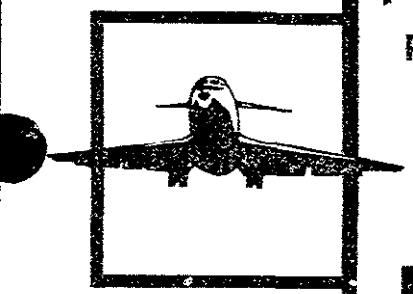

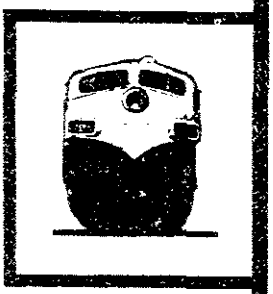

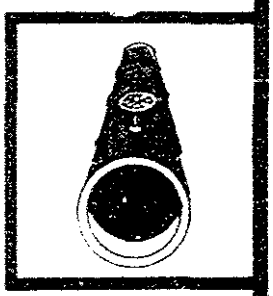

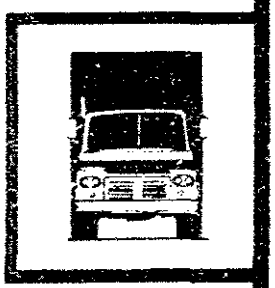

PB84-910406

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

LANDRY AVIATION
LOCKHEED LEARSTAR L-18, N116CA
SILVANA, WASHINGTON
AUGUST 21, 1983

NTSB/AAR-84/06

UNITED STATES GOVERNMENT

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NTSB/AAR-84/06	PB84-910406	

4. Title and Subtitle: Aircraft Accident Report--
Landry Aviation Lockheed Learstar L-18, N116CA
Silvana, Washington, August 21, 1983

5. Report Date: Nay 17, 1984

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.
3794-A

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
Aircraft Accident Report
August 21, 1983

14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

About 1832 p.d.t., on August 21, 1983, a Lockheed L-18 Learstar, N116CA, operated by Landry Aviation, Inc., crashed in a farm field adjacent to a State highway after an uncontrolled descent from 12,500 feet. The airplane had carried 24 sport parachute jumpers and 2 pilots. Fifteen parachutists successfuily parachuted from the airplane during the descent. Nine parachutists and the two pilots were killed.

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the operator and the pilot-in-command to assure proper load distribution during the jumper exit procedure. A more intensive program of surveillance by the Federal Aviation Administration may lead to the detection and elimination of some of the factors in the accident.

17. Key Words
Sport parachuting, weight and balance, center of gravity, airplane modifications, supplemental type certificate, seatbelts, FAA surveillance. operating limitations, door removed, sky diving

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)	20. Security Classification (of this page)	21. No. of Paces	22. Price
UNCLASSIFIED	UNCLASSIFIED	37	

NTSB Form 1765.2 (Rev. 9/74)

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NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D.C. 20594

AIRCRAFT ACCIDENT REPORT

Adopted: May 17,1984

LANDRY AVIATION, INC.
LOCKHEED LEARSTAR L-18, N116CA
NEAR SILVANA, WASHINGTON
AUGUST 21,1983

SYNOPSIS

About 1832 Pacific daylight time on August 21, 1383, a Lockheed 2-18 Learstar, N116CA, operated by Landry Aviation, lnc., crashed in a field adjacent to a State highway after an uncontrolled descent from 12,500 feet. The airplane had carried 24 sport parachute jumpers and 2 pilots. Fifteen parachutists successfully parachuted from the airplane during the descent; nine parachutists and the two pilots did not and were killed in the crash.

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the operator ana the pilot-in-command to assure proper load distribution during the jumper exit procedure. A more intensive program of surveillance by the Federal Aviation Administration may lead to the detection and elimination of some of the factors in the accident.

1. INVESTIGATION

1.1 History of the Flight

About 1810, 1/ on August 21, 1983, a Lockheed 2-18 Learstar, N116CA, eperated by Landry Aviation, Inc., as a sport parachute jump flight, departed the Arlington, Washington, municipal airport, on its fourth such flight of the day carrying sport parachute jumpers to a drop zone near Silvana, Washington, about 5 nautical miles west of the airport. This flight was to carry 24 parachutists to 12,500 feet mean sea level over the drop zone where a mass jump was to be made. The airplane was in a cargo configuration with no seats. There were 24 seatbelts in 2 rows of 12 which were attached to seat track/cargo tiedown rails in the floor, and the aft cabin entry door had been removed. For takeoff, the jumpers sat on the airplane floor in rows of three abreast facing aft. One jumper was said to have occupied a jump seat immediately behind the cockpit.

After departure, the airplane climbed in a large circular track around the drop zone. A Notice to Airmen (NOTAM) regarding the psrachute jump had been filed by the pilot with the Seattle Air Route Traffic Control Center (ARTCC) that morning before he commenced operations. In accordance with that NOTAM, the crew was in contact with the ARTCC during the climb for traffic advisories and to advise when the parachutists had jumped.

1/ All times herein are Pacific daylight time, based on the 24-hour clock.

Surviving parachutists stated that takeoff and climb to the jump altitude were normal. All the parachutists remained in the positions occupied at takeoff until jump altitude was reached. Surviving parachutists also stated that none of the jumpers seated on the floor used the available seatbelts. About 1 minute before the airplane arrived over the drop zone, two jumpers moved aft to the door to spot the airplane for the jump run and to relay maneuvering directions to the pilots by hand signal. As the airplane neared the drop zone, the jumpers moved to their prejump positions. Two jumpers moved outside the door, one forward of the door on a narrow external step holding on to an external handle, and one on the aft side of the doorway holding on to the aft door frame. A third positioned himself in the doorway by standing on the door sill, facing inboard, and holding onto the top door frame. Five more lined up as close as possible to the door. The other 16 Lined up in rows of 8 each along both sides of the cabin.

The jumpers stationed in the door stated that they were not aware of any airplane problem as they jumped. One of them observed the airplane after he fell away from it. He stated that it was in a steep right bank, that it then rolled over, the nose dropped, and that it entered a steep dive during which it made one or two slow spirals as it continued the steep dive until it struck the ground. Descriptions of the descent offered by several other jumpers were similar.

Three jumpers, the 9th, 11th, and 12th in the planned jump sequence, stated that they felt the aft end of the airplane drop, then oscillate slightly up and down, after which the airplane rolled to the right before the jumpers were able to reach the door and leave the airplane. Sixteen of the 24 jumpers were able to leave the airplane before and after the upset. One was killed and two were seriously injured when they struck the horizontal stabilizer; 13 were uninjured. All 16 parachutes functioned normally.

Witnesses on the ground, many of whom had watched previous flights of the airplane that day, stated that, just as the first jumper left the airplane, it rolled to the right, entered a steep dive, and rotated slowly two or three times during the dive. They stated that it struck the ground in a steep nosedown attitude slightly past vertical. They described loud "screaming" engine sounds which continued until the airplane struck the ground. Some witnesses described a light colored smoke trail coming from one of the engines during the latter part of the dive.

The Seattle ARTCC lost radar contact with N116CA at 1830:05. The accident occurred during daylight. The airplane struck the ground at latitude 48°13' north and longitude 122°14' west.

12 Injuries to Persons

Injuries	Crew	Passengers	Other	Total
Fatal	2	9	0	11
Serious	0	2	0	2
Minor	0	3	0	0
None	0	13	0	13
TOTAL	2	24	0	26

13 Damage to Airplane

The airplane was destroyed.

1.4 Other Damage

The airplane crashed on the downslope of the shoulder of State Highway 530 1 mile north of Silvana, Washington. The earth fill was displaced outward and upward, and the asphalt pavement was dispiaced upward and damaged by an intense gasoline-fed fire.

15 Personnel Information

The flightcrew was properly certificated and qualified in accordance with current regulations to conduct the flight. (See appendix B.) The crew ferried the airplane from Paine Field, Everett, Washington, lo the Arlington Airport between 0700 and 0800 on the day of the accident. The captain flew all the flights that day while a different pilot flew as copilot on the second and third parachute flights. At the time of the accident, the crew had been on duty about 11 hours. The captain had flown about 2.5 hours and the copilot about 1.3 hours up to the time of the accident.

16 Airplane Information

The airplane was manufactured by Lockheed Aircraft Corporation as a Model L-18 Lodestar. In 1957, it was modified by Pacific Aero Engineering Corporation to a Learstar Mark II configuration under Supplemental Type Certificate SA4-69. (See appendix C.) The airplane had been inspected and maintained in accordance with the approved maintenance program of the previous operator, who had used it in cargo operations under 14 CFR 135.

The empty airplane weight was 14,458 pounds and the maximum allowable takeoff weight was 22,500 pounds. The center of gravity limits were: forward limit 188 inches (27.8 percent mean aerodynamic chord (MAC)); aft limit 198.8 inches (37.2 percent MAC).

1.7 Meteorological Information

The sky was clear with unlimited visibility.

1.8 Aids to Navigation

Not applicable.

1.9 Communications

Not applicable.

1.10 Aerodrome and Ground Facilities

No? applicable.

1.11 Elight Recorders

The airplane was not equipped, nor was it required to be equipped, with a cockpit voice recorder or a flight data recorder.

1.12 Wreckage

The airplane struck the embankment of State Highway 530 vertically with the nose about 10° to 15° past vertical. Except for some small light pieces, the wreckage was confined to the impact crater which measured about 15 feet across. The wings were positioned at opposite sides of the crater, and both engines were buried about 6 feet into the earth. The empennage was in an inverted position at the southerly edge of the crater. A swath had been cut through the branches on the northerly side of a large tree about 20 feet from the southerly edge of the crater. The cut was at 80° from the horizontal and aligned with the Crater.

The fuselage disintegrated during impact and postcrash fire. Both wings were fragmented with leading edges crushed rearward. The left aileron, flap tracks, and flap remained attached to a separated section of rear spar. The left flap was partially intact. The outboard flap roller was lcdged in the outboard flap track in a partially extended position 8 inches back from the forward stop. This corresponds to a flap position between 15° and 18°. Approach flap position (20 percent) is about 17° to 18°. The right wing, except for the rear spar with aileron and flap attached, was consumed by postcrash fire. The right flap was in a partially extended position with the outboard roller lodged in the flap track about 8 inches from the forward stop.

The horizontal stabilizer and elevator were intact on the empennage. The elevator trim tab was intact, in a faired position, but could be moved freely by hand. The trim tab actuator was separated from the tab. The actuator rod was extended from the housing 5.13 inches, corresponding to nearly full nosedown elevator trim.

The landing gear struts and actuating linkages had separated from the wing. One landing gear actuator was found with the actuating rod in the extended position and bent at the housing.

Both propellers were destroyed. Both engine reduction gear boxes were destroyed, and several cylinders on both engines were separated irom the crankcases. The accessory drive gear boxes and accessories were destroyed by fire. The aft faces of both crankcases, which form the forward side of the blower housings, exhibited severe rotational scoring marks.

1.13 Medical and Pathological Information

Of the jumpers who were able to leave the airplane, one received fatal injuries and two were seriously injured. The two seriously injured jumpers left the airplane after it had roiled and begun its descent. They both stated they struck the horizontal stabilizer after exit but were able to open their parachutes; both suffered leg injuries. The locations in the airplane of those who were able to jump are shown in figure 5.

The fatally injured jumper was observed by other jumpers to have descended in a properly opened parachute. Postmortem examination showed that he sustained a through fracture of the L-3 vertebral body, torn back muscles, partial severance of the aorta, and complete severance of the inferior vena cava at the L-3 level. These injuries are consistent with severe impact to ?he lower back.

The 10 persons who were unable to leave the airplane were kiiled by the forces of impact. The bodies were fragmented severely, and no autopsies or toxicological examinations were performed.

1.14 Fire

A severe postcrash fire ensued upon impact and was confined to the crater created by impact. The first firefighting units arrived at the scene within 1 minute of impact and reported the fire under control about 9 minutes later.

1.15 Survival Aspects

The impact forces of this accident were not survivable. However, because the occupants were parachutists, several were able to leave the airplane before it crashed and descend safely by parachute. Some of the last jumpers to leave the airplane described extremely high acceleration forces which forced them against the sides of the fuselage and which required extreme physical effort to overcome in order to reach the door.

1.16 Tests and Research

None.

1.17 Additional Information

1.17.1 Role of Landry Aviation

Landry Aviation, Inc., was formed for the purpose of operating N116CA and another Lockheed L-18 Lodestar in air cargo service. To that end, the company had applied to the FAA for an operating certificate under 14 CFR 135. Landry negotiated a lease with the owner of the airplane after the previous lessee, who also had operated the airplane in cargo service, ceased operations and surrendered his operating certificate to the FAA. The airplane was inspected and maintained by Landry in accordance with the approved maintenance program of the previous operator by the same personnel who had maintained it for the previous operator. At the time of the accident, issuance of an operating certificate for Landry still was pending.

Landry Aviation began parachute operations in June 1983 after contacting several parachutists who indicated an interest in using that type of airplane. The two pilots who flew most of the parechute flights, including the captain of the accident flight, had flown the airplane regularly in the previous cargo operations. The copilot of the accident flight also had flown as copilot in the cargo operations and occasionally as copilot on jump flights. They did not have any experience in jump operations before June 1983. Between June and the day of the accident, the airplane made more than 40 flights to transport parachutists to the jump site. About 15 of these involved mass drops of 24 jumpers at once.

1.17.2 Airplane Modifications

When acquired by Landry Aviation, N116CA was configured as a cargo airplane; it had no passenger seats. There was a jump seat behind the cockpit. In addition to the main cabin entry door, there was one emergency window exit on the left side over the wing. There were three seat track/cargo tiedown rails installed in the floor. In June 1983, the installation of seatbelts for as many as 24 parachute jumpers, using the existing seat tracks, and the removal of the main cabin entry door for purposes of sport parachute jumping were approved in accordance with 14 CFR 43 by a mechanic who held an inspection authorization, and the FAA Flight Standards District Office was notified. An FAA maintenance inspector then issued a standard set of operating limitations to be

observed when operating N116CA with the door removed. These included restrictions on maximum speed, yaw, and bank angles; requirements for use of seatbelts; prohibition against smoking; and limiting operations to visual flight rules only. These operating limitations are in addition to those set out in the FAA-approved airplane flight manual.

Section **91.47** of those regulations states in part that:

> (a) Notwithstanding any other provision of this chapter, no person may operate a large airplane (type certificated under the Civil Air Regulations effective before April 9, 1957) in passenger carrying operations for hire with more than the number of occupants:
>
> (1) allowed under Civil Air Regulations 4b.362. . . .
>
> (2). . .However, an airplane type iisted in the following table may be operated with up to the listed number of occupants (including crewmembers) end the corresponding number of exits. . .approved ior the emergency exits of passengers. . .

Airplane Type	Maximum number of occupants including all crew members	Corresponding number of exits euthorized for passenger use
L-18	17	3

The owner of Landry Aviation, Inc., testified during deposition proceedings that some parachute jumpers had indicated that mass jump exits could he accomplished more easily if a step were installed adjacent to and forward of the door on the outside of the fuselage. In the week before the accident, four fxternaiiy mounted handholds and a plywood step were installed on the fuselage forward of the cabin entryway. The step was made of 3/4-inch plywood, was 4 inches wide 7 feet iong, and was attached by aluminum angle. (See figures 1 and 2.) He further testified that because similar installations had been made on other Lockheed L-18 airplanes used in jump operations, including a second airplane he had acquired, it was his opinion that the installation either was not a major alteration, and therefore did not require **FA.4** approval, or that it had Seen approved previously by the FAA for other airplanes. The installation of the step was not inspected and approved **by** an authorized inspector nor did Landry Aviation request approval from ?he FAA. No flight testing was conducted to determine 'he effects on airplane handling and performance. The pilot who flew on the second and third flights on the day of the accident stated that he noticed no different or unusual effects on the airplane characteristics with the step and handies installed or w' en the jumpers were standing on the steps.

After the accident, Landry Aviation contracted for an engineering study and analysis of the installation, and made the results available lo the Safety Board. The study indicated that the installation **had** negligible effects on airplane stability and control. The report of the study and analysis was reviewed by the Safety Board's Aircraft Performance Engineering Staff and found to be correct regarding the effects of ?he instaliation.

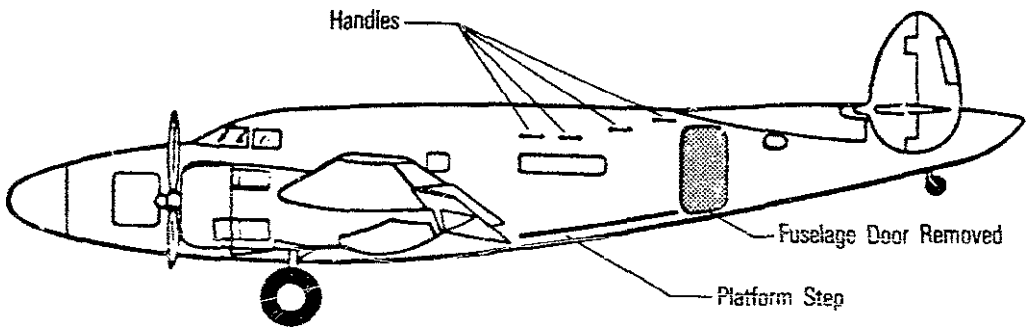


Figure 1.—Modifications to N116CA.

1.17.3 Airplane Weight and Balance and Loading

There was no evidence to indicate that the piiots of the accident flight calculated weight and balance for the loading condition of this particular flight. Another pilot, who had flown most of :he flights since parachute operations began, stated that before beginning such operations, he had performed general weight and balance calculations for loads of 16, 18, 20, 22, ana 24 jumpers. Those calculations were based on a weight distribution which assumed that the jumpers were seated for tskeoff and assumed that at the higher loads 12 jumpers would sit in ?he forward-most area of the fuselage designsted compartment X. The five loading compartments, A through F, are simply sections of the fuselage designated by painted lines on the cabin wall. (See figure 3.) The calculations were performed using the weight and balance work sheets used by the previous operator during cargo operations and assumed a weight of 175 pounds per jumper, including equipment. These calculations showed that in order to keep the center of gravity within the aft limit when 24 jumpers were carried, 3 would have to occupy the compartment immediately behind the cockpit, where there was a jump seat, and 12 would would hase to occupy the forward-most cabin compartment with the remainder in ?he 2 compartments designated B and C. Surviving jumpers stated that on this flight, as on previous flights, the passengers were seated in rows three abreast on the floor facing aft; their legs were drawn back so that persons in each succeeding row sat either against or between the legs of the persons forward of then. There may have been one jumper in the jump seat. They also stated that in this seating arrangement the jumpers normally did not use the installed seatbeits. Neither the Landry-derived seating arrangement, nor the actual seating arrangement, permitted use of seatbelts for takeoff by the jumpers in the center of each row.

Interior photographs of N116CA loaded for takeoff, which were made about 2 weeks before this acciden?. show jumpers seated as described and also show that only six jumpers occupied the space in the forward compartment. That compartment was 56.75 inches long: the next three compartments aft were 35.5 inches long. Using an

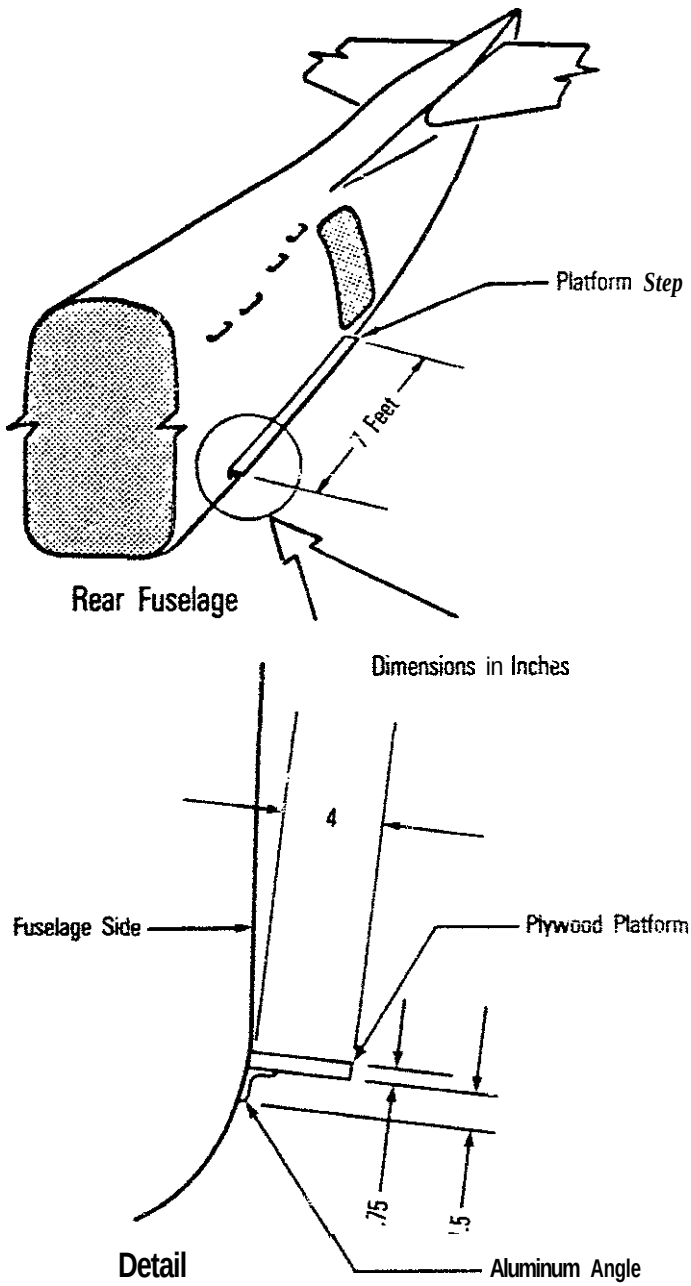


Figure 2.—Detail of step installation.

average front-to-back body depth of 10 inches 2/ and 10 inches for the thickness of the parachute pack, Safety Board investigators estimated weight and balance for the takeoff with 24 jumpers positioned. The estimate indicated the jumpers would have to occupy space back to compartment D. (See figure 4). That calculation provided an estimated center of gravity location at takeoff of 205.3 inches aft of the datum. The aft limit is 198.8 inches.

The pilot who performed the takeoff weight and balance calculations also stated that neither he nor the other pilots had made any weight and balance calculations for the load configuration of 24 jumpers positioned for a mass jump with 8 jumpers gathered at the door and on the outside step. Safety Board investigators also estimated weight and balance based on the airplane configuration described by the survivors. (See figure 5.)

All jumpers participating on the day of the accident had filed "experienced jumper waiver and information" forms on which they also entered their weight. These weights and the typical weights of parachutes and equipment were used by the Safety Board to determine the airplane weight and balance when they were in position for the jump. The position of each jumper as described by the jump coordinator who had assigned each jumper a specific place in the jump sequence and the body dimensions from the cited reference were used to estimate the placement of each jumper in the cabin. The fuel on board was estimated based on the number of flights since last refueling and the typical fuel consumption of previous jump flights. Using this information, the Safety Board calculated a jump configuration center of gravity location of 214.5 inches aft of the datum.

1.17.4 Procedure for Jump Run

The usual procedure followed by the Landry Aviation pilots for the jump run reportedly was based on discussions with the operator from whom Landry had purchased the second airplane. Once level at the drop altitude on the approach to the drop zone, the landing gear was lowered and the flaps were set at the approach position (20 percent). Power was set at 2,000 rpm and 23 to 25 inHg manifold pressure. The airspeed was maintained between 95 and 100 knots; the pilots considered 95 knots minimum speed. The Learstar approved airplane flight manual lists the following stall speeds: V_{SO} (full flaps, gear down) 76 knots; V_{S1} (flaps and gear up maximum gross weight) 91 knots, stall speed at maximum gross weight with approach flaps (20 percent) 85 knots. The jumpers wanted as slow an airspeed as possible to minimize the wind and slipstream effect. When the spotter signaled, power was reduced on the left engine to about 15 inHg until all jumpers had exited from the doorway on the left side of the airplane.

1.17.5 Previous Similar Incidents

During the investigation of this accident, the Safety Board learned of at least four other instances in which Lockheed L-18 airplanes entered steep nosedown descents while on jump runs with 24 or more jumpers on board. At least one of these was a Learstar modification and one was unmodified. The configuration of the others could not be confirmed. These four events were:

2/ Human Engineering Guide to Equipment Design (Revised. American Institute for Research) 1972, pages 492 and 504.

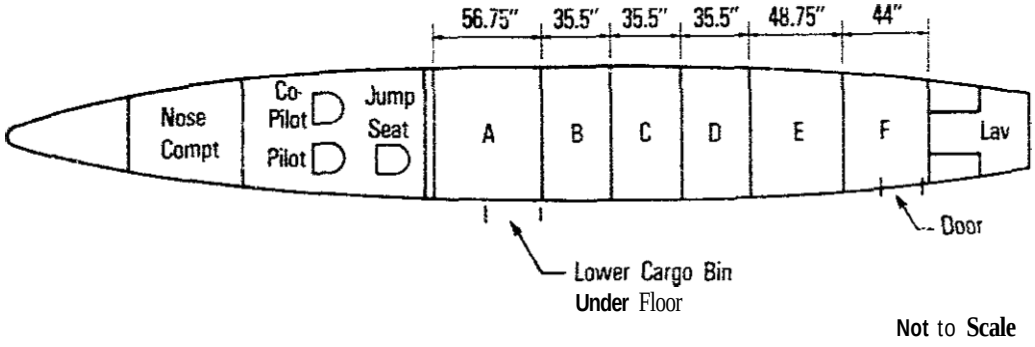


Figure 3.—Airplane configuration for weight and balance determination.

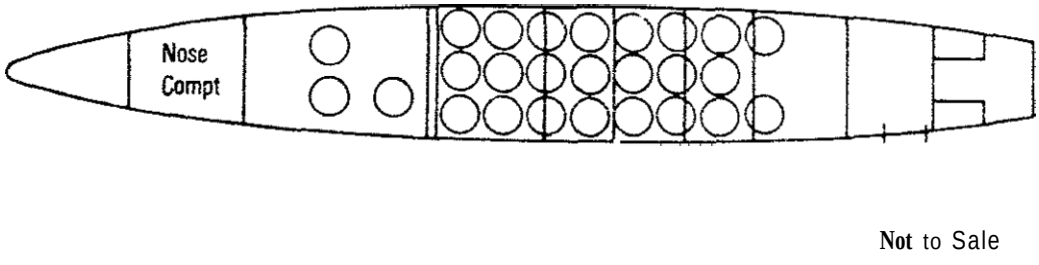
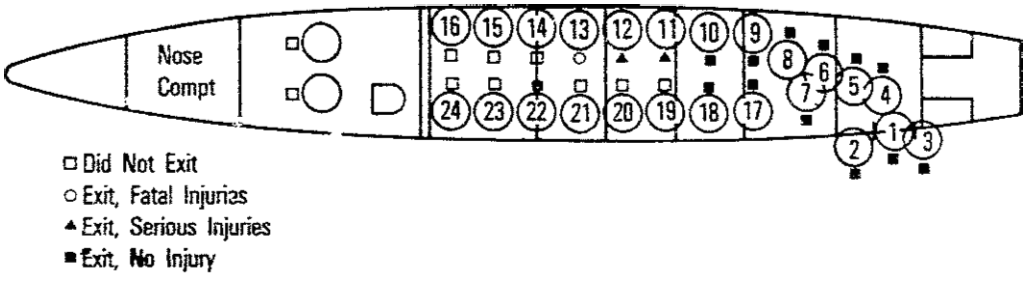


Figure 4.--Load configuration of takeoff based on Safety Board data.



Item	Weight	Arm inches aft of Datum	Moment
.irplane			
mpty Weight	14,499	131.53	2,776,931.40
)oor Removed	- 28.25	429.3	- 12,127.00
allast in			
)wer cargo bin	200.0	220.0	44,000.00
tep end			
andholds	+ 12.70	375.0	+ 4,762.00
ilots	400.0	135.0	54,000.00
ompartment A			
jumpers)	1055.0	217.0	405,790.00
ompartment B			
jumpers)	905	262.5	237,562.00
ompartment C			
jumpers)	815	298.0	242,870.00
ompartment F			
jumpers!	1,490	422.0	628,780.00
uel inboard fwd			
nks (80 gals.)	480	167.5	80,400.00
uter wing tanks			
60 gals.	960	175.0	168,000.00
otal weight	20,788	Loaded airplane moment	4,630,968.00

enter gravity = moment divided by weight

Figure 5.—Jumper positions and center of gravity position at time of upset.

Date	Location	No. of Jumpers	Altitude (feet)	Recovery Altitude (feet)
November IO, 1974	Casa Grande, Arizona	24	14,000	7,000
November 1975	Roswell, New Mexico	24	10,500	6,000
June 18, 1977	near Toledo, Ohio	25	12,000	10,000
April 1979	Tampa, Florida	24	12,500	3,000

The pilots involved in these occurrences were interviewed. Their accounts were similar to chose given by survivors and witnesses of the accident involving N116CA. The pilots stated that, while on drop runs at airspeeds of 95 to 100 mph, when the jumpers moved aft and gathered a? the doorway, an increasing amount of fcrward elevator was required io maintain level attitude until full or nearly full nosedown elevator was applied. As power was reduced and airspeed slowed, the elevator would no longer control the pitchup. All pilots reported that the tail dropped and the airplane rolled over and entered a steep, nosedown descent. One of the pilots described a **fully** developed spin, which he stopped with standard spin recovery procedures as described in the airplane flight manual. All of the pilots were able to recover to normal flight after a large altitude loss. The recovery technique was to add power, apply rudder against the roll, then, when the nose was down and airspeed was increasing, reduce power and recover irom the dive. They all stated that their experience caused them to revise their jump run procedures. The revisions most common among the pilots included maintaining higner airspeed on the drop run regardless of jumpers' requests; keeping the landing gear down, to move rhe center of gravity forward: and maintaining ful! forward main fuel tanks.

The pilot who had performed the original weight and balance computations for Landry stated that on one flight carrying 18 jumpers he had experienced a full nosedcwn trim and reached ?he limit of nosedown elevator trave! once the jumpers were in place to exit the airplane. To keep the nose from continuing io pitch up, he increased power and regained some elevator effectiveness. Following this, the pilots discussed with some of the jumpers the importance of their staying forward in the airplane and not crowding e: the door for exit. They also discussed among themselves the spin recovery procedures set out in the airplane flight manual. The manual stetes:

> . . .If a spin should be entered accidentally, normal recovery procedure for a two-engine airplane is recommended, namely, power on the inside engine, opposite rudder, and elevator control for nose down.

1.17.6 Regulation and Surveillance of *Sport* Parachute Activities

(a) Federal

Parachute jumping is regulated by the FAA under 14 CFK Part 105. However, the regulations deal primarily with the actual jumping activity and do not address airplane operations or modifications. Operators who curry parachute jumpers for hire are exempted from the provisions of 14 CFR Part 135 by Section 135.1(b)(6). 3/ However, the

3/ 14 CFR 135.1 Applicability

(b) This part does not apply to -

(6) Nonstop flights conducted within a 25 statute mile radius of the airport of takeoff currying persons for the purpose of intentional parachute jumps.

airplanes must be operated in accordance with 14 CPR Part 91, and any modifications or alterations are regulated by 14 CFR Part 43. Sport parachutists are not licensed by the FAA. The FAA and the U.S. Parachuting Association have agreed to encourage self-regulation within the sport, and the FAA's stated policy is to regulate where necessary for the safety of persons not participating in the sport.

Federal Aviation Operations Bulletin 83-1, "Sky Diving Surveillance and Authorizations," dated February 22, 1983, was issued to General Aviation Operations Inspectors following an accident involving an airplane with nonapproved modifications which was carrying 14 skydivers. It stated in part:

> Inspector conract with sky diving activities is generally limited to monitoring airshows where sky diving is involved, issuance of authorizations for jumps into congested areas, and, when requested by Air Traffic Control, providing input as to the safety of jumps into controlled airspace. The FAA policies with respect to sky diving have, in the past, been to regulate where necessary for the safety of persons not participating in the sport and to encourage self-regulation in the sport as necessary for the safety of the participants. Those policies, with few exceptions, have been successful and we are not proposing to change them.
>
> There is concern that some of the sky diving activities that are taking place involve the operation of aircraft in a manner not provided for in the aircraft type certification with no evaluation of the possible ramifications.
>
> The United States Parachuting Association has been informed of the FAA's concerns. Regions should have their district offices contact the local parachute organizations to express these concerns in a positive manner. Since the regulations involving aircraft modification are generally handled as airworthiness functions, and the majority of contacts with the sky diving community are made by operations inspectors, airworthiness inspectors should be involved where the proposed operations appear questionable.
>
> Operations inspectors reviewing applications for authorization to jump into congested areas or controlled airspace should look for any indication that these jumps will involve special stunts or more participants than the aircraft type certificate allows. When in doubt, coordinate with the airworthiness inspectors in the office or contact the appropriate engineering office.
>
> All inspectors shouid review the regulatory requirements associated with sky diving activities, including:
>
> 1. aircraft modifications necessary to accommodate sky diving:
>
> 2. proper documentation of these modifications;
>
> 3. determination of approved number of occupants of a given model by type certificate or STC;
>
> 4. seatbelts and emergency exits;

5. aircraft loading and weight and balance requirements.

The FAA maintenance inspector who inspected N116CA in connection with the Landry Aviation application for an operating certificate under 14 CFR Pari 135 said that he was aware that the airplane was being used in parachute operations. He also said he never observed any of these operations. When he inspected the airplane, the step and handholds were not installed. The manager of the Seattle Flight. Standards District Office stated that the FAA does not have a surveillance program directed at parachute operations and that such surveillance has a low priority among all the responsibilities of the District Offices. There had been no observation of the Landry parachute operations by inspectors from the Seattle Flight Standards District Office.

(b) Private

The U.S. Parachute Association (USPA) is an organization which represents sport parachute jumping in the United States. Of an estimated 35,000 participants in the sport, about 17,000 are members of the USPA. The Association, through regional officers, area safety officers. and a monthly magazine, disseminates parachuting safety information to its members. It also administers a program of safety standards and licensing standards governing its affiliated parachuting centers and individual members.

The USPA Area Safety Officers Handbook, Section 3, provides guidance for its Area Safety Officers in monitoring compliance with Federal Aviation Regulations during parachuting activities. The requirements for approval of door removal and step and handhold installations are addressed as follows:

> ...The most common modification is removal of the door. Other modifications include installation of jump steps. ..rearrangement of seatbelt fittings. ... Removal of the door. ..must be approved for the individual airplane by the FAA.
>
> ...Installation of steps ...are normally covered by Supplemental Type Certificates (STC), which are official FAA engineering approvals of changes regarded as affecting the flight characteristics or airworthiness.

The Handbook also discusses weight and balance limitations as follows:

> The aircraft operating manual under whose guidelines the pilot must fly ordinarily contains a good many operating limitations he must follow. The two most seriously affecting parachuting are those governing gross weight and loading. Many planes fly well at substantiaily over gross weight under ideal circumstances (cold, dry weather helps) but the pilot must consider how much fuel he has on board as well as how many passengers. The seating pattern of jumpers in an aircraft may allow excess weight to be concentrated at the rear of the plane, thus changing its flight characteristics in a manner that is potentially dangerous.

Some of rhe jumpers involved with the Landry operation, including the USPA Area Safety Officer, stated that they knew little of oirplane weight and balance limitations but were aware that they should stay "as far forward as possible" during takeoff. They stated that they assumed the pilots were operating the airplane safely.

2. ANALYSIS

The flightcrew was properly certificated and qualified in accordance with existing regulations. There was no evidence that medical or physiological problems affected their performance. Even though the duty day was long, it is unlikeiy that fatigue was a factor. With the exception of the recently installed step and handholds, the airplane was properly certificated and maintained. There were no uncorrected discrepancies listed in the maintenance records which could be related to the accident.

Because of the nearly complete disintegration of the airplane by impact and subsequent fire, little evidence could be obtained from the wreckage. However, there was no evidence from either witness testimony or from wreckage examination to indicate that a structural failure occurred. The heavy rotational scoring in the blower cases of both engines indicates high rotational speed at impact in both engines. The statements of ground witnesses concerning the loud, high pitch screaming sounds during the descent indicate that the engines were operating at high power. A high speed descent at high power would cause the engines to overspeed which would produce such sounds from the propellers. The white or light-colored smoke described by witnesses is not indicative of an engine fire, which would produce a heavy dark smoke. The white smoke was likely the result of oil spilled from the oil tanks during the initial roils or during the steep nosedown descent. Therefore, the Safety Board concludes that an airframe or engine malfunction was not involved in the loss of control snd departure from normal flight. It also concludes, based on the position of the landing gear strut and flap tracks, that the gear was extended and the flaps were set et 20 percent--normal procedure for the jump run. However, the Safety Board cannot determine positively whether the gear was down before the upset or whether it was lowered during a recovery attempt in an effort to shift the center of gravity forward.

The weight and balance computations worked out by Landry personnel for 24 jumpers in their takeoff positions showed that the airplane center of gravity would be very near the aft limit based on crowding jumpers in the forward compartment and jump seat. Even so, they did not examine the effect on the center of gravity with the jumpers moved into position for the jump. The Safety Board's center of gravity computations for the jump position show that the center of gravity would have been 16 inches aft of the aft limit. Typically as an airplane's center of gravity is moved aft, positive longitudina! stability is decreased to a point of neutral stability. Further aft movement of the center of gravity causes the airplane to become longitudinally unstable and the horizontal stabilizer and elevator to become less effective in controlling the noseup pitching moment. When full elevator travei is reached, any further pitchup is uncontrollable. This uncontrolled pitchup will cause an increase in the wing angle of attack until an aerodynamic stall occurs. The Safety **Board** is convinced that the loss of control and departure from level flight were the result of an extreme rearward shift in the center of gravity which resulted in a noseup pitch which could not be countered by full nosedown elevator deflection. The position of the elevator trim actuator shows that nearly full nosedown trim had been applied. This evidence, together with the descriptions of similar incidents provided by pilots involved, corroborate the Safety Board's conclusion.

The engineering analyses and flight tests performed pursuant to certification of the Learstar modifications to the basic airplane did not investigate airplane performance and stability at center of gravity locations beyond the aft limit. Therefore. stall speed and stall angle of attack for the airplane in the accident configuration are not known. In addition? the actual effect of the handholds and step or the effect of a person

standing on that step on the effectiveness of the horizontal stabilizer and elevator are not known. However, the Safety Board believes that these tended to reduce stabilizer and elevator effectiveness.

In previous incidents, pilots were able to recover *to* normal flight, even after a large altitude loss. However, in this instance, the pilot did not recover. Witness descriptions of the sounds indicate that the engines were probably at high power. The pilot may have increased power in an attempt to increase airspeed and fly out of the stall. If power was not reduced, it would have caused rapid acceleration and high airspeeds in the dive. At high speeds and with the elevator trim nearly full nosedown, pilot inputs required to overcome the high control forces were probably beyond the physical capabilities of the crew. Although the Safety Board cannot state with certainty the reasons why the appropriate power and trim changes were not made to assist recovery, one likely reason is the intrusion into the cockpit area of one or more jumpers who could have fallen into the area during the rolls or subsequent dive. If this did take place, the pilots could have been prevented from taking action to recover from the dive.

The three pilots associated with Landry Aviation, including the two involved in this accident, had flown the airplane in commercial cargo operations for more than a year before beginning the parachuting operations and should have been aware of the loading requirements of the airplane. The pilot not involved in the accident stated that he had some discussions with other Learstar operators who carry parachutists which led him to beiieve that carrying 24 jumpers was not unusual. However, he apparently had not heard about the previous incidents cited in this report ana had never considered examining the load condition created by jumpers moving aft *to* the door way; the pilots did discuss among themselves spin recovery procedures for the Learstar. The weight and balance calculations performed before the start of parachute operations at Landry showed that the center of gravity could only be kept within limits if 12 jumpers were confined to an area which could only accommodate 6 to 9. However, a comparison of the dimensions of cargo compartment A with the dimensions of a seated person wearing a backpack parachute show that it is impossible to seat 12 persons in that compartment. The photograph made by an observer on an earlier flight showed that typically only 6 persons occupied compartment A at takeoff and not the 12 assumed by the pilots in their weight and balance calculations. It, therefore, appears likely that takeoffs with 24 jumpers on board were made with the center of gravity beyond the aft limit. In addition, the number of occupants far exceeded the approved number based on available emergency exits, and the seating configuration aid not allow use of seatbelts by several jumpers. The Safety Board is concerned ?hat qualified and experienced pilots would *so* casually approach an operation significantly different from their prior experience without serious consideration of all aspects of the operation. The Board also believes that accomplishment of several successful flights with critical center of gravity conditions may influence operators and pilots into thinking that if the takeoff can be made, any problem which may occur during the jump procedure can be safely resolved because the altitude and mobility of the jumpers provide an adequate margin for recovery.

During the investigation, it became apparent that most of the parachutists, including the USPA Area Safety Officer, had little or no knowledge of the significance of airplane center of gravity limits. They were generally aware of the need to "stay as far forward as possible" for takeoff, but were not aware of the significant effects on airplane control of their lining up for the jump. They indicated generally thet they believed the

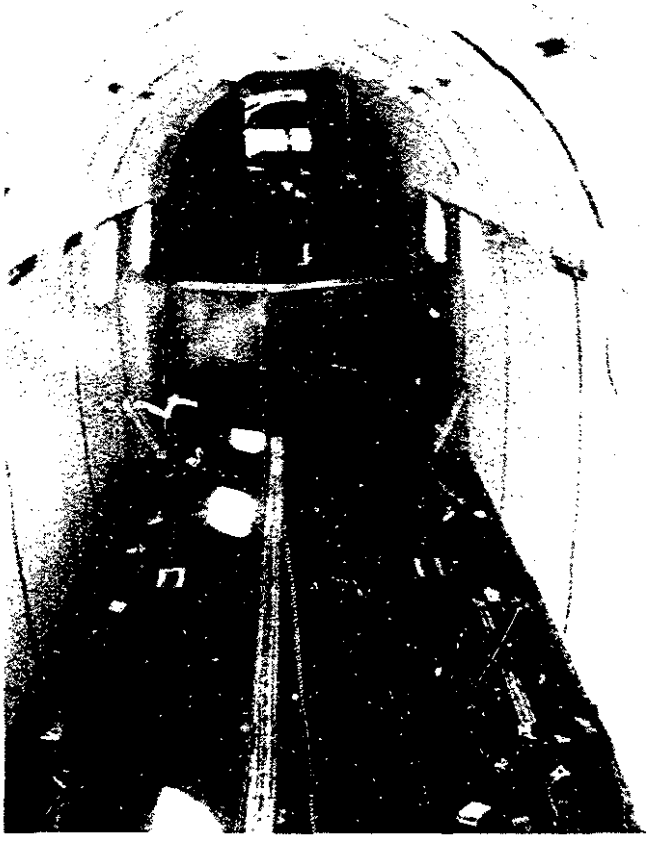


Figure 6.--Fuselage interior of N116CA showing seat belt installation.

pilots were responsible for assuring that weight and center of gravity limits were not exceeded and that, because the jump coordinator and the pilots had discussed the jump procedures, those procedures would not lead to unsafe operations.

The USPA has well established and detailed safety standards and procedures. However, they are directed almost exclusively to the parachute descent and landing. Little is directed to the loading and position in the airplane up to the time of the jump or to inherent operating limitations of airplanes. The Safety Board is aware that the USPA has pledged to implement a policy of self-regulation in an effort to assist the FAA in maintaining a level of safety in sport parachuting. The Safety Board believes that the **USPA** can improve that level of safety by informing and educating its members through publications, training documents, and regulations of the hazards associated with improper loading of airplanes and unapproved airplane modifications.

The Safety Board also notes that as a result of the Association's participation in this investigation it did circulate extensive information to its members through its publications of the circumstances and discrepancies identified during the investigation. The **USPA** also has begun, in consultation with the FAA, to compile and formulate guidelines and recommended procedures for jump pilots *to* be included in its training and other educational programs.

Figure 7.--Seating arrangement of jumpers in N116CA ;coking aft.

The Safety Board believes that, notwithstanding the low priority given by the FAA to surveillance of parachuting operations, when the FAA District Office inspectors became aware of Landry's intention to engage in parachuting activities, they should have made some effort to observe those activities und advise the operator of the various applicable regulatory requirements. Based on FAA Operations Bulletin 83-1, the Safety Board believes the inspectors should have ascertained that the original airplane modifications and operations were in accordance with applicable regulations. Had the FAA inspectors **reviewed** the sport jumping activities with Landry .Aviation, it would have been apparent that the operation with 24 parachutists would, of *necessity,* not *be* in compliance with several regulations, namely:

1. The airplane could not be loaded properly with :he c.g. within allowable takeoff limits if the parachutists were seated at locations where they could be restruined by seatbelts as required by 14 CFR 91.14.

2. The procedures to be used as the junipers exited the airplane would cause loading greatly exceeding the airplane's c.g. limits.

3 The number of parachutists carried aioft exceeded the regulatory maximum number of occupants allowable for the number of emergency exits. (14 CFR **91.47')**

4. TI:;? airplane had bean modified with rhe addition of a step and handholds without FAA approval by STC or Form 337. Consequently, there had peen no prior analysis or flight tests to confirm that the devices or intended use of the devices during flight would not affect the airplane3 controllability.

Therefore, the Safety Board concludes that the **FAA** should undertake additional action to further safe parachute operations and has made recommendations to that end. (See page 20.)

3. CONCLUSIONS

31 Findings

1. The pilcts were properly certificated and qualified for the flight.

2. The airplane had been maintained end certificated properly except for the nonapproved installatior, of a step and handholds. Although the efiect of the installation on the flight characteristics of the airplane was established after the accident to have Seen negligible, the effecr was not determined by flight resting after ine modifications were made.

3. There were no airplane or engine malfunctions or failures before departure from level flight.

4. The parachutists relied on the piiots in assure that their jumping procedures did not exceed the airplane's operating limitations.

5. The pilots were responsible for operating the airplane within the approved operating limits.

6. The operator and pilots of N116CA did not determine the effect on center of gravity of the proposed lineup sf jumpers at the doorway.

7. The center of gravity when the jumpers were positioned for the jump esceeded the aft limit by nearly 16 inches.

8. The pilot used nearlv fuil elevator nosedown trim

9. The loss of control and departure from level flight caused **by** the extreme rearward shift in the center of gravity resulted in a noseup pitch which was beyond the crew's control with full nosedown elevator deflection.

10. The USPA has an opportunitv to improve the level of safety of sport parachuting **by** informing and educating its members through its publications and training programs.

11. The FAA District Office inspectors did not conduct surveillance of the parachute operations in which N116CA was used, and had they done so would have noted a number of aspects of the operation which were not in compliance with the regulations.

32 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the operator and the pilot-in-command to assure proper load distribution during the jumper exit procedure. A more intensive program of surveillance by the Federal Aviation Administration may lead to the detection and elimination of some of the factors in the accident.

4. RECOMMENDATIONS

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

Amend 14 CFR 105 to require that persons who intend to operate aircraft for parachute jump activities obtain an initial approval for the use of the aircraft for this purpose from an appropriate FAA District Office, and require that persons seeking such approval present sufficient evidence to permit evaluation of the following:

- the effect of any aircraft modification such as door removal or external protuberances on the controllability or handling qualities of the aircraft.

- the relationship of the maximum number of persons to be carried abosrd the aircraft to the emergency exit. requirements of 14 CFR 91.47, the safety belt requirements of 14 CFR 91.14, and the aircraft's published weight and balance envelope for takeoff and landing.

- the parachute jump egress procedures to be used as they may affect adverserly the airplane weight end balance limitations and controllability during jump operations and mey require suitable placards on the aircraft defining specie: procedures needed to maintain controllability. (Class II, Priority Action) (A-84-55)

Direct FAA District Office inspectors to contact periodically operators known to use aircraft in parachute jump activities to review their operations to assure adherence to applicable regulations and good safety practices. (Class II, Priority Action) (A-84-56)

Encourage FAA District Office inspectors to maintain close liaison with the United States Parachute Association and local parachute clubs to foster appreciation for and adherence to good safety practices. (Class II, Priority Action) (A-81-57)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JIM BURNETT
Chairman

/s/ PATRICIA A. GOLDMAN
Member

/s/ G. H. PATRICK BURSLEY
Member

/s/ VERNON L. GROSE
Member

Vernon L. Grose, Member, filed the following concurring and dissenting statement:

The report, in general, carries my concurrence. Hcwever, I respectfully dissent on the probable cause became this accident is not due to a single cause. Like almost all accidents, it is a complex event with causes involving man, machine, management, end media (environment). The probable "cause," 3s adopted, addresses only human failure -- interestingly of two different parties. While it is unclear as to whether the Federal Aviation Administration is considered a causative agent, its inclusion as part of the probable cause statement is most confusing, inasmuch as any number cf things, events, or actions "may have led to the detection and elimination of some of the factors in the accident."

No revision of mandate is to acknowledge the reality of multiple causes of accidents. The National Transportation Safety Board is required, under 49 USC **1903** Section 304 (a)(1), to determine "the cause or probable cause or causes" (emphasis added) of any transportation accident.

Concluding what the probable cause ***of*** an accident may have been is important only if those causative elements provoke actions which either eliminate or reduce the possibility of the accident recurring. Proposing vague allusions of behavioral failure, as in this case, only to comply with a statutory requirement will not improve safety. Probable causes should be sufficiently specific that sharply-focused corrective action:. can be linked io each cause. Thus, it is the recommended actions that emanate from identified causes that give hnpe of increased safety.

Acknowledging more than one cause could appear to open the possibility cf an unlimited number of causes — and a de-focusing of impulse for corrective action. The key to the limitation of the number of causes lies in ihe feasibility and potential of corrective actions. In each ***of*** the six causes that I propose for this accident, there can be specific actions taken which are both feasible and efficacious.

Causal factors could be ranked, on a variety of bases, for their significance in any accident. Again, the only importance of ranking would !?e in allocating resources for correction, since preventing future accidents — not determining causation — is the raison d' etre for the accident investigation process.

Supported by the foregoing rationale, I propose this substitute statement on probable causation:

> The National Transportation Safety Board determines that the probable causes of the accident were, without implication of relative importance: (a) taking off and operating the aircraft with the center of gravity beyond the aft limit, (b) operating the L-18 aircraft with 26 occupants when the maximum allowable, with one passenger exit, was 17, (c) the absence of a parachute jump egress procedure that would maintain the aircraft center of gravity within allowable limits, (d) operating the aircraft at an airspeed lower than would allow longitudinal control during parachutists' exit, (e) attempting to perform a nearsimultaneous exit of 24 parachutists from a single doorway, and (f) continued operation of both engines at full power while in steep nosedown descent.

/s/ VERNON L. GROSE
Member

May 17, 1984

5. APPENDIXES

APPENDIX A

INVESTIGTION AND HEARING

Investigation

The Safety Board was notified of the accident about 2200 on August 21, 1983, and a team of four investigators was dispatched to the scene immediately. Investigative groups were established in the areas of operations, airworthiness, and human factors. Parties to the investigation included the Federal Aviation Administration, Landry Aviation, Inc., and the U.S. Parachute Association.

Hearing

A public hearing was not conducted. X I-day deposition proceeding was conducted September 27, 1983, at Seattle, Washington.

APPENDIX B

PERSONNEL INFORMATION

Pilot-in-Command

Michael Warren Petersen, 37, held commercial pilot certificate No. 1823169 with airplane single and multi-engine land and instrument ratings, and a Lockheed L-18 type rating issued in January 1983. He held a first-class medical certificate dated December 21, 1982, with the limitation that corrective lenses were required. He had about 9,000 hours of flight time, about 110 of which were flown in the Lockheed L-18.

Second-in-Ccmmand

John Fritz Eric, 32, held commercial pilot certificate No. 2227387 with airplane single and multiengine land, instrument, and helicopter/rotorcraft ratings. He also held a flight instructor certificate with the same ratings. He held a first-class medical certificate issued Juiy 12, 1983, with no limitations.

APPENDIX C

AIRPLANE INFORMATION

The airplane was owned by Command Aviation, Portland, Oregon, and leased to Landry Aviation, Inc. N116CA, serial No. 2472, was manufactured by Lockheed Aircraft Corporation as Lodestar model L-18-56 under type certificate A-723. In September 1957, it was modified to the Learstar Mark II configuration under Supplemental Type Certificate SA4-69.

The airplane was maintained under an approved continuous maintenance program with progressive 50-hour inspections. The last inspection was the 300-hour inspection performed June 6, 1983, at a total airplane time of 15,119 hours.

Powerplants

	Left Engine	Right Engine
Manufacturer	Wright	Wright
Model	R1820-76B	R1820-76B
Serial No.	BL 511016	W474 149
Hours Since Major Overhaul	369.5	719.52
Date of 300-hr Inspection	6/16/83	6/16/83
	Left Propeller	**Right Propeller**
Manufacturer	Hamilton Standard	Hamilton Standard
Model	33D50	33D50
Serial No.	N137850	D442
Overhaul Date	12/14/71	6/28/78
Time Since Overhaul	521.1	521.1

*U.S. GOVERNMENT PRINTING OFFICE : 1984 0-421-826/10016