Special Investigation Report on the Safety of Parachute Jump Operations

SPECIAL INVESTIGATION REPORT

NTSB/SIR-08/01
PB2009-917001

National Transportation Safety Board

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PB2009-917001
Notation 8042A
Adopted September 16, 2008

Special Investigation Report

Special Investigation Report on the Safety of Parachute Jump Operations

National Transportation Safety Board
490 L'Enfant Plaza, S.W.
Washington, D.C. 20594

National Transportation Safety Board. 2008. ***Special Investigation Report on the Safety of Parachute Jump Operations.*** **Special Investigation Report NTSB/SIR-08/01. Washington, DC.**

Abstract: This special investigation report describes the results of a National Transportation Safety Board review of 32 accidents that involved parachute jump ("or skydiving") operations and that occurred between 1980 and 2008. The report identifies the following recurring safety issues: inadequate aircraft inspection and maintenance; pilot performance deficiencies in basic airmanship tasks, such as preflight inspections, weight and balance calculations, and emergency and recovery procedures; and inadequate Federal Aviation Administration (FAA) oversight and direct surveillance of parachute operations. Parachute jump operators, many of which transport parachutists for revenue, maintain their aircraft under regulatory provisions that require little FAA oversight. Lack of operation-specific pilot training is also discussed. Safety recommendations to the FAA and to the United States Parachute Association are included. Appendix A details other current and past Safety Board recommendations related to parachute operations.

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ABBREVIATIONS

AC	advisory circular
AD	airworthiness directive
agl	above ground level
ATC	air traffic control
CAMI	Civil Aerospace Medical Institute
CFR	*Code of Federal Regulations*
cg	center of gravity
F	Fahrenheit
FAA	Federal Aviation Administration
FMS	flight manual supplement
FSDO	flight standards district office
lb	pound
MEL	minimum equipment list
msl	mean sea level
PMA	parts manufacturer approval
PTRS	Program Tracking and Reporting Subsystem
SB	service bulletin
SIL	service information letter
SPAS	Safety Performance Analysis System
TBO	time between overhaul
TCM	Teledyne Continental Motors
USPA	United States Parachute Association

Introduction

Parachute jump (“or skydiving”) operations, which the Federal Aviation Administration (FAA) defines as the activities performed for the purpose of or in support of the descent parachutists (or “skydivers”) who jump from aircraft, represent a segment of U.S. general aviation operations, which, according to data compiled by the United States Parachute Association (USPA),[1] transports parachutists on 2.16 to 3 million jumps annually.[2] Most parachute operations flights[3] are operated under the provisions of 14 *Code of Federal Regulations* (CFR) Part 91 and are typically revenue operations; parachute jump operators provide the flights as part of their services to parachutists who pay to go skydiving,[4] or parachutists pay dues for membership in parachuting clubs. The risks of parachuting are generally perceived to involve the acts of jumping from the aircraft, deploying the parachute, and landing; parachutists are aware of and manage these risks. However, a review of accident reports reveals that traveling on parachute operations flights can also present risks.[5] Since 1980, 32 accidents involving parachute operations aircraft have killed 172 people;[6] most of whom were parachutists.

[1] The USPA is a voluntary organization made up of about 31,000 individual members and about 270 operator members, referred to as “group members” or “drop zone” members. The USPA’s mission is to support and promote safe skydiving through parachuting training, rating, and competition programs, and it distributes safety information through printed publications and its website.

[2] According to a USPA membership survey, its members reported about 2.16 million jumps in 2007. In correspondence with a National Transportation Safety Board investigator dated February 5, 2008, the USPA director of safety and training noted that, because that number does not include jumps by students, and because skydiving activity has increased in the past few years, the current total number of parachutists’ jumps per year is likely closer to 2.5 to 3 million.

[3] According to 14 *Code of Federal Regulations* 105.3, parachute operations include both parachute jumps (the descent of parachutists from aircraft) and parachute drops (the descent of objects). The parachute operations discussed in this report involve parachute jumps.

[4] Types of paying passengers include licensed skydivers who pay only for a “lift ticket” on the aircraft and members of the public who, with little training, can be paired with an instructor parachutist-in-command to experience a tandem jump as a passenger-parachutist.

[5] According to USPA safety records, from 1992 through 2007, about 30 parachutists per year were killed in jumping mishaps. Safety Board accident data show that, for the same time frame, about five parachutist fatalities per year resulted from accidents involving parachute operations aircraft. Direct comparisons of associated risk are difficult to calculate due to the likelihood of multiple parachutists being carried on each flight and a lack of departure data for parachute jump operations. The Safety Board notes that the FAA does not have data on the number of parachute jump operators or the number and type of aircraft used in parachute jump operations in the U.S. The absence of these data precludes any calculations of safety statistics for parachute jump operations, including accidents rates.

[6] Fatal accidents excluded from this review were ground accidents in which persons walked into propellers, accidents related to the accidental deployment of parachutes and/or entanglement with aircraft, and one unauthorized parachute operation flight.

The National Transportation Safety Board's interest in performing this special investigation stemmed from its investigation of the July 29, 2006, accident involving a de Havilland DHC-6-100 that crashed after the right engine lost power during a 14 CFR Part 91 revenue parachute operation flight in Sullivan, Missouri.[7] The pilot and five parachutists were killed, and two parachutists were seriously injured. The investigation identified maintenance discrepancies on the airplane and deficiencies with the pilot's performance of emergency procedures; these issues prompted the Safety Board to examine accident reports for parachute operations to determine if such safety issues may be widespread. The results, discussed in this investigation report, show that these issues were present in many accidents. The investigation of the Sullivan, Missouri, accident also addressed accident survivability and restraints for parachutists; the resulting recommendations are detailed in appendix A of this report.

This special investigation report is not intended to represent a comprehensive statistical analysis of parachute jump operations accidents. Because most parachute operators are not required to maintain flight activity data, such an analysis is not possible. The purpose of this report is to discuss the safety issues identified during the Safety Board's investigation and to provide recommendations for addressing those issues.

The Safety Board's review of parachute operations accidents since 1980 identified the following recurring safety issues:

- Inadequate aircraft inspection and maintenance;
- Pilot performance deficiencies in basic airmanship tasks, such as preflight inspections, weight and balance calculations, and emergency and recovery procedures; and
- Inadequate FAA oversight and direct surveillance of parachute operations.

Although parachutists, in general, may accept risks associated with their sport, these risks should not include exposure to the types of highly preventable hazards that were identified in these accidents and that the parachutists can do little or nothing to control. Passengers on parachute operations aircraft should be able to expect a reasonable level of safety that includes, at a minimum, an airworthy airplane, an adequately trained pilot, and adequate Federal oversight and surveillance to ensure the safety of the operation.

[7] Summary information about this accident is in appendix A of this report. For more information, see National Transportation Safety Board, *Aircraft Accident Summary Report: Crash of Skydive Quantum Leap de Havilland DHC-6-100, N203E, Sullivan, Missouri, July 29, 2006*, NTSB/AAR-08/03/SUM (Washington, DC: NTSB, 2008).

The Safety Board is concerned that parachute jump operators, many of which advertise to the public and transport parachutists for revenue, are allowed to maintain and service their aircraft under 14 CFR Part 91 regulatory provisions that require little FAA oversight and surveillance, despite passenger loads of millions of parachutists per year. The Board is also concerned that parachute operations pilots are not required to undergo operation-specific initial and recurrent training, including preflight, weight and balance, and emergency procedures training, or recurrent FAA examinations in the types of aircraft that they fly. As a result of this special investigation, the Board has issued six safety recommendations to the FAA and two to the USPA.

1. BACKGROUND

1.1 Parachute Jump Operators

According to 14 CFR 119.1(e)(6), parachute operations conducted as nonstop flights within a 25-mile radius of the departure airport are exempt from the rules pertaining to commercial operators and are allowed to operate under 14 CFR Part 91. Additional parachute operations regulations pertaining specifically to aircraft radio and equipment, parachute equipment, flight visibility and cloud clearance, and operations over certain areas and within certain airspace are contained in 14 CFR Part 105.

The Safety Board reviewed 32 fatal parachute operations accidents that occurred since 1980. All involved 14 CFR Part 91 flights that met the definition of parachute jump operations, but the Board notes that the regulation does not specifically define what constitutes a parachute jump operator. Title 14 CFR 1.1 defines "operational control" as "the exercise of authority over initiating, conducting, or terminating a flight." Based on this definition, the Board considers a parachute jump operator to be any entity that has operational control over a parachute jump flight.

In its review of the 32 accidents, the Safety Board observed that the characteristics of the accident operators varied widely. Some operators provided services to thousands of paying passengers annually by using relatively large, turbine-powered, multiengine airplanes capable of carrying more than 20 parachutists per flight, whereas other operators used single-engine, piston-powered airplanes capable of carrying 3 or 4 parachutists per flight. Although most of the accident flights were flown by commercial and airline transport pilots, six of the accident flights were flown by private pilots. Private pilots are not authorized to fly aircraft for compensation or hire; however, some arrangements such as private parachuting clubs in which parachutists pay dues for membership or for part ownership of an aircraft used for parachute jump operations could be permitted to use private pilots, depending on the FAA's interpretation of the arrangement.[1]

1.2 Parachute Jump Operations Accidents

In spite of the differences among operators, several of the 32 fatal accidents reviewed shared common deficiencies in maintenance, pilot training and proficiency, and FAA oversight and surveillance. For example, 85 people were killed in 11 accidents in which the airplanes crashed following a loss of engine power shortly after takeoff. Most of these accident airplanes had maintenance or fuel quality deficiencies, and nearly all of the accident pilots failed to maintain adequate airspeed, or they made other critical procedural mistakes while responding to the engine emergencies. Ten accidents, which

[1] The nature of the operation for each of the six flights flown by private pilots was not detailed in the accident reports.

killed 65 people, involved the aerodynamic stalling and/or loss of control of the airplanes during powered flight, and one accident, which killed 6 people, involved a pilot who aerodynamically stalled the airplane after a loss of engine power at 3,700 feet above mean sea level (msl). Further, 12 of the 32 accident airplanes were loaded beyond their maximum gross weight.

Information from some of the accidents is specifically referenced, where applicable, in this report's discussion of each safety issue. Brief synopses of all the accidents, including flight histories, probable cause statements, and other pertinent information, are provided in appendix B, and summary information for each accident is provided in table 1.

Table 1. Fatal parachute jump operations accidents since 1980

NTSB identification, location, accident date	Airplane	Power loss?	Maintenance or mechanical issues?	Weight/ balance exceeded?	Inadequate airspeed/ stall?	Comments	Fatalities
ATL80FA051 Salisbury, North Carolina June 8, 1980	Cessna 172	yes	inadequate maintenance, overdue inspections	no	yes, causal	private pilot failed to abort takeoff following partial loss of engine power, stalled airplane	2
DCA81AA015 Loveland, Colorado April 17, 1981	Cessna TU206A	no	none detected	no	no	midair collision with commuter flight, no transponder, parachute operations allowed near airway	2 (plus 13 on other airplane)
FTW81FA079 Beaumont, Texas April 25, 1981	Cessna TU206B	no	none detected	yes, factor	no	private pilot exceeded design stress limits of airplane, door separated, horizontal stabilizer obstructed	1
LAX82FA024 Honolulu, Hawaii Dec. 5, 1981	Beech C-45H	no	none detected	yes, factor	yes, causal	private pilot unqualified for flight, exceeded center of gravity (cg) aft limit	11
LAX83FA012 Taft, California Oct. 17, 1982	Beech C-45H	no	none detected	yes, causal	yes, but prevention or recovery likely not possible	maximum gross weight exceeded by several hundred pounds, cg beyond aft limit	14
CHI83FA365 Marseilles, Illinois Aug. 6, 1983	Cessna 182	no	none detected	no	no	airplane crashed in airport pattern in a steep, descending left turn; reason for occurrence undetermined	1
DCA83AA036 Silvana, Washington Aug. 21, 1983	Lockheed L-18-56	no	airplane unairworthy due to unapproved modifications	yes, causal	yes, causal	cg beyond aft limit, pilot stalled airplane during parachutists' egress, improper operator supervision	11
ATL85FA072 Dublin, Virginia Dec. 30, 1984	Cessna 182A	no	none detected	no	no	private pilot deliberately buzzed a parked van, struck van with airplane's landing gear	1

NTSB identification, location, accident date	Airplane	Power loss?	Maintenance or mechanical issues?	Weight/ balance exceeded?	Inadequate airspeed/ stall?	Comments	Fatalities
ATL85MA286 Jenkinsburg, Georgia Sept. 29, 1985	Cessna 208	yes	known deficiencies in equipment, warning system disabled	yes	yes, causal	pilot stalled airplane following loss of engine power, operator's fuel source contaminated (recurrent problem), inadequate FAA surveillance of operator, seatbelts not used	17
LAX88FA241 Perris, California June 30, 1988	Helio HST 550A	no	failure of electrical stabilizer trim control	no	no	uncommanded full nose-down trim during return to airport	1
SEA91FA038 Estacada, Oregon Dec. 31, 1990	Cessna 182B	yes	muffler cones missing, carburetor heat inoperative, inspections inadequate	no	yes, causal	carburetor ice, private pilot stalled airplane following loss of engine power during takeoff	2
CHI91FA088B Osceola, Wisconsin Feb. 3, 1991	Cessna 182	no	none detected	no	no	midair collision, failure of private pilot and pilot of other airplane to see and avoid each other	5 (plus 2 on other airplane)
LAX92MA183 Perris, California April 22, 1992	de Havilland DHC-6-200	yes	none detected	yes, factor	no	loss of engine power during takeoff due to fuel contamination, pilot did not sump fuel tanks, pilot feathered wrong propeller, operator did not provide adequate pilot training	16
DCA92MA048 Hinckley, Illinois Sept. 7, 1992	Beech C-45H	yes	inadequate maintenance and inspection by operator, engine sat 18 years without preservation before being installed by noncertificated personnel	no	yes, but propeller possibly not controllable	loss of engine power during takeoff, propeller not feathered but possibly could not be feathered to maintain airspeed, seatbelts not used	12
NYC93FA154 East Moriches, New York Aug, 14, 1993	Cessna 182A	yes	Manufacturing defect of pistons, engine beyond time between overhaul (TBO), which is allowed under Part 91	yes, factor	yes, causal	following loss of engine power during takeoff, pilot stalled airplane attempting to return to runway rather than land adjacent to runway	1
NYC94FA128 Tremont City, Ohio July 16, 1994	Cessna R172K	no	none detected	yes	yes, causal (report cites control loss, describes stall-like descent)	pilot failed to maintain control of airplane during takeoff, factor was pilot's lack of experience in operation (first parachute operations flight)	4

NTSB identification, location, accident date	Airplane	Power loss?	Maintenance or mechanical issues?	Weight/ balance exceeded?	Inadequate airspeed/ stall?	Comments	Fatalities
NYC95MA220 West Point, Virginia Sept. 10, 1995	Beech 65	yes, reason unknown	airplane not airworthy due to unapproved modifications, fueling from jugs questionable	yes, causal	yes, causal	stalled during takeoff following loss of engine power	11 (plus 1 person in a home)
MIA97FA173 Homestead, Florida May 25, 1997	Cessna 205	no	none detected, however, operator could not locate maintenance records	no	yes, causal	stalled during parachutists' egress, pilot did not recover airplane from spin	6
SEA97FA201 Bremerton, Washington Sept. 1, 1997	Cessna 182C	no	none detected	yes, factor	yes, causal	stalled during takeoff	5
IAD97FA117 Smithfield, Rhode Island Sept. 6, 1997	Cessna 182E	yes, reason unknown	none detected	yes	yes, causal (report cites control loss, describes stall-like descent)	airplane lost engine power during takeoff, then pitched nose-high, rolled left, and descended to the ground	5
CHI98FA106 Grain Valley, Missouri March 21, 1998	Cessna U206G	yes, related to oil loss	none detected	no	yes, factor	pilot performed inadequate preflight check (airplane's oil filler tube and other parts loose), pilot failed to maintain airspeed following loss of engine power at 3,700 feet	6
IAD99FA043 Celina, Ohio May 9, 1999	Cessna 205	yes, related to fuel quantity	none detected	possibly	yes, causal (report cites control loss, describes stall-like descent)	pilot failed to fuel airplane, failed to maintain control of airplane after power loss; operator lacked published operational or safety procedures, failed to verify pilot's medical qualifications	6
LAX99LA190 Mokuleia, Hawaii May 22, 1999	Beech B90	no	none detected	no	no	pilot failed to use oxygen as required, became incapacitated due to hypoxia	1
CHI99MA269 Marine City, Michigan July 31, 1999	Beech 65-A90	no	airplane unairworthy (incomplete records and no compliance with five airworthiness directives [ADs])	no	yes, causal	pilot stalled airplane, had history of alcohol-related driving offenses (alcohol not determined to be related to accident but operator unaware of total arrests/convictions)	10
FTW99FA261 Bryan, Texas September 18, 1999	Cessna 182A	yes	fatigue cracking and separation of No. 6 cylinder head	no	yes, causal	pilot stalled airplane following power loss during takeoff	5

NTSB identification, location, accident date	Airplane	Power loss?	Maintenance or mechanical issues?	Weight/ balance exceeded?	Inadequate airspeed/ stall?	Comments	Fatalities
FTW01LA132 Fentress, Texas May 27, 2001	de Havilland DHC-6	no	none detected	no	no	pilots of two airplanes performed formation parachute operations flight, one airplane struck airborne parachutist, pilots not experienced in that type of operation	1
FTW03FA174 Cushing, Oklahoma June 21, 2003	Cessna 182H	no	engine beyond TBO, which is allowed under Part 91	no	yes, causal	pilot failed to maintain airspeed during powered flight, radioed that he did not know how to recover airplane from spin	1
MIA05FA017 Jacksonville, Florida Oct. 30, 2004	Cessna P206	no	engine beyond TBO, which is allowed under Part 91	no	yes, causal	pilot stalled airplane during powered flight, failed to follow checklist for elevator trim	1
MIA05LA096 Deland, Florida April 23, 2005	de Havilland DHC-6	no	none detected	no	no	pilot had inadequate visual lookout, struck airborne parachutist with airplane	1
CHI06FA210 Sullivan, Missouri July 29, 2006	de Havilland DHC-6-100	yes	compressor turbine blade fractures in right engine for undetermined reasons, engines beyond TBO, which is allowed under Part 91, airplane unairworthy due to inoperative equipment, other discrepancies	no	yes, causal	pilot failed to perform emergency procedures following loss of power	6
SEA07FA119 Marion, Montana May 12, 2007	Cessna 182C	no, but possibly imminent due to oil loss	none detected	yes, factor	yes, causal (report cites control loss, describes stall-like descent)	pilot performed inadequate preflight check (oil filler cap not secure), pilot failed to maintain control of airplane	5
DEN08FA078 Mount Vernon, Missouri April 19, 2008	Cessna P206	not yet determ-ined, but none reported	not yet determined	not yet determined	not yet determined, but preliminary report describes stall-like descent	preliminary information: survivors reported that pilot stalled or spun airplane during powered flight	2

2. Maintenance Issues

Maintenance is critical for parachute operations aircraft because jump operations typically involve a high ratio of cycles to flight hours and periods of climb power followed by sudden reductions in power (to descend), which can be particularly conducive to engine wear. Aircraft used in parachute operations are subject to the inspections required under 14 CFR 91.409; these include annual aircraft inspections, 100-hour inspections for aircraft that carry persons for hire, and additional requirements for turbopropeller-powered multiengine airplanes and certain other aircraft.

However, 14 CFR Part 91 requirements are not as extensive as the requirements for most other revenue, passenger-carrying operators, such as air carriers or on-demand Part 135 air-taxi and air-tour operators; these operators, unlike Part 91 operators, are required to incorporate their maintenance programs into an FAA-approved maintenance manual that specifies policies and procedures for ensuring that each aircraft is airworthy before it is released to service. Part 91 (excluding some provisions of Part 91, Subpart K, which apply to certain fractionally owned aircraft) does not contain the same mechanism for ensuring aircraft airworthiness before dispatch, but 14 CFR 91.403 does state that the owner or operator is responsible for maintaining aircraft in an airworthy condition, and 14 CFR 91.407(a) states that, following maintenance, an aircraft cannot be operated unless it has been approved for return to service by authorized maintenance personnel. Review of the 32 accidents showed that 8 of the accident airplanes were not airworthy at the time they were dispatched. Allowing such maintenance discrepancies not only indicates poor aircraft maintenance and inspection quality assurance practices, but also represents noncompliance with regulations.[2]

In addition to not being required to have FAA-approved maintenance programs, parachute jump operators, because they operate under Part 91, are not subject to the Federal regulations that require compliance with manufacturers' recommended maintenance instructions, such as service bulletins (SBs) and service information letters (SILs). Manufacturers often publish SBs or SILs that contain recommended time between overhauls (TBOs) and/or component service life limits[3] for their engines. Some of these publications indicate that parachute operations may induce more engine wear than most operations. For example, Teledyne Continental Motors (TCM) Aircraft Engine SIL98-9A, "[TBO] Periods," applicable to the reciprocating engines on airplanes involved in some of the accidents reviewed, states that "aircraft used in parachute jumping … may require more frequent engine overhauls than listed for the specific engine." Also, Pratt & Whitney SB 1803R1, "Turboprop Engine Operating [TBOs] and Hot Section Inspection Frequency,"

[2] Because of the regulatory noncompliance issues, these accidents are discussed in the "FAA Oversight and Surveillance Issues" section of this report.

[3] TBOs are typically based on hours, and life limits are typically based on cycles. According to an engine cycle formula published in Pratt & Whitney Canada SB 1002R24, "Turboprop Engine Rotor Components - Service Life," a full cycle consists of an engine start, one flight, and an engine shutdown. The Safety Board notes that many parachute operations pilots do not shut down the aircraft engines completely between flights. However, the SB also defines an abbreviated cycle as consisting of idle, takeoff, flight, landing, and idle, and it provides a formula for use in accounting for abbreviated cycles in an engine's accumulated total cycles.

applicable to the turboprop engines on an airplane involved in an accident in Sullivan, Missouri,[4] specifically excludes engines that have been used in parachute jump operations from eligibility for the manufacturer's program for extending TBOs.

In the 32 parachute operations accidents reviewed, at least 4 of the accident airplanes were powered by engines that were operated beyond their manufacturers' recommended TBOs. (See table 2.) Because these airplanes were operated under Part 91, the operators were not required to comply with the recommended TBOs.

Table 2. Accident airplanes with engine hours that exceeded recommended time between overhaul (TBO)

NTSB Identification, location, accident date	Airplane engine	Engine hours since overhaul	Recommended TBO
CHI06FA210 Sullivan, Missouri July 29, 2006	de Havilland DHC-6-100/ Pratt & Whitney Canada PT6A-20	Left: 5,829 Right: 6,493	3,600 hours
MIA05FA017 Jacksonville, Florida Oct. 30, 2004	Cessna P206/ Teledyne Continental Motors IO-550-F	1,774	1,700 hours or 12 years
FTW03FA174 Cushing, Oklahoma June 21, 2003	Cessna 182H/ Continental O-470-R	2,652	1,500 hours or 12 years
NYC93FA154 East Moriches, New York Aug. 14, 1993	Cessna 182A/ Continental O-470-L	N/A; more than 12 years since overhaul	1,500 hours or 12 years

Two of these airplanes crashed following a loss of engine power. On August 14, 1993, a Cessna 182A lost engine power during takeoff and crashed in East Moriches, New York. The investigation found that inadequate piston manufacturing (all were of the same design and part number and were not manufactured by the original engine manufacturer[5]) resulted in fatigue cracking in the skirts of all six pistons. (See figure 1 on page 8.)

Although TCM SIL98-9A notes that "TCM cannot provide a TBO for engines that have been assembled with non-TCM-approved parts," it is possible that, had an overhaul been performed within the TCM-recommended TBO or sooner, the inadequately manufactured pistons and/or cracking could have been detected and corrected before engine failure occurred. Similarly, although the Sullivan, Missouri, accident airplane's right engine (which lost power) sustained damage that precluded determination of the

[4] For more information, see National Transportation Safety Board, Aircraft Accident Summary Report, *Crash of Skydive Quantum Leap, de Havilland DHC-6-100, N203E, Sullivan, Missouri, July 29, 2006*, NTSB/AAR-08/03/SUM (Washington, DC: NTSB, 2008)

[5] The engine was equipped with Superior Air Parts pistons. The factual report for the accident noted that Superior Air Parts had ceased selling the accident piston part number, SA626992, in 1981 because it had been superseded by a new TCM design. The report also noted two service difficulty reports that documented other instances of cracking discovered on SA626992 pistons.

initial event that precipitated the overload fracturing observed on the compressor turbine blades,[6] it is possible that the initiating factor resulted from a condition that could have been detected and corrected during an engine overhaul performed within the manufacturer's recommended TBO.

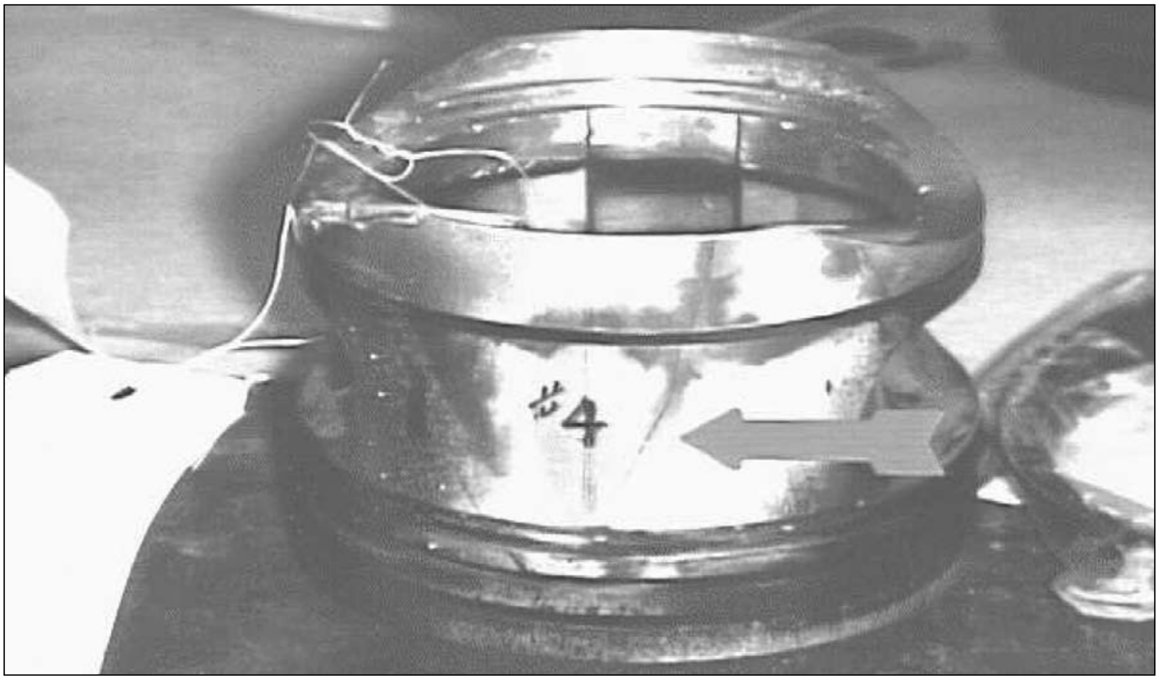

Figure 1. Cracking (visibility enhanced during examination with a liquid penetrant) on the No. 4 piston skirt from the East Moriches, New York, accident airplane.

The purpose of TBO and life-limit SBs and SILs is to establish periodic inspections of the engines to ensure their serviceability. The analysis involved in developing such SBs and SILs considers the cumulative effects of various stresses placed on the engine components over time and establishes a threshold that the manufacturer has determined will provide an acceptable level of safety. Federal regulations require that commercial operators, such as air carrier, air taxi, and Part 135 air tour operators, maintain and inspect their aircraft engines in accordance with these instructions, which provides an increased level of safety by increasing the likelihood that potentially problematic conditions could be detected and corrected, thus preventing more serious problems from developing.

Although some manufacturers indicate in their SBs and SILs that aircraft used in parachute operations may require increased engine maintenance and inspections, no mechanism is in place to ensure that the operators of these aircraft perform the recommended maintenance and inspections. The Safety Board concludes that, because parachute jump operations are particularly conducive to engine wear, the lack of

6 The compressor turbine blades were FAA PMA (parts manufacturer approval) blades manufactured by Doncasters, Inc., Turbo Products Division, part number T-023401J.

requirements for parachute jump operators to comply with manufacturer-recommended maintenance instructions for their aircraft, including SBs and SILs for TBO and component life limits, increases the potential for the persistence of conditions that could lead to engine failure. Therefore, the Safety Board believes that the FAA should require parachute jump operators to develop and implement FAA-approved aircraft maintenance and inspection programs that include, at a minimum, requirements for compliance with engine manufacturers' recommended maintenance instructions, such as SBs and SILs for TBO and component life limits.

The Safety Board recognizes that parachute jump operations include a wide variety of aircraft and operators, including some that operate for revenue and others that may involve some other type of business and/or nonbusiness arrangements. Although the Board intends that additional maintenance and inspection program requirements should be universally implemented by all operators, the Board acknowledges that the diversity of the parachute operations industry may require flexibility in determining the best mechanisms by which to implement maintenance program requirements. In addition, guidance materials could assist operators in developing effective aircraft inspection and maintenance quality assurance programs. Because the USPA is knowledgeable about skydiving operations and distributes safety information to its member operators through printed publications and its website (much of which is also accessible to nonmember operators and the public), the USPA can be a valuable resource with which the FAA can work to develop and distribute safety information for operators. Therefore, the Safety Board believes that the FAA should develop and distribute guidance materials, in conjunction with the USPA, for parachute jump operators to assist operators in implementing effective aircraft inspection and maintenance quality assurance programs. The Safety Board further believes that the USPA should work with the FAA to develop and distribute guidance materials for parachute jump operators to assist operators in implementing effective aircraft inspection and maintenance quality assurance programs.

3. Pilot Training and Proficiency Issues

A disturbing common denominator in nearly all of the accidents reviewed is that the pilots, most of whom were commercial or airline transport pilots,[7] were deficient in basic airmanship tasks, such as performing adequate preflight inspections of airplanes, complying with airplane weight and balance limitations, maintaining airspeed during powered flight, and executing emergency procedures. These deficiencies or combinations of these deficiencies were noted in nearly all the accidents with few exceptions.[8] The Safety Board is concerned that these pilots, whose experience levels in parachute operations ranged from one flight to hundreds of flights, were unprepared to provide the parachutists with the basic level of safety that passengers should have been able to expect from professional, for-hire, or parachuting club flight operations.

3.1 Inadequate Preflight Inspections

Preflight inspection of an aircraft represents one mechanism by which a pilot can mitigate potential flight risks before the aircraft leaves the ground. Such inspections, according to each aircraft's preflight procedures and checklists, typically include checking the airframe for discrepancies, checking flight control trim settings, and ensuring adequate fuel (quantity and quality) and engine oil. Twelve of the accidents reviewed involved a loss of aircraft engine power. Although a loss of engine power represents a challenging emergency requiring immediate and appropriate pilot responses, at least four of these engine-related emergencies could have been prevented if the pilots had adhered to basic preflight practices.

For example, the Cessna U206G that crashed on March 21, 1998, near Grain Valley, Missouri, lost engine power after losing engine oil because the pilot did not adequately check the security of the oil-filler tube and other components before the flight. (See figure 2 on page 11.)

Similarly, the pilot of a Cessna 182C that crashed in Marion, Montana, on May 12, 2007, failed to ensure that its oil-filler cap was secure before the flight, allowing engine oil to escape. Although that engine did not lose power, the escaping oil likely coated the windscreen and obstructed the pilot's view as he attempted to return the airplane to the airport for a precautionary landing.

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7 Six of the accident pilots were private pilots. Five of the accident airplanes flown by private pilots were piston-powered, single-engine Cessnas, and one was the Beech C-45H that crashed in Honolulu, Hawaii, on December 5, 1981.

8 The report for the Beech C-45H accident that occurred on September 7, 1992, in Hinckley, Illinois, did not rule out the possibility that the pilot may have been unable to attain a full-feather position on the left engine propeller. An inability to feather the propeller on the inoperative engine would make it very difficult for the pilot to maintain a controllable airspeed. Also, the airline transport pilot of a Helio HST-550A that crashed June 30, 1988, in Perris, California, due to an uncommanded nose-down elevator trim condition likely could not control the airplane because of the malfunction. One accident, which involved a commercial pilot of a Cessna 182 that crashed in Marseilles, Illinois, on August 6, 1983, crashed for undetermined reasons.

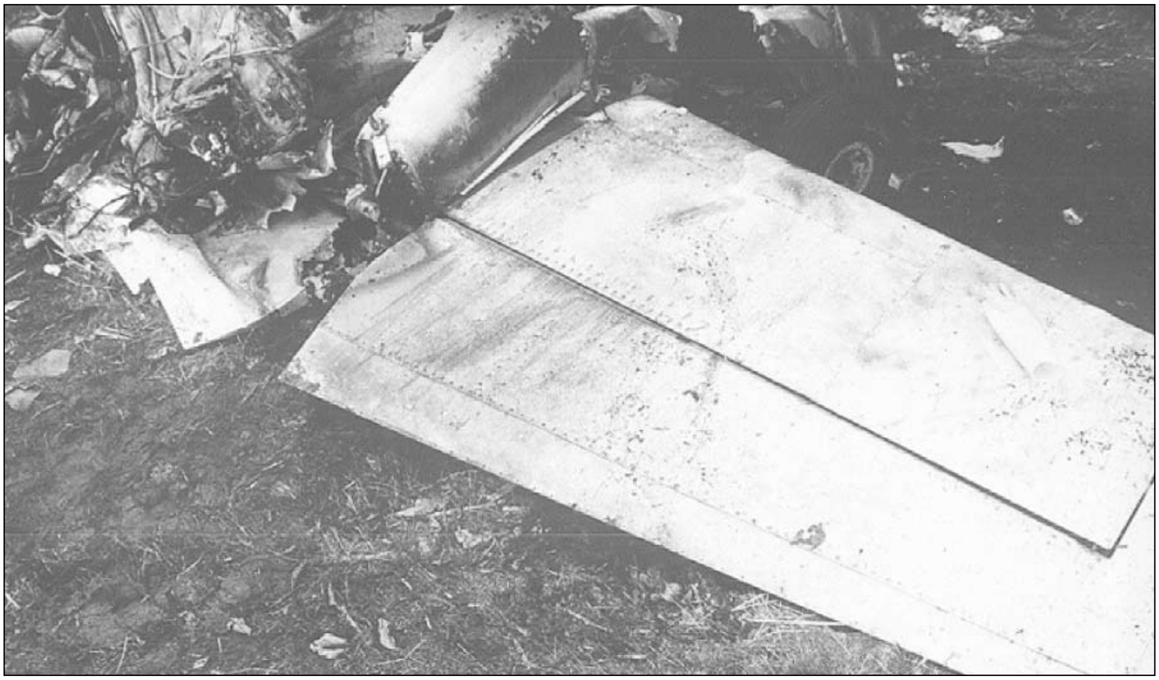

Figure 2. Engine oil coating the underside of the horizontal stabilizer on the Grain Valley, Missouri, accident airplane.

In addition, the May 9, 1999, accident in Celina, Ohio, involved a commercial pilot of a Cessna 205 who failed to ensure that the airplane had a sufficient amount of fuel on board. The airplane lost engine power during takeoff due to fuel exhaustion. Further, the two pilots of the de Havilland DHC-6-200 that crashed in Perris, California, on April 22, 1992, did not sump the airplane's fuel tanks after the airplane was fueled before the accident flight. That airplane lost engine power because of fuel contamination, which likely could have been detected if the pilots had performed routine preflight sumping of the airplanes' tanks.[9]

Also, one accident involving a functional, powered airplane could also have been prevented with appropriate preflight action. The commercial pilot of the Cessna P206 that crashed on October 30, 2004, in Jacksonville, Florida, failed to follow the before-takeoff checklist procedures and did not properly set the airplane's elevator trim for takeoff. A passenger who survived the accident reported that, during the takeoff, the airplane pitched up after becoming airborne and that the pilot responded by "frantically" moving the elevator trim wheel four or five times toward the nose-down direction. The pilot's remedial actions were not successful, and the airplane stalled and crashed about 400 feet from the edge of the runway.

9 Although the report for this accident did not publish excerpts from the airplane's preflight procedures checklist, routine preflight procedures for aircraft include using a sampler cup to drain a small quantity of fuel from the airplane's fuel tanks to visually check it for water, sediment, and proper fuel grade before the first flight of the day and after each refueling.

3.2 Noncompliance with Airplane Weight and Balance Limitations

Aircraft weight and balance computations represent another mechanism by which a pilot can mitigate potential flight risks before the aircraft leaves the ground. All pilots must ensure that an aircraft is loaded within its maximum allowable gross weight limitation before takeoff because excessive weight loading can adversely affect an aircraft's performance and controllability to the extent that, in some circumstances, the aircraft may be unable to obtain or sustain flight. In addition, parachute operations present unique challenges for pilots because the aircraft's load changes and shifts in flight as parachutists egress, and aircraft drag forces change as parachutists open and close aircraft doors and/or position themselves outside of the aircraft. Parachute operations pilots must consider these weight changes and perform multiple calculations before each flight to ensure that the airplane will remain within its cg limits for the duration of the flight. Failure to ensure that the loading remains within the cg limits can adversely affect an airplane's stall and spin characteristics and controllability and, thus, the pilot's ability to prevent a stall or to recover the airplane from an inadvertent stall or spin. In 9 of the 12 accidents involving airplanes that were loaded beyond their maximum allowable gross weights or outside their cg limits, the weight and balance issue was found to be a cause or factor.

In the September 1, 1997, accident involving the Cessna 182C that crashed in Bremerton, Washington, witnesses observed that, during takeoff, the airplane climbed to about 300 to 500 feet and began a left turn back toward the runway. The airplane's left bank increased, its nose dropped vertically, and it entered a spin and crashed about 900 feet from the end of the runway. The investigation found that the airplane's loading exceeded its maximum allowable gross weight and that there was no evidence of mechanical malfunction or engine power loss.

Similarly, in the October 17, 1982, accident involving the Beech C-45H that crashed shortly after takeoff in Taft, California, the airplane departed and climbed to about 150 feet, then its nose pitched up, and it rolled to the left and crashed. The investigation revealed that the airplane's loading exceeded its maximum gross weight by several hundred pounds, making it likely impossible for the pilot to maintain airspeed and control of the airplane.

In the accident involving the Lockheed L-18-56 that crashed on August 21, 1983, in Silvana, Washington, the airplane was at 12,500 feet when parachutists began to egress. The first parachutists who exited the airplane reported that they were unaware of any problem, but, after exiting the airplane, they saw it bank steeply and spiral down. The investigation found that the airplane's cg was behind its aft limit. Similarly, the Beech C-45H that crashed on December 5, 1981, near Honolulu, Hawaii, was loaded to about 10 inches behind its aft cg limit. That airplane entered a spin during a turn toward the jump area and descended into the water.

3.3 Failure to Maintain Airspeed During Powered Flight

Although several of the powered-flight accidents involved weight and balance or trim issues that could have adversely affected the pilots' ability to control the airplanes, at least three accidents, and possibly a fourth that remains under investigation, involved pilots who failed to maintain airspeed during powered flight in functional airplanes that were not reported to have been improperly loaded. These accident pilots not only failed to maintain airspeed to prevent a stall and/or spin from developing but also did not perform the necessary procedures to recover the airplanes from the stall/spin condition.

The pilot of the Cessna 205 that crashed May 25, 1997, in Homestead, Florida, had leveled the airplane at 3,500 feet and slowed it with the intent of allowing one parachutist to jump from the airplane before transporting the other parachutists on board to higher altitudes. As the first parachutist prepared to jump from the airplane, the airplane's left wing and nose dropped, and it entered a spin to the left. The airplane descended to the ground, and the pilot and five parachutists were killed; the parachutist who egressed at 3,500 feet survived. The investigation found that the commercial pilot failed to maintain airspeed as he slowed the airplane for the first parachutist's jump and that he failed to apply spin recovery emergency procedures. (See figure 3 below.)

A similar scenario occurred in the June 21, 2003, Cushing, Oklahoma, accident, when the commercial pilot of the Cessna 182H failed to maintain airspeed while parachutists were egressing, and the airplane entered a spin. A witness on the ground radioed the pilot and asked what was wrong, and the pilot replied that he was in a spin and did not know what to do. Although most of the parachutists managed to egress the spinning airplane, two were seriously injured, and the pilot was killed.

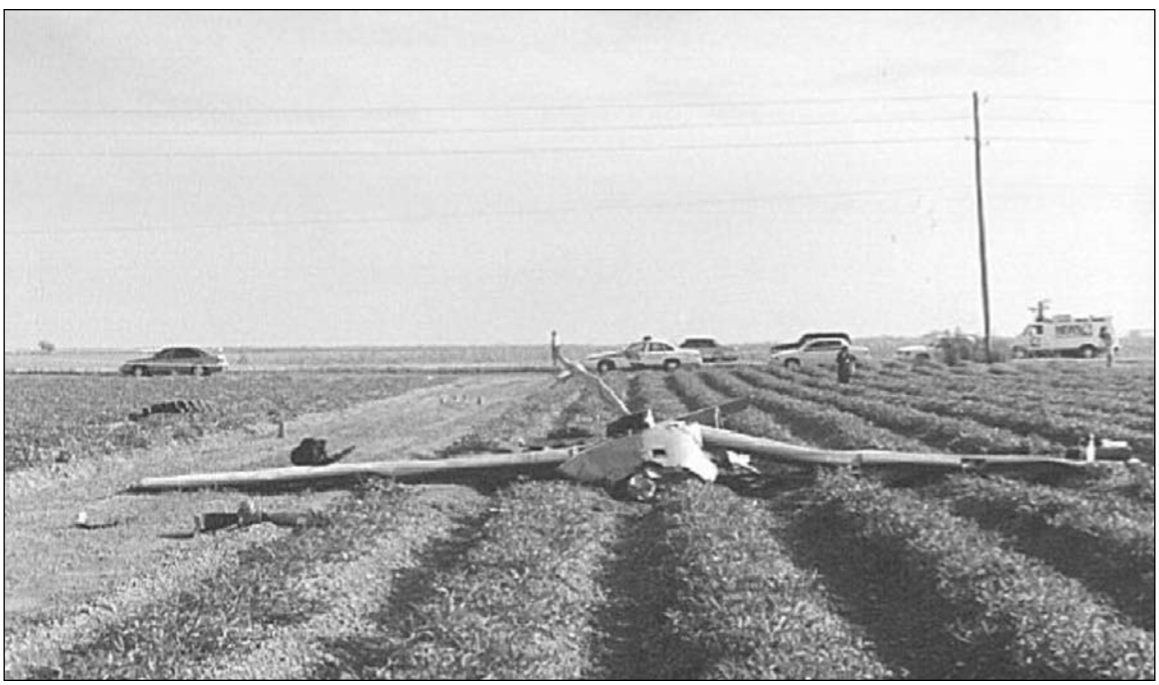

Figure 3. Wreckage of the Homestead, Florida, accident airplane.

Also, on July 31, 1999, a Beech 65-A90, crashed shortly after takeoff in Marine City, Michigan, killing the pilot and nine parachutists. Witnesses reported that the airplane seemed to be operating normally during taxi and takeoff but that the airplane did not climb any higher than 150 to 250 feet above ground level before it banked steeply to the left, its nose dropped, and it crashed to the ground. The investigation determined that the pilot stalled the airplane, which had no preexisting failures or conditions that would have prevented normal operation.

In addition, although the recent April 19, 2008, accident in Mount Vernon, Missouri, involving a Cessna P206 remains under investigation, information provided by two surviving parachutists indicated that the airplane had climbed to 10,500 feet msl for the parachutists to egress. One parachutist opened the door and noticed that the airplane had overshot the drop zone by about 1 mile and informed the pilot. She stated that, as the airplane started to make a right turn, the stall warning horn sounded, and the airplane "rolled off on its right wing" and entered a spin. Two parachutists were killed, the commercial pilot and one parachutist were seriously injured, and three parachutists were not injured.

3.4 Inadequate Performance of Emergency Procedures

In the 12 accidents that involved a loss of engine power (11 shortly after takeoff and one at 3,700 feet msl), nearly all of the pilots allowed the airplanes to stall and/or performed other critical procedural mistakes while responding to the engine emergencies.[10] For example, the commercial pilot involved in the previously referenced de Havilland DHC-6-200 accident in Perris, California, feathered the wrong propeller after the airplane lost power in one engine. Further, the investigation found that the operator failed to provide the pilot adequate training in the airplane.

In addition, in the previously referenced Celina, Ohio, accident (in which the pilot's failure to ensure that the Cessna 205 had a sufficient amount of fuel on board resulted in engine power loss during takeoff), the pilot also did not effectively perform emergency procedures, such as maintaining airspeed and gliding toward a suitable landing area, after the engine lost power. According to a pilot-rated witness, a field in front of the airplane could have been used for an emergency landing; however, the pilot lost control of the airplane, and it descended in a spin.

Similarly, the commercial pilot of the Cessna 182A involved in the East Moriches, New York, accident also failed to use a suitable landing area following a loss of engine power. The Safety Board found that the accident was caused, in part, by the pilot's improper decision to attempt to stretch his approach in order to reach the runway instead of landing the airplane adjacent to the runway.

[10] Six of these accident airplanes were also subject to weight and balance issues that, depending on the circumstances in each individual accident, could have adversely affected the pilots' ability to maintain airspeed following the loss of engine power.

Beyond possessing a current, valid airman medical certificate and a commercial pilot certificate (for revenue flights) or a private pilot certificate (for personal flights), no special qualifications are necessary for a pilot to perform parachute jump operations. Although most of the accident pilots met these qualifications,[11] some of the pilots had little or no initial or recurrent training relating to parachute operations or in the airplanes that they were flying. For example, the Celina, Ohio, accident pilot was hired the day of the accident and received a briefing and a familiarization flight before he began flying parachutists; he had about 2 hours total experience in the Cessna 205 he was flying. Currently, there are no requirements for pilots to receive specialized parachute operations training or to demonstrate proficiency with the operations or the aircraft that they fly.

Parachute operations pilots must comply with only the flight-review requirements of 14 CFR 61.56, which specify that pilots must, within the preceding 2 years, receive a minimum of 1 hour of flight training and 1 hour of ground training that cover a review of Part 91 rules and the maneuvers and procedures necessary for the pilot to demonstrate that he or she can safely exercise the privileges of the pilot certificate. This review can be accomplished in any aircraft for which the pilot is rated to fly; therefore, it would be possible for a pilot who flies parachutists for revenue in a 23-seat, twin-engine, turbine-powered DHC-6-200 to fulfill the flight review requirements with an authorized instructor in a 2-seat Cessna 152.[12] In contrast, other revenue operations pilots, such as those who fly Part 135 on-demand operations, are subject to initial and recurrent pilot testing programs, which include annual requirements for pilot testing on aircraft performance, operating limitations, and weight and balance for each type of aircraft flown, as well as competency checks to determine pilot competence in practical skills and techniques in the class or type of aircraft that they fly, as specified in 14 CFR 135.293.

The Safety Board is concerned that the accident pilots, all of whom were entrusted to fly parachutists as passengers, were deficient in performing critical, basic airmanship tasks and procedures and that these deficiencies, most of which likely could have been prevented with appropriate and effective training, contributed to the loss of numerous lives. The Board recognizes that parachute jump operations include a wide variety of aircraft and operators; however, the Board notes that, using various mechanisms, the FAA has successfully implemented pilot training, examination, and/or flight check requirements for a variety of operations. Examples of such mechanisms include ground training, flight training, and endorsement requirements (such as those required for high-altitude operations and high-performance or conventional landing gear aircraft) and flight checks (such as those required for Part 135 pilot-in-command and instrument proficiency or for authorization to deviate from certain special regulations pertaining to air tours).

The Safety Board concludes that the current flight review requirements for pilots contained in Part 91 are insufficient for parachute operations because they do not ensure that parachute jump operations pilots are proficient in the specific aircraft in which they fly

[11] The Celina, Ohio, accident pilot did not have a current airman medical certificate. The Honolulu, Hawaii, accident pilot, who was a private pilot, was recorded in the accident report as “unqualified” to perform the flight.

[12] Further, if the pilot owned only a single-seat aircraft, the pilot could complete the flight review in that aircraft; the authorized instructor would observe the flight from the ground.

passengers, and they do not adequately address the unique considerations for performing parachute operations flights, including frequent takeoffs, slow-speed maneuvering while the parachutists exit, and subsequent high-speed, low-power descents. The Safety Board further concludes that training and examinations can help ensure that pilots are familiar with the skills needed to perform parachute operations and with the specific characteristics of the aircraft that they fly; recurrent training and examinations would refresh these skills and serve as a reminder to pilots of their duty to operate in a safe manner. Therefore, the Safety Board believes that the FAA should require parachute jump operators to develop initial and recurrent pilot training programs that address, at a minimum, operation- and aircraft-specific weight and balance calculations, preflight inspections, emergency and recovery procedures, and parachutist egress procedures for each type of aircraft flown. The Safety Board also believes that the FAA should require initial and recurrent pilot testing programs for parachute jump operations pilots that address, at a minimum, operation- and aircraft-specific weight and balance calculations, preflight inspections, emergency and recovery procedures, and parachutist egress procedures for each type of aircraft flown, as well as competency flight checks to determine pilot competence in practical skills and techniques in each type of aircraft.

FAA Advisory Circular (AC) 105-2C, "Sport Parachute Jumping," contains suggestions for improving the safety of parachute jump operations and is intended to assist operators, pilots, and parachutists with complying with the regulations that pertain to parachute jump operations. Although the AC is an established source of safety guidance, the Safety Board notes that AC 105-2C, which has not been updated since January 2, 1991, contains only basic information regarding pilot responsibilities with regard to weight and balance calculations and proficiency, and it contains little to no information regarding pilot training and examination programs, preflight inspections, emergency procedures, and parachutist egress procedures. Therefore, the Safety Board believes that the FAA should revise the guidance materials contained in AC 105-2C to include guidance for parachute jump operators in implementing effective initial and recurrent pilot training and examination programs that address, at a minimum, operation- and aircraft-specific weight and balance calculations, preflight inspections, emergency procedures, and parachutist egress procedures.

In addition, because of the USPA's knowledge of parachute operations and its ability to widely disseminate safety information to both members and nonmembers, the Safety Board believes that, once AC 105-2C has been revised to include guidance for parachute jump operators in implementing effective initial and recurrent pilot training and examination programs that address, at a minimum, operation- and aircraft-specific weight and balance calculations, preflight inspections, emergency procedures, and parachutist egress procedures, the USPA should distribute this revised AC to its members and encourage adherence to its guidance.

4. Federal Aviation Administration Oversight and Surveillance Issues

As evidenced in many of the previously discussed accidents, many operations exhibited deficiencies; for example, eight of the accident airplanes were dispatched in unairworthy condition. Many of these discrepancies likely could have been detected by FAA inspectors had adequate direct surveillance visits been performed. The Safety Board has long been concerned with the adequacy of FAA surveillance of parachute operations and, on occasion, has determined that inadequate surveillance was a factor in an accident. A number of accidents in the 1980s and 1990s prompted the Board to recommend in 1994 that the FAA improve its surveillance of parachute operations. This section discusses those accidents, the Board's recommendation, the FAA's action in 1994 to increase its surveillance of parachute operations, and the accidents that have occurred since FAA's action.

4.1 Accidents Preceding Increased Surveillance Action

On September 29, 1985, a Cessna 208 crashed in Jenkinsburg, Georgia, killing the pilot and 16 parachutists. The airplane lost engine power on takeoff due to, in part, the operator's improper fuel servicing. Fuel recovered from various locations within the airplane's fuel system was contaminated with water, iron contaminants, and foreign material appearing to be brown algae, and dark, stringy material was found in the airplane's fuel filters. The operator fueled the airplane from 55-gallon drums that were stored in a manner that allowed rainwater to leak through the filler caps, and the airplane had a history of fuel contamination problems. The Safety Board cited both the operator's improper servicing of the airplane and the operator's operation of the airplane with known equipment deficiencies as the probable causes of the accident and cited the FAA's inadequate surveillance of the operation as a factor.

Fuel quality issues were noted in the Perris, California, de Havilland DHC-6-200 accident, as well. Fuel recovered from the airplane's forward fuel tank, the airport fuel truck, and the airport's main underground tank was heavily contaminated with water, an emulsifying agent, and bacterial growth. Had the FAA conducted adequate surveillance of the operator, the contaminated fuel at the airport may have been detected.

In addition, on September 7, 1992, a Beech C-45H crashed shortly after takeoff in Hinckley, Illinois, following a loss of engine power in its left engine. The engine that lost power had been inactive for 18 years without preservation before it was installed on the airplane by noncertificated personnel; however, a certificated airframe and powerplant mechanic with an FAA inspection authorization reported that he inspected the personnel's work and signed the airplane's logbooks for the airplane's annual inspection. After the installation, the airplane was flown about 184 hours since its most recent annual inspection, and there was no record of a subsequent 100-hour inspection. These maintenance program deficiencies, in particular, the operator's failure to comply with inspection requirements, likely could have been detected by adequate FAA surveillance.

Following these accidents, on February 17, 1994, the Safety Board issued Safety Recommendation A-94-19, which asked the FAA to do the following: "Direct flight standards district offices [FSDOs] to increase their surveillance of sport parachute operations and comply with their associated operations bulletins regarding parachute operations." Safety Recommendation A-94-19 was classified "Closed—Acceptable Action" on May 31, 1995, after the FAA's November 21, 1994, response that it had published Notice 1800.134, "Required National Flight Standards Program Work Functions," on July 8, 1994, to provideinstructions to FSDOs for the development and execution of annual national work program guidelines. In its response to the Board, the FAA stated that Notice 1800.134 "directs principal operations inspectors to perform increased interior and exterior ramp inspections" of parachute operations aircraft, to include particular attention to inadequate aircraft maintenance, contaminated fuel, inadequate training of pilots, pilot inattention to weight and balance and to aircraft operating limitations issued for parachute operations, among other areas. In its May 31, 1995, correspondence to the FAA, the Board closed the safety recommendation based on its understanding that Notice 1800.134 "requires" FAA inspectors to perform increased surveillance.

4.2 Accidents Since Increased Surveillance Action

The Safety Board notes that FAA Notice 1800.134 is no longer a current document. However, information in current FAA Order 8900.1, "Flight Standards Information Management System," is based, in part, on the former Notice 1800.134 and contains similar guidance for inspectors in Volume 6, "Surveillance," Chapter 11, "Other Surveillance," Section 5, "Surveillance of Sport Parachute Activities." However, the current information serves as guidance information only; such surveillance is not a mandatory task for inspectors. The current national flight standards work program guidelines listed in FAA Order 1800.56H contain no surveillance requirements for parachute operations.

The Safety Board notes that 16 of the 32 fatal parachute operations accidents reviewed in this report occurred after the FAA implemented the guidance in Notice 1800.134. These accidents claimed the lives of 77 people. Because few of the accident reports detailed FAA surveillance activity data for the respective operators, and because the FAA does not retain such data indefinitely, the Board is unable to determine whether or not FAA surveillance of parachute jump operators increased. However, a review of FAA Program Tracking and Reporting Subsystem (PTRS) data and Safety Performance Analysis System (SPAS) data for the operators of the three most recent parachute operations accident aircraft in the Safety Board's database (a nonfatal accident involving a Cessna 208B that lost engine power on June 1, 2008, in Greensburg, Indiana;[13] a nonfatal accident involving

[13] The 14 parachutists on board parachuted to safety following the loss of engine power, the cause of which has not yet been determined. The accident, CHI08LA144, was under investigation at the time of this report. Preliminary information for the accident is available at the Safety Board's website at <http://ntsb.gov/ntsb/query.asp>.

a de Havilland DHC-6-200 that sustained substantial damage during descent on June 29, 2008, near Baldwin, Wisconsin;[14] and the previously referenced April 19, 2008, Mount Vernon, Missouri, accident) revealed that two of the operators had no records of FAA surveillance visits. However, the Mount Vernon, Missouri, accident operator received an operations surveillance visit on December 7, 2007, and the airplane involved in the Baldwin, Wisconsin, accident received a ramp check on April 25, 2004, while being flown by an operator in Texas.

Although the Safety Board is pleased with the content of the FAA's parachute operations surveillance guidance materials contained in Order 8900.1, the nonmandatory surveillance is not effective. A comparison of the accidents that occurred in the 14 years before the safety recommendation was closed (1980 to mid-1994) with the accidents that occurred in the 14 years since (mid-1994 to present) revealed little difference in their respective causes, factors, and other safety issues, with the exception of a reduction in contaminated fuel accidents. In addition, several of the accidents that occurred since the FAA's action show that the operators were deficient in specific areas, such as inadequate aircraft maintenance, inadequate training of pilots, and pilot inattention to weight and balance, that should have been targeted for particular attention from inspectors.

The Safety Board recognizes that the FAA has limited resources; however, as shown in this special investigation, numerous parachute jump operators, some of which carried thousands of revenue passengers annually, exhibited unacceptable deficiencies that could have readily been identified during FAA inspections, had any or adequate inspections occurred. For example, the Sullivan, Missouri, accident airplane was maintained at the operator's discretion using an independent maintenance facility. According to the mechanic who performed many of the airplane's most recent repairs, he would bring discrepancies to the operator's attention, but the operator would decide which items should be repaired; the mechanic would perform only the maintenance that he was paid to perform. The mechanic recalled that the airplane's autofeather system had been inoperative since the operator acquired the airplane in 2001 and that the operator did not want him to repair it. The mechanic ensured that the system was deactivated and that a "DEACTIVATED" placard was placed in the cockpit near the autofeather switch. However, the operator did not have an FAA-approved minimum equipment list for the airplane and, therefore, was not authorized to dispatch the airplane with any inoperative equipment.

The investigation of the July 31, 1999, accident involving a Beech 65-A90 that stalled during climb after takeoff in Marine City, Michigan, killing the pilot and nine parachutists, revealed that the operator's airframe and engine maintenance records for the airplane's required inspections were incomplete and that there were no records of compliance with five air worthiness directives (ADs) applicable to the accident airplane. Compliance with ADs is mandatory for all operators.

[14] The pilot declared an emergency and landed the airplane safely; the 14 parachutists had egressed before the emergency occurred. The accident, CHI08LA190, was under investigation at the time of this report. Preliminary information for the accident is available at the Safety Board's website at <http://ntsb.gov/ntsb/query.asp>.

The investigation of the September 10, 1995, accident in West Point, Virginia, involving a Beech 65 that crashed following a loss of power in one engine on takeoff for undetermined reasons,[15] killing the pilot, 10 parachutists, and 1 person in a house (see figure 4 below), revealed that the airplane's cabin seats had been removed, but maintenance records did not indicate when. Further, the maintenance records did not contain recalculated weight and balance information to correspond with other modifications (the accident airplane was loaded over its maximum gross weight and beyond its aft cg limit at the time that it crashed).

Figure 4. Remains of the house impacted by the West Point, Virginia, accident airplane.

Further, the airplane's aft boarding door had been removed for parachute operations; however, the accident airplane model was not on an FAA-approved eligibility list of aircraft eligible for flight with the aft boarding door removed. In addition, the operator had an FAA-approved flight manual supplement (FMS) that had been altered to give the appearance that the door removal was authorized for the accident model airplane; the unaltered FMS listed model "A65" as eligible, but the operator's copy had been altered to remove the "A," giving the appearance that model "65" was eligible.

The maintenance discrepancies on these three airplanes likely could have been detected with adequate surveillance that included, at a minimum, a visit to the operator and examination of each airplane's maintenance logs. A review of PTRS and SPAS data

[15] Before the accident flight, the pilot and parachutists fueled the airplane from plastic jugs, at least one of which may not have been clean; this practice could have introduced a risk of contaminating the airplane's fuel.

showed that at least one of these operators (the Sullivan, Missouri, accident operator) had no record of surveillance visits pertaining to maintenance and operations.[16] This operator, which had been in business for more than 12 years at the time of the accident, averaged about 10,000 to 12,000 passengers per year, with a maximum of 15,000 passengers in 1 year. Although the number of surveillance visits, if any, performed on the other two operators is not known, the persistence of such airworthiness discrepancies on the airplanes suggests that the operators received either minimal or inadequate surveillance with regard to aircraft maintenance.

The Safety Board notes that, in addition to maintenance discrepancies that could have been detected with adequate maintenance surveillance visits, many of the operational deficiencies observed with the accident operators could have also been detected and corrected and the accidents prevented. For example, a ramp check could determine whether or not a pilot had appropriately computed the airplane's weight and balance for a flight, and a review of the operator's flight logs and data could provide an indication about whether or not the operator enforces the practice for all pilots and all flights. Similarly, an operations surveillance visit could provide an inspector some indication of the adequacy of an operator's pilot training program.

As these examples show, parachute jump operator deficiencies have persisted after the publication of FAA guidance materials calling for increased surveillance. These accidents also show that surveillance of operators has been inconsistent. The FAA's action to increase surveillance, therefore, did not have the effect that Safety Recommendation A-94-19 intended. The Safety Board concludes that the FAA's oversight and surveillance of parachute jump operators have been inadequate to ensure that operators are properly maintaining their aircraft and safely conducting operations. Therefore, the Safety Board believes that the FAA should require direct surveillance of parachute jump operators to include, at a minimum, maintenance and operations inspections.

[16] Of these six accidents, only the Sullivan, Missouri, accident investigation provided FAA surveillance activity records for the operator. The investigation found three SPAS records of FAA contacts with the operator; these were related to the operator's airspace waiver requests.

5. Conclusions

5.1 Findings

1. Because parachute jump operations are particularly conducive to engine wear, the lack of requirements for parachute jump operators to comply with manufacturer-recommended maintenance instructions for their aircraft, including service bulletins and service information letters for time between overhauls and component life limits, increases the potential for the persistence of conditions that could lead to engine failure.

2. The current flight review requirements for pilots contained in 14 *Code of Federal Regulations* Part 91 are insufficient for parachute operations because they do not ensure that parachute jump operations pilots are proficient in the specific aircraft in which they fly passengers, and they do not adequately address the unique considerations for performing parachute operations flights, including frequent takeoffs, slow-speed maneuvering while the parachutists exit, and subsequent high-speed, low-power descents.

3. Training and examinations can help ensure that pilots are familiar with the skills needed to perform parachute operations and with the specific characteristics of the aircraft that they fly; recurrent training and examinations would refresh these skills and serve as a reminder to pilots of their duty to operate in a safe manner.

4. The Federal Aviation Administration's oversight and surveillance of parachute jump operators have been inadequate to ensure that operators are properly maintaining their aircraft and safely conducting operations.

6. Recommendations

The National Transportation Safety Board recommends that the Federal Aviation Administration:

> Require parachute jump operators to develop and implement Federal Aviation Administration-approved aircraft maintenance and inspection programs that include, at a minimum, requirements for compliance with engine manufacturers' recommended maintenance instructions, such as service bulletins and service information letters for time between overhauls and component life limits. (A-08-63)
>
> Develop and distribute guidance materials, in conjunction with the United States Parachute Association, for parachute jump operators to assist operators in implementing effective aircraft inspection and maintenance quality assurance programs. (A-08-64)
>
> Require parachute jump operators to develop initial and recurrent pilot training programs that address, at a minimum, operation- and aircraft-specific weight and balance calculations, preflight inspections, emergency and recovery procedures, and parachutist egress procedures for each type of aircraft flown. (A-08-65)
>
> Require initial and recurrent pilot testing programs for parachute jump operations pilots that address, at a minimum, operation- and aircraft-specific weight and balance calculations, preflight inspections, emergency and recovery procedures, and parachutist egress procedures for each type of aircraft flown, as well as competency flight checks to determine pilot competence in practical skills and techniques in each type of aircraft. (A-08-66)
>
> Revise the guidance materials contained in Advisory Circular 105-2C, "Sport Parachute Jumping," to include guidance for parachute jump operators in implementing effective initial and recurrent pilot training and examination programs that address, at a minimum, operation- and aircraft-specific weight and balance calculations, preflight inspections, emergency procedures, and parachutist egress procedures. (A-08-67)
>
> Require direct surveillance of parachute jump operators to include, at a minimum, maintenance and operations inspections. (A-08-68)

The National Transportation Safety Board recommends that the United States Parachute Association:

> Work with the Federal Aviation Administration to develop and distribute guidance materials for parachute jump operators to assist operators in implementing effective aircraft inspection and maintenance quality assurance programs. (A-08-69)
>
> Once Advisory Circular (AC) 105-2C, "Sport Parachute Jumping," has been revised to include guidance for parachute jump operators in implementing effective initial and recurrent pilot training and examination programs that address, at a minimum, operation- and aircraft-specific weight and balance calculations, preflight inspections, emergency procedures, and parachutist egress procedures, distribute this revised AC to your members and encourage adherence to its guidance. (A-08-70)

7. Appendix A

Safety Recommendations Pertaining to Survivability Issues for Parachutists

Open Safety Recommendations

Following the Safety Board's investigation of the July 29, 2006, accident in Sullivan, Missouri, the Board issued four safety recommendations related to more effective restraints for parachutists. The recommendations were issued on September 16, 2008.

The following recommendations were issued to the Federal Aviation Administration (FAA):

> A-08-71
>
> Conduct research, in conjunction with the United States Parachute Association [USPA], to determine the most effective dual-point restraint systems for parachutists that reflects the various aircraft and seating configurations used in parachute operations.
>
> A-08-72
>
> Once the most effective dual-point restraint systems for parachutists are determined, as requested in Safety Recommendation A-08-71, revise Advisory Circular 105-2C, *Sport Parachute Jumping*, to include guidance information about these systems.

The following recommendations were issued to the USPA:

> A-08-73
>
> Work with the Federal Aviation Administration to conduct research to determine the most effective dual-point restraint systems for parachutists that reflects the various aircraft and seating configurations used in parachute operations.

A-08-74

Once the most effective dual-point restraint systems for parachutists are determined, as requested in Safety Recommendation A-08-71, educate your members on the findings and encourage them to use the most effective dual-point restraint systems.

Safety Recommendations A-08-71 through -74 are classified "Open—Await Response."

Closed Safety Recommendations

Previously, following the Safety Board's investigation of the April 22, 1992, accident in Perris, California, the Board issued seven safety recommendations (three to the FAA and four to the USPA) regarding parachutists' seating and restraints. These recommendations were issued on February 17, 1994.

The following recommendations were issued to the FAA:

A-94-16

In conjunction with industry, USPA, and CAMI [Civil Aerospace Medical Institute], develop and test universal restraint systems capable of providing adequate protection to parachutists similar to that provided for seated passengers. (Class II, Priority Action)

In response to this safety recommendation, CAMI, in conjunction with the Parachute Industries Association and the USPA, performed a series of dynamic sled tests to evaluate various types of restraint systems and occupant orientations for parachutists and produced a report on its findings.[1] Although none of the restraint methods tested were capable of providing protection to parachutists "similar to that provided for seated passengers," as requested, the FAA responded to the Safety Board on March 26, 1999, that the testing identified possible improvements in restraining parachutists and that it is not possible to provide the same level of protection for floor-seated parachutists that is afforded to occupants in seats. As a result, because the FAA's testing identified possible improvements in restraining parachutists, the Board determined that the FAA's actions met the intent of Safety Recommendation A-94-16 and classified it "Closed—Acceptable Action" on January 4, 2000.

[1] U.S. Department of Transportation, Federal Aviation Administration, Civil Aerospace Medical Institute, *Evaluation of Improved Restraint Systems for Sport Parachutists*, DOT/FAA/AM-98/11 (Washington, DC: DOT/FAA, 1998).

A-94-17

In conjunction with industry, USPA, and CAMI, provide for the seating of parachutists to assure an adequate level of crash energy absorption in the event of a survivable aircraft accident. (Class II, Priority Action)

In a November 2, 2000, letter to the Safety Board, the FAA reported that, because of the typically small size of the aircraft used in parachute operations, the installation of an energy-absorbing structure, such as crushable seating or modified flooring, would impact the flight mission by substantially reducing payload and adequacy of cabin emergency evacuation. The FAA further reported that such modifications would also significantly alter the performance and handling qualities of the aircraft and significantly change the airplane design and that any requirements for such a design change for existing airplanes "would constitute a ban on sport parachuting as it is known today. Consequently, the FAA does not intend to continue efforts to address the attenuation of vertical energy." As a result of the FAA's response, Safety Recommendation A-94-17 was classified "Closed—Unacceptable Action" on March 9, 2001.

A-94-18

Amend 14 CFR [*Code of Federal Regulations*] 91.30 to require each parachutist or other passenger who is seated on an aircraft cabin floor to use restraint systems. The restraint system must be designed, tested, and approved to provide a level of occupant protection similar to that provided for passengers in forward and aft facing seats that have a safety belt and shoulder harness. (Class II, Priority Action)

In response to this recommendation, the FAA reported that 14 CFR 91.107 already requires parachutists seated on an aircraft cabin floor to use restraint systems and that, although no restraint system for floor-seated parachutists could provide a level of protection similar to that provided to seated passengers, if an improved restraint system were developed and installed, the parachutists would automatically be required to use it. In a January 4, 2000, response letter to the FAA, the Safety Board acknowledged that regulations require parachutists to use restraints and that FAA guidance materials and actions since the recommendation was issued have resulted in improved operator adherence to the requirements. The Board also acknowledged that, despite CAMI's testing, no restraint system could be found that would meet the intent of the safety recommendation. As a result, Safety Recommendation A-94-18 was classified "Closed—Acceptable Alternate Action" on January 4, 2000.

The following recommendations were issued to the USPA:

A-94-20

Revise the USPA operations manual to require restraint system use during takeoffs and landings. (Class II, Priority Action)

A-94-21

> Publish and distribute the content of this recommendation letter to all USPA members. (Class II, Priority Action)

In response to Safety Recommendations A-94-20 and -21, the USPA developed the USPA Skydiving Aircraft Operations Manual and distributed it to its group member facilities, completed its manual revisions, and published multiple magazine articles (including at least one that referenced the Safety Board's letter in its entirety) emphasizing seatbelt use. As a result, Safety Recommendations A-94-20 and -21 were each classified "Closed—Acceptable Action" on August 11, 1997.

A-94-22

> Participate in the design, development, and testing of a universal restraint system that would provide adequate protection for parachutists seated on an aircraft floor. (Class II, Priority Action)

The USPA participated, as requested, in the previously referenced CAMI testing of seating for parachutists; therefore, Safety Recommendation A-94-22 was classified "Closed—Acceptable Action" on June 5, 2001.

A-94-23

> Participate in the design, development, and testing of seating for parachutists that would provide an adequate level of crash energy absorption in the event of a survivable aircraft accident. (Class II, Priority Action)

On June 2, 1997, the USPA informed the Safety Board that it had obtained samples of energy-absorbing material that could potentially be used as floor seating material in parachute operations airplanes but that it had not developed a plan, or been informed by the FAA of a plan, to test the material. After the USPA did not respond to follow-up correspondence from the Board in 1997 and 2000 requesting updates on USPA's progress, Safety Recommendation A-94-23 was classified "Closed—Unacceptable Action" on June 5, 2001.

Previous Safety Recommendation Pertaining to Federal Aviation Administration Surveillance of Parachute Operations

The Safety Board's investigation of the April 22, 1992, accident in Perris, California, also resulted in a recommendation regarding FAA surveillance of parachute operations. The following safety recommendation was issued to the FAA on February 17, 1994:

A-94-19

> Direct flight standards district offices to increase their surveillance of sport parachute operations and comply with their associated operations bulletins regarding parachute operations. (Class II, Priority Action)

Safety Recommendation A-94-19 was classified "Closed—Acceptable Action" on May 31, 1995, after the FAA responded on November 21, 1994, that "the FAA agrees with this recommendation" and that the FAA had published Notice 1800.134, *Required National Flight Standards Program Work Functions*, on July 8, 1994, to provide guidance to flight standards field offices on the development and execution of annual national work program guidelines. The FAA stated that the notice directed principal operations inspectors to perform increased interior and exterior ramp inspections of parachute operations aircraft, paying particular attention to inadequate aircraft maintenance and contaminated fuel, the use of restraint systems by parachutists during flight, the use of unapproved crewmembers' seatbelts, inadequate training of pilots, pilot inattention to weight and balance, and aircraft operating limitations issued for parachute operations.

APPENDIX B

Accident Synopses

Salisbury, North Carolina (ATL80FA051)

On June 8, 1980, a Cessna 172, N8866B, crashed near Thompson Farm Airport in Salisbury, North Carolina, following a partial loss of engine power during takeoff. The private pilot and one parachutist were killed. The airplane's annual inspection was overdue, water and dirt were observed in the gascolator, sludge was observed in the engine, and the engine's No. 6 exhaust valve was sticking.

The National Transportation Safety Board determined that the probable cause of the accident was the inadequate maintenance and inspection of the airplane and the pilot's inadequate preflight preparation, failure to abort the takeoff, and failure to maintain flying speed. Factors contributing to the accident were the partial loss of power; excessive wear on the engine pistons; sticking of the valve assembly; and water and other contaminants in the fuel.[2]

Loveland, Colorado (DCA81AA015)

On April 17, 1981, a Cessna TU206A, N4862F, collided in flight with a Handly Page HP-137 airplane in Loveland, Colorado. Two parachutists on board the parachute operations flight were killed, the airline transport pilot and two other parachutists received serious injuries, and one parachutist received minor or no injuries. All 13 people (the airline transport pilot, 2 flight crewmembers, and 10 passengers) on board the other airplane, which was an on-demand air taxi commuter flight operated under 14 *Code of Federal Regulations* (CFR) Part 135, were killed. The pilot of the parachute operations flight climbed the Cessna through 12,500 feet above mean sea level (msl) and in controlled airspace without communicating with air traffic control (ATC) personnel and without operating an altitude-encoding transponder; the flight was not in radar contact with an ATC facility. The air taxi commuter, which was in normal cruise flight, was in radar contact with ATC; however, ATC personnel issued no traffic advisories. The horizontal collision angle of the two airplanes was about 45°. Regulations allowed for and the ATC center permitted parachute jump operations both in and adjacent to airways.

The Safety Board determined that the probable cause of the accident was the Cessna pilot's failure to follow approved procedures/directives and the failure of both pilots to see and avoid the other airplane. Factors contributing to the accident were the rules, regulations, and standards for [ATC] personnel.

[2] The probable causes of older accidents in the Safety Board's database, including this accident, are provided in list form rather than as a probable cause statement. The probable cause statements provided for this accident and the following eight accident synopses are paraphrased from the lists.

Beaumont, Texas (FTW81FA079)

On April 25, 1981, a Cessna TU206B, N3414L, operated by a parachuting club, crashed in Beaumont, Texas, following an in-flight separation of a jump door window, which became wrapped around the horizontal stabilizer and obstructed the flight control surfaces there. The private pilot was killed, and none of the parachutists, who had successfully egressed the airplane, were injured. The pilot, who had accumulated 9 hours in the airplane type, exceeded the designed stress limits of the airplane during cruise flight. In addition, at the time of takeoff, the airplane was loaded to 7 inches behind its aft center of gravity (cg) limit.

The Safety Board determined that the probable cause of the accident was the pilot exceeding the designed stress limits of the airplane, which resulted in the flutter of the door frame and the subsequent obstruction of the flight control surfaces on the horizontal stabilizer. Factors contributing the accident were the in-flight separation of door's window and the improperly loaded airplane.

Honolulu, Hawaii (LAX82FA024)

On December 5, 1981, a Beech C-45H, N8185H, entered a spin during a turn toward the jump area at altitude and crashed into water near Honolulu, Hawaii. The private pilot and 10 parachutists were killed. One parachutist, who was one of four parachutists who attempted to egress, survived but was seriously injured. The investigation found that the airplane was loaded to about 10 inches behind its aft cg limit.

The National Transportation Safety Board determined that the probable cause of the accident was the pilot's failure to maintain flying speed and that factors contributing to the accident included the following: the pilot's inadequate preflight planning/preparation, the pilot's lack of qualifications to operate the airplane, and the improper loading of the airplane.

Taft, California (LAX83FA012)

On October 17, 1982, a Beech C-45H, N403SE, crashed shortly after takeoff from a private airport in Taft, California. The commercial pilot, an observer on board, and 12 parachutists were killed. According to a witness on the ground, shortly after the airplane departed, the engine power was reduced to climb power, and the landing gear was retracted. The airplane climbed to about 150 feet above ground level (agl), then its nose pitched up, and it rolled to the left and crashed in a steep left-banked, nose-down attitude.

Examination of the airplane revealed extensive ground fire damage but no evidence of preimpact mechanical discrepancies. The maximum certificated gross weight for the airplane was 8,750 pounds (lbs) with an aft cg limit of 117.6 inches. Although the amount of fuel on board at the time of the accident was not determined, the investigation found that, if the airplane had carried no fuel weight, its loading would have been about 580 lbs over its maximum gross weight. If the airplane carried 100 gallons of fuel, its estimated gross weight would have been about 9,939 lbs with the cg at 121 inches.

The Safety Board determined that the probable cause of the accident included the following: the pilot's inadequate preflight planning/preparation and the pilot exceeding the airplane's weight and balance limitations.

Marseilles, Illinois (CHI83FA365)

On August 6, 1983, a Cessna 182, N6351A, crashed while returning to Prairie Lake Airport in Marseilles, Illinois. The commercial pilot was killed, and none of the four parachutists, who had jumped from the airplane at 9,000 feet msl, was injured. The airplane was observed flying level about 500 feet agl in the approximate position for the left downwind leg for runway 36. About 1/2 mile north of the normal turn point for the base leg, the airplane entered a steep, descending left turn. Examination of the wreckage revealed no evidence of malfunction. Toxicology performed on and examination of the pilot revealed no evidence of an incapacitating problem. The Safety Board cited the probable cause of the accident as undetermined.

Silvana, Washington (DCA83AA036)

On August 21, 1983, a Lockheed L-18-56, N116CA, entered a steep bank and spiraled nose down and crashed nearly vertically on the ground in Silvana, Washington. The commercial pilot, the second pilot, and 9 parachutists were killed; 2 parachutists were seriously injured; and 13 parachutists were not injured. The airplane was at 12,500 feet when parachutists began to egress; the operator's usual procedure involved slowing the airplane to 95 to 100 knots, extending the landing gear and approach flaps, and reducing power on the left engine. The first parachutists who exited the airplane reported that they were unaware of any problem, but, after exiting the airplane, they saw it enter the bank and spiral down. Sixteen parachutists were able to egress, but three impacted the airplane's stabilizer.

Examination revealed that the airplane was equipped with 1 jumpseat and 24 floor seatbelts for parachutists. Its cabin door had been removed, and an unapproved step and four handholds had been installed outside and forward of the cabin door area. Also, the airplane had been loaded behind its aft cg limit, and the trim actuator was found in a position corresponding with full nose-up trim.

The Safety Board determined that the probable cause of the accident included the following: the operator's improper supervision, the pilot exceeding the airplane's weight and balance limitations, and the pilot's inadvertent stall.

Dublin, Virginia (ATL85FA072)

On December 30, 1984, a Cessna 182A, N4963D, struck a parked van with its landing gear and crashed near New River Valley Airport in Dublin, Virginia. The private pilot was killed. The flight was returning to the airport after the parachutists had egressed. The airplane was observed to fly over the drop zone, make a 180-degree turn to the left, and then line up on a van that was parked on a ridge. The airplane descended to 10 to 30 feet agl and made a low-altitude, high-speed run toward the van. A witness reported that the airplane appeared to dip under a low powerline in its path and that its landing gear then struck the van.

The Safety Board determined that the probable cause of the accident was the pilot's improper decision to perform buzzing and the pilot's misjudgment of the proper glidepath and altitude.

Jenkinsburg, Georgia (ATL85MA286)

On September 29, 1985, a Cessna 208, N551CC, operated by Air Carriers Express Service, Inc., crashed following a loss of engine power during takeoff from the sod runway at West Wind Sport Parachute Center in Jenkinsburg, Georgia. The airline transport pilot and 16 parachutists were killed. The airplane had climbed to about 300 feet agl when the power loss occurred; the airplane then banked steeply left and spiraled nose down to the ground. The airplane was configured to carry up to 18 parachutists. Fuel recovered from various locations within the airplane's fuel system was contaminated with water, iron contaminants, and foreign material appearing to be brown algae. Milky-colored fuel recovered from the engine's fuel control was about 34 percent water and contained iron contaminants. Dark, stringy material was found in the airplane's fuel filters. The operator fueled the airplane from 55-gallon drums that contained contaminated fuel. These drums were stored in a manner that allowed rainwater to leak through the filler caps.

The investigation revealed that the airplane had been operated for several weeks with known contamination of the fuel system. The owner/operator was informed by qualified maintenance personnel on at least two occasions of the need to purge and clean the airplane's fuel system before further flight; however, he continued to operate the airplane. On at least one occasion, the airplane was flown after contaminated fuel samples were repeatedly obtained. The airplane's flight manual states that all drain valves should be thoroughly drained until there is no evidence of water or sediment contamination before the flight.

Also, the airplane's stall warning circuit breaker was occasionally disengaged so that the warning would not startle the parachutists; however, damage precluded determination of the circuit breaker's preimpact position during the accident flight. The airplane was about 370 lbs over its maximum allowable gross weight and 1 inch forward of its forward cg limit. The parachutists did not use restraints, and lack of Federal Aviation Administration (FAA) surveillance of the operation was noted.

The Safety Board determined that the probable cause of the accident included the following: the operator's improper maintenance/service of the aircraft/equipment, the operator's operation of the airplane with known deficiencies, the pilot's failure to maintain airspeed, the pilot's inadvertent stall/spiral, and fuel contamination/water. The contributing factors included the following: a disengaged circuit breaker and disabled warning system, fuel system contamination, the pilot's improper use of procedures, and the FAA's inadequate surveillance of the operation.

Perris, California (LAX88FA241)

On June 30, 1988, a Helio HST-55A, N9991F, operated by Perris Valley Skydiving, crashed while returning to Perris Valley Airport in Perris, California.[3] The airline transport pilot was killed; none of the parachutists, who had already jumped from the airplane, was injured.[4] During the airplane's descent, the pilot was communicating with an air traffic controller and receiving radar advisories. After the airplane descended below 4,000 feet msl, the controller terminated the advisory services but then immediately advised the pilot to check for a stuck microphone switch. The airplane descended in an extreme, nose-low attitude and collided with a camping trailer and building. Examination of the airplane revealed that the elevator trim was found in the full nose-down position, and no other malfunctions were found.

The Safety Board determined that the probable cause of this accident was the failure of the electrical stabilizer trim control that resulted in an uncommanded full nose-down elevator trim command.

Estacada, Oregon (SEA91FA038)

On December 31, 1990, a Cessna 182B, N7288E, crashed during a forced landing into a tree farm following a loss of engine power shortly after takeoff from Beaver Oaks Airport, near Estacada, Oregon. Two parachutists were killed, the private pilot was seriously injured, and one parachutist received minor injuries. The temperature at the time of the accident was 40° Fahrenheit (F), and the dew point was about 36° F; this combination falls within the range favorable to induction system icing. The investigation revealed that the engine's muffler cones were missing from the engine.

The Safety Board determined that the probable cause of the accident was engine power loss due to carburetor ice and missing muffler cones as a result of inadequate maintenance inspection. In addition, the pilot failed to maintain adequate airspeed during the forced landing, which resulted in a stall.

3 Two accidents referenced in this report occurred in Perris; the other accident, which involved a de Havilland DHC-6-200, is referenced more frequently.

4 The report narrative did not indicate how many parachutists were initially on board. According to the factual report's form data, the airplane could seat 10 passengers.

Osceola, Wisconsin (CHI91FA088B)

On February 3, 1991, a Cessna 182, N6384A, collided in flight with a Piper PA-28 after departing L.O. Simenstad Municipal Airport in Osceola, Wisconsin. The private pilot and the four parachutists on board the Cessna (a high-wing airplane) and the certificated flight instructor and student pilot on board the Piper (a low-wing airplane) were killed. Shortly before the accident, the pilot of parachute operations flight had departed runway 10 in formation with another airplane (not the Piper). After takeoff, the pilot of the parachute operations Cessna discontinued the formation and departed the airport to the southeast, and the other airplane that had been in the formation departed to the northeast. About the same time, the Piper approached airport. No witnesses observed the collision. The parachute operations Cessna and the Piper converged and collided about 1.5 miles southeast of the airport, became entangled, and struck the ground together. The two accident airplanes converged laterally while on flight paths that angled toward each other.

The Safety Board determined that the probable cause of the accident was the failure of the pilots in both aircraft to see and avoid the other airplane.

Perris, California (LAX92MA183)

On April 22, 1992, a de Havilland DHC-6-200, N141PV, operated by Perris Valley Aviation Services, crashed during takeoff from Perris Valley Airport, Perris, California, following a loss of power in the airplane's right engine. The commercial pilot, the second pilot, and 14 parachutists were killed; six parachutists were seriously injured. Immediately after the airplane lifted off, the right engine lost power, the right wing lowered to about 90°, and the airplane crashed adjacent to the runway.

The ground loader stated that he had fueled the airplane from the airport fuel truck and that the flight crew did not sump the airplane's fuel tanks after the airplane was fueled. Examination of the airplane's forward fuel tank, which provides fuel to the right engine, was found to contain about 8 gallons of a heavily contaminated mixture of water, an emulsifying agent, and bacterial growth. Both the airport's fuel truck, which contained fuel transferred from the airport's underground tank the evening before the accident, and the underground tank contained the same contaminated mixture. Examination of the wreckage revealed that the left propeller control was seized in the feather position and that the left propeller blades were in the near-feather position.

The Safety Board determined that the probable causes of this accident were the pilot-in-command's inadvertent feathering of the wrong propeller following an engine power loss and the failure of the operator to ensure that the pilot was provided with adequate training in the airplane. Factors related to the accident were: water contamination of fuel in the airport storage tanks, the operator's lack of fuel quality control procedures, improper fuel servicing, improper preflight by the pilot(s), and exceeding the gross weight/forward cg limits of the airplane.

Hinckley, Illinois (DCA92MA048)

On September 7, 1992, a Beech C-45H, N3657G, operated by Hinckley Parachute Center, lost power in its left engine and crashed during takeoff in Hinckley, Illinois. The commercial pilot and 11 parachutists were killed. After the airplane lifted off, witnesses saw it flying at low altitude with smoke trailing from its left engine. Its wings tipped back and forth, then one wing dropped, struck the ground, and the airplane crashed. All of the parachutists were found in the center part of the fuselage with no evidence of restraint use.

Examination of the engine revealed that a supercharger bearing had failed in the left engine. Examination also revealed that the left propeller blades were found in an intermediate position between the operating range and the feathered position; the propeller's feathering motor relays were not recovered for examination. The left propeller had been changed several weeks before the accident, and there was no evidence that the left propeller had ever been successfully cycled to the full-feathered position. The operator and the pilots were not aware that the manufacturer, Hamilton Standard, issued Service Bulletin (SB) 657, recommending that full-feather checks be performed every 30 days.

The left engine was installed between January and April 1992 by noncertificated personnel; however, both the parachute center's owner and a certificated airframe and powerplant mechanic with an FAA inspection authorization reported that the mechanic told the noncertificated personnel what to do on the airplane and that the mechanic subsequently signed the airplane's logbooks for the airplane's annual inspection after the work was completed to the mechanic's satisfaction.[5] The airplane had flown about 184 hours since the last annual inspection, and there was no record of a subsequent 100-hour inspection.

Before installation on the accident airplane, the left engine had been inactive for about 18 years without preservation; it was last overhauled in February 1967 and had accumulated about 465.9 hours over the next 5 years before the airplane on which it was installed (not the accident airplane) was kept outside at an airport in central Florida. It remained there until August or September 1990, at which time an individual purchased the airplane and donated it to a museum located near Shreveport, Louisiana. The airplane was flown from Florida to Virginia and then to the museum, arriving on May 2, 1991. The pilots for each respective flight reported that the left engine used about 1/2 to 1 gallon of oil per hour, and one pilot reported that he believed that this was due to a badly worn or deteriorated supercharger seal and that the engine needed to be overhauled. The Hinckley Parachute Center owner purchased both engines and transported them to Hinckley between October and November 1991, installing the left engine on the accident airplane in early 1992.

The Safety Board determined that the probable cause of the accident was inadequate maintenance and inspection by the operator, which resulted in an engine power loss during the critical takeoff phase of flight. In addition, the pilot did not or was unable to

[5] Some of the information for this synopsis was obtained from the public docket for the accident.

attain a full-feather position on the left engine propeller, which would have most likely enabled the airplane to sustain minimum control airspeed.

East Moriches, New York (NYC93FA154)

On August 14, 1993, a Cessna 182A, N5010D, owned and operated by Skydive Long Island, Inc., crashed during an attempted return to the runway following a loss of engine power shortly after takeoff from Spadaro Airport in East Moriches, New York. The commercial pilot was killed, and the four parachutists were seriously injured. Several witnesses saw the airplane take off and reported that the engine did not sound like it was running normally. The airplane was observed to lose altitude on the downwind leg for the runway. The airplane then turned toward the runway, one wing struck the runway, and the airplane crashed. The computed estimated weight of the airplane at takeoff was 2,692 lbs. The maximum allowable takeoff gross weight is 2,650 lbs.

The airplane was powered by a Continental O-470-L engine equipped with Superior Air Parts pistons; the pistons carried the part number SA626992 and casting number SA632936. Engine logbook records disclosed that the engine had accumulated 3,369.2 hours total time at the time of the accident with 547.1 hours since engine overhaul. The engine received its last overhaul on December 8, 1980.

Examination of the engine revealed that the skirt of the No. 3 piston was missing and that the other pistons were cracked. The cracks in each piston were oriented along the longitudinal axis of each piston and originated in sharp corners on the inside of each piston skirt. The Safety Board's metallurgical examination of the piston pieces revealed that, for all of the pistons, the lower skirt area surface showed the presence of sharp casting recesses and that a series of elongated surface shrinkage cavities were present along the recess line. The cracks appeared to originate from the shrinkage cavities. The crack on one piston was opened up, and examination revealed that the propagation of the crack resulted from fatigue.

The Safety Board determined that the probable cause of this accident was engine failure due to a fatigue failure of the No. 3 piston. The fatigue failure was a result of inadequate manufacturing. In addition, the pilot made an improper decision during the forced landing by attempting to stretch his approach to reach the runway instead of landing in terrain adjacent to the approach end of the runway. As a result, the pilot lost control of the airplane, and it stalled on the runway. A factor that contributed to the accident was the overgross weight of the airplane.

Tremont City, Ohio (NYC94FA128)

On July 16, 1994, a Cessna R172K, N1124V, operated by Mad River Airport, crashed during takeoff from Mad River Airport, near Tremont City, Ohio. The commercial pilot and three parachutists were killed. Witnesses reported that the airplane's takeoff appeared normal but that the airplane leveled off about 200 feet agl. It then descended about 50 feet and continued forward for a moment before its right wing dropped, and it entered a steep descent and crashed into wooded terrain along the extended centerline of the runway.

No preimpact mechanical malfunction was found with the airplane. The airplane's passenger door, right front seat, and rear seat had been removed for the parachute operations flight; however, no record of a new weight and balance computation for the modifications was found. The airplane was estimated to be 76 lbs over its maximum takeoff weight. The accident flight was the pilot's first parachute operations flight and first flight with the airplane's door removed.

The Safety Board determined that the probable cause of the accident was the failure of the pilot to maintain control of the airplane. A factor related to the accident was the pilot's lack of experience in the type of operation.

West Point, Virginia (NYC95MA220)

On September 10, 1995, a Beech 65, N945PA, operated by the Peninsula Sky Diving Club, crashed following a loss of power in one engine during takeoff from the West Point Municipal Airport, West Point, Virginia. The airline transport pilot, 10 parachutists, and 1 person in a house were killed. Witnesses reported that they heard an engine misfiring during the airplane's takeoff and that they observed the airplane level off during the initial climb and start a shallow right turn. The bank angle gradually increased from shallow to steep as the nose dropped and the airplane descended. Other witnesses observed that the airplane was in a steep dive just before it crashed into the rear of a house and caught fire.

The airplane had flown seven parachute operations flights before the accident flight that day. After the seventh flight, the airplane needed refueling, but the quantity of fuel in the airport's underground fuel storage tank was below the electric cutoff level. A pilot witness stated that "it was suggested that we could, by using a hand pump, get some more fuel from the airport tank." The witness and others, including parachutists, manually pumped fuel into containers and carried them to the airplane to refuel it. A witness described that two jugs were used at first, and then another one was found in the hangar. A small amount of liquid that smelled like fuel was dumped from the jug before it was used in refueling the accident airplane.

Examination of the airplane revealed that the postaccident fire destroyed the accessory sections of both engines. Examination of the airplane disclosed evidence that the right engine had been shut down and that the right propeller had been feathered; however, no preimpact mechanical failure was found. A sample of excess fuel was obtained from the tank that was used to refuel the airplane, but no observable quantity of water or contamination was found.

Investigators calculated that, for the accident flight, the airplane's maximum gross weight was exceeded by 149.6 lbs and that the cg was 2.87 inches aft of the aft limit. Also, the airplane's seats and cabin door had been removed for parachute operations; however, the Beech 65 was not on the FAA-approved eligibility list for operation with its door removed. The operator provided investigators a flight manual supplement (FMS) that appeared to authorize such door removal, but examination of the document revealed that it had been altered by an unknown person. An unaltered FAA-approved FMS contained a signed and dated eligibility block that listed model "A65"; however, the copy of the document provided by the operator had been altered to remove the "A," thus, falsely giving the appearance that Beech "65" was eligible.[6]

In addition, the airplane's maintenance records did not indicate when the cabin seats were removed, but an FAA Form 337 showed floor-mounted seatbelts installed on October 16, 1990. The form stated that the aircraft weight and balance had been recalculated and logbook records updated. No such weight and balance figures were found in the logbooks. Additional modifications were made in May and June 1995 and Form 337s were submitted. The Form 337s stated that the airplane's weight and balance had been recalculated and the records updated; however, no entries were made in the airframe logbook.

The Safety Board determined that the probable cause of the accident was the pilot's inadequate preflight preparation, his failure to ensure the airplane's proper weight and balance, and his failure to obtain/maintain minimum control speed, which resulted in a loss of aircraft control after loss of power in one engine. A factor relating to the accident was the loss of power in the right engine for undetermined reasons.

Homestead, Florida (MIA97FA173)

On May 25, 1997, a Cessna 205, N8214Z, registered to Uninsured 205 LSG Corporation and operated by Skydive, Inc., entered a spin at 3,500 feet and crashed near Homestead General Airport, Homestead, Florida. The commercial-rated pilot and five parachutists were killed. One parachutist jumped before ground impact, deployed her chute, and landed uninjured.

The surviving parachutist stated that the flight was to climb to 3,500 feet and that she was to jump from that altitude. The flight was then to climb to a higher altitude for the remaining parachutists to jump. The flight reached 3,500 feet, the pilot slowed the airplane, and the parachutist took the jump position on the platform mounted on the right main landing gear. She stated that the wind resistance at this time was not as great as it had been during past jumps. As she waited for the jump signal from the jump company owner, he moved from the back of the aircraft to the right front seat area, which she had vacated. Shortly after this, the airplane's left wing dropped, and the airplane began turning to the left. The nose then dropped, and the airplane began to spin to the left. After an unknown number of turns, the parachutist jumped from the aircraft. As she descended using her parachute, she observed that the airplane continued to descend in a spin and crashed.

Postaccident examination of the airplane's structure, flight controls, engine, and propeller showed no evidence of precrash mechanical failure or malfunction. A review

[6] Some of the information for this synopsis was obtained from the public docket for the accident.

of the pilot's logbook and flight training records showed that the pilot received ground instruction in spin entry and spin recovery techniques but that there was no record that he had ever performed spins or spin recoveries in an aircraft. FAA regulations require that a private or commercial pilot receive ground instruction in spin entry and spin recovery techniques but does not require the private or commercial pilot to have performed spin entry and spin recovery techniques in an aircraft.

The Safety Board determined that the probable causes of the accident were the pilot-in-command's failure to maintain airspeed as he slowed for a parachutist to jump from the aircraft and his failure to apply spin recovery emergency procedures before ground impact. Contributing to the accident were the pilot-in-command's lack of training in spin recovery emergency procedures in an aircraft and the FAA's failure to require that a pilot demonstrate spin entry and spin recovery techniques in an aircraft.

Bremerton, Washington (SEA97FA201)

On September 1, 1997, a Cessna 182C, N9015T, operated by Blue Skies Skydiving Adventures of Dupont, Washington, collided with terrain shortly after takeoff from Bremerton National Airport, Bremerton, Washington. The commercial pilot and four parachutists were killed. The operator reported that the accident flight was to have been the last skydiving flight of the day and that the airplane, after departing from runway 19, climbed to about 300 to 500 feet agl before turning to the left and back toward the airport runway. Another witness stated that, during the left turn, the airplane increased its left bank until the airplane was approximately on a heading parallel to runway 1 and that the airplane's nose then dropped vertically and the airplane went into a one-half-turn spin. The airplane crashed into a shallow ravine and caught fire about 900 feet south of the departure end of runway 19, to the left of the runway's extended centerline.

No evidence of preimpact conditions interfering with normal operation was found during on-site examination or in follow-up examinations of the airplane's engine, propeller, and carburetor. A gross weight computation (based on airplane empty weight, reported fuel loading, and occupant and parachute weight estimates) indicated that the airplane was about 38 lbs over its maximum gross weight at the time of the accident.

The Safety Board determined that the probable cause of the accident was the pilot's failure to maintain adequate airspeed in a climbing turn at low altitude, resulting in a stall and impact with terrain. A factor was the pilot exceeding the aircraft's maximum takeoff gross weight limitation.

Smithfield, Rhode Island (IAD97FA117)

On September 6, 1997, a Cessna 182E, N3286Y, operated by Boston-Providence Skydiving Center, impacted the terrain during a forced landing on initial climbout at North Central Airport, Smithfield, Rhode Island. The commercial pilot and four parachutists were killed, and one parachutist received serious injuries.

The airplane's flight log indicated that it had flown eight skydiving flights earlier that day and that the airplane was fueled one flight before the accident flight. Witness statements indicated that the airplane departed and climbed to about 200 to 300 feet agl, then the engine lost power. The witnesses reported that the airplane pitched up to a nose-high attitude, rolled left, and descended until ground impact about 90° off the runway heading. Examination revealed that the airplane came to rest in an upright position, against the treeline of a wooded area. The propeller was found under the right wing. One blade was bent aft 90° with lengthwise scratching. The engine was test run, and no mechanical malfunctions were found.

No dated weight and balance calculations were located for the airplane, but handwritten weight and balance notes removed from the airplane indicated empty weight and balance figures for the airplane with the jump door installed. An estimated weight and balance for the accident flight was calculated, which revealed that the airplane's estimated takeoff weight was 2,930 lbs with an estimated cg of 48.67 inches. According to the pilot operating handbook for the airplane, the maximum allowable takeoff weight for the airplane was 2,800 lbs with a cg range of 38.39 to 47.32 inches.

The Safety Board determined that the probable causes of the accident were a loss of engine power for undetermined reasons and the pilot's failure to maintain control of the airplane.

Grain Valley, Missouri (CHI98FA106)

On March 21, 1998, a Cessna U206G, N506SD, caught fire and crashed while approaching the airport near Grain Valley, Missouri. The commercial pilot and five parachutists were killed. The flight was at 3,700 feet msl when the pilot canceled the operation with the FAA approach controller without explanation. Three witnesses at the airport said that the airplane had smoke and flames coming from the airplane's cowl and along the windshield as it approached the airport. They said that the airplane banked right at a low altitude and that its right wingtip struck the ground.

The investigation revealed that the engine, left side of the fuselage, bottom of the left wing and strut, horizontal stabilizer, and elevator were covered with oil film. The engine's oil filler tube was missing. The three filler-tube mounting screws were not found at the accident site. The upper threads of two of the three filler-tube mounting screw holes were deformed upward. The third screw hole threads were not deformed. The No. 6 cylinder valve rocker arm cover had five of its six screws missing, and the remaining screw was loose. The No. 6 cylinder's bottom spark plug lead nut was disconnected; its threads were not pulled. Examination of the engine revealed about 70 percent of the oil screen was covered by silver and bronze metallic debris. Holes were observed on the engine's left crankcase section near cylinder Nos. 2 and 6. The engine's internal components suffered damage typical of oil loss and heat distress, and the fracture features on the engine's fractured left crankcase section were typical of overstress.

The Safety Board determined that the probable cause of the accident was the pilot's inadequate preflight inspection, the partial loss of oil, and the resulting rod failure. A factor was the pilot's failure to maintain flying speed.

Celina, Ohio (IAD99FA043)

On May 9, 1999, a Cessna 205, N8157Z, operated by Grand Lake Skydiving, was destroyed during a collision with terrain following a forced landing after takeoff from Lakefield Airport in Celina, Ohio. The commercial pilot and five parachutists were killed. Several witnesses reported that, during climb after takeoff, the airplane's engine sputtered briefly then lost power. One pilot-rated witness reported that the engine "sputtered twice … and then nothing, pure silence. I ran to where I could see the plane and it was in a spin. … The plane came straight down. There was no forward motion. He had all that field in front of him. Why in the heck he didn't get the nose down, I don't know." Witnesses reported that three parachutists exited the airplane while it was spinning but that the airplane was too low; one witness estimated the airplane was about 300 feet agl when the first parachutist jumped. The parachutists did not achieve successful deployment of their parachutes and did not survive.

A review of jump logs and conversations with the operator revealed that the pilot flew three lifts of jumpers to about 10,000 feet. Each flight was about 30 minutes long, and the accident flight occurred during the fourth lift. The airplane departed on its first lift with 30 gallons of fuel and was not refueled before the accident flight. Examination of the airplane revealed 8 ounces of fuel were drained from the selected tank. A leak test revealed no leaks, and all fuel system components were operational with no preimpact anomalies. The parachuting club did not have a standard operating procedures document, and the club operator reported that club operations were at his direction.

According to the operator, the pilot was hired the day of the accident and was briefed on refueling procedures and how to measure fuel quantity in the tanks. The operator said that he provided briefings and demonstrated to the pilot in the airplane its flight characteristics, flight patterns, and jump procedures and that the pilot performed three takeoffs and landings during a 1.3-hour familiarization flight.

The operator provided weight and balance information, individual occupant weights, and a seating plan for the accident flight. The maximum gross weight for the airplane was 3,300 pounds and the aft cg limit was 47.27 inches aft of datum. Weight and balance figures for the accident flight were computed at a fuel weight of 60 pounds. Preliminary calculations revealed the airplane weighed 3,060 pounds with the cg at 48.30 inches aft of datum. A weight and balance was also computed using the same figures, minus the first parachutist that departed the airplane. The calculations revealed the airplane weight to be about 2,898 pounds and the cg 48.76 inches aft of datum.

The pilot held a commercial certificate with ratings for airplane single-engine land and instrument airplane. The pilot also held a private pilot certificate for airplane multi-engine land, visual flight rules only. The pilot's most recent third class medical certificate was issued July 9, 1997. Records revealed that the pilot's commercial certificate was issued on May 1, 1999; however, according to 14 CFR 61.39, "... to be eligible for a practical test for a certificate or rating issued under this part, an applicant must: Hold at least a current third class medical certificate, if a medical certificate is required."

The Safety Board determined that the probable cause of the accident was the pilot's failure to refuel the airplane, which resulted in fuel exhaustion and a loss of engine power. Also causal to the accident was the pilot's failure to maintain aircraft control after the power loss. Factors in the accident were a lack of published operational or safety procedures for the parachute club and the operator's failure to verify the pilot's medical qualifications.

Mokuleia, Hawaii (LAX99LA190)

On May 22, 1999, a Beech B90, N301DK, operated by Pacific International Skydiving Center, crashed into the Pacific Ocean near Dillingham Airfield Airport, Mokuleia, Hawaii, and sank to a depth of about 156 feet. The airline transport pilot was not found and was presumed to have been killed; the 13 parachutists had already jumped from the airplane and were not injured.[7] Ground witnesses observed that the airplane descended into the ocean in a left-wing-low, nose-down attitude. They did not hear the engines sputtering or popping or see the airplane make any erratic movements during its descent. Postaccident examination of the airframe, engines, and propellers revealed no preexisting impact anomalies.

Parachutists indicated that the two previous flights had been conducted at altitudes of at least 18,000 feet and that, during the accident flight, the parachutists jumped from 20,000 feet. One parachutist stated that, during the accident flight, he felt sick and was having a difficult time breathing because they had been at 20,000 feet for an unusually long time before making the jump. He further stated that a couple of the parachutists had paid the pilot to get him to climb to that altitude for the last jump. Other parachutists reported that, before exiting the airplane on the accident flight at 20,000 feet, they asked the pilot if he was okay. They noted that he had been unable to maintain a steady course and that he did not respond well to minor course corrections; one parachutist reported that, when the pilot was asked to turn the airplane 5°, he would turn it 90° and that he was zigzagging in the air.

No supplemental oxygen was found onboard the airplane during the recovery or subsequent examination of the wreckage, and no parachutists reported observing the pilot use supplemental oxygen. The airplane manufacturer noted that the airplane's pressurization system would have been rendered inoperable due to a nonsealed cockpit door. According to 14 CFR 91.211, *Supplemental Oxygen*: "No person may operate a civil aircraft of U.S. registry … at cabin pressure altitudes above 14,000 feet msl unless the required minimum flight crew is provided with and uses supplemental oxygen during the entire flight time at those altitudes." Hypoxia is defined as a physiological condition

[7] Some of the information for this synopsis was obtained from the public docket for the accident.

in which a person is bereft of needed oxygen. Judgment is poor and reaction time delayed. Total incapacitation, coupled with a loss of consciousness, can occur with little or no warning.

In addition, one of the parachutists stated that the accident flight was made after sunset and was performed without any lighting devices. Witnesses on the ground agreed that the accident happened about 20 to 25 minutes after sunset and that they noticed parachutists in the air with no lighting devices. According to 14 CFR 105.33, each person that jumps between sunset and sunrise should be equipped with a means of producing light that is visible for at least 3 miles. In addition, according to the chart supplement for the Pacific region, parachute jumps may be made at Dillingham Airfield up to 16,000 feet without filing a notice to airmen. According to an FAA inspector, during the accident flight, the pilot had not made any of the required radio calls to ATC, as required by 14 CFR 105.14. The inspector further noted that a review of the recorded radar data for the area disclosed that the airplane's transponder had not been turned on.

The Safety Board determined that the probable cause of the accident was the pilot's incapacitation due to the effects of hypoxia from repeated flights to altitudes above 18,000 feet msl without supplemental oxygen.

Marine City, Michigan (CHI99MA269)

On July 31, 1999, a Beech 65-A90, N518DM, operated by Parahawks Skydiving Center, crashed shortly after takeoff from Marine City Airport in Marine City, Michigan. The airline transport pilot and nine parachutists were killed. Witnesses reported that the airplane seemed to be operating normally during taxi and takeoff but that, during the climbout, the airplane did not climb above 150 to 250 feet agl. Witnesses report that the airplane entered a steep left bank, its nose dropped, and it crashed to the ground. Damage to the cockpit section of the wreckage indicated a nose-down crush angle of about 80°.

Examination of the engines and propellers revealed no preexisting failures or conditions that would have prevented normal operation. The engines exhibited indications of rotation, and the witness marks on both sets of propellers were consistent with the propellers operating in the governing range at impact. Control continuity was established from the right aileron, elevator, and rudder. The investigation revealed that the maintenance records for the airplane's required inspections were incomplete[8] and that there were no records of compliance with five airworthiness directives applicable to the accident airplane.[9]

[8] The last inspection (Phase 1) entered in the maintenance records for the airframe was completed on August 25, 1997, and the last entries in the left and right engine logbooks were recorded on February 18, 1998. A mechanic reported that he performed the airplane's Phase 2 and Phase 3 inspections and that the last phase inspection (Phase 3) was completed on June 30, 1999. Work orders for the accident airplane and partially completed Beech Phase 2 and Phase 3 inspection forms, which did not specifically identify the accident airplane, were on file at the mechanic's place of work.

[9] According to the FAA inspector's report in the public docket for the accident, with regard to the airworthiness directives, "without additional information these have to be considered not complied with."

The investigation also revealed Michigan State Motor Vehicle and court records indicating that the pilot had a history of arrests and convictions related to offenses involving alcohol and operating a motor vehicle. The first conviction on record was October 28, 1991, which resulted in a suspension of his driver's license for 6 months. The second conviction was on August 9, 1996, which resulted in a 3-month suspension of his driver's license. On September 11, 1998, the pilot was arrested on a charge of Operating Under the Influence of Liquor. The case had not come to trial at the time of the accident. According to the police report, the pilot was stopped about 0038 for improper lane use (weaving between the lanes of an interstate highway). The pilot failed a sobriety test and a preliminary breath test. A blood alcohol test indicated a reading of .12 grams of alcohol per 100 milliliters of blood. The arresting officer noted that "[The pilot] was advised that I suspected he was under the influence, and would be requesting him to take some sobriety test. At this point, [the pilot] asked me to just let him go, if I didn't let him go, he would lose his job."

The safety officer for the Parahawks Skydiving Center reported that, before the accident, he was unaware that the pilot had a record of alcohol-related offenses. The Parahawks Skydiving Center main pilot reported that he knew that the pilot had one driving while intoxicated incident but had not known of another offense. Both the safety officer and the main pilot reported that they learned about the accident pilot's other alcohol-related offenses through newspaper articles written after the accident.

Although postaccident toxicology tests for the pilot detected quantities of ethanol in some specimens, it was not possible to determine the source of the ethanol and whether or not it could be attributed to ingestion or postmortem ethanol formation. Although witnesses reported that the pilot had attended a party the night before the accident (Parahawks Skydiving Center was having its annual celebration that weekend), a police officer (a recreational parachutist who saw the pilot about 20 minutes before the accident flight) described the pilot as being in a good mood, smiling, and laughing. He stated that he talked with the pilot and observed no evidence of any effects of alcohol. Similarly, another witness who saw the pilot about 40 minutes before the accident reported that she and the pilot drank coffee together while he checked the weather for the day. She reported that the pilot seemed sharp and well rested.

The Safety Board determined that the probable cause of the accident was the pilot's failure to maintain adequate airspeed, which resulted in a stall, in-flight loss of control, and collision with the ground.

Bryan, Texas (FTW99FA261)

On September 18, 1999, a Cessna 182A, N4803D, operated by Ags Over Texas, crashed following a loss of engine power during takeoff from Coulter Field Airport near Bryan, Texas. The commercial pilot and the four parachutists were killed. Witnesses reported that, after takeoff, the airplane was climbing through about 300 to 400 feet agl when smoke became visible coming from the engine compartment. One witness reported that the airplane turned toward the runway and that the witness "thought it was going back to Coulter Field Airport. A few seconds later I saw it go straight down." Another witness stated that "the aircraft appeared to stall. The right wing dropped quickly, and the aircraft spun in, nose down, spin[ning] to the right, making one complete revolution before impacting the ground."

Examination of the engine revealed that the No. 6 cylinder head was separated where the cylinder attaches to the barrel. Metallurgical examination revealed that the cylinder head separated from its cylinder barrel as a result of fatigue cracking originating in the cylinder head thread. The cylinder displayed three work-order numbers on the flange skirt, indicative of the cylinder having had many hours of time in service and having been worked on at least three times. At the time of the accident, the engine had accumulated about 354 hours since overhaul. During that overhaul, six Nu-chromed overhauled cylinders were installed. It could not be determined how many hours the cylinders had accumulated nor how many times they had been overhauled. There is no requirement to track cylinder hours or overhaul occurrences.

The Safety Board determined that the probable cause of the accident was the pilot's failure to maintain aircraft control, resulting in an inadvertent stall. A factor was the loss of engine power as a result of fatigue cracking and separation of the No. 6 cylinder head.

Fentress, Texas (FTW01LA132)

On May 27, 2001, a de Havilland DHC-6, N125PM, collided in flight with a parachutist who had egressed another airplane (a Beech King Air 90) during a formation flight in the vicinity of Fentress, Texas. The parachutist who collided with the airplane was killed. Neither the commercial pilot and the 21 parachutists on board the de Havilland nor the commercial pilot and 8 parachutists on board the King Air were injured. Both airplanes, which were operated by Skydive San Marcos of Fentress, Texas, were being flown to perform a formation drop of parachutists from 14,000 feet msl.

The operator reported that this was the first formation drop flight for either pilot in a multi-engine airplane. Parachutists reported that the King Air and the de Havilland were initially in the correct formation with the King Air slightly behind, slightly right, and slightly lower than the de Havilland. Three parachutists climbed out of the King Air in preparation for the jump, and in the time that it took for those parachutists to climb out and for the loadmaster to tell the parachutists to exit, the King Air had flown past and was above the de Havilland.

The pilot of the King Air stated that the airplane approached the de Havilland's right side and was "a little fast." The King Air pilot reported that, upon seeing the de Havilland getting closer, the pilot decided to pitch and bank right to get more space and try to slow down. At that time, the pilot of the King Air lost visual contact with the de Havilland. Parachutists egressed from the King Air, and one parachutist collided into the right propeller of the de Havilland and began spinning out of control. The de Havilland pilot reported that "something suddenly hit the airplane" on what he thought was the right wing. The airplane started to vibrate, and the pilot shut down the right engine. Both airplanes were landed without further incident.

One parachutist, a videographer, who had egressed from the King Air, reported seeing the spinning parachutist. The videographer caught the spinning parachutist and deployed her reserve parachute by pulling the reserve handle; however, the reserve parachute did not fully inflate "due to being cut by the propeller." The spinning parachutist fell to the ground. The reserve parachute was found deployed.

The Safety Board determined that the probable cause of the accident was the King Air pilot's inadequate in-flight planning/decision in that he failed to remain in the agreed on formation position, resulting in one of his [parachutists] contacting the propeller of the de Havilland airplane. A contributing factor was the lack of total experience of both pilots in multiengine formation air drop flights.

Cushing, Oklahoma (FTW03FA174)

On June 21, 2003, a Cessna 182H, N8548S, operated by Oklahoma Skydiving Center, crashed following an in-flight loss of control near Cushing, Oklahoma. The commercial pilot was killed, two parachutists were seriously injured, two parachutists received minor injuries, and one parachutist was not injured. One witness, who was standing next to the skydiving hangar, observed one parachutist jump from the airplane and then observed the airplane bank to the left and enter a "nose dive, spinning in circles." Then, the witness observed two more parachutists exit the airplane. Another witness, who had a radio, observed the airplane "turn left and go into a flat spin, rotating to the left." The witness radioed the pilot and asked what was wrong, and the pilot replied that he was in a spin and did not know what to do. The witness replied, "flaps and power." When the airplane's altitude was about 800 feet, the witness heard the engine go from a low power setting to a high power setting and noticed another parachutist jump out. The airplane appeared to slow down from its rotation and descended below the trees.

One parachutist, who was seated on the right side of the airplane next to the exit door, reported that, when the airplane was about 3,500 to 4,000 feet, he helped the first jumper out without incident. After observing the jumper for a few seconds, he closed the door and turned to assist the second jumper. The parachutist reported that, at this point, he heard the "stall buzzer" go off, felt the airplane pitch down and to the right, and heard the pilot say that the airplane had stalled. Then, the parachutist opened the door and said "emergency, everyone out!"

Another parachutist, seated back-to-back to the pilot, reported that the airplane seemed to have a difficult time reaching 3,500 feet, the altitude designated for jumping. According to the parachutist, after the first jumper exited the airplane, the airplane started to turn left, and a buzzer went off. The parachutist reported that, as the buzzer was going off, the jumpmaster started talking to the pilot, then the nose of the airplane dropped "very quickly." The parachutist heard the jumpmaster say, "Get ready for your emergency procedures, we have an emergency!" The jumpmaster then turned around, opened the door, and jumped out. The parachutist tried to help one of the other jumpers exit the airplane, but she would not move, so the parachutist crawled to the door and fell out.

A third parachutist reported that the airplane's left wing "pointed almost straight down" and that he thought the plane was "going to roll." The pilot "corrected a little bit" but then banked again. The parachutist stated that the pilot got very busy and instructed everyone to leave the airplane. The parachutist stated that they started shuffling around to try and help one of the other jumpers exit the airplane. He stated that he moved up behind the pilot's seat and was looking at the jumpmaster and that the jumpmaster dove out. As the parachutist was helping one of the other jumpers, he pushed out the jumper who was also helping him, so he grabbed the last remaining jumper and started pushing her toward the door. He stated that he heard the airplane's engine "rev" and mentioned to the other jumper that he thought that the pilot had regained control of the airplane. He reported that the next thing he remembered was waking up with paramedics attending to him.

Examination of the airplane revealed that it impacted terrain in a wings-level attitude. No anomalies with the airplane were found. According to the factual report for this accident, the airplane was equipped with a Continental O-470-R engine that had accumulated 2,652.4 hours since major overhaul.

The Safety Board determined that the probable cause of the accident was the pilot's failure to maintain airspeed, which resulted in an inadvertent stall/spin.

Jacksonville, Florida (MIA05FA017)

On October 30, 2004, a Cessna P206, N2588X, registered to PTP, Inc., and operated by Jacksonville Extreme Sports, crashed shortly after takeoff from Herlong Airport, Jacksonville, Florida. One parachutist was killed, the commercial pilot and three parachutists were seriously injured, and one parachutist received minor injuries. Several witnesses at the airport reported that, shortly after the airplane lifted off, it entered a steep, nose-high attitude then pitched nose down, rolled left, and disappeared behind trees.

One parachutist reported that the airplane pitched up after becoming airborne. He moved forward and noticed that the pilot was "frantically" moving the elevator trim wheel 4 or 5 times toward the nose-down direction. The parachutist stated that the airplane then descended in a left-wing-low attitude. The parachutist and several witnesses at the airport reported hearing no discrepancies with the engine.

According to the factual report for this accident, the airplane was equipped in 2001 with a new Teledyne Continental Motors IO-550-F engine that had accumulated 1,774 hours since new. Examination of the airplane revealed no evidence of preimpact failure or malfunction of the engine, and flight control continuity was confirmed for roll, pitch, yaw, and pitch trim. The elevator trim tab actuator was measured and found extended approximately 1.2 inches, which is consistent with about 10° tab down (airplane nose up). The airplane's before-takeoff checklist indicates to set the elevator trim to the takeoff setting; the maximum elevator trim trailing-edge-down takeoff setting is 4°. The pilot reported that he had twice previously performed takeoffs in the accident airplane when the elevator trim was in the full nose-up position and that, during those occasions, he moved the elevator trim to the nose-down direction and continued the takeoff.

The Safety Board determined that the probable cause of the accident was the improper setting of the elevator trim by the pilot-in-command, his failure to follow the checklist related to elevator trim setting, and his failure to maintain [airspeed] during climb after takeoff, resulting in an inadvertent stall, uncontrolled descent, and in-flight collision with terrain.

Deland, Florida (MIA05LA096)

On April 23, 2005, a de Havilland DHC-6, N24HV, operated by Skydive Deland, Inc., collided with a cinematographer parachutist during the downwind leg for landing at Deland Municipal-Sidney H. Taylor Field, Deland, Florida. The cinematographer parachutist was killed, and the commercial pilot and 13 parachutists were uninjured. The airplane incurred substantial damage to the left wing.

The pilot stated that, after the 14 jumpers left the airplane at 13,500 feet, southwest of the airport, he started his descent to the northeast. He approached the airport from the northeast, overflew the airport, and made a left turn to enter the downwind leg for runway 23. He stated that he saw some parachutes on the ground and some in the air and that he believed that he had accounted for all jumpers. As he turned left, he saw a flash of colors and felt an impact and drag from the left wing. He landed the airplane as soon as possible.

Radar data indicated that the airplane was about 1,300 feet msl when it was approaching the runway from the northeast; the airport elevation is 79 feet msl. The airplane flew about 1,100 feet msl over runway 23 near midfield and was between 900 to 800 feet msl during the left bank entering the downwind for runway 23. The last radar capture showed the airplane at 300 feet msl as it approached runway 23. One parachutist stated that the parachute landing zone was located on the airport adjacent to the left side of runway 30. The published traffic pattern attitude for the airport is 1,000 feet agl for propeller airplanes.

One of the master tandem jumpers on the accident flight stated that the pilot did not give a briefing on which runway or approach he was going to use. The company's procedure is for the parachutists to avoid crossing runways below 1,000 feet and to stay about 300 feet away from the runways and for the pilot to avoid jumpers at all times. Due to the amount of jumps that are performed per day, there is no briefing before each flight. Approaches and runway selection depends on the individual pilot. A representative of the operator stated that only verbal guidance is given to the pilots to follow the FAA rules and that it is left to the pilots' discretion for approaches and runway selection. The acting airport manager stated that there is no agreement for airport operations between Skydive Deland and the city. Several pilots at the airport stated that, for several years, they communicated with the city regarding safety concerns with approaches and runway selection by the parachute jump operator. They stated that the city did not correct the situation.

The Safety Board determined that the probable cause of the accident was the pilot's inadequate visual lookout.

Sullivan, Missouri (CHI06FA210)

On July 29, 2006, a de Havilland DHC-6-100, N203E, operated by Skydive Quantum Leap, crashed into trees and terrain following a loss of engine power in the right engine shortly after takeoff from Sullivan Regional Airport near Sullivan, Missouri. The pilot and five parachutists were killed, and two parachutists were seriously injured. According to photographic evidence provided by a witness, the airplane was taxied onto the runway from an intersecting taxiway about 1,700 feet from the runway's west end; the airplane began its takeoff roll to the west from that location. Witnesses at the airport reported that they saw the airplane take off and climb to about treetop height, then they heard a "poof" or "bang" noise and saw flames and smoke coming from the right engine. Witnesses reported that the airplane lost some altitude but regained it, then flew at a level altitude about treetop height and turned to the right, disappearing from their view behind the treeline. Another witness, who was in the back yard of a residence located about 1/2 mile northwest of the end of the runway, stated that she saw the airplane flying straight-and-level but very low, then it dived nose first to the ground.

Disassembly examination of the left engine revealed rubbing in the compressor and turbine sections. No preimpact anomalies were detected. Disassembly of the right engine revealed that the compressor turbine disk was intact and its attached blades[10] were fractured. Microscopic examination of the fracture surfaces revealed features consistent with overload. No preimpact anomalies were observed forward of this point in the engine's gas path. The left and right engines had accumulated 5,829 hours and 6,493 hours since overhaul, respectively. According to Pratt & Whitney SB 1803R1, the manufacturer's recommended time between overhaul for the engines is 3,600 hours.[11]

Examination of both propellers revealed no preimpact anomalies. Examination of the right propeller assembly revealed that the blades were at high angles at impact, which corresponds to a feather or near-feather condition and that the blades cycled from high to low pitch when air pressure was applied to a fixture attached to the hub's mounting flange. Because of the impact damage to the cockpit propeller lever controls, it was not possible to determine their preimpact positions. The investigation revealed that the propeller autofeather system had been inoperative since the operator acquired the airplane in 2001 and that its status was placarded in the cockpit. According to 14 CFR 91.213, no person may take off in a turbine-powered airplane with inoperative instruments or equipment

[10] The compressor turbine blades were FAA PMA blades manufactured by Doncasters, Inc,, Turbo Products Division, part number T-023401J.

[11] Pratt & Whitney Canada reported that it had no documentation indicating that the operator had requested to participate in a TBO extension program.

installed unless an FAA-approved minimum equipment list (MEL) exists for that airplane and the airplane has within it a letter of authorization from the local flight standards district office (FSDO) authorizing its operation under the MEL. A review of records on file at the St. Louis, Missouri, FSDO revealed that the operator had no letter of authorization or MEL on file for the accident airplane.

The FAA's St. Louis FSDO had jurisdiction over the geographic area that included Skydive Quantum Leap's operations. Following the accident, a review of FAA Program Tracking and Reporting Subsystem (PTRS) data and Safety Performance Analysis System (SPAS) data showed three SPAS records of FAA contacts with Skydive Quantum Leap regarding the operator's Certification of Waiver or Authorization Application requests for airspace associated with the parachute operations. No PTRS or SPAS data showed records of any FAA contacts with the operator for maintenance or operations surveillance.

The Safety Board determined that the probable cause of the accident was the pilot's failure to maintain airspeed following a loss of power in the right engine due to the fracturing of compressor turbine blades for undetermined reasons. Contributing to some parachutists' injuries was the lack of a more effective restraint system on the airplane.

Marion, Montana (SEA07FA119)

On May 12, 2007, a Cessna 182C, N8771T, collided with terrain while maneuvering for a precautionary landing shortly after takeoff from Carson Field Airstrip, Marion, Montana. The commercial pilot and four parachutists were killed. Witnesses observed the airplane take off from runway 32, make a 180º turn toward the south, and then fly downwind and parallel to the runway at an altitude of between 300 and 500 feet agl. Near the end of the runway, the airplane made a left turn onto the base leg for runway 32, followed by a steep turn to the final approach before nosing into the ground and bursting into flames.

Examination of the airplane revealed that the engine's oil cap was not attached to the oil filler tube. As a result of the engine's oil filler cap not being secured to the oil filler tube, it is reasonable to expect that an amount of oil would have escaped the engine and blown back over the pilot's windscreen, thereby obstructing his vision. Further, weight and balance information for the flight indicated that the airplane was about 165 lbs over its maximum gross takeoff weight. The obstructed windscreen, coupled with the airplane's gross takeoff weight being exceeded, would most probably explain the pilot's loss of control while attempting to return to the runway. No preimpact anomalies were noted with either the airframe or the engine.

The Safety Board determined that the probable cause of the accident was the pilot's failure to maintain aircraft control while maneuvering to reverse direction. Factors included the airplane exceeding its maximum gross takeoff weight, improper preflight by the pilot by not securing an oil cap, the low altitude, and an obstructed windshield.

Mount Vernon, Missouri (DEN08FA078)

On April 19, 2008, a Cessna P206, N2537X, operated by Freefall Express Skydiving, Inc., impacted terrain following an in-flight loss of control near Mount Vernon, Missouri. Two parachutists were killed, the commercial pilot and one parachutist were seriously injured, and three parachutists were not injured. This accident was under investigation at the time of this report's release.[12]

According to two of the surviving parachutists, the airplane had climbed to 10,500 feet msl, and the pilot signaled for one of the parachutists to open the door. When she did, she noticed that the airplane had overshot the drop zone by about 1 mile, and she informed the pilot. She stated that, as the airplane started to make a right turn, the stall warning horn sounded, and the airplane "rolled off on its right wing" and entered a spin. Three parachutists exited the airplane and parachuted to safety. A fourth parachutist broke her right leg as she exited the airplane, but she parachuted to safety. The reserve parachute on the fifth parachutist deployed but became entangled around the tail of the airplane; she was killed. The sixth parachutist, who also did not survive, was found inside the airplane.

Examination of the accident site revealed that the airplane impacted trees and terrain and came to rest in a nose-down, slightly inverted attitude. Chop-like marks were evident on several tree trunks. Preliminary examination of the airplane revealed that flight control continuity was established.

[12] Preliminary information is subject to change and may contain errors.