In-Flight Engine Failure and Subsequent Ditching, Air Sunshine, Inc., Flight 527, Cessna 402C, N314AB, About 7.35 Nautical Miles West-Northwest of Treasure Cay Airport, Great Abaco Island, Bahamas, July 13, 2003

Micro-summary: **This Cessna 402C ditched following an engine failure.**

Event Date: **2003-07-13 at 1530 EDT**

Investigative Body: **National Transportation Safety Board (NTSB), USA**

Investigative Body's Web Site: **http://www.ntsb.gov/**

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About 7.35 Nautical Miles West-Northwest of Treasure Cay Airport, Great Abaco Island, Bahamas
July 13, 2003

Aircraft Accident Report

NTSB/AAR-04/03

PB2004-910403
Notation 7671A

National Transportation Safety Board
Washington, D.C.

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Adopted October 13, 2004

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

National Transportation Safety Board. 2005. ***In-Flight Engine Failure and Subsequent Ditching, Air Sunshine, Inc., Flight 527, Cessna 402C, N314AB, About 7.35 Nautical Miles West-Northwest of Treasure Cay Airport, Great Abaco Island, Bahamas, July 13, 2003.*** **Aircraft Accident Report NTSB/AAR-04/03. Washington, DC.**

Abstract: This report explains the accident involving Air Sunshine, Inc., flight 527, a Cessna 402C, which experienced an in-flight engine failure and was subsequently ditched about 7.35 nautical miles west-northwest of Treasure Cay Airport, Great Abaco Island, Bahamas. The safety issues discussed in this report include maintenance record-keeping and practices, pilot proficiency, Federal Aviation Adminstration (FAA) oversight, and emergency briefings. A safety recommendation concerning emergency briefings is addressed to the FAA.

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Abbreviations

A&P	airframe and powerplant
AAIP	Approved Aircraft Inspection Program
ARTCC	air route traffic control center
ATP	airline transport pilot
CFI	certified flight instructor
CFR	*Code of Federal Regulations*
CG	center of gravity
CVR	cockpit voice recorder
F	Fahrenheit
FAA	Federal Aviation Administration
FDR	flight data recorder
FLL	Fort Lauderdale/Hollywood International Airport
fpm	feet per minute
FSDO	Flight Standards District Office
Hg	mercury
KIAS	knots indicated airspeed
METAR	meteorological aerodrome report
MYAT	Treasure Cay Airport
MYGF	Grand Bahamas International Airport
PFD	personal flotation device
PIC	pilot-in-command
PMI	principal maintenance inspector
psi	pounds per square inch
PTRS	Program Tracking and Recording System
SB	service bulletin
SJU	Luis Munoz Marin International Airport
SRQ	Sarasota/Bradenton International Airport
TBO	time between overhaul
TCM	Teledyne Continental Motors
TSO	Technical Standard Order

Executive Summary

On July 13, 2003, about 1530 eastern daylight time, Air Sunshine, Inc. (doing business as Tropical Aviation Services, Inc.), flight 527, a Cessna 402C, N314AB, was ditched in the Atlantic Ocean about 7.35 nautical miles west-northwest of Treasure Cay Airport (MYAT), Treasure Cay, Great Abaco Island, Bahamas, following the in-flight failure of the right engine. Four of the nine passengers sustained no injuries, three passengers and the pilot sustained minor injuries, and one adult and one child passenger died after they evacuated the airplane. The airplane sustained substantial damage. The airplane was being operated under the provisions of 14 *Code of Federal Regulations* Part 135 as a scheduled international passenger commuter flight from Fort Lauderdale/Hollywood International Airport, Fort Lauderdale, Florida, to MYAT. Visual meteorological conditions prevailed for the flight, which operated on a visual flight rules flight plan.

The National Transportation Safety Board determines that the probable cause of this accident was the in-flight failure of the right engine and the pilot's failure to adequately manage the airplane's performance after the engine failed. The right engine failure resulted from inadequate maintenance that was performed by Air Sunshine's maintenance personnel during undocumented maintenance. Contributing to the passenger fatalities was the pilot's failure to provide an emergency briefing after the right engine failed.

The safety issues discussed in this report include maintenance record-keeping and practices, pilot proficiency, Federal Aviation Administration (FAA) oversight, and emergency briefings. A safety recommendation concerning emergency briefings is addressed to the FAA.

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1. Factual Information

1.1 History of Flight

On July 13, 2003, about 1530 eastern daylight time,[1] Air Sunshine, Inc. (doing business as Tropical Aviation Services, Inc.),[2] flight 527, a Cessna 402C, N314AB, was ditched in the Atlantic Ocean about 7.35 nautical miles west-northwest of Treasure Cay Airport (MYAT), Treasure Cay, Great Abaco Island, Bahamas, after the in-flight failure of the right engine. Two of the nine passengers[3] sustained no injuries, five passengers and the pilot sustained minor injuries, and one adult and one child passenger died after they evacuated the airplane.[4] The airplane sustained substantial damage. The airplane was being operated under the provisions of 14 *Code of Federal Regulations* (CFR) Part 135 as a scheduled international passenger commuter flight from FLL to MYAT.[5] Visual meteorological conditions prevailed for the flight, which operated on a visual flight rules flight plan.

The accident pilot was scheduled to fly the accident airplane on a 2-day trip sequence, which began about 0900 on July 12, 2003. The pilot flew five flights, each of which lasted about 1 hour, on the first day of the trip sequence. The last flight was from FLL to Sarasota/Bradenton International Airport (SRQ), Sarasota, Florida, and it arrived at SRQ about 1930. All of the first day's flights were uneventful, and the pilot reported no engine- or airframe-related discrepancies for any of the flights.

On July 13, 2003, the pilot arrived at SRQ about 0830 for the second day of the trip sequence. The pilot was scheduled to conduct five flights, each of which was to last about 1 hour. The first flight departed SRQ about 0930 and arrived at FLL about 1030. The second flight departed FLL about 1100 and arrived at MYAT about 1200. The third

[1] Unless otherwise indicated, all times in this report are eastern daylight time. The airplane was not equipped with a cockpit voice recorder (CVR) and was not required to be so equipped. Therefore, all times referenced in this report are approximations, except for the takeoff time, which was determined by reference to transcripts of voice recordings obtained from the Fort Lauderdale/Hollywood International Airport (FLL) air traffic control tower and the Miami Automated International Flight Service Station.

[2] Air Sunshine and Tropical Aviation Services are two separate companies owned and operated by the same people.

[3] Four of the nine passengers were children; one of the children was under 2 years of age and was seated on an adult passenger's lap during the flight.

[4] The search for, and rescue of, the surviving airplane occupants (and recovery of the bodies of the two other airplane occupants) is discussed in section 1.15.4.

[5] Under the provisions of Annex 13 to the Convention on International Civil Aviation, the investigation of an airplane crash is the responsibility of the state of occurrence (the state or territory in which an accident or incident occurs, which in this case was the Bahamas). However, the state of occurrence may delegate all or part of an investigation to another state by mutual arrangement or consent. At the request of the Bahamian Government, the National Transportation Safety Board assumed full responsibility for the investigation. The Bahamian Government designated an accredited representative to the investigation.

flight departed MYAT about 1215 and arrived at FLL about 1330. All of the flights were reported to be uneventful.

The pilot stated that, before departing on the fourth flight of the day, from FLL to MYAT, he conducted a preflight inspection of the airplane, which included checking the oil quantity. The accident flight was cleared for takeoff at 1427:11 and was estimated to last about 1 hour 10 minutes.

During postaccident interviews, passengers stated that, before starting the engines, the pilot briefed[6] them on the location of the personal flotation devices (PFD),[7] the exits, and the safety briefing cards[8] and on the need to keep their lapbelts fastened during the flight. One of the passengers who accompanied a child noted that the pilot's briefing did not include how to handle children during an emergency and added that the briefing was "short and rushed."

The pilot and adult passengers stated that the cruise portion of the flight was uneventful, and the pilot stated that the engine instruments showed no indications of a mechanical problem. The pilot indicated that the flight's cruise altitude was about 7,500 feet and that the cruise speed was about 160 knots indicated airspeed (KIAS).[9]

The pilot stated that, during the descent into MYAT, he maintained the same power setting that he used during cruise flight, which was about 2,300 rpm and 27 inches of mercury (Hg) manifold pressure. The pilot stated that, about 20 to 25 miles from MYAT (about 45 to 50 minutes into the flight), while descending to about 3,500 feet, he heard a bang and saw oil coming out of the right engine cowling.[10]

The adult passenger in the copilot's seat (the seat to the right of the pilot seat) reported seeing a "stream of oil" coming from the right engine and stated that he notified the pilot of his observation. Several of the other adult passengers reported seeing white smoke coming from the right engine. These passengers stated that the smoke was followed

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[6] Title 14 CFR 135.117(a) requires pilots to brief passengers orally before departure. Section 135.117(a) states that the predeparture briefing should include, in part, information on the use of safety belts, the location of and instructions for opening the passenger entry door and emergency exits, and the location of survival equipment.

[7] The airplane was equipped with 10 PFDs that were sealed in plastic pouches. Eight of the PFDs were stowed under the forward edge of each passenger seat. The PFDs for the pilot and copilot positions were stowed outboard of each pilot seat. For more information, see section 1.15.3.

[8] The safety briefing cards were contained in the stowage pockets located on the back of each seat.

[9] The airplane was not equipped with a flight data recorder (FDR) and was not required to be so equipped. Data from the Nassau Air Route Surveillance Radar (about 125 miles south of the accident site) did not indicate any targets in the Bahamas airspace consistent with the reported route and altitude of flight 527. Other aircraft were observed at an altitude of about 6,600 feet and above near Grand Bahamas Island and at an altitude of about 5,100 feet and above near the ditching site. All flight altitudes and speeds referenced in the report are based on the pilot's recollections.

[10] From June 12 to 14, 2003, Air Sunshine's Director of Maintenance and an assistant mechanic performed differential compression checks on the accident airplane's right engine cylinders during the airplane's last recorded engine maintenance. For more information about these checks, see section 1.6.1.2.1.

by a stream of oil and then the sound of a loud bang. They reported seeing parts falling from the engine after they heard the loud bang.

The pilot stated that, after he heard the bang, he reduced power to the right engine. The pilot indicated that, at the time of the event, the airplane's airspeed was about 135 to 140 KIAS. He added that the airspeed for a normal descent should be about 140 knots. The pilot stated that he then saw that the engine magnetos had penetrated through the engine cowling and that the magnetos were hanging from wires. He added that he did not see any other damage. He stated that he noticed that the right engine oil pressure indication was decreasing rapidly. He added that the fuel selector was "in the green" (that is, each engine was being provided fuel from its respective main fuel tank). He stated that he attempted to feather[11] the right propeller and shut down the engine[12] but that the propeller continued "wind-milling" (turning) slowly. The passenger in the copilot seat and the adult passenger in the seat behind the copilot's seat also reported that the pilot tried to feather the right propeller but that it continued to turn after the engine failed.[13]

The pilot stated that, after he attempted to shut down the right engine, he applied full power to the left engine and tried to fly the airplane but that he could not maintain altitude. He stated that he slowed the airplane to "blue line" (single-engine best climb rate) airspeed, which is about 105 KIAS, and that, at that point, the airplane was at a descent rate of about 200 to 300 feet per minute (fpm).

The pilot stated that he contacted Air Sunshine's station manager at MYAT after trying to shut down the engine. The station manager stated that the pilot told him that the right engine had failed and that he was at an altitude of about 3,000 feet. The manager added that the pilot asked him to contact the company's Director of Operations at FLL, which the manager did. Air Sunshine's Director of Operations told the manager to ask the pilot if the propeller on the failed engine was feathered, and the pilot responded that it was. The Director of Operations then asked the manager to get the airplane's distance from the airport, altitude, and descent rate; the pilot responded that he was about 15 miles from the airport[14] at an altitude of about 2,000 feet with a descent rate of about 200 fpm. The Director of Operations instructed the manager to tell the pilot to "keep the good engine at full power, bank to the good engine and to just stay calm and fly the plane." The pilot told the manager that he had already "done all of those things."

[11] Feathering means to rotate the propeller blades so that the blades are parallel to the line of flight to reduce drag and prevent further damage to an engine that has been shut down.

[12] The pilot stated that he did not follow Air Sunshine's procedures for an in-flight engine failure because he knew which engine had failed; therefore, he chose to immediately shut down the right engine. He added that he did not follow the engine failure checklist because he was "too busy flying the airplane." For more information about Air Sunshine's in-flight engine failure procedures, see section 1.17.1.1.

[13] The pilot and both passengers reported that the right propeller continued turning until the airplane contacted the water.

[14] The airplane was equipped with a global positioning system, which the pilot used to determine the airplane's distance from the airport.

The station manager stated that he then alerted local agencies about the emergency and instructed another Air Sunshine pilot, who had just taken off from Marsh Harbor, Bahamas, for FLL, to divert that flight toward flight 527 and follow the airplane until it reached the airport. The Air Sunshine pilot transmitted a distress call for flight 527, which the pilot of a nearby flight (Gulf flight 9267) heard and relayed to the Federal Aviation Administration (FAA) Air Route Traffic Control Center (ARTCC), Miami, Florida.

The pilot stated that, after talking to the station manager, he slowed the airplane to about 95 KIAS to try to maintain altitude. The pilot stated that, once he descended from about 1,500 to 1,000 feet, he realized the airplane could not make it to the airport and that he would have to ditch the airplane. The pilot stated that he ditched the airplane parallel to the waves with the flaps retracted. He added that, at the time of the ditching, the winds were about 15 knots, and the outside air temperature was about 80° to 90° Fahrenheit (F). The passenger in the copilot seat stated that the pilot did a good job ditching the airplane. He stated that he noticed a placard on the instrument panel with instructions for ditching, which stated that the airspeed should be kept in the "blue zone," and that the airspeed was within this zone during the ditching. Adult passengers described the contact with the water as "very hard." They stated that the airplane landed "flat" and that it did not dive into the water.

During postaccident interviews, the passengers stated that the pilot did not instruct them to retrieve their PFDs or to assume a brace position before contact with the water. The passengers stated that the only time the pilot addressed them after the right engine failed and before the airplane contacted the water was to tell them to "calm down."

The airplane was located at 26° 45.547' north latitude and 77° 31.642' west longitude. The accident occurred during daylight hours.

1.2 Injuries to Persons

Injuries	Flight Crew	Cabin Crew	Passengers	Other	Total
Fatal	0	0	2	0	2
Serious	0	0	0	0	0
Minor	1	0	5	0	6
None	0	0	2	0	2
Total	1	0	9	0	10

1.3 Damage to Airplane

The airplane sustained substantial damage.

1.4 Other Damage

No other damage was reported.

1.5 Personnel Information

1.5.1 The Pilot

The pilot, age 46, was hired by Air Sunshine in September 1995. He held an airline transport pilot (ATP) certificate, which was issued March 7, 1998, with a multiengine land rating. Additionally, he held a commercial pilot certificate with a single-engine land rating and a certified flight instructor (CFI) certificate with single-engine, multiengine, and instrument ratings. The pilot held an FAA first-class medical certificate, dated June 9, 2003, with no limitations.

According to the pilot, he began flight training at Aviation Training, Hayward, California. The pilot reported that, before he began working for Air Sunshine, he worked as a first officer on Embraer 110 airplanes for Payam Aviation Services, Tehran, Iran, for 2 years.

The pilot began working for Air Sunshine in September 1995, performing clerical work for about 6 months before starting the company's flight training. He served as first officer on the company's Embraer 110 for about 1 1/2 years, during which time he earned his ATP certificate. In 1998, he upgraded to captain on the Cessna 402. He resigned from Air Sunshine on September 29, 2002. From September 30 to November 11, 2002, the pilot received flight training at Arrow Air, Inc., in Miami.[15] The pilot left Arrow Air because he could not complete the training.[16] On November 23, 2002, the pilot was rehired by Air Sunshine.

Air Sunshine records indicated that the accident pilot had accumulated a total flying time of about 8,000 hours, about 5,500 hours of which were as pilot-in-command (PIC) and about 5,000 hours of which were in Cessna 402 airplanes. He had flown about 251, 69, 13, and 6 hours in the last 90, 30, and 7 days, and 24 hours, respectively. The pilot's last PIC line check occurred on July 9, 2002; his last PIC proficiency check occurred on January 14, 2003; and his last recurrent ground training occurred on June 14, 2003. A search of FAA records found no evidence of enforcement actions.

[15] Arrow Air is a 14 CFR Part 121 supplemental all-cargo air carrier. During the time that the pilot was in training, the company operated McDonnell Douglas DC-8 and Lockheed L-1011 airplanes.

[16] A review of Arrow Air's simulator training records for the pilot revealed that he had received a large number of "unsatisfactory" grades. Further, the records indicated that the pilot needed to improve his scanning and checklist skills, including response and organization.

FAA records revealed that the pilot had been involved in an incident on June 12, 1999, in which the nose landing gear collapsed during landing at FLL. The pilot and passengers were not injured, and the airplane sustained minor damage. The records also revealed that the pilot was involved in an accident on March 16, 2000, in which a tire failed during takeoff from FLL.[17] The pilot aborted the takeoff but was unable to keep the airplane on the runway. The pilot and passengers were not injured, and the airplane received substantial damage. Further, a review of the FAA's Program Tracking and Reporting System (PTRS) records revealed that, on September 13, 2000, the pilot failed a ramp check because his airplane was found to have numerous discrepancies and his passenger briefing was found to be inadequate.

As previously stated, the pilot was scheduled for a 2-day trip sequence on July 12 and 13, 2003. Between 0900 and 1700 on July 12th, the pilot flew five flights and accumulated about 5 hours of flight time. All of the flights were conducted in the accident airplane. The pilot stated that, after the last flight (FLL to SRQ), he ate, watched some television, and went to bed between about 2230 and 2300.

The pilot stated that he awoke about 0730 on July 13th and arrived at SRQ about 0830 to report for the second day of the trip sequence, which consisted of five scheduled flights starting about 0930. Each flight was expected to last about 1 hour. The pilot completed three of the scheduled flights before the accident flight occurred.

1.5.1.1 Flight Check History

Between April 1983 and February 1998, the pilot received the following notices of disapproval from the FAA:

- In April and May 1983, the pilot received notices of disapproval because he failed the entire flight test portion of the flight checks[18] he was receiving for his private pilot certificate. On June 22, 1983, the pilot was rechecked successfully, and he received his private pilot certificate.
- On October 30, 1985, the pilot received a notice of disapproval because he failed the "holding" and the "recovery from an unusual attitudes" portions of the flight check he was receiving for his instrument rating. On November 8, 1985, the pilot was rechecked successfully, and he received his instrument rating.
- In December 1987 and February 1988, the pilot received notices of disapproval because he failed the entire flight test portion of the flight checks he was receiving for his CFI certificate. On March 17, 1988, the pilot was rechecked successfully, and he received his CFI certificate.

[17] A description of this accident, MIA00LA109, can be found on the Safety Board's Web site at <http://www.ntsb.gov>.

[18] If a pilot receives a notice of disapproval for a flight check, the pilot can be required to be rechecked on the complete flight check or on designated portions of the flight check.

- In July 1988 and May 1989, the pilot received notices of disapproval because he failed the entire flight test portion of the flight checks he was receiving for his CFI instrument rating. In August 1989, he received another notice of disapproval because he failed the "holding" portion of the flight check and did not complete three other portions of the check. On December 8, 1989, the pilot was rechecked successfully, and he received his CFI instrument rating.
- In February 1998, the pilot received a notice of disapproval because he failed the "nondirectional beacon approach" portion of the flight check he was receiving for his ATP certificate. On March 7, 1998, the pilot was rechecked successfully, and he received his ATP certificate.

1.5.2 The Director of Maintenance

Air Sunshine's Director of Maintenance was hired by the company in March 1997 as a mechanic; seven months later, he was promoted to Director of Maintenance.

On October 28, 1989, the Director of Maintenance applied for his airframe and powerplant (A&P) certificate based on work experience[19] he obtained while working as an assistant mechanic from March 1985 to the date of the application. On October 24, 1990, the director took the oral and practical examinations required by 14 CFR 65.79.[20] He passed all of the oral examinations; however, he failed the following portions of the practical exam: Section I, General – Airframe and Powerplant, subsections (A) weight and balance and (B) completion of FAA Form 337; and Section IV, Powerplant Theory and Maintenance, subsection (A) troubleshooting of turbine engines. The director received additional training in these areas and retook the practical exam on October 30, 1990, at which time he received his A&P certificate. A search of FAA records found no evidence of enforcement actions.

The Director of Maintenance reported that, from March 1985 to August 1990, he worked as an assistant mechanic on Cessna 402 airplanes at Airways International, a 14 CFR Part 135 on-demand charter operator in Miami. From January 1988 to March 1989, he also worked part-time as an assistant mechanic on McDonnell Douglas DC-10 and Lockheed L-1011 airplanes at Eastern Airlines in Miami. From mid-1990 to mid-1996, he worked as a mechanic at Airways International. From August 1996 to March 1997, he worked as a mechanic on Cessna 402, 210, and 206; Piper Cherokee; Britten-Norman Islander; and Beechcraft 55 and 58 airplanes at Flightline of America, Pembroke Pines, Florida.

[19] According to 14 CFR 65.77, "Experience Requirements," "each applicant [for a mechanic certificate or rating]…must present either an appropriate graduation certificate or certificate of completion from a certificated aviation maintenance technician school or documentary evidence of…at least 30 months of practical experience concurrently performing the duties appropriate to both the airframe and powerplant ratings."

[20] According to 14 CFR 65.79, "Skill Requirements," "each applicant [for a mechanic certificate or rating]…must pass an oral and a practical test on the rating he seeks. The tests cover the applicant's basic skill in performing practical projects on the subjects covered by the written test for that rating. An applicant for a powerplant rating must show his ability to make satisfactory minor repairs to, and minor alterations of, propellers."

1.5.3 The Assistant Mechanic

Air Sunshine's assistant mechanic was hired by the company on June 6, 2000, to work in San Juan, Puerto Rico. In March 2003, he transferred to the company's facility at FLL. The assistant mechanic did not have an A&P certificate.

On March 31, 2003, the Director of Maintenance signed off a Certificate of Training for the assistant mechanic, indicating that he had completed 30 hours of basic indoctrination training. On April 30, 2003, the director signed off a Certificate of Training for the assistant mechanic, indicating that he had completed 60 hours of aircraft subjects training. On June 30, 2003, the director signed off a Certificate of Training for the assistant mechanic, indicating that he had completed 200 hours of on-the-job training for the "entire aircraft, airframe, engine, propeller, accessories, etc."

1.6 Airplane Information

The accident airplane, serial number 402C0413, was manufactured by Cessna Aircraft Company on November 24, 1980. The airplane was operated by several airlines[21] before being sold to Tropical International Airlines, Inc.,[22] on August 29, 1997. From mid-1997 to late 2000, the airplane was kept at the company's maintenance facility at FLL. Air Sunshine's President stated that, during this time, extensive maintenance was being performed on the airplane, including left and right engines and propellers replacement, sheet metal repair, corrosion treatment, and landing gear repair, to make it airworthy.

Tropical International Airlines leased the airplane to Air Sunshine on November 1, 2000.[23] The airplane was inspected in accordance with Air Sunshine's FAA Approved Aircraft Inspection Program (AAIP) on November 20, 2000, and found to be airworthy.[24] The airplane was added to the company's operations specifications on December 6, 2000.

The airplane was configured with a pilot seat (left side), a copilot seat (right side), and eight passenger seats. (See figure 1.) The airplane was equipped with a window escape hatch adjacent to the pilot seat (1A); an emergency escape hatch adjacent to seats 2B and 3B; and a two-section outward opening airstair door (main cabin door) adjacent to seats 4A and 5A, the lower portion of which was equipped with stairs. The pilot and copilot seats were equipped with lapbelts and single-strap shoulder harnesses, and the passenger seats were equipped with lapbelts.

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[21] On March 1, 1992, the airplane was involved in a nose landing gear collapse while being operated by Airways International. For more information about this accident, MIA92IA090, see the Safety Board's Web site at <http://www.ntsb.gov>.

[22] Tropical International Airlines was owned and operated by the same people who own and operate Air Sunshine.

[23] The lease agreement stated that Air Sunshine would be responsible for all expenses, including maintenance.

[24] For more information about Air Sunshine's AAIP, see section 1.6.1.1

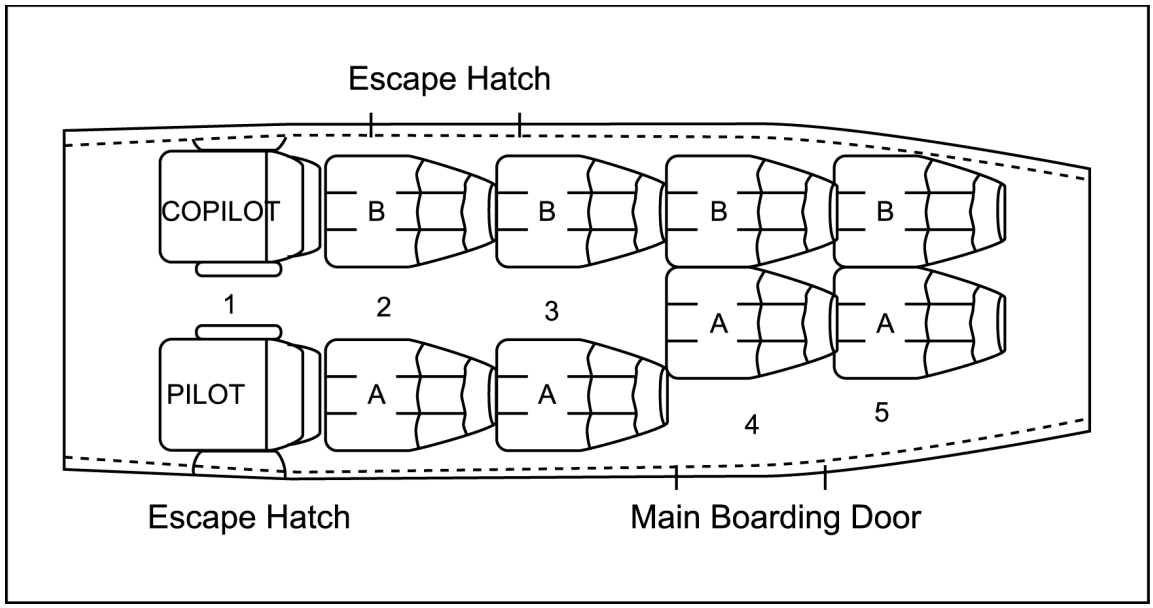


Figure 1. Interior configuration of the accident airplane.

According to the load manifest form for the accident flight, the airplane's takeoff weight was about 6,644 pounds, including 890 pounds of passenger weight,[25] 350 pounds of baggage weight, and 800 pounds of fuel weight. The airplane's takeoff center of gravity (CG) was 154.61 inches aft of the reference datum. After the airplane was retrieved from the water,[26] the baggage was removed from the airplane, dried, and weighed. The baggage weighed 440.85 pounds, 90 pounds more than the amount that was entered on the load manifest form. After applying the additional 90 pounds, the weight and CG were still within acceptable limits.[27]

1.6.1 Engines and Propellers

The airplane was equipped with two Teledyne Continental Motors (TCM) TSIO-520-VB reciprocating engines. These engines are turbo-charged and fuel-injected with six horizontally opposed air-cooled cylinders. The engines are rated for 325 horsepower at a power setting of 2,700 rpm with 39 inches Hg manifold pressure up to an altitude of 12,000 feet.

[25] Actual passenger weights were used to calculate the total passenger weight.

[26] The airplane was retrieved from the water on August 3, 2003. The retrieval was delayed because of choppy waters.

[27] According to the Cessna 402C *Pilot Operating Handbook*, the airplane's maximum gross takeoff weight is 7,210 pounds, and the maximum gross landing weight is 6,850 pounds. The maximum forward CG for flight 527 was 151.2 inches aft of the reference datum, and the maximum aft CG for the flight was 160.7 inches.

The engine cylinders incorporate an overhead inclined valve design. The cylinders have updraft intake inlets and downdraft exhaust outlets mounted to the underside of the cylinder heads. Each of the six cylinders is attached to the engine case by a series of threaded studs, through bolts, and nuts. Six 7/16-inch, 20 threads-per-inch studs are threaded into the case half for exclusive use at each cylinder location and are held down by 6-point nuts. Additional studs are positioned between the cylinders and are shared by adjacent cylinders. Two 1/2-inch through bolts, which are located at the engine crankshaft main bearing positions, are either shared by opposed cylinders or the opposite crankcase half and are held down by 12-point nuts.

The right engine, serial number 529092, and the left engine, serial number 811069-R, were manufactured by TCM on February 1, 1991, and January 1, 1997, respectively. Airmark Overhaul, Inc., in Fort Lauderdale[28] overhauled the right and left engines on December 14 and December 21, 1999, respectively.[29] At the time of overhaul, the right and left engines had times since new of 3,582.6 flight hours and 2,400.0 flight hours, respectively. The right and left engines were installed on the accident airplane on October 10 and 7, 2000, respectively. The last routine engine maintenance, which included changing the oil, inspecting the oil filter, looking for leaks, and performing a ground run-up, was conducted on July 8, 2003, and the time since overhaul for both engines at that time was 2,246.5 flight hours. At the time of the accident, both engines had a time since overhaul of 2,270.6 flight hours.[30]

The airplane was equipped with two McCauley Propeller Systems 3AF32C505-C three-bladed, dual-acting, constant-speed propellers. The blades are counterweighted to help move them toward higher blade angles (that is, toward feather) during operation. A feather spring inside the propeller moves the blades to the high-pitch (feather) stops. A centrifugal start-lock system, which uses spring-loaded pins that engage the piston as the propeller speed drops below approximately 600 rpm, prevents the blades from traveling all the way to feather during normal engine shutdowns, which reduces the load on the engine during subsequent engine starts.

1.6.1.1 Air Sunshine's Approved Aircraft Inspection Program

As a 14 CFR Part 135 operator, Air Sunshine had the option to operate either under the manufacturers' maintenance inspection programs or to develop and receive FAA approval for its own maintenance inspection program. From 1982 to 1992, Air Sunshine operated under the manufacturers' (Cessna, TCM, and McCauley Propeller) maintenance inspection programs.

In early 1992, under the oversight of the Fort Lauderdale Flight Standards District Office (FSDO), Air Sunshine developed and received approval for its own inspection

[28] Airmark Overhaul is an FAA-approved maintenance vendor for Air Sunshine.

[29] Maintenance records were not available from the dates of manufacture of the right and left engines to the dates of the overhauls.

[30] For information about TCM's recommended overhaul limit and Air Sunshine's overhaul interval, see section 1.6.1.3.

program. The company's initial AAIP was a 3-phase, 60-hour inspection program. A different phase was performed every 60 hours of operation along with a routine servicing check, which included an engine oil change, a ground run-up, and a visual inspection of the airframe. Phases 1 through 3 comprised one full cycle, and an airplane had to complete one full cycle (that is, the entire aircraft had to have been inspected) every 180 hours of operation.

On November 4, 2002, Air Sunshine submitted revision No. 10, which proposed to change the company's AAIP to a 6-phase, 60-hour inspection program, to the FAA for approval. On January 9, 2003, the FAA approved the change,[31] and the 6-phase, 60-hour inspection program was in effect at the time of the accident. Each of the six phase inspections focused on one major airplane section. Phase 1 covered the powerplants, including a focused engine inspection and a differential compression check of the engine cylinders; phase 2 covered the wings; phase 3 covered the cabin; phase 4 covered the landing gear; phase 5 covered the fuselage; and phase 6 covered the empennage. Phases 1 through 6 comprised one full cycle, and an airplane had to complete one full cycle every 360 hours of operation. The last phase 1 inspection was performed at FLL from June 12 to 14, 2003. During this inspection, each engine was determined to have a time since overhaul of 2,187 flight hours.

1.6.1.2 Differential Compression Checks

TCM Service Bulletin (SB) 03-3 states that differential compression checks are conducted to identify leaks in the engine cylinders and the sources of any leaks that were found and that leaks can be caused by abnormal or excessive wear inside the engine cylinders or their components, problems with the valves or valve seats, and cracks in the cylinders. The SB also states that compression checks should be conducted "at each 100 hour interval, annual inspection or when cylinder problems are suspected."[32]

According to SB 03-3, before conducting the differential compression check, the acceptable pressure leakage limit for the equipment being used and the atmospheric conditions at the time that the check is conducted need to be established. SB 03-3 contains the following instructions on how to perform differential compression checks on all of its engines:

- remove the most accessible spark plug from each of the six cylinders on each engine;
- turn the engine crankshaft by hand in the direction of rotation until the piston is coming up on top dead center at the end of the compression stroke;

[31] In early 1998, Air Sunshine requested that its operating certificate be transferred from the FAA's Fort Lauderdale FSDO to its San Juan FSDO. The FAA granted the request, and the transfer took place on June 2, 1998. The company's operating certificate was under the jurisdiction of the San Juan FSDO when the company applied and was approved to change its AAIP. For more information about FAA oversight of Air Sunshine, see section 1.17.2.

[32] For information about the postaccident change to the differential compression check interval and other changes to Air Sunshine's AAIP, see section 1.17.2.5.

- install a cylinder adapter in the spark plug hole and connect a differential pressure tester to the cylinder adapter and slowly open the cylinder pressure valve and pressurize the cylinder to 20 pounds per square inch (psi);
- continue to rotate the engine in the direction of rotation, against the pressure, until the piston reaches top dead center (that is, with the piston at the end of the compression stroke and the beginning of the power stroke);
- open the cylinder pressure valve completely;
- move the propeller slightly back and forth with a rocking motion while directing regulated pressure of 80 psi into the cylinder and adjust regulator as necessary to maintain a pressure gauge reading of 80 psi; and
- record the pressure indication on the cylinder pressure gauge.

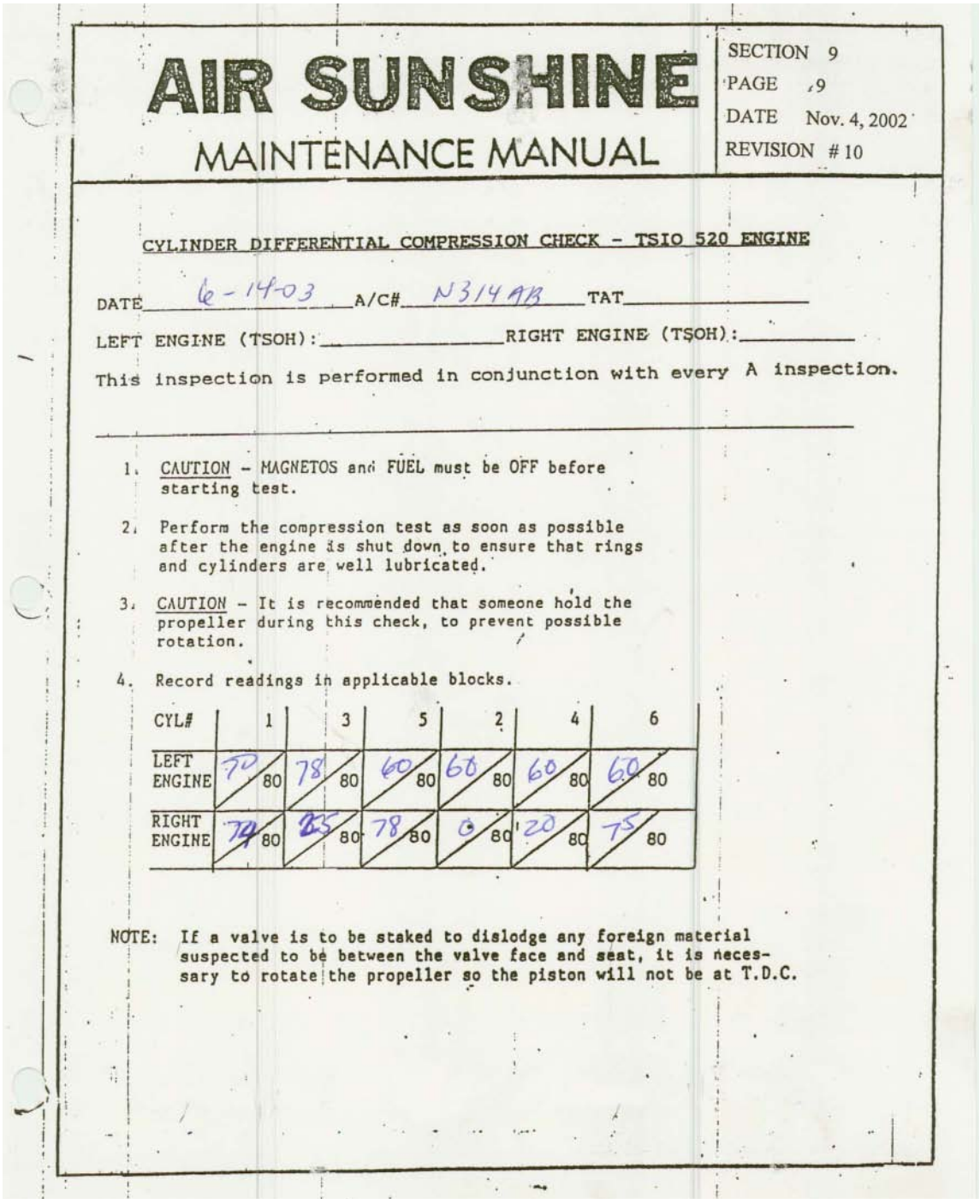
The difference between the pressure directed into the cylinder (80 psi) and the cylinder pressure shown on the regulator pressure gauge is the amount of leakage through the cylinder. Any cylinder pressure level greater than that established as the acceptable pressure leakage limit indicates an acceptable operating condition for a reciprocating engine. The SB recommends that, if the cylinder pressure levels are less than the acceptable pressure leakage limit, cylinder borescope inspections should be conducted.

1.6.1.2.1 June 12 to 14, 2003, Differential Compression Checks

As noted previously, the last differential compression checks performed on the accident airplane's engines occurred from June 12 to 14, 2003, as part of the airplane's last phase 1 inspection. According to the Director of Maintenance, he performed the checks on the left engine while the assistant mechanic watched and then recorded the readings in the inspection record. The cylinder differential compression check form[33] in Air Sunshine's Maintenance Manual contains the following: "CAUTION - It is recommended that someone hold the propeller during this check to prevent possible rotation." (See figure 2.)

The Director of Maintenance stated that, after completing the checks on the left engine, he asked the assistant mechanic if he felt capable of performing the checks on the right engine without supervision. The director stated that the assistant replied that he could perform the checks; as a result, the director left the assistant to perform the checks by himself without supervision. According to the director, he asked the assistant mechanic to record the compression check readings for the right engine on a sheet of paper so that he could review them before making the entries in the cylinder differential compression check form in the inspection records; however, the assistant mechanic recorded the readings directly in the inspection record. Figure 2 also shows the compression check readings (in psi) recorded in the inspection record by the assistant mechanic for both engines. Accounting for the check equipment used at the time that the checks were performed, the Safety Board determined that the acceptable pressure leakage limit was 54 psi.

[33] The cylinder differential compression check form is part of the company's AAIP phase 1 inspection package.



AIR SUNSHINE
MAINTENANCE MANUAL

SECTION 9
PAGE 9
DATE Nov. 4, 2002
REVISION # 10

CYLINDER DIFFERENTIAL COMPRESSION CHECK - TSIO 520 ENGINE

DATE 6-14-03 A/C# N314AB TAT _____

LEFT ENGINE (TSOH): _____ RIGHT ENGINE (TSOH): _____

This inspection is performed in conjunction with every A inspection.

1. CAUTION - MAGNETOS and FUEL must be OFF before starting test.
2. Perform the compression test as soon as possible after the engine is shut down to ensure that rings and cylinders are well lubricated.
3. CAUTION - It is recommended that someone hold the propeller during this check, to prevent possible rotation.
4. Record readings in applicable blocks.

CYL#	1	3	5	2	4	6
LEFT ENGINE	70/80	78/80	60/80	60/80	60/80	60/80
RIGHT ENGINE	74/80	55/80	78/80	0/80	20/80	75/80

NOTE: If a valve is to be staked to dislodge any foreign material suspected to be between the valve face and seat, it is necessary to rotate the propeller so the piston will not be at T.D.C.

Figure 2. Cylinder differential compression check form.

Note: According to the assistant mechanic and the Director of Maintenance, the number recorded for right engine cylinder No. 3 was "55." (Safety Board investigators who reviewed the document noted that the number could be either "55" or "25.") The assistant mechanic's signature and A&P certificate number have been redacted.

During postaccident interviews, the assistant mechanic stated that he had never performed a differential compression check before conducting the checks on the accident airplane's right engine. The assistant stated that his normal duties included changing oil, tires, cables, and spark plugs and cleaning the airplane. When a Safety Board investigator asked the assistant how to perform the compression check, he stated only that the spark plugs had to be removed from the cylinders and that the piston had to be at top dead center on its compression stroke.

The Director of Maintenance stated that, as he was reviewing and signing off on the day's maintenance work, he noticed that two of the readings obtained from the compression checks of the right engine (0 psi for the No. 2 cylinder and 20 psi for the No. 4 cylinder)[34] were "highly questionable." The director stated that he asked the assistant mechanic if he had been careful to get the piston at top dead center on its compression stroke on each cylinder when he performed the check. The director indicated that, although the assistant stated that he had been careful to get the piston into its required position, he appeared uncertain when asked specifically about the two questionable cylinder readings. The director told the assistant mechanic that the compression checks on the right engine cylinders would have to be repeated.

According to the Director of Maintenance, after he repeated the checks on the right engine, all of the cylinder's compression readings were in the 70-psi range, including the two cylinders with low readings from the first compression checks. The director stated that, when he did the rechecks, he was careful to get the piston at top dead center on its compression stroke and hold the propeller while adding the pressure. He added that, if the compression level readings had remained low, he would have grounded the airplane. The director stated that he had the assistant mechanic observe the checks and record the readings on a sheet of paper. The assistant mechanic stated that he gave the sheet of paper to the director but that he did not see what the director did with the paper. The director stated that he recorded the corrected readings on a new cylinder differential compression check form; however, company personnel did not locate the corrected form. The director stated that he did not conduct cylinder borescope inspections on cylinder Nos. 2 and 4 because the repeated compression checks yielded readings that were within acceptable limits.

The Director of Maintenance stated that the company had removed and replaced an engine cylinder assembly about five or six times in the last 3 years. The director stated that, before applying torque to the cylinder studs, maintenance personnel coated the studs with an aluminum-copper-graphite, lithium-based antiseize compound manufactured by Permatex. TCM SB 96-7B specifies that clean 50-weight aviation-grade engine oil should be applied to the studs and through bolts before applying torque. Permatex does not recommend using antiseize compound in high-vibratory environments because such use could contribute to the loss of torque.

[34] The Director of Maintenance stated that he would consider any reading below 58 psi to be too low and that low readings would require that the cylinder be rechecked. The director did not mention that the reading recorded for cylinder No. 3 was too low, even though he stated that it was "55."

1.6.1.3 Time Between Overhauls

TCM Service Information Letter 98-9A recommends that TSIO-520-VB engines have a time between overhaul (TBO) of 1,600 hours. Air Sunshine began operating its airplanes equipped with TSIO-520-VB engines in accordance with this recommendation. After Air Sunshine's inspection program received FAA approval in early 1992,[35] the company applied to the Fort Lauderdale FSDO for a 200-hour extension of its TBO per the procedures outlined in FAA Order 8300.10, *Airworthiness Inspector's Handbook*.[36] The FAA principal maintenance inspector (PMI) for Air Sunshine granted its request and allowed the company to increase its TBO by 200 hours. From late 1992 to late 1995, Air Sunshine applied for four additional TBO extensions (of 200 hours, 200 hours, 100 hours, and 100 hours) for a total TBO extension of 800 hours. The FAA granted approval for all of the requested extensions, which resulted in a TBO of 2,400 hours.

According to FAA Order 8300.10, approval of TBO extensions is granted based on "satisfactory service experience and/or a teardown examination of at least one exhibit engine." Neither the FAA nor Air Sunshine had retained the paperwork that related to the five requests for, and approvals of, the extensions of the company's TBO for longer than the 2 years required by the FAA. However, Air Sunshine provided the Safety Board with four teardown reports prepared by Airmark Overhaul (which were submitted as support for the first four TBO extension requests) and one report prepared by TCM (which was submitted as support for the last request). These reports were dated July 16, 1992; November 17, 1992; March 20, 1994; January 20, 1995; and October 9, 1995. All of the teardowns conducted by Airmark and TCM were of TCM-rebuilt engines.

After Air Sunshine received approval for the last 100-hour TBO extension, the company petitioned the Fort Lauderdale FSDO to change the company's operations specifications to reflect the 2,400-hour TBO, and the Fort Lauderdale FSDO granted the request under the condition that the company's airplane engines be rebuilt by TCM. In late August/early September 1999, after Air Sunshine transferred its operations certificate to the San Juan FSDO, the company petitioned the San Juan FSDO to remove from the company's operations specifications the requirement that TCM rebuilt engines must be used.

In a letter dated September 9, 1999, the FAA PMI for Air Sunshine stated that he would grant the company's request provided it (1) monitored the performance of newly overhauled engines and reported any abnormal conditions to the San Juan FSDO,[37] (2) used

[35] Air Sunshine was required to have its own AAIP to receive FAA approval for TBO extensions.

[36] FAA Order 8300.10 indicates that TBO extensions for reciprocating engines can be granted in increments of up to 200 hours.

[37] A review of Air Sunshine and FAA records revealed that the company made no reports to the FAA between the date of this letter and the date of the accident in which the company reported any abnormal conditions of its overhauled engines.

the approved overhaul facilities listed in its Maintenance Manual vendor list,[38] and (3) established standards for parts to be used during the overhaul process. The PMI added that, if the engines did not perform satisfactorily, the company's operations specifications would be amended back to the original TBO of 1,600 flight hours.[39]

1.7 Meteorological Information

The closest airport to the location of the airplane wreckage was Grand Bahamas International Airport (MYGF), Freeport, Bahamas, which was about 63.9 nautical miles from where the airplane was located. MYGF does not have an automated weather system. Weather observations are made by an on-site weather observer and are recorded in coordinated universal time. Eastern daylight time is 4 hours behind coordinated universal time.

The 1900 meteorological aerodrome report (METAR) (1500 local time, which was about 30 minutes before the ditching) indicated that winds were 160° at 8 knots, visibility was 10 nautical miles, clouds were broken at 2,000 feet, the temperature was 88.5° F, the dew point was 74.1° F, and the altimeter setting was 30.09 inches of Hg.

The 2000 METAR (1600 local time, which was about 30 minutes after the ditching) indicated that winds were 140° at 10 knots, visibility was 10 nautical miles, a few clouds were at 1,500 feet and were scattered at 2,000 feet, the temperature was 88.5° F, the dew point was 74.1° F, and the altimeter setting was 30.08 inches of Hg.

1.8 Aids to Navigation

The distance measuring equipment on the MYAT VOR[40] had been inoperative for several years.

1.9 Communications

No communication problems were reported.

1.10 Airport Information

MYAT was the destination airport for flight 527. The airplane was ditched about 7.35 nautical miles west-northwest of the airport.

[38] After its operations specifications were amended, Air Sunshine started using Airmark Overhaul, a company on the FAA-approved vendor list, to overhaul its engines.

[39] For information about postaccident changes to Air Sunshine's operations specifications, see section 1.17.2.5.

[40] VOR stands for very high frequency omnidirectional range.

1.11 Flight Recorders

The accident airplane was not equipped with either a CVR or an FDR and was not required to be so equipped.

1.12 Wreckage and Impact Information

1.12.1 General

The airplane was submerged in water for about 3 weeks after the accident. Underwater photographs taken before the airplane was recovered from the water showed that the window escape hatch adjacent to the pilot seat (1A) was open. The emergency escape hatch adjacent to seats 2B and 3B was found closed. The top and bottom portions of the main cabin door adjacent to seats 4A and 5A were found open.

Impact damage was noted on the lower fuselage skin from the wing main spar forward, and damage was noted on the nose cone. The landing gear was found retracted.

All of the airplane's major components,[41] except for the left aileron and the outboard section of the right elevator and balance weight, were recovered attached to the airplane. The separated sections were not recovered. The rudder trim tab actuator was found positioned between 5° and 10° trailing edge tab right; the elevator trim tab actuator was found positioned at 15° trailing edge tab down. The left flap was found extended about 15°, and the cowl flap was nearly closed. The right flap was found extended about 15°, and the cowl flap was open. An oil sheen was noted on the exterior surface of the right engine upper cowling, from the louvers aft to the trailing edge of the wing; on the interior surface of the upper cowling; and on the upper and lower exterior surfaces of the horizontal stabilizer.

The left fuel selector valve handle in the cockpit was found positioned to the left main fuel tank; the right fuel selector valve handle was missing; therefore, its position could not be determined. The emergency crossfeed/shutoff valve handle was found positioned to the crossfeed position. The left and right auxiliary fuel pump switches were found in the off position. The left and right cowl flap controls were found out (closed) and in (open), respectively. Both the flap selector and flap position indicator were found at about 15° flaps extended,[42] and the landing gear selector handle was found in the retracted position. The elevator trim indicator was found positioned to full nose up. The aileron trim indicator was found positioned slight left wing down. The rudder trim indicator was found positioned nose left.

[41] A major component is necessary for an airplane to sustain flight.

[42] During postaccident interviews, the pilot stated that he did not extend the flaps during the flight. The pilot stated that he would normally extend the flaps when he was about 3 miles from an airport. When he was asked how the flaps became extended to 15°, the pilot replied that after the ditching, some of the passengers crawled over him and that one of them might have hit the switch that extended the flaps. He stated that the flaps were extended electrically and that he had left the power on after the ditching.

All seats were found attached to the floor and were undamaged. All lapbelts were present and were found to operate normally. The seatback stowage pockets for seats 2A and 2B did not contain safety briefing cards;[43] all of the other stowage pockets contained briefing cards.

Six packaged PFDs were found in the airplane. One PFD was found forward of the pilot seat, and one PFD was found forward of the copilot seat. The remaining four PFDs were found in their stowage areas (under seats 2A, 2B, 3A, and 5A). The PFDs were brought to the Safety Board's headquarters in Washington, D.C., and were examined on August 28, 2003. The sealed plastic pouches were opened, and the PFDs were inflated by pulling the inflation rings. All of the PFDs were undamaged and were found to operate normally. Inspection records found inside the plastic pouches containing the PFDs indicated that they had been inspected within the past 5 years, in accordance with Federal regulations.

1.12.2 Engines and Propellers

The left engine was attached to the airframe, and the propeller was attached to the engine. The outboard lower engine cowling had separated and was not located. The left engine was removed and examined, under Safety Board supervision, at TCM's facility. All six cylinders and their valves were intact. No evidence of preexisting damage was found.

The left propeller was removed and examined, under Safety Board supervision, at McCauley Propellers' facility. The left propeller hub was intact and undamaged, and all three blades were installed in the hub. Examination of the left propeller revealed no evidence of preimpact damage. The feather-stop mechanism was attached and undamaged, and the start-lock mechanism[44] was intact and undamaged.

The right engine was attached to the airframe in its normal position, and the propeller was attached to the engine. Damage was noted on the leading edge skin from the engine outboard to the wing tip; the leading edge skin from the engine nacelle inboard of the wing root was crushed up and aft. The lower inboard engine cowling was separated and was not recovered; the lower outboard engine cowling was in place.

The right engine No. 2 (inboard aft) cylinder was found separated from the engine crankcase, exposing a portion of the crankshaft, and held onto the engine by the exhaust pipe tubing and by an electrical cable that was secured to the cylinder assembly by an adel clamp. The two magnetos were found protruding through the upper outboard engine cowling but remained attached to the engine by ignition leads. (See figure 3.) Two 6-point flanged nuts, one 12-point flanged nut with a fractured threaded piece, and a nonfractured connecting rod were recovered from the engine compartment area. Piston ring pieces were found in the partially separated No. 2 cylinder assembly.

[43] The stowage pockets on these seatbacks held the briefing cards for use by the passengers in seats 3A and 3B. For more information about the airplane's interior configuration, see section 1.6.

[44] As noted previously, the start-lock mechanism is a system designed to prevent the propeller from traveling all the way to feather during normal engine shutdowns.

Figure 3. Exterior of the upper outboard engine cowling.

The right engine was removed and examined, under Safety Board supervision, at TCM's facility. After engine disassembly at TCM, some of the right engine components were brought to the Safety Board's Materials Laboratory in Washington, D.C., for further examination. For additional information about the metallurgical inspections of the right engine components, see section 1.16.3.

The right propeller was removed and examined, under Safety Board supervision, at McCauley Propeller's facility. The right propeller hub was intact and undamaged, and all three blades were intact and installed in the hub and appeared to be in the feathered position. The blade angles were measured as follows: blade No. 1 was 82.2°, blade No. 2 was 82.4°, and blade No. 3 was 82.3°. The feather angle for this propeller is 82.2° (+/-0.3°). All of the blade counterweights were present and in place. The propeller piston was undamaged, and the centrifugal weights and springs were in place. The piston rod and feathering spring were intact, in place, and undamaged. The feather-stop and start-lock mechanisms were intact and undamaged.

1.13 Medical and Pathological Information

Fluid specimens obtained from the pilot were sent to the Royal Bahamas Police Force's Forensic Science Laboratory for toxicological analysis. The fluid specimens tested negative for alcohol and drugs.[45]

According to the Rand Memorial Hospital (Freeport, Grand Bahamas) autopsy report, the cause of death for the deceased 4-year-old child was "drowning secondary to plane crash." According to the Princess Margaret Hospital (Freeport, Grand Bahamas) pathology report, the deceased adult passenger had injuries "consistent with the history of plane crash accident." Further, the report stated that the deceased adult passenger had a cerebral contusion and rib fractures. The report also stated that a "section of both lungs showed edema and congestion."

1.14 Fire

No evidence of an in-flight fire was found, and the accident did not result in a postcrash fire.

1.15 Survival Aspects

1.15.1 General

The pilot reported that he was not wearing his shoulder harness when the airplane contacted the water and that he hit his head on the instrument panel during the ditching.[46] During postaccident interviews, one passenger stated that the pilot "did not appear to have much clarity and was not particularly coherent" after the ditching. Another passenger stated that he "took charge of the situation because the pilot was incoherent in the water." The passenger also stated that the pilot "did not look like he could swim" and that he had to give the pilot his PFD.

The passenger in the copilot seat reported a bump on his head and a cut on his leg. The passenger stated that he was not wearing his shoulder harness during the ditching because the pilot had not informed him before the flight departed that his seat was so equipped. The passengers in seats 2A and 2B reported bruises on their hips from the lapbelts. The passenger in seat 3B reported a contusion on her forehead.

After the airplane contacted the water, the pilot opened the pilot-side window hatch. The pilot, four adult passengers (from the copilot seat and seats 2A, 2B, and 3B),

[45] The drugs tested in the postaccident analysis included benzoylecgonine, barbiturates, benzodiazapines, and opiates.

[46] Title 14 CFR 91.105(b) requires that required flight crewmembers of a U.S.-registered civil aircraft keep their shoulder harnesses fastened while at their assigned duty stations during takeoff and landing.

and one child (who had been sitting on the passenger in seat 3B's lap) evacuated the airplane through the pilot-side window escape hatch. One adult and three children (from seats 4A, 4B, 5A, and 5B) evacuated the airplane through the main cabin door.

1.15.2 Emergency Briefings

Air Sunshine's FAA-approved General Operations Manual, Section 4, "Emergency Procedures," contains the following guidance to pilots on briefing passengers before a ditching:

- review the emergency ditching evacuation procedures with the passengers;
- instruct passengers to don life vests at that time, without inflating them in the airplane;
- review the operation of the inflation ring and the manual/oral blow-up tubes; and
- instruct passengers to inflate their life vests once they are outside of the aircraft.

As noted previously, passengers reported that the pilot did not tell them to retrieve and don their PFDs before the airplane contacted the water. They stated that the only time he addressed the passengers after the right engine failed and before the airplane contacted the water was to tell them to "calm down."

As the result of a postaccident focused inspection of Air Sunshine (conducted from July 22 to August 29, 2003), the FAA instructed the company to amend its emergency ditching procedures.[47] The amended procedures contain the following guidance to pilots on briefing passengers before a ditching:

- instruct all passengers to don life vests as soon as any emergency occurs during overwater operation;
- instruct passengers to familiarize themselves with emergency evacuation procedures, including special evacuation procedures for those passengers who are assisting others, such as children and handicapped individuals;
- review ditching procedures before ditching, including instructing passengers to partially inflate their life vests through the use of the blow-up tubes; and
- instruct passengers that, only once they have gotten outside the airplane, they should fully inflate their life vests by pulling the inflation ring.

1.15.3 Personal Flotation Devices

Title 14 CFR Part 135 requires specific emergency equipment, including approved life preservers and rafts, a survival kit, and an emergency locator transmitter, to be

[47] For more information about the FAA's postaccident focused inspection of Air Sunshine, see section 1.17.2.4.

installed on airplanes that conduct extended overwater operations (that is, operate flights over water at a horizontal distance greater than 50 nautical miles from the nearest shoreline). Because Air Sunshine flight 527 did not qualify as an extended overwater flight, the airplane was not required to be equipped with such emergency equipment. However, 14 CFR 91.205 requires that aircraft operated for hire over water and beyond power-off gliding distance to shore be equipped with approved flotation gear that is readily available to each occupant.[48]

The airplane was equipped with 10 PFDs.[49] According to the markings on the PFDs, they met the requirements of FAA Technical Standard Order (TSO) C-13e, which defines minimum performance standards for PFDs. The markings on the PFDs indicated that they were approved for use by adults and children and that children should have their PFDs put on them by adults per crew instruction.

The PFDs on the airplane were vests with two separate symmetrically arranged chambers and a retention strap. The PFD is donned when a user inserts its head through a hole in the PFD and fastens the retention strap around its waist. A PFD is inflated when the user pulls an inflation ring that discharges carbon dioxide cartridges into the two chambers. The user can also inflate a PFD by blowing into a tube that is located on each chamber. A correctly donned and inflated PFD that meets the requirements of TSO C-13e should provide the user with 35 pounds of buoyancy, automatically correctly position the user in the water within 5 seconds, and hold the user's nose and mouth "clear of the waterline."

Only 4 of the 10 PFDs installed on the airplane were retrieved and used by the passengers.[50] The passenger in seat 3B, who was holding a child on her lap, retrieved the PFD from under her seat. The passenger in seat 5A retrieved three PFDs and put them on the three children accompanying her before the airplane contacted the water.

According to the passenger in the copilot seat, he could not retrieve his PFD because it was wedged between the seat and the wall of the airplane. The passenger in seat 2A and another passenger who tried to help her stated that they could not retrieve the PFD for seat 2A "because the Velcro that closed the container [the fabric pouch] would not separate." These two passengers stated that they exited the airplane without the PFD when the water reached knee level. The passengers who were not able to retrieve their PFDs did not try to retrieve them until the airplane contacted the water.

Once the airplane occupants were in the water, airplanes circling the area at the time of the accident dropped several PFDs. The passengers retrieved some of these PFDs and distributed them. The adult female passenger (in seat 5A) and the child accompanying

[48] This requirement applied to flight 527.

[49] According to the President of Air Sunshine, after Tropical International Airlines purchased the airplane in 1997, that company installed the PFDs on the airplane, which were stowed in fabric pouches that the company had made.

[50] As noted in section 1.12.1, the six PFDs that were still in the airplane were found undamaged and were capable of normal operation.

her who died after the evacuation were not wearing a PFD when they were recovered from the water. The passenger in seat 1B reported that he took the PFD off of the child who died after the evacuation. This passenger stated that, when he took the PFD from the child, it was not inflated and that one of the inflation chambers had a hole in it. The passenger stated that he provided the PFD to another passenger and that the undamaged chamber inflated normally.[51] Another passenger stated that the other two children's PFDs were also not inflated and that he inflated one chamber on each of their vests.

No information indicates whether the other passengers donned their PFDs correctly. However, during postaccident interviews, none of the passengers appeared to be familiar with the proper donning and inflating procedures (for example, none of the passengers reported fastening the retention straps around their waists).

Passengers reported that the airplane sank within several minutes after contacting the water. Passengers stated that they tried to stay together in the water; however, two groups were eventually formed, and, because of the waves, the two groups drifted apart. Passengers reported that two of the children traveling with the female passenger in seat 5A were extremely frightened when they entered the water and that they were frantic to the point that they were "dangerous" to nearby passengers who were treading water. Passengers also reported that the female passenger in seat 5A who was not wearing a PFD was seen floating face down shortly after entering the water. The passengers were in the water for about 1 1/2 hours before being rescued, as detailed in section 1.15.4.

1.15.4 Search and Rescue

At 1533, the Air Sunshine pilot who had just taken off from Marsh Harbor transmitted a distress call. (That airplane's altitude was too low to allow the pilot to contact the Miami ARTCC directly.) The pilot of Gulf flight 9267 heard the distress call and relayed the message to the Miami ARTCC. At 1540, the Miami ARTCC notified MYGF that Air Sunshine flight 527 was in the water. MYGF personnel responded that the airport did not have any helicopters and that, therefore, it could not assist with the search and rescue. At 1541, the Miami ARTCC notified the U.S. Coast Guard at Opa-Locka, Florida, that the flight 527 airplane was in the water.

After receiving the notification, the U.S. Coast Guard launched from Air Station Miami one HH-65 (an Aerospaciale Dolphin helicopter), which departed about 1551 and arrived on scene about 1702, and one Falcon jet, which departed about 1606 and arrived on scene about 1636. In addition, the Coast Guard launched one HH-60J (a Sikorsky Jayhawk helicopter) from Andros Island, Bahamas, which departed about 1605 and arrived on scene about 1702.[52] Two life rafts were dropped from the Falcon after it arrived on scene. One of

[51] The deceased child's PFD was not recovered; therefore, the condition of her PFD could not be determined.

[52] According to the Coast Guard, about 1605, the winds at the crash site were about 11 knots, and the waves were about 4 feet high. The Coast Guard did not estimate wave height for the time of its arrival on scene.

the rafts landed near one of the groups of passengers[53] and was used by two adult passengers; the other raft did not land near any of the passengers.

A rescue diver from the HH-65 recovered the pilot, one child passenger, and two adult passengers, all of whom were hoisted into the helicopter and then flown to MYGF. According to the rescue diver from HH-60J, he found two children wearing PFDs, and each of the children was holding an arm of an adult female who was floating face down in the water and "appeared to be deceased." The diver recovered the two children, removed one of the children's PFDs, and placed the PFD on the deceased female.[54] The rescue diver then recovered two additional adult passengers who were hanging onto one of the life rafts dropped from the Falcon. All of these passengers and the rescue divers from both helicopters were hoisted into HH-60J.

At the request of a Royal Bahamian police officer, a private fishing boat went to the accident site about the same time as the helicopters arrived. Two men on the boat retrieved the bodies of two passengers. The flight crew of HH-60J stated that they saw occupants on the boat performing CPR on the two passengers. HH-60J dropped a rescue diver who determined that one of the passengers was a child. The rescue diver hoisted the child onto the helicopter and performed CPR on the child until landing at MYGF. The boat carried the deceased female passenger to MYGF. After arriving at the MYGF, all of the passengers that had been hoisted into HH-60J were transported to Rand Memorial Hospital.

1.16 Tests and Research

1.16.1 Cessna Airplane Performance Data

The Cessna 402C Aircraft Information Manual, Section 5, "Performance," contains a performance chart for estimating the airplane's climb rate with one inoperative engine. Conditions for the use of the chart include the following: operative engine power at maximum (2,700 rpm and 39 inches Hg manifold pressure), fuel flow in the white arc on the fuel flow gauge,[55] landing gear retracted, flaps at 0°, inoperative propeller feathered, wing bank 5° toward operative engine with about 1/2-ball[56] slip indicated on the turn-and-bank indicator, and inoperative engine cowl flaps closed. Safety Board investigators used the information from Cessna's performance chart and accounted for the

[53] According to the commander of HH-60J, when the helicopter arrived on scene, the passengers were clustered in three groups, about 110 yards away from each other.

[54] The rescue diver stated that he placed one of the children's PFDs on the deceased female so that she would be easier to locate after the survivors were retrieved from the water.

[55] According to Cessna's Aircraft Information Manual, white arc is used for "(Takeoff and Engine Inoperative Power-Sea Level to 12,000 feet) 200.0 Pounds per hour (16.8 psi) to 210.0 Pounds per hour (18.0 psi)."

[56] During coordinated, straight-and-level flight, the ball is centered between the turn-and-bank indicator's reference lines. In the event of an engine failure, the pilot banks 5° toward the operative engine to ensure that about a 1/2-ball slip is indicated on the turn-and-bank indicator to create the most efficient bank angle, which creates minimum drag.

weight of the airplane (between 6,444 and 6,534 pounds),[57] the outside air temperature (90° F), the winds (about 15 knots),[58] and the altitude (3,500 feet) at the time that the right engine failed in estimating that the airplane would have had a climb rate of about 200 fpm if nothing had occurred to negatively affect the airplane's performance.

Cessna provided the following climb rate penalty data:[59] flaps at 15° (the configuration at which the accident airplane was found) at 103, 100, and 95 knots yields penalties of -165, -155, and -145 fpm, respectively; a windmilling propeller (pilot and passenger statements indicated that the right engine propeller was windmilling, not feathered, after the right engine failed) yields a penalty of -400 fpm; cowl flap of inoperative engine open (the postaccident configuration in which the airplane's right engine cowl flap was found) yields a penalty of -9 fpm; and protruding magnetos (the right engine magnetos penetrated the engine cowling in flight) yields a penalty of -4 fpm.

1.16.2 Airplane Performance Study

The Safety Board conducted an airplane performance study to establish the effects that the pilot's actions, airplane damage, and windmilling propeller had on the airplane's performance after the right engine failed. Because the airplane did not have an FDR or a CVR and no radar data relating to the accident flight were available, the study used statements from the pilot, passengers, and Air Sunshine's station manager to determine the sequence of the pilot's actions throughout the flight.

With the use of the data provided by Cessna and a range of average indicated airspeeds between 115 and 95 knots,[60] the airplane performance study determined that the airplane's descent rate was between about 560 and 212 fpm during its descent from 3,500 to 2,000 feet. The airplane traveled between about 5 and 10 nautical miles during this portion of the flight. With the use of a range of average indicated airspeeds between 105 and 90 knots, the study determined that the airplane's descent rate was between about 429 and 360 fpm during its descent from 2,000 feet to the point of contact with the water. The airplane traveled about 7.6 nautical miles during this portion of the flight. At the time of the right engine failure, the airplane was about 20 to 25 miles from MYAT. The study determined that the airplane was airborne for at least 7 minutes after the right engine failed and before it contacted the water. At 90 knots, and with the engine damage, the airplane

[57] The difference in weight would have caused less that a 40 fpm difference in the climb rate.

[58] Airport weather data were obtained from Miami International Airport and MYGF. The data showed that the estimates provided by the pilot (the winds were about 15 knots, and the outside air temperature was 80° to 90° F) at the time of the ditching were accurate.

[59] Cessna could not quantify the penalties for the following variables that also could have decreased the climb rate: operation of the airplane at greater or less than the recommended wing bank of 5° toward operative engine; operation of the airplane at greater or less than the recommended 1/2-ball slip on the turn-and-bank indicator; and operation of the airplane on a nonsteady descent (for example, decreasing pitch angle to increase speed and then reducing pitch to arrest descent rate).

[60] According to the pilot, the blue radial on the accident airplane's airspeed indicator, which shows the single-engine best climb rate, was pointing to about 105 knots.

could have tolerated a descent rate of an average of about 200 fpm and been able to maintain flight and reach MYAT.

1.16.3 Metallurgical Inspections

1.16.3.1 Right Engine Cylinder Assemblies

The right engine No. 2 cylinder assembly was separated from the engine crankcase. The other five cylinder assemblies were intact and attached to the engine crankcase.

The Nos. 1, 3, 4, 5, and 6 cylinder bores were covered with corrosive material and sand and salt residue, consistent with salt water immersion. No discernible damage to the cylinder assemblies or to the valves was noted. All of the valves and valve springs were intact and undamaged. The valve faces and springs were coated with sand, salt, and oil, and the faces were oxidized.

The No. 2 cylinder assembly was generally intact with no apparent damage to the valves or cylinder head. The cylinder bore was covered by a layer of corrosive material; no large-scale marking, scoring, or gouging was found under the corrosion.

The No. 2 cylinder skirt area (the inboard portion of the cylinder that projects into the engine crankcase when assembled) was damaged and deformed in multiple places. The damage displaced various portions of the inboard edge of the cylinder skirt both toward and away from the cylinder centerline. The spacing between the deformed areas was about equal to the distance between the No. 2 cylinder hold-down studs and through bolts. The cylinder base flange was also damaged with the two upper aft mounting holes (at the intact stud locations) distorted adjacent to the inboard (case side) surface.

Five of the engine cylinder assemblies (Nos. 1 through 5) had markings on the heads and base flanges, identifying them as FAA Parts Manufacturing Approval components. The letters "EC" were steel-stamped into the cylinder head, indicating that the cylinders were manufactured by Engine Components, Inc (ECI). One of the valve rocker bosses on each of these cylinders was also marked with steel-stamped numbers 29689-1 through -5. The first five numbers corresponded to the work order number for the last engine overhaul performed by Airmark Overhaul, and the last number corresponded to the position of the cylinder (1 through 5). The cylinders were installed in their respective positions on the engine crankcase.

The markings on the No. 6 cylinder were not consistent with those on an ECI-manufactured cylinder. The letters "DET" and "E" and the number "99" were steel-stamped into the cylinder head. One of the valve rocker bosses was marked with the steel-stamped number "33258-3,"[61] and another of the rocker bosses was vibro-etched with the number "7-99."

[61] This work order number corresponded to a propeller strike inspection that was conducted on another one of the company's engines, serial number 816113-R. For more information about this engine, see section 1.17.1.3.1.

1.16.3.2 Right Engine Pistons

The Nos. 1, 3, 4, 5, and 6 pistons from the right engine were intact. The No. 2 piston was found fractured into two large pieces and many small pieces. Only about 35 percent of the No. 2 piston was recovered.

Magnified optical examinations of the fractures on the No. 2 piston found features consistent with overstress separations; no indications of preexisting cracking were found. On the largest piece, the piston was circumferentially fractured along the lower oil control ring and vertically in the plane of the piston pin but offset to one side. Deformation on the outer edge of the piston skirt adjacent to the fracture at the oil control ring groove was consistent with partial canting of the piston in the cylinder after the fracture occurred.

1.16.3.3 Right Engine Crankcase

The left half of the right engine crankcase was fractured and damaged in line with the No. 2 cylinder connecting rod, which was consistent with continued rotation of the engine and flailing of the connecting rod after the complete separation of the cylinder. The right half of the engine crankcase was also damaged in line with the No. 2 cylinder connecting rod. The main portion of the connecting rod was heavily distorted in the rod bearing and piston pin areas. The piston pin area had many impact marks, and the pin hole and bushing were flattened. The connecting rod bolt pieces were also distorted and fractured through the shank. Optical examinations revealed fracture features consistent with overstress separations. A portion of the crankcase, which contained the two upper center studs of the No. 2 cylinder, was missing.

The engine crankcase surfaces that contact the cylinder skirt and base flange of the No. 2 cylinder contained several different impact marks and contact features. Small, raised ridges were present on the forward side of the mounting face corresponding to the installed edges of the No. 2 cylinder base flange. Additionally, the bore portion of the crankcase that mates with the No. 2 cylinder skirt contained several sharp circumferential dents, scrapes, and other contact marks that are consistent with progressive outboard movement of the cylinder skirt. The cylinder skirt edge marks continued onto the lower portion of the mounting surface where a series of concentric dents, which matched the machined contour and overall radius of the innermost edge of the cylinder skirt, were found. Light fretting damage was noted in some areas of the contact surface with the cylinder base flange.

1.16.3.4 Right Engine No. 2 Cylinder Hold-Down Studs and Through Bolts

Of the eight hold-down studs and two through bolts that retain the No. 2 cylinder to the engine crankcase, three of the studs were found intact in the crankcase without nuts, four of the studs and the two through bolts were found fractured, and one of the studs was not found. The intact studs found in the crankcase without nuts had minimal thread damage.

The outboard portions of one of the fractured hold-down studs and one of the fractured through bolts were recovered. The stud piece was found without a nut attached,

and the through bolt piece was found with a nut attached. The outboard portions of the other three fractured studs were not recovered. The other fractured through bolt, which is where the nut would normally be, was not recovered. Figure 4 shows the condition in which the right engine No. 2 cylinder retention system components were found.

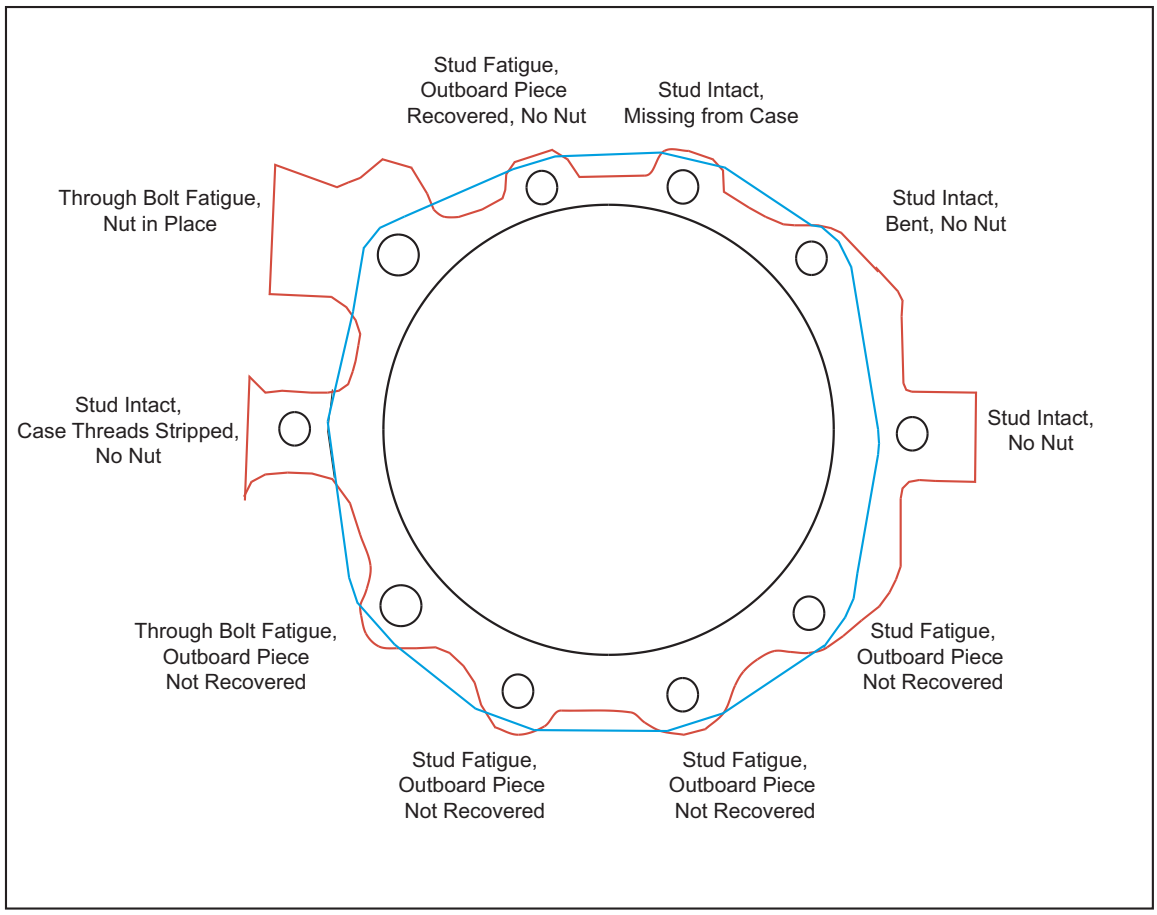


Figure 4. The condition in which the right engine No. 2 cylinder retention system components were found.

Note: The cylinder base flange is outlined in blue, and the mounting surface is outlined in red.

Optical and scanning electron microscopic examinations of four of the hold-down stud and two of the through bolt fractures found features that were consistent with high-stress and low-cycle fatigue propagation. For all of the studs and through bolts with fatigue cracking, initiation was from multiple locations in a thread root along one side of the fastener. The fatigue propagated in a high-stress manner with parallel fissures and striations until ductile overstress occurred at about 50 percent of the fastener's cross-section. Some spots of corrosive material were visible at random areas across the fractures; however, little or no oxidation or corrosion was apparent in the fracture origin areas. A comparison of height measurements of the No. 2 cylinder studs' features with features on other cylinder studs in the engine crankcase revealed that the studs had been installed to similar depths.

1.16.3.5 Cylinder Hold-Down Nuts

The cylinder hold-down nuts from the Nos. 1, 3, 4, 5, and 6 right engine cylinders were recovered on their respective hold-down studs and through bolts; three of the hold-down nuts were found in the engine compartment. Thirty 7/16-inch-diameter, 6-point, flanged cylinder hold-down nuts were examined. Two of these hold-down nuts were found in the engine compartment after recovery of the airplane, and 28 of these hold-down nuts were removed from the right engine cylinders during engine teardown.

Initial optical examinations found two different styles of nuts. Seven of the nuts had concave transition from the wrench flats to the enlarged washer flange. These nuts were consistent with an exemplar cylinder hold-down nut provided by Superior Air Parts with standard 7/16-20 UNF-3B thread form.[62] Twenty-three of the nuts had a convex transition from the wrench flats to the enlarged washer flange and were embossed with two opposed sets of parallel lines. These nuts were consistent with TCM flanged nuts with the optional, nonstandard Spiralock thread form.[63] According to TCM, the company has exclusively procured cylinder hold-down nuts with the Spiralock thread form since about 1990. One of the nuts found loose in the engine compartment was a Superior-style hold-down nut, and the other nut was a TCM-style nut with the Spiralock thread form.

According to Airmark Overhaul's Quality Assurance Manager, the company uses OEM-specified hold-down nuts or nuts provided by Superior Air Parts. The manager stated that, since he began working at Airmark in April 1984, if the company was overhauling an engine and 36 6-point cylinder hold-down nuts were needed and 24 with a TCM part number and 12 with a Superior Air part number were in stock, both types of nuts would be used to complete the overhaul rather than hold up production. He stated that this procedure was "accepted in industry."

1.17 Organizational and Management Information

1.17.1 Air Sunshine

Air Sunshine, Inc., was formed in June 1982 and began conducting Part 135 on-demand charter flights on September 2, 1982, and Part 135 scheduled commuter flights in 1983. The company provides commuter and charter services in South Florida and the Caribbean. The company has offices and a permanent maintenance facility in Fort Lauderdale. The company has a ticket counter and two rooms at Luis Munoz Marin International Airport (SJU), San Juan, Puerto Rico, but no permanent maintenance facility there. Air Sunshine's President stated that the company keeps its maintenance records in the two rooms it has at SJU.

[62] Standard 7/16-20 internal threads have a 7/16-inch major diameter and 20 threads per running inch of UN fine 60° threads with a class 3 fit.

[63] Spiralock internal threads are proprietary and were developed by Spiralock Corporation, a subsidiary of Detroit Tool Industries Company. The internal threads of the Spiralock nut engage the external threads at the crests of the stud threads.

At the time of the accident, the company employed 12 pilots, 10 of whom were captains and 2 of whom were first officers. According to Air Sunshine's President, the company typically employed three A&P-certified mechanics and one or two assistant mechanics in San Juan and four A&P-certified mechanics and three assistant mechanics in Fort Lauderdale. The company operated three to four flights daily out of FLL and about six to eight flights daily out of SJU with a fleet of seven Cessna 402C airplanes and one Embraer 110 airplane.

The Director of Maintenance stated that company maintenance was conducted in both Fort Lauderdale and San Juan. According to the director, if an airplane is in Fort Lauderdale when an inspection becomes due, the inspection is conducted there. He stated that, because most of the flights conducted on its Cessna 402 airplanes originated in San Juan, most of the inspections of these airplanes were conducted there.[64] Air Sunshine's President stated that extensive maintenance and sheet metal work were conducted in Fort Lauderdale because the company owned a hangar at FLL. He stated that inspections conducted in San Juan were typically conducted on the ramp and that, if an airplane needed to be "placed on jacks," the company would obtain hangar space at SJU.

Since March 26, 1987, Air Sunshine has experienced four incidents and six accidents, including the flight 527 accident. Three of the accidents, including the accident flight, resulted in fatalities. On January 23, 1992, a Cessna 402C crashed near Clewiston, Florida, and two people were killed. On February 8, 1987, a Cessna 402C crashed into the Atlantic Ocean while on final approach to Cyril E. King Airport, Charlotte Amalie, Virgin Islands, and two people were killed. Both accidents were determined to be caused by pilot error; no mechanical malfunctions were reported with either airplane.

1.17.1.1 Air Sunshine's In-Flight Engine Failure Procedures

In-flight engine failure procedures were taught during company training and were contained in Air Sunshine's Training Manual. The manual states that, if an engine were to fail in flight, the pilot should comply with memory items and follow the prescribed checklist. Air Sunshine's Training Manual, section 3, revision 6, dated May 10, 1990, contains the following in-flight engine failure procedures:

1. Inoperative Engine – DETERMINE.
2. Operative Engine – ADJUST as required.

Before Securing [shutting down] Inoperative Engine:

3. Fuel Flow – CHECK. If deficient, position auxiliary fuel pump to ON.
4. Fuel Selectors – MAIN TANKS (Feel For Detent).
5. Fuel Quantity – CHECK.

[64] Air Sunshine's General Manager reported to Safety Board investigators that the company conducted 45 inspections of its Cessna 402 airplanes in Fort Lauderdale and 17 inspections of its Cessna 402 airplanes in San Juan between January 1 and July 13, 2003.

6. Oil Pressure and Oil Temperature – CHECK.

7. Magneto Switches – CHECK ON.

8. Mixture – ADJUST. Lean until manifold pressure begins to increase, then enrich as power increases.

Air Sunshine's Training Manual states that, if the engine does not start after performing the first eight steps of the in-flight engine failure procedures, the pilot was to perform the following procedures:[65]

9. Inoperative Engine – SECURE [shut down].

    a. Throttle – CLOSE.
    b. Mixture – IDLE CUT-OFF.
    c. Propeller – FEATHER.
    d. Fuel Selector – OFF (Feel For Detent).
    e. Auxiliary Fuel Pump – OFF.
    f. Magneto Switches – OFF…
    i. Cowl Flap – CLOSE…

10. Trim Tabs – ADJUST 5° bank toward operative engine with approximately 1/2 ball slip indicated on the turn and bank indicator.

Air Sunshine's Training Manual also stated that, if an engine failure were to occur, the single-engine best climb rate should be maintained regardless of whether the altitude could be maintained because that speed guaranteed the best climb rate or the least altitude loss with an inoperative engine. Cessna's 402C Aircraft Information Manual, Section 3, "Emergency Procedures," states the following:

> The one engine inoperative best rate-of-climb speed becomes important when there are no obstacles ahead on takeoff, or when it is difficult to maintain or gain altitude in single-engine emergencies. The one engine inoperative best rate-of-climb speed is 104 KIAS with wing flaps and landing gear up. This speed is indicated by a blue radial on the airspeed indicator.

During postaccident interviews, the accident pilot stated that he was trained by Air Sunshine that, in the event of an in-flight engine failure, a pilot should push "all the engine levers forward (throttle, mixture, and propeller levers)." As noted previously, the pilot stated that his first action after he heard the bang and saw oil coming out of the right engine cowling was to shut down the failed engine. The pilot stated that he did not follow the company's in-flight engine failure procedures because he knew which engine had failed. The pilot added that he did not follow the in-flight engine failure checklist because he was "too busy flying the airplane." The passenger in the copilot seat stated that the pilot pushed the throttle, mixture, and propeller levers of the operative engine forward immediately after he tried to shut down the failed engine.

[65] These procedures were also contained in Cessna's 402C Aircraft Information Manual.

Air Sunshine's Director of Operations, who is also a check captain and conducts company training, stated that he trained pilots to perform the following procedures if an in-flight engine failure occurred: (1) mixture [lever] – full forward, (2) propeller [lever] – full forward, (3) throttles [lever] – full forward, (4) flaps – up [retracted], (5) gear – up [retracted], (6) fuel selector – on main tanks, (7) auxiliary pump – on, (8) identify the failed engine, (9) verify the failed engine, (10) feather the propeller, and (11) call for the [engine failure] checklist.

1.17.1.2 Ditching Procedures

Air Sunshine's Training Manual, section 3, contained the following ditching procedures:

> Landing Gear – UP.
>
> Approach – HEADWIND if high winds. PARALLEL to SWELLS if light wind and heavy swells.
>
> Wing Flaps – DOWN 45°.
>
> Power – AS REQUIRED (300 Feet Per Minute Descent).
>
> Airspeed – 95 KIAS minimum.
>
> Attitude – DESCENT ATTITUDE through touchdown.

The pilot stated, during postaccident interviews, that he did not extend the flaps before ditching.

1.17.1.3 Company Record-Keeping

1.17.1.3.1 Maintenance Records

As noted previously, although Air Sunshine's Director of Maintenance told Safety Board investigators that he and the assistant mechanic had repeated the compression checks after initially getting unacceptably low readings (below 54 psi) for two of the right engine cylinders (Nos. 2 and 4) during the airplane's last scheduled engine maintenance in June 2003, no documentation of the repeated checks was found. Further, no records were found indicating that any inspections or corrective maintenance had been performed on the right engine cylinders after getting the low compression check readings. As previously mentioned, TCM SB 03-3 recommends that, if cylinder pressure levels are lower than the limit established by the acceptable pressure leakage check (in this case, 54 psi), a cylinder borescope inspection is to be conducted. In addition, no records were found indicating that any of the right engine cylinders had been removed since the engine was last overhauled (December 14, 1999).

A review of Air Sunshine's maintenance records revealed that the number stamped on the No. 6 cylinder from the right engine did not match the number recorded in the maintenance records; however, the maintenance records for the right engine did not

indicate that the No. 6 cylinder had ever been removed or replaced. Air Sunshine's General Manager stated that, according to company records, the cylinder installed in the No. 6 position on the accident airplane was a cylinder previously installed in the No. 3 position on another one of the company's engines, serial number 816113-R, which was installed on N220RS. The General Manager stated that, from January to July 2001, engine serial number 816113-R was not installed on N220RS and that, during that time, the engine "was basically sitting in [the company's] parts room." He added that the No. 3 cylinder from engine serial number 816113-R must have been installed on the accident engine at some point during that time. However, the maintenance records for N220RS did not indicate that the No. 3 cylinder had ever been removed or replaced from engine serial number 816113-R. Further, a review of Air Sunshine's maintenance records revealed no reports to the FAA that any of the company's engines were running unsatisfactorily from the date that its operations specifications were amended (September 9, 1999) to the date of the accident.[66]

1.17.1.3.2 Aircraft Flight Logs

A Safety Board review of the accident airplane's flight logs from the first flight conducted on December 23, 2002, to the last flight conducted on July 12, 2003, revealed that the airplane had been operated a total of 543.8 hours on 559 flights. During this time, pilots reported three maintenance-related discrepancies.

A review of the flight logs also revealed that the first flight to be conducted after the last phase 1 check (June 14, 2003) occurred on June 16, 2003. From the June 16th flight to the first flight conducted on the day of the accident, the airplane had been operated a total of 79.7 hours on 83 flights. During this time, no pilot-reported maintenance-related discrepancies were recorded.

1.17.2 Federal Aviation Administration Oversight

1.17.2.1 General

Air Sunshine was initially certificated in 1982 by the Miami FSDO. The company's operations certificate was transferred to the Fort Lauderdale FSDO in 1986. As noted previously, in early 1998, Air Sunshine asked the FAA to transfer its operations certificate to the San Juan FSDO. The FAA granted the request, and the certificate was transferred to the San Juan FSDO on June 2, 1998.

According to the PMI for Air Sunshine, airplanes that are based at FLL are maintained there, and airplanes that are based at SJU are maintained there. The PMI, who is based in San Juan, reported that he scheduled three to four trips a year to FLL as part of his work program.

[66] As noted previously, the PMI stated that he would grant Air Sunshine's request to amend its operations specifications provided that the company monitored the performance of newly overhauled engines and reported any abnormal conditions to the San Juan FSDO.

1.17.2.2 San Juan Flight Standards District Office Preaccident Oversight of Air Sunshine

According to the FAA's planned oversight program for Air Sunshine, the PMI planned on conducting the following inspections for fiscal year 2003 (from October 1, 2002, to September 30, 2003): two required and two additional facility inspections at FLL, two required and two additional ramp inspections of the Embraer 110 at FLL, two required and two additional ramp inspections of the Cessna 402s at FLL, one required and one additional spot check of the Cessna 402s at FLL, one required aircraft (Embraer 110) records inspection and one additional aircraft records inspection at FLL, and one required maintenance records inspection and one additional maintenance records inspection at SJU. A review of FAA records indicated that, from October 1, 2002, to July 8, 2003, the PMI conducted 10 ramp inspections, 2 spot inspections, and 1 aircraft records inspection.

The review of FAA records also indicated that the PMI conducted an inspection of Air Sunshine's Fort Lauderdale facility from March 25 to 27, 2003. In an April 1, 2003, letter to the company, the PMI stated that he found five Maintenance Manual-related discrepancies during the inspection. The PMI also reported that he conducted an inspection of Air Sunshine's San Juan facility from July 8 to 10, 2003. In a July 15, 2003, letter to the company, the PMI stated that he found three Maintenance Manual- and three aircraft records-related discrepancies. None of the aircraft records-related discrepancies involved the accident airplane.

1.17.2.3 Fort Lauderdale Flight Standards District Office Postaccident Oversight of Air Sunshine

Although the Fort Lauderdale FSDO has no maintenance oversight responsibilities for Air Sunshine, according to an aviation safety inspector from Fort Lauderdale, after the accident, the Fort Lauderdale FSDO Manager contacted the San Juan FSDO Manager to advise him that the Fort Lauderdale FSDO wanted to conduct additional surveillance of Air Sunshine. A review of FAA records indicated that, from July 14 to September 30, 2003, personnel from the Fort Lauderdale FSDO conducted 2 facility inspections, which found scales that were out of calibration and cargo that was not secured; 21 ramp inspections, which found numerous maintenance-related discrepancies with Air Sunshine's Cessna 402C airplanes; and 5 spot inspections, which found numerous maintenance-related discrepancies.

1.17.2.4 San Juan Flight Standards District Office Postaccident Oversight of Air Sunshine

According to the FAA, after the accident, the San Juan FSDO increased surveillance of Air Sunshine in all areas. The FAA stated that, from July 14, 2003, to February 25, 2004, the San Juan FSDO conducted 45 inspections of the company.

From July 22 to August 29, 2003, the San Juan FSDO conducted a focused inspection of Air Sunshine. During this inspection, the FAA determined that the company's record-keeping system was inadequate, its maintenance program was deficient, its passenger briefing card and overwater safety briefing needed to be revised, its pilot training needed to be revised, and its engine compression check interval was too high.

The FAA stated that, as a result of these inspections, the following actions were taken:

- The FAA filed an Enforcement Investigative Report regarding the deficiencies found in Air Sunshine's record-keeping system. The FAA stated that subsequent records inspections revealed that the deficiencies were corrected.
- The FAA sent a letter to Air Sunshine, addressing all of the maintenance discrepancies. The FAA stated that all of the corrective actions were documented in its PTRS.
- The FAA sent a letter to Air Sunshine, requiring the company to revise its General Operations Manual, section 3 (relating to the passenger briefing card and the overwater safety briefing). On October 1, 2003, the FAA accepted revision No. 31, which amended the overwater safety briefing. On July 6, 2004, the FAA accepted revision No. 32, which amended the passenger briefing card.
- The FAA sent a letter to Air Sunshine, requesting that the company revise its FAA-approved Pilot Training Manual. On February 12, 2004, the FAA accepted revision No. 15, which corrected outdated information and training-hour requirements and conformed to the new format of FAA Order 8400.10, *Air Transportation Operations Inspector's Handbook*.
- On November 18, 2003, Air Sunshine submitted and the FAA approved revision No. 11 to Air Sunshine's AAIP, which lowered the compression check interval from 360 to 120 hours.

1.17.2.5 Additional Postaccident Actions

On February 26, 2004, Air Sunshine's PMI sent the company a letter regarding its AAIP. The PMI stated that, effective immediately, the company's Operations Specification Part D-101 would be amended to specify that only TCM could rebuild the company's TCM TSIO-520-VB engines. The PMI further stated that, pending mitigating actions on the part of Air Sunshine, he was proposing to reduce the TBO from 2,400 flight hours to the manufacturer-recommended TBO of 1,600 flight hours, effective March 12, 2004. The PMI asked Air Sunshine to provide in writing, by March 4, 2004, a detailed plan for any actions that the company planned on taking in response to the PMI's letter.

In a letter to the FAA dated March 3, 2004, Air Sunshine's General Manager responded that the company did not agree with the FAA that TCM rebuilt engines were superior to engines that were overhauled by Airmark Overhaul. He added that Airmark was a TCM distributor and that Airmark used TCM guidelines and "brand new millennium cylinders."[67] He further stated that "throughout the years we have found quality control and attention to details of Airmark highly superior to the mass production errors inherent of large factories like TCM." The manager asked the PMI to reconsider its decision to require Air Sunshine to use only TCM rebuilt engines.

The General Manager stated that the company would revise its AAIP to include a cylinder inspection every 1,600 flight hours, which would include replacement of valves,

[67] "Millennium" cylinders are Superior Air Parts cylinders. Five of the six cylinders from the right engine were ECI cylinders.

rings, and gaskets. The manager also stated that the cylinder inspection would include, if necessary, replacement of valve seats, guides, and pistons. He added that the company would revise its compression check interval and place additional constraints, such as replacing of cylinders if the compression levels fell below the limit established in accordance with TCM SB 03-3. The manager stated that the company had already revised its AAIP to require three compression checks during a 360-flight-hour inspection cycle (compression checks would be conducted once every 120 flight hours). At the time of the accident, one compression check was required during a complete inspection cycle (compression checks were conducted once every 360 hours).

The General Manager stated that Air Sunshine was also willing to conduct cylinder inspections on the four engines in its fleet that had more than 1,600 flight hours and that the company had already ordered one new TCM engine to replace an engine that had about 2,200 flight hours. The manager also stated that the company had followed all of the guidelines to obtain the TBO extension to 2,400 flight hours, including preparing five engine teardown reports, and that the company had operated for 11 years and for more than 100,000 flight hours under the extended TBO.

1.18 Additional Information

1.18.1 Previous Ditching Accidents

On January 1, 2002, a Piper PA-31 operated by Air Taxi, Inc., as a Part 135 nonscheduled commuter flight was ditched in the Atlantic Ocean after fuel exhaustion. Three passengers and the pilot sustained serious injuries, and one passenger died. According to the surviving passengers, the pilot did not conduct a preflight briefing or an emergency briefing before the ditching. Four of the PFDs on board the airplane were retrieved after the airplane was in the water.[68]

On August 20, 2000, a Piper PA-31 operated by Big Island Air as a Part 135 commuter flight was ditched in the Pacific Ocean after a loss of engine power. All of the passengers retrieved their PFDs before the ditching. The passengers reported that, shortly after the engine problem occurred, the pilot instructed them to retrieve and don their PFDs and assume a crash position. One passenger retrieved, donned, and partially inflated her PFD, but she was not able to evacuate the airplane and, as a result, died.

[68] A description of this accident, MIA04FA48, can be found on the Safety Board's Web site at <http://www.ntsb.gov>.

2. Analysis

2.1 General

The pilot was properly certificated and qualified under Federal regulations. No evidence indicated any preexisting medical or physical condition that might have adversely affected the pilot's performance during the accident flight.

The airplane was properly certificated and equipped in accordance with Federal regulations. The airplane was equipped with FAA-approved flotation gear, as required by Federal regulations.

The airplane was loaded in accordance with FAA-approved company weight and balance procedures. The weight and balance of the airplane were within prescribed limits during all phases of the flight.

Given the distance from shore at which the ditching occurred and the availability of emergency response equipment, the search and rescue efforts were timely and appropriate. The accident was survivable.[69]

The inoperative distance measuring equipment on the MYAT VOR was not a factor in this accident.

This analysis discusses the accident sequence, including the airplane's performance after the right engine failed and the cause of this failure. This analysis also discusses Air Sunshine-related maintenance issues, pilot proficiency, and the need for emergency briefings.

2.2 Accident Sequence

The accident flight departed FLL about 1427. The takeoff and cruise portions of the flight were uneventful. The pilot reported that the flight's cruise altitude was about 7,500 feet and that the cruise speed was about 160 KIAS.

The pilot reported that, while descending through an altitude of about 3,500 feet at an airspeed of about 135 to 140 KIAS and a distance of about 20 to 25 miles from MYAT, he heard a bang and saw oil coming out of the right engine cowling. Several of the passengers reported seeing white smoke coming from the engine followed by a stream of oil and then hearing a loud bang. The passengers reported seeing parts falling from the

[69] Although the accident was survivable, two passengers died after evacuating the airplane. Section 2.9 discusses the pilot's failure to conduct an emergency briefing after the right engine failed and this failure's effect on the outcome of the accident.

engine after they heard the loud bang. The pilot reported that, after attempting to shut down the right engine, he applied full power to the left engine and slowed to about 95 KIAS, but he could not maintain altitude. He stated that, once the airplane descended through an altitude of about 1,500 to 1,000 feet, he realized that the airplane could not make it to the airport and, therefore, he decided to ditch the airplane.

The on-site examination of the airplane after it was recovered from the water revealed that both of the right engine magnetos had penetrated through the engine cowling and that they were hanging onto the engine by their harnesses. After opening the engine cowling, the No. 2 cylinder was found separated from the engine crankcase at the cylinder flange. Therefore, the Safety Board concludes that the airplane's right engine failed while the airplane was descending through an altitude of about 3,500 feet.

2.3 Airplane Performance After the Right Engine Failure

Air Sunshine's Training Manual states that, if a failed engine does not start after performing steps 1 through 8 of the in-flight engine failure procedures (see section 1.17.1.1), the pilot should close the throttle, cut off mixture, and feather the propeller on the inoperative engine; move the fuel selector, auxiliary fuel pump, and magneto switches for the inoperative engine to off; and close the cowl flaps. The left fuel selector valve in the cockpit was found positioned to the left main fuel tank; the position of the right fuel selector valve was not determined. The right cowl flap was found open. Further, Air Sunshine's Training Manual states that, before ditching, the pilot should extend the wing flaps to 45°. The pilot stated that he did not extend the flaps before ditching; however, the Safety Board notes that the airplane was found with the left and right flaps extended to 15°.[70]

Several factors existed that adversely affected the airplane's performance, including the windmilling propeller (-400 fpm penalty), the protruding magnetos (-4 fpm penalty), and the open right engine cowl flap (-9 fpm penalty). In addition, flaps that are extended to 15° could cause a -145 to -165 fpm penalty. However, Safety Board investigators could not determine when the flaps were extended; therefore, it is unknown when the penalty for flaps at 15° started.

Several other factors could also have degraded the airplane's performance, including not flying at the recommended airspeeds, operating with a bank angle and sideslip not in accordance with Cessna's recommended in-flight engine failure configuration, and not maintaining a steady descent. However, Cessna could not quantify the penalties for these variables. The Safety Board calculated that, at an airspeed of 90 knots and with the engine damage, the airplane could have tolerated a descent rate of about 250 fpm and have been able to maintain flight and reach land. The pilot stated that, during the ditching, the descent rate was between about 200 and 300 fpm. Board calculations showed that the airplane's descent rate was between 560 and 212 fpm during its descent from 3,500 feet to 2,000 feet and was between 429 and 360 fpm during its descent from 2,000 feet to contact with the water.

[70] The pilot stated that one of the passengers might have hit the electrically controlled switch that extends the flaps while they were evacuating the airplane.

On the basis of this evidence, the Safety Board concludes that several factors contributed to the degradation of the airplane's performance and its inability to maintain flight and reach land, including the windmilling propeller, the protruding magnetos, the open right engine cowl flap, and the possibility that the flaps were extended to 15° at some point during the descent. The Safety Board further concludes that, during the descent from 3,500 to 2,000 feet, the airplane's descent rate was between about 560 and 212 fpm, and that, during the descent from 2,000 feet to contact with the water, its descent rate was between 429 and 360 fpm. The Safety Board also concludes that, if the average descent rate had been about 200 fpm or less, the airplane would have been able to maintain flight and reach MYAT.

The pilot stated that, when he tried to feather the right propeller, it continued to turn until the airplane contacted the water. Two passengers stated that the propeller continued turning until the airplane contacted the water. However, when the propeller was removed and examined, the blade angles were measured to be within the specified range for feather (82.2° +/-0.3°). Further, the propeller's start-lock mechanism showed no evidence of damage, such as witness marks, which would have been expected if the propeller had been on the start locks at the time that it contacted the water. Therefore, the Safety Board concludes that the right propeller was in the fully feathered position, but Board investigators could not determine at what point the propeller became fully feathered.

2.4 Right Engine Failure Sequence

Previous Safety Board investigations of engine cylinder separations have shown that cylinder stud failures generally occurred as a progressive sequence of fatigue fractures. Typically, the initial fracture has been caused by high-cycle, low-stress fatigue (indicating preexisting cracking that was not created during the engine cylinder separation) and has penetrated nearly the entire fastener section. Subsequent fractures have shown decreasing amounts of fatigue followed by overstress and fracture features that were increasingly indicative of high-stress propagation. However, the accident airplane right engine No. 2 cylinder stud fractures showed no evidence of a progressive sequence of fatigue, indicating that a sudden onset of higher loads occurred.

Although combustion instabilities, such as detonation or preignition, can cause the rapid increase of the loads on the studs, no evidence of such an event was found. A partial piston or ring failure can also increase the loads on the studs; however, metallurgical evidence indicated that the No. 2 cylinder piston fractures were caused by sudden overstress. Optical examinations of the fractured studs and through bolts confirmed that they failed as a result of high-stress fatigue.

Small, raised ridges observed on the forward side of the right engine No. 2 cylinder mounting face indicated that the cylinder was rocking on the engine crankcase, pivoting around the through bolt on the forward side of the base flange. For this motion to occur, some of the cylinder studs opposite of this location had to become fractured or the nuts opposite of this location had to become loose. Two of the studs from this area were found intact but without the nuts.

In addition, two intact cylinder hold-down nuts were found in the engine compartment area. Typically, cylinder hold-down nuts become separated from the cylinder hold-down studs if the threads on the nuts or studs are stripped (pulled out) or if the nuts become loose and unthreaded by vibration. The threads on the two cylinder hold-down nuts found in the engine compartment area were intact; the damage to the threads of the nonfractured studs in the engine crankcase was minimal. Therefore, the hold-down nuts on the two unfractured studs must have become loose and backed off of the studs. The Safety Board is unaware of any previous instances of cylinder separations in which the hold-down nuts completely backed off of multiple studs.

The loss of the cylinder hold-down nuts on the two unfractured studs would have caused the loads to be transferred to the remaining studs and through bolts. The increased load would have been sufficient to initiate and propagate high-stress fatigue fractures in four of the remaining studs and both through bolts; the loads on the remaining stud would have been sufficient to strip its case threads. The presence of fractures of the four broken studs, the fractures of the two broken through bolts, and the stripped case threads at another stud location indicated that the nuts were present on these studs and through bolts for a significant portion of the failure sequence.

Several sharp circumferential dents, scrapes, and other contact marks on the bore portion of the case that mates with the No. 2 cylinder skirt show that the failure of the No. 2 cylinder retention system caused the progressive outboard movement of the cylinder. At some point, the piston fragmented and, the connecting rod, wrist pin, and piston fragments separated from the engine.

On the basis of the metallurgical evidence, the Safety Board concludes that two or more of the right engine No. 2 cylinder hold-down nuts became loose and backed off of the studs, which resulted in the remaining studs and through bolts fracturing in high-stress fatigue, allowing the cylinder to separate from the engine.

2.5 Cause of the Loosened No. 2 Cylinder Hold-down Nuts

The probability that two or more cylinder hold-down nuts would simultaneously loosen is very low. Therefore, an outside influence, such as the application of insufficient torque to the nuts during maintenance, likely occurred. The Safety Board reviewed Air Sunshine's maintenance records to determine when insufficient torque might have been applied to the nuts.

Between the time of the last compression checks (June 12 to 14, 2003) and the accident, the engine accumulated 83 flight hours. No records were found indicating that any other maintenance was performed on the accident engine at the time of and after the last compression check. Although it is possible that insufficient torque was applied to the cylinder hold-down nuts during undocumented maintenance at the time of the last known

maintenance event,[71] it is also possible that insufficient torque was applied during undocumented maintenance subsequent to the last known event. However, if a mechanic does not apply enough torque to a nut during maintenance, the nut typically becomes loose soon afterward. Therefore, the Safety Board concludes that the simultaneous loosening of two or more of the right engine No. 2 cylinder hold-down nuts resulted from the application of insufficient torque, which was applied by Air Sunshine maintenance personnel during undocumented maintenance.

2.6 Air Sunshine Maintenance Record-Keeping and Practices

The Safety Board's review of Air Sunshine's maintenance records revealed several discrepancies. The review revealed that the number stamped on the No. 6 cylinder from the accident airplane's right engine did not match the number recorded in the maintenance records. The maintenance records for the right engine did not indicate that the No. 6 cylinder had ever been removed or replaced. Further, although the company's General Manager reported that the No. 6 cylinder was originally the No. 3 cylinder from another one of the company's engines, the maintenance records for the other engine did not indicate that its No. 3 cylinder had ever been removed or replaced. Air Sunshine's records showed no evidence that the company had reported any problems with its engine to the FAA[72] despite evidence found during this investigation that indicated that at least two cylinders were removed and replaced on two separate engines.

In 1998, Air Sunshine applied to change its AAIP from a 3-phase, 60-hour inspection program to a 6-phase, 60-hour inspection program. The FAA approved the change, which was in effect at the time of the accident. As a result of this change, engine differential compression checks were conducted once every 360 hours instead of every 180 hours. Subsequent to the accident, Air Sunshine changed its AAIP to require that three compression checks be conducted during a 360-hour inspection cycle (once every 120 hours), and the FAA approved this change. Although the company's modified AAIP increased the number of compression checks in a 360-hour cycle, the compression check interval is still well beyond the 100-hour interval recommended in SB 03-3.

In addition, during the last differential compression checks performed on the airplane's engines (from June 12 to 14, 2003), the assistant mechanic recorded readings of 0 psi for the right engine No. 2 cylinder and 20 psi for the No. 4 cylinder. Further, Safety Board investigators who reviewed the engine differential compression check form on which the assistant mechanic recorded the readings noted that the number recorded for the

[71] Typically, torque only needs to be applied to cylinder hold-down nuts after cylinder installations. Cylinders are not removed and reinstalled during compression checks; therefore, insufficient torque would not have been applied during the June 2003 compression checks.

[72] As noted previously, in a September 9, 1999, letter to Air Sunshine, the PMI stated that he would grant the company's request to amend its operations specifications to reflect the 2,400-flight-hour TBO if the company monitored the performance of newly overhauled engines and reported any abnormal conditions to the San Juan FSDO.

No. 3 cylinder could have been either 55 or 25. The Director of Maintenance told Safety Board investigators that, because the readings were low, he repeated the checks on all of the right engine cylinders. He stated that all of the readings were in the 70-psi range. However, Board investigators could not find any documentation indicating that the checks had been repeated.

The differential compression checks on the right engine were performed by an assistant mechanic without supervision or assistance, even though he did not have an A&P certificate. During postaccident interviews, the assistant mechanic stated that he had never conducted a compression check before conducting the checks on the accident airplane's right engine. When a Safety Board investigator asked the assistant how to perform the test, he did not appear to be familiar with the entire test. Further, Air Sunshine's Maintenance Manual contained a caution, stating that two people should conduct the compression checks.

The Safety Board notes that, for the compression checks to be conducted safely and properly, the two people who conduct the checks should have adequate training and experience. However, Air Sunshine's Director of Maintenance allowed a non-A&P certified assistant mechanic, who had never previously performed engine compression checks, to perform the checks by himself without supervision. Further, a review of the assistant mechanic's training records indicated that he did not complete on-the-job training for the entire airplane until 14 to 16 days after he performed the compression checks. The assistant mechanic should not have been working unsupervised during on-the-job training, which indicated that the company's on-the-job maintenance training was not adequate.

Last, during postaccident interviews, the Director of Maintenance stated that, when company maintenance personnel remove and replace an engine cylinder assembly, they coat the cylinder hold-down studs with an aluminum-copper-graphite, lithium-based antiseize compound manufactured by Permatex before applying torque to the studs. The use of the Permatex compound is not in accordance with TCM SB 96-7B. Permatex does not recommend using antiseize compound in high-vibration environments because it could contribute to the loss of torque. Although the threads of the right engine studs and through bolts showed no evidence of this compound, the Safety Board is concerned that Air Sunshine indicated that it was using an antiseize compound on its engines. The Safety Board concludes that, at the time of the accident, Air Sunshine's maintenance record-keeping and practices were not adequate.

Subsequent to the accident, the FAA conducted a focused inspection of Air Sunshine (from July 22 to August 29, 2003). During these inspections, the FAA determined that the company's maintenance program was deficient. The FAA stated that it had sent a letter to Air Sunshine in which all of the maintenance discrepancies were addressed and that all of the company's corrective actions in response to these discrepancies had been documented in the FAA's PTRS. Therefore, the Safety Board concludes that the FAA's oversight of Air Sunshine was in accordance with standard guidelines, but was insufficient to detect inadequate maintenance record-keeping and practices at the company.

2.7 Pilot Proficiency

A review of Arrow Air's simulator training records for the pilot revealed that he had received a large number of "unsatisfactory" grades and that he needed to improve his scanning and checklist skills, including response and organization.[73] Further, on September 13, 2000, the pilot failed a ramp check because an FAA inspector found that the airplane had numerous discrepancies and that his passenger briefing was inadequate.

Airplane performance calculations show that the windmilling propeller and the protruding magnetos alone were not sufficient to cause the airplane to descend as rapidly as it did. Other factors that were most likely caused or controlled by the pilot, including not flying at the recommended airspeeds and flap settings, operating with a bank angle and sideslip that were not in accordance with Cessna's recommended in-flight engine failure configuration, and not maintaining a steady descent, could have degraded the accident airplane's performance. If the pilot had been more proficient, he might have been able to decrease the descent rate enough to maintain flight and reach land.

A review of FAA records revealed that, from April 1983 to February 1998, the pilot failed nine flight checks. The pilot failed two flight checks that he was receiving for his private pilot certificate, one flight check that he was receiving for his instrument pilot rating, one flight check that he was receiving for his ATP certificate, two flight checks that he was receiving for his CFI certificate, and three flight checks that he was receiving for his CFI instrument rating.

Therefore, the Safety Board concludes that the pilot had a history of below-average flight proficiency, including numerous failed flight tests, before the accident flight, which contributed to his inability to maintain maximum flight performance and reach land after the right engine failed.

2.8 Pilot Failure to Use Shoulder Harness

Federal regulations require flight crewmembers of U.S.-registered civil aircraft to keep their shoulder harnesses fastened during takeoff and landing, including during a ditching. During postaccident interviews, the pilot stated that he did not have his shoulder harness fastened during the ditching. He added that, because his harness was not fastened, he hit his head on the instrument panel when the airplane hit the water, which made him dizzy. Two passengers indicated that the pilot was incoherent when he was in the water. One of the passengers also stated that the pilot "did not look like he could swim" and that he had to give the pilot his PFD. Therefore, the Safety Board concludes that the pilot was not wearing his shoulder harness during the ditching, and, because he was not wearing his harness, he sustained a head injury that reduced his ability to assist passengers after the ditching.

[73] The pilot did not complete Arrow Air's pilot training program.

2.9 Emergency Briefings

Air Sunshine's FAA-approved General Operations Manual stated that, before a ditching, the pilot should review the emergency ditching evacuation procedures with the passengers and instruct them to don their PFDs without inflating them in the airplane. The manual added that the pilot should also review with the passengers how to operate the PFDs. Because these instructions were also contained in the company's operations specifications, the instructions were required to be performed by the pilot.

In a 1985 safety study titled, *Air Carrier Overwater Emergency Equipment and Procedures,*[74] the Safety Board concluded that "the ability of flight and cabin crewmembers to assist passengers effectively during ditchings and following inadvertent water impacts may be the single most important factor in the survival outcome." As noted previously, passengers reported that, after the right engine failed, the pilot did not tell them to retrieve or don their PFDs before the airplane contacted the water. The passengers stated that the only time the pilot addressed them after the right engine failed and before the airplane contacted the water was to tell them to "calm down."

According to the Safety Board's airplane performance study, the airplane was airborne for at least 7 minutes after the right engine failed and before it contacted the water. Even though the pilot did not instruct the passengers to retrieve their PFDs, the passenger in seat 3B, who was holding a child on her lap, retrieved the PFD from under her seat, and the passenger in seat 5A retrieved three PFDs and put them on the children accompanying her. None of the other passengers or the pilot attempted to retrieve their PFDs before the airplane contacted the water. After the airplane was in the water, several of these passengers tried to retrieve their PFDs, but none was successful.

If the pilot had instructed the adult passengers to retrieve and don their PFDs and had reviewed how to operate the PFDs shortly after the right engine failed, all of the passengers would have had adequate time to retrieve and don their PFDs before the airplane contacted the water. The Safety Board is aware that, subsequent to the accident, Air Sunshine amended its emergency ditching procedures by adding the instruction that all occupants should don PFDs as soon as any emergency occurs during overwater operations.

The Safety Board concludes that, after determining that he was going to ditch the airplane, the pilot failed to conduct an emergency briefing, which was required by the emergency ditching procedures contained in Air Sunshine's General Operations Manual, and that this failure contributed to passenger fatalities. The Safety Board further concludes that the passengers would have had sufficient time to retrieve and don their PFDs if the pilot had instructed them to do so shortly after the right engine failed.

[74] For more information, see National Transportation Safety Board, *Air Carrier Overwater Emergency Equipment and Procedures,* Safety Study NTSB/SS-85/02 (Washington, DC: NTSB, 1985).

On January 1, 2002, a Piper PA-31 operated by Air Taxi, Inc., was ditched in the Atlantic Ocean after fuel exhaustion. Three passengers and the pilot sustained serious injuries, and one passenger died. According to the surviving passengers, the pilot did not conduct a preflight briefing or an emergency briefing before the ditching. None of the PFDs on board the airplane were retrieved until the airplane was in the water.

In contrast, on August 20, 2000, a Piper PA-31 operated by Big Island Air was ditched in the Pacific Ocean after a loss of engine power. All of the passengers retrieved their PFDs before the ditching. The passengers reported that, shortly after the engine problem occurred, the pilot instructed them to retrieve and don their PFDs and assume a crash position. As indicated by this event, if passengers aboard flights that operate over water are adequately briefed and have time to prepare during an emergency, deaths may be prevented.

The Safety Board concludes that having pilots provide adequate emergency briefings to passengers is an important survival factor. Therefore, the Safety Board believes that the FAA should issue a flight standards information bulletin to principal operations inspectors of all Part 135 single-pilot operators that carry passengers and operate over water, which familiarizes them with the circumstances of the Air Sunshine flight 527 accident and emphasizes the need for pilots to provide timely emergency briefings. The bulletin should state that these briefings should include, at a minimum, information about the location and operation of the on-board emergency equipment and exits.

3. Conclusions

3.1 Findings

1. The pilot was properly certificated and qualified under Federal regulations. No evidence indicated any preexisting medical or physical condition that might have adversely affected the pilot's performance during the accident flight.

2. The airplane was properly certificated and equipped in accordance with Federal regulations. The airplane was equipped with Federal Aviation Administration-approved flotation gear, as required by Federal regulations.

3. The accident airplane was loaded in accordance with Federal Aviation Administration-approved company weight and balance procedures. The weight and balance of the airplane were within prescribed limits during all phases of the flight.

4. Given the distance from shore at which the ditching occurred and the availability of emergency response equipment, the search and rescue efforts were timely and appropriate. The accident was survivable.

5. The inoperative distance measuring equipment on the Treasure Cay Airport very high frequency omnidirectional range was not a factor in this accident.

6. The airplane's right engine failed while the airplane was descending through an altitude of about 3,500 feet.

7. Several factors contributed to the degradation of the airplane's performance and its inability to maintain flight and reach land, including the windmilling propeller, the protruding magnetos, the open right engine cowl flap, and the possibility that the flaps were extended to 15° at some point during the descent.

8. During the descent from 3,500 to 2,000 feet, the airplane's descent rate was between about 560 and 212 feet per minute (fpm), and, during the descent from 2,000 feet to contact with the water, its descent rate was between 429 and 360 fpm.

9. If the average descent rate had been about 200 feet per minute or less, the airplane would have been able to maintain flight and reach Treasure Cay Airport.

10. The right propeller was in the fully feathered position, but Safety Board investigators could not determine at what point the propeller became fully feathered.

11. Two or more of the right engine No. 2 cylinder hold-down nuts became loose and backed off of the studs, which resulted in the remaining studs and through bolts fracturing in high-stress fatigue, allowing the cylinder to separate from the engine.

12. The simultaneous loosening of two or more of the right engine No. 2 cylinder hold-down nuts resulted from the application of insufficient torque, which was applied by Air Sunshine maintenance personnel during undocumented maintenance.

13. At the time of the accident, Air Sunshine's maintenance record-keeping and practices were not adequate.

14. The Federal Aviation Administration's oversight of Air Sunshine was in accordance with standard guidelines, but was insufficient to detect inadequate maintenance record-keeping and practices at the company.

15. The pilot had a history of below-average flight proficiency, including numerous failed flight tests, before the accident flight, which contributed to his inability to maintain maximum flight performance and reach land after the right engine failed.

16. The pilot was not wearing his shoulder harness during the ditching, and because he was not wearing his harness, he sustained a head injury that reduced his ability to assist passengers after the ditching.

17. After determining that he was going to ditch the airplane, the pilot failed to conduct an emergency briefing, which was required by the emergency ditching procedures contained in Air Sunshine's General Operations Manual, and this failure contributed to passenger fatalities.

18. The passengers would have had sufficient time to retrieve and don their personal flotation devices if the pilot had instructed them to do so shortly after the right engine failed.

19. Having pilots provide adequate emergency briefings to passengers is an important survival factor.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the in-flight failure of the right engine and the pilot's failure to adequately manage the airplane's performance after the engine failed. The right engine failure resulted from inadequate maintenance that was performed by Air Sunshine's maintenance personnel during undocumented maintenance. Contributing to the passenger fatalities was the pilot's failure to provide an emergency briefing after the right engine failed.

4. Recommendation

As a result of its investigation of the July 13, 2003, Air Sunshine flight 527 accident, the National Transportation Safety Board makes the following recommendation to the Federal Aviation Administration:

> Issue a flight standards information bulletin to principal operations inspectors of all Part 135 single-pilot operators that carry passengers and operate over water, which familiarizes them with the circumstances of the Air Sunshine flight 527 accident and emphasizes the need for pilots to provide timely emergency briefings. The bulletin should state that these briefings should include, at a minimum, information about the location and operation of the on-board emergency equipment and exits. (A-04-55)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

ELLEN ENGLEMAN CONNERS
Chairman

MARK V. ROSENKER
Vice Chairman

CAROL J. CARMODY
Member

RICHARD F. HEALING
Member

DEBORAH A. P. HERSMAN
Member

Adopted: October 13, 2004

5. Appendix

Appendix A
Investigation and Public Hearing

Investigation

The National Transportation Safety Board learned about the accident about 1545 on July 13, 2003. A go-team was not assembled, and the Safety Board did not immediately respond to the scene of the accident. An Air Safety Investigator from the Board's Southeast Regional Field Office departed Miami on July 31, 2003, to observe the recovery of the airplane, which occurred on August 3, 2003, about 1120. Investigators from Cessna Aircraft Company and the Federal Aviation Administration (FAA) were also present during the recovery.

Parties to the investigation were the FAA, Teledyne Continental Motors, McCauley Propeller Systems, and Cessna Aircraft Company. The Bahamian Government designated an accredited representative to assist in the investigation.

Public Hearing

No public hearing was held for this accident.

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