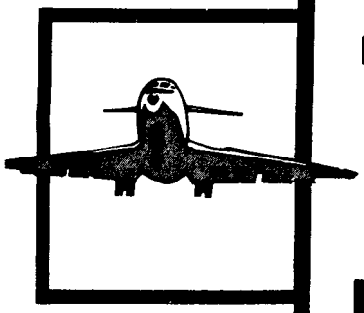

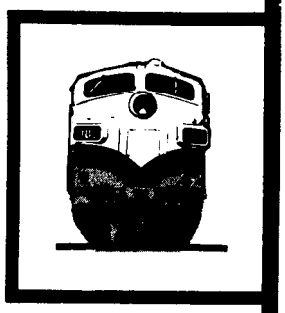

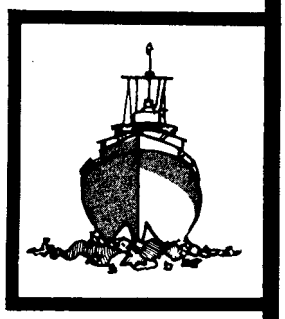

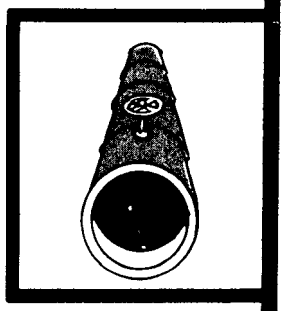

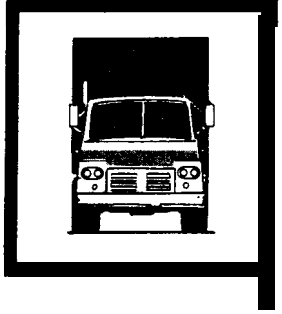

PB87-910404

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

SOUTHERN AIR TRANSPORT
LOGAIR FLIGHT 51, LOCKHEED L-382G
KELLY AIR FORCE BASE, TEXAS
OCTOBER 4, 1986

NTSB/AAR-87/04

UNITED STATES GOVERNMENT

TECHNICAL REPORT DOCUMENTATION PAGE

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15. Supplementary Notes

16. Abstract

Southern Air Transport% LOGAIR 15 flight, a Lockheed L-382G, was cleared for takeoff from Kelly Air Force Base, Texas, on an instrument flight plan. to Warner Robbins Air Force Base, Georgia, at about 0405 on October 4, 1986. Visual meteorological conditions prevailed. There were three flightcrew members aboard the military contracted domestic cargo flight operating under 14 CFR Part 121. All communications with the air traffic control tower were routine. Radar recorded that the airplane reached an altitude of about 700 feet above ground level. Witnesses reported an abnormally steep climb attitude followed by a turn and/or bank to the left, after which the airplane continued to roll to the left and struck the ramp area at about a 90° angle to the departure runway in a near-inverted attitude between two hangars and exploded. A severe ground fire ensued. All three flightcrew members were killed.

The National Transportation Safety Board determines that the probable cause of this accident was the use by the carrier of a nonapproved device designed to raise the elevator during loading operations which was not properly stowed by the flightcrew and which lodged in the controls, preventing the flightcrew from controlling the airplane during takeoff.

17. Key Words	18. Distribution Statement
LOGAIR; elevator control block; cockpit voice recorder; inverted; explosion; fire; metal shroud; control column; trailing edge up; full nose down trim; nose high attitude; abbreviated checklist; expanded checklist; operations manual; maintenance manual	This document is available to the public through the National Technical Information Service, Springfield, Virginia 22 16 1

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EXECUTIVE SUMMARY

Southern Air Transport's LOGAIR 15 flight, a Lockheed L-382G, was cleared for takeoff from Kelly Air Force Base, Texas, on an instrument flight plan to Warner Robbins Air Force Base, Georgia, at about 0405 on October 4, 1986. Visual meteorological conditions prevailed. There were three flightcrew members aboard the military contracted domestic cargo flight operating under 14 CFR Part 121. All communications with the air traffic control tower were routine. Radar recorded that the airplane reached an altitude of about 700 feet above ground level. Witnesses reported an abnormally steep climb attitude. followed by a turn and/or bank to the left, after which the airplane continued to roll to the left and struck the ramp area at about a 90° angle to the departure runway in a near-inverted attitude between two hangars and exploded. A severe ground fire ensued. All three flightcrew members were killed.

The issues related to this accident revolve about the use of a nonapproved elevator control blocking device designed and fabricated by at least two air carriers to prevent damage to the elevator control surfaces during loading operations. The device became jammed in the control yoke and prevented the flightcrew from controlling the airplane during takeoff. Removal and stowage of the elevator control block did not appear on the Abbreviated Checklist. No formal written company policy addressed the use of the elevator control block, although it was reportedly used on all LOGAIR flights. It was an unwritten practice for the first officer to remove the elevator control block and records indicate that the first officer of LOGAIR 15 had never been exposed to the device. Its use was not addressed either in ground or in flight training.

It was revealed that the FAA's principal operations inspector (POI) did not have a type rating in the L-382 and that he had been on an alternate assignment for 3 of the 5 months that he had been the POI for SAT, allowing him to devote only about 5 percent of his time to that airline. It was also learned that there had been no operational en route inspections by the FAA of SAT's L-382 airplanes, nor was there any requirement for them to conduct any.

Lockheed, at the request of the FAA, had documented four control column failures which were found to be consistent with the use of elevator control restraints in gusty wind conditions. Neither Lockheed nor the FAA notified users of their findings. After the accident the FAA circulated a General Notice cautioning against the use of elevator control blocks and noting that pressure on the control column with the restraints in place could cause cracking of some control columns. They did not recommend a one-time inspection, specifically below the floor where the cracks had occurred. Lockheed does not sanction the use of any control restraints under any conditions. Their L-3 82 Maintenance Manual contains both a note and a caution to this effect. Their Aircraft Flight Manual does not address the use of control restraints.

The National Transportation Safety Board determines that the probable cause of this accident was the use by the carrier of a nonapproved device designed to raise the elevator during loading operations which was not properly stowed by the flightcrew and which lodged in the Controls, preventing the flightcrew from controlling the airplane during takeoff.

As a result of its investigation the National Transportation Safety Board issued recommendations to the Federal Aviation Administration to alert air carrier inspectors to the possible safety hazards associated with this and other equipment and tools aboard their carriers' airplanes, to require an inspection for cracks in control columns below the floor, to place cautionary language in Operations Manuals, to notify foreign certification authorities of the circumstances of this accident, to require a specified number of en route inspections of a carrier by type of aircraft, and to provide for a minimum level of direct surveillance when a POI is occupied with other duties for extended periods of time.

NATIONALTRANSPORTATIONSAPETYBOARD
WASHINGTON,D.C. 20594

AIRCRAFTACCIDENTREPORT

Adopted: April 9, 1987

SOUTHERN AIR TRANSPORT LOGAIR FLIGHT 15
LOCKHEED L-382G
KELLY AIR FORCE BASE, TEXAS
OCTOBER 4, 1986

1. FACTUAL INFORMATION

1.1 History of the Flight

The flightcrew of Southern Air Transport's (SAT) LOGAIR 1/ flight 15, arrived at Kelly Air Force Base (AFB) about 2220 c.d.t. 2/ on October 2, 1986, and checked into a local hotel. They returned to Kelly Base Flight Operations about 0150 on October 4, 1986, to continue the domestic cargo flight, operating under 14 Code of Federal Regulations (CFR) Part 121, to Dover AFB, Delaware, via Warner Robbins AFB, Georgia. The inbound flight of LOGAIR 15, a Lockheed L-382G, N15ST, from Hill AFB, Utah, landed about 0220 on October 4, 1986, 4 hours late due to a maintenance problem with N250ST, for which N15ST had been substituted at Hill APB. The departing flightcrew of the continuing flight of LOGAIR 15 received a preflight briefing from Kelly AFB flight operations, which included information on the weather and the Class B and Class C 3/ explosives aboard the airplane.

As the airplane changed hands at Kelly AFB, the departing flightcrew spoke briefly with the arriving flightcrew; the arriving captain said N15ST was "in good shape" with no items to bring to the attention of the flight engineer.

Military personnel involved in the unloading and loading operations of the cargo said that there were no difficulties with either procedure. The flight engineer supervised the operation. Each of the ten cargo pallets aboard the airplane was secured both forward and aft by floor locks. The loading supervisor recalled that before working the flight he saw the elevator in a faired position with the horizontal stabilizer. (If the flight controls had been in their neutral position, the elevator would have been in a trailing edge down position relative to the horizontal stabilizer.)

At 0400:25 the flightcrew of LOGAIR 15 requested taxi instructions. They received both taxi instructions and their flight clearance and, began their taxi to runway 15 about 0401:10. At 0405:24 the crew informed the local controller that they were ready for takeoff.

1/ LOGAIR, for purposes of this report, is logistical support for the Air Force serving about 76 bases in the United States and using L-382, L-188, Boeing 727, and DC-9 type airplanes.

2/ All times appearing herein are central daylight time based on a 24-hour clock.

3/ Class B and Class C explosives are low order explosives and, according to the Air Force, consisted of dynamite propellants and rocket motors for ejection seats in the case of N15ST.

LOGAIR 15 was cleared for takeoff at 0405:24. The takeoff began near the approach end of runway 15. All radio communications with air traffic control (ATC) were normal. All cockpit communications were normal until 2 seconds after rotation, at 0407:12, when the captain asked for help from the first officer to push the control yoke forward. (See appendix D.)

The entire outline of the airplane was visible to the tower controllers due, in part, to the background lights of surrounding buildings, parking lots, and ramp areas. There were also several witnesses who observed the airplane from various locations on the base. They observed the airplane rotate about halfway between taxiways 2 and 3 (about 4,500 feet from the approach end of runway 15.) After liftoff the airplane climbed normally in line with the runway to about midfield (5,775 feet from the approach end) when, at an altitude of about 100 to 200 feet above ground level (agl), witnesses stated that the airplane transitioned to an extreme nose high attitude, estimated at between 40 and 90°. Some witnesses thought the pitch up was abrupt and others thought it was achieved in one continuous motion. The airplane climbed an additional 500 feet (approximately) and then it began a roll or bank to the left, which continued-as it began to lose altitude.

Radar data showed that at 0407:58 the airplane reached 1400 feet above mean sea level (msl); 4/ or about 700 feet agl.

The airplane struck the ramp area in a near inverted attitude on a heading of about 070° and at about a 90° angle to and east of the departure runway (15). The airplane then slid between two hangars and exploded. There were no pre-impact fires, explosions, or separations. Pre-impact engine sounds were described as normal.

The captain of the previous flight of N15ST stated in a postaccident interview that while performing the After Landing Checklist, "The first officer installed a gust lock between the 'foot rest' 5/ handles and the yoke on his [first officer's] side of the cockpit." (See figure 10.) The captain said that its installation was noteworthy to him because it had been a "considerable length of time" since he had seen a "gust lock" in use. (See section 1.6.) This captain had recently transferred from Transamerica Airlines (TIA), had been checked out as a captain, and had seldom flown in the LOGAIR system with SAT. The gust lock to which he referred also was called an elevator control lock, control block, uplock, or brace. This report will refer to the device as the TIA-type elevator control block. (See figure 1.) The elevator control block was nonapproved and was used to hold the elevator control surface in a faired to slightly trailing edge up position in order to prevent damage to the elevator control surface during cargo loading operations. Loading of the L-382 is accomplished from the rear of the airplane below the horizontal stabilizer. The elevator control block to which the previous captain referred was constructed of aluminum with a lo-inch long V-shaped channel and a 4-inch long U-shaped channel connected by a 4-inch tube which held the two pieces together with a through bolt and nut.

The first officer of the previous flightcrew confirmed that he had installed the elevator control block between his yoke and instrument panel foot rests before leaving the cockpit and that this was his customary practice. He stated that the device which he

4/ All altitudes appearing herein will be msl unless otherwise stated.
5/ The "foot rest" handles are installed on the lower instrument panel and provide a place for the feet to brace in order to produce leverage to move the control column in the event that hydraulic pressure is lost.

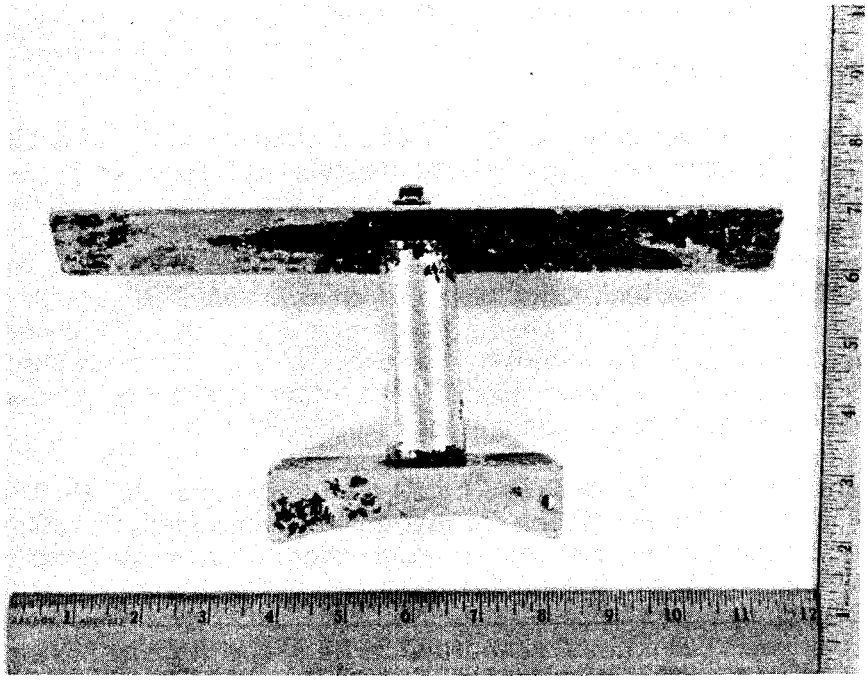


Figure l.-TIA-type elevator control block.

installed was painted red, was intact and structurally sound with no visible defects, and was not bearing a "remove before flight" warning banner. The purpose of the banner would have been to attract attention to the elevator control block and to assure its removal.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others	Total
Fatal	3	0	0	3
Serious	0	0	0	0
Minor/none	0	0	0	0
Total	3	0	0	3

1.3 Damage to Aircraft

The airplane was destroyed by impact and postcrash fire. The hull loss value was $8 million.

1.4 Other Damage

Buildings 1610 and 1612 (hangars) at Kelly AFB sustained fire and impact damage. In addition the safety valve on a natural gas line next to building 1500 (unoccupied) was damaged. There was minor damage to a parked C-21 (Lear 35) and the

following parked surface vehicles were destroyed: an Air Force crew bus, two government stepvans, two government pickup trucks, an aircraft tug, and three personal vehicles. The cargo aboard the airplane was destroyed.

1.5 Personnel Information

The flightcrew, consisting of a captain, a first officer, and a flight engineer, was certificated to conduct the flight. The captain had been employed by SAT in December 1983, as an L-382 first officer. He was upgraded to captain on November 6, 1985. His total flight time was 7,000 hours with a total L- 382/C-130 flight time of 3,767 hours. The captain and the flight engineer had flown together on numerous occasions. During September 1986, they had flown together on 6 LOGAIR flights in N15ST, 18 in N250ST, and 7 in N46965; each of these airplanes was equipped with an elevator control block at the times when they were flown by the captain and flight engineer. In addition, the captain had flown three trips in N15ST with other flightcrew personnel. It was determined that the captain was the flying pilot of LOGAIR 15.

The first officer was employed by SAT on September 28, 1986, 6 days before the accident, as an L-382 first officer. He was given ground training and flight training consisting of 4 1/2 hours in an airplane in which there was no elevator control block. According to SAT personnel, the use of the elevator control block was not addressed in either ground or flight training. After his training, the first officer flew as an observer on two LOGAIR routes which terminated at McClellan AFB, constituting his initial operating experience (IOE) at SAT. The airplane in which he received his IOE did not have an elevator control block aboard since it had only recently been placed in the LOGAIR system. The first officer's flight from McClellan AFB to Kelly AFB via Hill AFB on October 2, 1986, was made in N15ST, which had been flown to McClellan on a noncargo flight. According to the first officer of that noncargo flight, he did not install the elevator control block at McClellan, but stowed it on the floor to the right of his (first officer%) seat. Consequently, the first officer of N15ST probably did not see the device when he boarded the airplane on October 2, 1986. The first officer had a total flight time of 4,100 hours and had accrued about 107 flight hours in the L-382, 103 of which were with TIA between January 28, 1986, and May 30, 1986, after they had removed all elevator control blocks from their fleet of L-382s.

The flight engineer had been employed by SAT in October 1983 as an L-382 flight engineer. His total flight time was 16,800 hours with with a total L-382/C-130 flight time of 9,300 hours.

A review of the flightcrew's recent activities and background revealed no information of significance. They had received the prescribed off duty rest time. (See appendix B.)

1.6 Aircraft Information

The airplane, N15ST, a model L-382G, serial No. 4391, was manufactured by Lockheed Aircraft in 1971. (See appendix C.) It had been acquired by SAT approximately 3 weeks before the accident from TIA on a lease/option after that company had discontinued its 14 CFR Part 121 operations.

TIA's records indicated that they had removed an elevator control block, which had been designed and fabricated by Saturn Airlines and used by TIA when Transinternational and Saturn had merged in 1982, from N15ST on April 19, 1985, in

Asmara, Ethiopia, under a fleetwide directive to remove the devices. (For a detailed chronology of events relevant to the use of the elevator control block by TIA see section 1.17.2.)

An elevator control block found in the wreckage of N15ST was identical to the TIA-type block which reportedly had been removed from N46965, another L-382, and placed in N15ST by a SAT flightcrew member on September 14, 1986, when N15ST was in San Francisco being prepared for operations in the LOGAIR system. (See figure 2.) N46965 was removed from the LOGAIR system at that time. Subsequently, N15ST was delivered to McClellan AFB to begin operations in SAT's fleet. The airplane from which the control block had been removed was operated by SAT under a long term lease agreement with South Africa Freight Air.

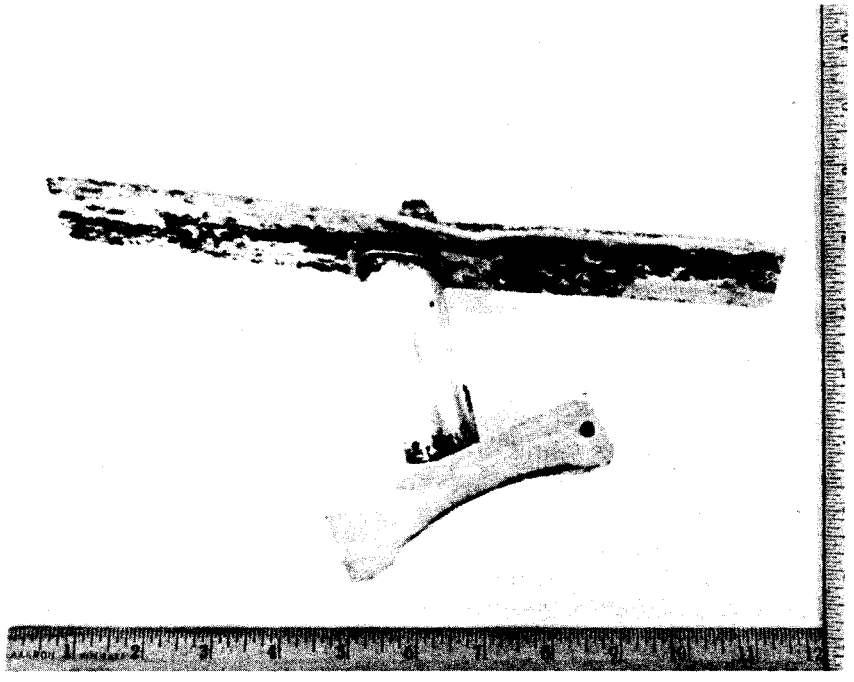


Figure 2.-Elevator control block found in wreckage of N15ST.

SAT had also designed and fabricated an elevator control block, which was no longer in use, for use in their airplanes. The SAT design was different in size and shape from TIA's device. (See figure 3.) At the time of the accident, there was only one in existence. According to SAT, only four were ever constructed. SAT's elevator control block was constructed in a wishbone shape and displaced the control column so far aft of neutral that it would not be possible for the flightcrew to occupy their seats with it installed.

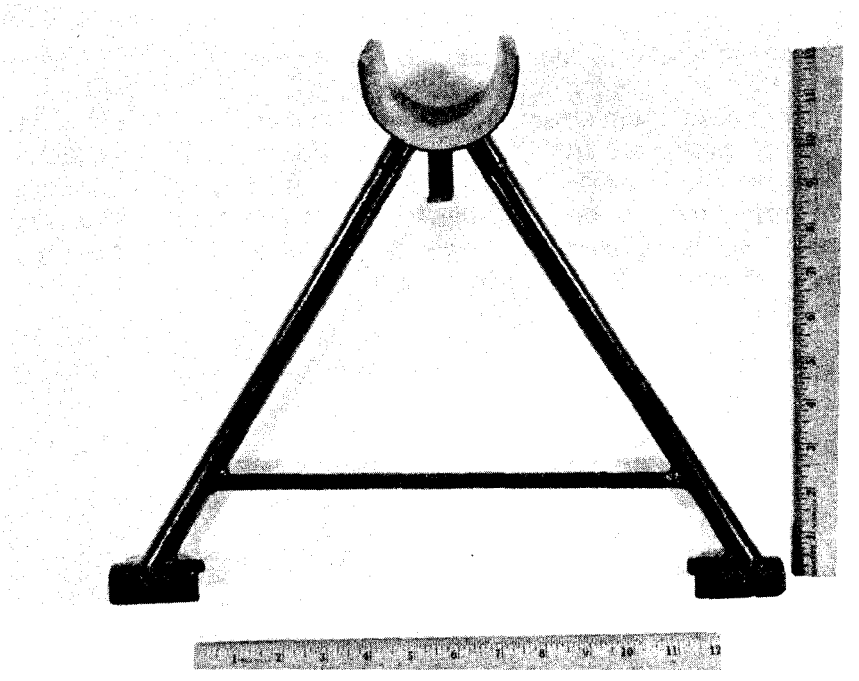


Figure 3.-SAT-type elevator control block.

There was no formal written policy at SAT regarding the use of the elevator control blocks, with the exception that its removal was addressed in the Expanded Checklist in its August 1986 revised Aircraft Operations Manual (AOM). According to the previous first officer, removal would occur after the start of the first engine when sufficient hydraulic pressure had been achieved. Other SAT personnel stated that it would frequently be removed, as soon as the suction boost pumps on the hydraulic panel were turned on.

The TIA-type elevator control block was commonly stowed on the cockpit floor to the right of the first officer's seat in N15ST, according to the previous first officer of the inbound LOGAIR 15 flight of N15ST on October 4, 1986. He stated that in some other airplanes in SAT's LOGAIR system it was hooked over a bracket on the lower right of the first officer's instrument panel. The block was not stowed there on N15ST because of the installation of the co-pilot% radar scope. According to SAT's chief flight engineer, the standard practice was to stow the elevator control block below the flight deck bunk behind sliding wooden doors when it was not in use. The flight deck bunk was located in the aft part of the cockpit.

The Lockheed-Georgia Company's Maintenance Manual for the L-382G carries the following note:

> Do not use mechanical restraining devices on the controls and control surfaces. Built-in snubbers in the booster packages will prevent slamming of the controls into their stops.

Additionally, the Maintenance Manual also carries the following caution:

> Do not install any rig pins in the elevator control system or secure the flight control column rigidly as a means of locking the elevators against wind gusts. Otherwise damage to the hydraulic booster is likely to result.

Neither TIA's Flight Operations Manual (FOM) nor SAT's AOM contained a similar note or caution. The AOM or FOM was carried aboard the airplane in addition to the Aircraft Flight Manual (AFM.) 6/

The takeoff weight of the airplane was below the maximum allowable takeoff weight and the center of gravity was within the allowable range.

1.7 Meteorological Information

The following special weather conditions were observed at Kelly AFB on October 4, 1986, at 0410: sky -- 1,500 scattered; visibility -10 miles; temperature --79° F; dewpoint --73° F; wind --150° at 8 knots; and altimeter 29.94 in. Hg.

The accident occurred during hours of darkness.

1.8 Aids to Navigation

Not applicable.

1.9 Communications

All communications between the flightcrew of N15ST and the Kelly AFB ATC tower were routine.

1.10 Aerodrome and Ground Facilities

Kelly AFB is a U.S. Air Force military airport located near San Antonio, Texas. Field elevation is 690 feet. There is one runway, designated as 15 and 33, which is oriented magnetically 155.2 and 335.2'. The runway is 11,550 feet long by 300 feet wide and is constructed of concrete. An ARTS IIIA computer derived recording of the flight was generated by the San Antonio ATC tower, San Antonio, Texas.

1.11 Flight Recorders

The airplane was equipped with a Fairchild A-100 cockpit voice recorder (CVR), serial No. 2521, and a Sundstrand FA-542 flight data recorder (FDR), serial No. 2124. The CVR and FDR were removed from the wreckage and delivered to the Safety Board's Engineering Services Division in Washington, D.C. where they were examined and transcribed.

6/ These documents met the same Federal requirement for an operations manual specific to the type of airplane being flown, usually called an AOM. The AOM is developed by the carrier and is based upon the FAA-approved manufacturer's AFM.

The CVR sustained severe heat damage. Aluminum case material had melted away and some circuit boards were destroyed by fire. The tape suffered heat damage and embrittlement on the quarter inch of the reel packed nearest the hub of the recorder. The portion of the tape containing the last 20 minutes of recording was undamaged. The recording revealed that the flightcrew was communicating on the intercom, which made the quality of the recording much better than it would have been if there had been no intercom.

A review of the CVR revealed that several items on the Before Start Checklist, the Before Taxi Checklist, and the Taxi to Takeoff Checklist were not audible. These were all flight engineer challenge and response items. Verbalization is required by the carrier in the AOM and became mandatory when the FAA approved the AOM. The lack of verbalization of required checklist items would constitute grounds for the FAA to fail a candidate on a checkride. Because of a high ambient noise level in the cockpit, SAT flightcrews used noise attennating headsets in their L-382 airplanes and a "hot mike" (open mike) intercom system. It was reported by SAT's vice president of operations that the system was very sensitive, so that even the breathing of the other crewmembers could be heard. He stated that other crewmembers found it irritating and disruptive to listen to a long list of challenge and response items and, since all three crewmembers were in close proximity to each other, they often substituted pointing and nodding for verbalization.

The following excerpt from the Before Start Checklist could not be related to a specific item. At 0353:54, the flight engineer said "What the . . . is this thing?" followed by the sound of laughter.

The flight control check was verbalized on LOGAIR 15. The captain stated, "Free and full travel on the rudders" and the first officer stated, "Free and full travel on top."

SAT trains their pilots and performs their L-382 control checks in the following manner: The captain performs a full rudder check and the first officer performs the aileron and elevator check, commonly referred to as "on top." The on top check consists of aileron full left, neutral, full right, neutral, and elevator full aft followed by full forward.

The following excerpts from the last 35 seconds of the CVR indicate that the flightcrew recognized that they had a problem, identified the problem, attempted to solve the problem, and did so just before impact.

At 0407:10, the first officer said, "Rotate," and at 0407:12, the captain said, ". . . help me on my yoke." At 0407:21, the captain said, "You got this . . . thing in here." At 0407:23 the flight engineer said, "Come on pull it . . . " and repeated, "Pull it back a little . . . pull it back a little," and then, "Did you pull it back?" At 0407:41, he said, "Okay, its clear now," and at 0407:42 the "whoop whoop pull up" of the ground proximity warning system (GPWS) began. The recording ended at 0407:45.

The FDR's foil recording medium had been subjected to heat, as evidenced by dark deposits on the foil surface and discoloration of the foil. All traces were recorded in a normal manner except the altitude trace which was not functioning and showed no movement.

The airspeed trace indicated that the airspeed increased during the takeoff roll and initial climb to a maximum of about 120 knots indicated airspeed (KIAS) followed by a decrease to about 80 to 85 KIAS. Then the speed increased again to 125 KIAS which was followed by a decrease to about 90 KIAS at impact.

The magnetic heading trace at takeoff agreed with the runway heading (150°) and the heading binary trace showed a southerly position during the takeoff and initial climb; however, following the initial loss of airspeed, the heading binary shifted from southerly to northerly and remained in that position until impact, confirming that the airplane had rolled to the inverted position and the heading indicator (gyroscope) had precessed 7/ before ground contact.

1.12 Wreckage and Impact Information

1.12.1 Airplane and Systems

The initial impact point was located at an elevation of 677 feet at 29°22'54" north latitude and 98°34'30" west longitude. Impact occurred about 7,357 feet from the approach end of runway 15 on a bearing of about 149° and about 1,599 feet to the left of the centerline of the runway on a bearing of about 72°. (See appendix E.)

The wreckage path was fanned out in a triangular pattern from the initial impact point. (See figure 4.) The most distant piece of wreckage, a piece of propeller, traveled more than 1,666 feet to the northeast and struck a safety valve on a natural gas line.

The cockpit and forward fuselage were fragmented and burned. No major intact sections were recovered and no meaningful cockpit instrument readings could be obtained. Some of the center fuselage sidewall and belly structure were identified in the wreckage. The right aft fuselage structure remained attached to the empennage, having separated about 10 feet forward of the cargo ramp hinge. Ground fire had consumed most of the left aft fuselage structure. Both the left and right main landing gear had separated from the fuselage.

A damaged elevator control block matching the description of the one installed by the first officer of the previous flight was found in the wreckage in the vicinity of the cockpit. The aluminum tube showed evidence of compressive overstress resulting in a tear in the area adjacent to the V-shaped channel. Additionally, the control column and a metal shroud (see figure 5) used to cover the rudder controls, located between the rudder pedals just forward of the first officer's control column, were recovered. The aft face of the metal shroud had a lateral puncture and scratch marks which conformed to the flange width of the 4-inch U-shaped channel of the damaged elevator control block. (See figure 6.) There were no marks or gouges -found on the control column which could be associated with the elevator control block.

The majority of the left wing structure was recovered. The majority of the right wing structure had disintegrated and burned. Both the right aileron fixed trim tab and the left aileron moveable trim tab were found in neutral positions. However,

7/ Precession is an inherent quality of rotating bodies, such as gyroscopes, whereby the application of a force to the plane of rotation produces a displacement of the plane by 90° to the direction of the applied force.

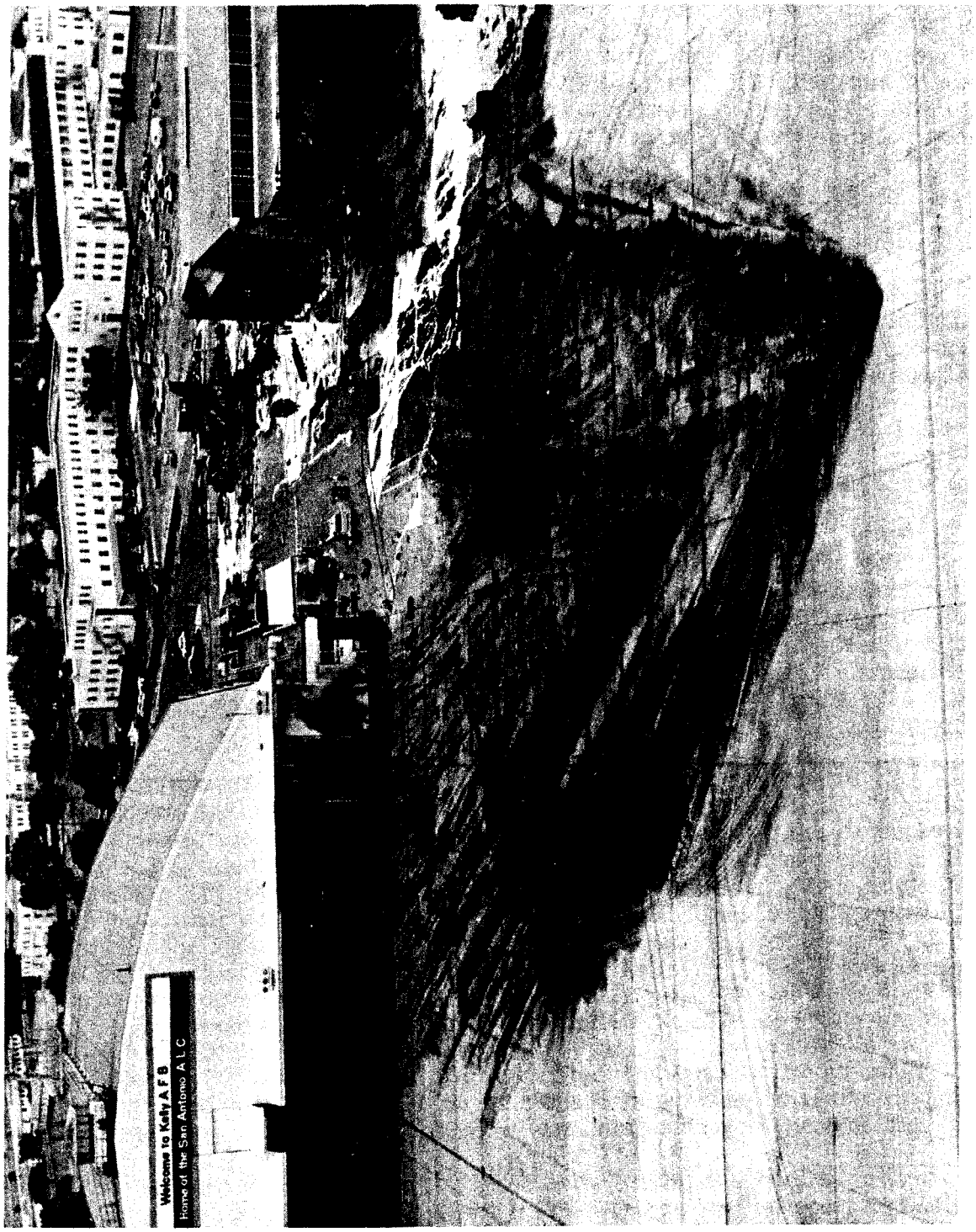


Figure 4.—Photograph of accident site.

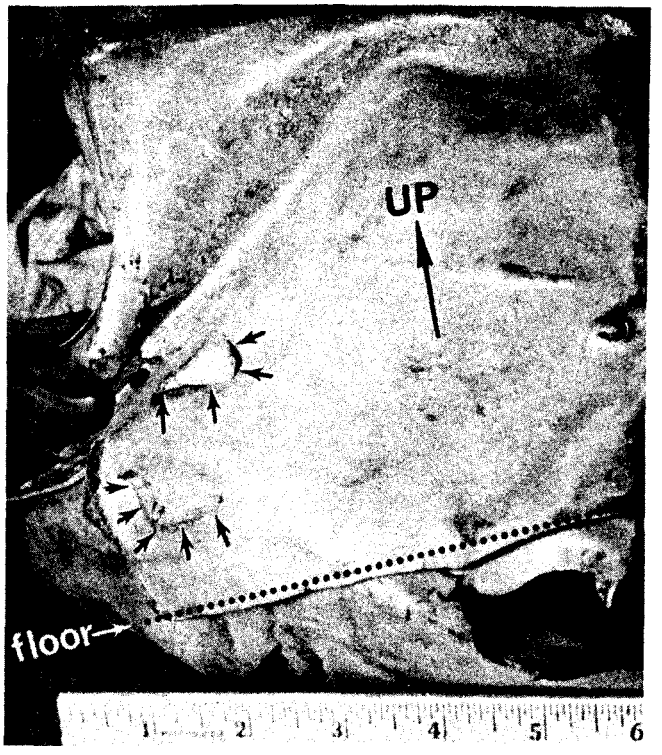


Figure 5.—Deformed metal shroud.

examination of the aileron booster assembly indicated that the actuator piston was fully retracted in a full right aileron trailing edge up position. Aileron control system continuity could not be established due to impact and fire damage.

The screwjacks (official Lockheed terminology) from the left wing's inboard flap were measured and their positions corresponded to 50 percent flap extension, which is takeoff configuration.

The empennage, including the cargo ramp and door, had impacted on its right side. The vertical stabilizer and rudder were bent to the left and those portions resting on the ground were damaged by fire. The left horizontal stabilizer and elevator were generally undamaged; the right horizontal stabilizer and elevator were extensively damaged.

The left elevator remained attached to the empennage and the left elevator trim tab remained attached to the elevator. The trim tab was measured at the inboard elevator trailing edge and the results revealed that it was in a full trim tab trailing edge up position resulting in a 6° nose down trim. The right elevator had separated and was found beneath the empennage; the right elevator trim tab remained attached to the elevator. The screwjacks were measured between the mounting bolt holes revealing a nearly full trim tab trailing edge up position. Elevator continuity was established between the elevator torque tube and the ends of the elevator push-pull rods. Elevator continuity could not be established from the booster assembly forward to the cockpit area due to impact and fire damage.

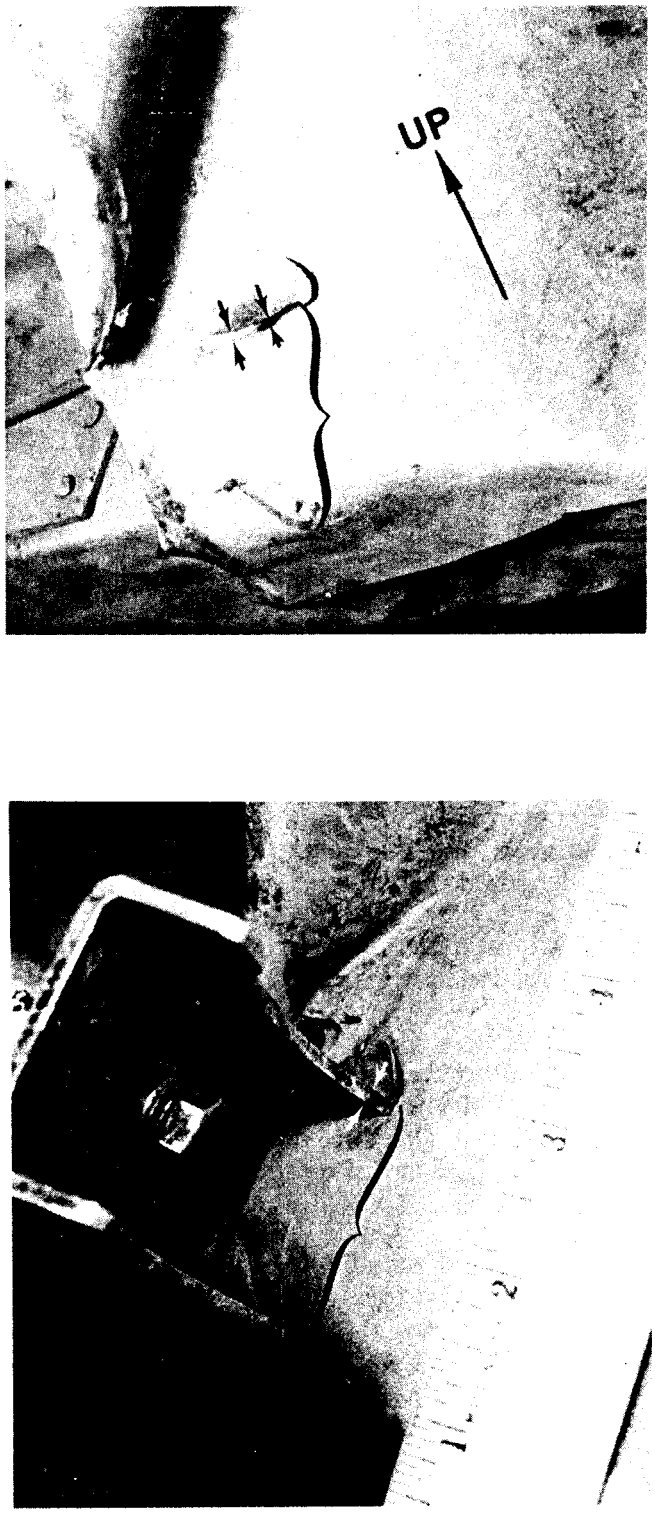


Figure 6.-Mating of witness marks and elevator control block.

The rudder and vertical stabilizer remained attached to the empennage. The rudder trim was found in a neutral position. Continuity could be established visually from the rudder booster assembly to the rudder torque arm.

The nose landing gear actuator was fully retracted and the down and locked indicator pin was visible, verifying a down and locked position. All four main gear were fully extended with their drag pins in the shelf bracket (locked).

No meaningful information could be extracted from the airplane% electrical system; however, the crew was in contact with Kelly AFB tower and witnesses reported that the navigational lights were on.

Most of the airplane% other systems (hydraulic, pneumatic, oxygen, etc.) were so severely damaged by impact and post crash fire that little information could be obtained.

1.12.2 Powerplants and Fuel System

All four engines were located and identified at the accident site. The Nos. 3 and 4 engines were found to the left of the wreckage path and the Nos. 1 and 2 engines were found to the right of the wreckage path, indicating that the airplane was inverted at impact. All four engines exhibited extensive impact damage in multiple locations. The gearboxes and propellers were separated from the engines. All of the torquemeter shafts exhibited twist and deflection. In all cases the torquemeter pick-up units exhibited heavy surface rub. All evidence indicated that there was significant power on the engines at the time of impact. Both the compressor and turbine blades were bent opposite to the direction of rotation. The No. 4 engine was split into two pieces.

Due to the massive destruction of the wings, only a few items from the airplane% fuel system could be identified (some fuel valves, boost pumps, vent lines, fuel probes, fuel eductors, and internal fuel lines). The left auxiliary bladder cells had some fuel inside. **All** three cells appeared to be continuous, but were damaged by the impact; they were not burned. Fuel analysis was not conducted because mechanics had drained the fuel into contaminated containers before investigators arrived. A fuel analysis of a sample from the truck which fueled LOGAIR 15 was conducted by the Air Force and no abnormalities were observed. The same truck was used to fuel two other aircraft and fuel analyses were conducted on samples from both with no abnormalities observed.

All four propeller barrels were located and identified in the vicinity of their respective engines. All major components were recovered, but because of the high impact forces and fire damage many parts could not be identified. Each propeller was disassembled in order to expose the propeller blade shim plate so that a propeller blade angle could be determined for the time of impact. All four propellers presented positive blade angles in the 40 to 42° (takeoff) range. All of the propeller blades were fractured and twisted or deformed to some degree; consequently, blade angle readings from the valve housing beta wheels and the dome piston stop rings were not consistent with the blade shim readings. All propeller blade bushing drive pins and retaining screws were found sheared.

1.12.3 Hazardous Materials

Most of the Class B explosives aboard were completely or partially recovered from the wreckage. Except for two rocket motors, all of the explosives had been

expended in the postcrash fire. Nine of an unknown number of Class C initiators were recovered. It could not be determined how many had been expended in the fire. There was no evidence of inflight detonation.

1.13 Medical and Pathological Information

According to the medical examiner of Bexer County, Texas, who performed autopsies on the remains of the flightcrew, there were no apparent pre-impact conditions which would have prevented the flightcrew from conducting their flight duties in a normal manner. The three flightcrew members died of severe traumatic injuries.

Toxicological tests conducted by the FAA's Civil Aeromedical Institute in Oklahoma City, Oklahoma, were negative for acidic or neutral drugs, basic drugs, and ethyl alcohol. Tests for carbon monoxide revealed insignificant (less than 7 percent) levels for all flightcrew members.

1.14 Fire

There was no evidence of inflight fire. Witnesses observed that the airplane exploded and burned upon impact. Explosions continued for more than an hour after the accident. The cockpit and forward fuselage were fragmented and subjected to extreme postimpact fire. The fire had consumed most of the left side of the aft fuselage structure.

1.15 Survival Aspects

This accident was nonsurvivable due to excessive decelerative forces, disruption of the occupiable space in the airplane, and the postcrash fire and explosions. One nearly whole crew seat, identified as the flight engineer's seat, was located in the wreckage. The bucket had no remaining upholstery and showed extensive heat damage as well as minor to moderate impact damage. The shoulder harnesses were still attached to the inertial reel, which functioned freely and without binding. The lap belt buckle was found in the open position and the shoulder harnesses were not attached to the buckle. Only fragments of the captain's and first officer's seats were recovered. One additional lap belt was found in the closed (locked) position. The fabric shoulder harness loops were not recovered and it could not be determined if they had burned away or were not used.

The accident was witnessed by ATC personnel who notified the Kelly AFB fire unit at 0409 by direct telephone line. The base maintains two fire standby stations; one was located only 700 feet from the accident site and was especially equipped to handle aircraft fires. Both units dispatched personnel and the Kelly AFB emergency plan was activated. Additionally, an emergency aid pact with Lackland AFB, Texas, which adjoins Kelly AFB, was activated and they dispatched standby fire apparatus and explosive and ordinance disposal (EOD) personnel. EOD personnel remained on duty at the accident site through October 5, 1986.

The fire was contained in about 12 minutes with major flareups continuing for another 18 minutes. Fire fighters remained on duty for the next several hours.

Security at the accident site was established upon the initial notification at 0409 and continued throughout the on-site investigation.

1.16 Tests and Research

1.16.1 Elevator Trim Tab Actuator

The elevator trim tab actuator was recovered from the wreckage and placed in another L-382 airplane. The unit was energized and the trim tab position indicator in the cockpit showed one needle width beyond the 5° nose down index. This was equivalent to full nose down elevator trim.

1.16.2 Elevator Booster Assembly

The elevator booster assembly was recovered and functionally tested on November 6, 1986, at Lockheed-Georgia Company, Marietta, Georgia. It was installed on a test fixture and 3,000 psi of hydraulic pressure was applied to the utility hydraulic system input side of the booster assembly. No leakage was visible. With the application of finger pressure to simulate pilot input for up or down elevator, the assembly pivoted freely and without resistance. The results were the same when hydraulic pressure was removed from the utility hydraulic system input side of the booster assembly and applied to the booster hydraulic system input side. Based on these test results no tear-down inspection was conducted.

1.16.3 Autopilot Elevator Trim Servo Motor

The autopilot elevator trim servo motor was functionally tested on November 6, 1986, at Lockheed-Georgia Company, Marietta, Georgia. It was installed on an autopilot avionics test bench and the unit was engaged and disengaged satisfactorily by inputs from the pilot switch. When installed on the servo motor test bench, there were indications that the pilot interlock switch portion of the servo motor was defective. However, when the unit was returned to the autopilot avionics test bench and plugged in, the unit continued to engage and disengage satisfactorily by signals from the pilot switch.

1.16.4 Elevator Control Block

At the time of the accident SAT used two TIA-type control blocks in their LOGAIR system exclusively. Until about a month or 2 before the accident when N15ST and other TIA airplanes were introduced into the fleet, two L-382 airplanes were used exclusively in the LOGAIR system. With minor exceptions, flightcrews were also assigned exclusively to the LOGAIR routes. The TIA-type elevator control block was always used on the LOGAIR routes. There may have been some exceptions in the last month or 2 before the accident. There was no written policy in regard to the elevator control block.

The deformed elevator control block from N15ST and an intact elevator control block of the same design were examined by the Safety Board's Materials Laboratory, along with the first officer's control column and the metal shroud which came from the area between the first officer's rudder pedals and just forward of his control column.

A rubber boot, which should surround the control column at the floor level, and the control wheel from the control column were missing and were probably consumed by fire. The fulcrum arm of the control column below the floor line had been fractured off. A deformation mark was found on the forward left side about 1/2 to 1 inch above the floor line. However, this mark could not be correlated with the elevator control block.

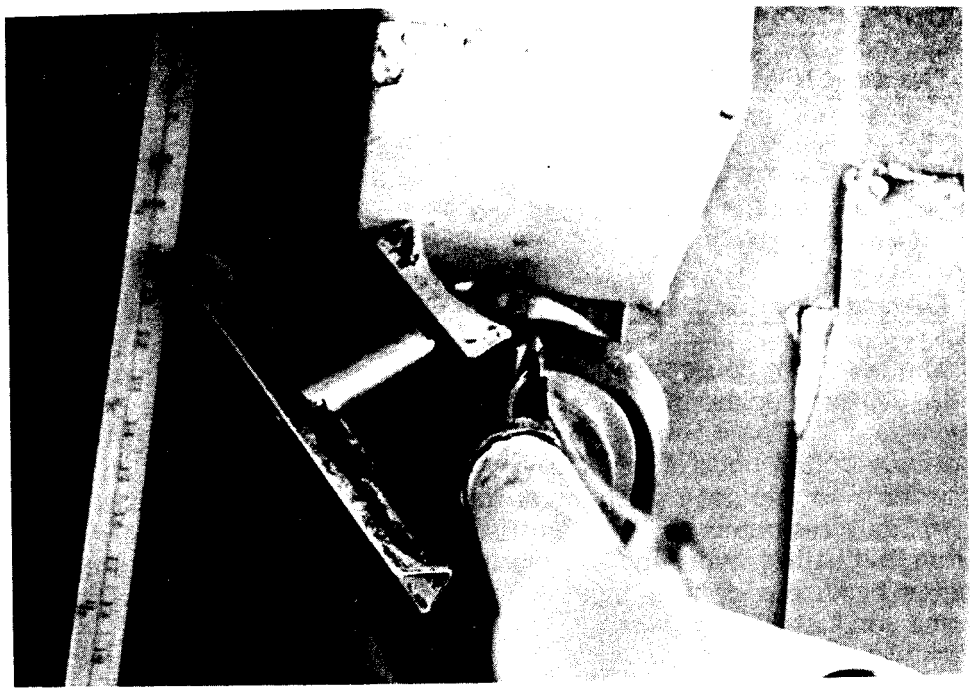


Figure 7.-Two views of probable position in which elevator control block jammed.

The aluminum box structure which formed a metal shroud between the first officer's rudder pedals was heavily deformed by crash impact forces. A puncture and scrape mark on the left side of the aft face of the shroud were found about 1 to 2 inches above the floor line., The distance between these marks matched the distance between the legs of the U-shaped channel of the elevator control block. (See figure 6.)

Lockheed C-130s were examined both at Kelly AFB during the on-scene investigation and at Andrews AFB on November 26, 1986. Numerous attempts were made to lodge an identical elevator control block between the control column and the metal shroud. When the device was positioned so that the interconnecting tube was oriented forward and aft, the control column had to be pulled to its aftmost position in order to jam the control block. Any forward control column movement caused the device to slip easily out of the wedged position. In order to replicate the positioning of the elevator control block, as indicated by the evidence of the components submitted for examination, the intact control block was placed with the 4-inch U-shaped leg resting between the shroud and the rubber boot around the control column and with the lo-inch V-shaped leg free from impingement upon either the shroud or the control column. (See figure 7.) When the control column was moved forward the soft sheet metal shroud was deflected forward by the U-shaped leg and the control block did not slip from the wedged position. Any further forward movement of the control column would have caused the U-shaped leg to penetrate the sheet metal shroud in the approximate location of the penetration in the accident airplane. With the control block jammed in this manner (see figure 8), the elevator of the C-130 was positioned in a trailing edge up position. (See figure 9.)

1.16.5 Full Flight Simulation

A C-130 Phase II simulator flight test was conducted at Little Rock AFB, Arkansas, on October 21, 1986. Several flight scenarios were flown using. the speeds, power settings, and weight and balance of the accident airplane. An intact elevator control block, identical in design and composition to the one aboard N15ST was used in the simulations. Placing the control block in the normally installed position between the footrests and the yoke produced a reading of 3.8° aft of the control column's neutral position. Takeoffs with the control block installed in this manner did not produce the abrupt high pitch up observed by some witnesses to this accident; however, it did produce a premature rotation. The device could be lodged between the control column and the metal shroud between the rudders at a control column position of 6° aft of its neutral position. This position produced an altitude of about 700 feet agl and a speed of about 80 KIAS before the simulator stalled and commenced a roll to the left. The Safety Board's measurements indicated that the distance between the control column and the metal shroud was similar in the C-130 simulator, a C-130, and an L-382. (See figure 10.) Lockheed confirmed that cockpit dimensions were identical in the C-130 and the L-382.

The control column position during normal initial rotation by the two test pilots who flew the simulator varied from .7 to 2.2° aft of its neutral position. Both pilots considered it highly unlikely that a pilot would initially rotate and climb with the control column positioned to 6° aft of its neutral position.

When a simulator takeoff was conducted with the elevator control block on the metal shroud, the control block moved aft and fell between the shroud and the control column.

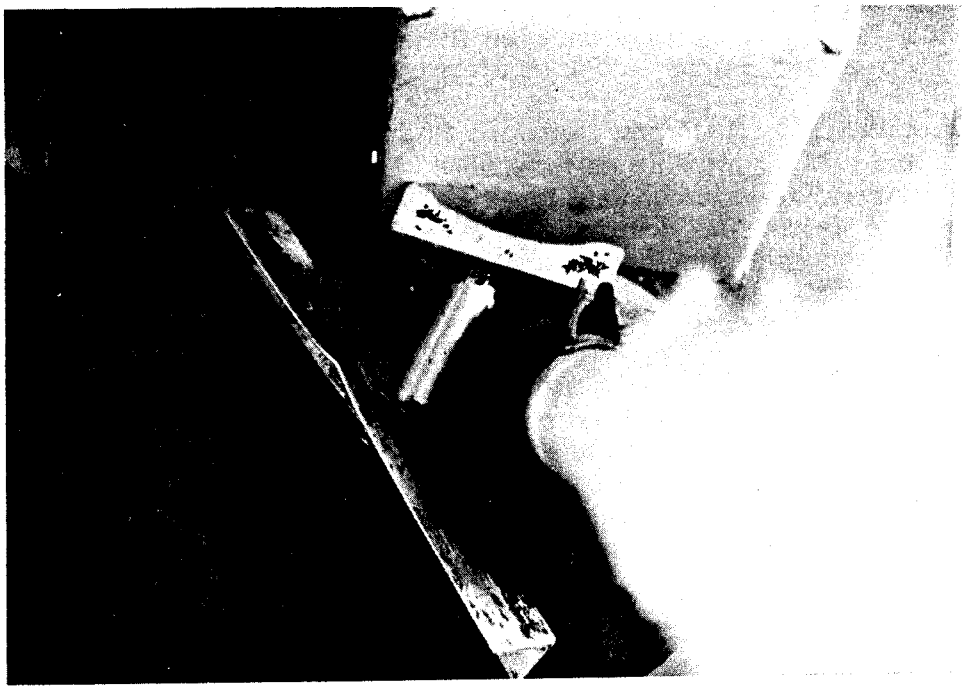


Figure 8.—Damaged control block in jammed position.

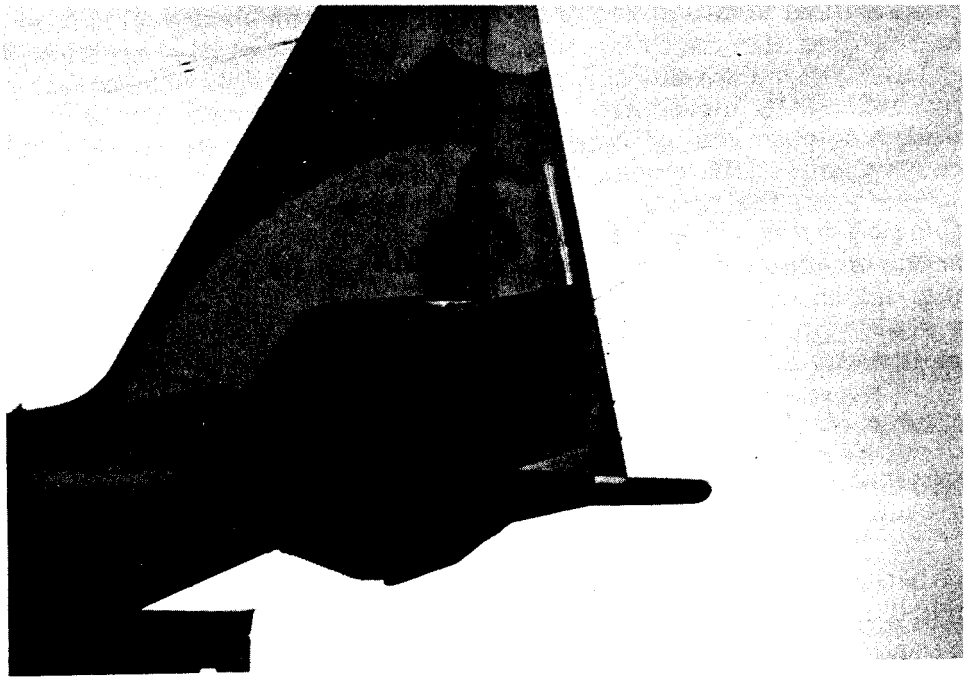
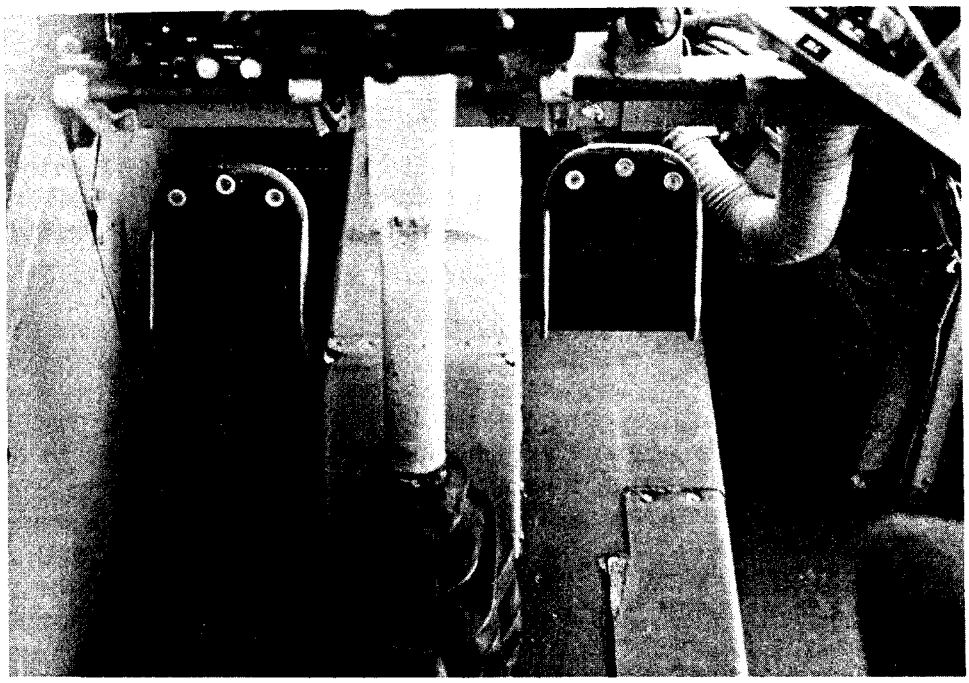


Figure 9.-Elevator position with control block jammed.



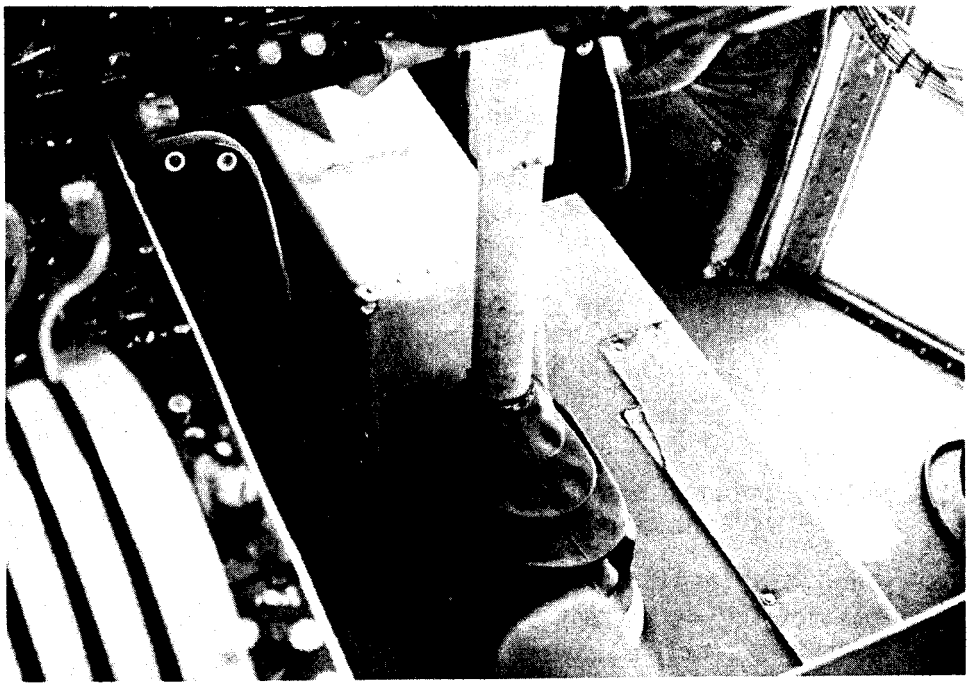


Figure lO.-Two views of control column and metal shroud.

1.17 Other Information

1.17.1 Takeoff With Control Block Installed

A former SAT L-382 first officer who flew infrequently in the LOGAIR system contacted the Safety Board and disclosed that on two separate occasions an elevator control block had been installed without his knowledge. (See figure 11.) In the first case, which occurred at Kelly AFB, he discovered the control block before takeoff when it fell to the cockpit floor as he pulled the control column full aft during the check of the flight controls.

In the second incident, which occurred at Hill AFB, the elevator control block was installed when he was away from the airplane. He did not notice the presence of the control block during the initial checklist and taxi procedures. When the flight control check was called before takeoff, in consideration of an obese captain in the left seat, he gave the control column only a token aft check which was insufficient to dislodge the control block. Forward movement of the control column seemed normal to him. His first indication of a problem was on the takeoff roll when he found that he needed to apply pressure to hold the nose down. He was unable to keep the nose down and at about 60 knots it became very light; at 80 knots the airplane flew. He aborted the takeoff and found that the elevator control block was still in place. The block as described by him was identical to the type found at the accident site and did not have a red "remove before flight" warning banner attached to it.

1.17.2 Chronology of Elevator Control Block At TIA

The investigation of this accident has revealed the following chronology of events relevant to the use of the elevator control block which had been fabricated by TIA.

1. March 7, 1985--A ramp inspection by a Federal Aviation Administraion (FAA) maintenance inspector during the replacement of the first officer's control column, which resulted from a TIA pilot report that the first officer's control column had about 1 inch more slack than the captain's on elevator movement, alerted the FAA to a broken control column in the under-the-floor area on N19ST, an L-382 operated by TIA.

2. March 21, 1985--The FAA contacted the TIA system analyst who stated that initially he had insufficient information, but had on that day (March 21) initiated a maintenance reliability report (MRR).

3. March 22, 1985--TIA launched a fleet-wide campaign to inspect the control columns below the floor in their L-382 fleet. No further cracks were discovered.

4. April 15, 1985--The Oakland, California, FAA Flight Standards District Office (FSDO) sent a letter to TIA requesting that they initiate corrective actions to preclude additional control column failures.

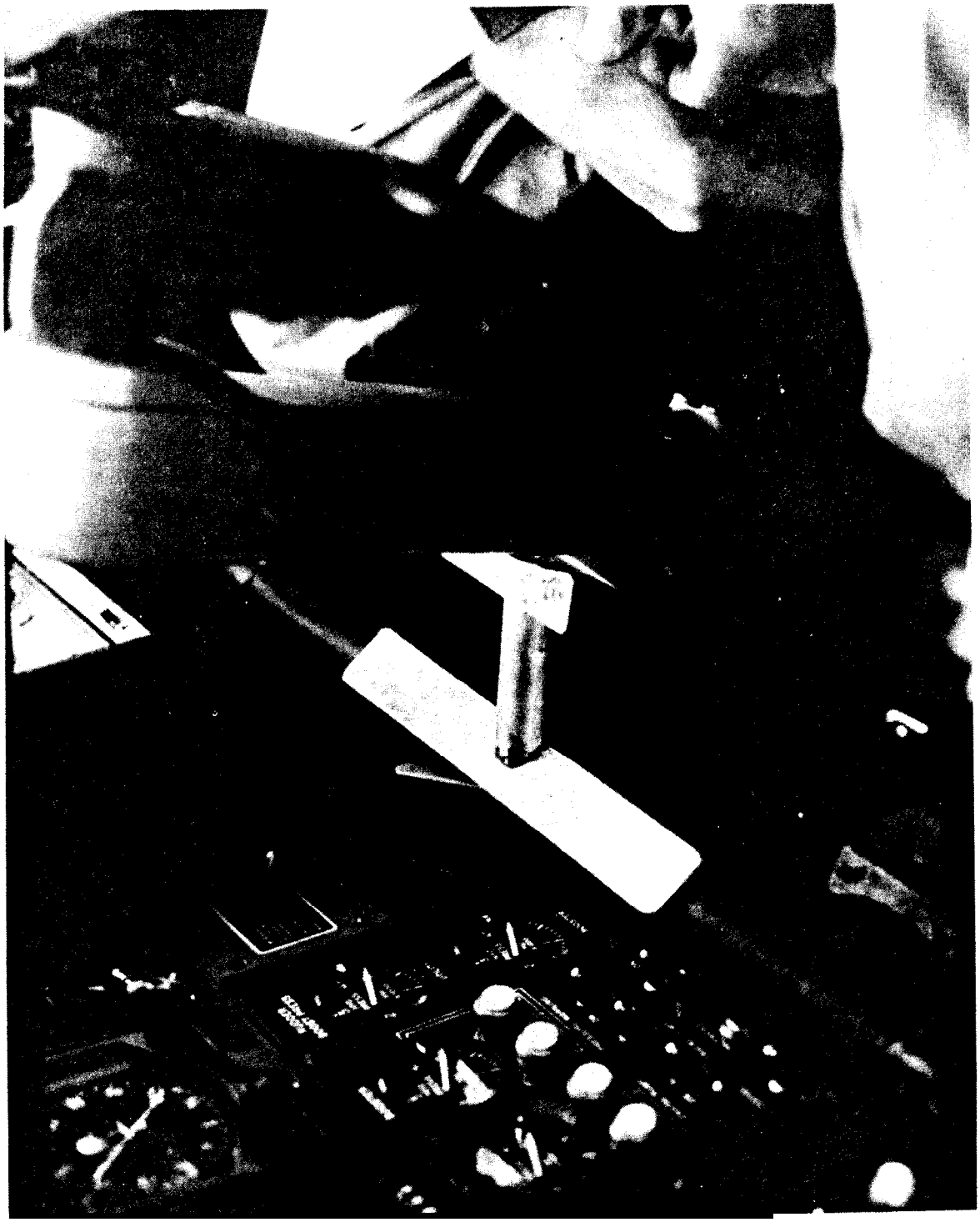


Figure 11.—Control block installed.

5. April 17, 1985--TIA issued a telex to each of their line stations requiring that the control blocks be removed from all L-382s and not used again.

6. April 23, 1985--An FAA Principal Maintenance Inspector (PMI) from the Oakland FSDO, who was responsible for the surveillance of TIA's maintenance, sent a memorandum to the FAA's Atlanta certification office stating that he believed that the control column failure was significant since there had been a similar failure in another TIA airplane in March 1984.

7. May 1, 1985--The FAA's Atlanta certification office requested further information regarding the failure from Lockheed.

8. June 12, 1985--Lockheed advised the Atlanta certification office that there had been four control column failures, two in military C-130 airplanes and two in TIA L-382 airplanes. Lockheed noted that all failures had occurred to magnesium cast column bases rather than to the newer aluminum cast bases.

9. September 17, 1985--Lockheed advised the Atlanta certification office that findings by their metallurgical and failure analysis group were consistent with the belief that the TIA control column which had failed in March 1985 had been restrained by a mechanical device.

10. January 1986--SAT, in the process of revising their L-382 AOM, requested and received a copy of TIA's L-382 FOM for review. The AOM used by SAT at that time did not address the use of a control block. The FOM which they received from TIA mentioned the removal and stowage of the control block in the Expanded Checklist, but not in the Abbreviated Checklist. SAT's revised AOM was effective in August 1986, and emulated TIA's FOM in that it also addressed the control block in the Expanded Checklist, but not in the Abbreviated Checklist.

1.17.3 Actions After October 4, 1986

Following the accident of LOGAIR 15, SAT issued a maintenance alert for their L-382 fleet on October 9, 1986, ordering the immediate removal of the control block from their airplanes and a below the floor inspection of all control columns. No cracked columns were found. SAT had not been informed by the FAA, Lockheed, or TIA before the accident of the potential for broken control columns resulting from the use of an elevator control block.

On October 14, 1986, the FAA issued a General Notice (GENOT) cautioning against the use of elevator leveler/control block devices to hold the elevator in neutral position during loading operations. The GENOT noted that pressure on the control column when such a restraint was in use could cause cracking in some control columns. There was no recommendation to conduct an inspection of control columns, specifically below the floor where the cracks had occurred.

The Safety Board spoke to the FAA L-382 project manager on November 6, 1986. He stated that the FAA had made no response to the Lockheed letter of September 17, 1985, that there had been no further correspondence, and that they did not plan to take any further action. The rationale for not taking further action was: (1) that it was redundant -the airplane has two control columns; (2) that such a failure could occur at any time, necessitating an inspection of the base after each flight; and (3) that the accident on October 4, 1986, at Kelly Air Force Base was not the result of a control column failure. He further stated that the discovery of cracked control columns was a maintenance problem and not an engineering problem.

Lockheed Engineering staff advised the Safety Board on November 6, 1986, that they would be in favor of an FAA advisory to operators who had ever used control column restraints to perform a one time inspection of the control column base below the floor.

1.17.4 SAT Operations

SAT, headquartered at Miami International Airport, Miami, Florida, was issued operations certificate No. SO-245 (AC) on December 31, 1973, by the FAA. As of June 10, 1986, the airline operated 17 L-382 airplanes and 7 Boeing 707-300 airplanes on a 14 CFR Part 121 Supplemental All Cargo Certificate. After June 10, 1986, it acquired 12 additional L-382 airplanes, including N15ST, from TIA on a lease/option when that company discontinued its 14 CFR Part 121 operations. N15ST had been operated by SAT for about 3 weeks. As a result of the lease/option arrangement, SAT picked up additional LOGAIR and Quick TRANS (Navy equivalent of LOGAIR) routes which had formerly been flown by TIA.

In addition to the airline's military cargo operations, i.e., LOGAIR and Quick TRANS, it also operated on a world-wide contract basis. SAT received its initial LOGAIR contract in October 1984. It was at this time that they began to use the TIA-type elevator control block. No one currently at SAT is able to recall how the control block came into the system. As of October 9, 1986, the airline employed 138 pilots and 61 flight engineers. There had been 11 replacements of flight personnel in the previous year.

1.17.5 Military Oversight and FAA Surveillance of SAT

LOGAIR contract carriers are selected and monitored by the Military Airlift Command (MAC). On a biennial basis a MAC survey team performs an on-site inspection of each carrier for the continuing approval of that carrier for Department of Defense (DOD) use. In alternate years, a "desk top audit" is performed. SAT received the continued approval of MAC in their most recent biennial inspection conducted in September 1986. Following the accident involving N15ST an additional on-site inspection was conducted and resulted in MAC's approving SAT for continued DOD use.

After a LOGAIR contract is signed and a carrier is in operation, monthly evaluation letters are forwarded to MAC by the Air Force Logistics Command (AFLC). This evaluation is limited to punctuality. A satisfactory reliability factor is 85 percent or better. SAT's reliability factor in fiscal year 1986 averaged 93.4 percent. AFLC also receives monthly reports from the various stations regarding the condition of the airplanes. Generally these are filed or, if there are a large number of negative reports, they are forwarded to MAC for follow-up. Both the director and the deputy director of AFLC's oversight operation expressed the opinion that SAT's flightcrews and operations were "top notch."

The FAA's FSDO No. 65 in Miami, Florida, had surveillance responsibility for SAT. As of July 30, 1986, FSDO 65 had a total of 77 inspectors, 8 short of their authorized staffing level. As of September 1, 1986, FSDO 65 had certificate and surveillance responsibility for 16 operators under 14 CFR Part 121, as well as 238 other operators, including commuters and other 14 CFR Part 135 operators, repair stations, and schools.

FSDO 65's work activity record for the the period between October 1, 1985, and September 30, 1986, revealed that two ramp inspections were performed on SAT L-382 airplanes in Miami, Florida. Neither of the two airplanes inspected was equipped with an elevator control block. There was no record of any operational en route inspections having been performed on SAT's L-382 airplanes; however, eight operational en route inspections were performed on SAT's Boeing 707 airplanes. Federal regulations specify the number of en route inspections which must be performed only by carrier and not by aircraft type.

FSDO 65 is required by the FAA's National Required Inspection Program to perform the following minimum numbers of inspections of SAT annually: two ramp inspections, two en route operations inspections, and two en route airworthiness inspections. Additionally, each region in which the airline operates determines a specific number of inspections to be conducted in their region. The results of these inspections in other regions are then forwarded to the airline's principal operations inspector (POI).

Two airworthiness en route inspections were performed on SAT's L-382 LOGAIR operations by FAA FSDO 67 in Salt Lake City, Utah, on December 5, 1985, and on June 16, 1986. No comments concerning the use of the device were logged as the result of either inspection. An elevator control block of the type that was found in the wreckage of N15ST was aboard one of the airplanes in a postaccident inspection. The other airplane was N46965, which had been removed from the LOGAIR system before the accident.

The FAA's POI assigned to SAT began his duties in May, 1986. Beginning in mid-December 1985, he had been assigned to oversee the 14 CFR Part 121 certification of Sun Coast Airlines, a Boeing 727 operation located geographically within the jurisdiction of FAA FSDO 63 in Ft. Lauderdale, Florida. Since FSDO 63 had no personnel who were experienced in 14 CFR Part 121 operations, FSDO 65 was directed by the FAA's Atlanta Flight Standards Division to conduct the certification. Following this assignment, SAT's POI devoted about 75 percent of his time for 8 months, until after July 27, 1986, to the certification process. His duties as SAT's POI were not assigned to anyone else during his absence and he was able to devote about 5 percent of his time to SAT. The POI also was assigned as the POI for Arrow Air (ARW), to which he devoted about 20 percent of his time.

SAT's POI was not rated, nor was he required to be rated, in the L-382. Therefore, he requested an L-382-rated POI from FSDO 65 to review SAT's draft AOM on August 19, 1986. The rated/reviewing POI had recently resigned his commission in the Air Force and had never seen an elevator control block; none of the military services uses a device such as an elevator control block. Verbal comments were made to SAT's POI who, in turn, forwarded them to SAT. This same L-382 rated POX, on August 21, 1986, reviewed SAT's L-382 Expanded Checklist. Again, comments were transmitted to SAT through their POI. SAT, after making modifications, resubmitted the Expanded Checklist on September 2, 1986, at which time the rated/reviewing POI gave his approval to SAT's POI.

On October 1, 1986, again at the request of SAT's POI, the L-382 rated POI reviewed SAT's L-382 AOM, which had been modified and resubmitted. The rated/reviewing POI gave his approval to SAT's POI. Regarding the entry contained in the Expanded Checklist, "Control Block -- Removed and Stowed," the rated/reviewing POI stated in a postaccident interview that he was concentrating on the required items, all of which were there, and the additional item "did not ring a bell." Neither SAT's POI nor the rated/reviewing POI was aware of the existence of the elevator control block before the accident.

2 ANALYSIS

2.1 General

The airplane was certificated, equipped, and maintained in accordance with Federal aviation regulations (FARs) and was operated with MAC's approval.

The flightcrew was certificated and each flightcrew member had completed the training prescribed by FARs. The investigation revealed that the flightcrew had met off-duty time and rest requirements. Autopsy and toxicological reports revealed no pre-existing physiological conditions that would have prevented the flightcrew from performing their flight duties in a normal manner. A background investigation revealed no significant information.

The Safety Board noted that the accident occurred about 0400. The crew had arrived in the San Antonio area from their west coast domicile about 2220 on October 2, 1986, and reported for duty at Kelly AFB about 0150 on October 4, 1986. Such an irregular schedule can lead to the disruption of circadian rhythm which has been demonstrated to have an effect on human performance. There are marked diurnal variations in the level of psychophysiological arousal with the lowest level occurring between about 2 a.m. and 7 a.m. for most individuals.

It was determined that the airplane was intact until impact. There was no evidence of pre-impact mechanical failures, fires, or explosions. All four engines were found to have been developing significant power at the time of impact.

The cargo had been loaded and secured properly. There was no evidence that the cargo shifted during takeoff. The weight and balance of the airplane was within limits.

Visual meteorological conditions prevailed and no significant weather phenomena existed at the time of the accident.

All communications with ATC were routine.

No discrepancies were found in any of the airplane's systems. There was no evidence of an elevator control system failure, elevator failure, elevator booster assembly failure, or of a loss of hydraulic pressure to the elevator booster assembly. No evidence was found to substantiate elevator control interference within the control system itself; however, there was evidence to substantiate interference external to the control system.

The conversation recorded on the CVR revealed that about 2 seconds after the first officer called for rotation, the captain requested help from the first officer to push the yoke (control column) forward. Considering the brief amount of time which elapsed

between the call to rotate and the request for help, it seems highly likely that the actual rotation occurred before the call. However, it does not seem likely that rotation was seriously premature since the captain made no comment to that effect either before V1 (108 knots) or before Vr (112 knots). The witnesses, both in the tower and on the ground, noted that the takeoff roll and initial rotation appeared to be normal. Since the altitude trace on the FDR did not function, it was not possible to make an accurate determination of the precise time or air speed when rotation occurred. About 9 seconds later the CVR revealed that something was jamming the control column and that the captain knew what it was. The object was subsequently cleared, apparently by the flight engineer, about 1 second before the "whoop whoop pull up" ground proximity warning of the GPWS began just before impact. The airplane was out of control at that time.

As a result of the findings on the CVR, it was possible to make an early determination that the object (called a "thing" by the captain) lodged in the controls was an elevator control block. A damaged elevator control block was subsequently found in the wreckage with other cockpit debris in the vicinity of the first officer's control column. A deformed metal shroud located forward of the first officer's control column and between his two rudder pedals, which provided a dust cover for the rudder controls, was found with a puncture and scratches which conformed to the flange of the U-shaped channel of the elevator control block. (See figure 4.)

The captain probably did not consider aborting the takeoff since there was no verbalization of a problem until after rotation. The flightcrew probably would have expected to continue the takeoff after V1 and to handle any subsequent emergency in the air. The emergency was not verbalized until after VR; therefore, the flightcrew elected to continue the takeoff. Considering the 30-second time frame following verbalization of a problem to the crash, the CVR revealed that the captain handled the ensuing pitch up in the best manner possible by initiating a turn/bank with rudder input. With sufficient altitude the airplane may have been able to recover from the unusual altitude. Considering the runway length (11,550 feet) and the nature of the emergency, aborting the takeoff may have been an option immediately upon recognition of the problem.

The crew briefing of LOGAIR 15 by the captain consisted, in part, of the following:

> . . .In the event of a malfunction before vee one, anyone can call abort and Ill come back to flight idle. If it's a prop malfunction, leave it in flight idle, bring the rest of 'em back, feather the bad one from the flight idle position, and you11 get on the yoke and Ill get on the steering and throttles. After vee one well continue our takeoff, get positive rate gear up, and then decide whether to change configuration. After that, well continue to climb out, take the required action, remaining VFR under radar control for return landing on one five.

The definition of V1 found in SAT's AOM is as follows:

> V1 is the maximum speed (calibrated air speed) at which the pilot, after recognizing an engine failure during the take-off run, can stop within the scheduled runway length. V1 is also the minimum **speed at which power failure can be experienced and the take-off** continued without over-running the scheduled flightpath.

As soon as the nose high control problem was recognized, it would have been reflexive on the part of the captain to apply full nose down trim in an attempt to alleviate the high pitch attitude. This action would have aggravated the situation by imposing higher control forces and the nose down trim would have increased the tendency to pitch up. When the elevator became jammed in a fixed. position, the trim tab would then serve the function of a movable control surface and the nose of the airplane would move opposite to the direction normally experienced from a trim tab input. In other words, nose down input by the flightcrew would move the trailing edge of the trim tab up, which normally would move the elevator down, causing the nose to pitch downward. However, in the abnormal circumstance of a jammed (fixed) elevator, the trailing edge up position of the trim tab would pitch the nose further up. Therefore, finding the elevator trim in the full nose down position was understandable in that it was most likely pilot-induced and was not a result of a mechanical malfunction.

2.2 Elevator Control Block

The Safety Board is aware of at least two types of nonapproved elevator control blocks, the purpose of which was to raise the elevator so that it was level with the cargo door or higher to prevent damage to the control surface during loading operations. One of these was designed and fabricated by the predecessor of TIA and the other by SAT. The Safety Board also learned that occupant restraints were occasionally used for the same purpose by some operators.

The Safety Board was able to determine a manner in which the elevator control block could have become lodged between the control column and the metal shroud without necessitating a gross aft movement of the control column at rotation, allowing it to jam the control column. By positioning the shorter U-shaped channel between the metal shroud and the control column, with the 4-inch tube angled left to right, and with the longer V-shaped channel displaced to the left side of the control column the device lodged easily. Furthermore, the physical evidence indicated a perfect alignment of the U-shaped channel with the puncture and scratch marks on the metal shroud. Previous efforts to lodge the device with the 4-inch connecting tube positioned forward and aft had resulted in its slipping out and it could only be jammed with an extreme aft movement of the control column.

It was determined that the elevator control block found in N15ST had been removed from another airplane and had been placed in N15ST when it was being prepared for operations in the LOGAIR system about 3 weeks before the accident.

According to SAT, a total of three elevator control blocks were in use in their system, two of the TIA type and one of the SAT type. The SAT fabricated device was larger and more conspicuous and would have prevented access to the pilot seats if installed and its use had been discontinued before the accident.

Since the captain and the flight engineer had been hired in December and October of 1983, respectively, and recently had flown exclusively in the LOGAIR system in which there was always an elevator control block on board, it is reasonable to assume that they knew about the device and its purpose. It is probable that the first officer had no knowledge of the device. Before his employment with SAT, he had flown as a first officer for TIA, after the date when TIA had removed all of the elevator control blocks from their L-382 fleet.

SAT did not provide any ground or flight training regarding the use of the elevator control block, although it was commonly agreed that it was the usual practice for a first officer to install and remove the device. There were no elevator control blocks on the airplanes in which the first officer had obtained his training or his IOE. His first opportunity to see the device was on October 2, 1986, when he served as first officer on N15ST on a flight from McClellan AFB, via Hill AFB, to Kelly AFB. The flight of N15ST to McClellan AFB was a noncargo flight; consequently, the elevator control block was not installed at McClellan AFB. En route, at Hill AFB, its installation would have been the responsibility of the first officer, who probably was not aware of its existence. The Safety Board believes that it is highly probable that the first officer of N15ST was not aware of the elevator control block before the departure from Kelly AFB on October 4, 1986.

According to SAT's chief flight engineer, when not in use the elevator control block was supposed to be stored under the flightdeck bunk behind sliding wooden doors. The device, when in use on N15ST was commonly stowed on the cockpit floor on the right side of the first officer's seat. It should be noted that the cockpit floor in that location was lower than the base of the metal shroud and the flight control column and, while not a prudent place to store the device, it did not pose an immediate hazard to flight safety in that location.

The arriving first officer said that he installed the elevator control block before leaving the airplane on October 4, 1986. Neither he nor any of the other arriving flightcrew mentioned its installation to the departing flightcrew, nor were they required to do so. The cockpit thunderstorm lights provide excellent illumination in the cockpit; however, the elevator control block in N15ST was a relatively inconspicuous device. According to the first officer of the previous flight, much of the original red paint had worn off and there was no longer a red "remove before flight" warning banner attached to make its presence more obvious. Consequently, it could have blended unobtrusively into the general cockpit environment. It would be possible to gain access to the pilot seats with the smaller elevator control block installed.

The Safety Board believes that the nonapproved elevator control blocking devices probably were developed by TIA's predecessor and by SAT, and subsequently used by TIA and SAT in the interest of flight safety to prevent damage to the elevator control surfaces during loading operations. However, without the simultaneous development of appropriate operational procedures, policies, and training in the use of such a tool, the potential safety hazards associated with its use were neither apparent nor corrected. If the air carriers who developed and used the devices had sought the approval of the FAA, appropriate procedures and cautions or warnings may have been developed. The Safety Board believes that the FAA should alert air carrier inspectors to the possible use of nonapproved tools by airlines which may pose potential hazards to flight safety.

2.3 Four Scenarios

Four possible scenarios regarding how the elevator control block came to be lodged between the first officer's control column and the metal shroud were considered: (1) the elevator control block had fallen out before the flightcrew arrived; (2) the elevator control block was installed and fell out when the aft control column check was performed; (3) the elevator control block was installed and fell out at rotation; and (4) the elevator control block was stowed on the metal shroud and fell off the shroud as a result of the takeoff roll acceleration and rotation.

According to SAT personnel there have been occasions when an elevator control block fell out of its installed position when the elevator surface was moved by gusty wind conditions or an external force. If this had occurred the flightcrew may not have detected the presence of the device behind the control column. The Safety Board was able to conduct a full control check with an elevator control block between the control column and the metal shroud in the position in which it fell on the aft elevator check, that is, oriented vertically. However, in order for the device to lodge in the manner in which the witness marks indicate it was in when it restricted forward control column movement, it would have had to reposition itself after the full control check. Although that scenario is plausible, the Safety Board noted that wind conditions were not gusty during the time that LOGAIR 15 was on the ground at Kelly AFB and the investigation revealed no unusual occurrences during the loading process which would have resulted in external movement of the elevator. The loading supervisor noted that the elevator was faired with the horizontal stabilizer, a condition which would exist only if the elevator control block was installed, thus establishing that it had not fallen out at that point. The flight engineer of LOGAIR 15 supervised the loading operation and should also have noted that the elevator was faired.

The Safety Board concludes that the elevator control block did not fall out before the flightcrew came aboard.

During the course of the investigation the Safety Board learned that on at least two separate occasions a first officer failed to detect and remove an elevator control block under circumstances similar to those under which N15ST was operating; that is, the first officer was not accustomed to using the device, the installation was by another party and unknown to him, and it was also a night flight with cockpit lighting restricted.

In one instance the elevator control block fell out on the aft elevator check. The CVR transcript from LOGAIR 15 indicates that all controls were free and had full travel. Although that check was verbalized, there was no way to determine if it was actually performed. No conversation and no noises are recorded to suggest that the device fell out on the aft control column check. Furthermore, it seems likely that the first officer would have noticed it if it had fallen out at that point, as did the other unfamiliar first officer who reported his experiences with the elevator control block. Since the first officer of LOGAIR 15 was new to the airline and had just completed his training, it would be reasonable to expect that he would have been meticulous in the performance of a full control check in accordance with company policy, in which case the elevator control block would have fallen out. The Safety Board believes that the first officer of LOGAIR 15 would have noticed the elevator control block if it had fallen out. Tests were conducted after the accident and the elevator control block produced a very loud noise when allowed to fall out on the aft control check. It also may have hit the first officer's legs or feet as it fell.

In the other reported instance, the same first officer who was involved in the first instance had only performed a token aft check in consideration of an obese captain. When the airplane flew prematurely, the takeoff was aborted and the device was discovered. When this exercise was repeated in the simulator, it also flew prematurely with the elevator control block installed. If the problem had developed before V1, the flightcrew probably would have aborted the takeoff. On LOGAIR 15 the emergency was not acknowledged verbally until after rotation, and the flightcrew elected to handle the emergency in flight.

Normal rotation requires less aft movement than the elevator control block requires in its normally installed position and the CVR transcript records no problems before rotation, such as premature liftoff. Therefore, it does not seem likely that LOGAIR 15 took off with the device installed.

The flight engineer stated, "Okay, it's clear now," before impact, so the device was probably free to move about at impact. The puncture in the soft sheet metal shroud probably would not result from a loose object in the cockpit during the impact sequence, as the flight engineer's statement that it was free would suggest. If the puncture did not occur at impact it must have been the result of pilot effort in pushing forward on the yoke. It could not have occurred if the elevator control block was in its normally installed position. However, the puncture could easily have occurred with the elevator control block jammed near the floor. So it seems unlikely that the device was in its normally installed position when the captain asked the first officer for help on his yoke.

The Safety Board concludes that LOGAIR 15 did not take off with the elevator control block installed and therefore eliminates the possibilities that it fell out either at the aft elevator control check or at rotation.

The most feasible scenario would appear to be that the elevator control block had been improperly stowed on top of the metal shroud and slid back into the position in which the Safety Board determined that the jam occurred, as evidenced by the witness marks.

SAT personnel stated that the device was never placed on the metal shroud. However, since the first officer had no knowledge of the elevator control block and no training in its use, he may have seen it, recognized it as a control lock of some kind, removed it, and placed it on the shroud. It is most likely that it would have been removed by the first officer since it was installed on his control column and would generally be removed after getting into the seat. A postaccident test indicated that it would require two pilots to pull the control column aft before the suction boost pump was turned on; however, after it was turned on it was very easy for one pilot to perform the aft movement. A normal takeoff followed by a pitch up, as observed by some witnesses, would support this hypothesis. The CVR transcript would also support this hypothesis, since there was no suggestion of premature flight as would have occurred if the block had been installed. In addition, only 2 seconds elapsed after the call for rotation before the captain asked for help on his yoke, at the time when he would have pushed forward on the yoke to lower the nose to attain V2. In the full flight simulator test it was demonstrated that a normal takeoff rotation would cause the elevator control block to fall between the control column and the metal shroud when it was stowed on the shroud. While a simulator demonstration does not necessarily equate to what may have occurred in the accident airplane, since it cannot duplicate airplane motion and acceleration forces, common sense alone would support that a loose object placed freely on a metal box-like structure would move aft and downward upon acceleration and rotation in the actual airplane.

The Safety Board concludes that the elevator control block had been improperly stowed on the metal shroud and slid back between the shroud and the control column at rotation, thus causing the controls to jam so that the flightcrew was unable to control the airplane during takeoff.

While the Safety Board has established that the first officer had probably not seen an elevator control block before and had received no training in its use, its design is similar enough to control locks of various designs that its function should have been

immediately apparent to him. It should also have been evident that anything placed on the metal shroud would shift aft with acceleration and rotation and that the small metal device should not only be removed, but stowed securely, so that it did not pose a hazard to flight safety.

The Safety Board cannot eliminate the collective responsibility of the flightcrew for removing the elevator control block since both the captain and the flight engineer had flown exclusively in the LOGAIR system for several years. and the elevator control block was used on all LOGAIR flights. Furthermore, they knew that the first officer was just beginning his career with SAT and should have been aware that he may have had no experience with the elevator control block which was a unique piece of equipment with a specific purpose and which was not on the Abbreviated Checklist. Additionally, the captain identified the problem only 9 seconds after recognition and the flight engineer, just 2 seconds later, had a solution, suggesting that both were thoroughly familiar with the elevator control block. The Safety Board believes that the captain and/or the flight engineer, as senior members of the flightcrew, should have taken the opportunity before the flight to familiarize the new first officer with the elevator control block.

2.4 Maintenance and Operations Manuals and Checklists

Lockheed's Maintenance Manual cautions against restraining the control surfaces in gusty wind conditions since the hydraulic booster might be damaged. Built-in snubbers in the booster package prevent the controls from slamming into their stops. In the event of complete hydraulic fluid depletion it is recommended that contour-type clamps be installed on the control surfaces. These cautions do not appear in Lockheed's Operations Manual, nor did they appear in TIA's or SAT's FOM or AOM. The installation and removal of the elevator control block was commonly performed by the first officer at SAT, not by maintenance personnel. Its purpose was not to serve as a gust lock against windy conditions, but only to fair the elevator to prevent damage during loading operations. In fact, its use in windy conditions was probably responsible for at least one control column failure at TIA. The Safety Board believes that an operational note, such as a caution against using restraints on the flight controls, should appear in the Operations Manual as well as in the Maintenance Manual.

It was determined that reference to the elevator control block appeared only in SAT's Expanded Checklist and not in their Abbreviated Checklist. The Abbreviated Checklist is used by the flightcrew in the cockpit and the Expanded Checklist enumerates all of the tasks associated with the item which will be verbalized with a challenge and response in the cockpit. SAT had just recently revised the Expanded Checklist in their AOM and their Abbreviated Checklist using TIA's checklists as models. Although earlier versions of TIA's Abbreviated Checklist mentioned the use of the elevator control block, the latest one did not, since the device was no longer used by them. In the Expanded Checklist, the device was included as a part of the item: Hydraulic Control Panel —— Set (pilot call). The expanded checklist is addressed in ground school and pilots are responsible for the information therein, but are not required to memorize it. It is reviewed on an annual basis, when revised, and occasionally may be consulted when a problem occurs in flight.

2.5 Checklist Omissions

The CVR revealed several items to which there was no audible challenge and response by the flightcrew in the Before Start and Taxi and Takeoff Checklists.

Considering the excellent quality of the CVR tape, the items in question probably were not verbalized or they would have been audible. The majority of those items were the responsibility of the flight engineer. One explanation for the deficiency may be that the sensitive hot mike system, which was in use with noise attenuating headsets, had probably discouraged unnecessary conversation and may have limited responses when prudence would have dictated otherwise. SAT's vice president of flight operations noted that there was a tendency for L-382 engineers who were upgrading to the 707, in which crew conversation is conducted without headsets or intercom, to carryover the habit of reading the checklists to themselves rather than aloud. The Safety Board does not condone the nonverbalization of checklists when company policy dictates otherwise, but also does not believe that the lack of a verbal response to checklist items by the flight engineer of LOGAIR 15 was a factor in this accident. Following the accident, SAT drew to the attention of their L-382 flightcrews the necessity to verbalize challenge and response checklist items.

2.6 Lockheed's Knowledge of the Elevator Control Block

Since Lockheed did not manufacture the elevator control block and did not recommend control restraints of any kind, except in the event of complete hydraulic fluid depletion, it was only by chance that they became aware of the use of an elevator control block by TIA in 1985. However, the Safety Board believes that Lockheed should have issued a service bulletin advising all operators of L-382/C-130 airplanes about the safety hazards associated with the use of unauthorized control restraints when it came to their attention. Lockheed engineering staff has advised the Safety Board that they would be in favor of an FAA Advisory to operators who had ever used restraints to perform a one-time inspection of control column bases below the floor.

The Safety Board believes that the cautions found in Lockheed's Maintenance Manual regarding flight control restrictions should be reiterated in their Operations Manual and that the addition should be circulated to all operators of L-382/C-130 airplanes.

2.7 FAA's Knowledge of the Elevator Control Block

In March 1985, a TIA pilot report resulted in the replacement of the first officer's control column and the discovery of a broken base below the floor. A ramp inspection by a PMI alerted the FAA to the occurrence. The use of an elevator control block in gusty or high wind conditions was suspected as the cause of the failure and the FAA directed TIA to initiate corrective action. As a result, TIA removed all elevator control blocks from their L-382 airplanes. and prohibited their further use. Subsequent tests by Lockheed confirmed that the failure was consistent with the use of a mechanical restraint. This information was forwarded to the FAA's Atlanta Certification Office; however, the FAA did not issue either maintenance or operations bulletins to inform other operators of the potential hazards of restricting the control column. The Safety Board believes that the FAA should have acted on this information by disseminating a maintenance and operations bulletin to operators of L-382/C-130 airplanes apprising them of the safety hazards associated with the use of unauthorized control restraints.

Following the accident involving N15ST on October 4, 1986, the FAA issued a GENOT on October 9, 1986, cautioning against the use of elevator leveler/control block devices to hold the elevator in neutral position during loading operations. The GENOT also noted that pressure on the control column when such a restraint was in use could cause cracking in some control columns. The GENOT did not suggest a one-time

inspection of control columns below the floor to determine if cracks may have already occurred. The Safety Board believes that such an inspection is warranted. As an additional step to correct this oversight in the GENOT, the Safety Board believes that an Airworthiness Directive (AD) should be issued to require a one-time inspection of control columns below the floor.

On November 6, 1986, the Safety Board spoke to the FAA's L-382 project manager who stated that the FAA did not plan to take any further action in the matter. The rationale was that the airplane had two control columns, thus providing redundancy; that such a failure could occur at any time requiring an inspection after each flight; and that the accident on October 4, 1986, at Kelly AFB was not the result of a control column failure.

While the Safety Board acknowledges that the accident of N15ST was not the result of a control column failure, it believes that the investigation revealed a safety deficiency which may be unknown to other L-382/C-130 operators in the United States and elsewhere. The Safety Board disagrees that an inspection would be required after each flight because if a carrier stopped using restraints of any kind there would be no need for any other inspections beyond the presently scheduled intervals. (See appendix C.) Redundancy notwithstanding, if the flying pilot of an airplane suddenly experienced a catastrophic control column failure in a critical phase of flight, the result could be the loss of control of the airplane from which recovery could conceivably be impossible. The Safety Board, therefore, believes that a one-time inspection below the floor to look for cracks in the bases of all control columns in L-382/C-130 airplanes in which control restraints have been used is needed.

2.6 FAA Surveillance

FAA's Miami FSDO 65 had the certificate responsibility for SAT. The minimum number of inspections required by the National Required Inspection Program for the airline was exceeded by the Miami FSDO. However, the requirement does not specify that inspections be conducted of each type of airplane operated by an airline, but only of the carrier itself. Consequently, while there were several operational en route inspections of SAT's Boeing 707 fleet, there were none conducted on SAT's L-382 airplanes. The Safety Board believes that the FAA should establish a minimum number of inspections for each type of airplane in an air carrier's fleet.

SAT's POI had been assigned that duty during an 8-month period when he was required to devote the majority of his time to the certification of another airline under the jurisdiction of another FSDO. Until about August 1986, he was unable to devote more than about 5 percent of his time to the direct surveillance of SAT, since he was also the POI for ARW and devoted about 20 percent of his time to the surveillance of that airline. While the Safety Board does not believe that this contributed directly to the accident, it does believe that the FAA should provide for the continuing direct supervision of 14 CFR 121 air carriers when the POI is occupied with other duties for extended periods of time.

As a result of its investigations of the August 25, 1985, accident in Auburn, Maine; the September 23, 1985, accident in Grottoes, Virginia; and the March 13, 1986,

accident in Alpena, Michigan, 8/ the Safety Board issued Safety Recommendation A-86-111 to the FAA:

> Develop and issue guidelines to air carrier district offices to provide for a minimum level of, continual direct surveillance of commuter air carrier operators when the Principal Operations inspector is occupied with other duties for extended periods of time.

On January 8, 1987, the FAA responded to A-86-111 stating that a memorandum to the regional flight standards division managers will be issued which will direct them to provide a minimum level of direct surveillance to assigned commuters when the POI is absent for an extended period of time. The status of this recommendation is "Open--Acceptable Action."

The Safety Board believes that similar actions should be taken by the FAA regarding the oversight of 14 CFR Part 121 air carrier operators.

The Safety Board appreciates the latest efforts of the FAA to alleviate substandard surveillance problems. In February 1984 they embarked upon an in-depth review of the entire flight standards inspection system. According to the FAA the review, entitled Project SAFE (Safety Activity Functional Evaluation), encompassed a forecast of increased aviation activity under deregulation, the National Air Transportation Inspections (NATI-I and II), the General Aviation Safety Audit (GASA), and an evaluation of existing regulations, directives, programs, and studies and reports concerning flight standards inspection programs. The elements of the flight standards system which received critical appraisal included regulations, directives, work programs, program management information, industrial safety findings, evaluation programs, budget, resources, position descriptions, classifications, hiring practices, career development, training, and supervisory evaluation. Deficiencies identified by Project SAFE have been addressed in an implementation, plan with a blueprint for short-term and long-range changes. The FAA has set targets in its implementation plan to update each part of the flight standards system by fiscal year (FY) 1988 and by FY 1989, to standardize and integrate the parts into an automated, interactive system for updating and documenting FAA performance.

The SAFE program is in its early stages and it will be a considerable period of time before measurable benefits can be derived and evaluated. The Safety Board believes that the findings of this accident warrant the development of more timely interim procedures and guidelines which will allow for continued surveillance of carriers during periods when the POI is unable to fulfill those duties because of other work demands.

SAT's POI was not rated in the L-382. Therefore, he turned over the responsibility for the review of SAT's revised AOM and Abbreviated Checklist to another POI at FSDO 65 who was rated in the airplane. The rated/reviewing FSDO 65 POI had recently left military service and was not familiar with the elevator control block. When reference was made to it in the Expanded Checklist, it simply ". . . did not ring a bell."

8/ For more detailed information, read Aircraft Accident Reports--"Bar Harbor Airlines Flight 1808, Beech B-99, N300WP, Auburn-Lewiston Airport, Auburn, Maine, August 25, 1985" (NTSB/AAR-86/06); "Henson Airlines Flight 1517, Beech B-99, N339HA, Shenandoah Valley Airport, Grottoes, Virginia, September 23, 1985" (NTSB/AAR-86/07); and "Simmons Airlines Flight 1746, Embraer EMB-110P1, Phelps Collins Airport, Alpena, Michigan, March 31, 1986" (NTSB/AAR-87/2).

The Safety Board believes that the FAA should strongly consider a mandatory requirement for its POIs to be rated in the category and class of all aircraft operated by the carrier for which the POI has certificate responsibility.

As a result of its investigation of the September 6, 1985, accident involving a Midwest Express DC-9 at Milwaukee, Wisconsin International Airport 9/ the Safety Board issued Safety Recommendation A-87-10 to the FAA:

> Require principal operations inspectors of 14 CFR 121 certificate holders to have training and experience commensurate with the air carrier involved, including a comparable type rating (e.g., turbojet powered transport category) in the category and class of aircraft to be used by the certificate holder.

The status of this recommendation is "Open--Awaiting Reply."

The Safety Board believes that the circumstances of this accident further emphasize the need for upgrading the qualifications and experience levels of POIs.

3. CONCLUSIONS

3.1 Findings

1. The airplane climbed in an abnormally high pitch attitude to about 700 feet agl.

2. The airplane rolled into a left bank and impacted in a near inverted attitude in takeoff configuration with gear extended and flaps at 50 percent.

3. The elevator trim tab was found in the full trailing edge up position, corresponding to full nose down trim.

4. There were no pre-impact separations, fires, or explosions and all four engines were developing power at impact.

5. The cargo, which consisted in part of Class B and C explosives, was securely loaded and the airplane's weight and balance were within allowable ranges.

6. The airplane was operated according to FAA regulations, company policy, and MAC requirements.

7. The airplane had one deferred maintenance item regarding inoperative autopilot trim.

8. Most of the airplane's systems components were destroyed in the postcrash fire.

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9 For more detailed information, read Aircraft Accident Report--"Midwest Express Airlines, Inc., Douglas DC-9-14, N100MC Milwaukee, Wisconsin, September 6, 1985" (NTSB/AAR-87/01).

9. The flightcrew was qualified, certificated, and physically capable of conducting the flight.

10. The captain and flight engineer were aware of the use of an elevator control block and the first officer probably was not aware of the device.

11. The elevator control block was commonly installed on the first officer's control column and it was the unwritten practice for a first officer to install and remove the device.

12. The first officer of the previous flightcrew installed the elevator control block before he left the airplane.

13. The elevator control block and the first officer's rudder pedal metal shroud were found in the cockpit wreckage near the first officer's control column.

14. The first officer's rudder pedal metal shroud had puncture and scratch marks which matched the U-shaped channel of the control block.

15. During the takeoff climb the flightcrew successfully removed the elevator control block from its lodged position between the first officer's control column and the rudder pedal metal shroud, but too late to recover the airplane.

16. The FAA was aware of the use of the elevator control block by some operators, but did not disseminate precautions against its use until after the accident.

17. Lockheed was aware of the use of the elevator control block by some operators, but did not issue a service bulletin to caution against its use.

18. The principal operations inspector for SAT was not rated in the L-382 and had been on an alternate assignment for 3 of the 5 months that he had been assigned to SAT.

19. The Abbreviated Pretakeoff Checklist did not address the removal of the elevator control block.

20. The first officer's training did not address the use of the elevator control block.

21. SAT had no written policy regarding the use of the elevator control block.

22. Precautions against the restraint of the control column were found in Lockheed's Maintenance Manual, but not in the Aircraft Flight Manual.

23. An elevator control block had been designed and fabricated by at least two operators of L-382 airplanes.

24. There had been no operational en route inspections of SAT's L-382 airplanes.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the use by the carrier of a nonapproved device designed to raise the elevator during loading operations which was not properly stowed by the flightcrew and which lodged in the controls, preventing the flightcrew from controlling the airplane during takeoff.

4. RECOMMENDATIONS

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

-to the Federal Aviation Administration:

Issue an Airworthiness Directive requiring an immediate one-time inspection below the floor for cracks in the bases of control columns in all Lockheed L-382 airplanes. (Class II, Priority Action) (A-87-30)

Issue a Bulletin to air carrier principal operations inspectors and principal maintenance inspectors to be alert to the possibility of nonapproved equipment and tools such as flight control restraints, which may be in use by operations or by maintenance personnel and which may pose a potential hazard to flight safety. (Class II, Priority Action) (A-87-31))

Require Lockheed to reiterate in their L-382/C-130 Aircraft Flight Manuals the CAUTION found in L-382/C-130 Aircraft Maintenance Manuals regarding the use of flight control restraints. (Class II, Priority Action) (A-87-32)

Notify foreign certification authorities about the circumstances of this accident and suggest appropriate remedial action. (Class II, Priority Action) (A-87-33)

Amend the National Required Inspection Program to require a specified number of en route inspections for each type of aircraft operated by an air carrier. (Class II, Priority Action) (A-87-34)

Develop and issue guidelines to Air Carrier District Offices to provide for a minimum level of direct surveillance of air carrier operations when the principal operations inspector is occupied with other duties for extended periods of time. (Class II, Priority Action) (A-87-35)

Notify the Department of Defense of the circumstances of this accident and suggest appropriate corrective actions to be directed to military users of Lockheed C-130 airplanes. (Class II, Priority Action) (A-87-36)

Research in cooperation with Lockheed past loading incidents in which L-382/C-130 elevators have been damaged with a view toward developing positive corrective measures to eliminate the problem. (Class II, Priority Action) (A-87-37)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JIM BURNETT
Chairman

/s/ JOHN K. LAUBER
Member

/s/ JOSEPH T. NALL
Member

PATRICIA A. GOLDMAN, Vice Chairman, did not participate.

April 9, 1987

5. APPENDIXES

APPENDIX A

INVESTIGATION AND HEARING

Investigation

The National Transportation Safety Board was notified about 0630 e.d.t. on October 4, 1986, that Southern Air Transport's LOGAIR 15 had crashed on departure from Kelly Air Force Base, Texas. A partial investigative team was sent from the Washington, D.C., headquarters. Safety Board specialists were assigned to chair groups in the following areas for investigation: operations, human performance, structures, systems, powerplants, survival factors, maintenance records', and flight recorders.

The following parties were designated to participate in the field phase of the investigation: The Federal Aviation Administration, Southern Air Transport, Lockheed-Georgia Company, Hamilton Standard, Transamerica Airlines, U. S. Air Force, and Allison Gas Turbine Division of General Motors Corporation.

Public Hearing

No public hearing or deposition procedure was conducted as a result of this inquiry.

APPENDIX B

PERSONNEL INFORMATION

Captain Peter H. Sammet

Captain Peter H. Sammet, 52, held Airline Transport Pilot Certificate No. 1335471, with the following ratings and limitations: airplane multi-engine land, L-382, commercial privileges airplane single-engine land, and Learjet. A first class medical certificate was issued on May 13, 1986, with the limitation that the pilot must wear correcting lenses while exercising the privileges of his airman certificate. His total flight time, as determined from his personal resume and SAT company records, was about 7,000 hours. As a pilot in the U.S. Air Force, he accumulated about 1,400 hours in the C-130, with 655 hours as pilot in command.

Captain Sammet completed his last hazardous material training on October 30, 1985, his last proficiency check on May 30, 1986, and his last line check on September 5, 1986.

First Officer Phillip A. DeCenzo

First officer Phillip A. DeCenzo, 31, held Airline Transport Pilot Certificate No. 278508195 with the following ratings and limitations: airplane multi-engine land, commercial privileges airplane single-engine land. He also held a flight instructor's certificate with the following ratings and limitations: airplane single- and multi-engine land and instrument airplane. A first class medical certificate was issued on April 30, 1986, with no limitations. His total flight time was about 4,100 hours with about 107 flight hours in the L-382.

Flight Engineer Leon L. Mulcahey

Flight engineer Leon L. Mulcahey, 60, held Flight Engineer Certificate No. 360149725, with the following rating and limitation: turbopropeller powered. He also held Mechanics Certificate No. 1114865 with the following ratings and limitations: airframe and powerplant. He held a second class medical certificate, issued on January 24, 1986, with no limitations. His total flight time, as determined by his resume and SAT records, was about 16,800 hours. As a flight engineer in the U.S. Air Force, he accumulated about 6,045 hours in the C-130.

Flight engineer Mulcahey completed his most recent hazardous materials training on September 18, 1986, and his most recent proficiency and qualification check on November 9, 1985.

APPENDIX C

AIRCRAFT INFORMATION

The Lockheed L-382G is a commercial, "stretched" version of the military C-130 "Hercules," a tactical military cargo transport airplane. It is an all metal, high wing, four-engine turboprop monoplane of semi-monocoque construction with fully retractable tricycle landing gear. The fuselage of the commercial version differs from the military in that 100 inches were added to the fuselage. Cargo is loaded through an aft cargo door and ramp. The cargo compartment is 672 inches long, 123 inches wide, and 108 inches high at the lowest point.

N15ST had accumulated a total of 45,621.9 hours in 20,472 cycles before its departure from Kelly AFB on October 4, 1986.

N15ST was leased by SAT from TIA on September 11, 1986. Under the lease agreement, TIA was required to perform all maintenance on the airplane. TIA's records indicated that a four-phase inspection program was used for the L-382. The inspection frequencies were at 125 hours (A service), 500 hours (M service), 3,000 hours (C service), and airframe inspections performed on a progressive overhaul basis. The most reeent inspection was M service, completed on October 2, 1986, at 45,594.6 hours.

It was determined that an inspection of the control columns below the floor of the L-382 would occur every seventh "C" inspection (21,000 hours) when an "intensified" control structural inspection would be conducted.

All records and files relevant to the maintenance of N15ST were examined, including daily log sheets, scheduled maintenance inspection computer printouts of life controlled and rotatable parts, deferred maintenance items, component change records, and overhaul records. The investigation concentrated on reviewing records concerning the airplane's flight control system. No deficiencies were found.

The airplane was in compliance with all applicable Service Bulletins and Airworthiness Directives. There were no flight control discrepancies in the recent history of N15ST. However, on September 24, 1986, at 45,502.6 hours, the autopilot elevator trim was reported to be out of service and was recorded as deferred maintenance item 7709.

APPENDIX D

COCKPIT VOICE RECORDER TRANSCRIPT

NATIONAL TRANSPORTATION SAFETY BOARD
Bureau of Technology
Washington, D. C.

SPECIALIST'S FACTUAL REPORT OF INVESTIGATION
COCKPIT VOICE RECORDER

BY

PAUL C. TURNER
AIR SAFETY INVESTIGATOR

WARNING

The reader of this report is cautioned that the transcription of a CVR tape is not a precise science but is the best product possible from an NTSB group investigative effort. The transcript, or parts thereof, if taken out of context, could be misleading. The attached CVR transcript should be viewed as an accident investigation tool to be used in conjunction with other evidence gathered during the investigation. Conclusions or interpretations should not be made using the transcript as the sole source of information.

TRANSCRIPT OF A FAIRCHILD COCKPIT VOICE RECORDER, S/N 2521, REMOVED FROM AN L-382, WHICH WAS INVOCVED IN AN ACCIDENT AT KELLEY AFB, SAN ANTONIO, TEXAS, ON OCTOBER 4, 1386

LEGEND

CAM	*Cockpit area microphone* voice or *sound source*
RDO	*Radio transmission from accident aircraft*
-1	*Voice identified as Captain*
-2	*Voice identified First Officer*
-3	*Voice identified as Flight Engineer*
-?	*Voice unidentified*
LA	Logair *eight six four*
UNK	*Unknown*
*	*Unintelligible*
#	*Nonpertinent word*
@	*Expletive deleted*
%	*Break in continuity*
( )	*Questionable text*
(( ))	*Editorial insertion*
---	*Pause*

NOTE: All times are expressed in central daylight time.

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
3:52:19			
CAM-1	Test, test		
3:53:01			
CAM-1	Okay, you're going to get times and temperatures today, right		
3:53:04			
CAM-2.	Yes sir		
CAM-1	Good		
3:53:09			
CAM-2	I get the times, you get the temps		
CAM-2	You want me to get the temps too?		
CAM-3	He'll ---		
3:53:12			
8AM-1	No, 'just write them down when I call 'em		
CAM-3	He'll tell 'em to you		
CAM-2	Yeah okay, gotcha		
3:53:22			
CAM-1	Before start engines check		
3:53:28			
CAM-2	Electrical panel		
CAM-3	Check		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
CAM-2	GTC control		
CAM-3	Set		
3:53:32			
CAM-2	Engine bleed		
CAM-3	Set		
CAM-2	Fuel control		
CAM-3	Set		
3:53:35			
CAM-2	Fuel quantity		
CAM-3	Checked		
CAM-2	Oil cooler flaps		
3:53:38			
CAM-2	Fixed and open		
CAM-2	Sync master		
CAM-3	Is off		
CAM-2	Temperature datum		
CAM-3	Automatic		
CAM-2	Ground idle button		
CAM-3	Slow		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
CAM-2	GPWS is checked		
3:53:48			
CAM-2	Seats and rudder pedals		
CAM-S	Left		
CAM-2	Right		
CAM-3	Engineer		
3:53:54			
CAM-3	What the @ is this thing		
CAM	((Sound of laughter))		
3:53:57			
CAM-2	Oxygen and smoke protection		
CAM-3	Checked		
CAM-1	Checked left		
CAM-2	Checked right		
3:54:02			
CAM-?	*		
CAM-2	Okay check out what's going on here		
3:54:08			
CAM-2	Altimeters		
CAM-l	Ah it's got nine nine two		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
CAM-2	Niner.niner two set and crosschecked right		
3:54:14 CAM-2.	Radio altimeter		
CAM-1	Four hundred feet		
3:54:16 CAM-2	Crew briefing		
3:54:18 CAM-1	Okay, we weigh one twenty eight, vee one is one oh eight, rotate at one twelve two at one twenty, VFS one fifty six taking off runway one five, the weather is good and it's --- we haven't got the clearance yet but I'm assuming it will be runway heading to one three thousand		
3:54:40 CAM-2	Okay		
3:54:41 CAM-1	Radar vectors and our filed altitude is one twenty four. Norm81 and emergency procedures remain the same. In the event of 8 malfunction before vee one any one can call abort and I'll come back to flight idle if it's 8 prop malfunction leave it in flight idle, bring the rest 'of 'em back, feather the bad one from the flight idle position and you'll get on the yoke and I'll get on the steering and throttles. After vee one		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
CAM-1 (cont'd)	we'll continue our takeoff get positive rate gear up and then decide whether to change configuration after that, we'll continue to climb out and take the required action, remaining VFR under radar control for return landing on one five		
3:54:32 CAM-1	Any questions?		
CAM-2	No sir		
CAM-1	Great		
CAM-2	Throttles and condition levers		
CAM-1	Set		
CAM-2	Hydraulic control panel		
CAM-1	Set		
3:55:42 CAM-2	Parking brake		
CAM-1	Set		
CAM-2	Ah GTC		
CAM-3	Set		
3:55:47 CAM-2	Duct leakage		
CAM-3	Check		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
CAM-3	Haven't got any		
3:55:49 CAM-2	Wheel chocks and landing gear lock		
CAM-3	Removed and aboard		
3:55:52 CAM-2	Smoke detector		
CAM-1	Checked		
CAM-2	DC power		
CAM-3	Battery		
3:55:56 CAM-2	Before start check complete		
3:56:05 CAM-1	Okay turning three		
CAM-3	There's a start light		
3:56:24 CAM-1	I got the time started'		
CAM-3	Yeah		
CAM-1	(Twenty' nine)		
3:56:45 CAM-3	Oil pressure's a little slow coming off the peg but		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
CAM-1	Yeah		
CAM-3	I'm sure it's all right		
CAM-1	Yeah, it's moving		
3:57:04 CAM-2	Fifty five, fifty eight		
3:57:09 CAM-1	Call that eight ten		
CAM-2	Eight ten		
3:57:27 cm-3	Generator's on		
3:57:33 CAM-1	Be says four is clear		
CAM-1	Turning four		
3:57:37 CAM-3	'Start eight		
3:58:03 CAM-2	Fifty five, fifty eight		
3:58:12 CAM-2	Ah seven eighty		
3:58:19 CAM-3	Generator's on		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
3:58:23 CM-1	Okay he says two's clear		
3:58:25 CAM-1	Turning two		
CAM-3	Start (on)		
3:58:53 CM-2	Fifty five, fifty eight		
3:58:58 CAM-3	Seven ninety		
3:59:03 CAM-3	I wish to @ they'ed turn those @ hydraulic pressure gauges over, I'd do it except that I probably @ somebody off		
3:59:09 CAM-3	Generator 's on		
3:59:12 CAM-1	Okay I pressed the mother, he said number one was clear		
CAM-1	Where did you go?		
3:59:19 CAM-2	He's over here in the truck I think		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
3:59:22			
CM-1	There is no, no, he down here * * okay he say clear and turning		
CM-3	start up		
3:59:54			
cm-2	Fifty five, fifty eight		
4:00:08			
CAM-3	Slow @ there isn't it, it just kind8 crap8 out like maybe the blade angle's hanging on it		
4:00: 16			
CM-3	It's eight thirty on that		
CAM-2	Eight thirty		
4:oo: 19			
CAM-3	Yeah		
		4:00:29	
		RDO-2	Ground Logair one five's ready to copy. and taxi
		4:00:37	
		GND	Logair one five cleared to Warner Robbine as filed except change route to read Jay one. thirty eight Seeds. direct Lufkin on departure fly runway heading climb and maintain one three thousand expect flight level two three zero one zero minutes after departure departure frequency will be one

INTRA-COCKPIT

TIME & SOURCE	CONTENT
0401:35 CAM-I	Okay before taxi
CAM-3	Front area
0401: 39 CAM-1	Clear left
CAM-2	Clear right

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT
	two five point seven squawk two four seven two taxi to runway one five wind one four zero at five altimeter two niner niner four
4:01:12 RDo-2	Okay Warner Robbins as filed except Jay one three eight to Seeds direct Lufkin as filed runway heading to one three thousand two three zero at ten two five point seven on departure squawking two four seven two
4:01:28 GND	Logair one five readback is correct
4:01:32 RDO-2	Thank you

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
0401:51			
CAM-1	1'11 leave it in emergency until I get around here		
cm-2	All righty		
0402:08			
CM-2	Okay, we're out at ah, call it zero nine zero zero		
CAM-1	Yeah		
0402:23			
CM-1	Yeah, let's wait until we get to there before we put it in the book but let's see		
0402:31			
CAM-2	O k a y		
0402:32			
CAM-3	Brakes normal		
CAM-1	Normal		
0402:36			
CAM-1	Excuse me		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
CM-1	Yeah		
CM-3	Antiskid on		
CAM-1	Antiskid's on		
0402:39			
CAM-1	Taxi check		
CM-3	Cot your brakes flight instrument8 and compasses		
CAR-1	Okay coming through two seventy checked on the left		
0402:48			
CM-2	Ah set and cross checked right		
CAM-3	Flight recorders		
		0402:53	
		LA	And Kelly ground Logair eight six four I'd like to have my clearance to Barksdale
CAM-2	Flight recorders		

INTRA-COCKPIT

TIME & SOURCE	CONTENT
0403: 00	
CAM-2	Flight recorders on
CAM-3	Okay flaps
CM-1	Okay flaps fifty
0403:06	
CM-3	Flaps how about your trim tabs
CM-1	One two three normal checked and set for takeoff
CAM-3	Flight controls
CAM-1	Free and full travel on the rudder8
0403: 14	
CAM-2	Free and full travel on top
CAM-3	Radars
CAM-1	On
CAM-2	Stand by on the right
0403 : 23	
CM-3	Okay, we're down to ice one and four and transpondet

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT
0403:05	
LA	Logair eight six four clearance on request

INTRA-COCKPIT,		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
0403:27 CAM-2	Transponder standing by right now, okay Seeds I believe is sixty four DME on the zero eight one radial of San Antonio		
CAM-2	Yeah		
0403:42 CAM-1	Let's see tower is twenty six two		
0403:53 CAM-2	And it's Jay one thirty eight to Seeds so that's the sixteen eight		
0404:03 CAM-1	Set number one		
CAM-2	You got it on number one and it's zero eight one outbound		
0404:15 CAM-2	Runway one five runway heading		
CAM-1	One three thousand		
CAM-2	One three thousand		
CAM-1	You already got that okay		
0404:27 CAM-2	We be all set		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
0404:58 CAM-2	. And I'm going to flip over to tower and tell 'em we're ready		
CAM-1	Okay		
		0405:02 RDo-2	Ah tower Logair one five's ready
CAM-2	* *		
		0405:12 TWR	Logair one five contact tower when ready for departure
		0405:16 RDO-2	Ah Logair one five's ready,
0405:22 cm-1	He doesn't know what frequency he's receiving on		
		0405:24 TWR	Logair one five last one thousand feet closed wind one five zero at four cleared for takeoff
		0405:33 RDo-2	One five *roger*
0405:36 CAM-2	Transponders on		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
0405:39			
CAM-1	Okay before takeoff check		
CAM-3	Okay whenever your ready for one and four captain		
0405:44			
CAM-1	One and four normal		
0405:50			
CAM-2	Off at zero five		
CAM-1	Yeah		
CAM-2	Final		
0405:59			
CAM-3	Before takeoff check is complete		
0406:34			
CAM-2	Finals clear		
CAM-1	Okay eight, twelve and twenty		
0406:44			
CAM	((Sound of clicks))		
CAM-3	Lights are-,out		
0406:45			
CAM-1	Set max power		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
0406:48 CAM-1	Airspeed's alive		
0406:55 CAM-P,	Sixty knots		
0406:59 CAM-1	My yoke		
0407:00 CAM-2	Your yoke		
0407:08 CAM-2	Vee one		
0407:10 CAM-2	Rotate		
0407:12 CAM-1	@ @ help me on my yoke		
0407:16 CAM-1	Help me on the yoke		
0407:17	God help push forward		
0407:19 CAM-2	I can't get it down		
0407:21 CAM-1	You got this @ thing in here		

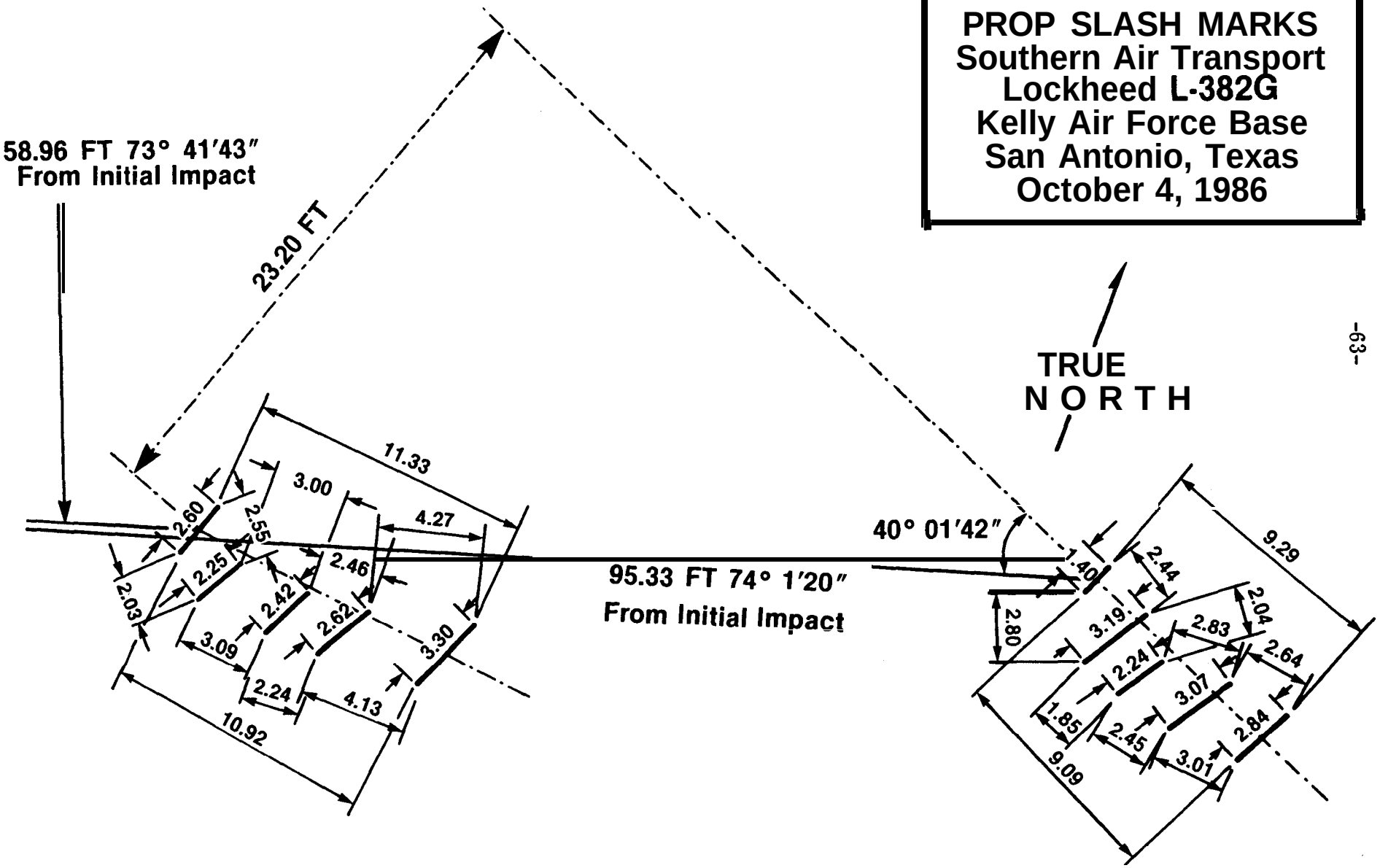
INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
0407:23			
CAM-3	Come on pull it ---		
CAM-3	Pull it back a little		
0407:26			
CAM-3	Pull it back a little		
CAM-3	Did you pull it back		
0407:27			
CAM-1	Okay let me roll it into a bank		
0407:32			
CAM-2	What's the airspeed doing		
0407:34			
CAM-1	@ @ it		
0407:35			
CAM-1	Okay, come on get it over		
CAM-2	We're dead *		
0407:38			
CAM-1	Lots of rudder		
CAM	((Sound of several clicks))		
0407:40			
CAM-1	Lots of rudder		

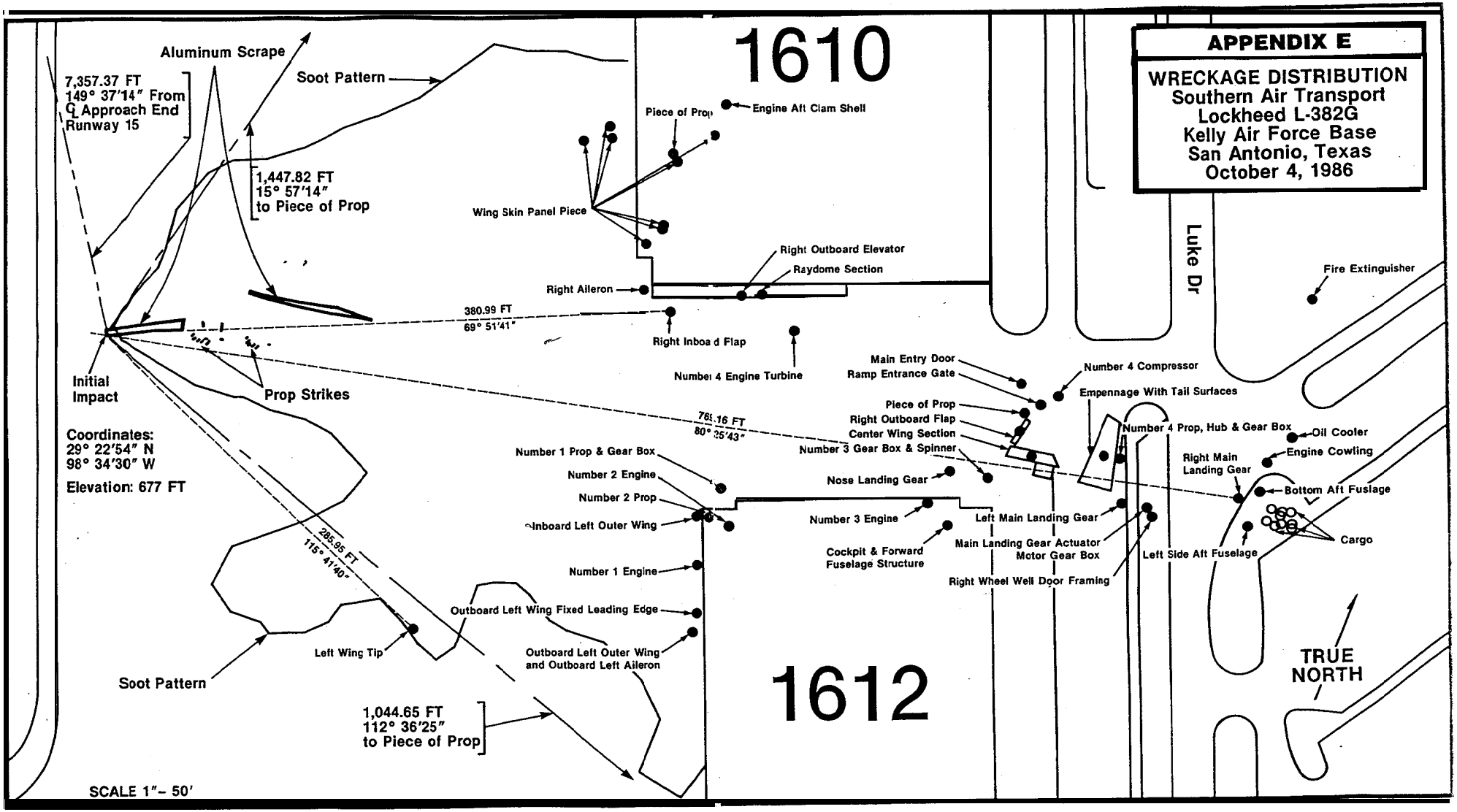
INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
0407:41 CAM-3	Okay it's clear now		
0407:42 GPWS	((Whoop whoop pull up))		
CM-?	Oh @		
0407:45	End of recording		

*U.S. G.P.O. 1987-181-101/40090

APPENDIX E

WRECKAGE DIAGRAMS




APPENDIX E
WRECKAGE DISTRIBUTION
Southern Air Transport
Lockheed L-382G
Kelly Air Force Base
San Antonio, Texas
October 4, 1986
1610
1612
Aluminum Scrape
Soot Pattern
7,357.37 FT
149° 37'14" From
℄ Approach End
Runway 15
1,447.82 FT
15° 57'14"
to Piece of Prop
Piece of Prop
Engine Aft Clam Shell
Wing Skin Panel Piece
Right Outboard Elevator
Raydome Section
Right Aileron
380.99 FT
69° 51'41"
Right Inboard Flap
Number 4 Engine Turbine
Initial
Impact
Prop Strikes
Coordinates:
29° 22'54" N
98° 34'30" W
Elevation: 677 FT
Main Entry Door
Ramp Entrance Gate
Number 4 Compressor
Empennage With Tail Surfaces
Piece of Prop
Right Outboard Flap
Center Wing Section
Number 3 Gear Box & Spinner
Number 4 Prop, Hub & Gear Box
Oil Cooler
Engine Cowling
Right Main
Landing Gear
Bottom Aft Fuselage
Nose Landing Gear
Number 1 Prop & Gear Box
Number 2 Engine
Number 2 Prop
Inboard Left Outer Wing
Number 3 Engine
Left Main Landing Gear
Cockpit & Forward
Fuselage Structure
Main Landing Gear Actuator
Motor Gear Box
Left Side Aft Fuselage
Cargo
Right Wheel Well Door Framing
285.95 FT
115° 41'40"
Number 1 Engine
Outboard Left Wing Fixed Leading Edge
Left Wing Tip
Outboard Left Outer Wing
and Outboard Left Aileron
Soot Pattern
1,044.65 FT
112° 36'25"
to Piece of Prop
Luke Dr
Fire Extinguisher
TRUE
NORTH
SCALE 1"= 50'