TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. NTSB-AAR-78-14	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Aircraft Accident Report – Midair Collision Involving a Falcon Jet, N121GW and a Cessna 150M, N6423K, Memphis, Tennessee, May 18. 1978		5. Report Date November 30, 1978
		6. Performing Organization Code
7. Author(s)		8. Performing Organization Report No.
9. Performing Organization Name and Address National Transportation Safety Board Bureau of Accident Investigation Washington, D.C. 20594		10. Work Unit No. 2366-C
		11. Contract or Grant No.
		13. Type of Report and Period Covered Aircraft Accident Report May 18, 1978
12. Sponsoring Agency Name and Address **NATIONAL TRANSPORTATION SAFETY BOARD** Washington, O. C. 20594		14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

About 1210 c.d.t. on May 18, 1978, a Falcon Jet DA-20, N121GW, collided in midair with a Cessna 150M, N6423K, 3.7 miles west of Memphis International Airport, Memphis, Tennessee. 'The Falcon Jet, which was on an instrument flight rules flight plan, had an instructor pilot and three students on board. *An* instructor pilot and one passenger were aboard the Cessna 150M.

The Cessna was VFR and was receiving Stage III radar service. Both aircraft were under control of Memphis tower controllers and were in radar and radio contact with the tower. The weather in the Memphis area was: Scattered clouds at *4,500* feet and visibility--6 miles with haze.

The National Transportation Safety Board determines that the probable cause of this accident was the failure of controller personnel to separate the aircraft as required by procedures established for **a** terminal radar service area, to insure that proper coordination was effected, to issue appropriate traffic advisories, and the failure of each flightcrew to see and avoid the other aircraft.

17. Key Words	18. Distribution Statement
Midair collision; IFR flight plan; Stage III radar service; radar and radio contact; 6 miles and haze; separation; see and avoid; proper coordination; traffic advisory; observed radar traffic; conflicting course.	This document is available to the public through the National Technical Information Service, Springfield, Virginia 22151

19. Security classification (of this report)	20. Security Classification (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	**UNCLASSIFIED**	39	

NTSB Form 1765.2 (Rev. 9/74)

TABLE OF CONTENTS

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

Adopted: November 30, 1978

MIDAIR COLLISION
FALCON JET DA-20, N121GW
AND
CESSNA 150M, N6423K
MEMPHIS, TENNESSEE
MAY 18, 1978

SYNOPSIS

About 1210 c.d.t. on May 18, 1978, a Falcon Jet DA-20, N121GW, collided in midair with a Cessna 150M, N6423K, 3.7 miles west of Memphis International Airport, Memphis, Tennessee. The Falcon Jet, which was **on** an instrument flight rules flight plan, had an instructor pilot and three students on board. **An** instructor pilot and one passenger were aboard the Cessna 150M.

The Cessna was VFR and was receiving Stage III radar service. Both aircraft were under control of Memphis tower controllers and were in radar and radio contact with the tower. The weather in the Memphis area was: Scattered clouds at 4,500 feet and visibility--6 miles with haze.

The National Transportation Safety Board determines that the probable cause of this accident was the failure of controller personnel to separate the aircraft as required by procedures established for a terminal radar service area, *to* insure that proper coordination was effected, to issue appropriate traffic advisories, and the failure of each flightcrew to see and avoid the other aircraft.

1. FACTUAL INFORMATION

1.1 History of the Flights

Falcon Jet

On May **18,** 1978, a Falcon Jet DA-20, N121GW, was being operated by Flight Safety International, Inc., as a training flight. A Flight Safety International flight instructor and three Saudi Arabian students were aboard. The Falcon was equipped with a transponder and an altitude encoding altimeter.

Flight Safety International was under contract to the Saudi Arabian Airlines to provide flight training for newly hired Saudi Arabian first officers. The training syllabus for that day called for multiple instrument approaches in the Memphis traffic pattern. Each student would fly 1 hour from the right (copilot) seat. At the end of each hour, students would change seats **on** the downwind leg. Students not flying would occupy the jumpseat and a seat in the cabin.

The instructor pilot received a weather briefing from the Memphis Flight Service Station (FSS) at *0820,* 1/ and filed an instrument flight plan which specified a 3-hour flight in the Memphis traffic pattern at **an** altitude of *2,000* ft. 2/

The Falcon departed runway 17L at 1007 and made multiple instrument approaches **to** runway 17R. Radio contact was maintained with the local controller (LC2) and the final controller (AR6). The instructor pilot made all air-to-ground communications. The Falcon was under radar control during the entire flight.

At 1208:35, the Falcon began a go-around from an instrument landing system (ILS) approach to runway 17R. LC2 cleared the flight "...climb to two thousand, turn right heading three two zero." The crew acknowledged this instruction. At 1209:18, LC2 advised the Falcon, "Golf Whiskey, give me a tight right turn now to three five zero to pass behind the traffic." The traffic LC2 was referring to was a light aircraft which had departed Memphis International Airport and was flying to the southwest.

At 1209:51, when the Falcon was at *2,000* ft and clear of the southwestbound traffic, LC2 visually inspected the LC1 controllers BRITE radar display, saw no conflicting traffic, and transmitted the following instruction: "Golf Whiskey, turn back left-er-now heading three two zero and contact approach **on** one two six point seven." The instructor

1/ All times herein are central daylight, based on the 24-hour clock.
2/ All altitudes and elevations herein are mean sea level unless otherwise specified.

pilot acknowledged the new heading and frequency. This series of vectors placed the Falcon downwind for runway 17R and in the LC1 controller's airspace.

At 1210:04, the Falcon contacted the AR6 controller and transmitted "Memphis Approach, Falcon one twenty one Golf Whiskey two thousand." AR6 responded at 1210:07, "Two one GW, radar contact fly heading three five zero." At 1210:12, the pilot of the Falcon replied, "three five zero, one two one Golf Whiskey." This was the last transmission from the Falcon. At 1210:19, the AR6 controller asked the Falcon, "What do ya want after this, another one?" The pilot of the Falcon did not respond.

According to the AR6 controller, shortly after the 1210:19 transmission, while looking at his radar display, he saw the Falcon begin a left turn to the northwest on a heading of about 320°. AR6 later stated that he was not concerned about the unauthorized turn because training flights "...sometimes...make turns that they should not make or are not instructed to make." Seconds later, AR6 saw a primary radar return at the Falcon's 11 o'clock position at a distance of less than 1 mile. He made no attempt to issue a warning to the Falcon, because he believed that the two aircraft were at different altitudes. The AR6 controller watched the targets merge and then saw the data block from the Falcon go into a coast mode.

The last transponder return from the Falcon was recorded at 1210:22. At 1210:32, a single primary radar return was recorded.

At the final impact, the Falcon's heading was 331" and the aircraft was in a 30" to 40" bank to the right.

Cessna 150M N6423K

Cessna 150M, N6423K, was being operated by the Memphis Flying Club. The pilot-in-command was a flying club instructor pilot; he was giving a familiarization flight to a prospective student before beginning a flight training program. The instructor pilot did not file a flight plan and was flying under visual flight rules (VFR). He did not request a weather briefing. The aircraft was not equipped with a transponder, nor was one required.

The Cessna departed Memphis International Airport at 1124 and proceeded west to West Memphis Airport. According to the owner of the aircraft, the instructor pilot was in the right seat of the aircraft when the flight departed Memphis International Airport.

After a brief stop, the Cessna departed West Memphis Airport at 1159 to return to Memphis International Airport. At 1205:47, the pilot of the Cessna contacted the final controller (AR2) at the Memphis

tower and requested landing instructions. At 1207:05, AR2 advised the Cessna, "Radar contact, fly heading one two zero, maintain two thousand, and expect to enter a left downwind leg for two seven over the terminal."

At 1209:17 AR2 called the local controller (LC1) on the tower interphone and transferred control of the Cessna by stating, "Primary target just south of Aulon." 3/

At 1209:25, AR2 transmitted, "Cessna two three Kilo, maintain 2,000, enter downwind leg over terminal building for two seven, contact tower one one eight point three, good day."

The Cessna contacted LC1 at 1209:56 and reported "...six four two three Kilo on a downwind for two seven."

At 1210:02, LC1 transmitted, "Enter left downwind, wind one two zero at four," and at 1210:06, the Cessna acknowledged the transmission. This was the last transmission from the Cessna. According to the LC1 controller, he then turned his attention to aircraft on the east side of the airport. The LC2 controller directed the LC1 controller's attention back to the Cessna by asking him if he had traffic to the west of the airport. LC1 advised that he had inbound traffic at 2,000 ft. He looked at the BRITE radar display and saw the Cessna radar target within 1 mile of the Falcon's transponder return. At 1210:33 LC1 attempted to issue a traffic advisory to the Cessna. He transmitted, "and two three Kilo . . ," and then saw a fireball near the aircraft's position.

The planes had collided in midair during daylight hours 3.7 miles from the Memphis International Airport. Coordinates at the collision site were latitude 30° 03' 04"N and longitude 90° 02' 05"W.

Ground witnesses reported the weather in the area as clear or clear and hazy. Those who observed one or both of the aircraft saw the aircraft clearly. They saw no maneuvers before the collision which could be considered evasive. All witnesses reported a flash or a fireball followed by a loud explosion. After the explosion they saw falling debris and the Falcon.

According to the witnesses, the Falcon continued straight and level for a few seconds when a fireball engulfed the aircraft just aft of the cockpit. The Falcon then turned to the right, rolled on its longitudinal axis, and dove to the ground.

3/ Aulon is an Outer Compass Locator 4.2 miles west of the departure end of runway 27.

Air Traffic Control

When the planes collided, there were four controllers and a supervisor on duty in the Memphis tower cab, including LC1 and LC2. 4/ The supervisor was working at the Ground Control-2 position at the time of the accident.

The local controllers, LC1 and LC2, were responsible for controlling traffic in the airspace within a 5-mile radius of the airport from the surface to 2,000 feet. LC1, who controlled operations on runway 9/27, was assigned the airspace east and west of the airport. The airspace north and south of the airport was controlled by LC2, who was responsible for aircraft operations on runways 17L/R and 35L/R. LC1 and LC2 were physically located within 10 ft of each other but operated on separate frequencies. (See figure 1.) On the day of the accident, LC1 and LC2 assumed their operating positions at 1150.

Final controllers AR2 and AR6 were in the IFR room located below the tower cab. They also controlled aircraft on different frequencies.

Control of the Falcon -- The Falcon was being controlled by LC2 and AR6 during the entire period as the aircraft made multiple instrument approaches. At 1209:51, when LC2 transferred control of the Falcon to AR6, he did not verbally coordinate the transfer with LC1. Instead, he looked at the BRITE radar display, saw no conflicting traffic, and instructed the pilot to contact AR6. When AR6 received the Falcon on his frequency, he assumed that the coordination between LC1 and LC2 had been accomplished. He then looked at the airspace ahead of the Falcon's target for traffic that might conflict with the Falcon's assigned vector of 350"; he saw none.

About 1210:19, AR6 saw the Falcon begin an unauthorized turn to 320". He made no attempt to correct the heading, because (1) the turn did not put the aircraft out of position for subsequent vectors; (2) initially, he was not aware of any conflicting traffic; and (3) he knew that the Falcon was a training flight and assumed the turn was made by a student under the supervision of the instructor pilot.

The AR6 controller testified that seconds after the Falcon began the left turn to 320°, he first saw the primary return of the Cessna. Although the two targets were within 1 mile of each other and on a converging course, he was not concerned because he believed that the aircraft were at different altitudes. Additionally, AR6 was accustomed to seeing primary targets in that area since low-level helicopter traffic frequently operated west of the airport and VFR traffic passed over the Memphis Terminal Radar Service Area (TRSA) at that point.

4/ There were four authorized visitors in the tower cab at the time of the accident. The visitors were standing by the cab door and were not talking to anyone.

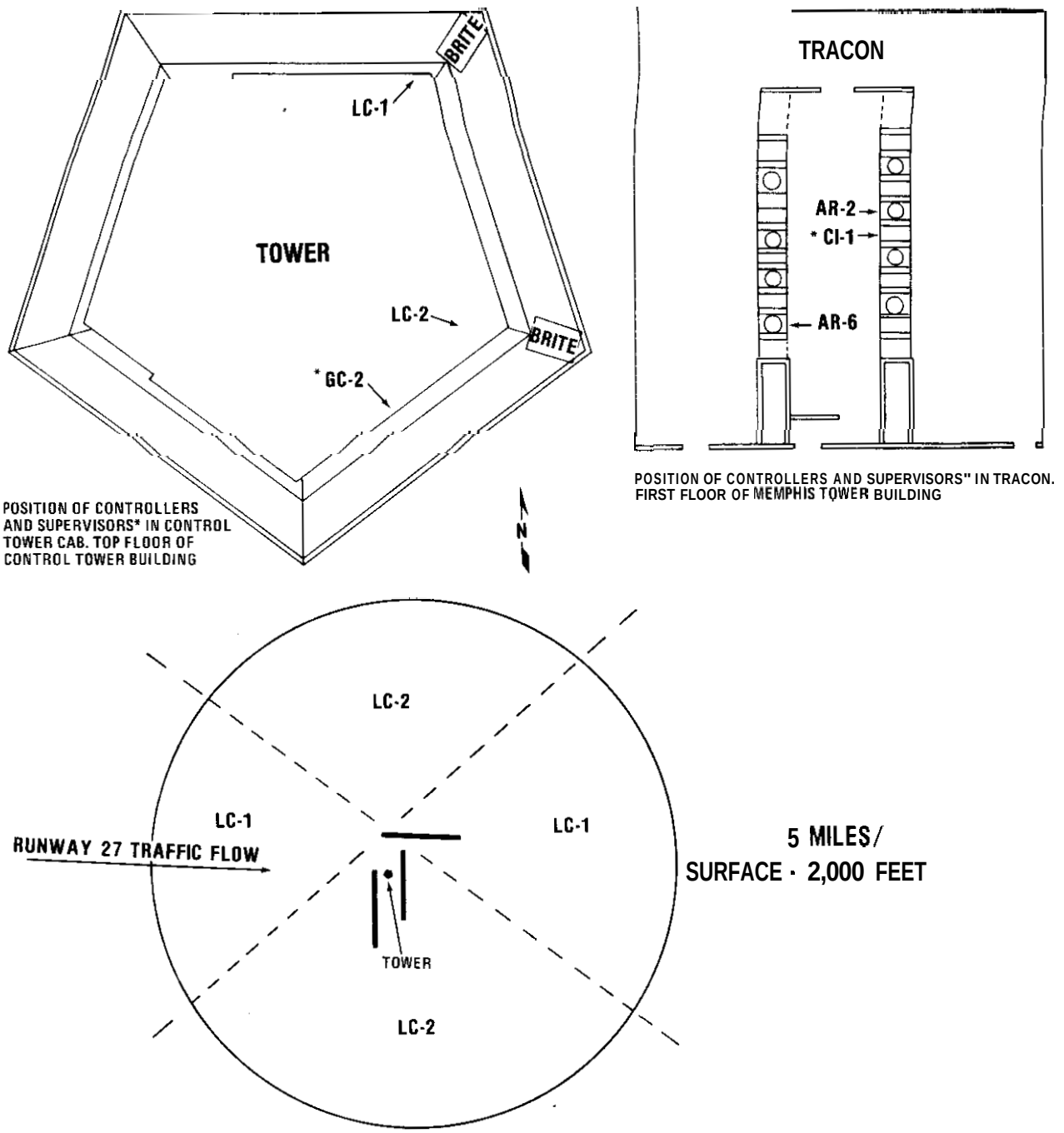


Figure 1. Memphis local controller area of responsibility.

tha Ce
strong
moved
AR2 ha
was su

Cessna
ahead
return
passin
refere
the po
traver
instru
the ea
his ai
to the
and sa
each o
adviso
the we
the BR

1.2

In

Fa
Sf
M:

1.3

1.4

which b
damage

1.5

for the
current

Control of the Cessna -- AR2 established radar contact with the Cessna at 1205:47. The primary radar return of the Cessna was strong when initial contact was established. However, as the aircraft moved closer to the airport, the size of the return diminished. When AR2 handed off the Cessna to LC1 at 1209:17, the primary radar return was smaller, but very discernible.

The LC1 controller stated that when he accepted control of the Cessna at 1210:02, he saw no conflicting traffic on the BRITE display ahead of the aircraft and he did not recall seeing the transponder return of the Falcon. He stated that he did not recall the Falcon passing through his sector before the accident nor did he recall any reference to its flight operation when he was briefed before assuming the position. He was not aware that the Falcon was being vectored to traverse his airspace at 2,000 ft. After LC1 gave the Cessna landing instructions at 1210:02, he turned his attention to other aircraft on the east side of the airport. LC1 was not aware that the Falcon was in his airspace until about 1210:20, when LC2 asked LC1 if he had traffic to the west. At this time, he looked back to the BRITE radar display and saw the radar returns of the two aircraft within 1 to 2 miles of each other and on a converging path. LC1 attempted to issue a traffic advisory to the Cessna, but as he looked out, he observed a fireball to the west of the airport. LC1's only observation of the Falcon was on the BRITE radar display just before the collision.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	5	1	0
Serious	0	0	0
Minor/None	0	0	0

1.3 Damage to Aircraft

Both aircraft were destroyed.

1.4 Other Damage

Falling debris from the Cessna damaged a trailer.

The debris from the Falcon was scattered over undeveloped land which bordered an industrial park. Three brush fires and limited ground damage resulted from the debris.

1.5 Crew Information

The crewmembers on both aircraft were qualified and certificated for the respective flights; all had received the training required by current regulations. (See Appendix B.)

The instructor pilot of the Falcon, who had instructed for Flight Safety International for about 1 1/2 years, was considered an excellent instructor. According to Flight Safety International personnel, he was a thorough, patient instructor, who was quick to point out mistakes made by his students. Three Saudi Arabian student pilots interviewed stated that he was a "very good" instructor and that he worked well with the Saudi students.

According to the instructor pilot's wife, he had retired at 2200 on the night before the accident and arose at 0700 on the morning of the accident. After breakfast with his family, he left for the airport at 0800. He was in good health and spirits the morning of the accident.

The instructor pilot of the Cessna was a part-time flight instructor. He retired at 2230 on the night before the accident and arose at 0700.

1.6 Aircraft Information

The Falcon Jet DA-20 was owned and operated by Flight Safety International, Inc. It was certificated, maintained, and equipped in accordance with current regulations and procedures. The weight and balance and center of gravity were within the prescribed limits at the time of the accident.

The Falcon was all white with horizontal gold, white, and blue stripes along the main fuselage below the window line and on the outboard sides of the engine cowling. The vertical stabilizer leading edge was blue with white and gold stripes on each side. The Falcon did not have strobe lights, but was equipped with anticollision lights on the vertical stabilizer and on the bottom of the fuselage.

The Cessna 150M was owned by Mr. Carlyle C. Wolf and operated by the Memphis Flying Club. It was certificated, maintained, and equipped in accordance with current regulations. The weight and center of gravity were within prescribed limits at the time of the accident. The Cessna's lower fuselage, wings, struts, horizontal stabilizer and elevators, vertical stabilizer, and rudder were white. The wingtips, upper engine cowling, and upper fuselage were red. The Cessna was not equipped with strobe lights, but was equipped with an anticollision light on the vertical stabilizer.

1.7 Meteorological Information

In the Memphis area, there was a low scattered layer of stratocumulus clouds with a high cirrostratus overcast. Visibility was reduced by haze, and winds were southeasterly at less than 10 kns. There were scattered rain showers and thunderstorms in the area, but not in the immediate vicinity of the airport.

Airport
25,000
dewpoir

Service
soundir
at 8,5(
over Na

that th
150 mi:

71° abo
during

1.8

1.9

1.10

for a i
runway
betwee

origin
was ru
mainte
contro
for ru
patter
2,500
on the
Proced
Airpor

Interr
Of the
instru
ILS ap

The surface weather observation from Memphis International Airport at 1157 was: Clouds--4,500 ft scattered, ceiling--estimated 25,000 ft overcast; visibility--6 miles, haze; temperature--75°F.; dewpoint--61°F.; wind--120° 8 kns; altimeter--30.11 in.

Radiosonde soundings had been taken by the National Weather Service at Nashville and Little Rock at 0700 and 1900. At 0700, the soundings showed a subsidence inversion at 6,200 ft over Nashville and at 8,500 ft over Little Rock. At 1900, the inversion was at 6,900 ft over Nashville and at 6,800 ft over Little Rock.

A pilot report, given to the Memphis FSS at 1130, indicated that the top of the haze layer was 6,500 ft. This report was made from 150 miles northeast of Memphis.

At the time of the accident, the sun was at an elevation of 71" above the horizon with an azimuth of 142°. The accident occurred during daylight hours.

1.8 Aids to Navigation

Not applicable.

1.9 Communications

There were no communications problems.

1.10 Aerodrome and Ground Facilities

Memphis International Airport, elevation 332 ft, was certificated for air carrier operations under 14 CFR 139. The primary air carrier runways were 17L/35R and 17R/35L. A new terminal complex was located between the two parallel runways.

The new runways and terminal were situated southwest of the original airport complex. The primary runway of the original airport was runway 9/27. The other runways in the old complex were closed for maintenance on the day of the accident. According to local air traffic control (ATC) directives, pilots were to fly right-hand traffic patterns for runway 17R and left-hand traffic patterns for runway 27. The traffic pattern altitudes for IFR operations were 2,000 ft for runway 17R and 2,500 ft for runway 17L. Different controllers control aircraft movements on the new and old runway complexes, and they use separate frequencies. Procedurally, the north and south portions of Memphis International Airport are controlled as though they are two separate airports.

Under the National Airport System Plan (1978-1987), Memphis International Airport is served by four designated reliever airports. Of the four airports, only one, West Memphis Airport, has facilities for instrument training. However, West Memphis Airport has only a VOR, not ILS approach facilities.

At the time of the accident, Memphis tower radar and associated equipment were operating properly. The Memphis tower utilizes ASR8 radar which is located on the airport. The antenna speed is 12 1/2 rpm. The facility has ARTS III equipment in operation, but no recording devices are available to record computer data. Additionally, Memphis tower has no terminal conflict alert system in operation.

The Memphis tower facility contained a terminal radar control facility. The ATC tower cab and the radar room are located in the tower near the center of the airport between runways 17L/R. The tower cab is about 190 ft above the airport surface. Local controllers can see the operating surfaces of the north and south airport areas.

Memphis Air Route Traffic Control Center (ARTCC) has a radar site 20 miles southeast of Memphis International Airport. Memphis ARTCC radar has a recording capability and an antenna speed of 6 rpm. The radar data from Memphis ARTCC were used to establish flight tracks for the accident aircraft. However, the data do not reproduce the exact picture of what the tower controllers saw on their radar displays.

A Depict Log Plot was requested from Memphis ARTCC for the period 1205:00 through 1213:00 for code 5511 (transponder code assigned to the Falcon and for primary radar returns). The plot was made each 30-second interval.

1.11 Flight Recorders

Neither aircraft was equipped with flight recorders, nor were they required.

1.12 Wreckage

The wreckage of both aircraft was confined to an area 1,300 ft wide and 2,300 ft long on a magnetic heading of 331°. (See Appendix E.)

No evidence of preexisting structural damage or control malfunctions was found on either aircraft.

Cessna 150

The Cessna 150 fragmented before ground impact. The right wing, which separated from the fuselage, exhibited a concaved leading edge just outboard of the right wing fuel tank. Blue paint scuff marks were noted at various locations on this wing leading edge.

The outboard 18.5 inches of the leading edge separated from the wing. This piece of the leading edge was recovered along the wreckage path. The leading edge had a large circular depression which was centered 84 to 90 inches inboard of the wingtip. The leading edge

in this area was bowed upward, and blue paint scuff marks were found on the lower side of the depression. The leading edge exhibited another smaller circular depression 55 to 60 inches inboard of the large depression. The inboard depression started 2 to 3 inches outboard of the right fuel tank.

The inboard depression was checked by placing the right Cessna wing adjacent to the left wing root leading edge of the Falcon Jet. The Cessna wing depression matched closely the leading edge of the Falcon Jet. The outboard larger depression with the blue paint scuff marks had a radius similar to that of the Falcon Jet fuselage immediately above the Falcon Jet wing.

The top area of the engine case exhibited two gouge marks about 2 inches aft of the forward end of the case. These marks ran diagonally across the engine centerline from left to right and aft as viewed looking aft from the front of the engine. The first mark measured 40° and the second mark measured 30".

The only instruments recovered from the Cessna 150 were the altimeter and the directional indicator. Only the face of the altimeter was recovered; there were no pointers. The setting was 30.8-; all further readings had been obliterated. The directional indicator provided a heading of 108" when matching damages within the unit were placed beneath the lubber line.

Falcon Jet

The Falcon Jet came to rest on a magnetic heading of 310°. It was relatively intact before ground impact. Most of the wreckage along the wreckage path was from the forward passenger cabin area between the main entry door and the right fuselage emergency exit window.

Evidence in the wreckage established that the wing-droop leading edge devices, speed brakes, trailing edge flaps, and landing gears were retracted. The Falcon Jet stabilizer trim setting was a 3° airplane-nosedown trim.

Detailed examination of the forward portiop of fuselage revealed red paint scuff marks just aft of the nose gear between fuselage frame (FF) 6 and FF9 about the 5 o'clock position between fuselage stringers 20R and 22R as viewed looking forward. The scuff marks ran diagonally from left to right and aft. These scuff marks were at an angle of 26" to the nearest fuselage stringer centerline. A large piece of the fuselage near FF12 exhibited scuff marks which were measured at a 20° angle from the fuselage centerline to the nearest stringer.

Several interior components and the lower fuselage structure between FF12 and FF19 were recovered along the wreckage path. Three of the fuselage structure pieces exhibited red paint scuff marks. The red paint scuff marks were located from the 5 o'clock to 7 o'clock positions looking aft along the fuselage.

The left wing leading edge, from the wing/fuselage root fairing outboard to rib 5, was broken into pieces of various sizes. Extensive red paint scuff marks were found on the lower skin surface. The red scuff marks extended outboard at 90° from the wing root rib for a distance of 69 inches. The scuff marks extended from the leading edge lower surface aft to the forward edge of the skin panel just forward of the rear spar. The red scuff marks were measured near the leading edge and near the wing root rib. This angle measured 27° from the wing root rib direction. The scuff mark angles after the initial impact point showed varied inconsistent angles.

The two engines were partially attached to the aft fuselage, and the engine inlet sections were buried 4 ft in the ground. The angle of impact for the aft fuselage section was about 60".

All flight control surfaces were accounted for. All fractures observed were typical of those caused by overloads. All the flight instruments were burned severely, and no numbers could be read. The flight directors on the pilot and copilot sides of the instrument panel indicated right banks of 40° and 20°, respectively. The radio magnetic indicator from the copilot's panel indicated a compass card heading of 330° under the lubber line.

1.13 Medical and Pathological Information

Postmortem examinations and toxicological analyses showed no evidence of preimpact incapacitation of any of the crewmembers. Occupants of both aircraft sustained multiple blunt force trauma.

1.14 Fire

There were postimpact fires only. They were limited to small brush fires and the wreckage of the Falcon; they were extinguished by local fire units.

1.15 Survival Aspects

The accident was not survivable.

1.16 Tests and Research

Visibility Study

A visibility study was conducted to determine the field of vision from each cockpit. Although collision geometry was reconstructed for the final 97 seconds of flight, only the final 47 seconds of flight was studied.

The study was conducted based on the following assumptions:

Aircraft	Altitude	Magnetic Heading	Attitude Roll	Attitude Pitch
Cessna 150M	2,000 ft	97° to 129°	Straight	Level
Falcon DA-20	2,000 to 2,100 ft	323° to 350°	From 25° to Straight	From 5° noseup to 5° nosedown

The aircraft were about 1.3 miles apart 16 seconds before the assumed point of impact. The visual sight angle from the Cessna to the Falcon Jet was about 29° to the right. The visual sight angle from the Falcon Jet to the Cessna was about 21.5" the left. The closure rate between the aircraft was about 250 kns.

Binocular photographs, 5/ taken from the cockpits of a Falcon Jet DA-20 and a Cessna 150, were prepared by the Federal Aviation Administration's (FAA) National Aviation Facility Experimental Center. These photographs, which are the basis of the cockpit visibility diagrams, were used as an aid to determine if the cockpit structures interfered with the detection of the other aircraft. (See figures 2, 3, and 4.)

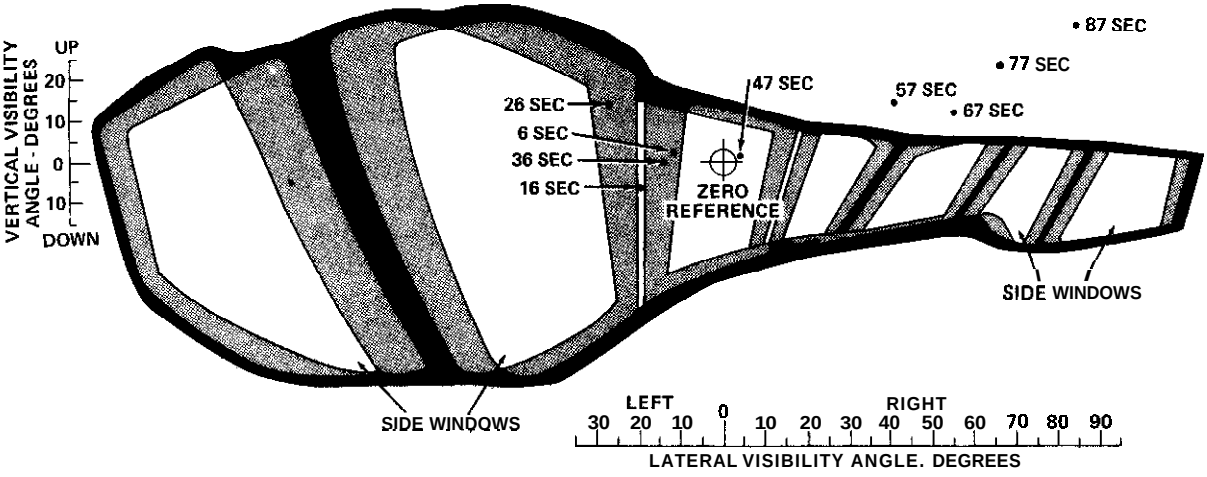
All reference to angles and locations of aircraft targets are based on the zero eye reference point. Had the seat occupants moved their heads or torsos, their eyes would have been in different locations and the visibility of the other aircraft would have been different from that shown on the diagrams.

1.17 Additional Information

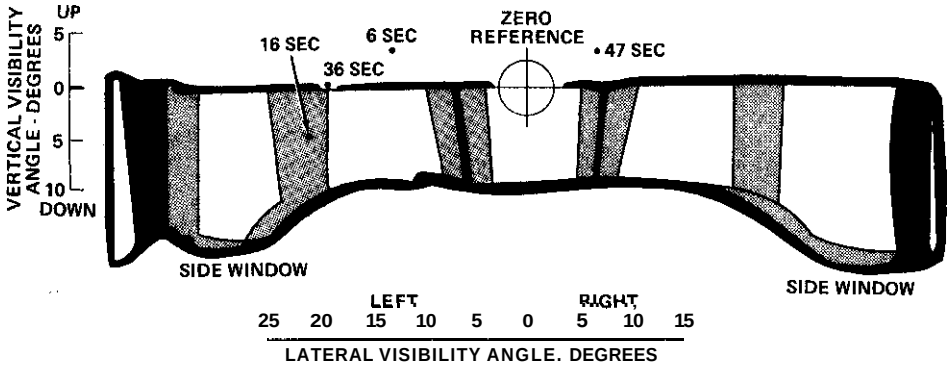
1.17.1 Flight Safety International Training Syllabus

The students in the Falcon Jet were being trained under contract for Saudi Arabian Airlines. The purpose of the program was to provide initial pilot training and an FAA pilot certificate with commercial, single and multiengine, instrument ratings. The three students, who were in the final stages of the training program, had received this training and the ratings during the initial phases of the program. This final phase was to transition the students into jet aircraft before entering the Saudi Arabian Airlines B-727 first officer training program. For this reason, the students were being trained to fly from the right seat. Since the training program consisted of multiple instrument approaches, it was possible that a vision-limiting device (hood) was in place in front of the student pilot in the right seat.

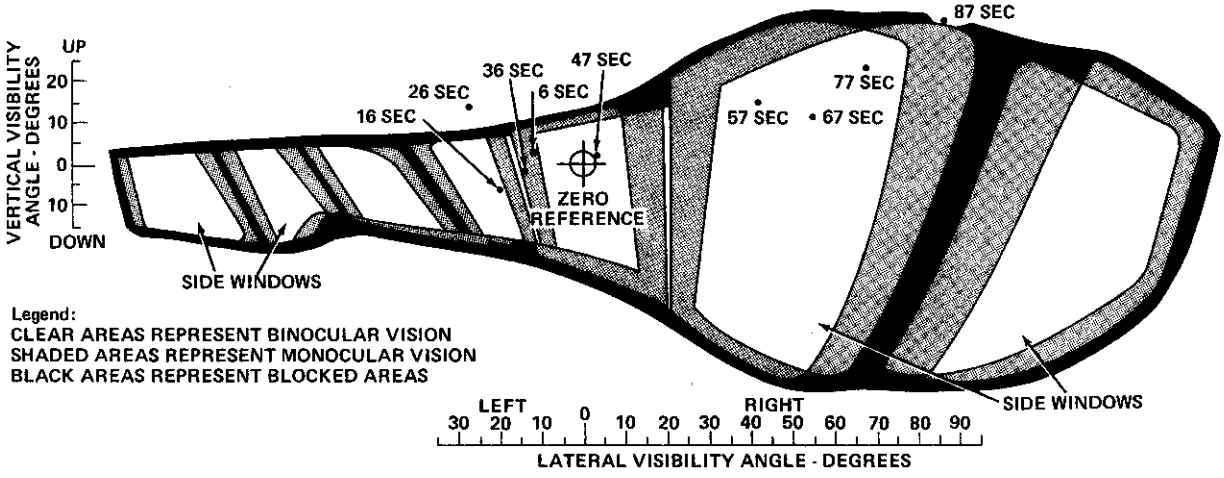
5/ A dual lens camera was used to record a panoramic view from the design eye reference point from each cockpit seat. These binocular photographs show the field of vision of each seat occupant based on his fixed-eye reference point.



FALCON FAN-JET LEFT SEAT VISIBILITY FROM DESIGN EYE REFERENCE POINT (PILOT)



FALCON FAN-JET OBSERVER SEAT VISIBILITY FROM DESIGN EYE REFERENCE POINT



FALCON FAN-JET RIGHT SEAT VISIBILITY FROM DESIGN EYE REFERENCE POINT (STUDENT)

Figure 2. Falcon Jet visibility from design eye reference points.

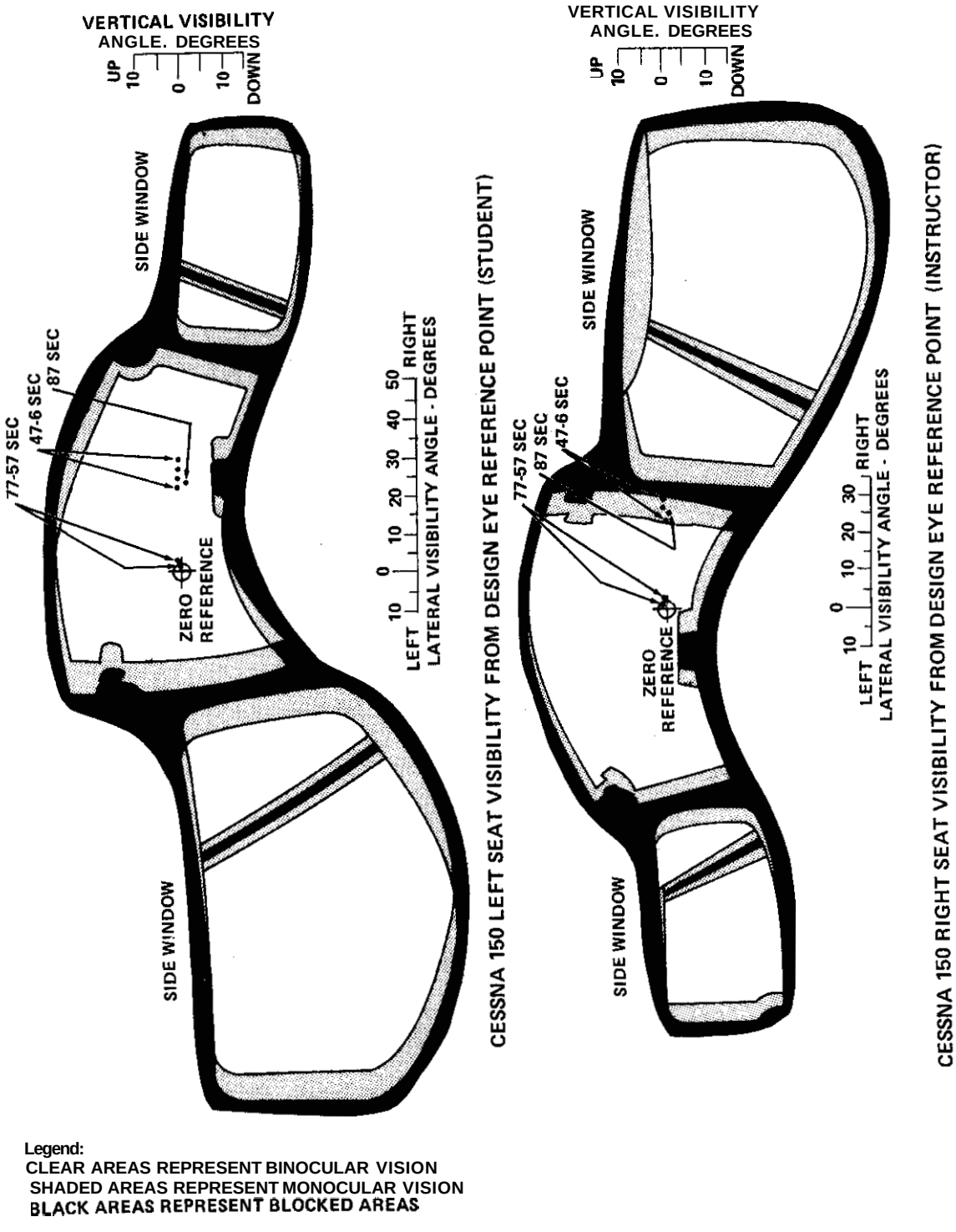


Figure 3. Cessna 150 visibility from design eye reference points.

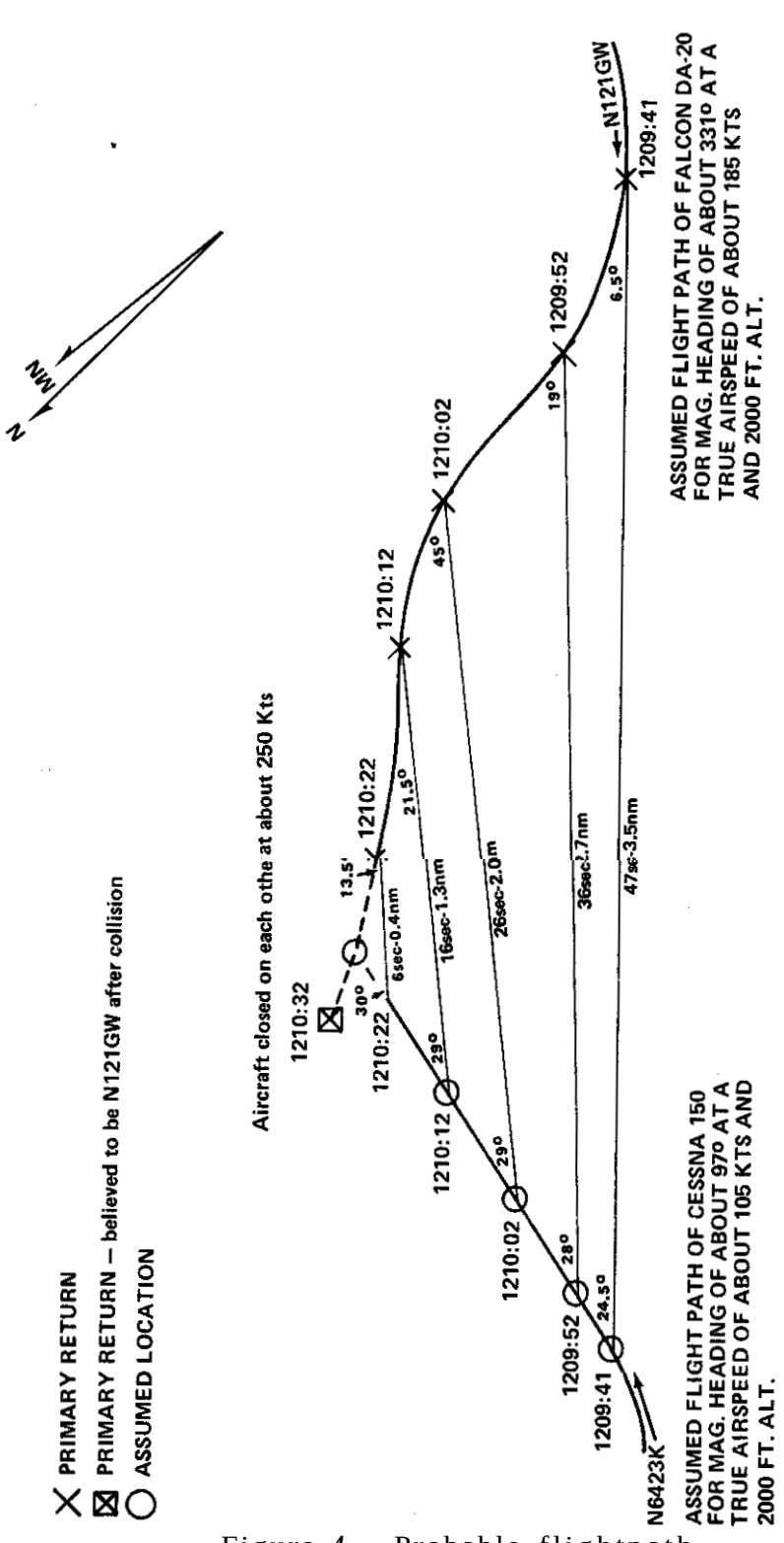


Figure 4. Probable flightpath.

Accord
instruction beir
of flight traini
understood instr
aircraft for di
included. Instr
appropriate hol
departures from
instrument appr
course approach'
also practiced.

Fligh
responsibilitie
aircraft. Befo
Pilot would bri
avoid" techniqu
for looking for

Excep
students fly th
training sessic
after 1 hour of

1.17.2 ATC I

The 1
purpose of the
VFR aircraft a
use of Stage I

The

is:

(a)
(b)
(c)

The
and ATC Proced
Stage III serv
aircraft. The
observed but t
provided all
lists, under t

"THI
PILI
TRA

According to a spokesman for Flight Safety International, the instruction being given at the time of the accident consisted of 1 hour of flight training for each student on board to assure that the student understood instrument flight techniques and methods used to maneuver the aircraft for different instrument approaches; emergencies were not included. Instrument departures were flown to a given holding fix at an appropriate holding aititude. Flight in a holding pattern and then departures from the holding pattern and transition to a requested instrument approach fix were practiced. ILS, VOR, ADF, and ILS back course approaches, missed approaches, and touch-and-go landings were also practiced.

Flight Safety International stressed the students-not-flying responsibilities in observing cockpit training and in looking for other aircraft. Before the first flight of the training day, the instructor pilot would brief the students on emergency procedures and "see-and-avoid" techniques. The student-not-flying on the jumpseat was responsible for looking for conflicting traffic.

Except for during seat changes and while on the runway, students fly the aircraft from the right seat at all times during the training session. Students normally changed seats on the downwind leg after 1 hour of training was completed.

1.17.2 ATC Procedures

The Memphis International Airport has a designated TRSA. The purpose of the TRSA is to provide radar separation between all participating VFR aircraft and all IFR aircraft operating within the TRSA through the use of Stage III radar service.

The designated TRSA airspace for Memphis International Airport is:

(a) Surface to 8,000 ft within 5 miles of the airport.
(b) 2,000 ft to 8,000 ft within 10 nmi of the airport.
(c) 3,000 ft to 8,000 ft within 15 nmi of the airport.

The Airman's Information Manual (AIM), "Basic Flight Information and ATC Procedures," explains the services available to pilots under Stage III service--radar sequencing and separation service for VFR aircraft. The AIM states, "Within the TRSA traffic information on observed but unidentified targets will, to the extent possible, be provided all IFR and participating VFR aircraft." In addition, the AIM lists, under "Pilot's Responsibility," the following:

> "THESE PROGRAMS ARE NOT TO BE INTERPRETED AS RELIEVING PILOTS OF THEIR RESPONSIBILITIES TO SEE AND AVOID OTHER TRAFFIC OPERATING IN BASIC VFR WEATHER CONDITIONS...."

14 CFR 91.67, Right-of-way Rules, states: "When weather conditions permit, regardless of whether an operation is conducted under Instrument Flight Rules or Visual Flight Rules, vigilance shall be maintained by each person operating an aircraft so as to see and avoid other aircraft in compliance with this section."

The FAA provided guidance for air traffic controllers in Handbook 7110.65A, Air Traffic Control, dated January 1, 1978. This Handbook lists specific procedures and requirements for controllers handling traffic in a Stage III TRSA.

Within a TRSA, Stage III service is mandatory on the controllers' part unless a pilot declares that he does not want to participate in the Stage III service. Stage III service requires that radar or vertical separation be maintained until visual separation between the aircraft is gained. Vertical separation in the TRSA is 500 ft between VFR aircraft and an IFR aircraft. Radar separation is a minimum of 1 1/2 miles.

In the Handbook, Chapter 3, Section 18, "Additional Services," Paragraph 510 states, "Provide additional services to the extent possible contingent only upon your capability to fit it into the performance of higher priority duties.. .."

Paragraph 510A, Note, "The primary purpose of the ATC system is to prevent a collision between aircraft operating in the system.... The provision of additional services is not optional on the part of the controller, but rather is required when the work situation permits."

Paragraph 511, TRAFFIC INFORMATION, states: "Unless an aircraft is operating within positive controlled airspace or omission is requested by the pilot, issue traffic information to aircraft on your frequency when in your judgment their proximity may diminish to less than the applicable separation minima."

1.17.3 Memphis ATC Tower Procedures

The facility had established procedures to permit IFR and VFR traffic to operate simultaneously from the north and south runway complexes. Flights operating under IFR frequently conducted multiple instrument approaches for training purposes. There were no special facility procedures published for that type of operation, and therefore, standard control procedures were applicable. These procedures required that the activities of the flights be coordinated among the controllers who were responsible for the airspace to be used.

The common procedure utilized for the runway 17R traffic pattern operation was for LC2 to vector the aircraft to a west or northwest heading at 2,000 ft and then transfer control to AR6, who would sequence

the aircraft for another approach. The controllers used this procedure during the 2 hours 3 minutes that the Falcon Jet flew in the traffic pattern for runway 17R.

The geographic layout of the airport dictated that an aircraft making multiple instrument approaches to runway 17R would have to fly through LC1's airspace on the downwind leg. Therefore, coordination between the LC1 and LC2 was mandatory to separate traffic.

A cab coordinator position (CC) was established to coordinate the activities of LC1 and LC2. However, this position did not have to be manned when, in the judgment of the tower cab supervisor, the air traffic could be handled safely by LC1 and LC2. When the CC position was unmanned, LC1 and LC2 were responsible for coordinating their own tasks. On the day of the accident, the CC position was manned until 1111. At that time, the supervisor left the position vacant to provide for the controller's lunch and relief breaks. In his opinion, the overall facility traffic was light. The LC2 stated that he believed the traffic situation at the time of the accident was moderate to heavy, whereas AR6 and AR2 could recall handling only one or two other aircraft. LC2 had made 23 transmissions in 2 minutes 42 seconds involving 7 aircraft. (See Appendix D for transmissions made by LC2 from 1207:21 to 1210:03.)

LC1 and LC2 could coordinate their tasks through communications over the interphone or by direct conversation within the tower cab. The controllers stated that visual coordination was also possible. Visual coordination takes place when a controller wishing to vector an aircraft into another controller's airspace looks at the BRITE display to see if there is conflicting traffic in the other sector. He then vectors his aircraft into the other controller's airspace without informing that controller. However, if visual coordination is employed, the controller initiating the vector is responsible to provide separation for the aircraft from all observed radar traffic while the aircraft is in the other controller's airspace. Although verbal coordination was effected on the previous approaches of the Falcon Jet, at the time of the accident visual coordination was employed.

1.17.4 Relative Flightpaths of the Falcon Jet and the Cessna 150.

The flightpath of each aircraft was determined from data received and recorded on Memphis ARTCC radar processing equipment for 1 1/2 minutes preceding the collision. The data showed that the Falcon had completed a right turn to a course of 350" magnetic a little more than 30 seconds before impact. The aircraft then drifted to the left. The last transponder return for the Falcon Jet on the assigned code 5511 was recorded at 1210:22 at 2,100 ft. The course during the 10-second interval between the final two transponder returns was 310° magnetic. The distance between successive transponder returns showed the groundspeed for the Falcon to average 191 kns.

The Cessna was not equipped with a transponder. Primary radar returns showed that the aircraft maintained an average course of 124° magnetic between 1209:01 and 1209:31. The final primary return received at 1209:51 showed that the aircraft had turned or was turning to the left. The average course during the 20-second interval between the final two radar returns was 106" magnetic. The distances between successive radar returns were not consistent; however, the groundspeed averaged 100 kns between the first plotted radar position and the position of impact.

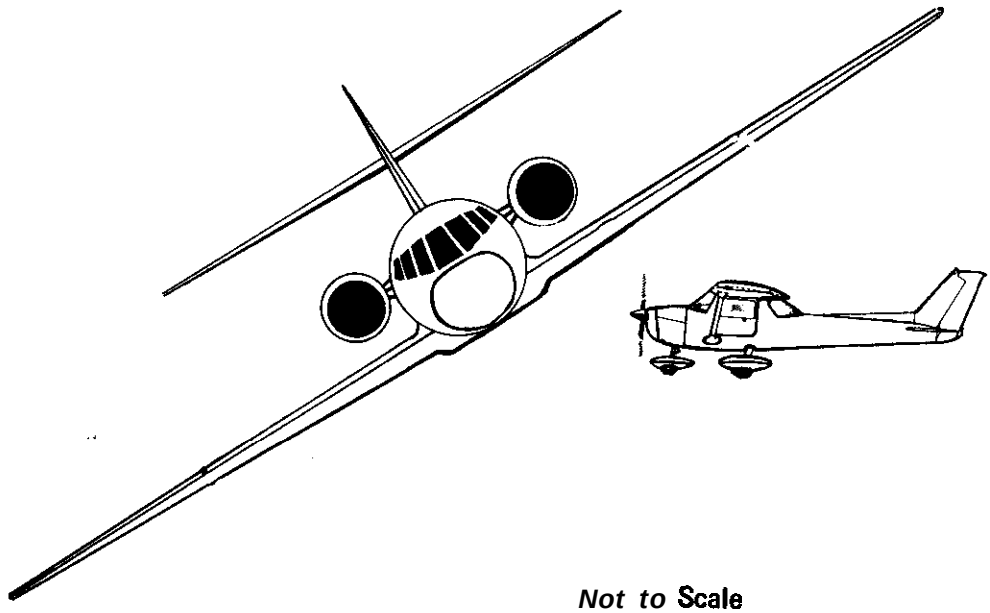
Although the precise time of impact could not be determined, a single primary radar return was recorded at 1210:32. There was no transponder reply corresponding with this return. The position was 323° magnetic from the last transponder return for the Falcon Jet (1210:22) and 087" magnetic from the last primary return from the Cessna (1209:50)

The wreckage of both aircraft exhibited distinct scratches or gouges which were used to determine relative headings and airspeeds at the instant of impact. The comparison of the location and direction of the scratches relative to the respective fuselage centerlines indicated that the Falcon Jet was banked about 35" to the right at the time of impact and that the included angle between the aircraft headings was about 126". (See figure 5.) The speed of the Falcon Jet was about 1.75 times the speed of the Cessna.

Based on the communications from the local controllers to both aircraft, on radar data, on the scratch-mark analysis, and on the wreckage orientation, the Falcon Jet was probably returning to its assigned heading of 350° and passing through 331° when it was hit. This conclusion is supported by the 330" heading indicated on the copilot's radio magnetic indicator. Although the damage to the directional indicator on the Cessna would imply that the aircraft was on a heading of 108" magnetic, it appears more likely that its heading was about 097" magnetic. That heading correlates with the scuff marks on the wreckage, the radar position plot, and the heading which would be expected had the aircraft been proceeding to the position for a downwind entry for runway 27. Based on reported wind velocities and direction, true airspeeds would have been about 185 kns for the Falcon Jet and 105 kns for the Cessna. This collision geometry indicates that the planes collided 3 or 4 seconds before the single primary radar return was received at 1210:32. (See Appendix C.)

1.18 New Investigative Techniques

None



Not to Scale

Figure 5. Relative positions of aircraft at impact.

2. ANALYSIS

The pilots were certificated properly and were qualified for the flights. There was no evidence that medical factors might have affected the flightcrews' performance.

The aircraft involved were equipped and maintained in accordance with regulations.

The lowest reported cloud layer in the vicinity of the accident was a scattered layer at 4,500 ft above ground level (a.g.l.). Since the surface visibility was 6 miles, both aircraft were operating clear of the clouds in visual meteorological conditions. With the inversion reported at 6,500 ft a.g.l, the visibility at 2,000 ft should not have been significantly less than the surface visibility. However, some reduction in flight visibility cannot be completely discounted, and a flight level visibility of 5 miles was possible at the time of the accident. The elevation angle of the sun was too high to interfere significantly with flight visibility, particularly with the diffusing effects of a cirrus overcast. The haze and sunlight were involved only to the extent that they would have caused colors to blend and contrasts to diminish, which would have made identification of an approaching aircraft more difficult.

The correlation of the radar data and other data indicate that the heading of the Falcon Jet was about 310° for the last 10 seconds of flight before the collision. Radar data showed the Cessna's final heading to be 097°.

The Falcon Jet was in a 30" to 40° right bank when it collided with the Cessna. Scratch marks, gouge marks, and depressions on aircraft debris substantiate that the Cessna and the Falcon Jet first made contact on the lower left side of the fuselage of the Falcon. The steep bank indicated by this evidence corresponds with the right banks of 40" and 20° on the flight directors located in the wreckage. As a result of the right bank in the final seconds, the heading of the Falcon when the planes collided was more than 330°. Based on the known heading of the Cessna, which was straight and level when the planes collided, and the measured scratches and gouges, the Falcon Jet's heading when the planes collided was about 331°. The horizontal collision angle between the longitudinal axis of the two aircraft was 126°.

Forty-seven seconds before the collision, the Cessna 150M would have been about 6.5" to the right of both the student's and the instructor pilot's iero reference points. This position afforded an unobstructed view of the Cessna, although the Falcon was in a 25° bank to the right and the aircraft were about 3.5 miles apart. This was the only time that both pilots in the Falcon had a completely unobstructed view of the Cessna. The Falcon rolled level and then into a left bank

as it continued toward the point of impact. From the 47-second timeframe until impact, the crew of the Falcon could see the Cessna only monocularly if neither the student nor the instructor pilot moved his head away from the zero reference point.

At 16 seconds before impact, the Cessna was about 1.3 miles from the Falcon and 21.5° to the left of the student pilot's zero reference point. The Cessna could have been detected monocularly since the windshield post partially obscured the Cessna from full binocular vision. If no hood was in place, it was possible that, for the 16 seconds before impact, the student pilot had an unobstructed view of the Cessna.

The instructor pilot's view of the Cessna was probably partially obscured for the final 47 seconds. During this time, the Cessna would have been between the front windshield and the side window, and the windshield post would have restricted binocular vision. However, the instructor pilot could have seen the plane monocularly during the time period and could have seen it clearly if he moved his head from the zero reference point.

The view from the jumpseat was completely' obstructed from *47* to *36* seconds before impact, and was periodically obstructed from 36 seconds until 6 seconds before impact.

The instructor pilot in the right seat of the Cessna would have had an unobstructed view of the Falcon from *77* seconds through 57 seconds before impact. The Falcon would have been within 3° of his zero reference point; however, the Falcon could have been between 4.1 and 5.2 miles away and the Cessna instructor pilot may have interpreted the Falcon as being in the airport traffic pattern and not on a converging path.

From the 57-second point until impact, the Falcon would have been in the right corner of the instructor pilot's windshield. In this position it would have been partially obscured for most of the time. However, the Falcon was visible monocularly.

The left seat occupant would have had a completely unobstructed view of the Falcon for *87* seconds. The Falcon's target would have ranged from the zero reference point to 30° right of that point.

In order to understand the events of this accident, it was necessary to analyze the see and avoid aspects as well as the failures of the ATC system. The crews of the Falcon and the Cessna were responsible to "see and avoid" any aircraft which could present a midair hazard according to *14* CFR 91.67 and the AIM. However, the Safety Board recognizes the practical drawback to the effectiveness of see and avoid in a high-density terminal area. The practical effectiveness of the see and avoid concept is further limited by the reliance of the pilot on the ATC system to provide radar separation.

The Safety Board believes that in a TCA or a TRSA, which are established to provide radar separation to aircraft, a pilot should be able to rely on the ATC system for accurate and timely traffic advisories and separation. Ultimately, the ATC system should be able to provide complete radar geparation through the use of improved technology and refined procedures. Until that time, however, the see and avoid concept must remain an integral aspect of the total air traffic system in order to provide a backup to the possibility of human or system error in the ATC system.

At the present time, the Board believes that while the controller assumes an increased responsibility for radar separation in a TRSA or TCA because of the equipment available to him, the responsibility of the pilot for the safe operation of his aircraft is not diminished.

Although both aircraft were visible at various times to each flightcrew, conditions existed which may have resulted in the failure of the pilots to detect the other aircraft. These conditions were:

- o They may have relied too heavily on the ATC system to provide separation services and traffic advisories.
- o The pilot of the Falcon may have been actively conducting flight training while the instructor pilot of the Cessna may have been orienting his passenger to the Memphis Airport and surrounding ground features.
- o The instructor pilot of the Falcon was in the left seat; therefore, any conversations he conducted would have been directed to the right side of the cockpit.
- o The instructor pilot of the Cessna was in the right seat and would direct his conversations to the left side of the cockpit.
- o The target would have been viewed through haze, which would reduce one's ability to descern shape, form, size, and motion.
- o The convergence angle of the two aircraft would have resulted in a lack of relative motion between the two aircraft.
- o The general color of the Falcon would have been difficult to see in the haze.

The Safety Board believes that a significant issue in this accident was the fact that active flight training was being conducted in a high density TRSA. The training was intermixed with air carrier and other general aviation activity, and is not inherently dangerous when controlled properly. In this situation, the lack of necessary instrument facilities at the designated reliever airports made it necessary for the Falcon to practice instrument approaches at Memphis International Airport. The Safety Board, however, has repeatedly urged that the FAA alleviate the need to conduct extensive flight training at larger

airports by developing the reliever airport system. Aviation forecasts indicate that air carrier, general aviation, and commuter operations will strain the capacity of existing major airports in the near future. The Board believes that the development of reliever airports, with all weather capabilities, will relieve the congestion caused by the increasing numbers of operatiqns and will allow a more suitable training environment away from major hub airports. Coincident with the development of reliever airports, the criteria for the emplacement of ILS systems should be modified to allow installation based on community needs rather than on an actual count of aircraft operations.

The Cessna and the Falcon were under radar control of air traffic controllers in the Memphis TRSA. The Falcon had completed numerous traffic patterns for runway 17R while operating on an instrument flight plan. On each occasion, the crew was provided vectors, traffic advisories, and radar separation according to the ATC procedures established for the Memphis TRSA. At the time of the collision, the Falcon was being controlled in the same manner in which it had been for the past 2 hours.

The Cessna was also in radar contact and was being controlled according to the procedures established for VFR Stage III arrival aircraft in the Memphis TRSA. Consequently, the pilot would have expected to receive traffic advisories and the radar separation provided by Stage III radar service.

The procedures outlined in the AIM and Air Traffic Controllers Handbook 7110.65A state clearly those conditions under which ATC shall provide separation between VFR aircraft receiving Stage III radar ser and IFR aircraft, and the procedures through which separation shall b provided. ATC personnel in the Memphis facility had the obligation to separate the Cessna and the Falcon in accordance with applicable criteri and to control the aircraft in the same positive manner afforded IFR aircraft.

Obviously, the ATC system failed to provide the separation minima required for known VFR and IFR traffic operating within, and participating in, a designated TRSA. The individual controllers who were responsible for the control of the two aircraft did not coordinate with each other as required for the specific operation being conducted. As a result, neither of the controllers involved with the Falcon were aware that the Cessna was inbound from the west, and the third controller, who was controlling the Cessna, did not know of the Falcon's traffic pattern operation through his airspace at 2,000 ft. The conflict was not recognized until the aircraft were so close that no corrective action was possible.

In this case, LC2 used an unsafe and unacceptable coordination technique. He "visually" coordinated to insure there was no conflicting

traffic. Unfortunately, once the Falcon was turned over to AR6, AR6 assumed that positive coordination with LC1 had been accomplished. As a result, he was unconcerned when he finally did see the Cessna's primary radar return. At that time, LC2 was not following the flightpath of the Falcon and, thus, was unable to recognize the hazard presented by the Cessna. Finally, LC1 handled the Cessna routinely. Had LC1 known that the Falcon was being vectored through his airspace at 2,000 ft, he could have provided heading or altitude separation. Since coordination was not effected, LC1 and AR6 were working independent of each other with aircraft at the same altitude--each unaware of the other's activities.

The Safety Board believes that the failure to coordinate the operation of the Falcon with the responsible controller personnel could have been a result of the workload of LC2 when coordination with LC1 should have been effected. The Safety Board recognizes that 23 transmissions in 2 minutes 42 seconds is a considerable workload, especially when several aircraft are involved. LC2's attention may have been diverted further by the need and additional time required for the Falcon to pass behind the westbound light aircraft at 1208:56. LC2 may have assumed that the other controllers were aware of the Falcon's presence in the traffic pattern and that separation would be applied routinely through the use of radar observations.

While the cause of the accident was precipitated by the failure of LC2 to coordinate properly, the Safety Board is also concerned by the assumptions made by the AR6 controller. When AR6 first saw the Falcon begin a turn from the assigned heading of 350° to 320°, he did not ask the pilot why the unauthorized turn was made. He stated he was not concerned because training flights "sometimes...make turns that they should not make or are not instructed to make. The only time it is of concern is if I have traffic or some need for him to stay on a certain heading..."

Although the AR6 final controller had only a few seconds to issue the proper traffic advisories to the Falcon, he should have made the attempt to do so. Furthermore, he should not have accepted a turn to a heading of 320° for any reason once the pilot had accepted the instruction to fly a 350° heading. The ATC system is a precise system, and assumptions of this nature cannot be tolerated.

A second invalid assumption made by AR6 was that the aircraft were not at the same altitude. AR6 assumed that since he was not told of the Cessna's presence west of the airport, the primary target he observed was unknown traffic either at 500 ft or above his airspace overpassing the Memphis TRSA.

Since AR6 did not have a heavy workload, there was no significant distraction to occupy his attention. To the contrary, he saw clearly the entire sequence of events without ever becoming concerned. He did state that if he had been aware of the Cessna, he could have applied separation criteria.

The Safety Board concludes that reliable primary radar target returns from the Cessna were depicted on the tower BRITE radar displays and on the radar screen of AR6, regardless of any anticlutter devices which might have been used. This conclusion is based on: (1) AR2 had no problem identifying and handing off the Cessna to LC1; (2) AR2 indicated that the primary returns of the Cessna were distinct before becoming slightly smaller; (3) LC1 accepted the handoff without difficulty and gave no indication of a weak or unsatisfactory target return; and (4) AR6 saw the primary radar return of the Cessna as did LC1 and LC2 just before the collision.

The Safety Board concludes that the primary radar return of the Cessna was visible on the radar displays for the whole time the aircraft was within range. If the Cessna had been transponder-equipped, controller personnel would have had a better opportunity to detect the coordination error because a data block tag would have been visible. However, the relative strength and size of the return was not relevant. If the controllers involved with the aircraft had communicated and coordinated properly, proper separation measures could have been implemented even if the Cessna could not be seen on radar. The key factor was the knowledge of the aircraft's presence.

The Safety Board believes that the decision by the tower cab supervisor to leave the cab coordinator position vacant contributed to the breakdown in coordination. Although the cab supervisor determined that the overall workload was light, the workload of LC2 was moderate to heavy. Since a primary responsibility of the coordinator was to coordinate cab operations, the traffic assessment must include the workload of LC1 and LC2. Had the coordinator position been manned, the likelihood of coordination being effected would have been much greater.

In addition to the decision not to man the coordinator's position, a breakdown in supervisory control was evident from other facts which were revealed. LC1 stated that when he assumed that position at 1150, he was not briefed on the operation of the Falcon, although the aircraft had been in the traffic pattern for almost 2 hours. The supervisor also stated that he did not know how coordination was being handled between LC1 and LC2. The Safety Board believes that had the supervisory effort been more farsighted, the conditions which lead to the accident would not have developed.

The control procedures utilized by the Memphis facility to control traffic were developed and tailored to meet local needs, consistent with the requirements of ATC Handbook 7110.65A. The need to integrate the activities of the two airport areas placed a unique responsibility on the controllers with respect to control responsibilities. While the facility operating procedures were adequate, it was imperative that specific procedures be strictly adhered to. No deviation was acceptable since the 2,000-ft traffic patterns left no margin for error. When

the coordination procedures broke down, there was no redundancy to provide an additional safeguard for aircraft. The Safety Board believes that, in this particular situation, redundancy was necessary to insure a safe flow of traffic. Designated traffic pattern altitudes which provide 500-ft vertical separation are additional safeguards which probably would have stopped the sequence of events leading to the accident.

In summary, the Safety Board believes that the ATC system has made steady progress in the advancement of aviation safety through the development of improved procedures, airspace designations, and automated equipment. In this accident, both aircraft were operating in a controlled environment which was designed to minimize the risk of collision between participating aircraft. However, the investigation revealed that the ATC procedures in effect lacked the redundant safeguards needed when controller coordination procedures were not followed. The Board believes that the state-of-the-art procedures and equipment did exist which could have prevented the accident.

Although aircraft operating in a TRSA are not required to be equipped with a transponder in order to receive Stage III service, the aircraft transponder is an essential element in the current and future automated ATC environments. Aircraft without transponders place an added workload on controller personnel, because they do not have a reinforced radar target or the advantage of a data block tag on the target. A transponder is required for flight operations conducted above 12,500 ft and in designated terminal control areas. In addition, it is necessary to the functional operation of the NAS A en route automated environment and the ARTS III terminal automated environment. The conflict alert system, now operational in the en route environment, is being installed in the terminal environment. When the conflict alert system becomes fully established the transponder will be even more essential.

Additional detection and midair collision avoidance systems include the Beacon Collision Avoidance System (BCAS) and the Discrete Address Beacon System (DABS). Each of these systems, which are currently being developed, has the potential to provide significant safety benefits to the future ATC system. As with the conflict alert system, the transponder is essential to the operation of DABS and BCAS. The Safety Board believes that conflict alert, DABS, BCAS, and the transponder could have provided the needed system redundancy to prevent this accident.

In this case, had the Cessna been equipped with a transponder, the data block ARTS III tag would have displayed the aircraft identification and altitude. This data tag would have made detection by controller personnel immediate and, thus, eliminated the confusion from lack of controller coordination. The transponder would also have placed the Cessna in the ATC system on an equal basis with the Falcon, rather than as a primary target which could easily be confused with nonparticipating TRSA traffic.

Had the Cessna been transponder-equipped and had a conflict alert system been installed at the Memphis facility, control personnel would have received both aural and visual conflict alarms. The warning would have allowed controllers the opportunity to recognize the hazard and to take measures to prevent the collision. Further, had the Falcon been equipped with %CAS, another means of detecting the collision potential, the collision would have been highly unlikely.

The Safety Board concludes that all aircraft operating in a TRSA I should be Mode C transponder-equipped. Further, the Board strongly recommends that any systems developed should be installed and developed expeditiously to insure that the ATC system utilizes the most effective and efficient detection and separation equipment available to the industry.

3. CONCLUSIONS

3.1 Findings

1. The crewmembers were certificated and qualified for the flight.

2. The aircraft were certificated and maintained in accordance with FAA requirements.

3. The in-flight visibility was probably 5 miles.

4. Each aircraft should have been visible to the crew or pilot of the other aircraft in sufficient time to avoid the collision.

5. Neither crew exercised the proper and required see-and-avoid procedures.

6. The angle of collision was about 126° with the Falcon in a 30° to 40° right bank. The Cessna was straight and level.

7. Both aircraft were operating in the TRSA according to established ATC procedures.

8. Both aircraft were in both radar and radio contact with the tower.

Both crews were expecting radar separation service and traffic advisories as required by ATC procedures.

Proper radar separation and traffic advisories were not provided by controller personnel,

11. Memphis TRSA did not have an established procedure to insure coordination for IFR aircraft which were conducting multiple instrument approaches.

12. The primary radar return of the Cessna should not have affected adversely ATC procedures.

13. LC2 had a moderate to heavy workload at the time the accident occurred.

14. LC2 vectored the Falcon Jet northwest after a missed approach in accordance with accepted procedures for aircraft conducting instrument approaches.

15. LC2 failed to coordinate with LC1.

16. LC1 was not aware that the Cessna would be in conflict with any traffic in his airspace and performed his controller duties accordingly.

17. AR6 assumed that LC2 had coordinated with LC1 on the Falcon in LC1's airspace.

18. AR6 was not aware that the Cessna was approaching the airport from the west.

19. AR6 should have corrected the Falcon Jet when the aircraft was turned from the assigned heading of 350° to 320".

20. AR6 made incorrect assumptions regarding the conflict represented by the primary target of the Cessna.

21. Visual coordination was an inadequate form of coordination since the LC2 controller handed off the Falcon Jet to AR6. In reality, no coordination took place.

22. LC1 and AR6 were controlling separate aircraft at the same altitude without any knowledge of what the other was doing.

23. The tower cab supervisor did not insure that proper coordination procedures were effected in the tower.

24. LC1 did not receive a proper briefing before assuming that position.

25. The intersecting traffic patterns at 2,000 ft were not acceptable because they did not provide an adequate margin of safety.

3.2

probal
to se
termi
effec
each

Board

BY TH

Novem

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the failure of controller personnel to separate the aircraft as required by procedures established for a terminal radar service area, to insure that proper coordination was effected, to issue appropriate traffic advisories, and the failure of each flightcrew to see and avoid the other aircraft.

4. SAFETY RECOMMENDATIONS

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

"Evaluate the closed traffic pattern operations conducted at Memphis International Airport and consider establishment of a procedure whereby high performance or turbine jet aircraft conducting multiple approaches for training purposes be assigned an altitude of 2,500 ft or above, which wculd place responsibility for control of the aircraft with TRACON personnel. (Class II, Priority Action)(A-78-79)

"Evaluate operational data for each TRSA location and establish two categories of TRSA's. Those locations handling the largest volume of traffic with automated ATC equipment available should be designated TRSA I locations. The remaining areas would be designated TRSA II locations. (Class II, Priority Action) (A-78-80)

"Require Mode "C" transponder equipment for operations within a TRSA I and Group II TCA and require that a pilot of a VFR flight traversing a TRSA I establish radio contact with the appropriate ATC facility before entering the designated airspace. (Class II, Priority Action)(A-78-81)"

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JAMES B. KING
Chairman

/s/ ELWOOD T. DRIVER
Vice Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PHILIP A. HOGUE
Member

November 30, 1978

5. APPENDIXES

APPENDIX A

INVESTIGATION AND DEPOSITIONS

1. Investigation

The National Transportation Safety Board was notified of the accident about **1300 on** May 18, 1978. The Safety Board immediately dispatched an investigative team to the scene. Investigative groups were established for operations, air traffic control, witnesses, weather, human factors, systems, and structures.

Parties to the investigation were: Federal Aviation Administration, Flight Safety International, Inc., National Business Aircraft Association, Professional Air Traffic Controllers Organization, Aircraft Owners and Pilots Association, and the Falcon Jet Company.

2. Depositions

Deposition proceedings were conducted in Memphis, Tennessee, **on** May **23, 1978.** Parties to the proceedings were: The Federal Aviation Administration, Flight Safety International, Inc., National Business Aircraft Association, Professional Air Traffic Controllers Organization, and the Aircraft Owners and Pilots Association.

APPENDIX B

PERSONNEL INFORMATION

John H. Mitchell, Jr.

Mr. Mitchell, 33, had been employed by Flight Safety International for about 18 months. He held Airline Transport Pilot Certificate No. 1745870, issued October 5, 1976, with commercial privileges L-382 and private privileges airplane single-engine land. He had a type rating for the Falcon DA-20. He held a flight instructor certificate, and a ground instructor certificate with advanced and instrument ratings. Mr. Mitchell was an FAA-designated pilot proficiency examiner in DA-20 aircraft and the DA-20 simulator. His first-class medical certificate was issued January 6, 1978, with no limitations.

Mr. Mitchell passed a flight test for designation as a pilot proficiency examiner on April 4, 1978, which was equivalent to a biennial flight review. He had served in the U.S. Air Force for 9 years, during which time he had performed as an instructor pilot and a chief evaluation officer. His current duties with Flight Safety International included ground, simulator, and flight instruction.

Mr. Mitchell had a total of 3,647 flight-hours. This included about 350 hours as pilot-in-command of DA-20 aircraft.

Saudi Arabian Students

Each of the Saudi students held temporary FAA commercial pilot certificates and first-class medical certificates with no limitations. They all had single and multi-engine and instrument ratings.

The students came to this country to train with Flight Safety International. They had no flight time prior to the onset of the training. Under Flight Safety International, each student completed a course of instruction designed to provide an FAA certificate, about 300 hours of flight time, and a complete knowledge of Federal Air Regulations. All flight time, with the exception of 4 hours, was in propeller-driven aircraft.

Danny M. Conaway

Mr. Conaway, 30, was a part-time instructor pilot with the Memphis Flying Club. He held commercial pilot certificate No. 2147289, issued May 15, 1975, with airplane single and multi-engine land, instrument airplane, and L-382 ratings. He also held a flight instructors certificate with an airplane single-engine land rating issued May 15, 1975, and re-issued February 21, 1977. His second-class medical certificate was issued February 14, 1978, with no limitations.

Mr. Conaway had been an Air Force pilot from 1971 through 1974. Since 1974, the majority of his flight time had been in twin-engine aircraft. He completed a biennial flight review on March 15, 1978. He had recorded 1,615 hours of flight time.

His student, Steve Norman, was on a familiarization flight and held no certificates.

Air Traffic Control Specialist Ronald M. Stratton (LC1 Controller)

Mr. Stratton holds an Air Traffic Control Certificate. He was employed by the FAA in November 1967 and was assigned to the Memphis facility in March 1977. He became a full performance level controller at Memphis in June 1977. He reported for duty at 0645.

Air Traffic Control Specialist Samuel W. Brasewell (AR2 Controller)

Mr. Brasewell holds an Air Traffic Control Certificate. He served as a U.S. Air Force Air Traffic Controller before becoming employed by the FAA in 1960. He was assigned to the Memphis facility in 1960 and became a full performance level controller in 1962. He reported for duty at 0730.

Air Traffic Control Specialist Richard McLean (LC2 Controller)

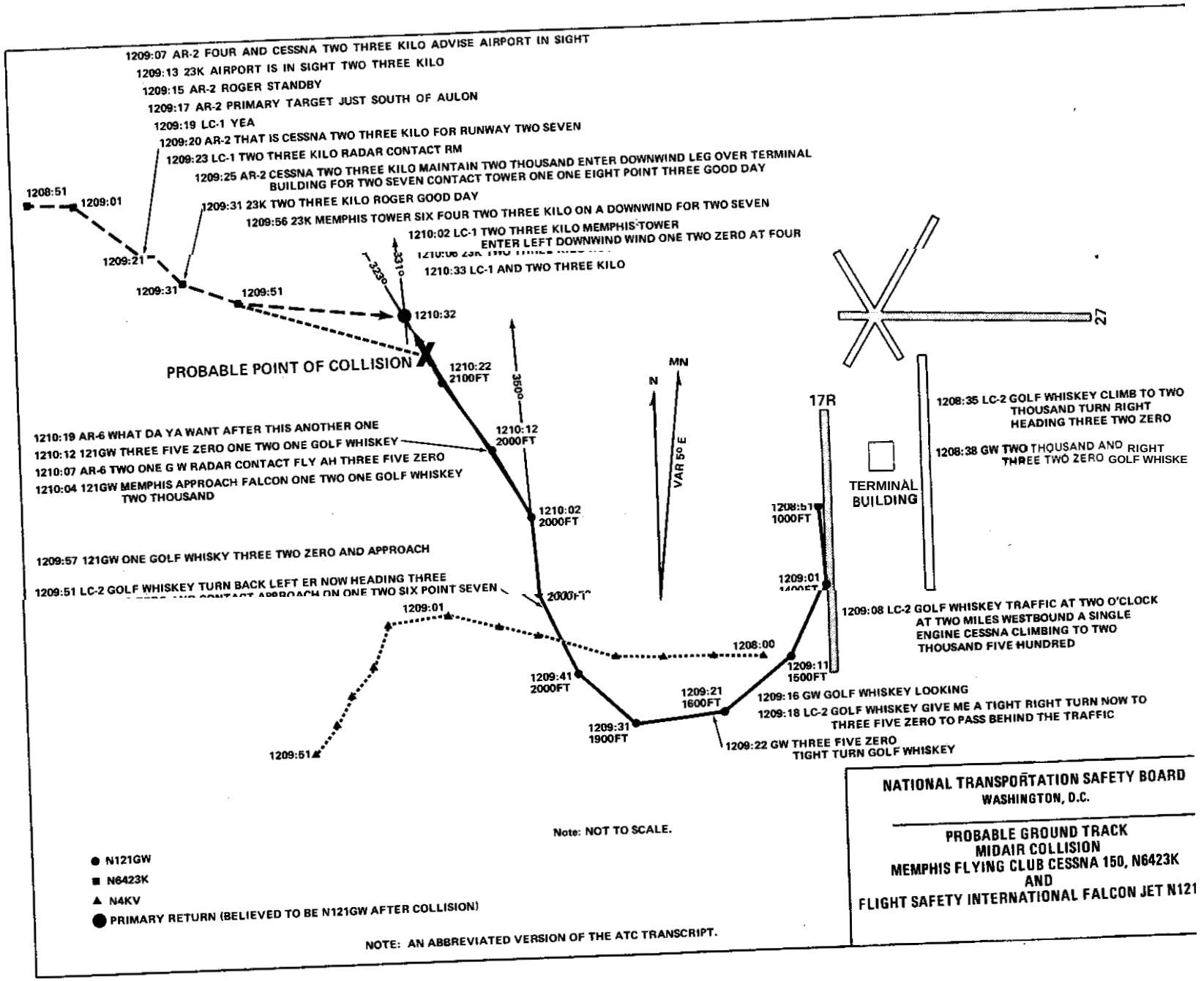
Mr. McLean holds an Air Traffic Control Certificate. He was employed as an Air Traffic Controller in 1971 and has been at the Memphis facility since March 1973. Mr. McLean reported for duty at 0630 on the day of the accident.

Air Traffic Control Specialist David N. Scott (AR6 Controller)

Mr. Scott holds an Air Traffic Control Certificate. He was hired by the FAA in April 1971 and was assigned to Memphis Facility in February 1977. He became a full performance level controller at Memphis in July 1977. Prior to joining the FAA, he had been an air traffic controller with the U.S. Air Force for 4 1/2 years. He reported for duty at 0730 on the day of the accident.

Supervisory Air Traffic Control Specialist Allen Stoddard (Tower Cab. Supervisor)

Mr. Stoddard holds an Air Traffic Control Certificate. He was employed by the FAA in 1959 and was assigned to the Memphis facility as a supervisor in 1974.



NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

PROBABLE GROUND TRACK
MIDAIR COLLISION
MEMPHIS FLYING CLUB CESSNA 150, N6423K
AND
FLIGHT SAFETY INTERNATIONAL FALCON JET N121

1210:03:

APPENDIX D

LC2 TRANSMISSIONS

LC2 made the following transmissions between 1207:21 and 1210:03:

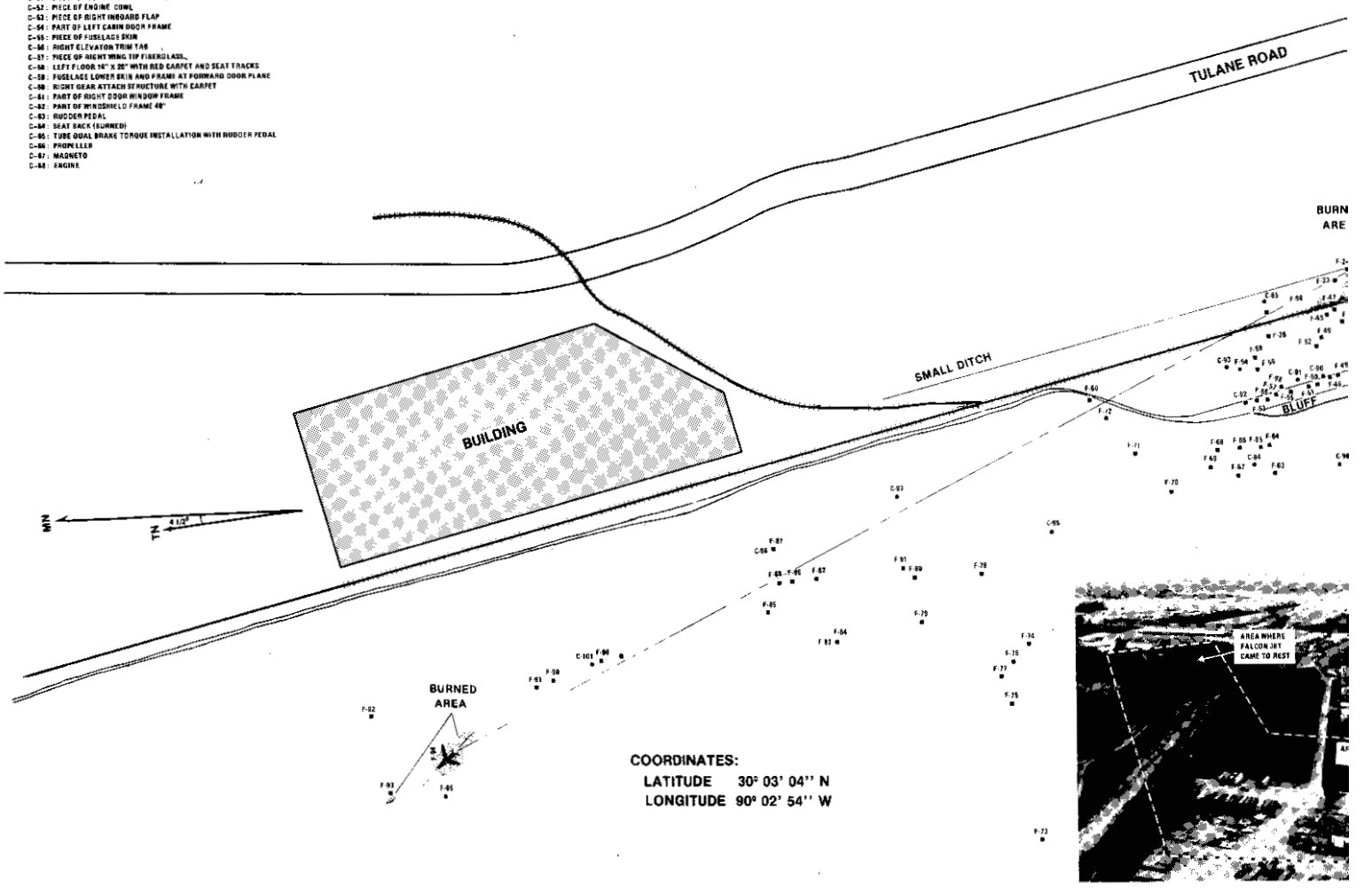
1207:21	LC–2	One oh one BG cleared to land one seven left, wind one eight zero at five
1207:28	LC–2	Golf Whiskey cleared touch and go
1207:30	LC–2	Here
1207:38 and 1207:44		Interphone comments by LC2
1207:48	LC–2	Kilo victor heading two seventy if that will help you
1207:53	LC–2	Four kilo victor, contact approach on one one niner point one
1208:08	LC–2	Delta four oh seven, taxi into position and hold
1208:32	LC–2	One four zero at six
1208:35	LC–2	Golf Whiskey, climb to two thousand turn right heading three two zero
1208:42	LC–2	Delta four oh seven, cleared for takeoff
1208:50	LC–2	Delta seven forty one, you next on the right
1208:56	LC–2	Sky tam two four taxi into position and hold
1209:02	LC–2	Taxi into position and hold
1209:09	LC–2	Golf Whiskey, traffic at two o'clock at two miles westbound, a single engine Cessna climbing to two thousand five hundred
1209:18	LC–2	Golf Whiskey, give me a tight right turn now to three five zero to pass behind the traffic
1209:24	LC–2	Lear BG, right ahead ground point nine
1209:33	LC–2	Express seventy three nineteen, cleared to land, wind one six zero at five
1209:41	LC–2	Ah negative you can make normal approach to men . . . the equipment is there the men are gone
1209:47	LC–2	Delta seven forty one, cleared for takeoff
1209:51	LC–2	Golf Whiskey, turn back left er now heading three two zero and contact approach on one two six point seven
1209:59	LC–2	Delta four oh seven, call departure
1210:03	LC–2	Sky tam two four cleared for takeoff

CESSNA PARTS LEGEND

C-1 : LEFT WING PANEL TO INBOARD END OF AILERON.
C-2 : RIGHT WING STRUT 66" LONG
C-3 : LEFT HAND UPPER COWL
C-4 : PROP SPINNER BACKPLATE WITH SOME FIBERGLASS ATTACHED.
C-5 : RIGHT HAND ENGINE MUFFLER.
C-6 : WHIP ANTENNA, TOP OF FUSELAGE.
C-7 : CARB. HEAT HOSE.
C-8 : HORIZ. STAB. (LEFT & RIGHT), LOWER 15" OF VERTICAL FIN, FUSELAGE UPPER SKIN TO 41" FORWARD OF HORIZ. STABILIZER LEADING EDGE.
C-9 : RIGHT FUEL TANK.
C-10 : PART OF WINDSHIELD FRAME 24".
C-11 : RIGHT WING PANEL FROM FUSELAGE TO TIP, INBOARD HALF OF AILERON ATTACHED.
C-12 : LEFT WHEEL AND TIRE – MAIN GEAR.
C-13 : VERTICAL STABILIZER AND RUDDER (UPPER 37").
C-14 : LOWER RIGHT COWL PIECE 20" x 20" WITH TAXI LIGHT.
C-15 : LEFT FUSELAGE SKIN PANEL AFT OF ENTRY DOOR.
C-16 : RIGHT FIBERGLASS WING TIP.
C-17 : RIGHT OUTBOARD HALF OF AILERON.
C-18 : LEFT FUEL CELL PIECE.
C-19 : LOWER RUDDER (LOWER 17").
C-20 : FUSELAGE LOWER SKIN NEAR LEFT MAIN GEAR ATTACH POINT (18" x 24").
C-21 : RIGHT MAIN LANDING GEAR STRUT AND FAIRING.
C-22 : RIGHT FUSELAGE SKIN JUST AFT OF COWLING 8" x 20" WITH PART OF FRAME.
C-23 : LOWER FUSELAGE SKIN INCLUDING FRAME WITH ELEVATOR BELL CRANK, APPROX. 24" x 24".
C-24 : LOWER INSTRUMENT PANEL GROUP, INCLUDING IGNITION SWITCH, PRIMER, BRAKE, MASTER SWITCH, PANEL LIGHTS, INCLUDES MOST OF FIREWALL.
C-25 : VACUUM REGULATOR.
C-26 : FLOOR FORWARD OF SEAT TRACKS WITH (RED) CARPET, UNDERFLOOR FRAME, PULLEYS AND 1/3 BRAKE LINE.
C-27 : TRAILING EDGE OF WING 30" x 11".
C-28 : TOP SECTION OF LEFT FUEL TANK WITH FILLER NECK.
C-29 : RIGHT FUSELAGE AT DOOR FRAME 3" x 12" (EXTENSIVELY CRUSHED).
C-30 : FUSELAGE LOWER SKIN 41" FORWARD OF LEADING EDGE HORIZ. STAB. EXTENDING 36" (ONE COMPLETE SKIN PANEL).
C-31 : LOWER FUSELAGE FRAME UNDER COCKPIT, INCLUDING PULLEY.
C-32 : AFT 22" OF RIGHT ENTRY DOOR, WINDOW AND FRAME MISSING.
C-33 : LEFT ENGINE MUFFLER.
C-34 : INSTRUMENT PANEL FLIGHT GROUP – FRAME ONLY – INSTRUMENTS GONE.
C-35 : RIGHT DOOR PART WITH LATCH 4" x 28".
C-36 : WING UPPER CENTER SECTION 29" x 11".
C-37 : INBOARD END OF LEFT FLAP 11" x 15".
C-38 : FUSELAGE SIDE PANEL ON RIGHT COWL AREA INCLUDING EXTERNAL HANDLE FOR CLIMBING ON STRUT TO CHECK FUEL, ALSO INCLUDES INSTRUMENT/RADIO COOLING AIR VENT 28" x 16".
C-39 : BACKING FOR INSTRUMENTS AND RADIO – ATTACHES TO GLARE SHIELD.
C-40 : RUDDER PEDAL AND BRAKE ATTACHMENT.
C-41 : LEFT CABIN DOOR SUPPORT FRAME INCLUDING 4'5" OF SKIN AND ONE DOOR HINGE HALF.
C-42 : LEFT CABIN DOOR – GLASS AND FRAME MISSING.
C-43 : LEFT MAIN LANDING GEAR STRUT WITH STEP AND FAIRING.
C-44 : 1/2 NOSE LANDING GEAR YOKE.
C-45 : OIL TANK.
C-46 : NOSE GEAR TIRE.
C-47 : CARBURETOR.
C-48 : PIECE OF FUSELAGE UPPER SKIN
C-49 : LEFT OUTBOARD SECTION OF LEFT FLAP 31" x 19".
C-50 : RIGHT AND LEFT EXHAUST PIPE.
C-51 : BAGGAGE COMPARTMENT UPHOLSTERY
C-52 : PIECE OF ENGINE COWL
C-53 : PIECE OF RIGHT INBOARD FLAP
C-54 : PART OF LEFT CABIN DOOR FRAME
C-55 : PIECE OF FUSELAGE SKIN
C-56 : RIGHT ELEVATOR TRIM TAB
C-57 : PIECE OF RIGHT WING TIP FIBERGLASS.
C-58 : LEFT FLOOR 16" X 20" WITH RED CARPET AND SEAT TRACKS
C-59 : FUSELAGE LOWER SKIN AND FRAME AT FORWARD DOOR PLANE
C-60 : RIGHT GEAR ATTACH STRUCTURE WITH CARPET
C-61 : PART OF RIGHT DOOR WINDOW FRAME
C-62 : PART OF WINDSHIELD FRAME 48"
C-63 : RUDDER PEDAL
C-64 : SEAT BACK (BURNED)
C-65 : TUBE DUAL BRAKE TORQUE INSTALLATION WITH RUDDER PEDAL
C-66 : PROPELLER
C-67 : MAGNETO
C-68 : ENGINE
C-69 : FUSELAGE LOWER SKIN JUST AFT OF BAGGAGE COMPARTMENT 37" LONG BY 92" WIDE
C-70 : RIGHT UPPER FUSELAGE SKIN AND AFT WING SPAR CARRY-THROUGH WITH RIGHT SHOULDER HARNESS
C-71 : VACUUM FILTER, LEFT SIDE
C-72 : CESSNA DOOR PLASTIC
C-73 : RIGHT COWL SKIN 20" X 20" WITH "COMMUTER" LETTERING
C-74 : LUGGAGE AREA CARPET
C-75 : FUSELAGE SKIN AND RIGHT MAIN LANDING GEAR ATTACH POINT
C-76 : LEFT FUEL TANK
C-77 : PIECE OF RIGHT WING TIP FIBERGLASS
C-78 : SMALL PIECE LEFT LANDING GEAR ATTACH FITTING
C-79 : GLARE SHIELD
C-80 : RIGHT MAIN GEAR STEP
C-81 : BRAKE ASSEMBLY RIGHT WHEEL
C-82 : RADIO SPEAKER
C-83 : LEFT UPPER FUSELAGE SKIN AND AFT WING SPAR CARRY-THROUGH WITH LEFT SHOULDER HARNESS
C-84 : CABIN AIR VENT
C-85 : FUSELAGE FRAME AT RIGHT WING MAIN SPAR INCLUDING FITTINGS (WING AND FUSELAGE)
C-86 : PIECE OF SKIN LEFT FLAP 11" X 16"
C-87 : SMALL 10" X 12" LEFT FUSELAGE SIDE PANEL AND FRAME AFT OF BAGGAGE COMPARTMENT
C-88 : COWLING INSPECTION DOOR
C-89 : RIGHT FORWARD DOOR SUPPORT WITH ONE HALF HINGE
C-90 : FUSELAGE LOWER SKIN PANEL 41" NEAR HORIZ. STAB. LEADING EDGE
C-91 : FUSELAGE FRAME AT LEFT WING MAIN SPAR INCLUDING FITTINGS (WING AND FUSELAGE)
C-92 : AILERON CONTROL COLUMN CHAIN
C-93 : NOSE LANDING GEAR SCISSORS
C-94 : THROTTLE, MIXTURE CONTROLS, FLAP CONTROL, 1/3 WIRE BUNDLE COPILOTS SIDE
C-95 : SEAT BASE
C-96 : RIGHT MAIN LANDING GEAR WHEEL AND TIRE
C-97 : PART OF WINDSHIELD FRAME 25"
C-98 : CARPET HEEL PAD
C-99 : FUSELAGE STRUCTURE WITH SEAT BELT FITTING
C-100 : MAGNETO
C-101 : SEAT FRAME

FALCON PARTS LEGEND

F-1 : FUSELAGE BELLY STRUCTURE PN-MY 22086 WITH RED PAINT SCUFF
F-2 : FUSELAGE BELLY ROTATING BEACON BASE PLATE
F-3 : FUSELAGE PIECE WITH BLUE AND GOLD PAINT
F-4 : ENTRY WAY AND FORWARD CABIN HEADLINING
F-5 : CABIN AIR CONDITIONING DUCTING
F-6 : UNDER FLOOR STRUCTURE
F-7 : INTERIOR SIDE PANEL, LOWER FLOOR LEFT SIDE
F-8 : FUSELAGE SKIN WITH INSULATION MATERIAL 13" X 15"
F-9 : PIECE OF OVERHEAD INTERIOR 15" X 29"
F-10 : INSULATION
F-11 : LOWER PASSENGER SEAT CUSHION
F-12 : WINDOW SHADE FROM CABIN
F-13 : INTERIOR HALF OF PASSENGER WINDOW
F-14 : WOODEN MAGAZINE RACK
F-15 : LEFT SIDE AISLE STRUCTURE 80" LONG FROM UNDER NO. 1 LEFT SEAT
F-16 : CARPET (GRAY)
F-17 : HEADLINER INSULATION
F-18 : FUSELAGE LONGERON WITH RED PAINT SCUFF MARKS AT FRAME 18 AT 5 O'CLOCK POSITION WITH RED CARPET FOUND IMBEDDED
F-19 : INDIRECT LIGHTING COVER (FULL CABIN LENGTH)
F-20 : LEFT NO. 1 SEAT FROM CABIN
F-21 : HEADLINER INSULATION
F-22 : COAT HANGER FROM FORWARD COAT AND BAGGAGE AREA
F-23 : HEADLINER INCLUDING OVERHEAD SIDE LIGHTS
F-24 : HONEY COMB WITH WOOD ATTACHED
F-25 : GASPER AIR DUCT
F-26 : WOOD PANELING 19" X 25"
F-27 : INTERIOR HALF OF PASSENGER WINDOW
F-28 : VINYL SOUNDPROOFING
F-29 : CABIN OVERHEAD MOLDING WITH LIGHT ATTACHED
F-30 : WINDOW REVEAL COVERING (INTERIOR)
F-31 : HEAVY FRAME APPROX. 18" LONG INCLUDES INSULATION AND SKIN
F-32 : TOP OF RIGHT STORAGE CABINET FORWARD OF RIGHT NO. 1 SEAT (INTERIOR PANELING)
F-33 : INDIRECT LIGHTING COVER (FULL CABIN LENGTH)
F-34 : INTERIOR PANELING
F-35 : CABIN OVERHEAD MATERIAL
F-36 : ENTRY WAY AND FORWARD CABIN HEADLINING INSULATION
F-37 : TRIM RELAY BOX, TYPE MY 20-63220
F-38 : LOWER SEAT CUSHION
F-39 : FUSELAGE FRAME 18" LONG
F-40 : FRAME 13 AT 5 O'CLOCK LOWER FUSELAGE PIECE WITH SCRATCHES AND RED PAINT MARKS
F-41 : DOOR TO STORAGE CABINET
F-42 : RIGHT FORWARD WAINSCOT CAP (UNDER WINDOWS)
F-43 : DRAG CHUTE
F-44 : UNDERFLOOR FRAME
F-45 : WINDOW REVEAL COVERING (INTERIOR)
F-46 : FLOORING MATERIAL
F-47 : UPHOLSTERY
F-48 : COAT HANGER
F-49 : AIR CONDITIONING DUCTING 25" LONG
F-50 : CABIN OVERHEAD MOULDING
F-51 : WAINSCOT CAP UNDER WINDOWS 53" LONG
F-52 : UNDERSEAT FLOORBOARD PN MY 20 201 1183801A (STA. NO. 3 LEFT)
F-53 : RIGHT NO. 1 CABIN SEAT WITH TRACKING MECHANISM
F-54 : INTERIOR PANELING
F-55 : PASSENGER OXYGEN MASK
F-56 : WINDOW REAVEAL COVERING
F-57 : PARTIAL SEAT TRACK 10" LONG
F-58 : HEADREST FROM PASSENGER SEAT
F-59 : INTERIOR CLOSEOUT PANEL (UPHOLSTERY MISSING)
F-60 : TOP FRONT COMPARTMENT (FORWARD BAGGAGE AREA) SURVIVAL EQUIPMENT SHELF
F-61 : FUSELAGE INSULATION
F-62 : PART OF CABINET/BULKHEAD 8" X 20"
F-63 : UNDER SEAT DUCTING (FORWARD)
F-64 : CABIN INSULATION
F-65 : PLACARD "CHAIRS TO BE IN MOST OUTBOARD AND UPRIGHT POITION DURING TAKEOFF AND LANDING"
F-66 : WINDOW SHADE
F-67 : PIECE OF OVERHEAD SIDE MOLDING
F-68 : INTERIOR PANELING
F-69 : CABIN INSULATION
F-70 : PIECE OF OVERHEAD SIDE MOLDING
F-71 : CABIN OVERHEAD OXYGEN MASK CONTAINER
F-72 : STORAGE CABINET DOOR ASSEMBLY (LEFT-FORWARD OF LEFT NO. 1 SEAT)
F-73 : RADAR NOSE CONE
F-74 : FORWARD RIGHT CABIN INTERIOR BULKHEAD
F-75 : INTERIOR HALF PASSENGER WINDOW
F-76 : INTERIOR HALF PASSENGER WINDOW
F-77 : COUCH BACK CUSHION
F-78 : INTERIOR PANELING
F-79 : CABIN OVERHEAD OXYGEN MASK CONTAINER
F-80 : MAIN OXYGEN BOTTLE RACK AND REGULATOR
F-81 : CABIN FLOOR BOARD
F-82 : TOP OF CARD TABLE
F-83 : HONEYCOMB PANEL
F-84 : FLOORBOARD MY 20 201101302
F-85 : SIDEWALL AIRCONDITION DUCT
F-86 : PIECE OF FORWARD BAGGAGE COMPARTMENT STRUCTURE WITH PART OF BAGGAGE STRAP LOOP
F-87 : OVERHEAD SIDE MOLDING OVER EMERGENCY EXIT
F-88 : INTERIOR PANELING
F-89 : LEFT LOWER FUSELAGE SKIN BETWEEN FRAME 12 AND FRAME 15 AT 7 O'CLOCK POSITION WITH SCRATCHES AND RED PAINT MARKS
F-90 : FUSELAGE LONGERON AT FRAME 20, 5:30 O'CLOCK
F-91 : WING FILLET RIGHT SIDE AT FRAME 20 APPROX. 5 O'CLOCK
F-92 : MAIN OXYGEN BOTTLE
F-93 : INTERIOR PANEL - UPHOLSTERY MISSING
F-94 : SIDE WINDSHIELD
F-95 : RADAR DISH ANTENNA
F-96 : OVERWING ESCAPE HATCH
F-97 : LEFT WING ICE LIGHT
F-98 : NOSE LANDING GEAR DOOR
F-99 : LOWER FORWARD PART OF AILERON TRANSFER BOX

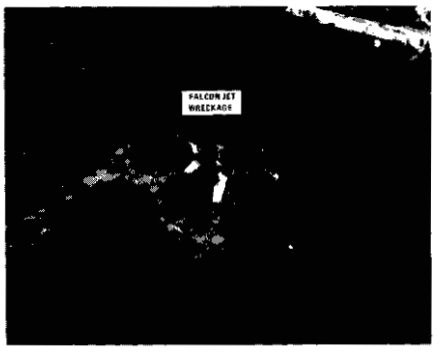


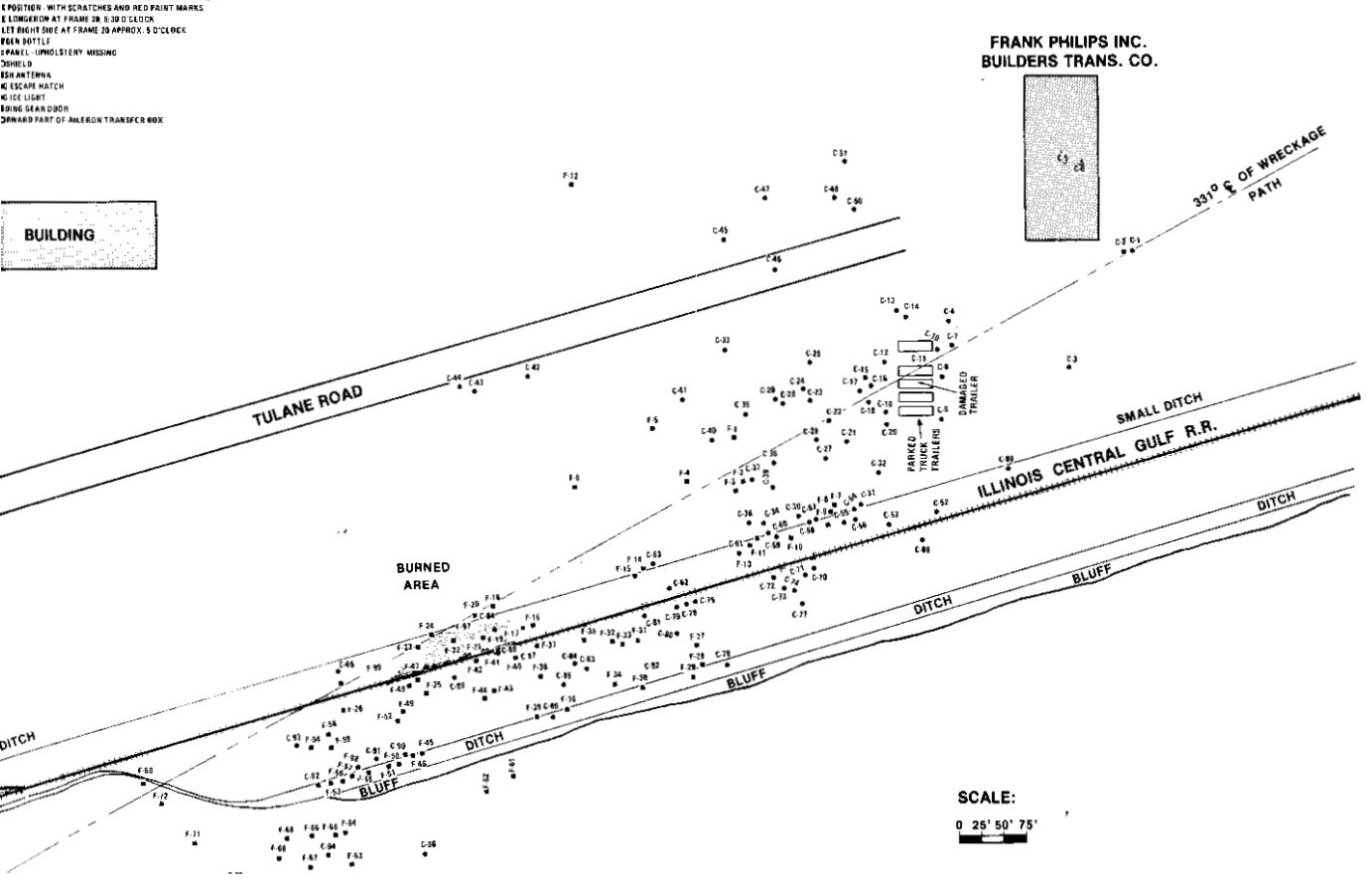
GRAVES ROAD

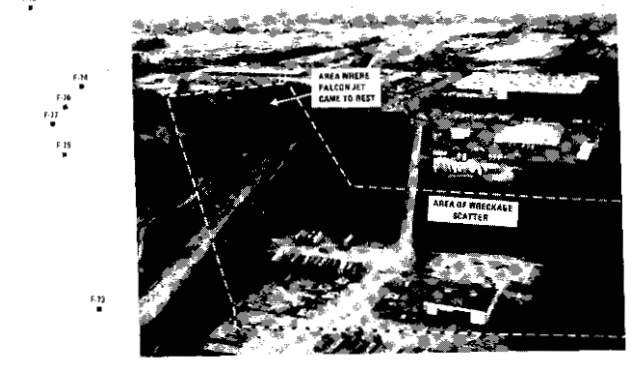
APPENDIX E

GEND

T COMPARTMENT (FORWARD BAGGAGE AREA) SURVIVAL
T SHELF
INSULATION
CABINET/BULKHEAD 9" X 26"
AT DUCTING (FORWARD)
ULATION
"CHAIRS TO BE IN MOST OUTBOARD AND UPRIGHT POSITION
RADE?" AND LANDING"
RADE
OVERHEAD SIDE MOLDING
PANELING
ULATION
OVERHEAD SIDE MOLDING
RHEAD OXYGEN MASK CONTAINER
CABINET DOOR ASSEMBLY (LEFT-FORWARD OF LEFT NO. 1
SE CONE
RIGHT CABIN INTERIOR BULKHEAD
HALF PASSENGER WINDOW
HALF PASSENGER WINDOW
CK COSHION
PANELING
RHEAD OXYGEN MASK CONTAINER
GEN BOTTLE RACK AND REGULATOR
OOR BOARD
RD TABLE
OR PANEL
ARD MY 20 20310B1042
, AIRCONDITION DUCT
FORWARD BAGGAGE COMPARTMENT STRUCTURE WITH PART OF
STRAP LOOP
SIDE MOLDING OVER EMERGENCY EXIT
PANELING
ER FUSELAGE SKIN BETWEEN FRAME 12 AND FRAME 15 AT
K POSITION - WITH SCRATCHES AND RED PAINT MARKS
E LONGERON AT FRAME 28: 6:30 O'CLOCK
ET RIGHT SIDE AT FRAME 20 APPROX. 5 O'CLOCK
YGEN BOTTLE
PANEL - UPHOLSTERY MISSING
OSHIELD
SH ANTENNA
E ESCAPE HATCH
SIDE LIGHT
DING GEAR DOOR
ORWARD PART OF AILERON TRANSFER BOX







NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

WRECKAGE DISTRIBUTION CHART
MIDAIR COLLISION

FLIGHT SAFETY INTERNATIONAL, FALCON JET,
N121GW AND MEMPHIS FLYING CLUB,
CESSNA 150M, N6423K