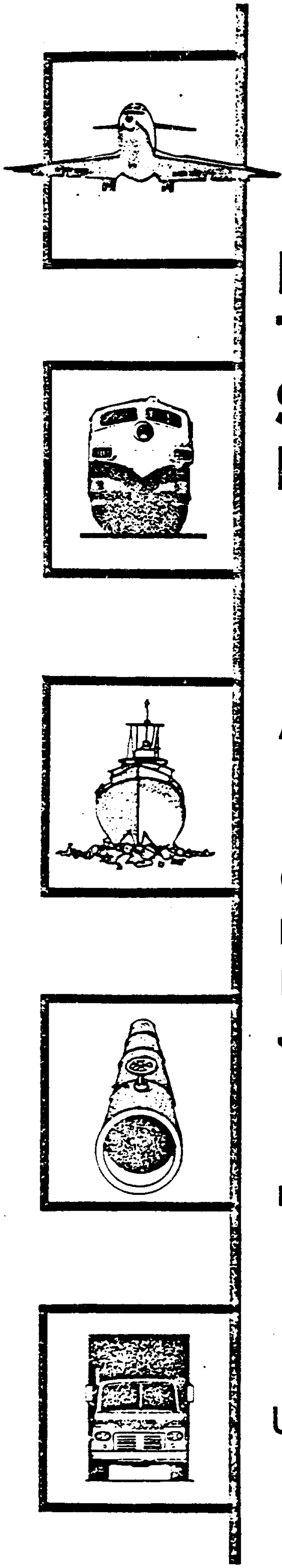


PB86-9 10401

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

GALAXY AIRLINES, INC., LOCKHEED ELECTRA-L-I 88C, N5532 RENO, NEVADA JANUARY 21, 1985

NTSB/AAR-86/01

UNITED STATES GOVERNMENT

SEE ALSO: NTSB Reporter May 1986

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No.
NTSB/AAR-86/01

2. Government Accession No.
PB86-910401

3. Recipient's Catalog No.

4. Title and Subtitle Aviation Accident Report
Galaxy Airlines, Inc., Lockheed Electra-L-188C
N5532, Reno, Nevada, January 21, 1985

5. Report Date
February 4, 1986

6. Performing Organization Code

7. Author(s)

8. Performing Organization Report No.

9. Performing Organization Name and Address

National Transportation Safety Board
Bureau of Accident Investigation
Washington, D.C. 20594

10. Work Unit No.
4102C

11. Contract or Grant No.

12. Sponsoring Agency Name and Address

NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D. C. 20594

13. Type of Report and Period Covered
Aviation Accident Report
January 21, 1985

14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

About 0102:30 Pacific standard time on January 21, 1985, Galaxy Airlines Flight 203, a Lockheed Electra charter flight en route to Minneapolis, Minnesota, departed runway 16R of the Reno-Cannon International Airport. Approximately one minute later, the crew requested a turn to a left downwind to return to the-airport because of a vibration in the airplane. In accordance with the request, the tower controller cleared the flight to make a left turn to a downwind traffic pattern. The airplane crashed at 0104 into an area 1 1/2 miles from the departure end of runway 16R, and 3/4 mile to the right of the extended runway centerline. The impact and subsequent fire killed the crew of six and 64. of the 65 passengers. onboard.. The airplane was destroyed. The sky was clear and the visibility was 12 miles at the time of the accident.

The National Transportation Safety Board determines that the probable cause of this accident was the captain's failure to control and the copilot's failure to monitor the flight path and airspeed of the aircraft. This breakdown in crew coordination followed the onset of unexpected vibration shortly after takeoff. Contributing to the accident was the failure of ground handlers to properly close an air start access door, which led to the vibration.

17. Key Words

Vibration; cockpit resource management; crew training; stress; L-188; Lockheed Electra; air start access door; ground handling; FAA surveillance; stall buffet; crew coordination; airspeed; pilot error; pilot technique; Fatigue-stress

6-9-86

18. Distribution Statement
This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classification (of this report)
UNCLASSIFIED

20. Security Classification (of this page)
UNCLASSIFIED

21. No. of Pages
88

22. Price

NTSB Form 1765.2 (Rev. 9/74)

i

CONTENTS

SYNOPSIS 1

1. FACTUAL INFORMATION 1
1.1 History of the Flight 1
1.2 Injuries to Persons 8
1.3 Damage to Aircraft 8
1.4 Other Damage 8
1.5 Personnel Information 8
1.5.1 The Flightcrew 8
1.5.2 -The Ground Handlers 10
1.6 Aircraft Information 11
1.6.1 General Infor ma tion 11
1.6.2 Aircraft History 11
1.7 -Meteorological Information 12
1.8 Aids to Navigation 13
1.9 Communications 13
1.10 Aerodrome Information 13
1.11 Flight Recorders 13
1.12 Wreckage and Impact Information 14
1.13 Medical and Pathological Information 15
1.14 Fire 15
1.15 Survival Aspects 16
1.15.1 Passenger Survival 16
1.15.2 Crash/Fire Rescue Rcsponsc 16
1.16 Tests and Research 17
1.16.1 Examination of Vibrations in N5532 17
1.16.2 Reports of Vibrations in the Electra 17
1.16.3 Electra Flight Test 22
1.17 Additional Information 22
1.17.1 Galaxy Airlines Flight Training 22
1.17.2 Air Traffic Controller Actions 23
1.17.3 Certification and Surveillance 24
1.17.4 Galaxy Managcmcn t Turnovcr 27
1.17.5 Airplane Flight Path 27
1.18 New Investigative Tcchniqucs 27

2. ANALYSIS 28
2.1 General 28
2.2 Source of the Vibration 28
2.3 Operational and Human Performance Factors 30
2.3.1 The Flightcrew 30
2.3.2 Air Traffic Controller 35
2.3.3 Ground Handlers 36
2.4, Survivability 38
2.5 Certification and Oversight 38
2.5.1 The Elcctra Air Start Access Door 38
2.5.2 Condition of the Aircraft 39
2.5.3 Certification, Inspection, and Survcillancc 40

Preceding page blank

3. CONCLUSIONS 41
3.1 Findings 41
3.2 Probable Cause 43

4. RECOMMENDATIONS 43

5. APPENDIXES 45
Appendix A--Investigation and Public Hearing 45
Appendix B--Personnel Information 46
Appendix C--Aircraft Information 48
Appendix D-Transcript of Cockpit Voice Recorder 49
Appendix E-Approximate Depths, Distances, and Widths Between Propeller Blade Rotational Contact (Cut) Marks 76
Appendix F-Memo to Electra. Operators 81
Appendix G--Narrative and Photographs on Electra Flight Test 82
Appendix H-FAA Surveillance and Flight Checks 85
Appendix I-Ground Track of N5532 With Correlated CVR Quotations 86

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D. C. 20594

AIRCRAFT ACCIDENT REPORT

Adopted: February 4, 1986

GALAXY AIRLINES INC.
LOCKHEED ELECTRA-L-188C N5532
RENO, NEVADA
JANUARY 21, 1985

SYNOPSIS

About 0102:30 Pacific standard time on January 21, 1985, Galaxy Airlines Flight 203, a Lockheed Electra (N5532) charter flight en route to Minneapolis, Minnesota, departed runway 16R of the Reno-Cannon- International Airport. Approximately one minute later, the crew requested a turn to a left downwind to return to the airport because of a vibration in the airplane. In accordance with the request, the tower controller cleared the flight to make a left turn to a downwind traffic pattern. The airplane crashed at 0104 into an area 1 1/2 miles from the departure end of runway 16R, and 3/4 mile to the right of the extended runway centerline. The impact and subsequent fire killed the crew of six and 64 of the 65 passengers onboard. The airplane was, destroyed. The sky was clear and the visibility was 12 miles at the time of the accident.

The National Transportation Safety Board determines that the probable cause of this accident was the captain's failure to control and the copilot's failure to monitor the flight path and airspeed of the aircraft. This breakdown in crew coordination followed the onset of unexpected vibration shortly after takeoff. Contributing to the accident was the failure of ground handlers to properly close an air start access door, which led to the vibration.

1. FACTUAL INFORMATION

1.1 History of the Flight

On January 21, 1985, Galaxy Airlines Flight 203, a Lockheed Electra L-188C (N5532), was operating under 14 CFR 121 requirements on a flight from Rcno, Nevada (RNO) to Minneapolis, Minnesota (MSP). The charter flight had been coordinated as a gambling junket for Galaxy through a broker agent.

About 1610 1/ on January 20, flight plans for four flights of N5532 were filed with the Seattle Flight Service Station. The Galaxy flights, sequentially numbered 201 to 204, were from (Seattle to Oakland,) (Oakland to Reno,) Reno to Minneapolis, and (Minneapolis to Seattle.) The flightcrew of Galaxy 203 began their duty period when' they reported for duty at' about 1815 at the Seattle-Takoma International Airport (SEA), Seattle, Washington. The crew's original scheduled departure time had been 1530; however, the Galaxy Airlines flight follower 2/ told them earlier by telephone that the flight would be delayed until about 2000. After reporting for duty they spent about an

1/ All times herein are Pacific standard time based on the 24-hour clock.
2/ Flight Follower - A person who has been given flight locating responsibility by the Director of Operations for each aircraft under his control. Galaxy Airlines is authorized by its Operations Specifications to use a flight following system in lieu of a dispatch system.

hour to an hour and a half watching television in the Pacific Southwest Airlines (PSA) crew lounge. The incoming Galaxy charter flight with 77 passengers aboard arrived in Seattle from Las Vegas, Nevada, at 2000. A PSA ramp service man saw the departing flight engineer check the fuel quantity in N5532 manually, but he did not see a crewmember perform a walkaround inspection. The airplane departed SEA at 2019 on a ferry flight to Oakland. The ramp serviceman said that when the airplane was airborne, the flightcrew radioed back their thanks for the quick turnaround. The airplane arrived at Oakland at 2225.

At Oakland, 65 passengers, returning from the Super Bowl football game, were boarded. During the stopover at Oakland, a boarding passenger visited the cockpit and spent about 20 minutes talking to the captain. The passenger remembered commenting that the cockpit looked "worn"; however, the captain assured him that, for its age, the airplane did not have many hours on it. The passenger noted, in addition, that the crew appeared to be in a hurry and, in his words, "pushed it" from Oakland to Reno. He remembered that the captain had told him that they (the crew) had to go to Minneapolis, and be back in Seattle by seven o'clock on January 21. He said that the crew appeared to be rested. When questioned about whether there were unusual vibrations during the flight, the passenger answered no; however, he did not remember the landing in Reno since he may have been asleep at the time. After it landed in Reno, N5532 was parked at a gate on the western side of runway 16R, close to the departure end.

The airplane was serviced-by personnel from the Reno Flying Service and a broker agent, who, as part of his responsibilities to Galaxy Airlines, met Galaxy airplanes and oversaw both passenger handling and airplane servicing. A total of seven individuals from the Reno Flying Service performed ground service duties on N5532. They included a fueling supervisor and two assistants who- connected the fuel truck and the ground electrical and air start units to the airplane, as well as fueled it. In addition, four other persons, a ground handling supervisor and three ground handlers, performed the remainder of the airplane's servicing while it was parked. These duties included loading and offloading baggage, installing and withdrawing the wheel chocks, cabin cleaning, lavatory and potable water servicing, driving the passenger vans between the airplane and the gate, starting up and later disconnecting the air start and ground electrical units, and providing ground directions to the flightcrew for airplane parking and initial movement from the gate. Although Galaxy procedures required it, no record of Galaxy 203's weight and balance was left at the Reno Flying Service nor was one delivered by mail to Galaxy's main office. Galaxy's Operations Manual required the captain to leave a duplicate of this form at each departing station.

At 0021:28, while ground servicing was being carried out, the crew contacted the Reno tower stating, "Reno clearance, ah, Galaxy two oh three is IFR to Minneapolis, uh, with the information." 3/

The tower controller then issued the following clearance:

> Galaxy two oh three, Reno Clearance, cleared to the Minneapolis St. Paul Airport via the Reno Seven Departure, as filed. Maintain one three thousand, expect one niner zero five minutes after departure. Departure frequency will be one one nine point two. Squawk three three zero four.

3/ Automatic Terminal Information Service (ATIS) information "India," which described current airport weather and runway operations, was current.

The flight plan, which had been filed earlier in the day with the Seattle Flight Service Station (FSS), contained the following information:

> Aircraft N5532, Galaxy Flight 203, L188/A, true air speed 320 knots, departure point RNO, proposed departure time 08202, cruising altitude 190. Route of flight Jet Route (J) 32 ABR, J 70 GEP, Destination MSP, estimated time en route 4 hours; fuel on board 6 hours: alternate airport DLH: number aboard 102.

During ground servicing, a fuel truck was backed into a point about 5 feet behind the trailing edge of the right wing. The rear of the truck was located about 10 feet from the fuselage. The flight engineer supervised the refueling and checked the fuel load in each tank using the airplane's installed sight gauges. A total of 2,357 gallons of Jet A fuel was added. When the refueling was completed, the fueler unhooked the hose and stowed it on the fuel truck along with the electrical grounding cables. As he climbed on the truck, he saw the flight engineer securing the single point fueling panel. The fueler then drove the truck to another location.

The engine air start cart was then moved into a position about where the fuel truck had been parked. The fueling supervisor said that he had connected both the air start and ground power units. The departing passengers arrived at the gate from Lake Tahoe in buses but, because the arriving passengers were still on the airplane, the buses were sent to the Reno Flying Service lounge and off-loaded. The buses then returned to the airplane to transport the deplaning passengers. When the airplane was ready, the departing passengers were brought to the airplane in a series of van trips. As the passengers were boarded, the ground handling supervisor and two other persons loaded 67 pieces of luggage into the aft baggage compartment. The flight engineer had instructed the ground handlers to load the luggage in this way since the forward bin contained crew bags and galley stores. The luggage was not weighed before it was loaded, on the airplane.. Sixty-five passengers were boarded in groups. During the latter part of the passenger loading, the ground handling supervisor removed the baggage belt loader from the aft cargo compartment and closed the door. He noticed the flight engineer finishing the engine servicing, apparently having already closed the forward cargo compartment. The forward cargo compartment was closed when the ground handling supervisor made his pre-departure check. He then took his position at the left front of the aircraft for the engine start. Although he ordinarily communicated with the flightcrew by means of a headset connected to the aircraft, he was unable, after several attempts, to establish such communications with Galaxy 203. As a result, he used standard hand signals for this purpose. The flightcrew then flashed the taxi lights on and off several times in apparent acknowledgment that hand signals were now being used.

At this time in the cockpit, the crew was preparing for the engine start. At 0055:51 the captain asked, "How does the clearance read?" The first officer responded, "We're cleared the Reno Seven Departure 4/ as filed." The captain then asked the first officer several questions concerning departure. The cockpit voice recorder (CVR) indicated that the before start checklist was not completed properly. There was no verbal response by the captain to the flight engineer's check items. Ten check list items were then skipped and six items were called for in incorrect order. Fourteen more items, required at intermediate stations, were not called out. No prddeparture briefing, which was also required, was recorded -on the CVR. A reason for this was later suggested

---

4/ The Reno Seven Departure is a standard instrument departure (SID) for aircraft departing runways 16R and 16L on an instrument flight rules (IFR) departure.

by the president of Galaxy who testified that because the flightcrew members ". . .were in a hurry when they got in, he (the captain) would have immediately got the clearance and probably did the departure briefing at that time." Galaxy's broker agent at Reno similarly described the captain as in a hurry. He testified that the captain, whom he described as "very conscientious" and "very punctual," was angry because he believed that the flight was over three hours late. He testified that:

> He really assumed from the time he left Seattle that he was running late, and when he arrived in Oakland, he was looking for the passengers who had not arrived from the Superbowl Game. So when they did arrive, he boarded them as quickly as possible and got them on their way to Reno.

Although the broker agent explained to the captain that the schedule had been changed, and this did put him at ease somewhat, he described the captain as still upset, "for professional reasons."

Following ground servicing the ground handler supervisor signalled to the crew that they could commence engine starting. However, after engines one and four were started, he noticed that the other ground handler was unable to disconnect the air start hose. It was stretched taut from the power cart to the airplane's air start access panel, located on the underside of the right wing leading edge, close to the fillet area. (See figures 1 and 2.) He gave the flightcrew an emergency stop signal. He then left his. position, disconnected the hose, and returned to his previous position. He testified that although he thought he did, he could not remember closing the air start access door. This door is about 8 1/2 by 11 inches in size. After the ground handling supervisor disconnected the hose, the other ground handler picked it up and folded it onto the air start cart. She said that she did not close the access door nor did she see it being closed; instead, after stowing the hose, she drove the tractor and pulled the air start cart away from the airplane. The power cart was pulled away from the airplane by the fueling supervisor.

According to Galaxy's policy, it was the captain's prerogative to extend the landing flaps to the full down position when taxiing close to parked aircraft. At 0058:42 the captain called for and the first officer confirmed full flaps after the number four engine had been started. However, no one on the ground remembered seeing the flaps lowered during engine start or as the airplane taxied out of the immediate gate area.

At approximately 0059 the first officer requested taxi instructions. Reno tower almost immediately thereafter cleared Galaxy 203 to taxi to runway 16 R.

The airplane, which was taxiing on two engines, numbers one and four, had been directed, by the ground handling supervisor to make a left turn from its parked position. The airplane had been parked on a westerly heading and required the left turn to take it southward. The airplane followed the taxi lane eastward to the parallel taxiway, then turned left again and taxied northward about a hundred yards to runway 16R.

At 0100:34 the captain said, "Okay, start 'em up." At 0100:45 the captain called for alternate flaps, 5/ and the call out was repeated by the first officer. At 0101:27 the captain told the first officer to switch to the control tower and perform the takeoff checklist. At 0101:32 the first officer requested takeoff clearance. Four seconds later Galaxy 203 was given clearance to take off from runway 16R.

5/ Alternate flaps, which are 39 percent (10°), are used for takeoff.

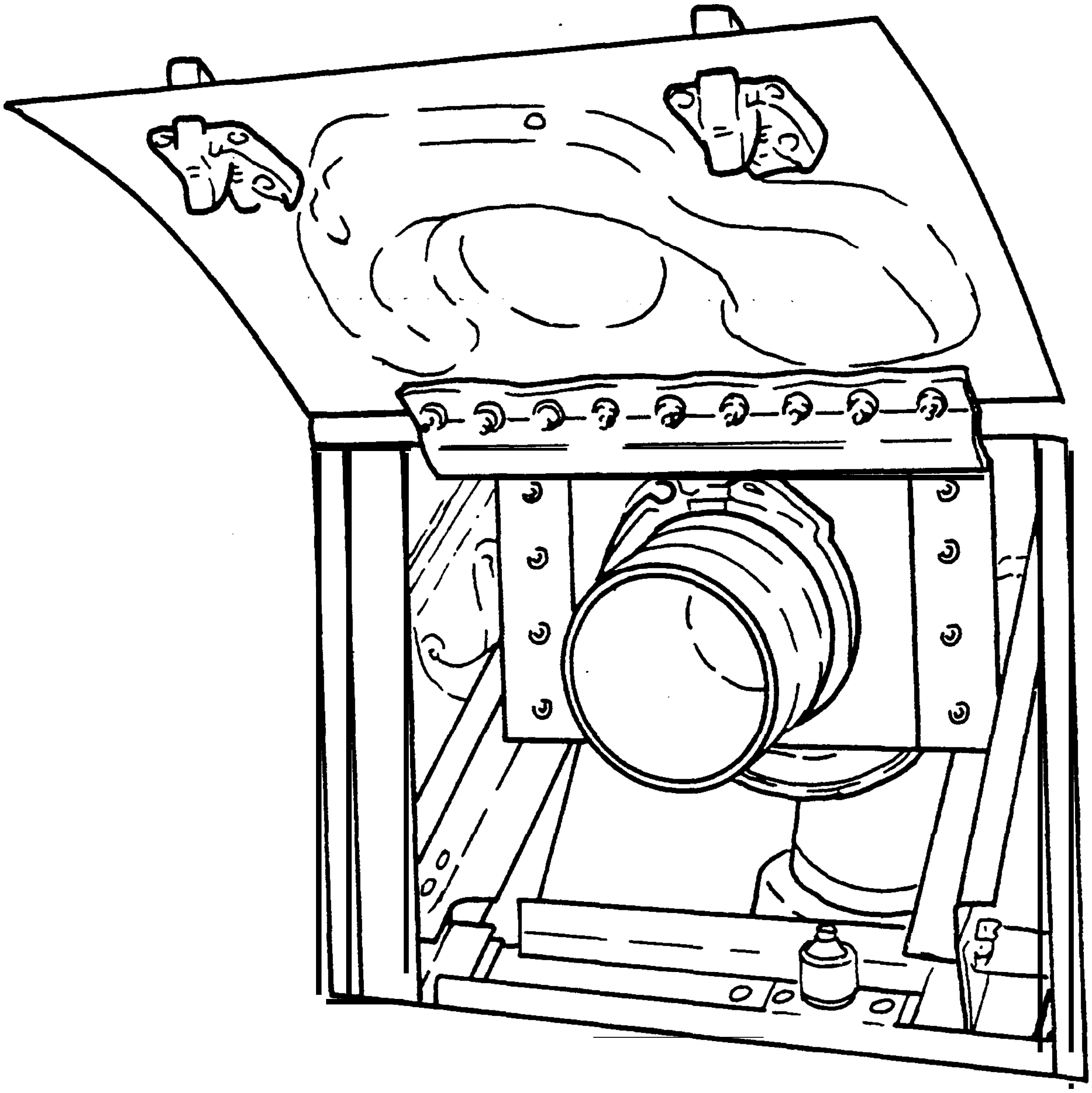


Figure 1.--Air start access door.

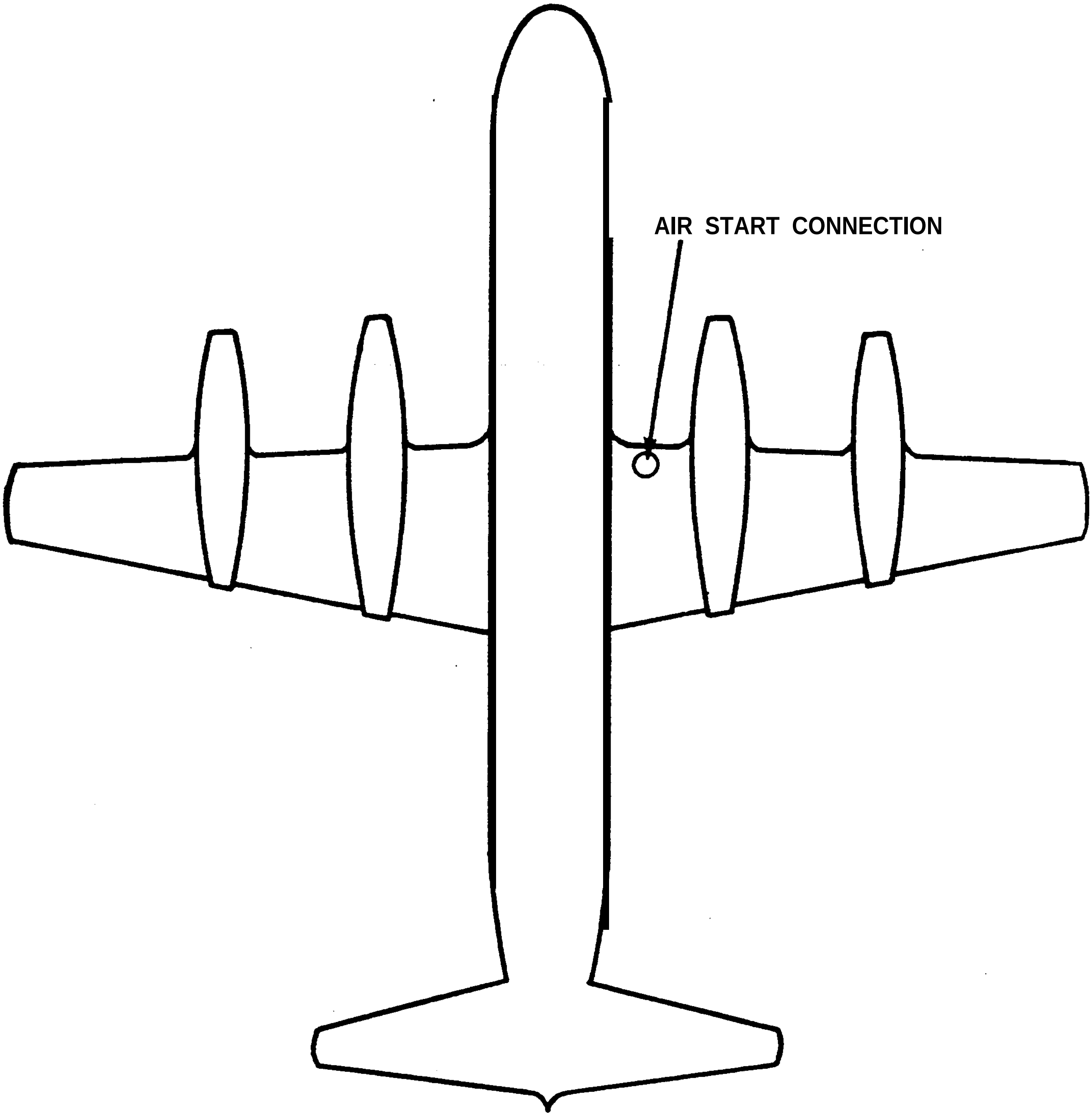


Figure 2.--Location of air start access door.

At 0102:44 the sound of engine power increase could be heard on the CVR. At 0103:01 a sound similar to a glare shield rattle or nosewheel shake was heard. Four seconds later, the captain said, "My yoke."

At 0103:19 the first officer called out "V-one." Almost simultaneously a sound characterized as a "thunk" was heard. Four seconds later, the first officer called "V-two." This call was followed by another "thunking" type sound.

At 0103:26 the captain called for gear up. The first officer acknowledged the order. At 0103:29 the captain asked the flight engineer, "What is it, Mark"? He responded, "I don't know. I don't know, Al."

At 0103:37 the flight engineer said, "That's METO." 6/ Three seconds later the captain ordered the flight engineer, "Okay pull 'em back from METO." At 0103:43 the captain directed the first officer. to request-permission from the tower to execute a turn to a left downwind to return to the field. Two seconds later the request was made to the Reno tower. At 0103:50 the flight engineer said: "RPMs look stable, horsepowers look good." At 0103:55 the captain told the first officer to "Tell 'em we have a heavy vibration." The first officer so informed the tower at 0103:58.

At 0104:00 the tower cleared Galaxy 203 to maintain VFR conditions and to enter a left downwind to runway 16 right. The controller also asked, "Do you need the equipment"? Two seconds later, after the captain told him, "Yeah," the first officer responded, "That's affirmative." The Reno tower controller then asked Galaxy for the number of people on board and fuel remaining. At 0104:13 the first officer replied, "Sixty-eight and we got full fuel." At 0104:14 the Ground Proximity Warning System (GPWS) sounded. At 0104:18 the first officer said, "A hundred knots." He repeated this three seconds later. At 0104:24 the captain called for maximum power. Six seconds later the sounds of impact were recorded. The cockpit voice recorder terminated at that time.

The broker agent said that he remained at his position at the gate and watched the aircraft taxi to the takeoff end of runway 16R. He said that to him the airplane appeared to have lifted off *'earlier than usual," but he felt that it was acceptable because of the relatively light load and the cold temperature. He then drove to the Rcno Flying Service office to sign the bills for services rendered. He reached the office about a minute after lift off and heard what he described as a muffled "pahboom." Hc said that he did not think about it. On his way home hc passed an ambulance, the significance of which he did not know at the time.

The tower controller said that after he issued the takeoff clearance to Galaxy 203, the airplane stopped on the runway for 10 to 15 seconds before it started its takeoff roll. He said that the takeoff roll appeared normal, and the airplane lifted off about 4,000 feet down the runway. The controller estimated that the airplane was about one to two hundred feet above the ground when it passed over the departure end of runway 16R. Other witnesses who were in the airport vicinity said the aircraft reached a maximum altitude of 200 to 250 feet. The controller said that it was about over the end of the runway when the radio transmission was made requesting the return to the airport. He said that he cleared the flight to return to the runway and looked away from the airplane to write down some information and when he looked up again, he could no longer see it. As he was looking for the airplane, he saw a fireball at about ground level.

6/ MET0 - Maximum except takeoff'cngine power.

The lone survivor among those onboard the aircraft described the takeoff as "smooth," but then he felt the airplane stop its climb. It then hit turbulence with two specific "thumps" and as he said, "...the airplane went phum, phum." He added that he had experienced inflight turbulence similar to this before, but in a storm and at a high altitude. He also described the "thumps" as coming from the right side of the airplane. The airplane then began a right turn. He knew that it was a right turn because the stars became visible through the window to his left. He did not recall feeling any vibration; he remembered someone saying on the airplane's public address system, "We're going down." The airplane then made ground contact.

Ground witnesses generally agreed that the airplane was not on fire before impact and described hearing noises that were similar to metallic "bangs" or the sounds caused by the rotors of a large helicopter. Another witness characterized the sounds as "a propeller surging in and out. . ."

The accident occurred during darkness, at 39° 27' 55" north latitude and 119° 46' 56" west longitude.

1.2 Injuries to Persons

Injuries	Cockpit crew	Cabin crews	Passengers	Other	Total
Fatal	3	3	64 7/	0	70
Serious	0	0	1	0	1
Minor	0	0	0	0	0
None	0	0	0	0	0
Total	3	3	65	0	71

1.3 Damage to Aircraft

The airplane was destroyed by impact and fire.

1.4 Other Damage

A furniture store directly adjacent to the impact area was damaged. Seven recreational vehicles parked in the primary impact area were destroyed.

1.5 Personnel Information

1.5.1 The Flightcrew

The flightcrcw, flight attendants, and local controller were qualified in accordance with existing Federal Aviation Regulations and had received the required training. (See appendix B.)

7/ Two passengers who died within two weeks of the accident arc included in the list of fatalities.

From 1981 to 1983 the captain was employed part-time by CCI, the company that had been headed by the president of Galaxy, where he flew the Electra. In August 1983, when Galaxy began operating, he flew the Electra, also as a part-time employee. At that time, he was also flying Learjet and Sabreliner type equipment for several companies, as a part-time employee. He joined Galaxy as a full-time employee in 1984. The captain and the president of Galaxy had flown together extensively in the Electra prior to their association at Galaxy and CCI. With his military experience, much of it in the P-3 aircraft, the military version of the Electra, the captain had accumulated over 5,000 hours in that airplane. He was an Electra check airman at the time of the accident, although he was not designated by the FAA to perform those duties for Galaxy. He had accrued about 14,500 total flight hours and was more than 20 years older than both the first officer and flight engineer.

Although he had extensive experience in the airplane, the captain was still required by the FAA when he joined Galaxy full time, to comply with CFR 121.415(a)(1) and 121.419(b)(1)(ii) and take the full Galaxy airplane indoctrination course, including initial ground and flight training. The ground training phase was completed during August 1984. On September 9, 1984 he was given 3 hours of differences training between the passenger-carrying Electra (N5532) and the cargo model utilized by Galaxy. On the same day he satisfactorily completed a pilot-in-command proficiency flight check of 0.9 hours in N5532. This included approaches to stalls. The check pilot described the captain as a "very competent pilot" on the flight check appraisal form.

A first officer who had flown with him described the captain as a good pilot. Another testified that he "knew the plane. He would teach a lot if you were willing to learn." He got along "great" with the crews. The chief pilot of Galaxy characterized him as "extremely professional and he flew the airplane well above average, better than most pilots." He added that the captain interacted as well as "any other captain at Galaxy" with other crewmembers. A first officer described him as the type of captain who would often check first officers on their knowledge of equipment and procedures. Another said that he was "always in command." The president of Galaxy, who was an experienced Electra first officer and flight engineer, testified that he had "flown all over the world with (the captain) and he was one of the finest captains I have flown with."

The first officer was hired by Galaxy in June 1984. At the time of the accident, he had over 5,000 total-flight hours and 172 hours in the Electra, all of which were accrued at Galaxy. He received 40 hours of basic indoctrination and 80 hours of initial classroom training on the airplane from June 16, 1984 to July 17, 1984. In September 1984, he was observed in a flight in the Electra. The chief pilot, who observed the flight, commented that his "performance on all maneuvers was marginal,.. however, within prescribed limits. Basic instrument scan weak. Company procedures also weak." He was observed several weeks later in which the same check pilot wrote, "F.O.s skills. . . are improving. Basic instrument procedures . . . and instrument scan are still weak." On September 30, 1984, he successfully completed, in the Electra, a second-in-command proficiency check.

The flight engineer was hired by Galaxy in July 1983. At the time of the accident, he had accrued 262.3 hours of flight engineer time, all in Galaxy Electra equipment. According to the president of Galaxy, he had been associated with the president for "many years," first as a mechanic's helper and then as a mechanic before hc received his flight engineer instruction. He attended the company ground school from September 10 to September 22, 1983. In that time, he received 120 hours of classroom instruction in general company indoctrination and initial airplane training. From June 15 through July 29, 1984, he was given 27 hours of instruction in a flight procedures trainer and 18 hours of instruction in N5532. He completed satisfactorily his flight engineer check ride on July 29, 1984. There were no comments about his performance on line or proficiency check flights that he had received.

The first officer and captain flew 40.8 hours together over 9 days in October. During 4 of those days, the flight engineer flew 23.3 hours with the captain and first officer. In November, the captain and first officer flew 9.1 hours together in a 2-day period. The captain and flight engineer flew 31.5 hours together in December, over 8 days. AU three flew together from January 4, 1985 to the day of the accident. The flights, which totaled 26.7 hours, were completed over 6 days. Several of these flights were operated through Reno.

1.5.2 The Ground 'Handlers

Reno Flying Service, a fixed- base operator (FBO) which employs approximately 100 people, provided the ground servicing to Galaxy Airlines at Reno. The airline prepaid an oil company for fuel, which then authorized Reno Flying Service to fuel Galaxy's airplanes up to the prepaid limit. Rcno Flying Service, which provided a variety of ground services to aircraft operators in Reno, including several major airlines, serviced about 30 to 35 aircraft daily. Although these included a variety of aircraft types, including passenger carrying jet transports, Reno Flying Service had not serviced a Lockheed Electra until Galaxy began their Rcno operations in December 1984. According to Galaxy's broker agent, Reno Flying Service was the "most professional" of the three FBOs located at Reno, and they provided servicing to the majority of charter flights operating there. No contract existed between Galaxy and Reno Flying Service; Galaxy prepaid the Reno Flying Service for services and the account was charged as services were provided. The services included baggage handling, passenger loading, fueling, cabin cleaning, lavatory and water servicing and ground electrical connections and air starting.

Important

*

Reno Flying Services provided their ground handlers with two types of training, on-the-job-training and classroom training. Supervisors performed on-the-job training in servicing procedures during employees' 60-day probationary period. Classroom training consisted of 12 to 20 hours of instruction in topics such as baggage and cargo loading and off-loading, ground equipment operation, and cabin cleaning. At the time of the accident, the ground handling supervisor had received all training given by the FBO; the ground handler who first attempted to disconnect the air start hose had received the on-the-job training but pot the classroom training. The ground handler had serviced between five and seven Electras; the supervisor had never serviced one. The supervisor held an FAA mechanic's license with airframe and powerplant ratings. No FAA training or certification requirements apply to aircraft ground handlers.

Specific ground services were provided to Galaxy at the request of the broker agent or flightcrew member, through the Reno Flying Service supervisor on duty at the time. Duties were assigned to the ground handlers by the ground handling supervisor on duty. Ground handlers could be assigned to any of the ground handling duties, with the exception of aircraft fueling. The fueling supervisor assigned aircraft fueling duties to aircraft fuelers. Ground handlers serviced all aircraft types. According to the ground handler supervisor, the ground handler who ". . .removes a nozzle is responsible for closing the door," which should bc accomplished immediately after removal of the hose. The practice of connecting and disconnecting air start hoses, according to the supervisor, was the same regardless of aircraft type; however, the location of the access panels differed among aircraft types. The ground handling supervisor was responsible for determining that all aircraft access and cargo doors were closed.

Reno Flying Service, when first contacted by the Galaxy broker agent, requested assistance from the airline since it had not previously serviced an Electra, and therefore was unfamiliar with the location of various access doors on the airplane. The broker agent assured them that either he or a Galaxy mechanic would meet each Galaxy airplane that was serviced at Reno. No specific training on servicing the Electra was requested by the FBO nor was it provided by Galaxy. However, a Galaxy representative was present at each Galaxy operation at Reno.

1.6 Aircraft Information

1.6.1 General Information

The airplane, a Lockheed Electra, United States Registry N5532, was operated by Galaxy Airlines. (See appendix C.) Galaxy Airlines, Inc., had leased the airplane from Aircraft Sales Company, -Springfield;- Virginia; -on -May 31, 1983. Before this agreement, Consolidated Components, Inc. (CCI) had leased N5532 from Aircraft Sales Company on July 9, 1982. N5532 was the only passenger carrying Electra that Galaxy operated. In September 1984, Galaxy acquired and operated two Electras for cargo handling. At the time of the accident, Galaxy was operating three Electras. -

1.6.2 Aircraft History

At the time of the accident, the airplane had no history of unexplained vibrations or buffeting.

In May 1984, N5532 was in charter service to a Presidential candidate. While the airplane was enroute to Dallas, it encountered severe turbulence. The United States Secret Service, following the landing, requested the FAA to examine the airplane. The FAA conducted ramp inspection in Dallas on May 4, and the flight data recorder was read out on May 8, 1984. There was no finding, as a result of these inspections, that the airplane was mechanically deficient, either before or after the incident. The FAA concluded that N5532 encountered severe unexpected turbulence which did not damage it.

The airplane had been modified sometime between 1975 and 1979 by another operator. About 1,100 pounds of lead ballast were added to the aft baggage bin at fuselage station (FS) 8/ 1,000 as a result of a change in the cabin configuration designed to increase seating capacity. The 1981 airplane weighing results were consistent with previous weighings. However, the 1983 weighing showed a change in N5332's empty weight center of gravity (CG) from 14.7 percent to 25.5 percent mean aerodynamic chord (MAC).

The weight and balance computations for the accident flight were derived by the NTSB on the best available information regarding passenger seating. With the last three rows of seats and the lounge empty, as prescribed by Galaxy's operations and weight and balance manuals, and assuming random seating of the remaining passengers as described by the survivor onboard Galaxy 203, the CG would have been 32.8 percent MAC. The airplane gross weight was 100,345 pounds, below the maximum allowable weight of 116,000 pounds.

A second computation was made assuming that the passengers were seated in a forward loading configuration. The resultant CG was 30.88 percent MAC. The allowable aft CG limit for takeoff was 32 percent MAC.

8/ Fuselage Station is the horizontal distance from a fixed reference point on an aircraft fuselage.

Galaxy twice requested, and was granted on both occasions, an extension from the FAA to Airworthiness Directive (AD) 74-01-07, which required inspections of the propellers on the Electra at 36-month intervals. The second extension was valid from January 8, 1985 to January 22, about 45 months after the propeller's previous inspection. The extension was requested since Galaxy did not have a replacement propeller and the inspection would have necessitated taking N5532 out of service. The propeller had been removed from the airplane during November 1984, stored in a hangar, and was returned to service on January 8, 1985, on the number 2 engine of N5532. That aircraft, which used a loaner propeller during the interval in which that propeller was off the aircraft, was used in revenue service at that time.

Galaxy's Principal Maintenance Inspector (PMI) testified that he participated in the process by which Galaxy requested the extension, a standard practice of compliance with the AD provisions for requesting an extension. The PMI examined all four propellers on the airplane, including the propeller in question while it was. in storage. He then forwarded Galaxy's request for the extension, with his concurrence, to the appropriate FAA office responsible for the final decision regarding the AD.

The propellers on the Lockheed Electra were manufactured by Aero Products. During routine record reviews by the company it was discovered that some operators, who had not been performing scheduled inspections, found corrosion in the propellers. To require operators to perform the inspections, the FAA issued the AD specifying inspections at 36-month intervals. The AD, however, allowed operators to request extensions of the required inspection interval provided there was sufficient evidence that maintenance and inspection procedures on the propeller had been carried out and that another similar propeller on an airplane of the operator was in good condition. In such instances, according to the FAA Manager of the Engine and Propeller Standards Staff in the northeast regional office, where evidence supporting the extension request was sent, extensions were generally granted. According to his testimony:

> The nature of the AD being essentially to require maintenance action, is such that we would not have a problem with making such an extension, as opposed to a fatigue type AD or an AD where there is a specific time limit in the metal parts themselves.

As a result, lengthening the inspection intervals was routine, provided that the operator complied with the manufacturer's service bulletin inspection and maintenance requirements. The FAA representative stated that he knew over 30 operators employing at least 42-month AD inspection intervals, and two-thirds of these employed a 55-month in tcrval.

1.7 Meteorological Information

Surface Observations.--Surface observations reported by the National Weather Service Office at Reno Cannon International Airport at about the time of the accident were as follows:

> Time--0050; type--surface aviation; sky--clear; visibility--12 miles; temperature--28° F.; dew point--24° F.; wind--290 degrees 4'knots; ltimeter--30.07 inches.
>
> Time--0125; type--local; sky--clear; visibility--l2 miles; temperature--27° F.; dew point--24°F.; wind--calm; altimeter--30.07 inches; remarks-aircraft mishap.

Time--0150; type--surface aviation; clouds--14,000 feet scattered; visibility--l2 miles; temperature--27°F.; dew point--25°F; wind--360 degree 6 knots; altimeter--30.08 inches.

The density altitude for the Reno Cannon International Airport at the time of the accident was 3220 feet.

There were no SIGMETS or AIRMETS applicable to the Reno area at the time of the accident. The Center Weather Service Unit (CWSU) at the Oakland Air Route Traffic Control Center issued no meteorological impact statements or center weather service advisories for the Reno area.

1.8 Aids To Navigation

There were no reported problems with aids to navigation.

1.9 Communications

There were no reported problems with communications.

1.10 Aerodrome Information

The Reno Cannon International Airport (RNO) is located in Washoe County, Nevada, southeast of the city center of Reno, Nevada. The airport is fully certificated under 14 CFR 139. There are three runways, 07/25, 16R/34L, 16L/34R, all constructed of concrete. Runway 07/25 is 6,101 feet long and 150 feet wide. Runway 16R/34L is 9,000 feet long with a 1,000 foot overrun at both ends; both the runway and overruns are 150 feet wide. Runway 16L/34R is 5,592 feet long and 75 feet wide. The elevation of the airport is 4,400 feet above sea level.

1.11 Flight Recorders

The airplane was equipped with a Lockheed Model 109-C Flight Data Recorder (FDR), serial No. 545. The recorder was intact but had been subjected to mechanical and fire damage. The outer case exhibited molten metal. The foil cassette had no foil recording medium across the recording platen; however, there was foil medium on the takeup spool. All of the foil medium, which was wound loosely on the takeup spool, had been sealed with a piece of transparent tape 1.2 inches long. The foil supply spool was empty. Consequently, the flight data recorder was not operating at the time of the accident.

Examination of the foil disclosed that all parameter and auxiliary traces were present and active to the end of the foil. The exposed foil covered at least 30 minutes of a flight. The scribed traces were normal in appearance. It was determined, based on records of the most recent servicing of the FDR, that N5532 had operated 117 hours after the tape had run out. Title 14 CFR 121.343(a) states:

> No person may operate a large airplane that is certificated for operations above 25,000 feet altitude or is turbine engine powered, unless it is equipped with one or more approved flight recorders that record data (1) (on) time, altitude, airspeed, vertical accelcra tion and heading.

The airplane was also equipped with Fairchild A-100 Cockpit Voice Recorder (CVR) Serial No. 1656. The CVR case was fire-damaged, but the tape housing and tape remained in good condition. The recording was of good quality. (See appendix D.)

1.12 Wreckage and Impact Information

The airplane came to rest in a recreational vehicle parking/sale lot adjacent to a main highway.

Major sections of the fuselage and cockpit area were burned by post-impact fire. The forward fuselage crown, underbody, cockpit, and nose wheel well had also sustained impact damage and were burned by post-impact fire. A section of the fuselage was also melted. On the forward section, the nose gear strut outer cylinder had separated from the airplane structure, and the braces were sheared.

The main gear was found in the up and locked position. The wheels and tires exhibited fire damage. The wheel well area was crushed and compressed around the wheels and tires. All main landing gear doors were recovered at the accident site and were laid out for inspection. The left-hand aft door remained attached to the landing gear structure of the right wing. All main gear doors were accounted for except the forward half of the left wing left-hand aft door. Examination of these doors disclosed general crushing rearward and upward. No evidence of preexisting cracking was found on any of the door hinges or actuator push/pull tubes.

The left trailing edge flap airfoil structure was completely consumed by fire. The flap control rods (torque tubes) and jackscrews were at their respective locations. The fuselage from the wing rear spar, fuselage station (FS) 695, to the tail cone, FS 1295, was completely consumed by fire. The cabin floor, from FS 731 to 1091, was intact, but was damaged by fire and smoke.

The vertical fin and rudder and the horizontal stabilizer and elevators were completely consumed by fire. The imprints of the melted horizontal stabilizer and elevators were visible on the ground. The de-ice tubing of the horizontal stabilizer and trim tab balance weights were the only remnants of the empennage.

All wing flap tracks and carriage assemblies were damaged by impact and ground fire. Two of the inboard flap tracks for the left flap assembly contained preexisting cracks due to cyclic fatigue. The fatigue crack on the most inboard flap track was small, and complete separation of the track from this cracked area was determined to have occurred following extensive impact damage. The other flap track (second inboard) exhibited a relatively large preexisting fatigue crack with subsequent overstress extension which was present before the fire damage.

The aileron, elevator, and rudder hydraulic boost packages sustained massive fire damage. These units could not be functionally tested; however, internal examination disclosed that they were in the "Hydraulic Power" mode at impact. The elevator hydraulic boost unit's piston rod was fractured. Examination of the fracture surface disclosed that the fracture was the result of bending overstress.

A door, approximately 8 1/2 x 11 inches, was recovered among debris after the wreckage was released to the operator and moved from the crash site. It was free of fire damage. This door was initially identified by Galaxy personnel and then positively identified by the Safety Board as a ground air start connection door of a Lockheed

Electra. The door contained two "Hartwell trigger lock" fasteners. Examination of the scratch marks on the fasteners disclosed that one of them had been open at impact. The position of the other fastener could not be determined because of impact deformation.

The power sections of the Nos. 1, 2, 3, and 4 engines remained in the main wreckage area. Each of these power sections and their respective nacelles sustained heavy fire damage. The Nos. 1, 3, and 4 power sections remained partially attached to their respective nacelles, while the No. 2 power section was separated from its nacelle. All four engine driven generators were recovered and exhibited fire and impact damage. Disassembly and inspection of all four engines disclosed some molten material due to fire damage but no evidence of operational distress or preexisting mechanical failures.

The examination of the components in the No. 1 engine showed the presence of greater than normal amounts of carbon/oil coke type deposits as well as an accumulation of carbon around the labyrinth seal of the rear -turbine-bearing. This indicates that vent passages of the turbine shaft bolt spacer were probably blocked, causing engine oil to vent through the air vents of the compressor rotor along with the normal charging air. This condition, which results in excessive oil consumption, does not affect engine operation or performance adversely. It would account for reports of smoke venting from the No. 1 engine.

All four propeller assemblies including their reduction gear assemblies had separated from their respective power sections. The propeller hubs and nearly all the blades were found in the general wreckage area. The Nos. 2 and 3 propellers were found in the main wreckage while the No. 1 propeller was found near a burned recreational vehicle just east of the main wreckage site.

Four sets of ground slash marks were found at the initial impact area. These ground slash marks were identified as those made by the blades from the Nos. 1, 2, 3, and 4 propellers, respectively. The distances between the blade slash marks ranged from 25 to 55 inches. The width of the marks ranged from 18 to 60 inches, and the depth of the marks ranged from 3 to 14 inches. The condition of the No. 3 blade from the No. 1 propeller suggested that this blade struck a concrete drainage pipe.

The ground slash marks made by the propellers were used to calculate the airplane's estimated ground speed, using an average propeller slash mark distance of 31 to 32 inches. The airplane's average ground speed at impact was determined to have been about 105 to 106 knots. (See appendix E.)

Detailed disassembly and inspection of all recovered propeller parts and components disclosed no evidence of preexisting mechanical malfunctions or failures, or corrosion.

1.13 Medical and Pathological Information

The results of the autopsies and the toxicological examinations of the flightcrew disclosed no evidence of preexisting physiological conditions or substances present which could have affected adversely their performance.

1.14 Fire

There was no evidence of inflight fire. The airplane's fuel tanks were ruptured on initial impact and were ignited immcdiatcly, most probably from contact with hot parts of the engine. The fire propagated rapidly, resulting in near total destruction of the major portions of the airplane.

1.15 Survival Aspects

1.15.1 Passenger Survival

Of the three persons who survived the initial impact, one died on January 29 due to massive head injuries, while the second died on February 4, 1985 as a result of thermal injuries. The sole survivor, a 17-year-old male, was thrown clear of the airplane onto the adjacent highway. However, he sustained first and second degree burns to his face and parts of his body as well as lacerations and contusions. He had been seated in seat 6A, next to his father, who was seated in 6B and was one of the initial survivors. The son told investigators that just before impact he covered his face with his arms and pulled his legs up. He had seen movics on how to prepare for a crash, but he did not think that bending over in a prone position would have helped. He believed that he was thrown through a bulkhead. He landed on a highway, approximately 40 feet forward of the nose. He was still strapped in his seat. He "ripped off" his seatbelt, got up, and ran as "fast as he could" toward a field, away from the airplane.

Twenty-seven passengers who had been seated toward the front of the airplane died as a result of blunt force trauma, caused by the disintegration of the front of the fuselage. The crushing of the front of the aircraft resulted in a loss of occupiable space and structure which precluded any possibility of occupant survival. Three passengers, who had been sitting in the front of the aircraft, died of both burns and impact trauma.

Twenty-two passengers died of burns, the inhalation of the products of combustion, and some associated impact trauma. Fifteen of these individuals were seated in the rear of the airplane and seven in the front. They had survived the initial impact as evidenced by their inhalation of products of combustion. It *is* unknown if they would have survived their injuries had there not been a fire.

Sixteen passengers died as a result of the fire only and did not suffer identifiable impact trauma. Fourteen of the sixteen had been seated toward the rear of the airplane. It was noted that the seats at the rear and center rear (rows 16 to 20) were still attached to the floor, indicating that the crash forces did not exceed 9G's in the forward direction.

1.15.2 Crash/Fire Rescue Response

The local controller notified the airport Crash/Fire Rcscuc (CFR) units and the airport dispatcher of the accident at 0105. The airport dispatcher immediately notified all airport and city rescue units and two medical centers. Information was provided at this time that 71 people were aboard and that thc airplane had over 2,300 gallons of fuel aboard.

The captain of the Washoc County Airport Authority (WCAA) fire department was notified by crash phone that a Lockheed type aircraft had crashed near Meadowood Mall. Three pieces of equipment were dispatched on a first alarm assignment. On thc way to the scene, the WCAA fire department captain ordered a second alarm assignment, of two additional pieces of equipment. At this time, the aircraft type, Electra, was relayed to the CFR crews. All off-duty personnel were recallcd at this time. At 0113, thc WCAA fire department captain arrived at thc sccnc'and began directing firefighting operations. Shortly thereafter, at thc request of the WCAA, Reno Fire Department personnel and equipment arrived at the scene.

The fire broke out at the crash site and burned back about 500 feet to the point of the wing tank rupture. It extended to a furniture store and recreational vehicles that were parked nearby. Propane gas tanks and the small quantities of gasoline in these vehicles exploded, contributing to the overall fire. The fire was contained in a matter of minutes, with full control accomplished at approximately 0130. **None** of the early-arriving firefighters observed any survivors at the crash site.

1.16 Tests and Research

1.16.1 Examination of Vibrations in N5532

Spectral diagrams of the cockpit voice recorder were prepared in an attempt to identify the cause of the excessive vibration in the aircraft. No signature was found which would identify failure of a system or of a structural component on the airplane. The vibration appeared strongest in the area of 9 hertz. However, it occasionally was detected as low as 6 hertz. An examination of the recording made by the Rcno Air Traffic Control Tower revealed a strong 7 to 8-hertz modulation of the transmitted voice from the first officer on N5532.

1.16.2 Reports of Vibrations in the Electra

One hundred and seventy Electras were manufactured by Lockheed, all with an 8 1/2 x 11 inch air start access door in the wing. However, at the request of six commercial operators and the FAA, which purchased one Electra, 74 of the 170 that were manufactured had an additional air start access door installed on the fuselage aft of the wing. Both are similarly accessible. The military version of the Electra, the P-3, also manufactured by Lockheed, has a wing mounted air start access door located further aft than that of the Electra. As a result, the door is not affected by the airflow in the same manner as the Electra door and, if opened in flight, the aerodynamic consequences would be inconsequcn tial. A former official of Lockheed Corporation described how an Electra would be affected aerodynamically if a wing mounted air start access door was left open. He testified that this:

> . . . could be the source of a heavy buffet resulting from major separation of (air) flow over the inboard wing and the resulting flow field striking the horizontal tail, driving the airplane and buffet heavily, very similarly to a stall buffet. At this particular location (there is) . . . a very high local flow field which increases the local angle of attack in that region, far above the normal angle of attack of the airplane or the fuselage reference line of the deck angle if you will. If that door is left open (this) could cause the door to come up and act like a very severe spoiler.

His comments were supported by reports received by the Safety Board following the accident. Several flightcrew members who had flown the Electra described experiences they had encountered which resembled the vibrations reported by Galaxy 203. All occurred at low speeds, just after rotation and lift off. Further, all were found to have been caused when the air start access door was inadvertently left open and then pulled upward by the airstrcam.

In one incident a flight engineer said that the vibrations led the captain to believe that the aircraft was in a stall. The captain then added power, lowered the nose, and flew out of the vibrations. In another case, the first officer characterized the vibrations he experienced as "very severe." Hc and the captain both believed that the aircraft was about to stall. When they increased power, the vibrations seemed to decrease. Another flight engineer also experienced vibrations immediately after takeoff. When the captain lowered the nose and increased the airspeed to about 160 knots, the buffetting ended. A captain who had experienced the vibrations twice flew out of them when he increased power. He believed that if someone unfamiliar with the phenomenon encountered it, ". . . it might be a little hair raising to him." Another captain experienced the vibrations four or five times. When he added power and increased the airspeed to 150 knots, the vibrations stopped. A third captain noted that when the air start access door is left open, "three hard bumps occur at approximately 75 feet above lift off." The bumps, which occur in rapid sequence, are felt in the entire aircraft and are quite audible. He noted, however, that there is otherwise no degradation in the aircraft% flight characteristics.

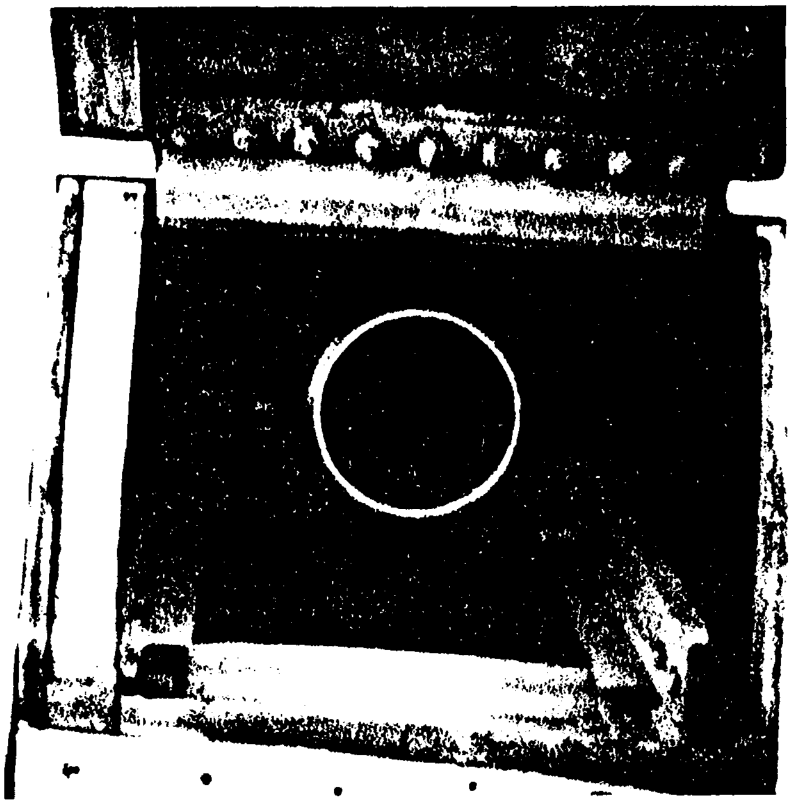
Galaxy's own former Director of Operations experienced the vibrations on rotation once in the 1970's. He testified that it was " . . .a severe buffeting as if it was an impending stall." When he increased the airspeed to' 160 knots, the buffeting ceased. He did not inform Galaxy personnel of the vibrations because it was such an isolated event in his 10,000 hours of flying. In addition, he testified that, "It's so long ago; I never had the problem or heard of anybody else having the same problem again, ever."

Several Electra operators, with pilots who had encountered such severe vibrations, modified the air start access doors. (See figures 3, 4, 5.) One carrier, which operates 21 Electras in cargo operations, modified the air start access doors of all the Electra airplanes in its fleet, either on its own or through the acquisition of already modified airplanes from other operators. The Safety Board was unable to determine when these modifications were carried out or the extent to which the FAA was aware of these modifications. No supplemental type certificate (STC) was issued by the FAA for modification of Electra air start access doors, because the modifications were relatively minor and did not affect structural characteristics of the airplane. Lockheed Corporation has collected and categorized data on vibrations encountered by' Electras. No records existed on vibrations caused by an open air start access door, despite the fleet-wide modification of the access door by at least one Electra operator. Before the accident, neither Lockheed nor the FAA had advised carriers of the modifications made by other operators or the reason for the modifications. Subsequent to the accident, the Lockheed California Company alerted operators, in a letter dated May 30, 1985, "to be aware of heavy vibrations which could occur in the Electra immediately after takeoff. This could be produced by an open air start access door." (See appendix F.)

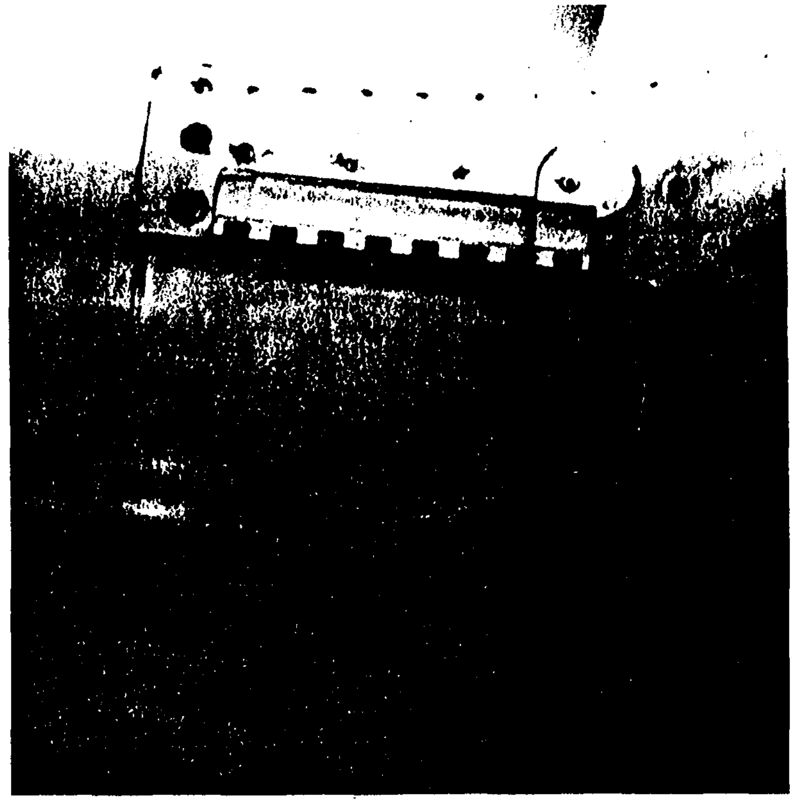
At the time the vibrations occurred to the Electra pilots who reported them to the Safety Board, no system existed in which pilots could report either operational or mechanical difficulties to a governmental organization without assurances of non-reprisal. In 1976, however, the National Aeronautics and Space Administration implemented the Aviation Safety Reporting System (ASRS) in which pilots were provided the opportunity to report such difficulties, with protection from FAA enforcement action assured under 14 CFR 91.57. ASRS was designed to encourage members of the aviation community to report problems so that others could be informed of them and corrective action taken, if needed. However, to further provide anonymity to reporters, aircraft type is not included in the reporting system, only general aircraft size and category. As a result, when a search of ASRS reports with regard to the Electra was performed at the request of the Safety Board, no difficulties in the Electra were noted in the ASRS file.

Operators are required by 14 CFR 121.703 to report to their FAA maintenance inspectors within 24 hours any of several failures, malfunctions, or defects that occur during airplane operation. The vibration that could be caused by an open air start access

Figure 3.--Modifications to the Electra air start access door.

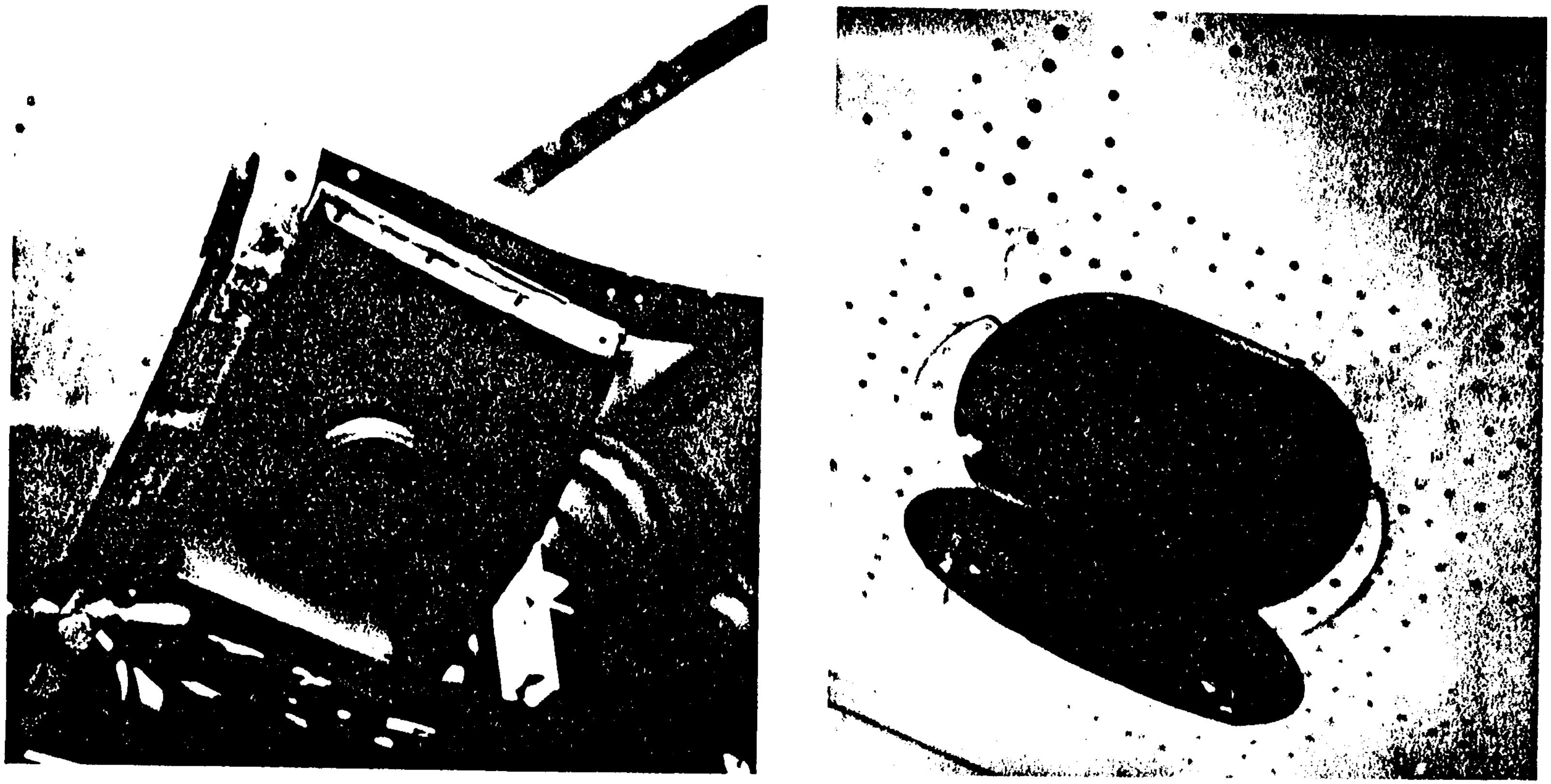


RHF Airlines Passenger Electra, S/N1112 ground air start connector - access door open. Cavity open into fillet area. No box installed around nozzle. Appears to be original installation.



RHF Airlines Passenger Electra, S/N11 12 ground air start connector - access door open. Door measures 14" spanwise, 8 1/2" chordwise. Appears to be original access door installation.

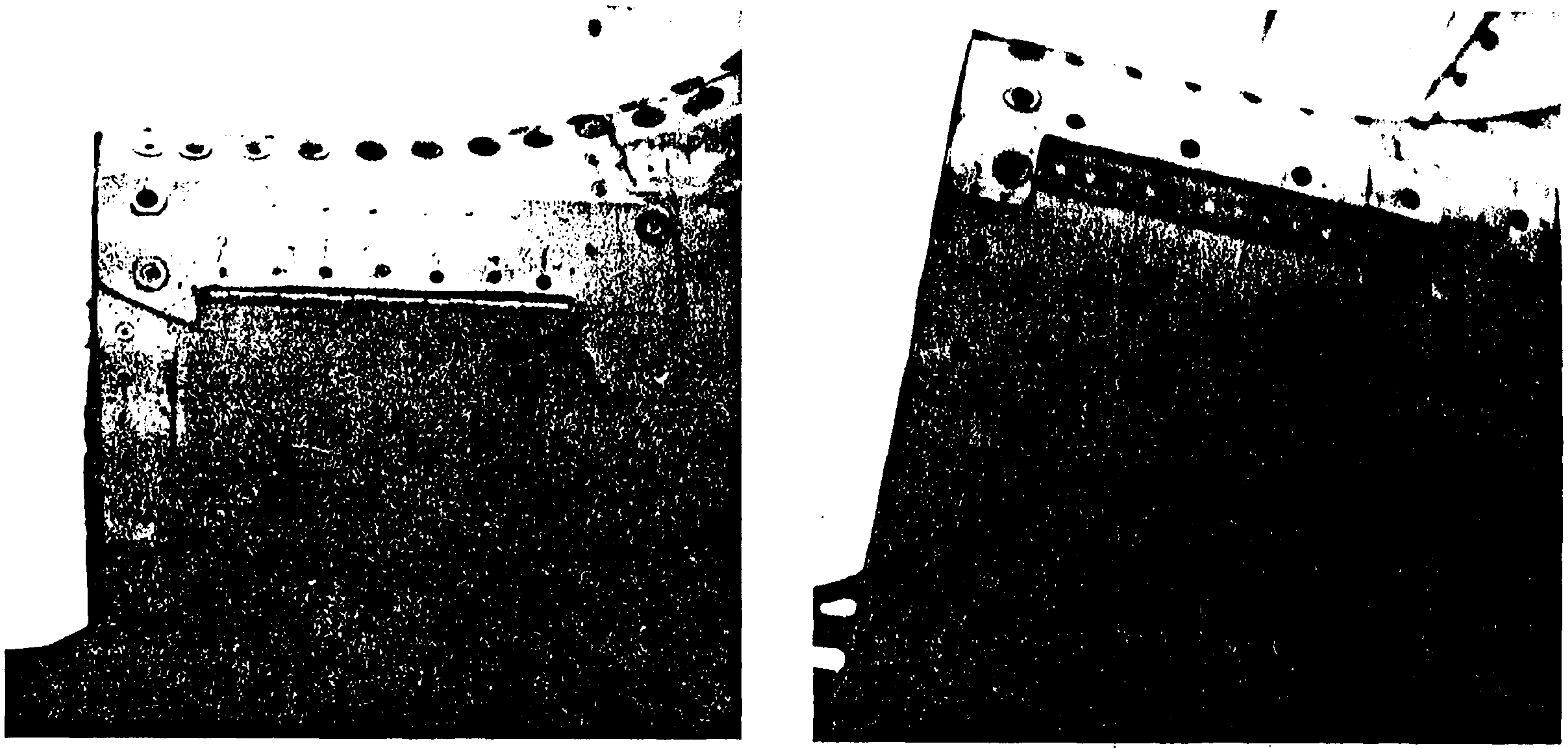
Figure 4.--Modifications to the Electra air start access door.



CAM Air Cargo Electra, S/N 1092 ground air start connector access - box surrounds nozzle. Fillet and access door installation similar to S/N 1085.

TPI Cargo Electra, S/N 2002 ground air start connector located in aft fuselage. FWD. Connector not installed.

Figure 5.--Modifications to the Electra air start access door.



CAM Air Cargo Elcctra, S/N 1085
ground air start connector acccss covcr.
Door mcasurcs 8 1/2" spanwisc, 7 1/2" chordwise.

TPI Cargo Elcctra, S/N 2002
ground air start connector access
conncc tor rcmovcd, cover installcd
with screws. Uscs aft connector.

door, since it does not require major structural repair or involve major powerplant or systems failure, is not required to be reported. As a result, there was no report of Electra air start access doors producing vibrations among the Service Difficulty Reports.

1.16.3 Electra Flight Test

Following reports that an open air start access door could cause severe vibrations to an Electra, the Safety Board commissioned a flight test with a government-owned Electra in an effort to replicate the vibrations reported when the air start access door is unlatched. (See appendix G.) The test also sought to examine the nature of the airflow in and around the access door, and to observe the aerodynamic consequences of the open door on the airplane under three phases of flight: while taxiing, at rotation, and during the stall maneuver. The airplane was instrumented for atmospheric research and was exceptionally well maintained. The area adjacent to the air start access door was tufted with yarn about four inches long, and a television camera was mounted to view and record the door and the airflow in the surrounding area. The test was begun at the Colorado Springs, Colorado airport, which is 1,760 feet above the altitude of the Reno airport. The conditions of the flight test differed from those experienced by Galaxy 203 in several respects. The test aircraft was approximately 20,000 pounds lighter than N5532. In addition, the rotation rate employed for liftoff was different than would have likely been expected in a revenue passenger flight, and airspeed was maintained above 105 knots at all times.

The test indicated that the door faired in the slipstream during takeoff and inflight. Further, just prior to takeoff and during the stall test, as the airspeed decreased and the angle of attack increased, the tufts showed that the stagnation point of the airflow moved aft of the door for a little over half its length. However, neither following rotation nor during the flight did the door swing up over the leading edge of the wing, nor did it create any noticeable effect inside the aircraft.

1.17 Additional Information

1.17.1 Galaxy Airlines Plight Training

Galaxy required newly hired crewmembers to receive 40 hours of basic indoctrination training and 80 hours of initial training on the aircraft. These included such topics as company procedures, Federal Aviation Regulations, general operating practices, and the Electra systems and operating requirements, as approved by the FAA under 14 CFR 121.

Initial flight training consisted of the following instruction:

1. engine failure on takeoff prior to V 1
2. engine failure on takeoff after V 1
3. over/under ‘rotation
4. stall recovery
5. engine(s) out maneuvers/procedures
6. recovery from excessive sink rate
7. no-flap procedures.

The Galaxy Airlines training manual called for recovery from the stall at the “nibble.” This was described by the carrier’s former chief pilot as, "the first indication of a stall in the Electra.” The manual further advised that stall “buffeting is definitely not desired at any time during the maneuver." Stall recovery was performed in the flight regime at this "nibble." The former chief pilot testified that, "that is the way the FAA wants it done on their flight check and that it is exactly how we train them to do it."

Beginning in December 1983, Galaxy employed a former Eastern Air Lines instructor as their Electra ground school instructor. He had taught ground school on the Electra to Eastern pilots for about 7 years. Before he became a ground instructor, he was a mechanic with Eastern on the Electra. The instructor said that he taught the operational aspects of the airplane. He said that he ". . .taught everything but performance. Although I was teaching operations, I occasionally got into nuts and bolts when questions arose."

He said that in teaching emergency procedures he emphasized three basic rules:

1. Get rid of the noise (e.g., fire bell, warning horn)
2. Declare the type of emergency to the crew, and
3. Declare who is going to fly the aircraft.

Galaxy also used its chief pilot and director of operations as instructors to teach additional flight related topics.

Galaxy did not perform, nor was it required to perform, training in cockpit resource management, also known as crew coordination. This has been defined 9/ as: ". . .the effective utilization of flightcrew members (and other resources) to enhance crew interaction, communication and decisionmaking in multi-crew aircraft operations." Programs to improve cockpit resource management are currently implemented at four major domestic carriers. Two other carriers are developing such programs while another two use Line Oriented Flight Training (LOFT), in which cockpit resource management techniques are incorporated. Several non-major and regional carriers have also begun to implement cockpit resource management into their pilot training curricula. In addition, several foreign carriers in the Netherlands and Australia, among others, have included this as an integral part of their pilot training.

Galaxy personnel testified that they addressed the topics of cockpit resource management within the broader area of emergency procedures, as illustrated by a former company first officer who testified that during an emergency the carrier taught that:

> ...the captain delegated duties in the aircraft, whether he decided that he was going to fly it and the first officer and flight engineer would look after the emergency, or the first officer fly it and the emergency would be handled from there.

1.17.2 Air Traffic Controller Actions

The controller testified that he interpreted Galaxy 203's request to return to the field, with emergency equipment standing by, as a declaration of an emergency by the crew although they did not actually declare one. The controller then asked the crew, "How many people on board and say amount of fuel remaining?" The first officer answered and the controller then asked, "Sixty-eight people and twelve hundred pounds of fuel?" He testified that he then started to write down this information noting the time and the personnel on board, the fuel remaining, and the nature of the problem."

9/ Strauch, B. Cockpit resource management: Where do we stand? Proceedings of the Third Symposium on Aviation Psychology. Columbus, Ohio; 1985, 437-444.

He then started to scan the horizon to visually locate the aircraft and glanced at his radarscope to see if it was radar identified, which it was not. He then called for the emergency equipment. Although the precise time at which this call was made cannot be verified, the control tower's records indicate that it was at 0105.

The FAA Air Traffic Control Handbook (FAA 7110.65D) instructs controllers, in the event of an emergency, to:

> Start assistance as soon as enough information has been obtained upon which to act. Information requirements will vary, depending on the existing situation. Minimum required information for inflight emergencies is as follows:
>
> (1) Aircraft identification and type;
> (2) Nature of the emergency.
> (3) Pilot's desires.

The Handbook then states:

> After initiating action, obtain the following items or any other pertinent information from the pilot or aircraft operator as necessary.
>
> (1) Aircraft altitude.
> (2) Fuel remaining in time.
> (3) Pilot reported weather.
> (4) Pilot capability for IFR flight.
> (5) Time and place of last known position.
> (6) Heading since last known position.
> (7) Airspeed.
> (8) Navigation equipment capability.
> (9) NAVAID signals received.
> (10) Visible landmarks.
> (11) Aircraft color.
> (12) Number of people on board.
> (13) Point of departure and destination.
> (14) Emergency equipment on board.

In addition, a letter of agreement between the Reno Air Traffic Control Tower and the Washoe County Airport Authority (WCAA) specified that in the event of an emergency, the responsible controller was to obtain information from the flightcrcw on the number of passengers and the amount of fuel onboard.

At the time of the accident, no aircraft were aloft in the vicinity of the Rcno airport. One operations vehicle was on the airport surface and one aircraft was about to request permission to push back from the gate. The accident occurred at a time of day when, due to the low volume of traffic, one controller performed all duties of the combined clearance, -ground, local, and radar positions.

1.17.3 Certification and Surveillance

The president of Galaxy Airlines had coordinated single entity, gambling junket, charters under 14 CFR 125, for about two years using N5532, while president of a different corporation. According to Galaxy's former director of operations, the company applied for operating authority under 14 CFR 121 to comply with the FAA's interpretation that the requirements of Part 125 did not apply to such charters but were more appropriately carried out under Part 121. As part of the application for Part 121 operating authority, a Certificate of Public Convenience'and Necessity had to be obtained from the Civil Aeronautics Board (CAB). Galaxy's president, who had been associated with several companies which had encountered financial difficulties and accrued substantial debts, terminated his association with those companies and purchased Galaxy Airlines, which had an existing Certificate of Public Convenience and Necessity. During its investigation, the CAB, whose functions have since been merged into the Department of Transportation, determined that . there was no longer an association between the president of Galaxy and those companies. The CAB then allowed the new owner and president of Galaxy to operate under the Certificate that had already been granted to Galaxy's previous owners.

On August 14, 1983, the FAA granted Galaxy the authority to operate as a supplemental carrier under 14 CFR 121. Surveillance of Galaxy was the responsibility of the FAA's Flight Standards District Office (FSDO) in Miami. The Principal Operations, Maintenance, and Avionics inspectors were based in that office. Although Galaxy's management was based and records were maintained at their Ft. Lauderdale corporate headquarters, their operations moved periodically according to existing contractual charter agreements. The company's passenger operations typically consisted of charter service from various locations to Las Vegas and Atlantic City as well as point-to-point service.

FAA Order No. 8000.9, "District Office Geographic Responsibility Concept," describes the procedures for continued FAA surveillance of operators outside the area of the FSDO with the primary responsibility for an operator's surveillance. The order states, in part:

> This arrangement does not prohibit the principal inspector from scheduling inspections in another office area when he/she considers additional surveillance is needed. The principal inspector should keep the office with geographical area responsibility apprised of the operator's activities and plans, and their effect on that office. Regional offices should also be coordinated with, as necessary, to familiarize them with the certificate-holding office's work program that is outside their district office boundaries. When a principal inspector becomes aware of a need for action by another district office, the principal inspector should contact the appropriate person in that office to satisfy the requirement.

The Safety Board determined that there were no communications between Galaxy's Principal Operations Inspector (POI) and inspectors in other FSDOs in which Galaxy was operating, requesting their assistance in survcilling the operator.

Galaxy's Operation Manual required that checklists be performed in a standard challenge and response for mat. In an en route inspection performed on July 30, 1984, Galaxy's FAA Principal Operations Inspector commented that ". . .responses to checklists not correct 50 percent of the time." Galaxy's Director of Operations at the time of this inspection said that he had not received such a report and was unaware of it.

From the time Galaxy was granted operating authority under 14 CFR 121 to the accident, FAA teams from outside the Miami FSDO conducted two major inspections of Galaxy, *one* a NATI-I (National Air Transportation Inspection) and the other an AQAFO

(Aeronautical Quality Assurance Field Office) inspection. (See appendix H.) These inspections disclosed some minor deficiencies. Almost all of the FAA's ramp, spot and en route surveillance checks of Galaxy were performed on N5532.

On April 25, 1985, the Principal Maintenance Inspector (PMI) of Galaxy testified that the results of the NATI-I inspection, ordered by the Secretary of Transportation to examine closely the practices of 14 CFR 121 carriers, indicated that:

> . . .there was some discrepancy in maintenance training records. The records were subsequently located in the operations training area instead of (in) the maintenance training storage (area).

When the PMI was asked to "characterize one particular area" that was "most a problem with the carrier," in his surveillance of it, he testified that:

> Maintenance-wise, again, we had some record keeping problems and some misunderstanding on sign-offs. I think there were something like six areas that there were findings which they were all in record keeping and technical in nature. There was no airworthiness findings whatsoever. . .it is a record keeping problem, and that is really the only problem that I have seen.

On February 5, 1985, the Galaxy PMI wrote to Galaxy to inform it that the FAA was investigating irregularities concerning maintenance procedures and records. These included operating an airplane beyond its required "A" service check. In a second letter, also dated February 5, 1985, the PMI informed Galaxy that the FAA was investigating three separate violations concerning aircraft N5532: operating the airplane 53 hours beyond a required intermediate check, lacking overhaul records to determine the overhaul status of the flap asymmetry valve, and recording five different total aircraft times for compliance with AD 68-23-05, a required inspection of the wing structure. On April 4, 1985, the PMI wrote another letter to Galaxy to inform them that Galaxy was under investigation for violation of additional regulations. These included not performing a required structural inspection, flying N5532 beyond two required service checks, and not entering required maintenance items in the aircraft log. The latter violations were alleged to have occurred prior to the accident and were not related to conversation on the CVR in which the captain and flight engineer of Galaxy 203 agreed not to enter a maintenance item in the log.

Safety Board investigators, following the accident, examined Galaxy's records and determined that there were several instances of corrections and changes made to aircraft total times in the log book of N5532. These were described by Galaxy personnel as corrections to inadvertent addition and subtraction mistakes that had been made by crewmembers.

On April 26, 1985, Galaxy's Principal Operations Inspector (POI) testified at the Safety Board's public hearing on the results of the AQAFO inspection of Galaxy that had been carried out in June 1984 by the southern region of the FAA. In response to the question of whether any of the discrepancies noted in the AQAFO report were serious, he answered, "No." He also testified that following the accident, the FAA increased their surveillance of Galaxy. As a result of that increased surveillance, he testified that be was "satisfied with their present operations." On April 3, 1985, the FAA Flight Standards District Office (FSDO) in Miami forwarded to FAA attorneys the results of an investigation begun on February 8, 1985, in which 176 violations of 14 CFR 121.503(d), pilot flight and duty time, were alleged to have occurred during the period September 1, 1984 through January 24, 1985. An inspector from the Miami FSDO had performed the investigation and informed Galaxy of the allegations on February 25, 1985.

These violations concerned 176 trips taken by 11 Galaxy flightcrew members that were alleged to have occurred in violation of the requirement. that flightcrew members operating under 14 CFR 121 not fly in excess of 100 hours in a 30 consecutive day period. Among the Galaxy flightcrew members cited were the first officer and flight engineer of Galaxy 203, who were alleged to have flown 8 and 76 trips respectively in violation of that requirement. In both cases the most recent of the violations were alleged to have taken place over two and one half months before the accident and as a result, the consequences of such flight activities were not considered to have affected the performance of the flightcrew of Galaxy 203.

The results of both the maintenance and operations investigations, of Galaxy as well as a maintenance investigation carried out by the FAA Principal Avionics Inspector (PAI) of Galaxy, are still pending. Some of the alleged violations have been forwarded to the U.S. Attorney's office for civil action in which penalties totaling several hundred thousand dollars have been sought. Others are still awaiting discussion between Galaxy and the FAA.

The POI of Galaxy was responsible for three other carriers operating under 14 CFR 121. POIs in Miami were assigned to varying numbers of carriers according to the size of each operation. An inspector assigned to a large operator, for example, was not assigned to others, while those assigned to smaller operators were assigned to more than one.

1.17.4 Galaxy Management Turnover

From August 1983, when Galaxy was first granted 14 CFR 121 operating authority, to the time of the accident, a number of individuals occupied each of several management positions at Galaxy. According to testimony by the president of the airline, there were five different directors of maintenance, "three or four" directors of operations, two chiefs of quality control, and two chief pilots.

1.17.5 Airplane Flight Path

Galaxy 203's flight path was reconstructed from witness statements, atmospheric conditions, airplane configuration, CVR data, and performance data for the Electra. In addition, the track of N5532 from the start of the takeoff to impact provided a known distance/time relationship. (See appendix I.)

It was determined that the airplane lifted off the runway following a takeoff roll of approximately 3,430 feet. The V1 and V2 speeds were 104 and 120 knots, respectively, as the flightcrew had calculated. With engine power on, the onset of the stall buffet would have occurred at approximately 130 knots of calibrated airspeed (KCAS) in a 30° bank and 121 knots with the wings level. With engine power off, the airplane would have stalled at about 110 knots in a 30° bank and at about 103 knots with the wings level.

1.18 New Investigative Techniques

None.

2. ANALYSIS

2.1 General

The flightcrew was properly certificated and qualified in accordance with applicable regulations for the non-scheduled, domestic, passenger flight. The flight attendants and local air traffic controller were also properly trained and qualified to perform their duties. Weather was not a factor in the accident.

The Safety Board concludes that shortly after takeoff Galaxy 203 experienced a vibration followed by the onset of aerodynamic stall buffet and impact into the ground. The investigation focused on the cause of the vibration and the events which may have contributed to its onset. The flightcrew's actions immediately before the accident and during the emergency were examined closely. The role of the local tower controller was also studied to determine the extent to which his actions and interpretation of the FAA controller's handbook influenced the results of the accident and the subsequent rescue efforts. Finally, the investigation examined the initial certification and continuing FAA surveillance of Galaxy and their possible relationship to the cause of the accident.

2.2 Source of the Vibration

According to the cockpit voice recorder (CVR), Galaxy 203 began its takeoff at 0102:44 when the sounds of engine power increase could be heard.

At 0103:29 the captain asked the flight engineer, "What is it Mark?" referring to the heavy vibration. His subsequent call for power reduction indicates that he suspected that the engines or propellers were the cause and he acted accordingly. This directly affected his subsequent actions and consequently, the sequence of events for the duration of the flight. The Board considered all likely sources of the reported vibration. These included engines and propellers, wing flaps, landing gear doors, flight controls, and the air start access door. The likelihood of each causing the vibration was considered after careful study of the wreckage, applicable reports by the manufacturer and carriers, as well as an assessment of the potential aerodynamic effects of each source.

Engine and Propellers.-- The Safety Board determined that the propellers and engines were operating at the time of impact. This conclusion was based on the presence of uniform ground slash cuts caused by the propellers when they contacted the ground and the distribution of melted and resolidified material within the engines. The angles of each slash mark and the distances between successive marks indicate that all four powerplants were developing power at or near takeoff levels at the time. All four propeller hubs and nearly all of the blades from these hubs were found in the general wreckage area. Although two of the blades were found about 500 yards from the area, the Safety Board concludes that the blades contacted a concrete drainage pipe which, in combination with the high engine power at impact, caused them to separate and to bc thrown a substantial distance from the other components.

All fractures and separations pertaining to the propeller blades were typical of the gross overstress conditions caused by impact with the ground and objects on the ground. All of the major components contained with the four propellers were generally undamaged and were adequately lubricated.

The four powcrplants were disassembled after the accident and examined for indications of preexisting damage or failure. None were found. Further, there was no evidence of preexisting damage to the engine mounts or "V" frame tubes and diagonal tie struts that support the engine, gear box, and related components.

The internal components of engine No. 1 were examined closely since that engine was reported to have been venting smoke several hours before the accident while the aircraft was taxiing in Las Vegas. The engine disassembly showed a relatively minor vent passage blockage which would not have affected the engine's operation but would have caused the venting of the smoke from heated engine oil.

There was no physical evidence to indicate that any of the propellers "surged in and out," as a witness described. However, changes in the power settings of the Electra's engines would cause corresponding changes to the pitch of the propellers, which rotate at a constant rate of 1,020 revolutions per minute (RPM). This would produce rather audible changes in the engine and propeller noise that would be heard- in the vicinity of the airplane. Since there were several changes to the power settings of the engines of Galaxy 203, this probably accounted for the witness' description. Consequently, the Safety Board concludes that the engines and propellers of Galaxy 203 operated normally throughout the flight.

Wing Flaps.--The Safety Board concludes that the flaps were operational before the accident and, as a result, did not cause the reported vibration. Although the flap structures were consumed by the post-impact' fire, the flap tracks and flap jackscrews, the actuating mechanisms for the flaps, were accounted for. One of the flap jackscrews was fractured; however, metallurgical examination revealed that it fractured on impact from overload. The flap tracks showed no signs of preexisting damage that could have prevented normal operation. Although several tracks showed small fatigue cracks, these cracks were too small to have affected the structure of the flaps and, therefore, could not have caused the vibrations.

Landing Gear Doors.--The possibility of open landing gear doors causing the vibrations encountered by Galaxy 203 was considered because of the "clanking" type noises described by one eyewitness. These noises could have been caused by the aerodynamic buffeting of a loose landing gear door. However, the damage on all landing gear doors was consistent with that sustained with crushing in the upward direction, indicating that all doors were closed at impact. All damage in the door hinges and actuating rods was typical of gross overstress and impact loading while retracted. There was no evidence of preexisting damage. Lockheed Corporation, in addition, had no reports of vibrations in the Electra due to loose landing gear doors. Consequently, the Safety Board concludes that the landing gear doors were not the source of the vibration.

Flight Controls.--Although much of the structure of N5532 was consumed by the post-impact fire, the presence of hydraulic power in N5532 inflight was evident by the location of the landing gear in the retracted position and the flight control booster units in the hydraulic "power" mode. Lockheed had no record of flight controls and the control boost package, the rudder, or elevators and ailerons causing severe vibrations in the Electra at speeds below that of normal cruise and at altitudes below those ordinarily associated with the cruise regime. As a result, the Safety Board concluded that the flight controls did not cause the severe vibration in the aircraft.

Air Start Access Door.--Following the accident, the Safety Board received reports by experienced Electra flightcrew members who described experiences in which an open air start access door caused severe air frame vibrations at, or immediately following, rotation for takeoff. It was reported that the vibrations closely resembled those associated with a stall. One testified that, ". ..it felt like the airplane was coming apart."

The aerodynamic effects of an open air start access door inflight, due to its location near the wing fillet and the wing leading edge, approximate what was found to have occurred to Galaxy 203. These effects were described in detail in the testimony of a Lockheed official who characterized the possible “spoiler” type effects produced by an open air start access door.

The Safety Board’s metallurgical examination of a door identified as the air start access door of N5532 indicated that at least one of the two latches on the air start door was open at impact while the position of the other latch could not be ascertained. Further, it could not be determined whether a single latch could have effectively secured the door inflight. However, it is doubtful, given the nature of the type of fasteners used on the door, that one would have been fastened and one not, since this would have caused the door to be manifestly ill-fitted when closed.

The results of the Safety Board commissioned flight test of an Electra were judged to be inconclusive due to the differences in weight, CG, and possibly, rotation rate between the test aircraft and N5532. However, the tufts of yarn fixed to the wing in the area of the air start door did indicate that a reverse airflow occurred during rotation, which is the type of airflow needed to cause an open door to pivot forward over the leading edge of the airfoil. This action would produce the spoiler type effects described by the former Lockheed Corporation official.

The evidence supports the conclusion that the air start access door was the source of the vibration encountered by Galaxy 203. The reports by other Electra pilots, of similar vibrations produced by open access doors, the aerodynamic effects of an open door, the scratch marks on the open latch of the door from N5532, and the actions of the ground handlers following the starting of engine numbers 1 and 2, all suggest that the door was not closed properly prior to the airplane leaving the gate area. Therefore, the Safety Board concludes that the air start access door was not closed properly when Galaxy 203 took off; this led to its pivoting forward and up and above the leading edge of the wing, which disrupted the airflow over the wing and created the vibrations reported by the flightcrew. However, the Board does not believe that the vibrations caused the accident since there is no evidence that there were problems controlling the airplane and other flightcrews had been able, when faced with similar vibrations, to maintain control of the airplane.

2.3 Operational and Human Performance Factors

2.3.1 The Flightcrew

All of the evidence demonstrates that the controllability of N5532 was not compromised by the open air start access door. All systems, propellers, powerplants, and structural components were found without preexisting damage and were functioning at impact. Although the open air start access door would create vibrations, particularly at low air speeds, the airplane could have been controlled and flown safely had the flightcrew responded appropriately to the perceived emergency while at a low altitude. The Board believes that the crews’ inappropriate response of reducing power below METO and their failure to monitor airspeed and other performance parameters led directly to the accident. Consequently, the performance of the crew was examined closely in an attempt to comprehend the reasons for these inappropriate actions.

There was no evidence of physiological factors adversely affecting the crew's performance. Likewise, there was no indication that the crewmembers were fatigued or otherwise incapacitated.

The crew actions do, however, suggest a carelessness with regard to their adherence to procedures. For example, at Reno the flight engineer instructed ground handlers to load all passengers' baggage in the aft bin of N5532 since the forward bin contained crew bags and galley stores. Further, according to the surviving passenger of Galaxy 203, passengers were seated throughout the airplane, and not in accordance with Galaxy Airline's weight and balance manual, which required that passengers be seated forward of row 18 when the passenger load was between 25 and 66 passengers. Both of these actions suggest that the flightcrew did not compute an accurate CG during their flight planning. Had they done so, they most likely would have found that the CG was beyond the allowable aft limit.

There is no evidence that the crew complied with procedures with regard to the final weight and balance computations of Flight 203. Galaxy procedures, as written in their Operations Manual, specify that the captain is "responsible for the correct completion of the weight and balance form for the aircraft, as well as causing a duplicate to be made and left at each departing station..." Personnel at Reno Flying Service did not remember having received this form from the flightcrew.

Similarly, the "before start" check list was not completed. According to the CVR, there was no verbal response by the captain to the flight engineer's check items. Ten check list items were then skipped, three items were called for in reverse order, and three more items, in incorrect order, were called for. Fourteen more items, required at intermediate stations, were not called out. The captain's answer should have been specific, rather than the "Yeo" which he gave in response to some items. In addition, there was no pre-takeoff briefing by the captain.

The remaining pre-takeoff actions that the crew performed further demonstrate a careless approach to required procedures. No reference to the "before taxi" checklist was heard on the CVR, and 11 items on the "before takeoff" checklist were not read aloud. If these were accomplished silently by the flight engineer, he failed to advise the captain when they were completed.

The Board believes that these actions demonstrate a lack of appreciation by the crew in general, and the captain in particular, of the need to adhere to standard operating procedures. The general behavior of the captain, as noted from the CVR conversations, was contrary to that generally described by pilots and others who had flown with him or had known him professionally. The pilots who had flown with him characterized him as a very good pilot who was a thorough professional.

This inconsistency between his performance on the night of the accident and the general high esteem in which he was held by his peers could have been influenced by a sense of urgency he may have felt to commence the flight. This urgency was suggested by the president of the airline, who testified that the required pre-departure briefing was not recorded by the CVR because the flightcrew was in a "hurry." This characterization was also supported by Galaxy's Reno broker agent, who testified that the captain was angry because he believed that the flight was over three hours late.

In addition, this sense of urgency may have been felt because, according to the filed flight plan, N5532, Galaxy's only passenger carrying aircraft, was scheduled to depart for Seattle one hour and twenty minutes after their originally scheduled time of arrival in Minneapolis-St. Paul. Consequently, a. significant delay into Minneapolis-St. Paul would have further delayed the succeeding flight to Seattle.

According to sound spectral analysis of the CVR, shortly after Galaxy 203’s takeoff, airframe vibrations in the range of six to nine hertz were felt. The captain’s question to the flight engineer, "What is it, Mark”? followed by his command to retard the power, indicate that he believed that the powerplants or propellers were causing the vibration. He then commanded power to be reduced below MET0 on all four engines. The Safety Board believes that the captain’s initial assumption that the powerplants may have produced the vibration was not inappropriate since malfunctions in powerplants or propellers could have caused it. However, his reducing power on all four engines, at a low altitude and at a low airspeed, followed by his failure to take alternate action when the vibration continued, led directly to his failure to control the airplane.

A proper course of action in response to an engine or propeller vibration shortly after takeoff would have been to maintain MET0 power until the airplane reached a safe altitude and then reduce power in one engine at a time. Thus, if the vibration was reduced, the engine or propeller causing the problem would have been apparent. At the same time, sufficient power would have.been generated by the other engines to maintain both airspeed and a safe altitude. Nevertheless, reducing power on all four engines simultaneously would not have caused the accident, provided the captain had immediately restored MET0 power when it was evident that the power reduction did not decrease the vibration. This was particularly critical since the airplane was so close to the ground. Although it was dark, and hence it would have been difficult to see the ground, the captain should still have been aware of their proximity to it since they had just taken off. Consequently, he should have been particularly sensitive to the need to maintain altitude and airspeed.

The Safety Board believes that the captain attempted, but was unable, to perform adequately the dual tasks of troubleshooting (that is, locating the source of vibration) and flying the airplane. Not until 0104:24, six seconds before impact, did he call for full or maximum power. At that time, because of the significant prolonged power reduction, the airplane’s altitude and airspeed deteriorated beyond the point at which recovery could have been accomplished successfully.

The Board examined several factors that could have affected the performance of the flightcrew members to determine why they took inappropriate actions. These factors include airplane vibration, personality factors and crew coordination, training and experience, and the effects of acute stress. Each one was examined to determine the extent to which it may have, either alone or in combination, contributed to the breakdown in the crew performance.

Airplane Vibration.--It is likely that the vibration in N5532 masked the kinesthetic sensations associated with the stall buffet. In normal conditions, if a flightcrew member allows the airspeed to decrease to the low levels that Galaxy 203 achieved, he or she would be alerted to a hazardous flight condition by the sensations of the stall buffet. The crew must depend on these sensations in order to detect the onset of the stall since the Electra has neither an aural stall warning device nor a stick shaker. As a result, the captain’s ability to recognize the impending stall, through kinesthetic cues, may have been affected adversely by the masking effects of the vibrations.

Effects of Acute Stress.--Piloting an aircraft during emergency conditions can be extremely stressful. Loss of control, failure to correctly perceive aircraft performance parameters, and misinterpretation of verbal communications can have fatal consequences. The deleterious effects of this stress on pilot performance have been documented in the research literature. 10/

10/ Roscoe, Stanley, N. Aviation Psychology. Ames, Iowa: The Iowa State University Press, 1980.

Hart and Bortolussi 11/ found that inflight errors that pilots commit may increase the workload they experience, thereby causing subsequent errors. They theorized that:

> Whenever pilots slip, blunder, err, or even hesitate, whether due to inattention or overload, additional workload may be created. First, the error must be recognized and identified. Next, the operator may be forced out of a well-learned, automatic sequence of action and required to exert additional effort to resolve the consequences of the error. Finally, the task itself may change, so that additional tasks have to be performed as a consequence of the error.

The specific type of error that can occur during a stressful situation has been described by Bond et al. 12/ They wrote that:

> Fixation of attention occurs when a pilot concentrates on one set of stimuli to the exclusion of others which also require his attention. It is most apt to occur when the pilot is emotionally aroused. Fascination of attention is similar to fixation. In this kind of failure the pilot perceives all significant aspects of the situation but still fails to make the proper response.

The response to the emergency by the crewmembers of Galaxy 203 in general and the captain in particular shows evidence of their having been affected adversely by stress, to the point that each of their performances deteriorated. The captain's delay in recognizing the airplane's deteriorating airspeed and performance and the first officer's continued communication with the air traffic controller to the exclusion of monitoring airplane performance, demonstrate that they persisted in inappropriate courses of action beyond the point when alternates should have been chosen- As the reduction in power failed to decrease the vibrations, the stress of the crewmembers probably increased and their ability to first perceive the deterioration in airplane performance and then to develop alternative courses of action to correct the effects of the power reduction, particularly in the short amount of time available for corrective action, decreased to the point where corrective action was no longer possible.

. Personality and Crew Coordination.--The captain was characterized as "always in corn mand." In addition, a first officer described him as the type of captain who would often check first officers on their knowledge of equipment and procedures. This characteristic of "being in command" may have been heightened by the composition of the flightcrew on Galaxy 203. The first officer and flight engineer differed considerably from the captain in two important dimensions that affect the nature of the interpersonal relationships of flightcrew members in the cockpit: age and flight experience. The captain was more than 20 years older than the junior crewmembers, and he had been piloting aircraft in general and the Electra in particular for years, whereas the others had been operating the airplane for only a few months. Such diversity can contribute, under routine circumstances, to deference by the junior crewmembers to the senior member. Under the type of critical conditions that Galaxy 203 experienced, where flight experience is a valuable asset in responding to an emergency, the interaction could, and

11/ Hart, S.G., and Bortolussi, M.R. Pilot Errors as a Source of Workload. Human Factors, 1984, 26, 545-556.
12/ Bond, N.A., Bryan, G.L., Rigney, J.W., and Warren, N.D. Aviation Psychology, Los Angeles, California: University of Southern California, 1968.

did, become one-sided as demonstrated by CVR conversation. @he captain, who typically employed a commanding leadership style, took complete control of not only his actions but also those of the other flightcrew members after the onset of the vibrations)

Despite their relative inexperience, the junior crewmembers were qualified in the Electra. \They could have assisted the captain in monitoring the flight instruments and controlling the aircraft. Instead, they responded directly to the captain's commands; the first officer, by communicating with the Reno tower, and the flight engineer, by monitoring the engines. If the first officer had noted the airspeed sooner and forcefully informed the captain of the deteriorating airspeed, thus acting contrary to the captain's direction, it is possible that power could have been applied in sufficient time to have prevented the accident.)

Moreover, the inappropriate actions of the first officer extended beyond his interaction with the captain to his interaction with the local air traffic controller as well. His failure to place more important aircraft monitoring duties at a higher priority than responding to the question of the controller, albeit in accordance with the captain's direction, demonstrated a failure to apply a critical tenet of flying: aircraft control takes precedence over all other flight related duties.

Given the composition of the crew on Galaxy 203 and their differences in age and flight experience, it is possible that training in crew coordination or cockpit resource management techniques may have enhanced the quality of the interaction of the crewmembers as well as their ability to cope effectively with their increasing acute stress. Certainly, the actions of the crewmembers suggest that a less dominating captain and a more assertive junior crew would have likely improved the flightcrew's overall response to what quickly developed into an emergency. Although Galaxy personnel testified that they addressed crew coordination in training, there is no record of it in the curriculum nor in the crew's training records. Moreover, Galaxy personnel appeared not to understand fully the concepts themselves as illustrated by a former pilot's description of Galaxy's emergency resource training and crew responsibilities during emergencies.

The Board believes that this accident again demonstrates the need for training in crew coordination or cockpit resource management, a need that has been identified in past accidents. As a result, the Board reiterates Recommendation A-85-27, in which it urged the Federal Aviation Administration to:

> Conduct research to determine the most effective means to train all flightcrcw members in cockpit resource management, and require air carriers to apply the findings of the research to pilot training programs.

The FAA has responded that it is in the process of creating a program to develop and apply advanced behavioral analysis to flight safety. This program should address the need cited in this recommendation. The Safety Board urges the FAA to develop such a program and implement its results as soon as practical. It has classified the response to this recommendation as "Open-Acceptable Action."

However, this accident demonstrates the need for all flightcrew members who are engaged in passenger transport, to be trained in cockpit resource management. While there is currently little data to support the merits of a particular cockpit resource management curriculum or instructional medium to carry out training in it, the Safety Board believes that a substantial number of flightcrew members arc unaware of the tenets of cockpit resource management, when these tenets arc critical to flight safety, and how they should be practiced in flight. Consequently, the Safety Board concludes that action should be taken before the results of the FAA sponsored research are determined.

The FAA provides guidance in several aspects of piloting and flight instruction. Guidance in cockpit resource management can be particularly beneficial to small carriers, such as Galaxy, who may not have access to the resources available to larger carriers to implement a program of training in cockpit resource management. The Safety Board believes that the size of the carrier should not play a part in its ability to implement training in this important topic. Consequently, the Safety Board believes that the FAA should provide, on a interim basis, guidance in the principles of cockpit resource management to all carriers who are engaged in passenger transport.

Training and Experience.--Galaxy Airlines followed Electra training procedures approved by the FAA under 14 CFR 121. The procedures call for stall training in the airplane itself since high fidelity simulators for the Electra are not available.

However, training in the full stall or approach to the stall was not required and was not performed. Stall training wassuch-that-recovery was-ini-tiated at the very onset of stall recognition. The lack of training beyond entry into the stall buffet in the Electra, with the possible masking effects of the vibrations, may also have prevented the flightcrew of Galaxy 203 from recognizing that they were in a stall situation. However, the Safety Board does not consider the lack of such training a factor in the accident because the flightcrew certainly had other cues readily available, such as airspeed and performance instrument indications, to provide information on the deteriorating airplane performance.

2.3.2 Air Traffic Controller

Shortly after takeoff, at 0103:45, the first officer on Galaxy 203 informed the controller that they wanted to return to the field. Thirteen seconds later the first officer explained to him the reason for the request: a "heavy vibration in the aircraft." The controller immediately cleared them for a return to the airport and asked, "Do you need the (emergency) equipment?" Two seconds later, the first officer of Galaxy 203 responded "affirmative."

The controller testified that he interpreted this response as a declaration that Galaxy 203 was in an emergency condition. While the crew of N5532 should have declared an emergency, the controller nevertheless treated this as an emergency. His assessment of the situation was timely and appropriate.

He then asked the crew, "How many people on board and say amount of fuel remaining?" The first officer answered and the controller then said, presumably to ensure accuracy: "Sixty-eight people and twelve hundred pounds of fuel?" As the first officer was answering the controller, the CVR indicates that the Ground Proximity Warning System (GPWS) began alerting the crew to "Pull up, Pull up."

FAA Air Traffic Control Handbook offers controllers only general guidance in responding to an inflight emergency since emergencies are so varied. However, it does direct the controller to act on an emergency once information on the pilot's desires and the nature of the emergency are learned. By immediately clearing Galaxy to return to the airport, the controller responded appropriately to the situation.

In addition, a letter of agreement between the Rend Air Traffic Control Tower and the Washoe County Airport Authority directs the controller, in the event of an inflight emergency, to provide crash/fire-rescue units with information on the number of people and the amount of fuel onboard. By soliciting this information from the crew, he acted in accordance with this letter of agreement.

However, the Safety Board believes that the FAA should reexamine the need for controller requests for such information during critical inflight events. Although the first officer acted inappropriately under the circumstances by responding to the controller and not monitoring the aircraft's instruments, it is clear that the ATC requests increased flightcrew workload at a critical point in the flight.

The Safety Board recognizes that inflight emergencies create demands for information. Crash/fire-rescue units may require information on the number of people and the approximate amount of fuel aboard. However, the need to solicit such information from a flightcrew responding to the emergency *is* less clear. The Safety Board believes that the FAA should reexamine both the guidance it provides controllers on information requirements during inflight emergencies and the letters of agreements its Air Traffic Control Towers have signed with local crash/fire-rescue agencies, so that the abilities of flightcrew members to respond to emergencies are not compromised by emergency response-related information requirements. The Safety Board believes that if a reexamination provides satisfactory documentation of the need to solicit such information for crash/fire-rescue units, then the FAA should develop alternative methods of obtaining this information so that flightcrew members are disturbed as little as possible during an inflight emergency.

2.3.3 Ground Handlers

The actions of the ground handlers were examined closely for their relationship to the accident. Since the Safety Board concludes that an open air start access door was the source of the reported vibrations in N5532 and since the ground handlers attempted to close that door as part of Reno Flying Service's ground servicing agreement with Galaxy, the Safety Board concludes that the ground handlers failed to close the door properly and then failed to notice that the door was not closed.

The actions of the ground handlers suggest that the circumstances of the ground servicing of Galaxy 203 were unique; specifically, the disruption to a routine of ground handling while Galaxy 203 was in the process of moving from the gate.

First, the ground handling supervisor assumed that the ground-to-cockpit headset was working and he could talk directly to the flightcrew to begin the final servicing of Galaxy 203. When the headset did not operate, he had to disconnect it and implement an alternative, commonly used, method of communication--hand signals. The flightcrew of Galaxy 203 indicated their awareness of the change in communication by flashing their lights on and off.

He then gave the signal directing Galaxy 203 to taxi, when he realized that the air start hose was still connected. He quickly gave the flightcrew the emergency signal to stop because the ground handler was still trying to disconnect the air start hose. He was unable to talk to the ground handler due to the noise levels generated by the two engines of N5532, so he quickly walked over to her, determined the type of difficulty she was encountering, disconnected the hose, and motioned to her to leave. This disruption allowed the almost habitual action of closing the air start door either to be overlooked or to be accomplished improperly. Moreover, the ground handlers' preoccupation with the requirements of completing the servicing of Galaxy 203 was evident by their not noticing that the flaps on the airplane were lowered. Their inability to notice the movement of this relatively large piece of the airplane's structure suggests the ease with which they failed to notice that the air start access door, a considerably smaller item, was not closed properly.

The Safety Board has investigated several accidents in which disruptions to crew routines, which were in and of themselves relatively inconsequential, led flightcrew members to fail to carry out critical flight monitoring or handling responsibilities, with subsequent disastrous consequences. 13/ In this accident, the Safety Board concludes that a disruption to a ground handling routine which had been performed previously many times led to the ground handlers' not performing a simple task, closing an air start access door. As in those accidents, the disruption to a routine contributed to the accident.

The Board assessed the training program of the ground handlers and the method of delegating aircraft servicing responsibilities to determine the extent to which one or both may have contributed to their actions with regard to Galaxy 203. The training that the Reno Flying Service provided its ground handlers was neither suggested nor required by the FAA. It encompassed general topics on ground handler safety as well as specific procedures for aircraft servicing, such as behavior with regard to rotating propellers and de-icing methods.. . . The -ground-handling supervisor, a licensed mechanic, according to a well established practice of Reno Flying Service, should have been the person who closed the air start access door since he had removed the air start hose. Additionally, he had several years of experience in servicing a wide variety of aircraft. Therefore, he should have been, and he testified that he was, aware of the importance of closing all aircraft doors that had been opened. Since closing access doors and panels are relatively simple tasks that do not require specialized training, the Safety Board believes that the ground handling supervisor was qualified to perform the duties assigned to him despite his lack of specific training or experience on Electra airplanes.

The procedure that the Rcno Flying Service employed for delegating aircraft servicing responsibilities was appropriate. Supervisors delegated specific duties, but the responsibility for closing a door or panel belonged to the individual who had completed the service which had required the door or panel to have been opened. It is doubtful that improved delegation of servicing responsibilities for ground handlers would have resulted in a different outcome with regard to the air start access door of N5532 since this concept is so clear and unambiguous.

The Safety Board believes that all persons who have responsibility for servicing, operating, or directing aircraft share in the safe outcome of that aircraft's operation. This accident illustrates the importance of ground handlers to, and their responsibility for, the operation of Galaxy 203. Consequently, the Safety Board concludes that the ground handlers contributed to the cause of this accident by failing to properly close the air start access door on N5532.

Despite the ground handler's contribution to the cause of this accident, the Safety Board believes that supplemental carriers such as Galaxy, operating under 14 CFR 121, must ensure that all servicing performed on their aircraft meets the requirements of 14 CFR 121.123. 14/ The Safety Board believes that the flightcrew of

13/ Aircraft Accident Report: "Eastern Air Lines, Inc., L-1011, N310EA, Miami, Florida, December 29, 1972" (NTSB-AAR-73-14). Aircraft Accident Report: "United Airlines, Inc., McDonnell-Douglas, DC-8-61, N8082U, Portland, Oregon, December 18, 1978" (NTSB-AAR-79-7).

14/ 14 CFR 121.123 states, in part, that:

> Each supplemental air carrier or commercial operator must show that competent personnel and adequate facilities and equipment (including spare parts, supplies, and materials) are available for the proper servicing, maintenance, and preventive maintenance of aircraft and auxiliary equipment.

Galaxy 203 met the requirements of 14 CFR 121.123 since the flight engineer personally supervised or performed critical tasks such as baggage loading, fueling, and engine servicing, and since the broker agent supervised the servicing of the passenger cabin. Only the relatively simple tasks of connecting and disconnecting ground power units wire performed, unsupervised, by Reno Flying Service personnel. Consequently, because of the relative simplicity of the tasks, the Safety Board concludes that Galaxy met the intent of 14 CF 121.123. However, the Safety Board believes that because all operators may not adhere to this regulation, the FAA should inform supplemental operators of their responsibility, described in this regulation, for the services that arc performed on their aircraft.

2.4 Survivability

The accident was partially survivable in that 16 individuals survived the initial impact and apparently were not physically injured. However, they were killed by the fire which began immediately upon impact and engulfed the airplane very rapidly. Others died as a result of the fire and some associated trauma. It is not known how many of these occupants could have survived had there not been a fire; however, the rapidity of the ignition and spread of the fire in this accident prevented their survival. Consequently, the post-mpact fire played a major role in the cause of the fatalities. The three passengers who survived the crash and the fire did so because they had been thrown from the airplane upon impact. Nevertheless, two did not survive their injuries.

The distribution of causes of death among the passengers was closely related to their location on the airplane. Most of the passengers killed by blunt force trauma were seated toward the front of the airplane while passengers killed by the fire were seated toward the rear. Passengers were found to be uniformly distributed throughout the airplane, which-is consistent with information given by the survivor.

The only survivor of the accident, a 17-year-old male, probably survived the accident because he was propelled 40 feet forward of the burning aircraft. As a result, hc was not engulfed in the fire that consumed the airplane when it came to rest. In addition, his assumption of a curled up position before the impact may have prevented his head or extremities from striking airplane or ground structures.

2.5 Certification and Oversight

2.5.1 The Electra Air Start Access Door

The investigation disclosed that vibrations caused by open air start access doors on the Electra were known to many pilots and that Galaxy's former director of operations had experienced the phenomenon during the 1970's. Reports of other Electra pilots who had experienced the open access door seem to support the sense that they were not aware of the cause of the severe vibrations during the encounter, but the experience remained with them as a significant event in their careers.

Several carriers with pilots who had encountered such severe vibrations from open air start acccss doors modified thc doors. One such carrier operates a fleet of 21 Electras, each of which has been modified. Since thc FAA has not issued a supplemental type certificate (STC) to modify the door, operators can acquire an Electra which has one of any number of air start access door types, nonc of which require additional FAA aircraft certification.

The Safety Board concludes that the possible adverse consequences of an air start access door opening inflight are such that the FAA should require operators to modify these doors, as soon as possible, to prevent these consequences from occurring. The Board believes that the FAA should issue an airworthiness directive to Electra operators to require that these doors be so modified.

Galaxy was not informed of the problems that could be encountered inflight in the Electra when an air start access door is inadvertently left open. Several reasons seem to explain why they and other operators were not so informed. At the time the Electra was first certificated and operated, no system existed for pilots to directly communicate with a government agency about operational problems concerning an aircraft with assurance that retribution would not be taken against them. This problem has since been corrected, up to a point; by the establishment in 1976 of the Aviation Safety Reporting (ASRS) system. The Electra vibration problem also did not fall within a clearly defined category of the FAA's Service Difficulty. Reporting. (SDR) requirements since it did not involve a major structural or mechanical defect. In addition, as the time since the Electra was first certificated has advanced, the communications between operators and the manufacturer of the airplane, which has long since ceased production of that airplane, have become increasingly less direct. The problem of communication has been exacerbated by the increasing number of operators, such as Galaxy, who operate rela tively small Electra fleets. As a result, neither the FAA nor Lockheed was apparently aware of the potentially adverse consequences of an open air start access door on the Electra since neither had records of these types of vibrations in their files, despite the fact that some pilots knew of the problem. Had the flightcrew of Galaxy 203 been informed, they would have been prepared to respond when confronted with the vibration. The Safety Board concludes that until all Electra wing mounted air start access doors are modified, the FAA should inform operators of the potential inflight aerodynamic consequences encountered with Electra airplanes both to ensure that all pilots of Electras are made aware of the problems and that they can recognize and react appropriately to such situations.

2.5.2 Condition of the Aircraft

The airplane was properly certificated and equipped in accordance with existing Federal regulations. However, it was not maintained in accordance with the requirements of 14 CFR 121 because the flight data recorder (FDR) had run out of recording medium over 100 flight hours before the flight of Galaxy 203. Although Galaxy's operating manual specifies that the FDR be checked before each flight, there is no indication that the flightcrew of Galaxy 203 performed this check.

The Board believes that it is incumbent on an operator to adhere to all applicable regulations. The requirements contained within 14 CFR 121.343(a)(1) are explicit with regard to aircraft operations and the use of flight data recorders. That such a recorder was not, and had not been, operating for some time before the flight of Galaxy 203 indicates that both the crew of that flight and the carrier failed to appreciate the need to adhere to regulations. The Board is concerned that inadequate adherence to such procedures can and did carry over to methods of operation that directly affected flight safety.

The investigation also noted a high probability that N5532 was not within acceptable weight and balance limitations at the time of the accident. In 1981 and in 1983 the aircraft was weighed. The second weighing revealed an approximate 1,000-pound decrease in the aircraft's empty and operating weight and, more importantly, a dramatic shift in its operating CG from 14.7 percent to 25.5 percent MAC. Although the 1981 weighing was consistent with previous weighings, suggesting that it was accurate, the 1983 weighing resulted in a significant alteration in its weight and balance. However, there is no indication that Galaxy personnel questioned the discrepant weighing, nor was the airline able to suggest an explanation for the discrepancy.

The carrier's weight and balance manual specified that under certain passenger load conditions the last three passenger seat rows and the lounge were to be left vacant. If the passengers were seated randomly, as was indicated by witnesses, then with the actual number of passengers on board Galaxy 203, the aircraft CG would have been at 32.8 percent MAC, aft of the takeoff CG limit of 32 percent MAC. Had the passengers been seated in a forward loading configuration, the CG would have been within its limits. However, the Safety Board concludes that the effects of the aft CG on aircraft control were slight since power and pitch control were available and sufficient to have maintained airplane control following takeoff; therefore, the aft CG was not causally related to the accident.

The loose adherence of the flightcrew of Galaxy 203 to procedures has already been addressed. The lack of records showing that the carrier attempted to learn the reasons for the discrepant weights of N5532 indicates that the carrier itself did not present to its employees a concern that all procedures be followed. Therefore, the Board must conclude that the carrier either did not adequately supervise its employees or failed to convey to them the need to follow operating procedures, or both.

2.5.3. Certification, Inspection, and Surveillance

The president of Galaxy had been previously associated with an airline that had encountered financial difficulties. After he had demonstrated successfully that he was no longer associated with that company, the CAB was satisfied that Galaxy, under his tenure, should be granted a ccrtificatc. The CAB investigated the safety records and operating backgrounds of the company's management personnel through its communications with the NTSB and FAA. The CAB/DOT records also show that the continuing economic fitness of Galaxy was monitored.

The Safety Board believes that full adherence to required procedures and regulations by a carrier depends on a continuous interaction between that carrier and responsible government agencies. This interaction, critical though it is in aviation, is especially critical when a carrier is new and its procedures are still evolving with the evolution of the operations. Moreover, due to its unique history, Galaxy should have been, and the Safety Board believes was not, inspected beyond the high level usually required by a relatively young carrier. It experienced an uncommonly high turnover among critical management personnel. It was controlled by an individual with a less than optimum record of compliance with financial obligations. The rccordkccping, which was recognized by Galaxy's principal inspectors as deficient, showed numerous instances of changes to aircraft logs. Its operations moved periodically according to contractual needs, but the major portion of the FAA surveillance activities was confined to the south Florida area in spite of stated procedures which should provide for surveillance outside this area.

At times, the FAA's surveillance of Galaxy displayed the type of activity that the Safety Board considers proper; for example, comprehensive examination of the propeller on engine No. 2 of N5532 and its history before it granted approval of Galaxy's request for an extension of a required inspection. However, the fact' remains that only after the accident was the FAA able to discover alleged violations of operational and maintenance regulations that occurred before the accident and that were sufficiently critical for the FAA to seek several hundred thousand dollars in civil penalties against

Galaxy. In contrast, FAA inspectors, including the one who performed the investigation that resulted in the alleged maintenance violations, indicated during the Safety Board's public hearing general satisfaction with the degree of Galaxy's compliance with FAA rcgula tions.

Therefore, the Safety Board concludes that FAA surveillance of Galaxy's operations and maintenance was seriously deficient. Moreover, that inspectors who were aware or were in a position to be aware of the FAA's investigation of Galaxy expressed in their testimony general satisfaction with Galaxy's compliance with FAA regulations indicates that FAA inspectors were less than forthcoming in their interaction with the Safety Board in the conduct of its investigation.

Had the FAA carried out the type of surveillance of Galaxy that it performed after the accident, it is possible that Galaxy's operations would have improved substantially before the accident. Further, the Safety Board believes that it is imperative that the FAA, as the responsible agency for assuring operator compliance with federal aviation regulations, monitor and inspect operators to the extent necessary to verify that proper compliance is achieved. In addition, since Galaxy's operations were unique in that its charter bases were moved periodically to various locations and since there was no indication that the FAA carried out proper surveillance of operations based outside of south Florida, the Safety Board believes that the FAA should establish and enforce procedures to ensure that consistent levels of surveillance and inspection are carried out regardless of where an operator bases its operations.

3. CONCLUSIONS

3.1 Findings

1. The flightcrew was properly certificated and qualified to fly the flight.

2. The airplane was not maintained in accordance with applicable Federal regulations and company procedures. However, noncompliance with Federal regulations and company procedures did not contribute to the accident.

3. The four propellers were being driven by their respective power sections at the same governed speed, and all were operating normally.

4. There was no evidence of preexisting structural failures to the airplane or to flight control systems.

5. Galaxy Airlines' normal operating checklist did not contain a provision for checking nor did N5532's flightcrew check FDR operation prior to the flight of Galaxy 203. N5532 flew approximately 117 hours without an operable flight data recorder, in violation of 14 CFR 121.343.

6. The flightcrew did not process duplicate flight planning forms in accordance with company procedures.

7. The flightcrew did not complete the required checklists prior to the flight. Some checklist items that were performed were not in accordance with the required challenge and response format.

8. Substantial inconsistencies in the airplane's weight and balance were accepted without adequate followup by Galaxy management.

9. N5532 was probably loaded beyond its aft CG limit for takeoff, although its effect on airplane control was slight.

10. The ground handlers failed to close properly the air start access door before the airplane was taxied from the service ramp due to the disruption of the servicing of Galaxy 203.

11. The responsibility for providing for competent personnel to service its aircraft according to 14 CFR 121.123 belongs to the operator.

12. The FAA did not issue a supplemental type certificate for various modifications on Electra air start doors that had been performed by operators, nor was a supplemental type certificate required for these modifications.

13. The captain reacted to the airplane's vibration by reducing power significantly in all four engines, indicating that he believed the vibration was caused by the powerplants or propellers.

14. The airplane entered aerodynamic stall buffet because of insufficient engine power to maintain flight, at too low an altitude to effect recovery.

15. The local air traffic controller followed established procedures in requesting information from the flightcrcw on the number of people and fuel onboard, after they requested to return to the airport.

16. The first officer of Galaxy 203 acted inappropriately by responding to the air traffic controller's requests, and failed to monitor the airplane's airspeed and altitude until it was too late to recover from entry into stall buffet. When recovery was finally attempted, impact could not have been prevented.

17. The captain attempted both to determine the cause of the vibration and fly the airplane simultaneously, which he was unable to do.

18. Galaxy Airlines did not conduct formal training in cockpit resource management techniques.

19. The airplane's vibrations probably masked the inherent indications of aerodynamic stall buffet.

20. The accident was almost completely non-survivable due to both impact forces and post-impact fire.

21. Galaxy was certificated by the CAB/DOT and the FAA to operate as a supplemental carrier under 14 CFR 121.

22. FAA inspection and surveillance of Galaxy was deficient, although this did not contribute to the cause of the accident.

3.2. Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the captain's failure to control and the copilot's failure to 'monitor the flight path and airspeed of the aircraft. This breakdown in crew coordination followed the onset of unexpected vibration shortly after takeoff. Contributing to the accident was the failure of ground handlers to properly close an air start access door, which led to the vibration.

4. RECOMMENDATIONS

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

> Issue an Airworthiness Directive to Electra operators to modify the air start access door to prevent an inadvertent inflight opening from affecting airfoil aerodynamics. (Class II, Priority Action) (A-86-14)
>
> Until such time as Electra air start access doors are modified, issue an Air Carrier Operations Bulletin to have Principal Operations Inspectors inform operators of Electra aircraft of the potential of an open air start access door to cause vibration or buffet during takeoff and inflight, and ensure that such information is included in recurrent pilot training programs for these operators. (Class II, Priority Action) (A-86-15)
>
> Establish and enforce procedures to ensure that adequate surveillance of operators is maintained when a carrier's operations are located away from the office responsible for the carrier's ongoing surveillance. (Class II, Priority Action) (A-86-16)
>
> Instruct Principal Operations Inspectors to verify that supplemental operators are fulfilling their responsibility to ensure that competent personnel are available to properly maintain and service the operator's aircraft at all transient locations. (Class II, Priority Action) (A-86-17)
>
> Evaluate the information needed by crash/fire-rescue agencies to deal with inflight emergencies, and the best method of obtaining that information, so that flightcrew members are disturbed by air traffic controllers as little as possible while they are responding to an inflight emergency. (Class II, Priority Action) (A-86-18)
>
> Provide, to all operators, guidance on topics and training in cockpit resource management so that operators can provide such training to their flightcrew members, until such time as the FAA's formal study of the topic is completed. (Class II, Priority Action) (A-86-19)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JIM BURNETT
Chairman

/s/ PATRICIA A. GOLDMAN
Vice Chairman

/s/ JOHN K. LAUBER
Member

February 4, 1986

APPENDIXES

APPENDIX A

INVESTIGATION AND PUBLIC HEARING

1. Investigation

The National Transportation Safety Hoard was notified of the accident about 0450 eastern standard time on January 21, 1985 and immediately dispatched an investigative team to the scene from its Washington, D.C. headquarters. Investigative groups were formed for operations/witnesses, air traffic control, meteorology, survival factors, structures, powerplants, systems, flight data recorder, maintenance records, cockpit voice recorder, and airplane. performance. In addition, human performance specialists were assigned to and participated in the investigation.

Parties to the investigation were the Federal Aviation Administration, Lockheed - California Corporation, Allison Gas Turbine Division of General Motors Corporation, Pacific Propeller, Inc. - IMC Magnetics Corporation, Galaxy Airlines, Inc., and the Airport Authority of Washoe Country.

2. Public Hearing

A three-day public hearing was held in Sparks, Nevada, beginning April 23, 1985. Parties to the hearing were the Federal Aviation Administration, Galaxy Airlines, Inc., Lockheed - California Corporation, Pacific Propeller, Inc. - IMC Magnetics Corporation, and Allison Gas Turbine Division of General Motors.

APPENDIX B

PERSONNEL INFORMATION

Allen D. Heasley - Captain

The captain was born January 11, 1936. He was employed by Galaxy Airlines in August 1983, having been employed by Galaxy's predecessor company, Consolidated Components, Inc., on a part-time basis from August 1981 to December 1983. He held airline transport pilot certificate No. 1759839, dated May 11, 1983, for airplane multiengine land with ratings in the L-188, Lear Jet, .DC-3, and N-265 aircraft and corn mercial privileges airplane single engine land.

His current first class medical certificate, dated August 31, 1984, contained the limitations: "Holder shall wear glasses for near vision while exercising the privileges of this airman certificate."

The captain had approximately 14,500 total flight hours, about 5,600 of which were in the Lockheed L-188.

In the past 90 days, 30 days, and 24 hours, Captain Heasley had flown 123.1, 55.3, and 3.1 hours, respectively.

Kevin Charles Fieldsa - First Officer

The first officer was born May 14, 1957. Hc was employed by Galaxy Airlines on June 1, 1984. He became qualified as a first officer in the L-188 on September 30, 1984. He held airline transport pilot certificate No. 264132766, dated June 23, 1981 for airplane multiengine land and commercial privileges, airplane single engine land. His flight instructor certificate No. 2614132766 CFI, dated March 11, 1981, for airplane single and multiengine, instrument airplane had expired.

His first class medical certificate, dated December 3, 1984, contained no limitations.

The first officer had accumulated approximatcly 5,000 total flight hours. He had flown 172 hours in the Electra.

In the past 90 days, 30 days, and 24 hours, First Officer Fieldsa had flown 112.5, 44.4, and 3.1 hours, respectively.

Mark Charles Freels - Flight Engineer

The flight engineer was born April 12, 1961. He held flight engineer - turbopropcller powered, certificate No. 262611197, dated July 27, 1984. Hc also held a mechanic certificate, with airframe and powerplant ratings No. 262611197, dated September 30, 1983.

His current second class medical certificate, dated July 3, 1984, contained no limitations.

The flight engineer had 262.3 total flight hours, all of which were in the Elcc tra.

In the past 90 days, 30 days, and 24 hours, Flight Engineer Freels had flown 193.3, 65.4, and 3.1 hours, respectively.

Flight Attendants

Flight Attendant Heather Coston was employed by Galaxy on September 19, 1983. She completed 56 hours of initial training on September 1, 1983 and 15 hours of recurrent training on February 4, 1984.

Flight Attendant Donna Cutillo was employed by Galaxy on February 24, 1984. She completed 60 1/2 hours of initial training on February 6, 1984.

Flight Attendant Sheila Morales was employed by Galaxy on December 22, 1984. Her flight attendant training records were onboard N5532 and were destroyed in the accident.

Air Traffic Controller

Kenneth G. Moen, Air Traffic Control Specialist at the Reno Air Traffic Control Tower, was employed by the FAA on May 30, 1982. From 1977 to 1981 he was an Air Traffic Controller in the US Army. Upon his employment by the FAA he was assigned to the Reno Tower. He was a full performance level controller, qualified to operate all positions in the Tower.

Ground Handlers

John Easter, ground handling supervisor with the Reno Flying Service, was employed by them on August 1, 1981. From 1977 to 1981 he was a helicopter crew chief with the US Marine Corps. He holds an FAA mechanic certificate with airframe and powerplant ratings.

Lisa Whitaker, ground handler with the Reno Flying Service, was employed by them on November 1, 1984.

APPENDIX C

AIRCRAFT INFORMATION

The airplane was a Lockheed Electra L-188C, United States Registry N5532, Serial No. 1121, manufactured in 1960, and owned by Consolidated Carrier International, doing business as Galaxy Airlines, Inc. The airframe had accrued 34,148.9 hours total time, in 33,285 cycles, at the time of the accident.

The airplane was powered by four Allison 501D13 turboprop engines.

Engines	#1	#2	#3	#4
Serial Number	501488	500567	500977	501344
Date installed	7-12-79	3-19-81	3-l-80	319-81
Overhauled by	Unknown, if over-hauled	National Airmotive	Eastern Airlines, Inc.	Aviation Power Supply

Propellers	#1	#2	#3	#4
Manufacturer	Aero Products	Aero Products	Aero Products	Aero Products
Model	A6441FN-606	A6441FN-606	A6441FN-606	A6441FN-606
Serial Model	HC2721	HC647	HC2338	HC2728
Date installed	4-15-84	l-lo-85	6-10-84	8-18-82
Time since overhaul	396	1,982 1/	3,392/ 2	1,810

1/ The #2 propeller overhaul was extended to l-22-85 by FAA.
2/ This exceeds the requirements.

APPENDIX D

TRANSCRIPT OF COCKPIT VOICE RECORDER

LEGEND

CAM	Cockpit area microphone voice or sound source
RDO	Radio transmission from accident aircraft
-1	Voice identified as Captain
-2	Voice identified as First Officer
-3	Voice identified as Flight Engineer
-4	Voice identified as communicating with cockpit crew
-?	Voice unidentified
UNK	Unknown
TWR	Reno Tower
GND	Ground Control
GPWS	Ground proximity warning system
*	Unintelligible word
#	nonpertinent word
%	Break in continuity
(	Questionable text)
(( ))	Editorial insertion .
———	Pause
Note:	All times are expressed in Pacific standard time.

INTRA-COCKPIT

TIME & SOURCE	CONTENT
12:34:35	
CAM-1	Give me the Colorado snow height
CAM-?	They are at nine too
CM-?	Okay
CAM-2	* * * what do they go Eor?
CAM-1	They were cheap, I bought 'em in Utah and I think they were about twenty-five dollars
CAM-1	I haven't worn 'em skiing
CAM-2	What kind of flight time will we have to Minneapolis today
CM-1	Four houre
CM-1	Four hours
CM-?	Four hours
CM-1	No help at all from the wind
CAM-2	None at all huh?
CM-1	A hundred knots on the nose comi ng over and no help going back
CAM-2	Yeah, yeah

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT

INTRA-COCKPIT

TIME & SOURCE	CONTENT
CAM-1	Although I can't complain, this is the first bad one I've had, I've been lucky * *
CAM-?	If we get off the ground at twenty-five to one * * * a half hour at most
CAM-1	I'm ready as soon as I get passengers
CAM-?	((Sound of yawn))
12:37:00 CAM-3	Ah that looks a little better on the oil huh
CAM-2	Yeah
CAM-3	Be daylight when we get there
CAM-2	Yup, I get to call Barbara up again and wake her up, she really likes that attention
CAM	((Sound of tapping))
12:38:00 CAM-1	Ah before start checklist
CAM-3	Take the vibrators off the altimeters and put it on the tachometers

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT

APPENDIX D

INTRA-COCKPIT

TIME & SOURCE	CONTENT
CM-3	Circuit breakers aud swi tches
CM-3	Oxygen system
CAM-2	Yea *
CAM-3	Static ewitches
CM-?	* *
12:38:10 CAM-3	RMDI
CM- I	Yeo
CM-3	"E" handles
CAM-1	Yeo
CAM-3	Fuel quantities
CAM-3	Oil quantities * *
CAM-3	Hydraulic quantity * *
CAM-1	You write up my icing check light?
CAM-3	Huh?
12:38:20 CM- 1	Did you write up my icing check light

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT

INTRA-COCKPIT

TIME & SOURCE	CONTENT
CAM-3	Oh, no I didn't, I don't have one
CAM-1	Write it up then
CAM-1	See if we can get a manifest * *
CAM-3	Yeah but it generates a lot of paper-work if you can't get it fixed right then
CAM-1	* * manifest * *
CAM-3	I'd rather put it down on a separate sheet of paper
CM- 1	Write it on your separate sheet of paper
CAM-3	Cause otherwise if its not cleared by the next flight, you have to defer it to the original log then clear it
CAM-1	Write it down
12:39:15 CAM-3	Okay
CM- 2	It doesn't even show that hill on this sheet * * *
CM-I	This think can clear the hill * *
CAM-2	* localizer * * *

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
CAM-?	Do you see that on the approach plate?		
CAM-?	Ah here it is		
CAM-?	Thank you		
CAM-4	You're welcome		
CAM-4	Kevin, do you want yours now?		
CAM-2	Yeah I'll take one now		
CAM-1	Are there a lot of extra ones now?		
CAM-4	Yeah		
CAM-?	Huh?		
CAM-4	Yes sir * *		
12:43:00 CAM-1	Can I have a black cup please		
CAM-4	A what?		
CAM-1	A black coffee		
CAM-4	Kevin what do you want?		
CAM-2	I'll take a coke		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TINE & SOURCE	CONTENT
cm-2	How much fuel do we have on board (Al)		
CAM-I	Twenty-six		
CAM-1	(Shove it in one)		
CAM-?	*		
12:43:40 CAM-2	Radar vee direct Minneapolis		
CAM-3	Excuse me let me get my seat here		
12:44:00 CAM-3	Okay Kevin, my takeoff nine fifty		
CAM-3	What's the story here Al, I haven't had a takeoff in a month		
CAM-I	Takeoff * * *		
CAM-?	((Sound of laughter))		
CAM-?	* *		
CAM-?	This is it		
12:44:30 CAM-3	I.could do wfthout going to Minneapolis tonight		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
CAM-?	Probably wouldn't bother me a bit		
CAM-3	I'd get over it a couple of beers and I'd get over it		
CAM-4	Kevin * * * what 1 want to know is		
CAM-I	Stay below twenty-five thousand * *		
CAM-3	Yeah my personnel flight attendant is handling that * *		
CAM-3	Bring 'em out elxty-five, no sixty-eight are all the bags loaded, sixty-eight sixty-eight are all the bags in?		
12:47:40 CAM-3	They kept trying to unload our bags, we'd come out and three or four of our bage would be out on the ramp, throw it back in the bi n and eay "crew bags, crew bags", we'd come back and three or four would be back on the ground, throw 'em back in the bin "crew bags"		
CAM-2	Hope they didn't get mine yeah		
CAM-I	We're going to use full flaps for taxi-out and alternate for takeoff		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
CAM-7	* *		
12:48:15 CAM-2	* the rotors are tied down		
CAM-1	* blow one over		
CAM-3	I didn't think you cared much for helicopters any more		
CAM-2	* paperwork *		
CAM-2	Trying to avoid paperwork		
CAM-3	The one thing I can fly better now		
CAM-3	I love it		
CAM-I	Do you have an air cart out there		
CAM-3	Yeah		
12:49:00 CAR-3	Probably can't any more, it's been years since I've flown 'em		
CAM-1	I saw a Jack * *		
CAM-3	That's two things I can fly better		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
CAM-3	,Did you fly, you didn't fly the Gazelle did you just flew the FH-eleven hundred		
CAM-1	No I flew * *		
CAM-?	*		
CAM-3	Did you fly the Gazelle * *		
CAM-3	Any IFR, the grey and black one		
CAM-1	Yeah * demo pilot showed me a hundred and fifty six knots		
CAM-?	Yeah		
CAM-1	* * every rivet		
CAM-3	Eddie and I ueed to cruise around in seven nix mike alpha at a hundred and fifty a hundred and forty-five		
CAM- 3	I jurt wanted out		
CAM-3	That Gazelle was a piece of cake, Eddie taught me in the FH-eleven hundred, you know where she had two rotor blades		

INTRA-COCKPIT | **AIR-GROUND COMMUNICATIONS**

TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
12:50:00 CAM-3	And no SAS got in that Gazelle man and three rotor blades and rotary tail rotor, those things (perk flick) on the SAS and you can let go of it		
CM-1	Then it's true, they don't have a tail rotor huh		
CM-?	* *		
CAM-3	Yeah there running oil around the outride of it • oil cooler		
12:50:30 CM-3	That thing was nice and qulet, no vibration, amooth, fast		
CAM-1	Tel 1 you what, a hundred and Fifty-six knots, I don't want no part of that thing back there		
CAM-3	That was the demo helicopter * * * Eddie didn't complain that bad		
CM-1	(That's fine) with me * *		
CAM-3	We just, we frequently went a hundred and forty-ff ve, a hundred and fifty, you know during training and stuff		

INTRA-COCKPIT

TIME & SOURCE	CONTENT
12:51:00 CM-3	It great, you juet pull max collective pull max collective and just counter it with the cyclic till you just, you know, you get max L over D basically, right
CAM-3	Get that sucker about like this man ehed just shoo, you end up almost on the collective stop
CAM-1	You hear about (Don?)
CAM-2	No (Philip)
CAM-3	No ah * rich
CM- l	He has a house in Aspen, he has about ten acres * * takes off his helicopter starts out going about twenty snagged a wire with the left skid wraps it around his throat, wraps around the skid like a teather
CAM-1	Uh huh
CAM-3	Is he alive?
CM- 1	Yeah, he wasn't killed

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT

INTRA-COCKPIT

TIME & SOURCE	CONTENT
CAM-1	Like that not immediately, the blades come almost down to where they hit the tall rotor and that of course it brought It to a stop, so It actually pulled it backwards a little bit so he tried to go again
CAN-?	* * a pleaeure
CAN-1	Okay Ron
cAH-4	If you need me, I'll be In the office tomorrow morning just call me
CAM-1	Okay
CAM-1	Have a good one
CAM-1	So he ah
CAN-1	So he didn't know he'd hit, didn't know what happened but he just stopped
CAM-3	Broke it huh
12:53:00 CAN-I	He was over, he couldn't land, he was over a ravine so he started forward again and it happened again, he started looking around and he figured out he'd hit a wire *

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
CAM-1	So he hovered and the wire left him 'about, I don't know, I guess a couple of hundred feet from the pole and there was no place inside the wire they could 1 and		
CAN-?	Yep		
CAM-3	Oh #		
12:53:30 CAN-I	He let somebody off in a hover and let down close to the ground, they ran to the house and brought a whole bunch of wooden boxee, filled some rocks and stuff like that		
CAM-3	Why didn't they get bolt cutters and cut him loose?		
CAN-I	Well, they were afraid of high voltage, actually they would have cut off all the power to the valley, they never knew that wire was etrung across --- there were no poleo		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME 6 SOURCE	CONTENT
CAM-3	I bet he's got a bunch of orange balls on it now doesn't he?		
CAM-1	Oh he knows it's there now		
CAM-3	WOW		
CAM-3	He's real lucky he didn't hill himself -- real lucky		
CAM-3	You usually don't get away with that #		
CAM-1	You've got another ten (knots) * *		
CAM-?	That's okay		
12:55:00 CAM-3	The mechanic come around?		
CAM-?	* * *		
12:55:12 CAM-4	Ready to bring the stairs up?		
CAM-3	Any time you are		
CAM-3	Got it		
CAM-1	Okay, turn four		
	((The original transcript begins here))		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME lb SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
CAM-1	Okay, turn four		
CAM-1	Four clear?		
12:55:32 CAM-3	No air		
CAM-2	Four clear		
cAu-3	No air		
12:55:37 CAM-2	Boy, did you see that		
CAM-3	What's that?		
CAM-2	A falling star		
CAM-?	Should of had * camera out		
12:55:51 CAM-?	How does the clearance read?		
cm-2	We ate cleared the Reno seven departure as filed		
		12:55:55 RDO-?	* * * north runup for a runway check
		12:55:59 CND	Ops four ground, proceed as requested

INTRA-COCKPIT | AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
12:56:03 CAM-2	Reno seven is tracking outbound on the one six localiter, three forty-three outbound --- (on the)		
CAM-1	We taking off on three four?		
CAM-2	No (sir) we're taking off on one six		
12:56:24 CAM-1	One six		
CAM-2	Got three four three in the window		
CAM-1	Right		
12:56:32 CAM-2	There are mountains all over the place		
CAM-1	Put the localizer on mine and the DME on yours		
12:56:42 CAM-1	One oh eight seven, you say?		
CAM-2	Yes sir its on ILS, DME on one oh nine three one oh nine three		
12:56:49 CAM-1	oh it is, huh		
12:57:00 CAM-1	Ready to go up on four		

APPENDIX D

INTRA-COCKPIT

TIME & SOURCE	CONTENT
CAM-3	Ah, go ahead and turn it on their air
12:57:07 CAM-3	I got a good etart on it --- fast rotation
12:57:42 CAM-1	Ships power
CAM-1	The only advantage of turning on their air is you go to ships power before you start number one
12:58:42 CAM-1	Lower full flaps
CAM-2	Full flaps
12:59:05 CAM-3	Up on one
CAM-1	Up on one
12:59:12 CAM-3	Up on four
CAM-1	Up on four
12:59:19 CAM-3	(Closed)
CAM-3	Buss transfer
CAM-1	Clear right

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT

INTRA-COCKPIT TIME & SOURCE	CONTENT	AIR-GROUND COMMUNICATIONS TIME & SOURCE	CONTENT
CAM-2	Clear right		
		12:59:26 RDO-2	Reno Ground, Galaxy two oh three at Reno flying service taxi
		12:59:32 GND	Galaxy two oh three Ground' taxi runway one six right
		12:59:36 RDO-2	One six right Galaxy two oh 'three
12:59:56 CAM-1	oh #		
CM-3	What		
CAM-1 .	(There's a thing) right here, I'm about about to run over		
01:00:04 CAM-1	Turned me right into it		
01:00:34 CAM-1	Okay, etart 'em up		
		01:00:35 RDO-?	Can we have taxiway bravo on the east side and the lights lit
		01:00:40 GND	Roger

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME 6 SOURCE	CONTENT
01:00:45 CM- 1	Flaps alternate		
CAM-2	Flaps alternate		
01:00:51 CM- 1	Bleeding off of one		
CAM-3	Yeah bleeding off number one		
01:01:27 CM-?	Switch to tower and takeoff checklist		
		01:01:32 RDO-2	Reno Tower, Galaxy two oh three ready for takeoff one six right
		01:01:36 TWR	Galaxy two oh three Reno Tower wind calm clear for takeoff
01:01:40 CAM-3	Flight instrument8		
		RDO-2	Cleared for takeoff Galaxy two oh three
		01:01:44 TWR	Ops hold short of one six right
		01:01:46 RDO-2	Is that for Galaxy two oh three hold short of one six right

INTRA-COCKPIT

TIME & SOURCE	CONTENT
01:01:53 CAM-3	Flight instruments
CAM-1	Set
cAn-2	Set on the right
CAM-3	Trim tabs
CAM-2	Ten up, three right, zero
CAM-3	Controls
01:02:00 CM- 1	On the bottom
CAM-2	On the top ((simultaneous with above))
CAM-3	Vee one, vee two
CAM-2	One hundred and four
CAM-2	One hundred and twenty
CAM-2	And one hundred and sixty

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT
01:01:49 TWR	Negative, that was for a'vehicle on the al rport
01:01:52 RDO-2	Okay

INTRA-COCKPIT TIME & SOURCE	INTRA-COCKPIT CONTENT	AIR-GROUND COMMUNICATIONS TIME & SOURCE	AIR-GROUND COMMUNICATIONS CONTENT
CAM-2	(Nine seven one) for takeoff		
01:02:20 CAM-3	Flaps		
CAM-2	Alternate ((alternate flaps is ten degrees))		
CAM-1	I'm going to make the takeoff		
01:02:36 CAM-3	Takeoff checks complete		
CM-?	That's it		
01:02:44 CAM-2	Cleared for takeoff		
CAM	((Sound similar to power increase))		
01:02:45 CAM-1	Okay, we go out this thing and then what		
01:02:48 CAM-3	Beta lights are out		
01:02:49 CAM-2	Co outbound on the localizer to fourteen point nine		
01:02:52 CM-?	Then what		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
01:02:54 CAM-?	Climb to one three thousand vectors (in route)		
01:03:01 CAM	((Sound similar to glare shield rattle))		
01:03:05 CM-1	My yoke		
CM	((Sound similar to glare shield rattle dampening))		
01:03:19 CAM-2	Vee one		
01:03:21 CM	((Sound of thunk))		
01:03:23 CAM-2	Vee two		
CM	((Sound of t hunk))		
01:03:26 CM-1	Gear up		
01:03:27 cm-2	Gear up		
01:03:29 CM-I	What is it Mark		

INTRA-COCKPIT TIME & SOURCE	INTRA-COCKPIT CONTENT	AIR-GROUND COMMUNICATIONS TIME & SOURCE	AIR-GROUND COMMUNICATIONS CONTENT
CM	((Sound of thunk))		
01:03:30 CAM-3	I don't know	01:03:30 TWR	Ops four at your discretion cross
01:03:34 cAn-3	I don't know Al		
01:03:36 CAM-I	Okay ah		
01:03:37 CAM-3	That's METO		
01:03:40 CAM-1	Okay pull 'em back from METO		
CAM-?	Okay ((between "back" and "from" above))		
01:03:43 CM-1	Tell 'em we need to make a left downwind to get outta here, get it back on the ground		
		01:03:45 RDO-2	Galaxy two oh three like to make a left downwind, we gotta get back on the ground
01:03:50 CM-3	RPMs look stable, horsepowers look good		
		01:03:51 TWR	Galaxy two oh three say again

INTRA-COCKPIT TIME & SOURCE	CONTENT	AIR-GROUND COMMUNICATIONS TIME & SOURCE	CONTENT
		01:03:54 RDO-2	Ah sir, we'd like to make a left downwind
01:03:55 CAM-1	Tell 'em we have a heavy vibration		
		01:03:58 RDO-2	We've gotta heavy vibration in the aircraft
CAM-3	Jesus		
01:03:59 CAM-?	(Okay)		
CAM-?	(I've got it)		
		01:40:00 TWR	Galaxy two oh three roger ah maintain VFR and a left downwind for one six right and do you need the equipment
CAM-7	(Pull the power)		
01:04:05 CM	((Sound similar to eta11 buffet onett, loose cockpit equipment begins to rattle))		
01:04:07 CM-1	Yeah		
		01:04:08 RDO-2	That's affirmative
		01:04:10 TWR	Roger, how many people on board and say amount of fuel remaining

INTRA-COCKPIT TIME & SOURCE	INTRA-COCKPIT CONTENT	AIR-GROUND COMMUNICATIONS TIME & SOURCE	AIR-GROUND COMMUNICATIONS CONTENT
01:04:11 CAM-?	(Okay put more power back)		
		01:04:13 RDO-2	Sixty eight and we got full fuel
01:04:14 GPWS	Whoop whoop, pull up		
CAM-3	Pull up		
GPWS	Whoop whoop, pull up		
CAM-3	Pull up		
		01:04:17 TWR	Sixty eight people and twelve hundred pounds of fuel?
01:04:18 CAM-2	A hundred knots		
01:04:19 CAM-(3)	God, god		
01:04:21 CAM-2	A hundred knots		
01:04:24 CM-1	Max power		

((This page revised April 8, 1985))

INTRA-COCKPIT

TIME & SOURCE	CONTENT
01:04:25 CAM-3	Max power
01:04:30 CM	((Sound of impact))
01:04:31	((End of recording))

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT

APPENDIX E

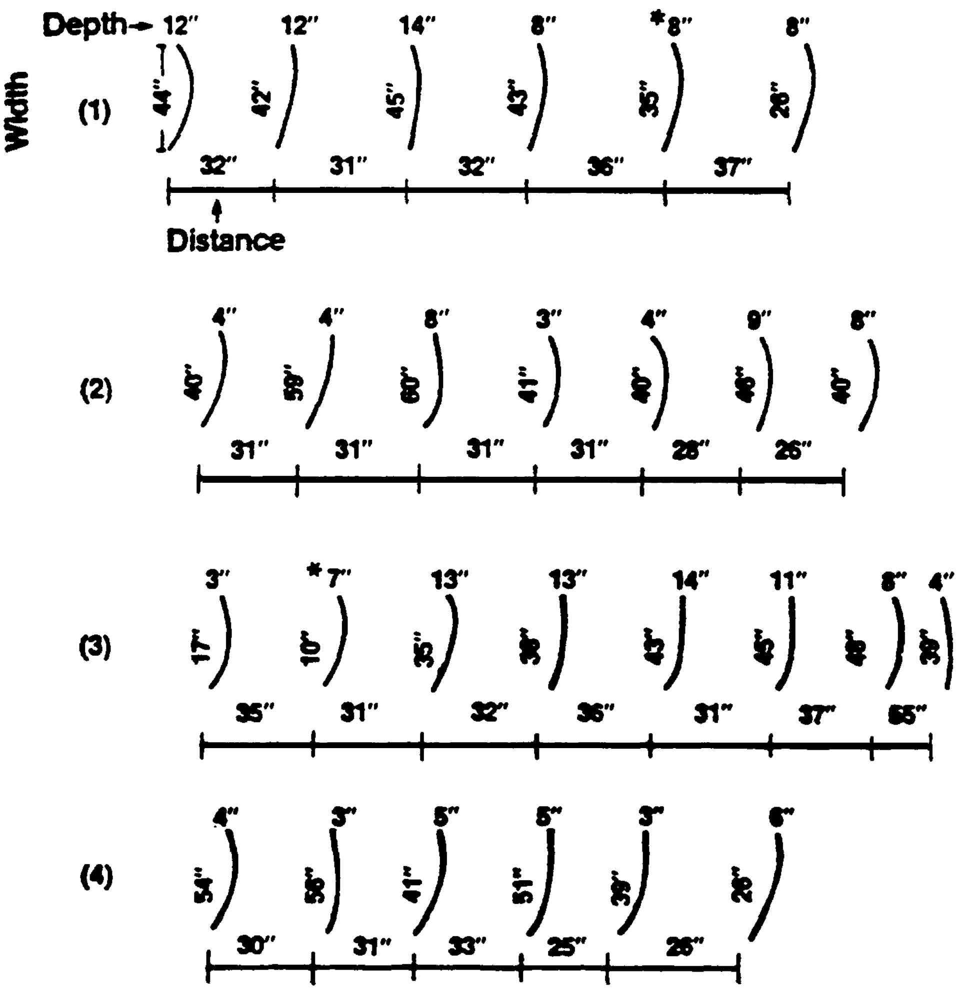
Approximate Depths, Distances, and Widths Between Propeller Blade Rotational Contact (Cut) Marks

Legend

(1) No. 1 Propeller Blade (6 cuts)
(2) No. 2 Propeller Blade (7 cuts)
(3) No. 3 Propeller Blade (8 cuts)
(4) No. 4 Propeller Blade (6 cuts)
* Indicates that a blade struck a concrete drainage pipe

Depths, Distances, and Widths are in inches

Direction of Airplane's Travel →



Allison

March 21, 1985

National Transportation Safety Board
Bureau of Technology
800 Independence Avenue S.W.
Washington, D.C. 20594

Attn: Edward P. Wizniak

Subject: Galaxy Electra Accident
Reno, Nevada, January 21, 1985

Dear Mr. Wizniak:

In accordance with your request, I have enclosed information relating to estimated aircraft speed based on the propeller slash marks and estimated propeller performance for the estimated airspeed and the reported ambient conditions at the time of the accident.

The aircraft ground speed, at the time the propeller slash marks were made, may be determined as follows:

1. For each propeller, the initial two or three slash marks were spaced 31 inches to 32 inches apart or an average 31 1/2 inches or 2.625 ft.

2. The propeller should have been in governing at 100% or 1020 rpm. Since the initial slash mark spacing was the same for each propeller, all propellers were running at essentially the same speed and it is therefore logical to assume they were operating at 100% or 1020 rpm.

3. 1020 rpm = 17 rps or .0588 sec/rev. or .0147 sec/1/4 rev. Therefore, the slashes occurred .0147 seconds apart.

4. It follows that the aircraft advanced 2.625 ft. in .0147 seconds.

5. Therefore, aircraft ground speed at the time the slash marks occurred $= \frac{2.625 \text{ ft}}{.0147 \text{ sec}} = 178.57$ ft/sec

$= 121.7$ mph

$= 105.7$ knots

Mr. E. P. Wizniak
Galaxy Electra Accident
March 21, 1985
Page 2

6. You will note that for a 32 inch slash spacing, the ground speed is 107.4 knots and for a 31 inch slash spacing, the ground speed is 104.0 knots.

A special propeller performance curve applicable for this accident was prepared using the basic A6441FN-606 propeller performance curves and the following specific conditions relating to this accident:

Propeller rpm	100%
Ambient pressure	25.58 inches Hg
Ambient temperature	27°F
Airspeed	105.7 knots

A copy of the curve is attached. Please note that for each knot decrease in airspeed, the power will increase approximately 20 horsepower.

The estimated horsepower corresponding to the average blade angle for each propeller as determined by the propeller examination is shown in the following table:

Propeller Position	Average As Found Blade Angle	Estimated Horsepower	Average Impact Blade Angle	Estimated Horsepower
1	40.4	2800	40	2680
2	48.2	5000*	35.9	1670
3	37.8	2100	38.6	2300
4	41.4	3080	41.4	3080

*This value is beyond the capability of the engine.

Please note that estimated takeoff engine performance for the accident conditions is approximately 3300 shaft horsepower. It would be possible to analyze the results differently by using individual blade impact marks rather than averages. For example, the Number 1 propeller had two blades with distinct impacts at 42° blade angle which corresponds very closely to takeoff engine power.

Mr. E. P. Wizniak
Galaxy Electra Accident
March 21, 1985
Page 3

Although the data does not check out perfectly in all respects, it is reasonable, and considering the inaccuracy involved and the unpredictable occurrences during impact conditions, the results indicate the engines and propellers were operating normally in the high power range at the time of impact.

Very truly yours,

ALLISON GAS TURBINE DIVISION
GENERAL MOTORS CORPORATION

R.W. Hatch

R. W. Hatch
Product Safety Engineer

/ad
Attachment

cc: Mr. George F. Bollinger - Lockheed
Mr. Martin Buckman - FAA
Mr. E. Ross Gibbs - PPI
Mr. Richard C. Rutz - Hamilton Standard

TECHNICAL DATA REPORT

Allison | EDC NO REF | PAGE 2 OF 3 | PAGES | REPORT NO. AR.1290-226

TITLE

A6441FN-606 PROPELLER PERFORMANCE

PREPARED J. Jaeger 3/20/81

CHECKED

APPROVED

Calculerions:

Engine Speed N_e = 100%

Ambient Pressure P_a = 25.58 in Hg

Ambient Temperature T_a = 27°F

Air Speed V = 105.7 KTAS

$$\delta = \frac{P_a}{P_{STD}} = \frac{25.58}{29.92} = 0.8549$$

$$\theta = \frac{T_a}{T_{STD}} = \frac{27 + 460}{519°R} = 0.9383$$

J = .007355 x V = .007355 x 105.7 KTAS = 0.7774

C_p obtained from Acroproducts Curve No. AA-250, page 7 (6/5/57)
A6441FN-606 Propeller Power Coefficient (C_p) vs. Advance Ratio(J)
for a range of Blade Angles (B_{42}) using tip Mach # = 0.7

PSHP = .95361 x 10^4 x C_p x δ/θ

J	δ/θ	B_{42}	C_p	PSHP
.7774	.9111	35	.172	1494
"	"	36	.196	1703
"	"	37	.220	1911
"	"	38	.247	2146
"	"	39	.276	2398
"	"	40	.308	2676
"	"	41	.342	2971
"	"	42	.374	3249
"	"	43	.410	3562
"	"	44	.446	3875
"	"	45	.481	4179

DISTRIBUTION

FORM 4936 (REV. 2-82)

APPENDIX F

MEMO TO ELECTRA OPERATORS

Number 25
30 May 1985
Page i of 1
Electra: 10

LOCKHEED — MEMO TO ELECTRA OPERATORS — ELECTRA

OPERATING INFORMATION

SUBJECT: UNUSUAL VIBRATION/BUFFETING DURING TAKEOFF

INTRODUCTION:

The purpose of this letter is to alert flight crews to a condition where strong airplane vibration or buffeting can be experienced immediately after takeoff and the cause cannot be readily identified.

A recent accident took place in which 'heavy vibration' vas reported by the crew immediately after takeoff. The accident occurred while the airplane was returning to the airport.

DISCUSSION:

At present the cause of the 'vibration' has not been positively determined. However, during the accident investigation a number of previously unreported vibration/buffeting incidents of a similar nature came to light. In these cases the source of the vibration/buffeting was believed to be an open ground air start connection door. This door is locaced on the lover surface of the right wing leading edge close to the fuselage (BL 68 to BL 79). If the door is not latched prior to takeoff, it apparently is possible for the door to open fully during the takeoff rotation and act as a spoiler ahead of the leading ● This reportedly causes high levels of vibration/buffeting (similar to that associated with a stall) with no apparent indication of the source. Although it can be disconcerting, this vibration/buffeting does not have any significant affect on the ability to control the airplane, and it will not cause any structural damage other than perhaps a bent or lost access door.

Increasing the airspeed will result in reduced vibration and the vibration reportedly ceases at speeds in the 105 to 160 KCAS range. At these speeds the door returns co a nearly closed position where it no longer disturbs the airflow over the wing leading edge. Once the reported vibration had ceased, no reports of any unusual vibration or buffeting vere reported during the subsequent landings.

An attempt was made to reproduce this phenomenon during a flight test program at Peterson AFB, Colorado in which the door was intentionally left open before the takeoff. The results vere inconclusive in that the door did not move forward and no unusual vibration or buffeting occurred.

CONCLUSION:

In view of the above, it is recommended that if unusual vibration or buffeting occurs during the takeoff rotation and initial climb, and there is no obvious cause, eontinoe to fly the normal flight profile. Any buffeting caused by an open ground air start access door should cease vhm the speed has reached about 160 KIAS.

APPENDIX G

NARRATIVE AND PHOTOGRAPHS ON ELECTRA FLIGHT TEST

Tufts of yarn about 4 inches long were attached to the ving skin in the vicinity of the airstart door by duct tape; Several were attached on the front hinge line of the door, two on the edge of the door and several behind it (see photo 1). In this picture (photo 1), which was taken just prior to. rotation during takeoff, the tufts can be seen to fair toward the rear in the slip stream. The door is open a bit because of the negative pressure produced by the airfoil. This phenomena was observed in flight at airspeeds of over 150 knots as well. It is exactly what was expected.

Photograph one was taken during the takeoff roll prior to rotation.

Photograph two was taken during rotation when a large angle of attack and ground effect could be expected to produce reverse airflow in the area of the airetart door. As can be seen in this photograph, the tufts in the vicinity of the front hinge are experiencing forward or reverse airflow. The two located near the latch at the rear of the door are near the area of stagnant airflow and are being forced inside the door area. This shows us that reverse airflow exists nearly to the rear of the door vhcre it could cause it to blow open as has been reported to have happened in the past.

Photograph three was taken during climbout at an airspeed of around 150 knots. In this case the tufts of yarn in the vicinity of the latches have streamlined aft showing that the airflow is front to rear. Eovever, the front tufts located in front of the hinge line are still experiencing on airflow forward up and over the leading edge of the wing. This shows that the airflow is still onto the door and not streamlined over it. If the door was not present airflow would be into the open area behind the door.

Photograph four was taken as the aircraft was being stalled. The tufts are reacting similarly to what they vere doing when the aircraft was rotated. The tuft located near the latches is going into the open door. What we do not see is the effect of ground effect which would cause more forward airflow as the aircraft is rotated.

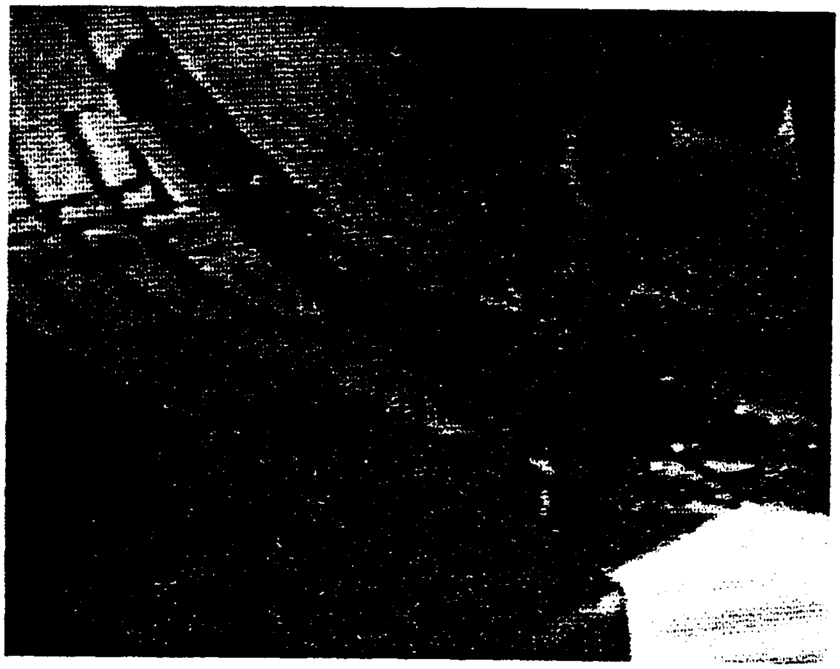


Photo 1. Air start door prior to rotation at takeoff.
Arrows indicate the action of the tufts.

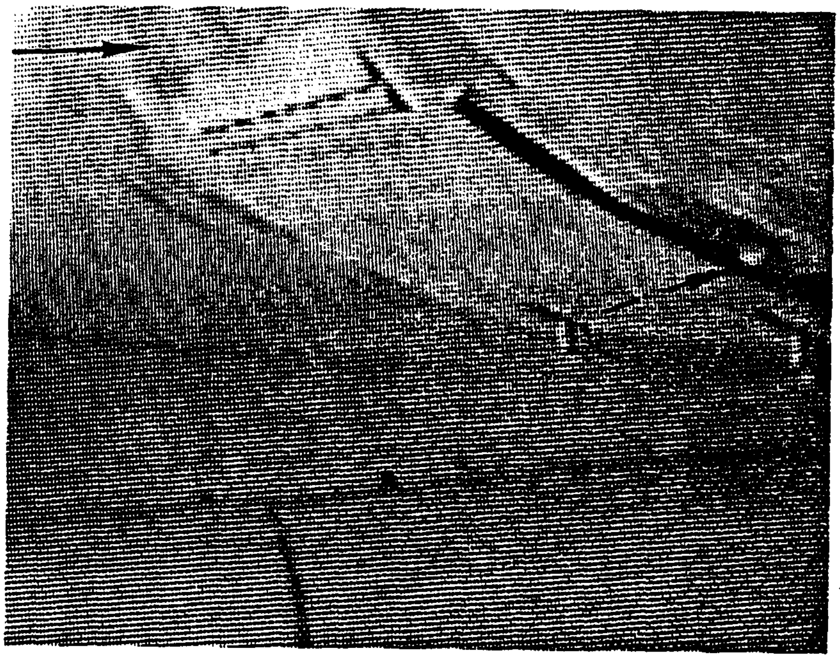


Photo 2. Aircraft rotation.

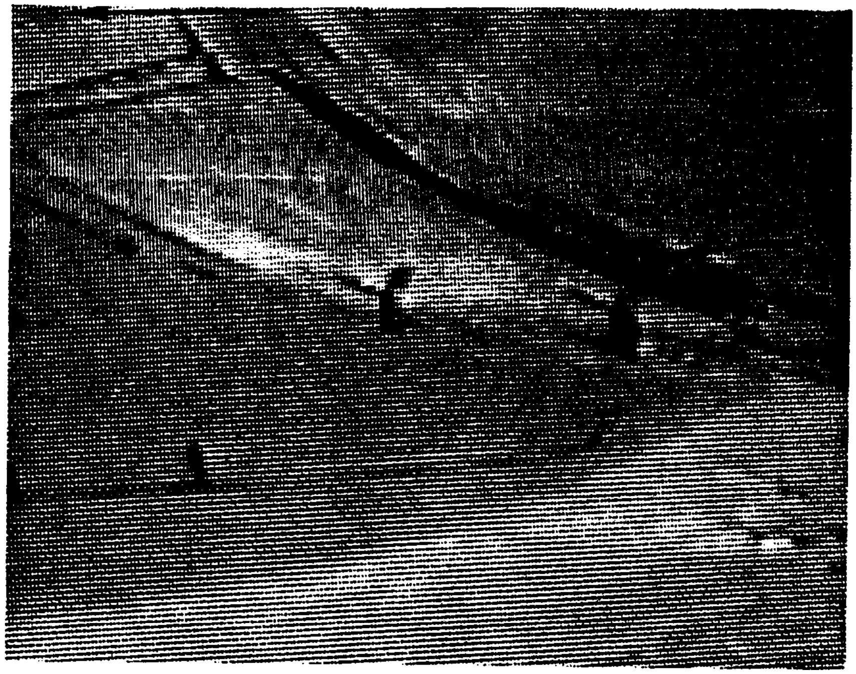


Photo 3. Air start door during climb; 150 knots airspeed.

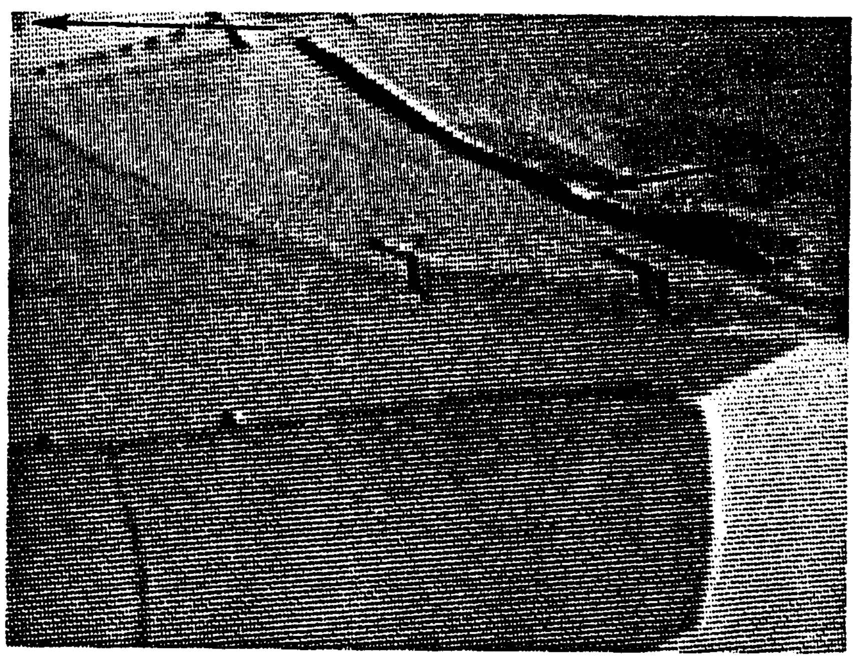


Photo 4. Aircraft being stalled.

APPENDIX H

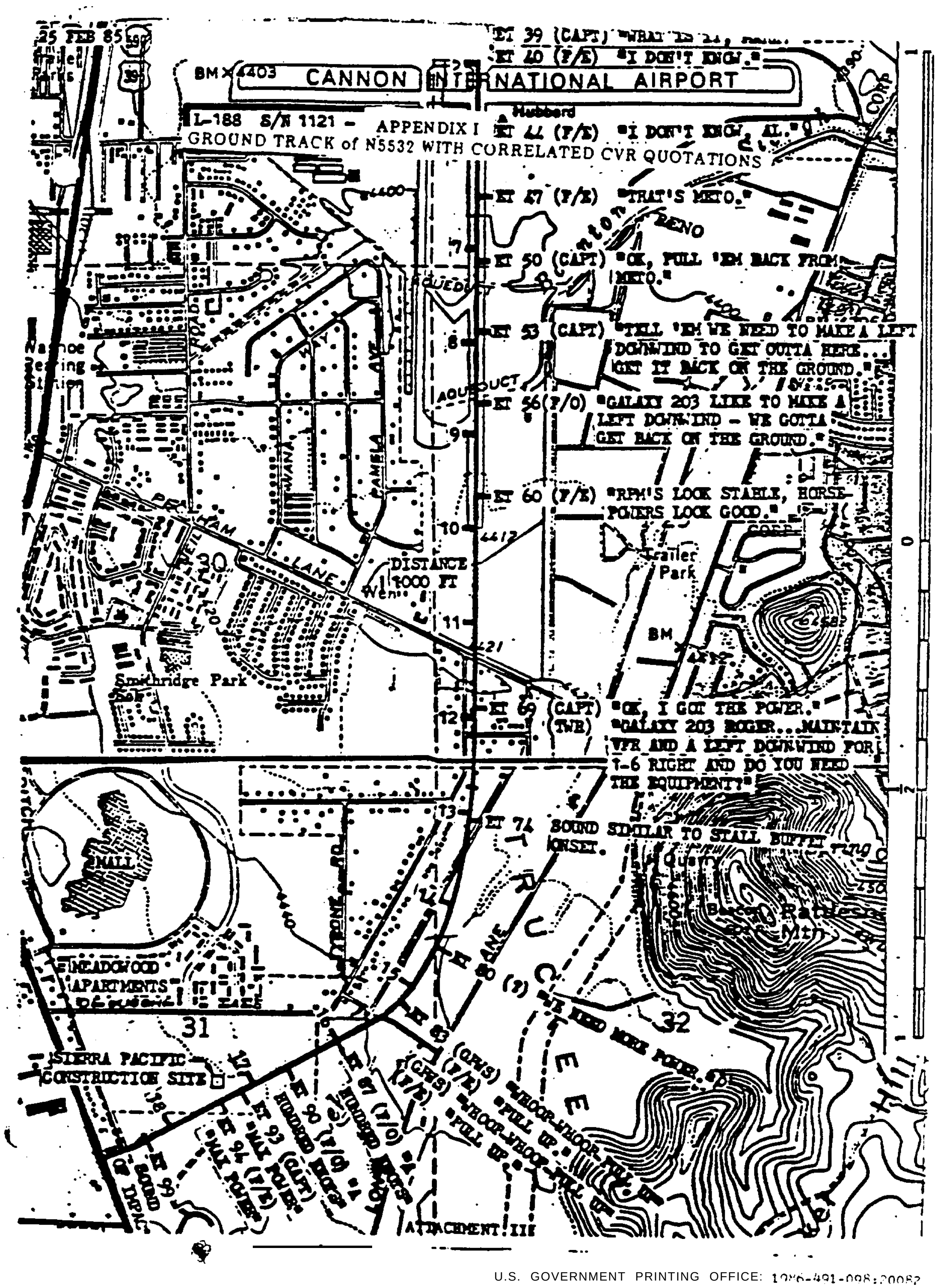
FAA SURVEILLANCE AND FLIGHT CHECKS

Date	By POI	By PMI	By Other Inspectors
11/15/83			check Airman Observations (Sheridan) N5532
1/31/84		Spot check (N5532)	
3/15/84			NATI-I Team PIC check (Whitehouse) (N5532)
5/4/84			Ramp Insp. (N5532)
5/5/84		Spot check (N5532) (Severe weather insp.)	
5/8/84			FDR Readout (N5532)
6/12/84		Facilities	
6/22/84	Crew Records		
6/25-28/84			AQAFO Team
7/3/84			F/E Initial (Freels) ck Airmen Observation (Whitehouse/Sheridan 15532 P/f Initial Nekia)
7/24-25	AQAFO followup		
7/30/84	Enroute Inspection		
8/8/84		Ramp Inspection (N5532)	
10/4-5/84	Training		
10/10/84		Spotcheck (N5532)	
10/18/84			ATP Type Rating (Richards)
10/22/84 10/23/84	Sub Base Insp. (ACV)	Sub Base Insp. BDL Enroute Inspection	
11/9/84			ATP Type Rating
12/84			L-188 Examiner Designation

Pox = Principal Operations Inspector
PMI = Principal Maintenance Inspector
NATI = National Air Transportation Inspection
AQAFO = Aeronautuical Quality Assurance Field Office

APPENDIX I

GROUND TRACK of N5532 WITH CORRELATED CVR QUOTATIONS



U.S. GOVERNMENT PRINTING OFFICE: 1986-491-098:20082