray, date of birth November, 14, 1953, held airline transport pilot certificate No. 2136321, issued July 29, 1982, with the ratings and limitations of airplane multiengine land, commercial privileges, airplane single-engine land. He also held a control tower operator certificate, No. 553848236, issued January 3, 1979. His first-class medical certificate, issued July 31, 1986, imposed the limitation of wearing correcting lenses while exercising the privileges of his airman certificate.

First Officer Ray was hired by SkyWest Airlines as a first officer on SA-226/227 airplanes on August 4, 1986. As of January 5, 1987, he had accrued a total flight hours of about 4,555 hours of which about 1,205 hours were in the SA-226/227 airplanes. In the 90 days, 30 days, and 24 hours before the accident he had flown about 273 hours, 86 hours, and 2 hours and 42 minutes, respectively. His duty time during the 24 hours before the accident was 7 hours. His rest time during the 24 hours before the accident was about 17 hours. Duty times for the previous 90, 60, and 30 days was about 527,346, and 162 hours, respectively.

On August 14, 1986, First Officer Ray had completed a Part 135 proficiency check in the SA-226/227 airplane. His last ground school on the airplane was completed on August 13, 1986.

Mooney

The flight instructor, Paul Lietz, date of birth June 5, 1932, held a commercial pilot certificate, No. 001564661, issued April 6, 1979, for airplane single- and multiengine land, and instrument airplane privileges. He also held a flight instructor certificate, the latest issue of which was on November 19, 1986, with the same aforementioned ratings and privileges. His second-class medical certificate, issued November 13, 1986, contained the limitation that the holder, shall possess correcting lenses for near vision while exercising the privileges of his airman certificate. He also held a statement of demonstrated ability, No. 10107925, for high-frequency hearing loss from his right ear.

The latest pilot logbook provided to the Safety Board by Mr. Lietz's family showed a total of 2,547.8 flight hours and 1331.9 hours as a flight instructor, as of December 26, 1986, the last entry in the logbook.

The student pilot, Chester A. Baker, date of birth July 2, 1947, held private certificate No. 52964681, issued August 29, 1981, with ratings for airplane single-engine land. Mr. Lietz was shown as the flight instructor for the private pilot training. Mr. Baker held a third-class medical certificate, issued August 29, 1985, with no limitations.

A pilot's flightlog identified as Mr. Baker's was located in the airplane wreckage. The log showed that Mr. Baker received initial flight training beginning on May 28, 1980, in a Cessna 150. On August 21, 1981, Mr. Baker received an unsatisfactory rating on this private pilots checkride administered by a designated flight examiner. At that time, he had logged 36.6 hours dual instruction and 21 hours solo flight time. After receiving 2.9 hours of additional dual flight, on August 29, 1981, he satisfactorily completed the private pilot examination.

The flightlog showed about 301 hours total time of which about 59 hours were dual. He had received a biennial flight review given by Mr. Lietz in a PA-28-180 on September 3, 1985.

APPENDIX C
AIR TRAFFIC CONTROL TRANSCRIPT



U.S. Department
of Transportation
Federal Aviation
Administration

Memorandum

Subject: Transcription Concerning the
Accident of SKW834, A Swearingen
Merlin IV Metro on January 15, 1987
Approximately 1952 UTC

Date: 1/16/87

From: Quality Assurance and Training
Specialist, SLC ATCT

**Reply to
Attn. of:**

To:

This transcription covers the time period from January 15, 1987, 1932 UTC, to January 15, 1987, 1957 UTC.

AGENCIES MAKING TRANSMISSIONS	ABBREVIATIONS
Salt Lake TRACON - Bear Position	B
Salt Lake TRACON - Final Position	F
Salt Lake Tower - Local Control	LC
Life Flight N90F	LN90F
Turbo Commander N101RW	N101RW
Horizon Air 555	QXE555
Skywest 834	SKW834
Skywest 806	SKW806
Skywest 873	SKW873
Salt Lake Center Sector 31	ZLCR31
Western 16	WA16

Western 432	WA432
Air Med 10	AM10
Western 96	WA96
Skywest 575	SKW575
Western 612	WA 612
Centurion N02C	N02C
Western 422	WA422

I hereby certify that the following is a true transcription of the recorded conversation pertaining to the subject accident.


David L. Lawton

Attachment

1931:56	LN90F	Salt Lake departure Life Flight nine zero fox with you out of ah eleven five for fourteen
1932:01	B	Life Guard nine zero fox trot departure roger proceed direct Pocatello
1932:03	LN90F	Nine zero fox
1932:41	B	Life Guard King Air nine zero fox trot contact Salt Lake Center one two eight point three
1932:45	LN90F	One twenty eight three good day
1932:47	B	Good day
1932:52	N101RW	Departure one zero one Romeo Whiskey with you ah heading two four zero climbing to eight
1932:57	B	Commander one zero one Romeo Whiskey Salt Lake departure radar contact climb and maintain niner thousand
1933:02	N101RW	Whiskey to nine
1933:22	B	Commander one Romeo Whiskey verify your type commander
1933:26	N101RW	Turbo commander
1933:27	B	Thanks
1934:15	B	Commander one Romeo Whiskey turn left heading one (Five)* zero
1934:16		(unintelligible) you on guard two forty three point oh how do you read
1934:23	N101RW	(Okay, one five oh)* (unintelligible) Hill Tower
1934:56	B	Commander one Romeo Whiskey advise when you have Salt Lake landing information Sierra
1935:01	N101RW	We have Sierra
1935:03	B	All right thanks turn left heading one five five now commander one Romeo Whiskey

1935:17 B Commander one Romeo Whiskey turn left heading one five five

1935:21 N101RW Ah Whiskey one fifty five

1935:54 N101RW Ah Whiskey has Salt Lake in sight

1936:00 B Roger I'll pass that along expect a visual approach clearance abeam the airport

1936:02 B What's your runway preference then nine correction one Romeo Whiskey

1936:05 N101RW Three four right

1936:06 B Okay

1936:37 QXE555 Salt Lake approach Horizon Air triple five Sierra one six thousand

1936:42 B Horizon Air five fifty five Salt Lake approach descend and maintain one zero thousand fly heading one four five vector for visual approach runway three four left

1936:51 QXE555 Ok ah one hundred forty five degrees ah one zero thousand Horizon five fifty five

1936:59 B Roger

1937:06 B Commander one Romeo Whiskey fly heading one four five contact approach one two five point seven

1937:11 N101RW One two five seven ah hundred and forty five so long

1937:14 B Good day

1937:19 B Horizon Air five fifty five keep your speed up in the descent for traffic to follow

1937:23 QXE555 Five fifty five we'll do it

1937:45 SKW834 Salt Lake approach Skywest eight thirty four is with you one six thousand with Sierra

1937:49 B Skywest eight thirty four Salt Lake approach fly heading ah one zero zero

vector for visual approach runway
three four left descend and maintain
one zero thousand

1937:57 SKW834 Ok one hundred on the heading and
down to one zero thousand Skywest
eight thirty four

1939:09 B Skywest eight thirty four turn right
to heading one four zero

1939:12 SKW834 Right to one four zero Skywest eight
thirty four

1940:03 SKW806 Approach Skywest eight oh six one six
thousand we have Sierra

1940:07 B Skywest eight oh six Salt Lake
approach fly heading one three zero
vector for visual approach runway
three four left descend and maintain
one zero thousand

1940:13 SKW806 One thirty on the heading down to one
zero thousand Skywest eight oh six

1941:42 SKW873 Salt Lake approach Skywest eight
seventy three is descending to nine
and we have Sierra one six thousand

1942:07 B Skywest eight seventy three Salt Lake
approach fly heading one zero zero
vector for visual approach runway
three four left descend and maintain
one zero thousand

1942:14 SKW873 Down to one zero thousand and a
heading of one zero zero Skywest
eight seventy three

1942:31 B Horizon five fifty five turn left
heading one four zero

1942:35 QXE555 Ah one four zero Horizon five fifty
five

1942:37 B Skywest eight oh six turn left
heading one two zero

1942:41 SKW806 One two zero Skywest eight oh six

1943:40 B Skywest eight thirty four ah say
flight conditions

1943:45	ZLCR31	Bear thirty one
1943:46	SKW834	(Skywest eight thirty four)* (unintelligible)
1943:46	ZLCR31	Western sixteen and Western four thirty two reduced to two fifty
1943:50	B	Skywest eight thirty four roger
1943:51	B	Horizon five fifty five turn left heading one three zero
1943:55	QXE555	One three zero Horizon five fifty five
1943:59	WA16	Western sixteen out of one eight zero for one seven thousand with Sierra
1944:03	B	Western sixteen Salt Lake approach say speed
1944:07	WA16	Two five zero
1944:08	B	Western sixteen roger fly heading one three zero descend and maintain one four thousand vectors to a visual approach runway three four
1944:17	WA16	Heading one three zero one four thousand Western sixteen
1944:19	B	Skywest eight seventy three say speed
1944:23	SKW873	Skywest eight seventy three two four five
1944:25	B	Skywest eight seventy three roger can you maintain that
1944:28	SKW873	Yes sir that's affirm
1944:31	B	Roger turn right heading one two zero Skywest er correction ah one one zero Skywest eight seventy three
1944:35	SKW873	One one zero on the heading Skywest eight seven three
1944:38	B	Western sixteen if practical reduce speed to two three zero you're following a metroliner
1944:42	WA16	Sixteen reduce

1944:45	B	Horizon triple five descend and maintain niner thousand
1944:47	QXE555	Down to nine Horizon triple five
1944:54	B	Skywest eight oh six descend and maintain one zero thousand
1944:57	SKW806	Down to ten Skywest eight oh six
1945:05	B	Skywest eight seventy three descend and maintain one zero thousand
1945:16	SKW873	Skywest eight seventy two say again
1945:17	B	Skywest eight seventy two verify you've been cleared to one zero thousand on a descent
1945:20	SKW873	Skywest eight seventy two that's affirmative going to one zero thousand
1945:23	B	Skywest eight seventy three roger turn right heading one two zero
1945:26	SKW873	One two zero on the heading Skywest eight seventy three
1945:28	B	Horizon triple five turn right to heading one five zero and contact approach one two ah standby for frequency
1945:35	QXE555	Roger one five zero
1945:40	B	Horizon triple five contact approach on one two five point seven
1945:43	QXE555	Twenty five seven good day
1945:44	B	Good day
1946:34	SKW834	Skywest eight thirty four descend and maintain niner thousand
1946:36	SKW834	Niner thousand Skywest eight thirty four
1946:42	WA432	Approach Western four thirty two nineteen point one for seventeen w i t h Sierra

1946:46	B	Western four thirty two Salt Lake approach fly heading one three zero for vectors to a visual approach runway three four descend and maintain one two thousand
1946:52	WA432	One three zero the vector and has it been as bumpy as they recommend it
1946:56	B	Ah I think we're just getting some light chop in the valley hasn't been any ah serious reports yet
1947:01	WA432	Ok thank you
1947:03	B	Western sixteen descend and maintain one one thousand
1947:06	WA16	Western sixteen to one one thousand
1947:09	B	Skywest eight thirty four turn right to heading one five zero contact approach one two zero point niner
1947:13	SKW834	One fifty on the heading one two zero point nine Skywest eight thirty four
1947:18	B	Skywest eight thirty four make that frequency one two five point seven
1947:21	SKW834	Twenty five seven Skywest eight thirty four
1947:28	SKW834	Approach Skywest eight thirty four is with you descending to niner thousand we have the airport
1947:33	F	Skywest eight thirty four Salt Lake
1948:15	F	Horizon five fifty five turn left heading zero niner zero descend and maintain six thousand
1948:19	QXE555	Zero nine zero down to six Horizon triple five
1948:27	QXE555	And we do have the airport in sight sir
1948:29	F	Horizon five fifty five make it as short as you can cleared for visual approach runway thre four left there's trafficsouth a Boeing

1948:33	QXE555	(Okay I'll make a)* short approach cleared for the visual approach Horizon triple five
1948:36	AM10	Approach Air Med ten
1948:38	F	Air Med ten Salt Lake
1948:40	AM10	Air Med ten off the University southbound to the prison
1948:42	F	Air Med ten roger ident altimeter two niner eight zero
1948:45	AM10	Air Med ten
1948:51	F	Western Ninety six traffic eleven o'clock eight miles eastbound seven thousand descending a dash eight for the left
1948:57	WA96	Negative contact Western ninety six
1948:59	F	Western ninety six roger have the airport
1949:01	WA96	Ah affirmative
1949:02	F	All right thanks
1949:04	F	Horizon five fifty five contact tower one one eight point three
1949:07	QXE555	Eighteen three (bye)*
1949:08	F	Air Med ten radar contact altimeter two niner eight zero
1949:13	SKW575	Salt Lake approach Skywest five seventy five we're with you niner thousand
1949:17	F	Skywest five seventy five Salt Lake roger
1949:19	F	Skywest eight thirty four descend and maintain seven thousand
1949:22	SKW834	Out of nine for seven Skywest eight thirty four
1949:31	SKW806	Approach Skywest eight oh six with you nine thousand
1949:34	F	Skywest eight oh six roger

1949:38	SKW575	Skywest five seventy five nine thousand
1949:40	F	Skywest five seventy five roger
1949:42	F	Western ninety six start slowing to your approach speed your following the dash eight at five miles ahead contact tower one one eight point three
1949:49	WA96	Western ninety six going to the tower
1949:50	F	Western six twelve report the airport in sight
1949:53	WA612	Western six twelve we've got it
1949:54	F	Western six twelve change your runway to runway three four right cleared visual approach
1949:57	WA612	Okay three four right Western six twelve
1950:12	F	Centurion zero two Charlie you can descend now turn your downwind
1950:16	N02C	Zero two charlie
1950:28	F	Skywest eight thirty four traffic ten to nine o'clock four miles six thousand Boeing seven ah thirty seven three hundred
1950:33	SKW834	Skywest eight thirty four has the traffic
1950:35	F	Skywest eight thirty four plan to follow that traffic there's traffic south of him eleven o'clock six miles northbound seven thirty seven out of seven thousand five hundred for the right
1950:42	SKW834	Okay we'll follow the first one Skywest eight thirty four
1950:44	F	Skywest eight thirty four wait a minute report the second one in sight
1950:48	SKW834	Eight thirty four okay we're looking for him

1950:51	F	Centurion zero two charlie can you turn base now
1950:54	N02C	Affirmative
1950:55	F	Zero two charlie turn base for three four right contact tower one one eight point three there's a Boeing south to follow you
1950:59	N02C	Zero two charlie
1951:02	F	Skywest eight thirty four ten o'clock four miles seven thousand four hundred
1951:07	SKW834	Eight thirty four we're looking
1951:09	F	Western six twelve traffic will be a metroliner turning in beside you for three four left contact tower one one eight point three
1951:14	WA612	Western six twelve roger good day
1951:15	F	Skywest eight thirty four turn left heading zero seven zero
1951:19	SKW834	Left zero seven zero Skywest eight thirty four
1951:23	F	Skywest eight oh six descend and maintain seven thousand
1951:28	F	Skywest eight oh six descend and maintain seven thousand
1951:31	SKW806	Seven thousand eight oh six
1951:32	F	Skywest eight thirty four's traffic's ten to eleven o'clock three miles
1951:37	SKW872	Approach Skywest eight seventy two with you nine airport in sight
1951:40	F	Skywest eight seventy three Salt Lake roger
1951:43	F	Skywest eight thirty four turn left heading zero five zero

1951:46	SKW834	Left to zero five zero Skywest eight thirty four still have no contact on that traffic
1951:50	F	Skywest eight thirty four roger turn further left heading three six zero
1951:53	SKW834	Left to three six zero
1951:55	F	Skywest five seventy five maintain eight thousand
1951:58	SKW575	Five seventy five
1951:59	*	(unintelligible) (oh shit)* Level at eight
1952:01	F	Skywest eight thirty four is cleared visual approach runway three four left
1952:09	F	Skywest eight thirty four cleared visual approach runway three four left
1952:18	F	Skywest eight thirty four Salt Lake
1952:24	WA422	Salt Lake Approach Western four twenty two's with you we have Sierra we're on the approach passing eleven thousand
1952:30	F	Western four twenty two roger
1952:32	F	Skywest eight thirty four Salt Lake
1952:36	F	Skywest 575 there should be traffic at eleven o'clock three miles your company was at seven thousand I've lost him on the radar
1952:43	SKW575	We're looking no contact
1952:45	F	Local - Final
1952:46	Tower	Local
1952:49	F	You see Skywest eight thirty four out there south of the marker any place
1952:50	Tower	No no I don't
1952:51	F	What happened to him

1952:52	Tower	I don't know it just went I just saw it go into coast and I just asked what happened to him
1952:54	F	All right we may have a problem down there
1952:57	F	Skywest five seventy five I'm gonna have to leave you at eight thousand now till I found out what happened to your company
1953:01	SKW575	Okay we got a visual on the runway but I can't see the company
1953:04	F	Roger
1953:06	F	Skywest eight oh six maintain eight thousand
1953:08	SKW806	Okay going back up to eight skywest eight oh six
1953:10	F	You see Sky eight I don't know what happen to him
1953:11	B	Final - Bear
1953:12	F	Final
1953:14	B	Where's Western ah can I keep Western sixteen coming
1953:15	F	Hey I'm in trouble down here I lost Skywest eight thirty four I don't know where he is
1953:17	B	LC
1953:19	F	Skywest eight thirty four Salt Lake
1953:25	F	Skywest five seventy five fly runway heading maintain eight thousand
1953:27	SKW575	Skwyest eight seventy five Wilco
1953:29	F	Skywest eight oh six climb and maintain eight thousand
1953:33	SKW806	Eight oh six roger
1953:34	F	Skywest eight seventy three reduce speed to one eight zero

1953:36	SKW873	Skywest eight seventy three comin' back
1953:38	F	Western four twenty two maintain niner thousand on the localizer
1953:43	WA422	Four twenty two maintain nine thousand
1953:46	WA16	Western sixteen ah leveling at nine (unintelligible)
1953:48	LC	Final - Local
1953:49	F	Final
1953:52	LC	I got a call on the crash station right now they're saying possible midair collision at ah possibly at Airport Number Two
1953:56	SKW575	Salt Lake Skywest five seventy five we cancel IFR we get down
1953:59	F	Five seven five seventy five affirmative descend at your discretion VFR contact tower one one eight point three
1954:04	SKW575	We're canceling thanks
1954:06	F	Five seventy five
1954:07	LC	Airport Number Two
1954:07	F	Canceled
1954:09	WA16	Western at nine airport in sight
1954:13	F	Calling approach say again
1954:15	WA16	Western sixteen nine thousand airport in sight
1954:17	F	Western sixteen thank you fly heading one six zero
1954:20	WA16	One six zero
1954:21	F	Skywest eight oh six turn right heading one six five
1954:24	SKW806	One six five Skywest eight oh six

1954:31	F	Skywest five seventy five contact tower one one eight point three
1954:36	F	Local - Final
1954:37	LC	Local
1954:38	F	Skywest five seventy five's VFR
1954:38	LC	I got um (unintelligible)
1954:46	WA422	Approach Western four twenty two ah how far ah how long before we can start down
1954:50	F	Western four twenty two I just had a metroliner seven thousand turn inbound I don't know where he is we had a possible mid air over Airport Number Two with him I can leave ya at nine thousand until I find out what happened to that airplane
1954:58	WA422	Okay
1955:01	F	Skywest eight seventy three turn right heading one six five
1955:05	SKW873	Right one six five Skywest eight seventy three
1955:10	F	Skywest eight oh six turn left heading three six zero oh ah make it zero one zero Skywest eight oh six
1955:16	SKW806	Zero one zero Skywest eight oh six
1955:53	F	Air Med ten radar service terminated squawk one two zero zero frequency change approved
1956:19	F	Western four twenty two turn left heading three one zero maintain niner thousand we're changing runways to one six contact departure one two six point eight
1956:27	WA422	Four twenty two roger
1956:28	F	Skywest eight seventy three turn left heading zero seven zero
1956:30	SKW873	Zero seven zero Skywest eight seventy three

1956:38 B Final - Bear

1956:38 F Final

1956:40 B Western four thirty two is in a right
turn to heading zero nine zero nine
thousand expecting a visual one six

1956:43 F Anybody else from the north Mike

1956:44 B No

1956:45 F I'm ah kinda shook at the moment
(unintelligible)

1956:45 B (all right)*

1956:57 F Skywest eight oh six turn left
heading three four zero

1957:59 SKW806 Three four zero Skywest eight oh six
we have the airport

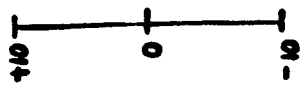
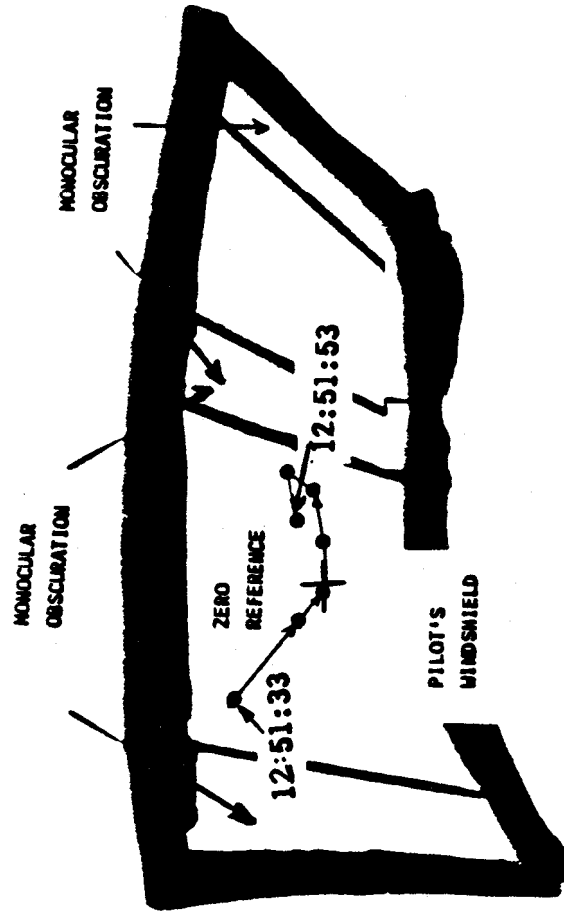
1957:02 F Skywest eight oh six we're changing
to one six sir and ah we'll get ya
back around here in a minute

*This portion of the recording is not
entirely clear, but this represents
the best interpretation possible
under the circumstances.

END OF TRANSCRIPT

APPENDIX D
COCKPIT VISIBILITY PLOTS

FAIRCHILD METRO II , N163SM
PILOT'S EYE REFERENCE
5 INCHES AFT OF REAR MOST CONTROL COLUMN
POSITION (13.5 INCHES AFT INSTRUMENT PANEL)
44 1/8 INCHES ABOVE SEAT TRACK

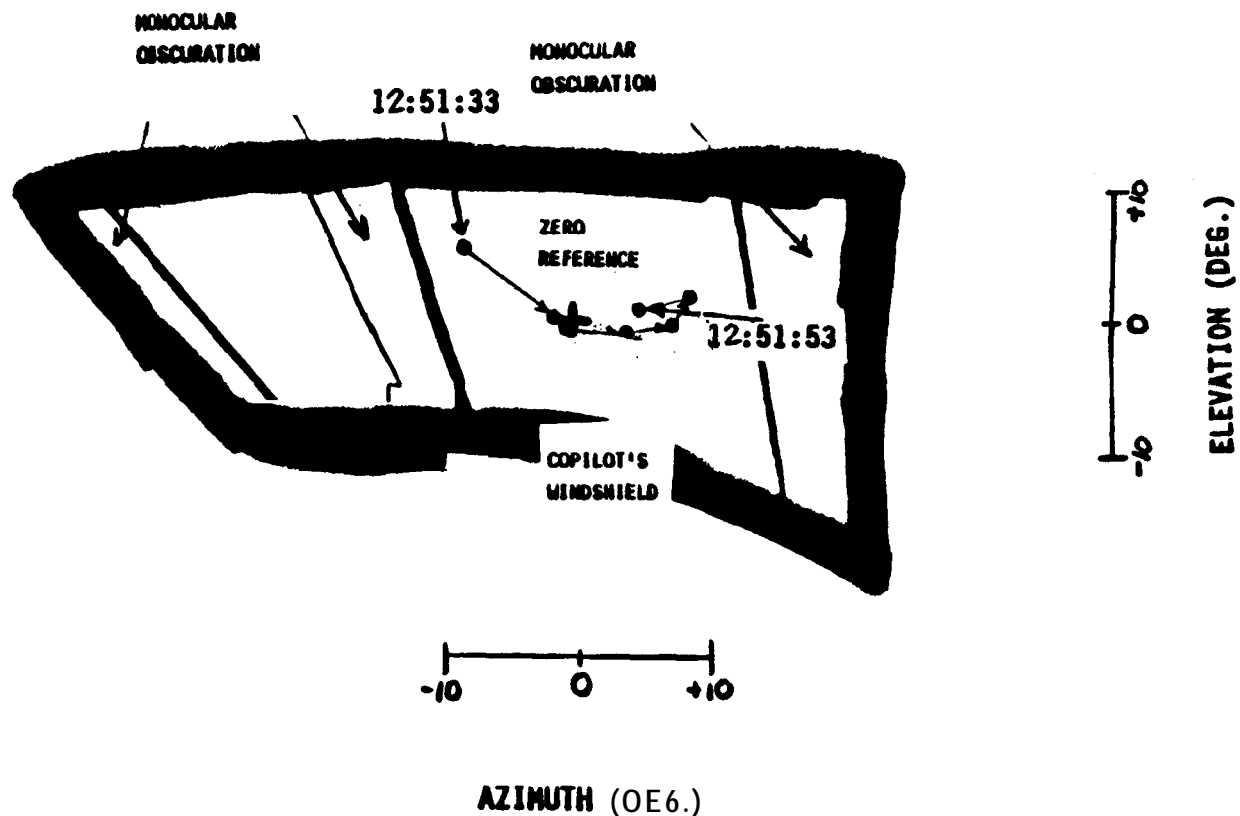


ELEVATION (DEG.)

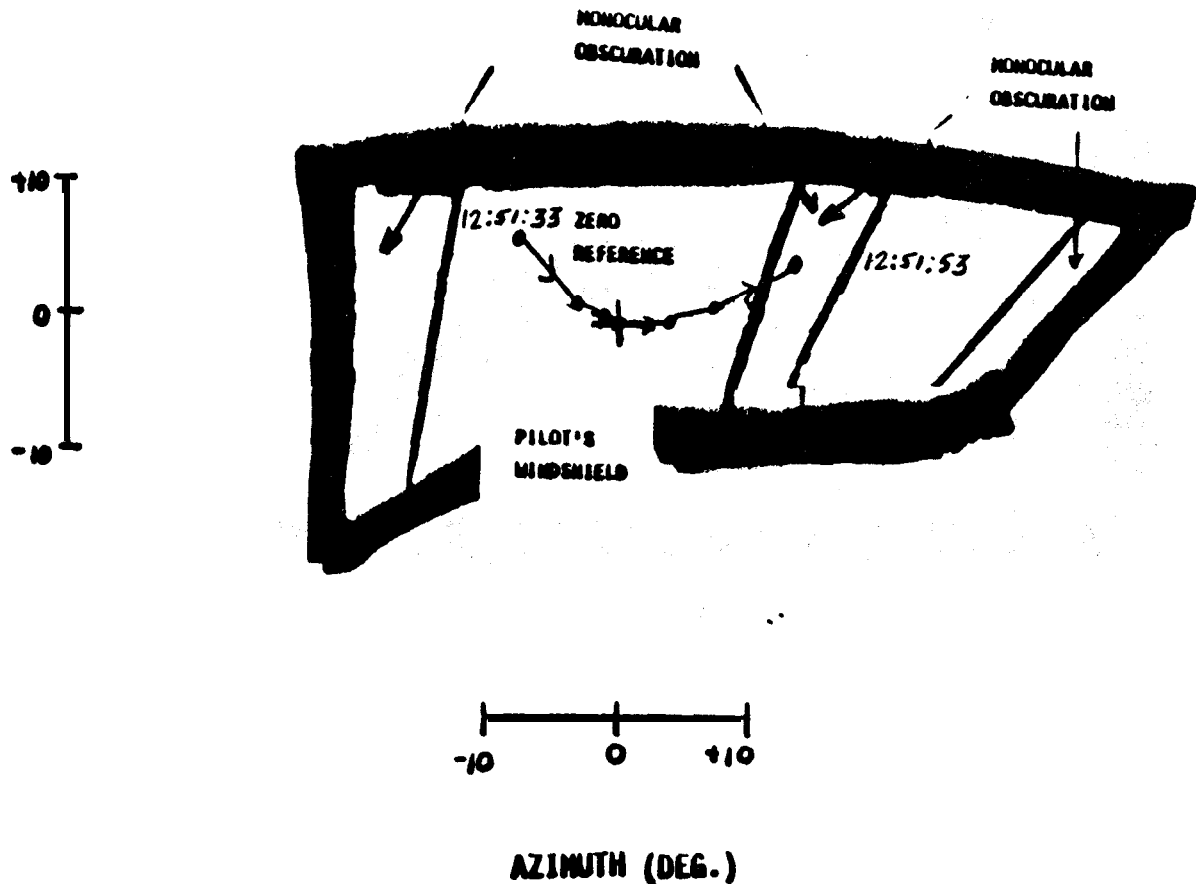


AZIMUTH (DEG.)

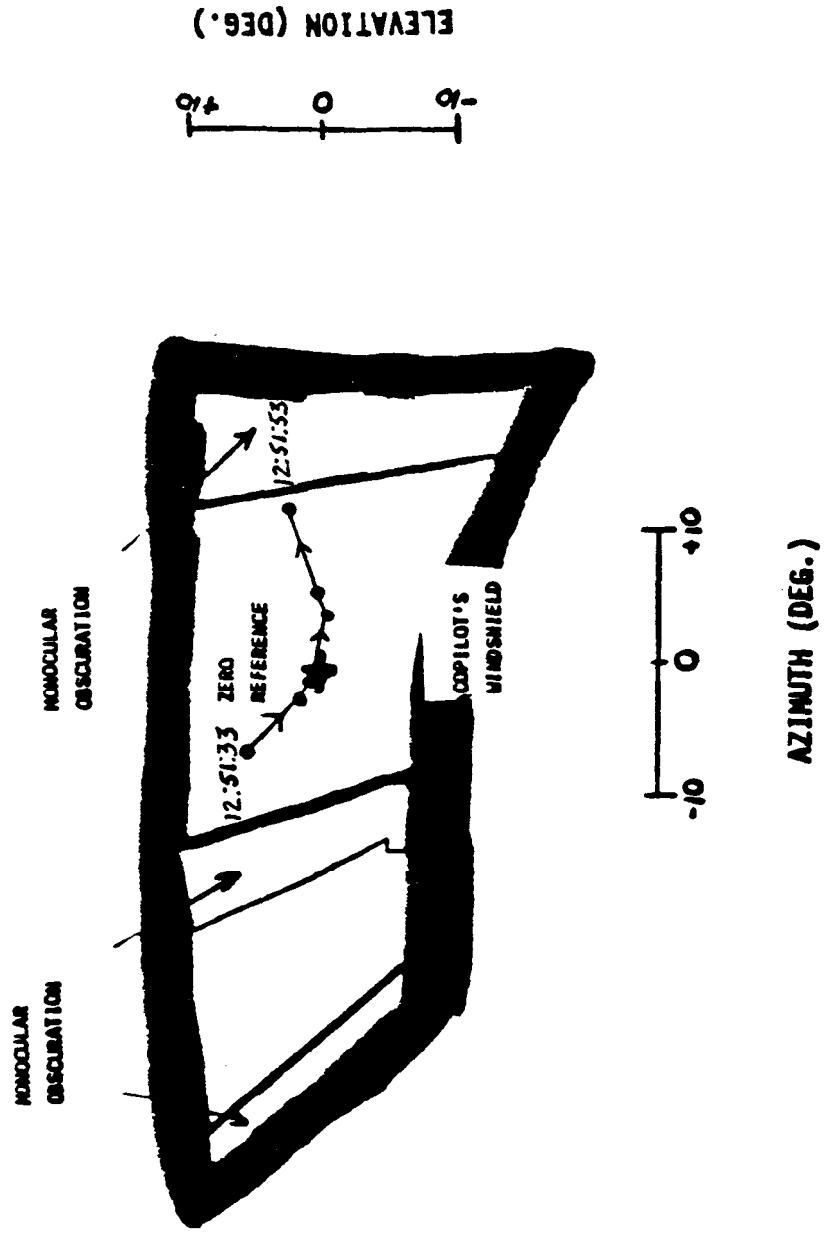
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COPILOT'S EYE REFERENCE
5 INCHES AFT OF REAR MOST CONTROL COLUMN
POSITION (13.5 INCHES AFT INSTRUMENT PANEL)
44 1/8 INCHES ABOVE SEAT TRACK



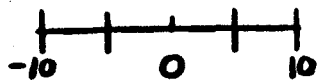
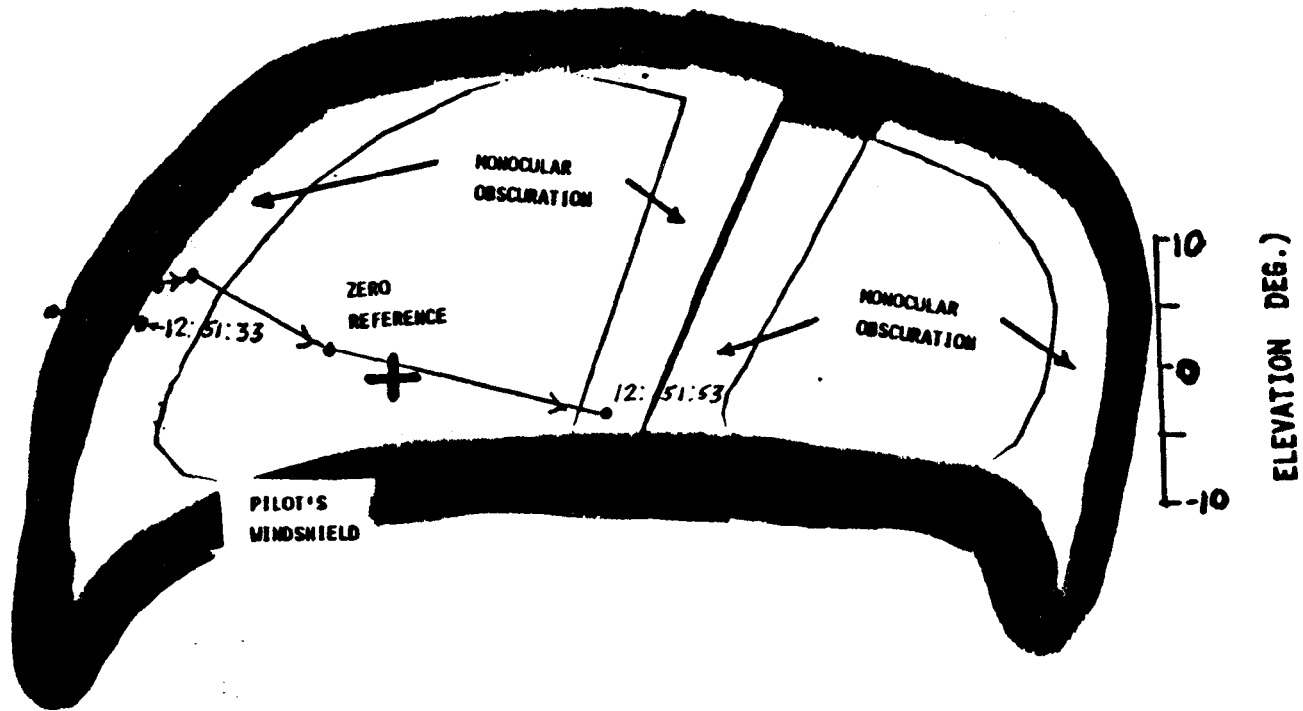
FAIRCHILD METRO II N163SM
PILOT'S EYE REFERENCE
5 INCHES AFT OF REAR MOST CONTROL COLUMN
POSITION (13.5 INCHES AFT INSTRUMENT PANEL)
44 1/8 INCHES ABOVE SEAT TRACK



FAIRCHILD METRO 11 , N163SM
COPILOT'S EYE REFERENCE
5 INCHES AFT OF REAR MOST CONTROL COLUMN
POSITION (13.5 INCHES AFT INSTRUMENT PANEL)
44 1/8 INCHES ABOVE SEAT TRACK

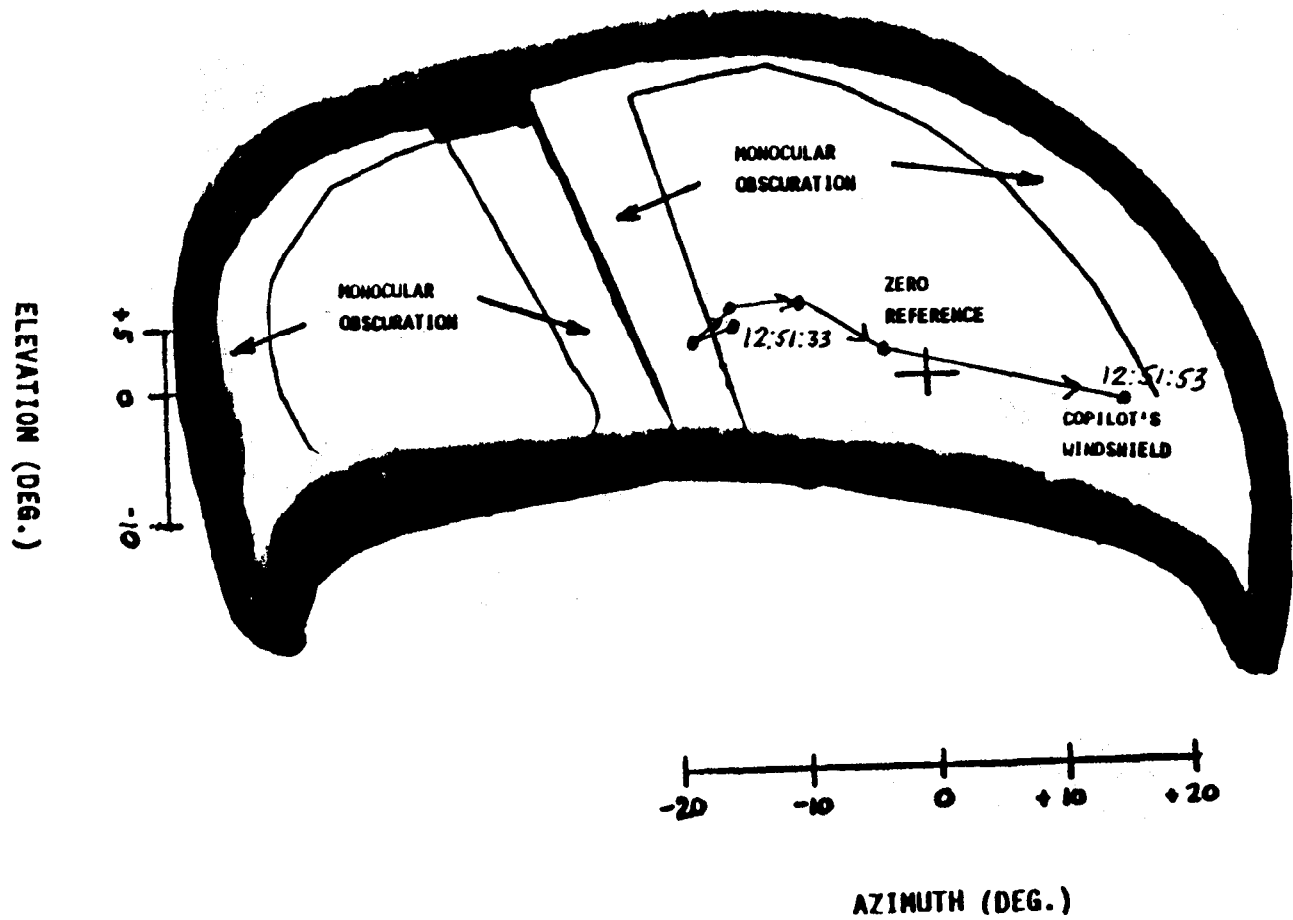


MOONEY 20C, N6485U
PILOT'S EYE REFERENCE IN ACCORDANCE WITH CAM 4B
37 1/2 INCHES ABOVE SEAT RAIL
21 5/8 INCHES AFT OF INSTRUMENT PANEL

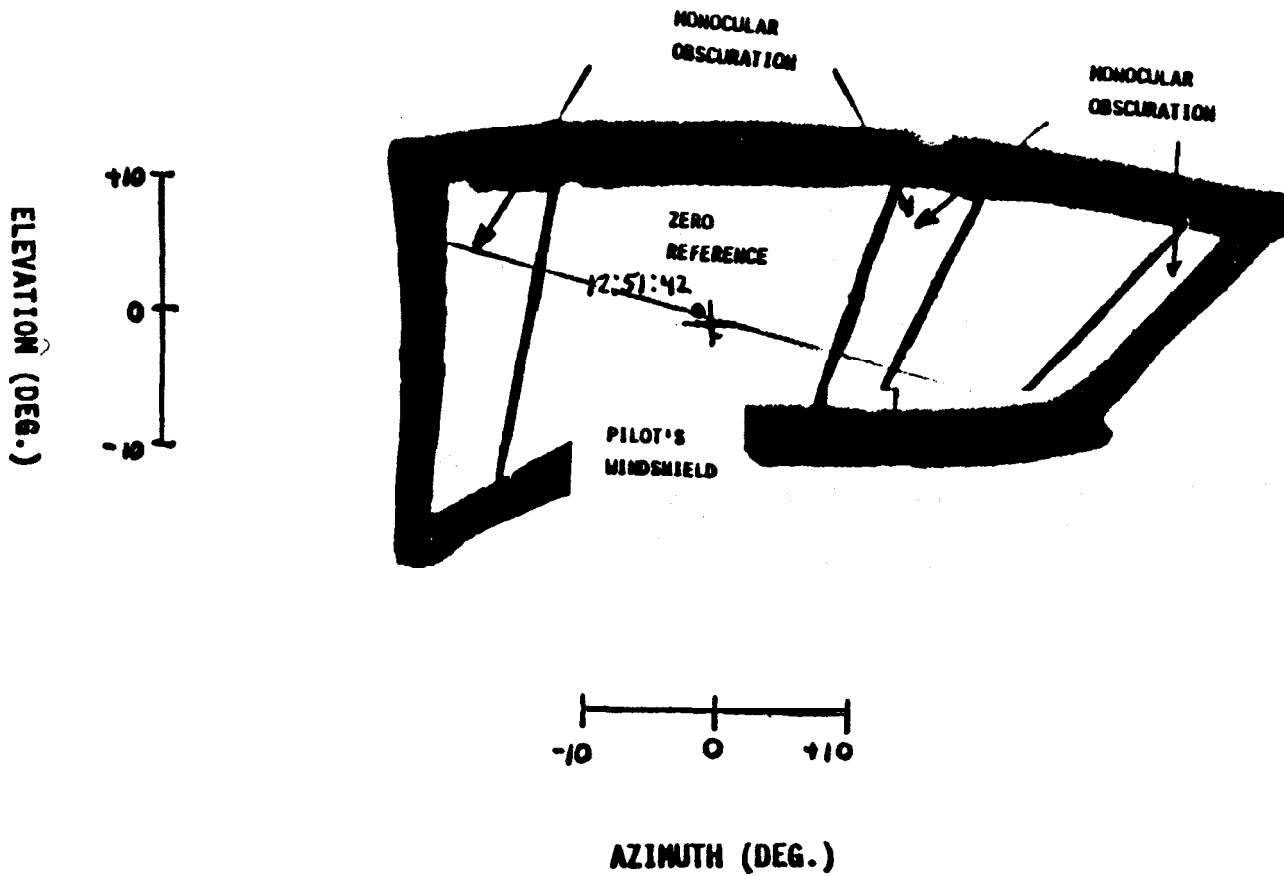


AZIMUTH (DEG.)

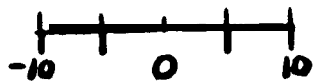
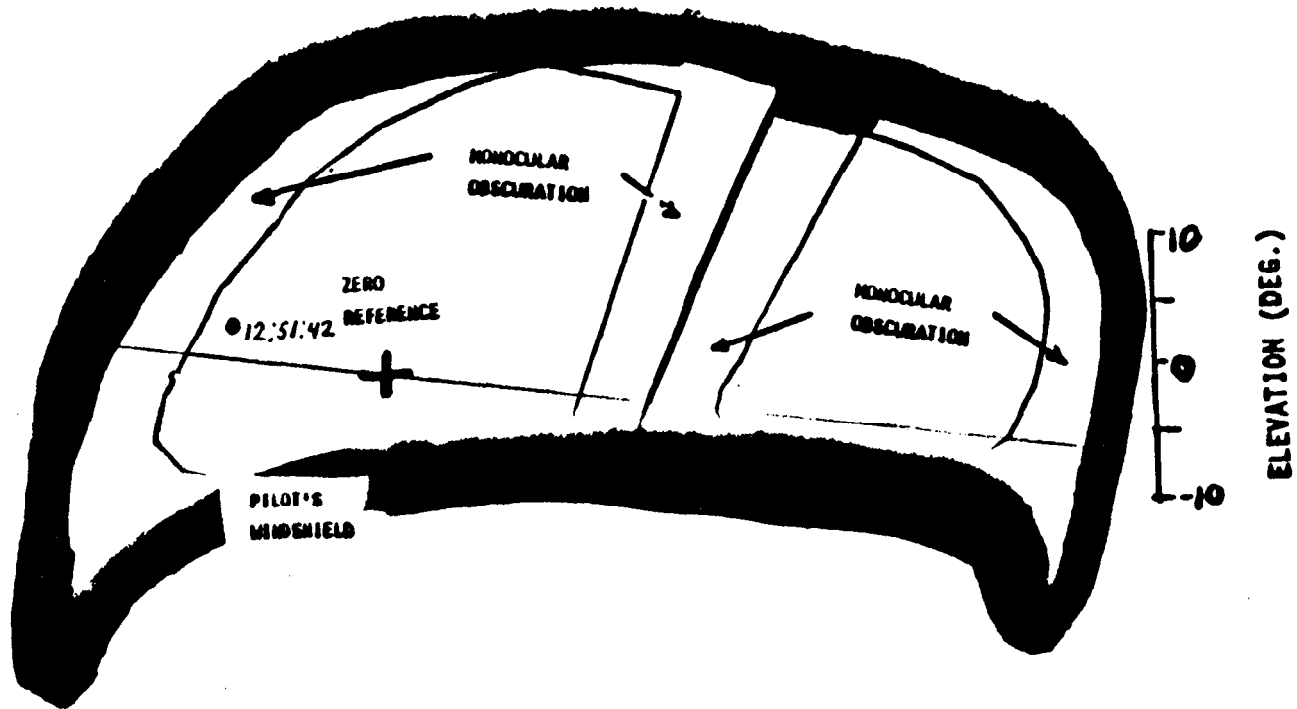
MOONEY 20C, N6485U
COPILOT'S EYE REFERENCE IN ACCORDANCE WITH CAM 4B
37 1/2 INCHES ABOVE SEAT RAIL
21 5/8 INCHES AFT OF INSTRUMENT PANEL



FAIRCHILD METRO II, N163SW
PILOT'S EYE REFERENCE
5 INCHES AFT OF REAR MOST CONTROL COLUMN
POSITION (13.6 INCHES AFT INSTRUMENT PANEL)
44 1/8 INCHES ABOVE SEAT TRACK

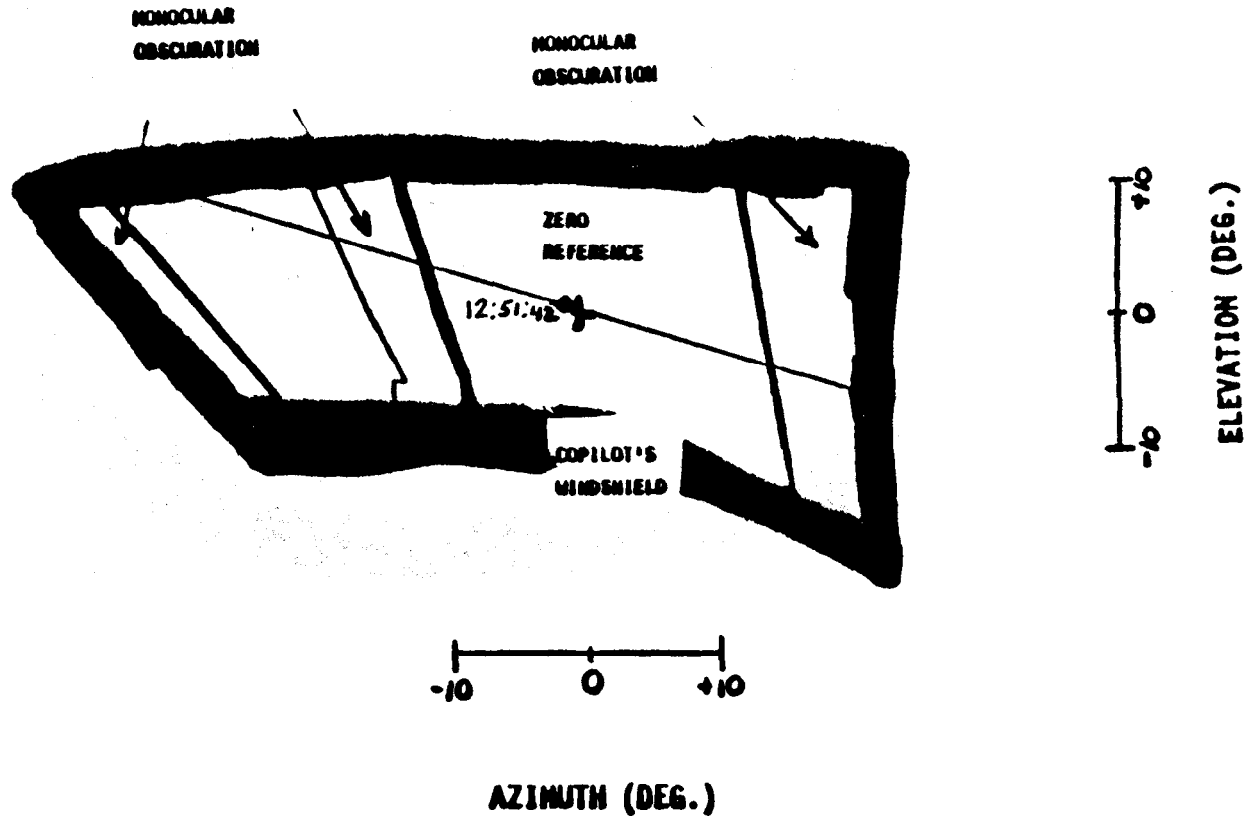


MOONEY 20C, N6485U
PILOT'S EYE REFERENCE IN ACCORDANCE WITH CAN 4B
37 1/2 INCHES ABOVE SEAT RAIL
21 5/8 INCHES AFT OF INSTRUMENT PANEL

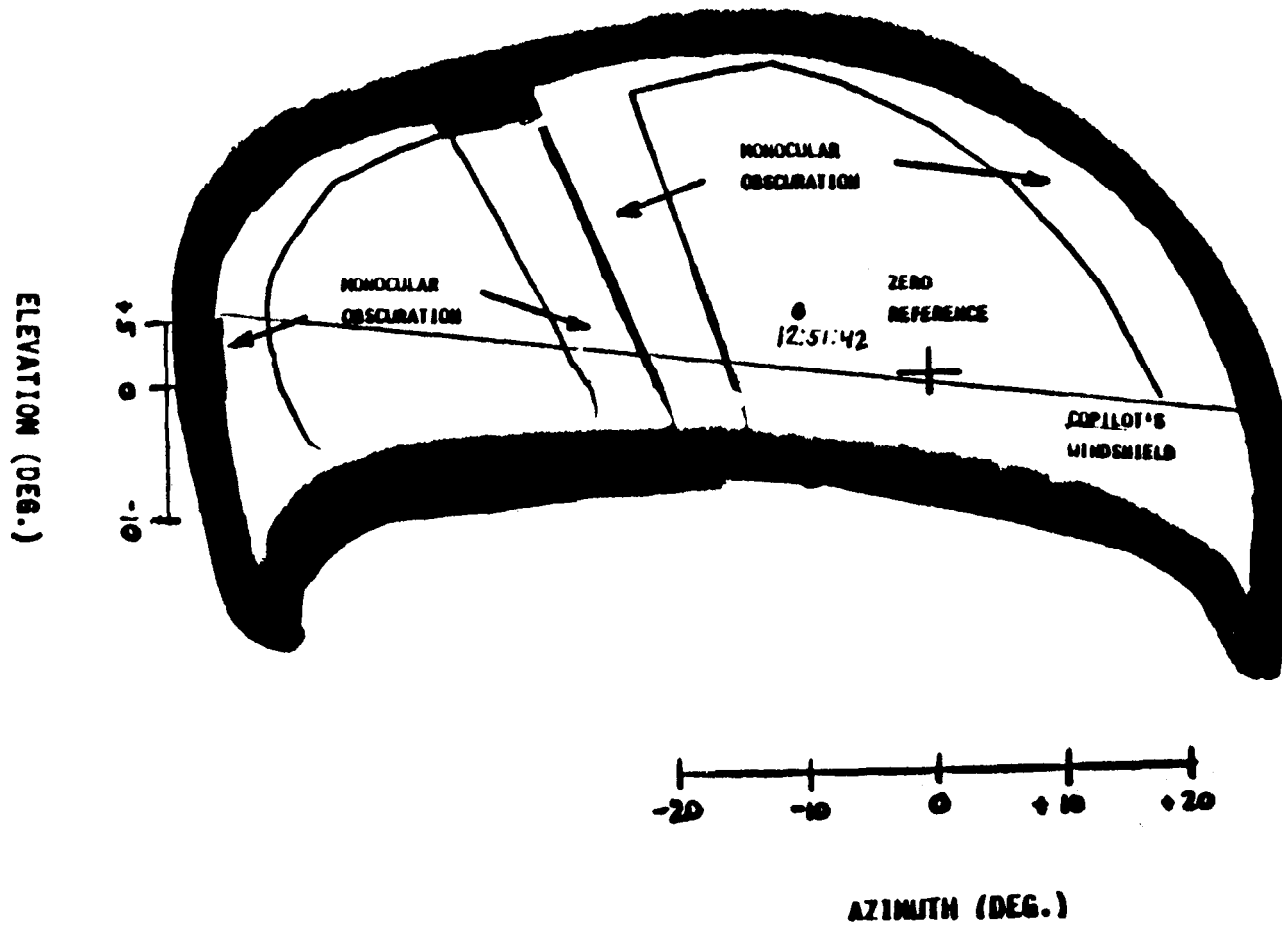


AZIMUTH (DEG.)

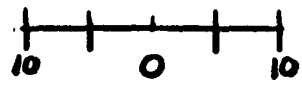
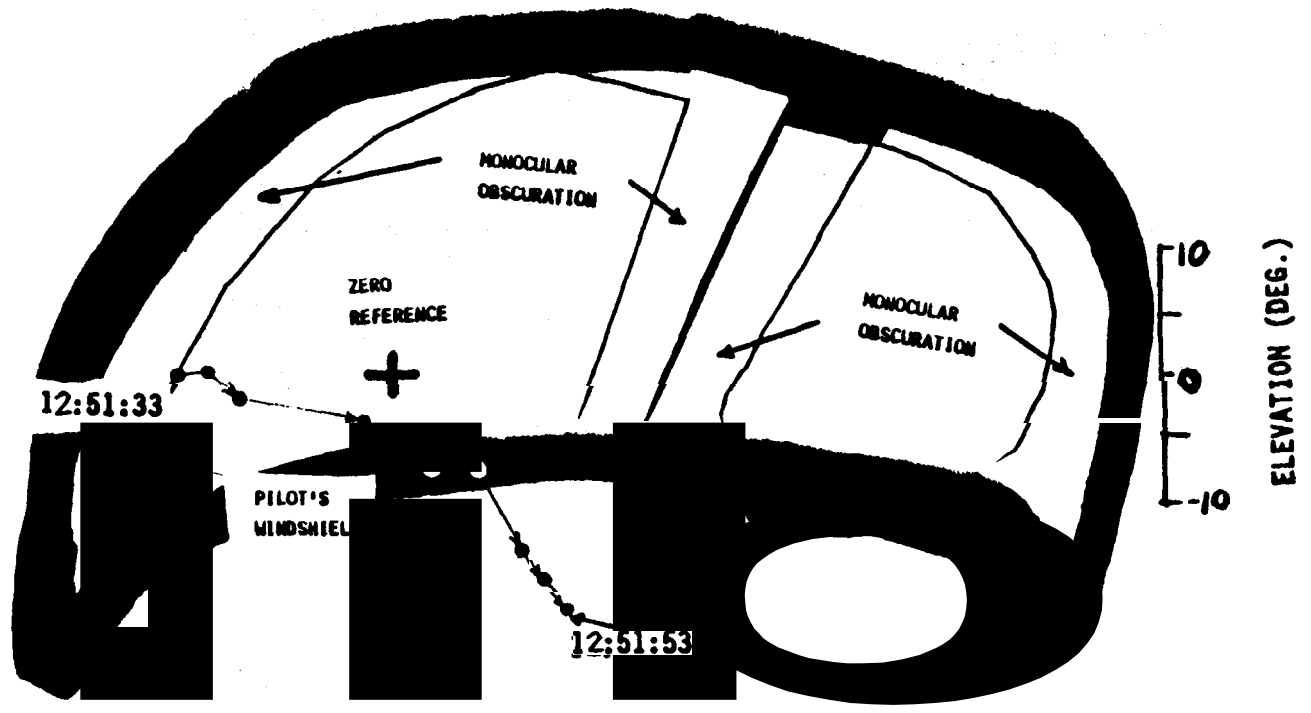
**FAIRCHILD METRO II, M163SM
COPILOT'S EYEREFERENCE
5 INCHES AFT OF REAR MOST CONTROL COLUMN
POSITION (13.6 INCHES AFT INSTRUMENT PANEL)
44 1/8 INCHES ABOVE SEAT TRACK**



MOONEY 20C, N6485U
COPILOT'S EYE REFERENCE IN ACCORDANCE WITH CAN 48
37 1/2 INCHES ABOVE SEAT RAIL
21 5/8 INCHES AFT OF INSTRUMENT PANEL

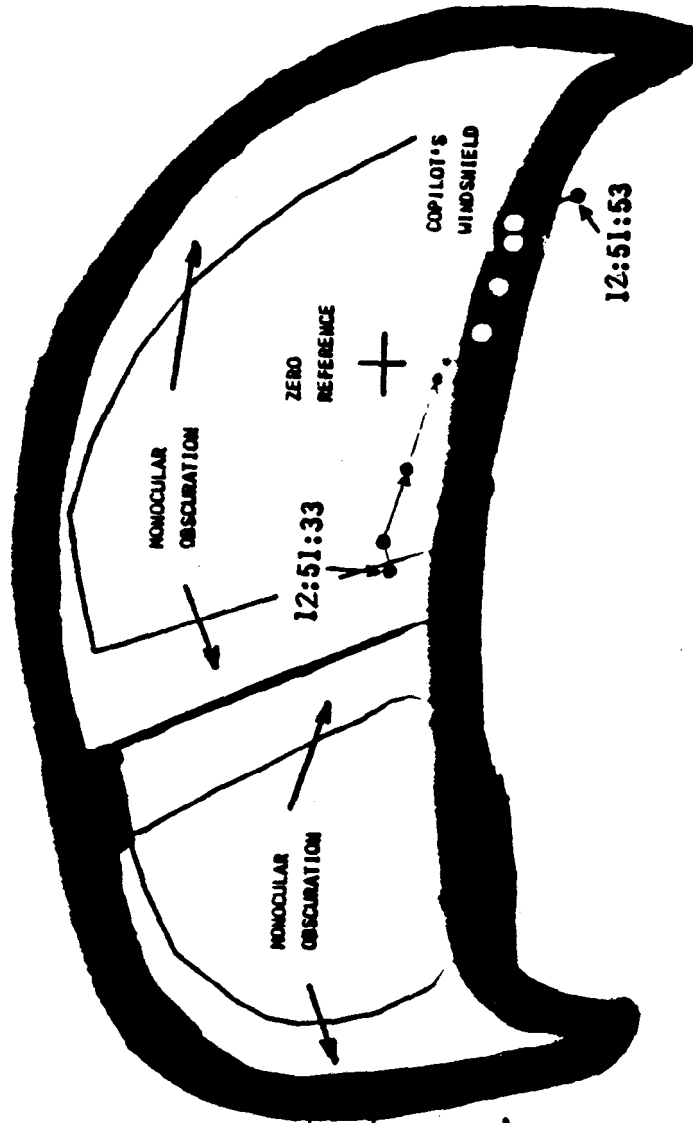


MOONEY 20C, N6485U
PILOT'S EYE REFERENCE IN ACCORDANCE WITH CAM 4B
37 1/2 INCHES ABOVE SEAT RAIL
21 5/8 INCHES AFT OF INSTRUMENT PANEL



AZIMUTH (DEG.)

MOONEY 20C, N6485J
COPILOT'S EYE REFERENCE IN ACCORDANCE WITH CAM 48
37 1/2 INCHES ABOVE SEAT RAIL
21 5/8 INCHES AFT OF INSTRUMENT PANEL



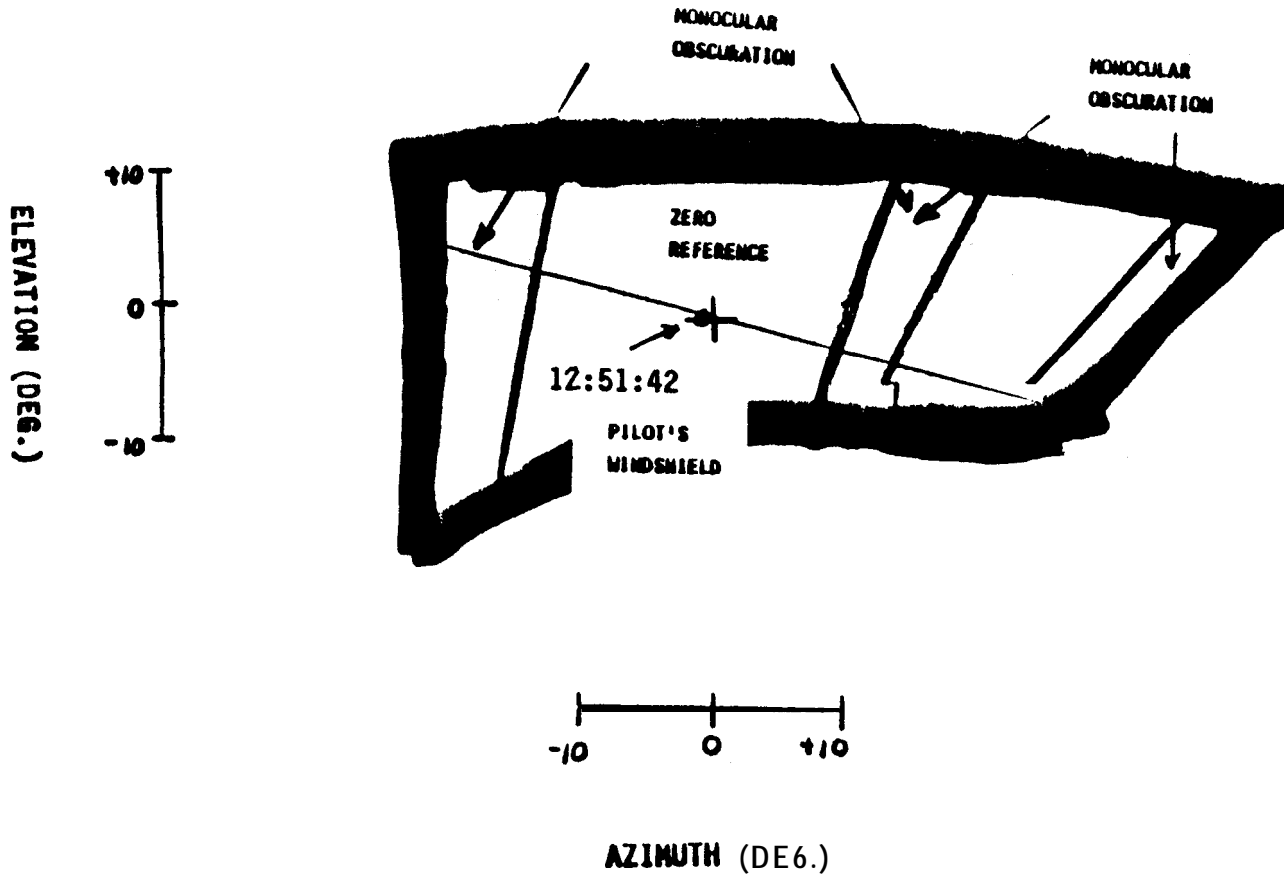
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ELEVATION (DEG.)

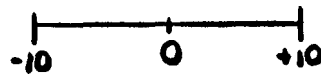
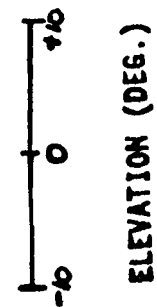
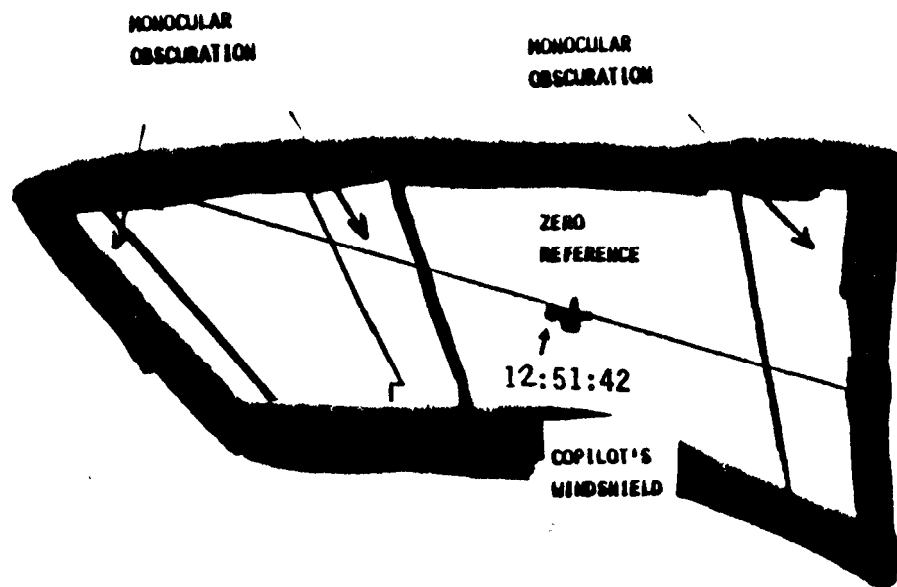
-20 0 +20

AZIMUTH (DEG.)

FAIRCHILD METRO II, N163SM
PILOT'S EYE REFERENCE
5 INCHES AFT OF REAR MOST CONTROL COLUMN
POSITION (13.5 INCHES AFT INSTRUMENT PANEL)
44 1/8 INCHES ABOVE SEAT TRACK

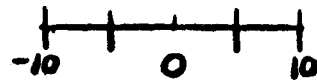
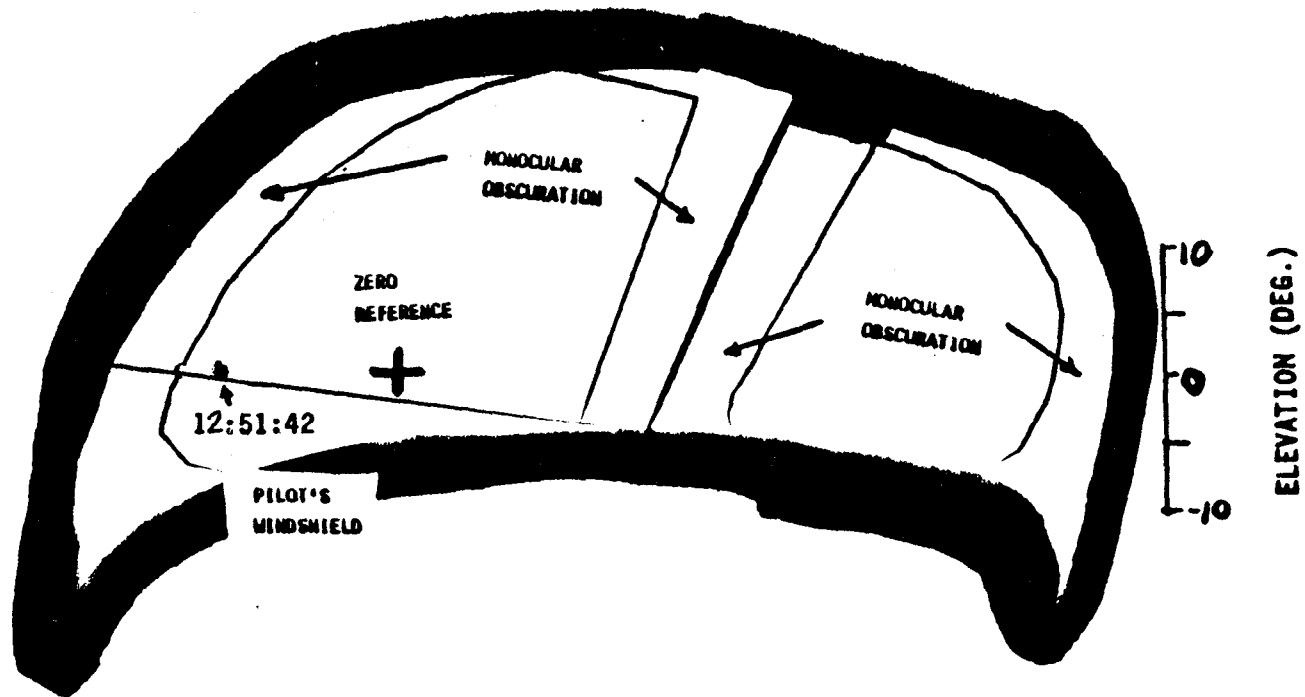


FAIRCHILD METRO II , N163SW
COPILOT'S EYE REFERENCE
5 INCHES AFT OF REAR MOST CONTROL COLUMN
POSITION (13.5 INCHES AFT INSTRUMENT PANEL)
44 1/8 INCHES MOUE SEAT TRACK



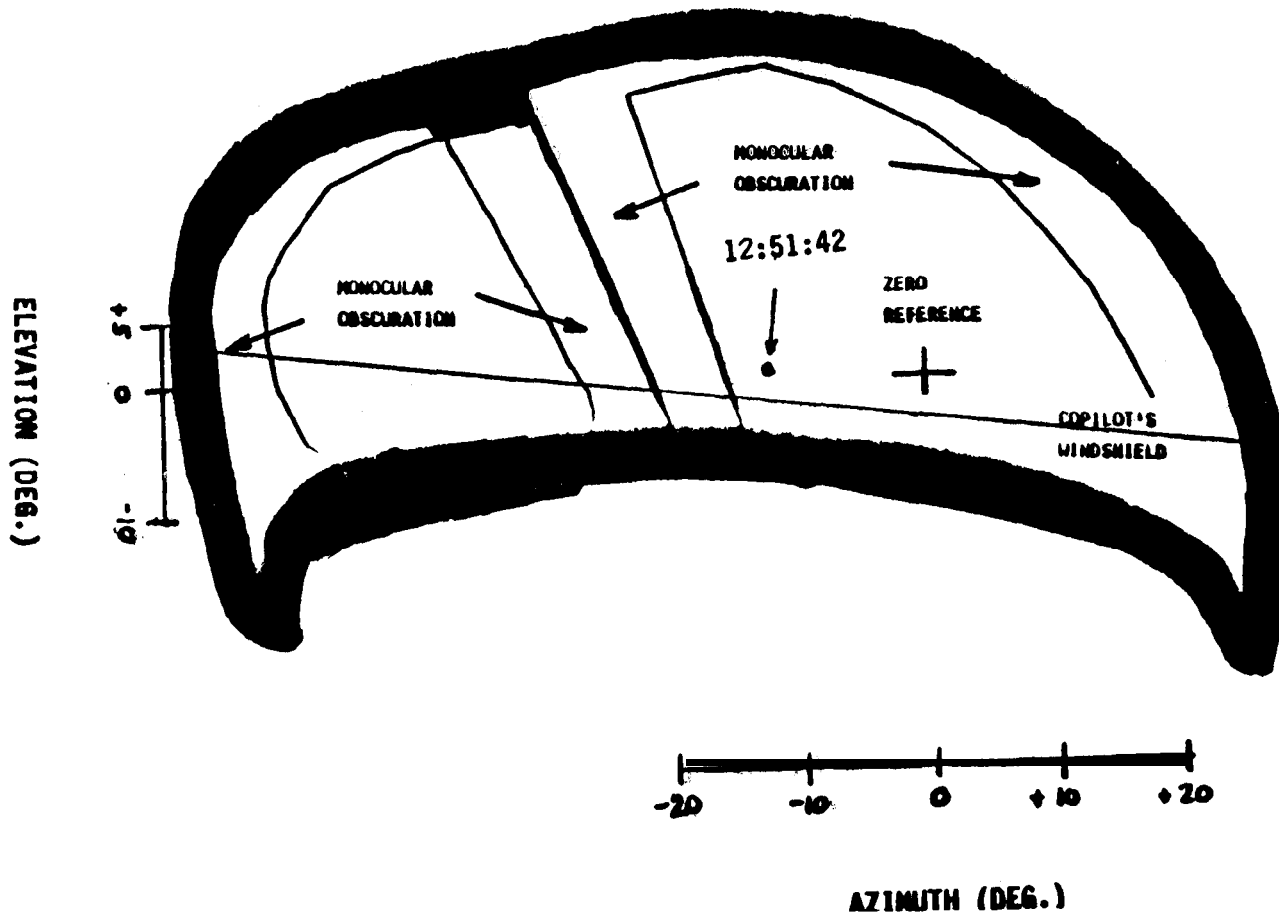
AZIMUTH (DEG.)

MOONEY 20C, N6485U
PILOT'S EYE REFERENCE IN ACCORDANCE WITH CAN 4B
37 1/2 INCHES ABOVE SEAT RAIL
21 5/8 INCHES AFT OF INSTRUMENT PANEL



AZINUTH (DEG.)

MOONEY 20C, N6485U
COPILOT'S EYE REFERENCE IN ACCORDANCE WITH CAM 48
37 1/2 INCHES ABOVE SEAT RAIL
21 5/8 INCHES AFT OF INSTRUMENT PANEL



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