In-flight Separation of Right Wing Flying Boat, Inc. (doing business as Chalk's Ocean Airways) Flight 101 Grumman Turbo Mallard (G-73T), N2969 Port of Miami, Florida December 19, 2005



ACCIDENT REPORT

NTSB/AAR-07/04
PB2007-910405

National Transportation Safety Board

Aircraft Accident Report

In-flight Separation of Right Wing
Flying Boat, Inc. (doing business as Chalk's Ocean Airways) Flight 101
Grumman Turbo Mallard (G-73T), N2969
Port of Miami, Florida
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National Transportation Safety Board. 2007. ***In-flight Separation of Right Wing, Flying Boat, Inc. (doing business as Chalk's Ocean Airways) Flight 101, Grumman Turbo Mallard (G-73T), N2969, Port of Miami, Florida, December 19, 2005.*** **Aircraft Accident Report NTSB/AAR-07/04. Washington, DC.**

Abstract: This report explains the accident involving Flying Boat, Inc. (doing business as Chalk's Ocean Airways) Flight 101, a Grumman Turbo Mallard (G-73T) amphibious airplane, which crashed into a shipping channel adjacent to the Port of Miami, Florida, shortly after takeoff from the Miami Seaplane Base. Safety issues discussed in this report focus on air carrier maintenance programs and practices and Federal Aviation Administration (FAA) oversight procedures for air carrier maintenance programs. Safety recommendations concerning these issues are addressed to the FAA.

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Abbreviations

AC	advisory circular
AD	airworthiness directive
ASOS	automated surface observing system
CAMI	Civil Aeromedical Institute
CAMP	Continuous Airworthiness Maintenance Program
CASS	Continuing Analysis and Surveillance System
CFR	*Code of Federal Regulations*
c.g.	center of gravity
CVR	cockpit voice recorder
DER	designated engineering representative
DOT	Department of Transportation
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FLL	Fort Lauderdale/Hollywood International Airport, Fort Lauderdale, Florida
FSAW	flight standards information bulletin for airworthiness
GMM	general maintenance manual
METAR	meteorological aerodrome report
MIA	Miami International Airport
PMI	principal maintenance inspector
POI	principal operations inspector
S/N	serial number
SAIB	special airworthiness information bulletin
SAFO	safety alert for operators
STC	supplemental type certificate
WS	wing station
X44	Miami Seaplane Base, Miami, Florida

Executive Summary

On December 19, 2005, about 1439 eastern standard time, a Grumman Turbo Mallard (G-73T) amphibious airplane, N2969, operated by Flying Boat, Inc., doing business as Chalk's Ocean Airways flight 101, crashed into a shipping channel adjacent to the Port of Miami, Florida, shortly after takeoff from the Miami Seaplane Base. Flight 101 was a regularly scheduled passenger flight to Bimini, Bahamas, with 2 flight crewmembers and 18 passengers on board. The airplane's right wing separated during flight. All 20 people aboard the airplane were killed, and the airplane was destroyed by impact forces. Flight 101 was operating under the provisions of 14 *Code of Federal Regulations* Part 121 on a visual flight rules flight plan. Visual meteorological conditions prevailed at the time of the accident.

The National Transportation Safety Board determines that the probable cause of this accident was the in-flight failure and separation of the right wing during normal flight, which resulted from (1) the failure of the Chalk's Ocean Airways maintenance program to identify and properly repair fatigue cracks in the right wing and (2) the failure of the Federal Aviation Administration (FAA) to detect and correct deficiencies in the company's maintenance program.

The safety issues discussed in this report focus on air carrier maintenance programs and practices and FAA oversight procedures for air carrier maintenance programs. Safety recommendations concerning these issues are addressed to the FAA.

1. Factual Information

1.1 History of Flight

On December 19, 2005, about 1439 eastern standard time,[1] a Grumman Turbo Mallard (G-73T) amphibious airplane, N2969, operated by Flying Boat, Inc., doing business as Chalk's Ocean Airways flight 101, crashed into a shipping channel adjacent to the Port of Miami, Florida, shortly after takeoff from the Miami Seaplane Base (X44). Flight 101 was a regularly scheduled passenger flight to Bimini, Bahamas, with 2 flight crewmembers and 18 passengers[2] on board. The airplane's right wing separated during flight.[3] All 20 people aboard the airplane were killed, and the airplane was destroyed. Flight 101 was operating under the provisions of 14 *Code of Federal Regulations* (CFR) Part 121 on a visual flight rules flight plan. Visual meteorological conditions prevailed at the time of the accident.

On the day of the accident, the accident flight crew flew the airplane from Fort Lauderdale/Hollywood International Airport (FLL) in Fort Lauderdale, Florida, to X44 as Chalk's Ocean Airways flight 110. According to the flight log, the airplane departed FLL about 1305 and landed at X44 about 1321.[4]

The airplane departed X44 on the accident flight about 1438 and crashed into the water about 1 minute later. Of about 15 witnesses interviewed, most reported that the airplane's right wing separated from the rest of the airplane in flight, that smoke or fire came from the wing or a fireball in the sky, and that the airplane subsequently descended into the water.[5] About one-half of these witnesses reported that they heard an explosion associated with the wing separation.[6]

Most of the wreckage was located in about 30 feet of water. Lifeguards who patrolled Miami Beach on foot and on jet skis were the first to respond to the accident scene. Miami emergency dispatch notified the Miami Coast Guard and the Miami Beach Police Department by telephone about the accident. The Miami Coast Guard log showed

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[1] Unless otherwise noted, all times in this report are eastern standard time, based on a 24-hour clock.

[2] Of the 18 passengers, 3 were lap-held infants. Eleven of the passengers were citizens of the Bahamas; the seven other passengers and the flight crew were U.S. citizens.

[3] The G-73T technically has one wing structure. For the purpose of this report, "right wing" generally refers to any wing area on the right side of the airplane's fuselage, and "left wing" generally refers to any wing area on the left side of the airplane's fuselage.

[4] During a postaccident interview, the chief pilot of Chalk's Ocean Airways stated that the accident airplane had been scheduled to depart from FLL about 0815 but had been delayed because of weather.

[5] Some witnesses provided video and digital still images that captured segments of the accident sequence. For more information, see section 1.16.2.

[6] An explosives examination performed on the wreckage found no evidence of explosives. For more information, see section 1.16.3.

that the Miami Coast Guard launched an HH-65 helicopter to the accident scene about 7 minutes after receiving notification of the accident and began recovery efforts about 6 minutes afterward.

1.2 Injuries to Persons

Table 1. Injury chart.

Injuries	Flight Crew	Cabin Crew	Passengers	Other	Total
Fatal	2	0	18	0	20
Serious	0	0	0	0	0
Minor	0	0	0	0	0
None	0	0	0	0	0
Total	2	0	18	0	20

1.3 Damage to Airplane

The airplane was destroyed by impact forces.

1.4 Other Damage

No other damage was noted.

1.5 Personnel Information

1.5.1 The Captain

The captain, age 37, held an airline transport pilot certificate with ratings for airplane multiengine land and sea. She held a Federal Aviation Administration (FAA) first-class medical certificate dated September 27, 2005, with a limitation that required her to wear corrective lenses while exercising the privileges of this certificate. The captain received a type rating for the G-73T in May 2005. FAA records indicated no accident or incident history or enforcement action, and a search of records at the National Driver Register found no history of driver's license revocation or suspension.

The captain was hired by Chalk's Ocean Airways in March 2003.[7] The captain's most recent line check occurred on August 14, 2005, and her most recent G-73T proficiency check was on May 10, 2005. Company records indicated that the captain had accumulated 2,820 hours of total flying time, including 1,330 hours as a pilot-in-command, 1,630 hours in the G-73T, and 430 hours as a G-73T pilot-in-command. She had flown 723, 203, and 85 hours in the 12 months, 90 days, and 30 days, respectively, before the accident. In the 24 hours before the accident, the captain had flown about 2.5 hours.

On the day of the accident, the captain was scheduled to fly seven flight segments for a total of 4.1 hours of flying time. (The accident occurred on the second flight segment.) The captain's first flight was scheduled to depart from FLL about 0815 but was delayed by a low fog layer that prevented flying. The captain had to wait in the airport terminal. According to the chief pilot, who had also waited at FLL to depart, the captain seemed to be upbeat, friendly, smiling, and alert.

According to company flight logs, on the day before the accident (December 18), the captain's first flight segment began about 0635 and was a repositioning flight to return the airplane to FLL. The captain then flew seven additional flight segments, with the last one ending about 1730. She accumulated a total of 6.9 hours for the day.

On December 17, the captain was on duty and flew the accident airplane on 10 flight segments. The first officer who flew with the captain during those trips stated that the captain appeared to be in a good mood. The first officer also stated that, after a layover at a hotel, the captain appeared rested when flying resumed early on the morning of December 18.

Company records indicated that the captain was off duty from December 12 to 16, 2005. According to her husband, the captain slept all day on December 16 because they had arrived home from a personal trip the night before (December 15), and she was exhausted.

In addition to her flying duties, in August 2005, the captain was appointed as the company's director of safety.[8] According to a company representative, the captain spent about 2 days per month accomplishing her director of safety activities, which involved attending meetings, performing safety audits, and reporting safety concerns directly to the general manager.

According to the captain's husband, on days when the captain was on duty, she awoke about 0430. During the winter, she returned home from work between 2030 and

[7] The captain flew the G-73T as a first officer until receiving her type rating on the airplane.

[8] According to 14 CFR 119.65(a)(1), a Part 121 certificate holder must have a qualified person "serving full-time" as director of safety. However, according to FAA Order 8400.10, "Air Transportation Operations Inspector's Handbook," "in a small Part 121 operation, the director of safety functions may be an additional function of a current manager. Any request for a management deviation involving a director of safety position must be approved by AFS-200." The company's FAA-approved operations specifications listed the captain as the director of safety.

2100 and went to bed by 2230. He stated that she was healthy and strong but that, during the year before the accident, her health had been affected by the stress of work demands. He also stated that, although she felt loyal to the airline and liked the company's director of operations, she had begun applying for another flying job because she was becoming physically exhausted, was not enjoying the job any longer, and was interested in a higher salary.[9] Her husband added that, despite the situation at work, she had a positive frame of mind.

Before the captain's employment with Chalk's Ocean Airways, she was a flight instructor[10] for Angel Air Flight Training, Chandler, Arizona, from May 2002 to February 2003 and a charter coordinator for Scottsdale Flyers, Scottsdale, Arizona, from March 2000 to March 2002.

1.5.2 The First Officer

The first officer, age 34, held a commercial pilot certificate with ratings for airplane single- and multiengine land and sea and an FAA first-class medical certificate dated January 31, 2005, with no limitations. FAA records indicated no accident or incident history or enforcement action, and a search of records at the National Driver Register found no history of driver's license revocation or suspension.

The first officer was hired by Chalk's Ocean Airways in April 2005. He received company ground school training from April to mid-June 2005 then took a 3-month break.[11] He received company flight training from September to October 2005 and completed a G-73T proficiency check on October 19, 2005. He completed his company's initial operating experience on November 21, 2005. Company records indicated that the first officer had accumulated 1,420 hours total flying time, including 1,200 hours as a pilot-in-command, 100 hours as second-in-command, and 71 hours in the G-73T. He had flown 71, 58, and 1.1 hours in the 90 days, 30 days, and 24 hours, respectively, before the accident.

Company records indicated that the first officer had been on duty from December 15, 2005, to the day of the accident. On the day of the accident, he was scheduled to fly seven flight segments for a total of 4.1 hours of flying time. A company maintenance manager at FLL observed the first officer about 0620 on the morning of the accident as he conducted a preflight inspection of the accident airplane. The maintenance manager stated that the first officer looked normal and energetic. The maintenance manager also saw the first officer about 1300 and described him as being friendly and happy.

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[9] According to the captain's husband, she also voiced concerns about the company's maintenance of its airplanes. Additional information from interviews with the captain's husband and with other company personnel regarding the company's maintenance program appears in section 1.18.3.

[10] The captain received her flight instructor certificate with a rating for airplane single-engine land in February 2002.

[11] According to Chalk's Ocean Airways personnel, in April 2005, the company hired more first officers than it needed and had to postpone the flight training for some because of aircraft availability issues.

The accident flight was the first officer's first pairing with the captain. Company pilots described the first officer as a likable and helpful person who was happy working for the company and who had good piloting skills for his experience.

Before his employment with Chalk's Ocean Airways, the first officer was a line service technician for Reading Flite Academy, Reading, Pennsylvania, from April to August 2002 and was pilot/dispatcher for Quest Diagnostics in Reading from June 2002 to April 2005.

1.6 Airplane Information

The accident airplane, a Grumman Turbo Mallard (G-73T), serial number (S/N) J-27, was a turbine-conversion amphibious airplane equipped with two Pratt & Whitney PT6A-34 turbopropeller engines[12] and Hartzell HC-B3TN-3D constant-speed, three-bladed propellers. The airplane was manufactured by Grumman Aircraft Engineering Corporation in May 1947 and was originally certificated as a G-73 model equipped with Pratt & Whitney radial piston engines.[13] At the time of original certification, the airplane's maximum gross weight was 12,750 pounds, and it was configured to carry 2 flight crewmembers and 10 passengers.

Chalks Ocean Airways acquired the airplane in 1980 and modified it to a G-73T model in July 1981 by replacing its piston engines with turbopropeller engines in accordance with FAA-approved supplemental type certificate (STC) SA2323WE.[14] The modification to the G-73T model included an increase in the airplane's maximum gross weight to 14,000 pounds. Also, in July 1981, the airplane's cabin was modified to a 17-seat passenger configuration in accordance with STC SA4410SW, and its avionics were upgraded.

At the time of the accident, the airplane had accumulated 31,226 total flight hours and 39,743 total cycles.[15] Information about the hours for the powerplants and propellers appears in table 2.

[12] One engine was a PT6A-34AG model, which has identical specifications and limitations as the PT6A-34. "AG" denotes it was originally configured for agricultural aviation.

[13] Grumman ended production of the G-73 airplane in 1951.

[14] For more information about the STC, see section 1.18.1.

[15] An aircraft cycle is one complete takeoff and landing sequence.

Table 2. Powerplant and Propeller Information for the Accident Airplane

Powerplant	Time since new	Date of last overhaul	Time since last overhaul
Engine			
No. 1 (left)	7,515 hours	March 2005	1,154 hours
No. 2 (right)	9,036 hours	July 2004	3,037 hours
Propeller			
No. 1 (left)	11,117 hours	March 2005	1,154 hours
No. 2 (right)	17,995 hours	October 2003	2,657 hours

According to the weight-and-balance manifest form for the accident flight, the airplane's takeoff weight was 13,828 pounds,[16] which was less than the maximum takeoff weight of 14,000 pounds. The takeoff center of gravity (c.g.) was 21.8 percent mean aerodynamic chord, which was within the c.g. limits of 17.7 to 26.0 percent. The zero fuel weight was 12,488 pounds, which was less than the maximum zero fuel weight of 12,800 pounds.

The accident captain and another first officer had flown the accident airplane on December 17, 2005 (2 days before the accident) for 10 trip segments. According to that first officer, the airplane flew normally. He stated that the airplane underwent maintenance before these trips and that he and the accident captain conducted a 15- to 20-minute operational check flight before beginning passenger service that day. He stated that the captain commented that the airplane came out of maintenance in good shape and that, during passenger service, he felt no unusual vibrations and observed no fuel, oil, or hydraulic fluid leaks.

1.6.1 Wing Structure

The wing structure of G-73 and G-73T airplanes includes a center wing box that spans the center of the wing from left wing station (WS) 125 to right WS 125.[17] The fuselage walls intersect the wing box at left and right WS 34. Portions of the wing box structure serve as the left and right fuel tanks.

[16] Chalk's Ocean Airways did not allow carry-on baggage. The manifest form listed the total passenger weight as 2,475 pounds, which was derived from taking the number of noninfant passengers (15) and multiplying it by 165 pounds in accordance with the company's average weight program. The FAA approved the program's 165-pound-per-passenger estimate on the basis of a company survey of actual passenger weights. Although Chalk's Ocean Airways' operations specifications had been amended to require that the company should use only actual passenger weights, on September 7, 2005, the company petitioned the FAA to reconsider this requirement. In a letter dated September 26, 2005, the FAA notified the company that the effective date of the actual weight requirement was postponed pending the FAA's review and final response to the petition.

[17] Each WS is designated "right" or "left," depending on its location in relation to the airplane's centerline, and WS numbers correspond to the distance in inches outboard from the airplane's centerline.

The structural components of the wing box include the front spar, the rear spar, the stringers, the ribs, the upper skin, and the lower skin.[18] The skin panels are attached by fasteners to stringers; the three stringers for the lower skin panel are known as Z-stringers because of their shape.[19] The vertical surface of each Z-stringer, called a web, has two slosh holes[20] located just outboard of the wing ribs at WS 34 and WS 48. Figure 1 shows a general diagram of some wing box components.

The accident airplane's wing structure was certificated in accordance with the requirements in Part 4aT of the *Civil Air Regulations*, dated November 1, 1943, and amended March 8, 1944. The certification requirements included a static strength analysis, which is performed using loads that do not vary with time and have a constant magnitude, such as a steady 1 G flight condition.[21] No requirements for a fatigue analysis existed at the time the G-73T was originally certificated as a G-73. A fatigue analysis is performed using loads that vary in amplitude and frequency; these loads are referred to as dynamic, cyclic, or repetitive loads. Examples of these loads include taxiing on a rough runway, taxiing on rough water, taking off and landing, and encountering turbulence during flight.[22]

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[18] Spars are beam-like structures that are the principal structural members of the wing. The spars are oriented parallel to the airplane's lateral axis, which runs wingtip to wingtip. The vertical surfaces of each spar are called webs, and the top and bottom of each spar are called spar caps. Wing ribs are the structural crosspieces of the wing that are oriented forward to aft. Ribs give the wing its cambered shape. Ribs for the wing box are located at the centerline and at 18 wing stations (9 on the right and 9 on the left). Skin is the smooth outer covering of an aircraft. The skin panels discussed in this section are sheet metal panels that make up the upper and lower surfaces of the wing and wing box structure.

[19] Stringers are also structural components of the wing but are much smaller than spars. The wing box stringers are oriented parallel to the airplane's lateral axis, and, like spars, their vertical surfaces are called webs. The top and bottom of each Z-stringer's web have horizontal flanges that face in opposite directions. Thus, in cross-section, the stringer has the shape of the letter "Z."

[20] The slosh holes are the round openings in the vertical surface of each Z-stringer that allow fuel inside the tank area of the wing to move forward and aft.

[21] G is a unit of measurement that is equivalent to the acceleration caused by the earth's gravity (32.174 feet/second^2). A 1 G flight condition is represented by wings-level, steady-state flight.

[22] Fatigue failure is the sudden and catastrophic separation of a part into two or more pieces under normal operating loads as a result of a crack that grows due to repeated variations in load over a period of time. Failure takes place after a fatigue crack reaches a critical length then propagates suddenly.

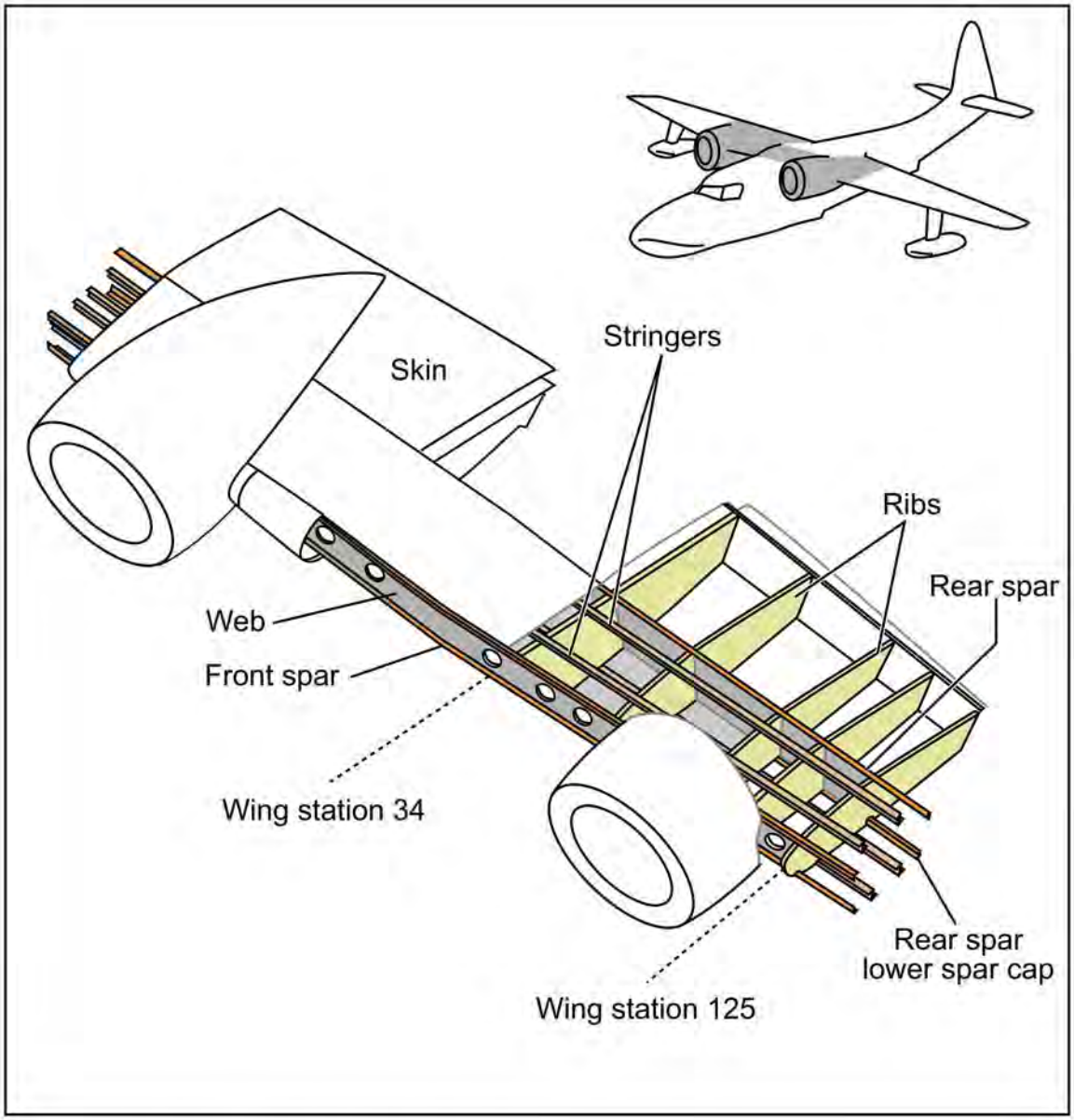


Figure 1. G-73/G-73T Wing Box Components

Note: For illustrative purposes only. For figure clarity, some components are shown not to scale, and others are not depicted.

1.6.2 Maintenance Information

1.6.2.1 Company Records of Right Wing Repairs

National Transportation Safety Board investigators reviewed Chalk's Ocean Airways' flight log sheets for the accident airplane from January 1995 to December 1999 and February 2001 to December 18, 2005 (the day before the accident); Chalk's Ocean

Airways could not provide the flight log sheets from January 2000 to January 2001. No open maintenance items appeared on the log sheets that were reviewed.

During July 2005, three flight log maintenance record entries for fuel leaks in the right wing root area were recorded. These entries stated the following: "fuel leak right wing root," "fuel leaking in … right wing root," and "fuel leaking from … right aft bottom." Also, during September 2005, three flight log maintenance record entries noted a "fuel leak from right [wing] dry bay."[23] Maintenance records indicated that the July and September 2005 fuel leak discrepancies were corrected by removing the existing sealant and applying new sealant.[24]

Safety Board investigators also reviewed routine and nonroutine work cards[25] for the accident airplane's C checks[26] from 2001 to 2005 and found eight references to fuel leaks on the right wing. A nonroutine work card from an August 2005 check indicated "fuel leak … lt [left] & rt [right] wing tanks …" and a corrective action of "cleaned lt & rt fuel tanks, repaired as req'd [required] and sealed … re-fueled … no leaks noted at this time." Also, while the airplane was undergoing its December 2005 C1 check, a fuel leak discrepancy was noted, and the nonroutine work card indicated "rt fuel tank bottom aft corner has leak" and a corrective action of "rt wing fuel tank bottom aft corner leak repair and sealed."

1.6.2.2 Major Repairs and Alterations of the Wing

A review of FAA records for the accident airplane indicated that an FAA form 337, "Major Repair and Alteration,"[27] was on file for a major repair that was made on April 13, 1992, to the rear spar upper spar cap at right WS 34. According to the engineering information submitted with the form, this repair was made because of structural corrosion under the skin and popped rivets that were discovered during inspections on the right wing at WS 34. The information indicated that, when the skin was removed, light-to-moderate corrosion was also found on the top aft spar.

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[23] The dry bay is a compartment that contains electronic, hydraulic, and mechanical components. The dry bay for the G-73T is located inside the center wing box between left and right WS 34 and is adjacent to the wing fuel tanks.

[24] The flight logs also documented numerous discrepancies regarding elevator flutter, elevator vibration, and elevator trim. For some of these discrepancies, the flight logs showed that maintenance personnel tried to resolve the problem several times before it was eventually corrected.

[25] According to FAA Advisory Circular 120-16D, work cards, although not required by regulations, are often used in air carrier maintenance programs to comply with regulations for performing maintenance and for maintenance recordkeeping.

[26] C checks are scheduled maintenance visits designed to ensure a complete inspection of the airplane over the course of 20 calendar months. The C checks are divided into six categories of work, C1 through C6, to be performed at 80-day intervals. For more information, see section 1.6.2.3.

[27] According to FAA Order 8300.10, "Airworthiness Inspector's Handbook," a major repair is a repair that "might appreciably affect weight, balance, structural strength, performance, powerplant operation, flight characteristics, or other qualities affecting airworthiness" or a repair that "is not done according to accepted practices or cannot be done by elementary operations."

Another FAA form 337 showed that a major repair to the rear Z-stringer at right WS 50.5 was made on July 6, 2000. Chalk's Ocean Airways could not provide the Safety Board with corresponding company maintenance records or a description of the discrepancy that resulted in this repair. During visual examination of the airplane wreckage, investigators observed that the rivets used in the repair were not installed in accordance with Advisory Circular (AC) 43.13-1B, section 4, figure 4-6, "Riveting Practice and Rivet Imperfections."[28] Specifically, some rivets used in the repair had undersized shop heads and were overdriven, and one rivet through the skin and stringer flange at the slosh hole was of a larger size and different head type than specified. Evidence of additional maintenance work, which involved the use of angles and blind rivet fasteners at the rib-to-stringer interface, was observed; however, this type of work was not documented in the engineering drawing or on FAA form 337.

Examination of the wreckage also discovered evidence that a major repair was made to the lower right wing skin at the location where the wing separated from the fuselage. Maintenance records provided by Chalk's Ocean Airways did not contain any entry for this major repair, which consisted of one external and three internal doublers[29] applied in the area of a long chordwise skin crack just outboard of right WS 34. Company maintenance records contained an entry indicating that, on May 6, 1992, the lower wing skin at left WS 34 received a major repair; examination of the wreckage showed that this repair had characteristics similar to the repairs observed near right WS 34. The areas with the repair doublers observed during the examinations would not have been visible on the exterior of the airplane because a fairing[30] between the wing and fuselage covered each area. The fairings also covered a fuel sump drain on each wing.

Examination of both the repair to right WS 34 (date of repair unknown) and the May 6, 1992, repair to left WS 34 revealed evidence that the rivet installation for each was not in accordance with AC 43.13-1B, section 4, paragraph 4-57c, "Rivet Edge Distance"; figure 4-5, "Rivet Hole Spacing for Single-Lap Sheet Splices"; figure 4-6, "Riveting Practice and Rivet Imperfections"; and figure 8, "Holes." Specifically, some fastener holes were observed at edge distances less than specified, rivet-hole spacing was less than specified, and some holes did not meet specifications because they were double-drilled.[31]

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[28] The engineering drawing for this repair indicated that the riveting needed to be performed in accordance with AC 43.13-1B. Technical data referenced in such drawings become approved data.

[29] A doubler is material that is intended to relieve load in the structural element to which it is attached.

[30] Fairings are shaped and rounded panels on the exterior of the airplane that are typically installed in areas where the wing or other structural units meet the fuselage at angles. The purpose of fairings is to smooth out the airflow in these areas during flight.

[31] A double-drilled hole is a hole consisting of two intersecting, nonconcentric-drilled holes in which a portion of the hole from the first drilling remains after the second hole is drilled.

1.6.2.3 Continuous Airworthiness Maintenance Program

The Flying Boat, Inc., operations specifications for Chalk's Ocean Airways indicated that the air carrier was authorized to use a continuous airworthiness maintenance program (CAMP),[32] the latest revision of which was approved by the FAA on November 21, 2005. Basic CAMP requirements include aircraft inspection, scheduled and unscheduled maintenance, overhaul and repair, structural inspection, required inspection items, a continuing analysis and surveillance system (CASS) program,[33] and outsourcing maintenance. The company's CAMP included the following maintenance items:

- Transit service, which was to be performed overnight every 48 hours or less at bases where maintenance personnel are available. Company records showed the last transit service on the accident airplane was performed on December 19, 2005 (the day of the accident).
- Engine service, which was to be performed every 250 flight hours. Company records showed the last engine service on the accident airplane was performed on October 19, 2005 (No. 1 engine) and November 12, 2005 (No. 2 engine); both occurred within the 250-hour requirement.
- C checks, which were divided into six scheduled maintenance visits, C1 through C6. These visits, which were to be completed at 80-day intervals, were designed to completely inspect the airframe, components, systems, and appliances within 20 calendar months. Company records showed the airplane's most recent C check was completed December 17, 2005.[34] In accordance with the Grumman Service Manual, the airplane's external components were washed with fresh water during each of the C checks to minimize the effects of corrosion on those components.[35]

1.6.2.4 Continuing Analysis and Surveillance System Program

As part of its FAA-approved CAMP, Chalk's Ocean Airways was required to maintain a CASS program that identified and corrected deficiencies in the company's maintenance program. As part of a CASS, operators are required to monitor the mechanical performance of the flying fleet by collecting and analyzing operational data. This includes the day-to-day monitoring and long-term monitoring of each airplane. To accomplish this task, operators typically set repair thresholds by establishing the number of times a discrepancy may reoccur in a given period, usually specified in days or hours. If

[32] A CAMP combines the maintenance and inspection functions used to fulfill an operator's total maintenance needs.

[33] For more information about the company's CASS program, see section 1.6.2.4.

[34] The most recent C check for the right wing, which was maintenance visit C3, was completed March 23, 2005. According to the C3 checklist, the inspection covered right WS 34 to 400 and included preliminary inspection/corrosion control, lubrication, avionics check/inspection, and main landing gear inspection.

[35] Company maintenance personnel stated that the airplane's external components were also washed with fresh water during transit service maintenance, but the transit service cards did not show this task.

a discrepancy recurs within the established repair threshold, further troubleshooting, such as maintenance and/or engineering, would be needed, and, at times, grounding of the airplane would be necessary.

Chalk's Ocean Airways conducted monthly CASS meetings to review the previous month's maintenance discrepancies. Records indicated that FAA representatives, including the air carrier's principal maintenance inspector (PMI), attended the January, October, and November 2005 meetings.[36] Minutes from the CASS meetings for January through November 2005 included mechanical interruption reports, logbook information, airplane discrepancies, and minimum equipment list information for each company airplane.[37] The minutes for the July and September 2005 CASS meetings referenced fuel leaks on the accident airplane. The July 2005 minutes referenced six fuel leaks on either the accident airplane's left or right wing during a 5-day period; the September 2005 CASS meeting minutes referenced a fuel leak from the accident airplane's right wing dry bay area for 3 consecutive days.[38] None of the 2005 CASS meeting minutes directly referenced any of the accident airplane's wing box structural fractures.

1.6.2.5 Aging Airplane Inspection and Records Review

The operations specifications for Chalk's Ocean Airways also indicated that the air carrier must have an aging aircraft inspection and records review. Title 14 CFR 121.368, "Aging Airplane Inspections and Records Reviews," paragraph (b)(1), requires initial and repetitive inspections and records review of airplanes operating under Part 121 (except for those airplanes operating entirely within the state of Alaska) and exceeding 24 years of service on December 8, 2003. The regulation requires that the initial inspection and records review take place no later than December 5, 2007, and that the repetitive inspections occur at intervals thereafter not to exceed 7 years. According to 14 CFR 121.368(b), the purpose of the regulation is for the operator to demonstrate to the FAA that "the maintenance of age-sensitive parts and components of the airplane has been adequate and timely enough to ensure the highest degree of safety."

On October 7, 2005, Chalk's Ocean Airways' PMI conducted the company's aging airplane inspection and records review. At the time, the accident airplane had accumulated 31,012 flight hours and 39,404 flight cycles. The review included the April 13, 1992, major repair to the rear spar upper spar cap at right WS 34 and the May 6, 1992, major repair to the lower wing skin at left WS 34. The review found that no further action was required for these repairs. The review did not include the doubler repair that was observed on the chordwise skin crack just outboard of right WS 34 and for which Chalk's Ocean Airways did not have records. On November 4, 2005, the PMI sent a letter to Chalk's Ocean Airways indicating that the aging airplane inspection and records review had been

[36] Chalk's Ocean Airways could not provide CASS meeting attendance records for March and May 2005, so there was no record of whether FAA representatives attended those meetings.

[37] The December 2005 CASS meeting had not been held at the time of the accident.

[38] As mentioned previously, maintenance records showed that the repair methods used to address these fuel leaks involved removing and replacing the sealant in the fuel tank.

completed. The PMI noted that paperwork discrepancies found during the review were corrected by the air carrier during the C5 and C6 inspections.

The accident airplane, because of its size and the date of its type certificate, would not be subject to the additional inspection requirements of 14 CFR 121.370a, "Supplemental Inspections," which apply to transport-category, turbine-powered airplanes (except for those airplanes operating entirely within the state of Alaska) that were type certificated after January 1, 1958, and had a maximum passenger seating capacity of 30 or more or a maximum payload of 7,500 pounds. Title 14 CFR 121.370a(c) requires that, after December 20, 2010, the maintenance programs of the affected airplanes must include "FAA-approved damage-tolerance-based inspections and procedures for airplane structure susceptible to fatigue cracking that could contribute to a catastrophic failure. These inspections and procedures must take into account the adverse affects repairs, alterations, and modifications may have on fatigue cracking and the inspection of this airplane structure." On July 24, 2006, the Safety Board issued Safety Recommendation A-06-52 to address the exemptions contained in this regulation; see section 1.18.2.1 for more information.

1.7 Meteorological Information

The nearest weather reporting station is located at Miami International Airport (MIA), Miami, Florida, which is about 8 nautical miles from X44. MIA has an automated surface observing system (ASOS) that is maintained by the National Weather Service and records continuous information on wind speed and direction, cloud cover, temperature, precipitation, and visibility.[39] The ASOS transmits an official meteorological aerodrome report (METAR) each hour. A METAR at 1443 on the day of the accident indicated the following: wind from 340º at 7 knots, visibility 4 miles, ceiling overcast at 1,200 feet, temperature 23º C, dew point 18º C, and altimeter 30.09 inches of mercury.

1.8 Aids to Navigation

No problems with any navigational aids were reported.

1.9 Communications

No communications problems were reported.

[39] Cloud cover is expressed in feet above ground level. Visibility is expressed in statute miles.

1.10 Airport Information

X44 is located on Watson Island and about 2 miles east of Miami. X44 has a water runway that is 15,000 feet long and 600 feet wide and is oriented northwest/southeast. The water runway has an elevation of 0 feet mean sea level. X44 has no published instrument procedures. Chalk's Ocean Airways' terminal was built in 1926.

1.11 Flight Recorders

1.11.1 Cockpit Voice Recorder

The airplane was equipped with a Fairchild model A-100A solid-state cockpit voice recorder (CVR), S/N 52969. The CVR did not sustain any heat or structural damage, but the recorder was wet because of its immersion in the water. The tape was removed from the recorder and was cleaned and dried. The audio information was extracted without difficulty.

The CVR recording contained channels of audio data for the pilot and copilot stations and the cockpit area microphone.[40] Although audio was recorded on each of these channels, the audio was unintelligible. The Safety Board noted, specifically, that the characteristics of the audio were similar to that of the tape having been recorded over multiple times without being erased between recordings.

The CVR chassis was sent to L3 Communications[41] for evaluation of its functionality. According to the L3 Communications evaluation report, testing revealed a failure of the electronic circuit card for the erase head. The evaluation report indicated that this condition was most likely the reason for the failure of the erase-head functionality of the recorder and that, on the basis of the Safety Board's finding of multiple overwriting on the CVR-recorded channels, this failure most likely occurred sometime before the accident.

The evaluation report further indicated that the CVR "push to test" operation would not likely identify a failure of the erase head because the recorded test tone amplitude would be detected despite the presence of previously recorded audio.[42] On March 24, 2006, the Safety Board issued Safety Recommendation A-06-23, which addressed this and other issues related to CVR functionality. Section 1.18.2.2 provides information about this recommendation.

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[40] The CVR was equipped with another channel for a third flight crewmember. Because the G-73T was not configured for a three-person flight crew, that CVR channel was unconnected.

[41] L3 Communications is the owner of Fairchild model CVRs.

[42] L3 Communications stated that one way to ensure correct operation of the erase-head function was a service check of the CVR. With regard to the accident airplane, Chalk's Ocean Airways' operations specifications did not require CVR service checks.

1.11.2 Flight Data Recorder

The airplane was not equipped with a flight data recorder (FDR). The FAA stated that 14 CFR 121.344a, "Digital Flight Data Recorders for 10-19 Seat Airplanes," applied to the accident airplane and that the regulation excludes 10-to-19 seat, turbine-powered airplanes that were brought onto the U.S. registry on or before October 11, 1991.

1.12 Wreckage and Impact Information

The right wing separated from the fuselage in flight, and the remainder of the airplane broke up on impact with the water. Most of the main wreckage was scattered within a debris field of about 200 feet by 200 feet and was oriented along a 122º magnetic heading. The fuselage, left wing, left engine, landing gear, and empennage were located within the main debris field. All of this wreckage was submerged in the water along a rock jetty. The separated right wing with the right engine attached was located about 160 feet northwest of the main debris field. The center wing box structures were fractured where the wing intersected the fuselage at right WS 34, allowing the right wing to separate.

Examination of the wreckage found that the right wing fuel tank was breached and that fire damage was evident on the right wing. Fire damage and soot were also present on fuselage skins and empennage skins aft of the right wing. The left wing showed no evidence of fire damage.

Safety Board investigators documented and reconstructed the airplane's center wing box. The reconstruction consisted of locating and identifying the right and left wing front and rear spars and upper and lower stringers and skins from about right WS 60 to left WS 60. Detailed examination of the wreckage fractures revealed areas of fatigue on multiple elements of the wing box structure, including the lower skin panel aft Z-stringers at right and left WS 34 (emanating from the fuel slosh holes), the skin at the edge of the doubler repairs at right and left WS 34, the rear spar lower spar cap at right WS 34, and the forward spar lower spar cap near left WS 53.

The recovered fracture surfaces from the wing box were sent to the Safety Board's Materials Laboratory in Washington, D.C., for visual and fractographic examinations. To facilitate the examination, the internal and external repair doublers that were located near right and left WS 34 were removed from the lower skin.

The upper part of figure 2 shows an overall view of right WS 34, including the locations of the rear spar lower spar cap, rear Z-stringer, the chordwise fracture in the lower skin, the crack (approximately parallel to and outboard of the chordwise lower skin fracture) in the lower skin, and the external and internal doublers. The lower part of

figure 2 shows a view with the doublers detached. Fatigue fracture features were found in the rear spar lower spar cap, rear Z-stringer, skin fracture (inboard), and skin crack (outboard).[43]

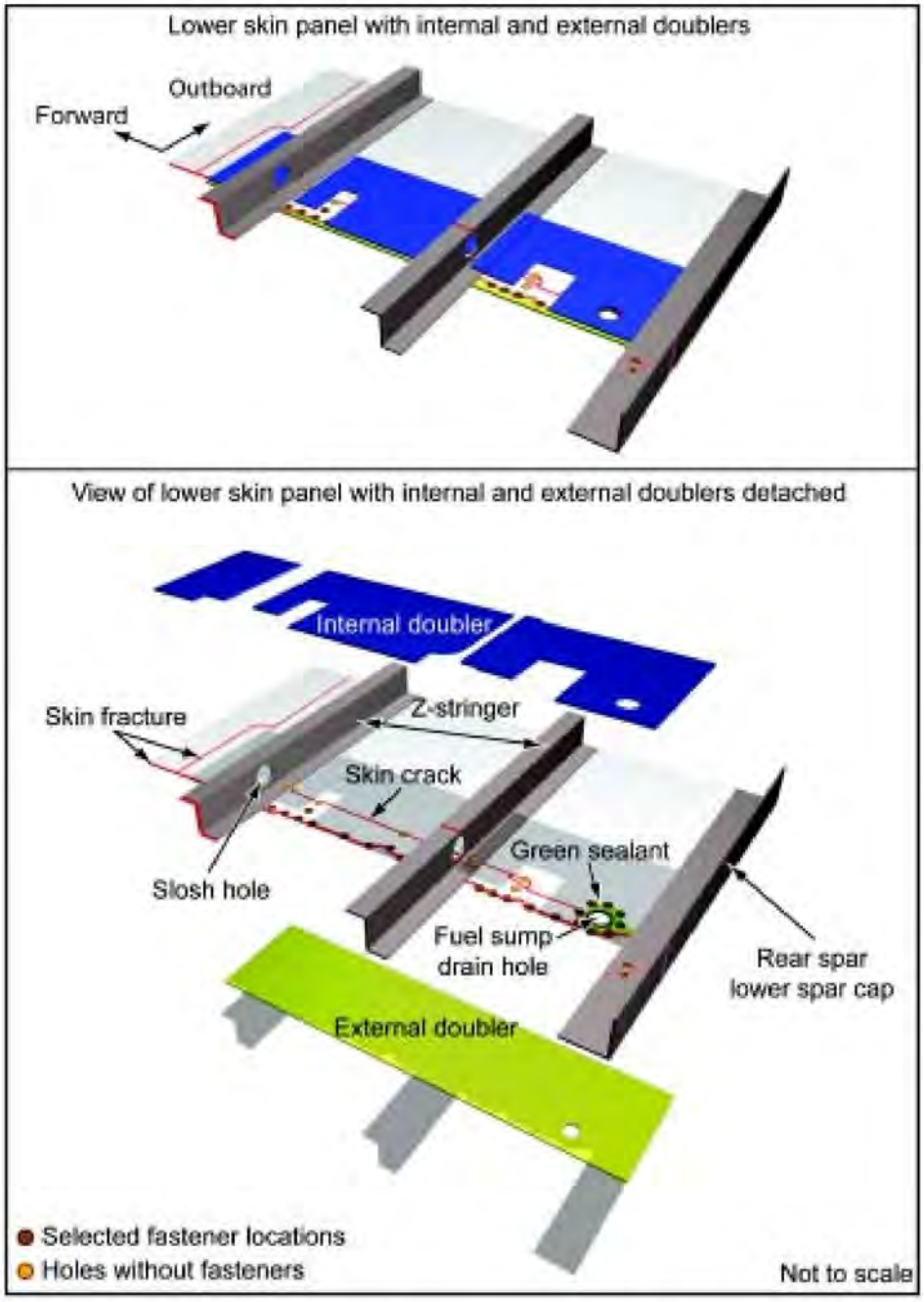


Figure 2. Locations of Fractures Near Right Wing Station 34

[43] Overstress fracture features were found on the entire fracture surfaces of the middle Z-stringer, forward Z-stringer, and forward spar lower spar cap at right WS 34.

Figure 3 shows a photograph of the external doubler that was adjacent to right WS 34 before it was removed from the lower skin for examination. The lower skin crack that was observed in the area that had been covered by this external doubler was about 16 inches long. The aft end of the crack extended from the skin trailing edge to a point near the aft side of the middle Z-stringer lower flange.

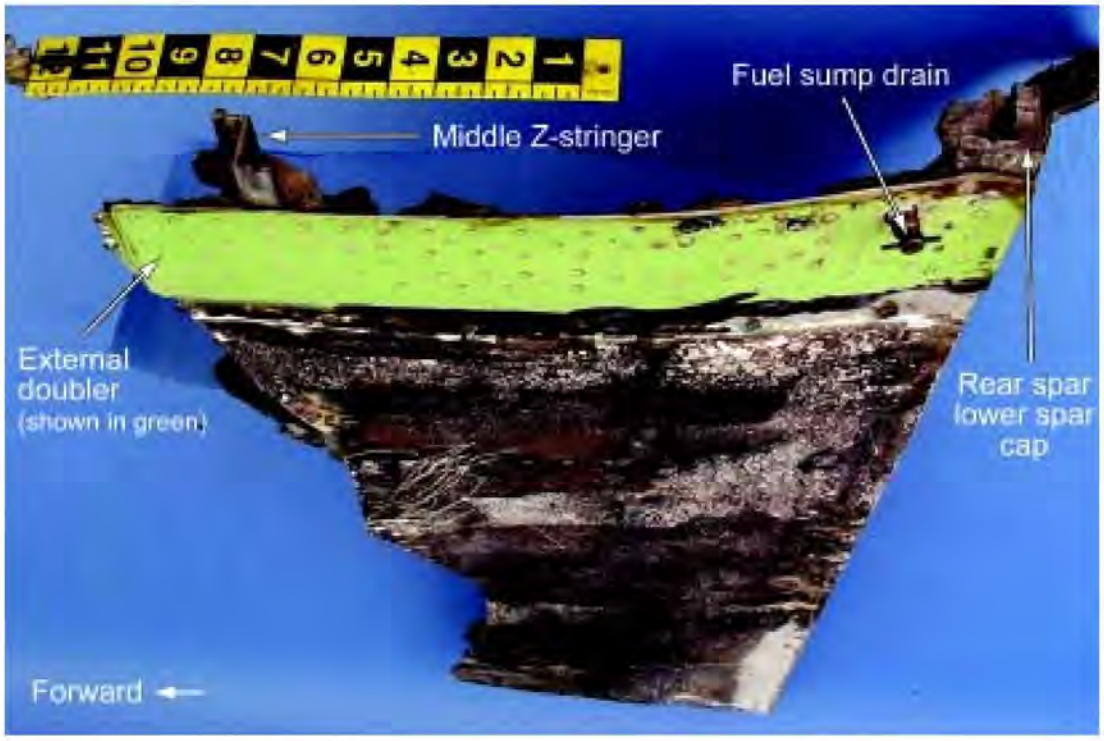


Figure 3. External Doubler Adjacent to Right Wing Station 34 (Before Removal)

The skin crack under the doublers at right WS 34 (see figure 4) intersected three unfilled machined holes in the skin that exhibited features consistent with stop drill holes.[44] These holes were located about 7, 9, and 16 inches forward of the skin trailing edge. Several fasteners at the inboard end of the doubler were inserted through hard green sealant around the fuel sump drain.

[44] A stop drill hole is made at the tip of a fatigue crack to temporarily retard the propagation of a fatigue crack until a more permanent repair can be made.

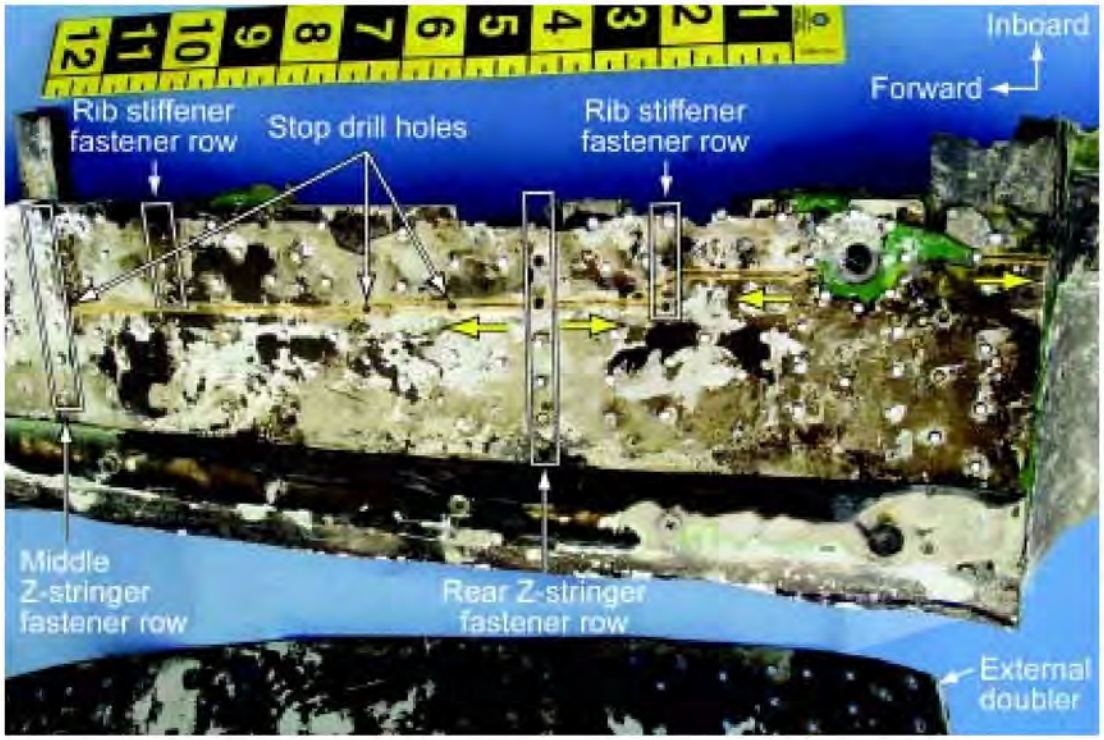


Figure 4. Lower Skin Crack in the Area That Was Covered by the Doublers Adjacent to Right Wing Station 34

Note: The yellow arrows show the direction that each segment of the crack propagated.

The fractographic examination at right WS 34 found that fatigue in the rear Z-stringer initiated from the slosh hole in the Z-stringer located about 1.5 inches outboard of right WS 34, as shown in figure 5. Sanding marks were observed under the sealant around the edge of the slosh hole, and sealant was observed on the fracture surface. In the sanded area, deformed material was observed curled over onto the edges of the fracture surface.



Figure 5. Right Wing Rear Z-Stringer Fracture

The skin crack under the doublers at right WS 34 had an aft segment with fatigue features emanating from the area of corrosion around the fuel sump drain and a longer forward segment with fatigue features that initiated from a fastener hole adjacent to the rear Z-stringer fracture.

The lower skin chordwise fracture (inboard of the skin crack) at the separated area intersected the fastener holes at the inboard edge of the doublers. Regions of fatigue emanated from several of the fastener holes. Sliding contact marks consistent with repeated opening and closing of the chordwise skin fracture were observed on the surface of the external doubler between several fastener locations in the inboard fastener row for the doubler.

Fatigue in the rear spar lower spar cap initiated from a double-drilled hole for a threaded fastener in the horizontal flange of the spar cap located about 1 inch inboard of right WS 34, as shown in figure 6. Multiple fatigue origins were observed along the double-drilled hole through the thickness of the horizontal flange. Relatively flat regions with large numbers of crack arrest positions, indicating slower growth fatigue cracking, emanated from the fatigue origin areas both forward and aft of the hole. The remainder of the fatigue regions had a mixture of curving flat regions (indicating areas of relatively slow crack growth) with crack arrest positions separated by rougher regions without crack arrest positions (indicating relatively fast crack growth or overstress regions). The portion

of the crack aft of the hole propagated from a length of 0.07 to 0.44 inch in about 11 increments of rapid crack growth.

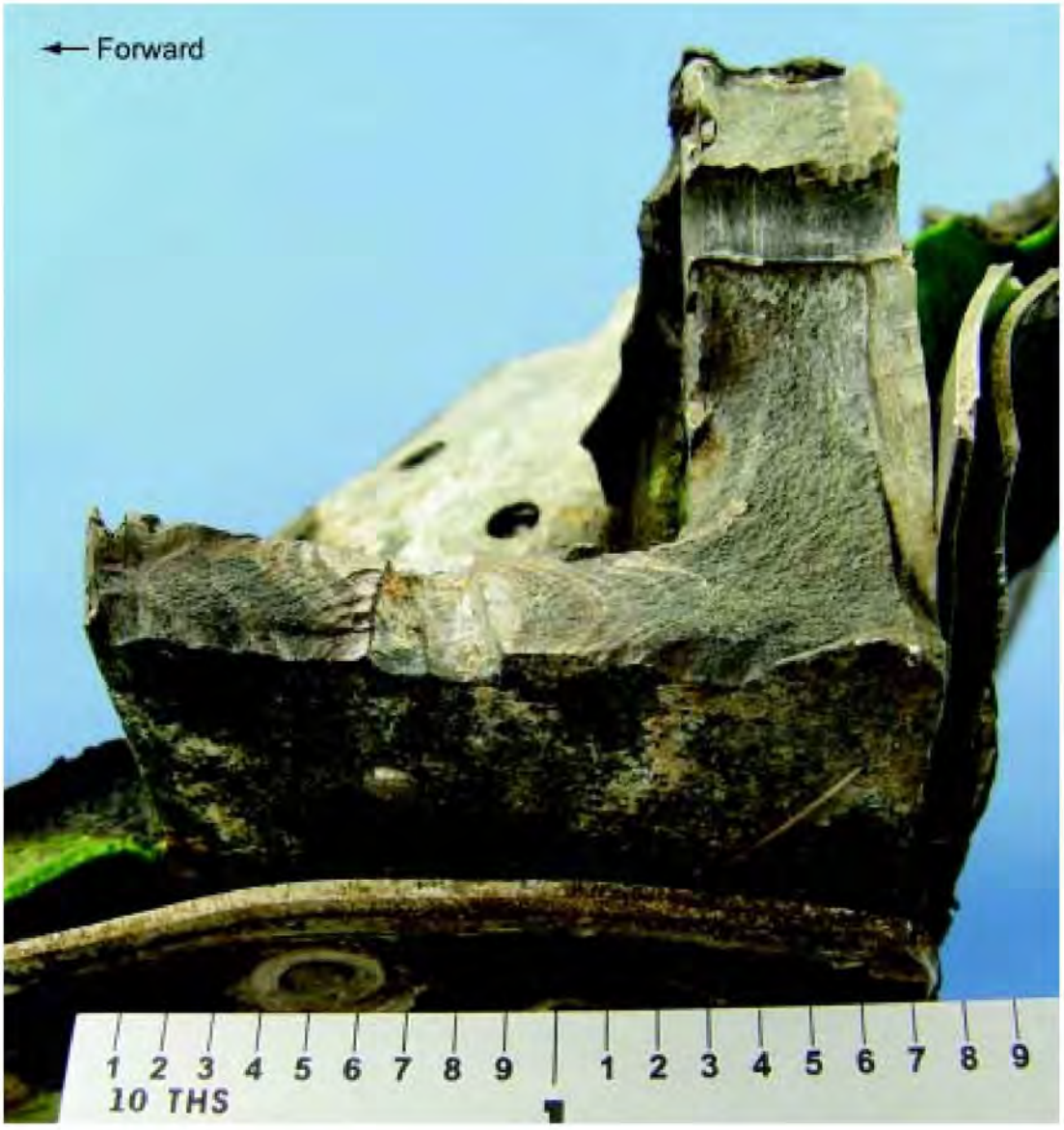


Figure 6. Right Wing Rear Spar Lower Spar Cap Fracture

Examination of the left wing indicated that fatigue fracture features were found in the rear Z-stringer, middle Z-stringer, front spar lower spar cap, and lower skin fractures near left WS 34. One external and two internal doublers were attached to the lower skin panel at the aft side of the wing box at left WS 34. The lower surface of the external doubler showed evidence around the fuel sump drain that was consistent with corrosion in that area.

The left wing front spar lower spar cap had a transverse fracture about 5 inches outboard of left WS 34. This area had not been repaired and did not have adjacent structural element failures. A portion of the horizontal flange of the spar cap had fatigue features that emanated from a hole for a threaded fastener to attach a wing leading edge panel. The aft portion of the fatigue region contained multiple relatively rough regions, which was indicative of an overstress fracture that was progressing fairly rapidly. These fracture regions were interspersed between regions with crack arrest positions.

1.13 Medical and Pathological Information

Toxicology tests were performed by the FAA's Civil Aeromedical Institute (CAMI) on specimens from the captain and first officer. The specimens were tested for ethanol and a wide range of drugs, including major drugs of abuse. All specimens tested negative, except that diphenhydramine was detected in urine specimens from the captain and quinine was detected in tissue specimens from the first officer.[45]

1.14 Fire

Postcrash examination of the wreckage indicated the occurrence of an in-flight fire on the separated right wing and on exterior skin surfaces of the fuselage and empennage aft of the right wing. The left wing showed no evidence of fire damage.

1.15 Survival Aspects

The Miami medical examiner performed autopsies of the airplane occupants, and the autopsy reports indicated the cause of death for each was "plane crash." A review of the reports revealed the main pathologic findings for each occupant were multiple blunt force injuries.

1.16 Tests and Research

1.16.1 Additional Grumman G-73T Examinations

Safety Board investigators examined other G-73T airplanes following the accident. One airplane, N142PA, was also owned by Chalk's Ocean Airways and was used for passenger service at the time of the accident. Like the accident airplane, N142PA was built in 1947 as a G-73 model and was subsequently modified to a G-73T. Also, N142PA

[45] Diphenhydramine, commonly known by the trade name Benadryl, is an over-the-counter antihistamine with sedative effects, often used to treat allergy symptoms or as a nighttime sedative. It is not quantified in CAMI results unless a substantial quantity is present. Diphenhydramine was not detected in the captain's blood specimens. Quinine is found in tonic water and is not quantified in CAMI results, unless a substantial quantity is present.

had a similar number of flight hours and cycles as the accident airplane. The left wing aft spar attachment point on N142PA showed evidence of grinding in some areas, and the right wing aft spar attachment point had corrosion. Extensive corrosion was present on other areas of the airplane.

In August 2005, N142PA's right wing lower skin was replaced from the centerline to the nacelle. The designated engineering representative (DER)[46] who provided engineering approval for this major repair stated that Chalk's Ocean Airways informed him in June 2005 that fuel was leaking from the right wing-to-body fairing. The DER also stated that his subsequent inspection[47] found that fuel was leaking out of a lower skin crack on the right wing and that his analysis showed that the crack, which was about 22 inches in length, had reduced the load-carrying capacity of the right wing box by about 50 percent.[48] The DER stated that he recommended that the wing be removed for repair but that Chalk's Ocean Airways did not want to remove the wing. As a result, the fuselage skin was pulled away from the area of the skin crack so that the lower wing skin could be replaced. The DER stated that, when the skin was removed, he noticed that all of the stringers were corroded and cracked, so they were removed and replaced. He also noticed that many of the repairs that had previously been made on the rest of the wing appeared to be "quite old."

Although fatigue- and damage-tolerance requirements were not part of the G-73's original certification (which was the certification basis for the G-73T), a fatigue- and damage-tolerance-based approach was employed in the August 2005 repair to the right wing on N142PA. The repair included instructions for continued airworthiness,[49] which indicated that the repair should be inspected every 24 months or 6,020 flight hours, whichever occurred first. These inspections were intended to detect cracks before they reached their critical crack length (that is, the point at which fracture occurs rapidly without increased load).

In July 1999, a repair was made to N142PA's lower left wing skin, which extended across the wing-to-fuselage junction. According to the structures DER who designed this repair for Chalk's Ocean Airways, an area of corrosion around the fuel sump drain was removed, a 14-inch crack (emanating from the forward edge of the corrosion to a point

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[46] A DER is a qualified technical person who is authorized by the FAA to perform certain examinations, testing, and inspections necessary to determine compliance with applicable airworthiness standards and who offers technical expertise with state-of-the-art knowledge. A DER completes FAA form 8110-3, "Statement of Compliance with the *Federal Aviation Regulations*," to indicate that the engineering changes are in accordance with regulations. The company is responsible for implementing the changes stated on the form and completing FAA form 337 after the repair has been accomplished.

[47] During this inspection, the DER noticed a doubler on the left wing lower skin with a 17-inch crack. (The DER provided the Safety Board with a photograph showing this crack.) According to the DER, he asked Chalk's Ocean Airways if he should provide the engineering for the repair of the left wing, but the company indicated that it would take care of the repair.

[48] The DER's analysis showed that the skin and stringers carried about 70 percent of the load and that the spar caps carried 30 percent of the load.

[49] Instructions for continued airworthiness are a series of maintenance actions that help to ensure the continued airworthiness of a repair. DERs can include these instructions as part of FAA form 8110-3.

that was 9 inches forward) was stop-drilled and slotted, and a doubler was placed over the top of the wing skin in this area. This repair was designed with a static strength analysis only.

Safety Board investigators also examined a privately owned G-73T airplane, N632SS. That airplane was undergoing restoration at Mirabella Aviation, Jupiter, Florida. Chalk's Ocean Airways had owned the airplane briefly beginning in November 2005 and had maintained it as a spare parts airframe before selling it. Like the accident airplane, N632SS was built in 1947 and was subsequently modified to a G-73T. N632SS had fewer flight hours (about 16,000) and cycles (about 30,000) than the accident airplane.

In July 1977, N632SS was substantially damaged when it crashed and sank during an attempted takeoff from Great Bear Lake in Canada. The airplane was recovered, rebuilt, and used during the 1980s for revenue operations. According to Mirabella staff, the airplane was again damaged in 1989 when it was subjected to flooding during a hurricane.

At the time of the examination of the airplane, the left wing had been removed, the outboard wing sections had been separated from the center wing box, and the lower wing skin was removed from the center wing box. Investigators found that, although corrosion was present on the wing structure, the corrosion was generally not as severe as that found on the airplanes in the Chalk's Ocean Airways fleet and that only one rear Z-stringer had a similar amount of corrosion.

The rear Z-stringer was sent to the Safety Board's Materials Laboratory for examination. The examination found that the rear Z-stringer had a fatigue crack that was located about 1.5 inches outboard of the rib at left WS 48. The examination also found that the fatigue emanated from the slosh hole in the web of the Z-stringer. In addition, the examination found that the corrosion was particularly severe in the web and flange areas above the slosh hole.

1.16.2 Video and Image Study

Segments of the accident flight were captured by witnesses with personal video and still cameras and by a U.S. Coast Guard video surveillance security camera. Copies of the video and still images were submitted to the Safety Board's Vehicle Recorder Division, Washington, D.C., for review.

One video from a personal video camera was recorded by a witness on the deck of a cruise ship that was located across the main channel from X44. The video does not show the accident but contains footage of the accident airplane arriving and departing from X44. The only noise heard on the video that is associated with the airplane is that of the powerplants after the airplane's departure.

Another video from a personal video camera was recorded by a witness on a beach north of the accident site. The video does not show the right wing separating but captures

the airplane in a nose-down attitude of between 35º and 45º after the separation. The video shows no obvious smoke or debris coming from the airplane, but, in the upper right corner of view, a cloud of fire and black smoke appears behind the airplane. The airplane and the cloud of fire and smoke follow a similar trajectory and impact the water behind a rock jetty.

The digital surveillance video was recorded by a U.S. Coast Guard station camera located near the east end of the main channel. The video shows the accident airplane passing over Miami Harbor toward the ocean and traveling away from the camera. About the time that the airplane moves into the center of the camera's view, it has become too small to be seen. About 9 seconds after the airplane disappears, a bright flash appears in the area where the airplane was last seen. Black smoke then begins emanating from the flash, and the trail of smoke falls toward the water.

A digital still image taken by a witness in a vehicle traveling on a nearby causeway shows the accident airplane in the water during its takeoff roll. Both propellers appear to be in motion. A bright streak located outboard of the right engine appears to be a flashing light. A second digital image, which was taken by a witness in a vehicle traveling on the same causeway, shows the airplane shortly after liftoff above the main channel.

1.16.3 Examination for Explosives

Specimens from the accident airplane were sent to the Federal Bureau of Investigation's laboratory in Quantico, Virginia, to determine whether explosives or explosive residues were present. None of the explosives or explosive residues for which the laboratory screens was found on the specimens.

1.17 Organizational and Management Information

Flying Boat, Inc., held an air carrier certificate to conduct Part 121 passenger operations originally issued on December 10, 1990, and reissued on March 19, 1997, by the FAA Southern Region. The company's operating certificate was managed by the FAA South Florida Certificate Management Office, and the Miami, Florida, Flight Standards District Office was responsible for oversight. Flying Boat began operating passenger service under the business name Chalk's Ocean Airways in July 1999, in reference to the original airline, Chalk's Flying Service, which was founded in 1919. Since 1919, Chalk's Flying Service was owned and operated by various owners under various business names.[50] At the time of the accident, Chalks Ocean Airways had 82 employees, including 10 pilots, 12 mechanics, and 5 mechanic assistants.[51]

[50] Chalks Flying Service was purchased in the 1980s by a hotel and casino development company. That company then sold the airline to several south Florida business investors, who operated the airline under the name Pan Am Air Bridge. In July 1999, the airline was bought by a Florida businessman and began operating on the Flying Boat certificate as Chalk's Ocean Airways.

[51] According to a company representative, the other employees represented functions such as reservations, dispatch, and station personnel.

Also, at the time of the accident, Chalk's Ocean Airways' flights were based at X44 and flew to destinations in the Bahamas. Most of the flights were over open water, and most of the destination airports were seaplane bases. Chalk's Ocean Airways operated three G-73T airplanes for revenue service, all of which had the same configuration.[52] The airplanes would typically fly six to eight cycles each day.

On the day after the accident, Chalk's Ocean Airways flew one more scheduled flight (in N142PA) from Bimini to Fort Lauderdale. Afterward, the airline ceased flight operations.

1.17.1 Maintenance Organization

Flying Boat, Inc., also held a Part 145 repair station certificate issued on August 24, 1993. The Chalk's Ocean Airways General Maintenance Manual (GMM) contained an organizational chart of the maintenance organization and described the duties of company maintenance and inspection personnel.

As outlined in the GMM, the general manager was in charge of the entire maintenance organization. The director of maintenance and the chief inspector/director of quality control reported to the general manager. According to the GMM, the director of maintenance was responsible for "maintaining Company aircraft in an airworthy condition at all times, including all maintenance, repairs, and modifications performed." The director of maintenance was also responsible for reviewing daily status sheets to ensure efficient and smooth coordination of maintenance tasks, verifying that assigned work packages were completed, ensuring that parts were ordered, overseeing the scheduling of airplanes to ensure dispatch reliability, and serving as the vice chairman at the monthly CASS meetings. In addition, the production manager (also referred to as the maintenance supervisor), lead mechanics, and mechanics reported directly to the director of maintenance.

The chief inspector/director of quality control was responsible for the inspection of all work performed. The chief inspector/director of quality control was also responsible for ensuring that maintenance, inspections, airworthiness directives (AD), repairs, and modifications were conducted according to FAA and company policy; accepting or rejecting all work that was accomplished on company airplanes by company shops, maintenance contractors, or vendors; inspecting all incoming parts; maintaining training records of all company inspection and maintenance personnel; maintaining all company manuals; and serving as the chairman during the monthly CASS meetings. The inspectors

[52] At the time of the accident, one revenue service airplane, N130FB, was not operable because its engines had been removed for maintenance. In addition, Flying Boat, Inc., had another G-73T, N2974, and a G-73, N1208, listed on its certificate that were not airworthy at the time of the accident. Besides the airplanes in Chalk's Ocean Airways' fleet, only three other G-73/G-73T airplanes were in revenue service at the time of the accident and were being operated as sightseeing airplanes in Australia. The remaining airplanes in the G-73/G-73T fleet were operated by personal or corporate owners, most of whom maintained their airplanes as showpieces.

(including those designated as required inspection item inspectors) and the CASS/aircraft records technician reported directly to the chief inspector/director of quality control.

Chalk's Ocean Airways did not have an engineering department to oversee structural airplane issues. As a result, the company contracted with DERs for major repairs of the airplane's structure.

Section 3 of Chalk's Ocean Airways GMM, volume 5 (dated May 24, 2005), contained the maintenance policies and procedures used to ensure the airworthiness of company airplanes. Page 53006, paragraph a, stated that each corrective action was to include "a reference to FAA approved data, such as repaired in accordance with GMM, chapter, sec[tion], page or any other FAA approved document applicable to corrective action signoff."

1.17.1.1 Additional Maintenance Information

In March 1981, Frakes Aviation in Cleburne, Texas, purchased the G-73 type certificate from Grumman. As a result, Chalk's Ocean Airways did not have engineering, maintenance, and operating support from the original aircraft manufacturer. Also, a structural repair manual was not issued for the G-73 because it was not required at the time the airplane was manufactured.[53] According to Frakes Aviation personnel, the company had no involvement with G-73/G-73T repairs and no formal interaction with Chalk's Ocean Airways for at least the 15 years that preceded the accident.

1.17.2 Postaccident Actions

In December 2005, after the accident, the Department of Transportation's (DOT) Air Carrier Fitness Division suspended Chalk Ocean Airways' economic authority to operate under the Flying Boat, Inc., Part 121 certificate.[54] The DOT stated that the air carrier had 1 year to "prove to [the DOT] that the public interest is best served if they [Chalk's Ocean Airways] re-start their operation." As of the 1-year target date, Chalk's Ocean Airways was not operating its own airplanes; the Part 121 certificate remained suspended, and the company had entered into a wet lease[55] arrangement with another certificated carrier to provide transportation. Flying Boat, Inc., retained its Part 145 repair station authorization for Chalk's Ocean Airways; however, according to an FAA inspection on December 14, 2006, there was little activity.

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[53] For operators of airplanes for which no structural repair manual was issued, AC 43-13 provides information on typical structural repairs that have been approved by the FAA. The AC contains methods, techniques, and practices "for the inspection and repair of … civil aircraft, only when there are no manufacturer repair or maintenance instructions."

[54] For more information about the history of the DOT's concerns about the economic fitness of Chalk's Ocean Airways, see section 1.18.5.

[55] According to the FAA, a wet lease is a leasing agreement whereby a certificate holder agrees to provide an aircraft and at least one crewmember to another direct air carrier.

On December 23, 2005, the FAA issued Special Airworthiness Information Bulletin (SAIB)[56] NM-06-18, which advised G-73 and G-73T operators of the circumstances of this accident. The SAIB stated, in part, the following: "FAA is considering the need for mandatory detailed inspections of parts or all of the wing structure on the fleet of G-73 airplanes. If FAA determines that the accident airplane wing's pre-separation condition is potentially manifest in other G-73 airplanes, the FAA will take appropriate action."

On December 30, 2005, the FAA issued Emergency AD 2006-01-51, which directed operators of G-73 and G-73T airplanes to do the following:

> Before further flight, perform a detailed visual inspection to detect repairs, cracking, or corrosion of the wings from wing station (WS) 77L to WS 77R, front spar to rear (main) spar; remove any repair that is found, to allow for inspection of the wing structure underneath the repairs; and remove the sealant from the interior of the wet bays to allow for inspection of the skins, stringers, and both spars.

This visual inspection was to be performed in accordance with a method that has been approved by the FAA. Because no such method existed at the time that the AD was issued, the AD effectively grounded all G-73/G-73T airplanes. At the time, there were 31 U.S.-registered G-73/G-73T airplanes, about 15 of which were considered airworthy. The AD also required that an FAA aircraft certification office approve reports of any findings, repairs performed, or alternate methods of compliance.

Since the time that the AD was issued, the FAA approved, on a case-by-case basis, six privately owned G-73/G-73T airplanes to fly for an interim period of 200 flight hours. At least two other privately owned airplanes were undergoing evaluation. Also, the FAA recently approved a private owner's alternate means of compliance for the AD, and work has begun on the airframe of that airplane. That airplane and the rest of the G-73/G-73T fleet remain prohibited from further flight until individually approved by the FAA to be in compliance with AD 2006-01-51 or an approved alternate method.

1.17.3 Federal Aviation Administration Oversight

As stated previously, the Flying Boat, Inc., operating certificate for Chalk's Ocean Airways was managed by the FAA's South Florida certificate management office. At the time of the accident, the Chalk's Ocean Airways PMI had been in that position for about 5 years. He was also responsible for overseeing two other Part 121 air carriers.

During a postaccident interview, the Chalk's Ocean Airways PMI stated that the number of times he visited the company each month varied depending on his workload and that he attempted to be at each monthly CASS meeting. The PMI also stated that his work included inspections of the maintenance facility, vendors, and airplane records; ramp inspections; and the aging aircraft inspection and records review program. The PMI indicated that he was "comfortable" with the maintenance being conducted on the

[56] SAIBs are informational in nature and are not mandatory.

company's airplanes. He added that the maintenance program met all Federal Aviation Regulation (FAR) requirements.

1.18 Additional Information

1.18.1 Applicable Federal Aviation Regulations

As stated previously, the accident airplane was modified from a G-73 model to a G-73T model in accordance with STC SA2323WE, and its seating configuration was modified in accordance with STC SA4410SW. A review of the STCs showed that both were held by Frakes Aviation. In August 1968, Frakes Aviation applied to the FAA for the STC to replace the piston engines with turbopropeller engines and to increase its maximum gross weight from 12,750 to 14,000 pounds. The FAA issued STC SA2323WE to Frakes Aviation in April 1971. In October 1979, Frakes Aviation applied to the FAA for an STC to increase the number of passenger seats in the cabin from 10 to 17. The FAA issued STC SA4410SW to Frakes Aviation in July 1981.

Title 14 CFR 21.19, "Changes Requiring a New Type Certificate," had been in effect since February 1965, more than 3 years before Frakes Aviation applied for the engine modification STC. The version of the regulation that was current at the time of the STC application stated in paragraph (b)(2) that a new application for a type certificate was required for transport-category airplanes if the proposed change included engines using different principles of propulsion. However, the FAA granted Frakes Aviation the option to use the airplane's original type certificate (which was issued in September 1947) as the basis for the analysis required for the modifications, instead of requiring Frakes to apply for a new type certificate for the G-73T airplane.[57] The practice of applying former regulations instead of new regulations is known as grandfathering.

As a result of the FAA's decision, Frakes Aviation performed the analysis for the engine modifications[58] in accordance with Part 4aT of the *Civil Air Regulations*, dated November 1, 1943, and amended March 8, 1944. As mentioned previously, this regulation required a static strength analysis, which is performed using loads that do not vary with time and that have a constant magnitude. The regulation did not include any provisions for a fatigue strength analysis for an expected service life for the airplane's structural components.

Because the FAA allowed Frakes Aviation to perform the analysis per the airplane's original type certificate, the G-73T airplane was not made subject to 14 CFR 25.571, "Fatigue Evaluation of Flight Structure," which had been in effect since

[57] An STC applicant can request to negotiate the certification basis with the applicable FAA aircraft certification office, and all decisions are made at the discretion of the FAA Administrator.

[58] Frakes Aviation used STRATO Engineering Company, Inc., of California to perform the engineering analysis.

February 1965. The version of 14 CFR 25.571 that was in effect at the time that Frakes applied for the STC was dated October 1966 and required, in part, the following:

> (a) Strength, detail design, and fabrication. Those parts of the structure (including wings, fixed and movable control surfaces, the fuselage, and their related primary attachments), whose failure could result in catastrophic failure of the airplane, must be evaluated under the provisions of either paragraph (b) or (c) of this section.
>
> (b) Fatigue strength. The structure must be shown by analysis, tests, or both, to be able to withstand the repeated loads of variable magnitude expected in service.
>
> (c) Fail safe strength. It must be shown by analysis, tests, or both, that catastrophic failure or excessive structural deformation, that could adversely affect the flight characteristics of the airplane, are not probable after fatigue failure or obvious partial failure of a single principal structural element.

1.18.2 Previous Related Safety Recommendations

1.18.2.1 Supplemental Inspections

According to 14 CFR 121.370a, "Supplemental Inspections," the maintenance programs of certain airplanes are required to include damage-tolerance-based supplemental inspections and procedures in addition to the aging airplane inspection and records review required by 14 CFR 121.368. The FAA issued the final rule for 14 CFR 121.370a in February 2005; however, the final rule differed substantially from the December 2002 interim final rule by exempting certain airplanes from the supplemental inspection requirements. The supplemental inspection requirements in the final rule for 14 CFR 121.370a apply only to transport-category, turbine-powered airplanes that were type-certificated after January 1, 1958, and that have a maximum passenger seating capacity of 30 or more seats or a maximum payload of 7,500 pounds.[59] The final rule also changed the compliance date from December 5, 2007, to December 10, 2010. In addition, both the December 2002 interim final rule and the February 2005 final rule exempted airplanes that are operated entirely within the state of Alaska.

In a July 24, 2006, letter to the FAA, the Safety Board referenced this accident and stated that it was concerned that the exemptions allowed certain airplanes, including the G-73T airplane, to carry passengers under Part 121 without having to undergo

[59] The December 2002 interim final rule required supplemental inspections for all airplanes operated under 14 CFR Part 121, all U.S.-registered multiengine airplanes operated under 14 CFR Part 129, and all multiengine airplanes used in scheduled operations under 14 CFR Part 135 (with the exception of certain Alaska and smaller airplane operations mentioned later in this section).

supplemental inspections. Because of these concerns, the Board issued Safety Recommendation A-06-52 on July 24, 2006, which asked the FAA to do the following:

> Require records reviews, aging airplane inspections, and supplemental inspections for all airplanes operated under 14 *Code of Federal Regulations* (CFR) Part 121, all U.S.-registered airplanes operated under 14 CFR Part 129, and all airplanes used in scheduled operations under 14 CFR Part 135. This would include those airplanes operated under 14 CFR Part 135 that carry nine or fewer passengers and those that are operated in scheduled cargo service.

On November 20, 2006, the FAA stated that airplanes that were type-certificated before 1958 and that had a maximum passenger seating capacity of less than 30 seats were not included in the final rule requiring damage tolerance-based supplemental inspections because it would be cost prohibitive to do so. The FAA estimated that fewer than 80 aircraft operated under Part 135 would be in scheduled operation in 2010, the compliance date for the supplemental inspections. The FAA stated that it would address the discovery of any age-related problems or unsafe conditions for these airplanes through continued operational safety programs and ADs. The FAA further stated that, if operators of small airplanes wanted to voluntarily develop supplemental inspections programs, they could refer to AC 91-60, which was being revised and would be completed in 2007.

On March 21, 2007, the Safety Board issued a response letter and asked that the FAA reconsider its position regarding the exemption of aircraft from the supplemental inspection requirements. In the letter, the Board stated that, until such reconsideration, Safety Recommendation A-06-52 is classified "Open—Unacceptable Response."

1.18.2.2 Cockpit Voice Recorder Functionality

During its investigation of the March 23, 2004, accident involving a helicopter that crashed into the Gulf of Mexico,[60] the Safety Board found that the CVR data recovered during that investigation were of limited use because of a CVR anomaly that was not detected during the functional check of the CVR after installation. As a result, on March 24, 2006, the Board issued Safety Recommendation A-06-23, which asked the FAA to do the following:

> Require all operators of aircraft equipped with a cockpit voice recorder (CVR) to (1) test the functionality of the CVR before the first flight of each day as part of an appoved aircraft checklist and (2) perform a periodic maintenance check of the CVR as part of an approved maintenance check of the aircraft. The CVR preflight test should be performed according to procedures provided by the CVR manufacturer and should include listening to the recorded signals on each channel to verify that the audio is being recorded properly, is intelligible, and is free from

[60] National Transportation Safety Board, *Controlled Flight into Terrain, Era Aviation, Sikorsky S-76A++, N579EH, Gulf of Mexico, About 70 Nautical Miles South-Southeast of Scholes International Airport, Galveston, Texas, March 23, 2004,* Aviation Accident Report NTSB/AAR-06/02 (Washington, DC: NTSB, 2006).

> electrical noise or other interference. The periodic maintenance check of the CVR should include an audio test followed by a download and review of each channel of recorded audio. The downloaded recording should be checked for overall audio quality, CVR functionality, and intelligibility.

In response, the FAA issued Safety Alert for Operators (SAFO) 06019 on November 8, 2006, advising operators to test CVR functionality before the first flight of the day and to add this test to their approved checklists. The SAFO emphasizes the importance of operators ensuring they have procedures and training for the functional test of the CVR. The SAFO also recommends that operators ensure that training requirements for testing of CVRs are emphasized during initial and recurrent training and that all pilots of aircraft equipped with a CVR test the function of the CVR before the first flight of each day as part of an approved aircraft checklist.

According to the FAA, the release of the SAFO was to be accompanied by a flight standards information bulletin for airworthiness (FSAW) that would instruct airworthiness aviation safety inspectors to ensure that operators perform periodic CVR maintenance checks, including checks of all possible combinations of intercom and microphone audio selections. These checks would ensure that all permutations of these selections were connected to the appropriate CVR channels and did not inhibit normal selectable functions or create loss in fidelity or intelligibility. As of April 2007, the FAA had not yet issued the FSAW.

In a letter to the FAA dated April 12, 2007, the Safety Board noted that the SAFO did not provide the specific guidance for the CVR preflight test included in the recommendation. The Board also reminded the FAA that the FSAW should include sufficient detail to ensure that nonfunctional CVR systems are identified and repaired as quickly as possible. On April 12, 2007, the Board classified Safety Recommendation A-06-23 "Open—Unacceptable Response," pending the FAA's revision of the SAFO and issuance of an appropriate FSAW.

1.18.3 Postaccident Interviews Regarding Maintenance of Chalk's Ocean Airways' Airplanes

The Safety Board interviewed Chalk's Ocean Airways pilots, the husband of the accident captain, the company's director of operations, the company's maintenance supervisor, and two DERs regarding Chalk's Ocean Airways' maintenance policies and practices. Their interviews are summarized in sections 1.18.3.1 through 1.18.3.4, respectively.

1.18.3.1 Former and Current Company Pilots

The Safety Board interviewed four pilots who were employed by Chalk's Ocean Airways at the time of the accident, the husband of the accident captain, and three pilots who had left the company before the accident. According to some pilots, in August 2004, all of the company captains had met with their director of operations to discuss shared

pilot concerns about the maintenance of company airplanes, including concerns about visible cracks and degraded rivets on some airplanes. Some pilots recalled that, during the meeting, the pilots had stated that they wanted to know that actions would be taken to ensure their safety and that the director of operations seemed to be concerned and told them that the airplanes would be examined.[61]

Some of the pilots stated that they were concerned about the amount of time maintenance items on company airplanes were deferred and that the director of maintenance and the maintenance supervisor told them that that skin cracks in the airplanes were superficial. Some of the pilots stated that they voiced concerns about fuel leaks, most of which occurred near the location where the wing meets the fuselage, and that the company told them that the leaks involved sealant in the fuel tanks and that the tanks would be resealed. One current company captain stated that fuel leaks had to be written up multiple times before they were fixed and that, in 2004, the same fuel leak was written up between 10 and 15 times.

Two current company first officers stated that company maintenance was "great" and that, when any problems were found with the airplanes, they would be fixed or grounded.

One former captain stated that, in November 2004, he experienced an in-flight emergency when he lost elevator control of the airplane during climbout because of an elevator cable that failed. He stated that he landed the airplane without incident using elevator trim. This captain stated he resigned from his job at Chalk's Ocean Airways on the day of the event because he had a job offer from another company.

Another former captain stated that he experienced loss-of-engine-power events during flights in January and February 2005. The flight crews were able to land the airplane each time without incident. This captain stated he resigned after the February 2005 engine failure because of his concerns with company maintenance issues.

Another captain stated that he resigned from the company solely because of his concerns with maintenance issues. This captain stated that, just before submitting his resignation letter (dated January 28, 2005) to the company, he provided the company's director of maintenance with a five-page letter (dated January 13, 2005) outlining his concerns.[62] The captain's letter stated that the most common reaction to a maintenance problem that could not be fixed quickly was for the mechanic to ask the captain of that airplane if he would fly it anyway; the letter stated that the second most common reaction was for the mechanic to sign off that the airplane was fixed when it actually was not fixed. The letter further indicated that "delayed maintenance, ignored maintenance, and lack of maintenance on our aircraft has caused an alarming trend to develop that has been all but

[61] The accident captain's husband stated that the captain was concerned that company airplanes were not well maintained and that she would speak daily about problems with the airplanes.

[62] This captain stated that he submitted this letter and tendered his resignation after being informed by the director of maintenance that he would be receiving disciplinary action (either a downgrade to first officer or time off) because of his difficulties in dealing with maintenance personnel.

ignored by the maintenance department and management altogether." In addition, in the letter, the captain suggested that the company "fix the aircraft when they do break, and improve our preventative maintenance, which is obviously sadly lacking."

1.18.3.2 Director of Operations

The Chalk's Ocean Airways director of operations has been in that position since August 2001.[63] He was an active pilot who conducted most acceptance flights after maintenance because he wanted to personally confirm that the airplanes were safe before other pilots flew them.[64] He stated that the company responded seriously to the comments expressed by its former captain by systematically checking airplane logbooks to confirm that all of his maintenance concerns had been addressed and fixed. The director stated that he was satisfied that these issues had been resolved and that the airplanes were safe to fly.

The director of operations stated that he did not agree with the former captain's assertion that, among pilots, there was a general concern with airplane maintenance. The director pointed out that only two captains left the company because of maintenance concerns and that several other captains could provide a more favorable view of the company. He also pointed to the company's 86-year "unblemished" safety record before the time of the accident.[65]

The director of operations stated that fuel leak concerns raised by pilots were "always a company concern" and that they were addressed before a flight was released. He also stated that every crack reported by pilots was corrected. He stated that the accident captain, as director of safety, was responsible for the safety aspect of flight and ground operations. He indicated that she discussed routine items during monthly meetings. He stated that he did not recall any time during these meetings in which she raised a concern about maintenance. The director further indicated that each captain could decide not to fly an airplane if a problem, including maintenance, existed.

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[63] The director of operations has also been the company's general manager since February 2005.

[64] The director of operations stated that he had to limit his flying after August 2005 because of medical issues.

[65] A review of Safety Board accident and incident data revealed that on March 18, 1994, two Chalk's Ocean Airways crewmembers were killed when the G-73T they were piloting crashed on takeoff. The Board determined that the probable cause of the accident was the "failure of the pilot-in-command to assure that the bilges were adequately pumped free of water (adequately preflighted), which resulted in the aft center of gravity limit to be exceeded, and the failure of the aircrew to follow the checklist. A factor related to the accident was the water leak." For more information about this accident, see MIA94FA097 on the Board's web site at <http://ntsb.gov>. Other Chalk's Ocean Airways accidents and incidents include a hard landing in 2002; a landing-gear fatigue failure in 2001 due to unserviceable parts installed on an airplane; a control yoke overload separation in 2000; a nose landing-gear failure in 1984; and an elevator-trim actuator failure in 1984. For more information about these events, see MIA02WA063, MIA01IA144, MIA00IA186, MIA84IA147, and MIA84IA077, respectively. Also, the previously mentioned November 29, 2004, event, in which a pilot reported he lost elevator control due to a broken elevator cable but landed the airplane safely, is reflected in a service difficulty report that Chalk's Ocean Airways submitted to the FAA.

1.18.3.3 Maintenance Supervisor

The Chalk's Ocean Airways maintenance supervisor at the time of the accident had been employed with the company for about 28 years and had been in that position for 26 years. He stated that he attended the yearly recurrent training on the company's GMM and the Grumman service manual[66] and was present at most of the monthly CASS meetings.

The maintenance supervisor stated that Chalk's Ocean Airways management gave him all of the resources, including airplane parts and personnel, to maintain the airplanes in an airworthy condition and that he did not sense "any pressure from upper management to keep the airplanes flying no matter what." He also stated that sometimes it took several attempts to determine the cause of a discrepancy and implement a fix to solve the problem. The maintenance supervisor further stated that he was not involved with any of the DER structural repairs.[67]

The maintenance supervisor did not recall accomplishing, or instructing one of the company's mechanics to accomplish, the doubler repair at right WS 34 on the accident airplane. He recalled seeing the repair several times during the C3 (right wing) inspection but thought that the repair "must have been done prior to Chalk's getting the airplane." The maintenance supervisor stated that he did not recall seeing any paperwork for this repair.

During the postaccident interview, the Safety Board showed the maintenance supervisor a picture of stop drill holes in the area of the doubler repair at right WS 34 on the accident airplane. The maintenance supervisor stated that he had not previously seen the stop drill holes and that he did not recollect instructing any of the mechanics to accomplish a stop drill repair in the area. He further stated that the repair was not accomplished using best maintenance practices.[68]

1.18.3.4 Designated Engineering Representatives

A structures DER stated that he worked with Chalk's Ocean Airways during the 5 to 6 years that preceded the accident. He indicated that most of the work performed for the company was the reverse engineering[69] of parts that were affected by corrosion. To accomplish this work, he prepared a design drawing and a stress report, along with FAA form 8110; this form provided approval for the replacement parts, which were made of modern materials whose design properties were equivalent to those of the former

[66] The chief inspector provided this and all other recurrent training at the company.

[67] Either a company mechanic or an outside mechanic recommended by the DER would accomplish these repairs.

[68] As mentioned in section 1.6.2.2, several characteristics of the repair were not in accordance with AC 43.13-1B.

[69] Reverse engineering is the process of recreating a drawing or specification for a component by analyzing a manufactured product for which a drawing or specification is unavailable.

materials. The DER stated that the August 2005 right wing repair on N142PA was the first time he had worked on the wing structure of an airplane in Chalk's Ocean Airways' fleet.

Another structures DER stated that he had worked with Chalk's Ocean Airways on four or five repairs since 1999, including the July 1999 lower left skin repair to N142PA. He also worked with the company on the July 2000 rear Z-stringer repair (right WS 50.5) to the accident airplane. The DER stated that this repair, which was needed because of a fatigue crack in one of the slosh holes, consisted of nesting two angles on the stringer in the region of the crack. The DER further stated that this repair was accomplished when the airplane was having major maintenance performed and that he did not recall any other damage or corrosion on the rest of the airplane at that time.

1.18.4 Grumman Customer Service Bulletin

Grumman issued Customer Service Bulletin No. 89 in May 1963. The bulletin stated that corrosion was the "greatest maintenance problem" for watercraft and that, for G-73 airplanes operating in a saltwater environment for most of their service life, corrosion might occur in the lower skin of the wings in the fuel tank areas. The bulletin also stated that corrosion might be occurring if one or all of the following conditions were present: chronic leakage of fuel; looseness of sealant in the tanks; and/or blisters, swelling, or visible corrosion in the skin in the tank areas.

The bulletin further stated that local repairs would probably correct the corrosion, but, if the aircraft had much saltwater operation in the past or if extended saltwater operations were anticipated in the future, the lower wing skin should be completely removed for a thorough cleaning, inspection, and resealing. In addition, the bulletin stated that wing skin removal and resealing of the fuel tanks would improve the fuel tightness and corrosion resistance of the tanks.

1.18.5 Department of Transportation Concerns About the Economic Fitness of Chalk's Ocean Airways

As part of the DOT's informal continuing fitness review of Chalk's Ocean Airways, the Air Carrier Fitness Division sent the company a letter dated April 14, 2004, that expressed its concerns about the company's "weak" financial position and what it considered to be excessive subservicing.[70] The DOT notified the FAA of its concerns by sending copies of the correspondence to the principal operations inspector (POI) assigned to Chalk's Ocean Airways. In a four-page attachment to the fitness review letter, the DOT also noted that, during discussions with the POI, the POI indicated that "his overall impression of the air carrier's operations was that it seems to be run more like a Part 135 air taxi operation rather than the Part 121 operator it is." The DOT review also indicated that the POI expressed concerns "that the management team may be too busy with their

[70] Subservicing is the practice of transferring passengers to other carriers.

flight duties to effectively attend to their administrative and oversight duties on the ground."

In a follow-up e-mail on August 11, 2004, the DOT asked the POI, "Aside from the subservice issue, do you have any concerns with the carrier's operations and/or management?" In an e-mail reply that day, the POI stated, "I do not."

In a letter dated November 4, 2004, Chalk's Ocean Airways responded to the DOT that it used subservicing when fleet maintenance requirements prevented it from using its own airplanes. These maintenance events included both scheduled and unscheduled maintenance items. In a January 5, 2005, letter to the company's general manager, the DOT reiterated its concerns about the company's economic viability and its subservicing arrangements.

2. Analysis

2.1 General

The captain and the first officer were properly certificated and qualified under Federal regulations. No evidence indicated any medical or behavioral conditions that might have adversely affected their performance during the accident flight. There was no evidence of flight crew fatigue.

The accident airplane was certificated and equipped in accordance with Federal regulations. The recovered components showed no evidence of any system or powerplant failures but showed evidence of multiple failures of wing structural components.

The fire damage to the fuselage and empennage was a result of the failure of the right wing and the subsequent breach in the wing fuel tank. The accident was not survivable. The emergency response was timely.

This analysis discusses the in-flight separation of the accident airplane's right wing, Chalk's Ocean Airways' maintenance of the accident airplane and other airplanes in its fleet, the FAA's oversight of the Chalk's Ocean Airways maintenance program, and certification issues pertaining to aging aircraft.

2.2 In-flight Breakup Sequence

On the basis of the accident airplane's takeoff weight and airspeed, the wing structure developed normal aerodynamic loads during takeoff, and these loads, in turn, created normal internal loads. However, the right wing separated from the airplane at WS 34 while the airplane was operated within its certificated design envelope, rendering the airplane uncontrollable. The airplane departed on the accident flight with preexisting damage to some wing structural components, however, the damaged components were not visible to the flight crew. The Safety Board concludes that there was no evidence from the performance or appearance of the airplane that would have provided warning to the flight crew of the right wing's imminent failure and that there was nothing that the crew could have done to regain control of the airplane after the in-flight separation of the right wing. Section 2.2.1 discusses the fracture scenario and the right wing's structural performance.

2.2.1 Fracture Scenario

Examination of the right wing revealed preexisting fatigue fractures and cracks in the rear Z-stringer, lower skin, and rear spar lower spar cap, each of which contributed to reducing the wing structure's ability to carry load. An analysis of each component's fracture characteristics, rub evidence and other characteristics observed on some

components and on some maintenance repairs, and evaluation of the typical load-bearing characteristics of the wing structure design were performed to produce a general timeline and likely sequence for the respective failure of each fractured component. Section 2.3 discusses the importance of this sequence as it relates to opportunities for repairing each damaged component before they cumulatively resulted in wing failure.

The analysis revealed that the airplane's right rear Z-stringer (as shown in figure 5) likely fractured first. Several features indicated that the right rear Z-stringer had been fractured for some time, most likely years, before the accident.[71] Fatigue initiated at the slosh hole in the web of the Z-stringer just outboard of right WS 34. No anomalies, such as material defects, mechanical damage, or corrosion, were identified as factors to cause fatigue initiation at the slosh hole. It is likely that fatigue initiated at the slosh hole because the number of load cycles on the stringer exceeded its fatigue life.[72]

After the right rear Z-stringer fractured, the lower skin developed a fatigue crack (as shown in figure 4). Because of the load-bearing characteristics of the wing structure design, initiation of a skin-fatigue crack in this location would be unlikely unless the rear Z-stringer was already fractured.[73] The skin crack, which was about 16 inches in length, consisted of two segments that initiated from two areas. Both segments of the skin crack propagated forward and aft of the initiation sites. The aft segment of the crack initiated from an area of corrosion and missing skin material around the fuel sump drain near right WS 34. The forward segment of the skin crack (the longer of the two segments) initiated from a rear Z-stringer fastener hole (the first fastener hole outboard of the fracture). Several features observed on this crack and on maintenance repairs associated with the crack suggest that the crack also likely developed over a period of months to years.

For example, three stop drill holes were observed in the crack path forward of the initiation site at the rear Z-stringer fastener hole (about 7, 9, and 16 inches forward of the skin trailing edge), indicating that the skin crack was detected by maintenance personnel on at least three occasions, likely over the course of months to years, and that crack extension beyond the previous stop drill hole was detected at least twice. The external and internal doublers were likely applied after the third stop drill hole had been drilled and after the skin crack propagated forward up to the middle Z-stringer. Missing skin material replaced with hard green sealant was observed between the doublers around the fuel sump drain. In this area, several fasteners at the inboard edge of the doublers went through the

[71] These features included the following: the overstress region on the upper flange was worn, which was consistent with rubbing of mating fracture surfaces over time; sanding marks were observed around the slosh hole that deformed the edges of the fracture face, and sealant was present in the fracture surface, indicating that the flange was cracked or fractured at the time the sanding and sealant procedures were performed; and one of the three internal doublers was covering the lower flange of the Z-stringer at the fracture location.

[72] Fatigue life is the number of load cycles that a component experiences before failure is expected due to fatigue fracture.

[73] If the rear Z-stringer were intact, it would carry most of the load, thereby reducing the load on the skin at the stringer fastener row. However, the right rear Z-stringer on the accident airplane was broken, causing the load to shed to the skin and leading to fatigue of the skin emanating from a fastener hole adjacent to the fracture.

sealant instead of skin material and, thus, would not provide load transfer across the skin crack in that area.

Multiple-site fatigue damage was observed on the skin fracture surface (inboard of the stop-drilled crack) at the inboard fastener row for the external doubler adjacent to right WS 34. At some time before the accident, several of these sites linked up in overstress to form a fracture through the skin at the rear Z-stringer and, most likely, several inches forward and aft of the Z-stringer.[74]

After the lower skin fractured, fatigue cracks initiated in the rear spar lower spar cap (as shown in figure 6). The initiation of these fatigue cracks was likely late in the overall sequence of events because the fracture features indicated relatively rapid growth under relatively high stresses. Fatigue in the rear spar lower spar cap initiated from a double-drilled hole in the horizontal flange of the spar cap for a threaded fastener attaching the wing to the fuselage.[75] Although a double-drilled hole could be considered an initiating defect in many cases, in this case, fatigue initiated from multiple sites through the thickness of the horizontal flange (including both the narrow and wide areas of the double-drilled hole) indicating that stresses in the spar cap were high enough to cause fatigue initiation from any fastener hole in the area, with relatively few load cycles.

Further, fatigue in the rear spar progressed rapidly from a relatively small, slow growth region. The portion of the crack aft of the hole propagated from a length of 0.07 to 0.44 inch in about 11 increments of rapid crack growth; each increment was most likely associated with an individual flight cycle. Also, more than one-half of the rear spar lower spar cap fractured in overstress. The relatively small size of the slow growth region and the limited overall size of the fatigue region indicated that stresses on the rear spar lower spar cap were relatively high as the crack propagated under normal flight loads, and the high stresses were most likely a result of the shedding of load from the fatigue-fractured and cracked rear Z-stringer and lower skin.

The Safety Board's residual strength and fatigue analyses[76] of the right wing structure revealed that the fatigue cracks grew to their critical crack length and that the remaining wing structure could no longer sustain the applied loads. The Safety Board

[74] Evidence of relative movement between the inboard side of the skin fracture and the doubler at its inboard fastener row, which was consistent with the fracture opening and closing, was observed on the surface of the doubler between several fastener locations, including the fastener for the right rear stringer and the adjacent two fasteners aft of the stringer.

[75] The age of the double-drilled hole could not be determined. It is possible that both holes could have been drilled at the time the airplane was manufactured, and it is also possible that the second hole was drilled during maintenance.

[76] The residual strength and fatigue analyses assumed 1 G flight loads that were obtained with and without fuel and were applied to the wing structure. The resulting reaction forces and associated stresses were computed for the undamaged wing. The stresses were then recomputed with certain elements either completely removed or their cross-sectional areas reduced, based on the amount of fatigue damage present in the wing structure. Stress concentration factors were then applied, and new stresses were computed and compared with the material yield and ultimate stresses. A crack-growth analysis was performed for the spar cap and the wing skin to determine the number of cycles required for the fatigue fractures to reach their critical crack length.

concludes that the right wing separated from the accident airplane at WS 34 because of preexisting fatigue fractures and cracks in the rear Z-stringer, lower skin, and rear spar lower spar cap and that this multiple-element fatigue damage reduced the residual strength capability of the wing structure and caused the fatigue failure of the wing during normal flight operations.

2.3 Chalk's Ocean Airways Maintenance Program

The Chalk's Ocean Airways maintenance program was ineffective in identifying and correcting the longstanding structural problems that led to the in-flight separation of the accident airplane's right wing near WS 34. Because several of these problems occurred over months and years, company maintenance and inspection personnel had multiple opportunities to identify and correct the individual damaged components and, thus, could have prevented the wing failure.

2.3.1 Ineffective Repairs on the Accident Airplane

Although maintenance personnel detected some problems and attempted repairs, many of the repairs were ineffective in that they did not properly restore the load-carrying capability of the wing structure. Ineffective repairs observed on the accident airplane included documented repairs performed by company maintenance personnel and some undocumented repairs. Also, company inspection personnel failed to identify that the repairs were ineffective. The ineffective repairs observed on the accident airplane included the following:

- Sanding marks were observed around the rear Z-stringer slosh hole and fracture lips at right WS 34, suggesting that the sanding was an attempt to remove cracking that had been detected in the Z-stringer. The cracking, however, was not completely removed, and the crack continued to propagate over time.
- One of the three internal doublers at right WS 34 had a portion that covered the lower flange of the rear Z-stringer, suggesting that the portion of the doubler covering the Z-stringer was an attempt to reinforce the fractured Z-stringer. Doubling only the lower flange did not restore the strength of the fractured Z-stringer.
- Multiple-site fatigue damage at the inboard fastener row for the doublers at right WS 34 linked up in the area of the rear Z-stringer before the wing separated, indicating that repairs in this area did not restore the strength of the rear Z-stringer.

- Several fasteners in the inboard row of fasteners for the doubler repair at right WS 34 were inserted through sealant near the fuel sump drain instead of the lower skin.[77] This resulted in ineffective load transfer between the skin and the doublers in that area.
- Three stop drill holes were located in the area of the doubler repair to the lower skin at right WS 34. The stop drill holes showed that the skin crack was detected at least three times before the doublers were applied and that the crack had extended twice from the location of a previous stop drill hole. Continued crack growth from a stop drill hole is indicative of an underlying structural problem that was not properly addressed in previous maintenance actions.

On July 6, 2000, a major repair to the accident airplane's rear Z-stringer was performed at right WS 50.5 using a DER drawing that indicated that the riveting was to be performed in accordance with AC 43.13.[78] This repair was not part of the fracture scenario but was, nonetheless, ineffective because the rivets used in the repair did not meet the standards described in the AC. Some rivets had undersized shop heads and were overdriven, and a rivet through the skin and stringer flange at the slosh hole was of a larger size and different head type than specified, which was not in compliance with the engineering drawing for the repair. A fatigue crack in the skin emanated from the hole with the large rivet.

In addition, flight logs documented numerous fuel leak discrepancies involving the accident airplane that occurred over several months before the accident. Many of these discrepancies occurred near the area where the right wing separated from the airplane. The Chalk's Ocean Airways director of maintenance stated that fuel leaks reported by pilots were addressed before a flight was released. However, the flight logs showed that the fuel leak discrepancies often took several attempts to resolve but would then recur. Because the wing skin and other wing box structures make up the wing fuel tanks, wing fuel leaks can be indicative of discrepancies with the wing box structure. The Safety Board concludes that the repetitive fuel leaks near the area where the accident airplane's right wing separated from the fuselage were indicators of structural damage inside the right wing. This issue is further discussed in section 2.3.2.

Other maintenance-related problems existed with the accident airplane. For example, during postaccident metallurgical examinations, corrosion was observed in many locations throughout the airplane's structure,[79] with some areas showing significant pitting and thinning. Also, the metallurgical examinations showed significant fatigue

[77] AC 43.13 shows typical structural repair methods for aluminum structure, but the repairs described in this and the preceding two bulleted items were not included as examples of typical structural repair methods. Also, AC 43.13 does not include any reference to indicate that cracks can be removed by sanding, as described in the first bulleted item.

[78] Technical data referenced in engineering drawings are considered to be approved data, and Chalk's Ocean Airways GMM requires that all maintenance be performed in accordance with approved data.

[79] The Safety Board could not determine whether Chalk's Ocean Airways had received and implemented Grumman Service Bulletin No. 89, which addressed the problem of corrosion for airplanes that operated in a saltwater environment (see section 1.18.4).

cracks on the left wing, including one crack on the left wing front spar lower spar cap that had extended from an area of corrosion damage and had begun to progress fairly rapidly. The crack was located in an area that had not been repaired and did not have adjacent structural element failures. If the accident airplane had not experienced a catastrophic failure at right WS 34, the crack in the left wing front spar lower spar cap likely would have eventually led to a catastrophic failure.

In addition, Chalk's Ocean Airways' maintenance records did not contain any entry for the doubler repair to the accident airplane's lower skin at right WS 34. During a postaccident interview, the company's maintenance supervisor stated that he did not recall accomplishing, or instructing one of the company's mechanics to accomplish, the repair. The maintenance supervisor stated that he recalled seeing the repair several times during the C3 (right wing) inspection but thought that the repair "must have been done prior to Chalk's getting the airplane." The company's maintenance records showed that, on May 6, 1992, a doubler repair was made to the accident airplane's lower skin at left WS 34. Metallurgical examination showed a substantially greater amount of corrosion damage in the left wing doubler repair compared to corrosion damage in the right wing doubler repair. Thus, the right wing repair appeared to be more recent than the May 1992 left wing repair.

As a result, the Safety Board concludes that Chalk's Ocean Airways most likely performed the doubler repair to the accident airplane's lower skin at right WS 34 and that this repair should have been reflected in the company's maintenance records. It is possible that this repair was accomplished between January 2000 and January 2001, the time period for which the company was unable to provide flight log sheets. The Safety Board further concludes that the doubler repair to the accident airplane's lower wing skin at right WS 34 was ineffective because the doublers did not restore the load-carrying capability of the skin in the area of the fuel sump drain and the repair did not properly address the underlying cause of the skin cracking, which was the cracked or fractured rear Z-stringer.

2.3.2 Recurring Discrepancies

As previously stated, Chalk's Ocean Airways' flight logs documented numerous fuel leak discrepancies involving the accident airplane. Minutes from the July 2005 CASS meeting showed that the accident airplane had a fuel leak from either the left or right wing near the fuel tank six times during a 5-day period. Also, the minutes from the September 2005 CASS meeting showed that the accident airplane had a fuel leak in its right wing dry bay for 3 consecutive days. The repair methods used to address these fuel leaks involved removing and replacing the sealant on the fuel tank.

As mentioned previously, the Chalk's Ocean Airways' repair methods to resolve the fuel leak discrepancies were not effective, as demonstrated by the recurring leaks in the same areas. As part of its CAMP and CASS program, Chalk's Ocean Airways was required to monitor the mechanical performance of the flying fleet by collecting and analyzing operational data. However, the company's evaluation of the recurring leaks was inadequate because it failed to recognize that the leaks were repeated indicators of

structural damage inside the right wing. A thorough evaluation of the leaks should have recognized that, because the leaks recurred after repeated skin repairs, the skin repairs were not effective. This should have prompted further evaluation to determine a more effective repair; in the case of the accident airplane, further evaluation should have detected the structural damage inside the wing that led to skin cracks and the recurring leaks. Correction of that structural damage not only would have corrected the leaks but also would have prevented the accident.

If Chalk's Ocean Airways had established a repair threshold that limited the number of times such a discrepancy may recur in a given period, the recurrence of the leaks following multiple repairs may have prompted further troubleshooting, maintenance, engineering, and/or grounding of the airplane. The Safety Board concludes that the establishment of repair thresholds in all maintenance programs would help ensure that repeated occurrences of a specific discrepancy are sufficiently evaluated. Therefore, the Safety Board believes that the FAA should verify that the maintenance programs of commercial aircraft operators include stringent criteria to address recurring or systemic discrepancies to include, if necessary, further analysis of the discrepancies through a comprehensive engineering evaluation.

2.3.3 Other Fleet Maintenance Issues

Maintenance-related problems also existed with another G-73T airplane in Chalk's Ocean Airways' fleet, N142PA. According to the structures DER who provided engineering approval for the August 2005 major repair to the lower right wing skin of that airplane, Chalk's Ocean Airways informed him 2 months earlier that fuel was leaking from the right wing-to-body fairing. The DER inspected the airplane and found that fuel was leaking from a 22-inch crack in the right wing lower skin; the crack was covered by the fairing and reduced the load-carrying capacity of the right wing box by about 50 percent. The DER also found that all of the stringers on the right wing were corroded and cracked and that many of the other repairs visible on the rest of the wing appeared to be "quite old."[80] As a result of the DER's findings, the wing repairs involved replacing all of the stringers (including lower Z-stringers) and the lower wing skin from the centerline to the nacelle. The Safety Board concludes that, on the basis of the repetitive nature of the fuel leaks on the accident airplane and the structural damage that was found during the fuel leak inspection of another company airplane that led to the August 2005 replacement of that airplane's lower right wing skin and stringers, Chalk's Ocean Airways should have performed a comprehensive inspection of and maintenance on the wing structures of the airplanes in its fleet.

[80] In addition, the DER noticed that a doubler on the left lower wing skin had a 17-inch crack. The Safety Board confirmed the existence of the right wing lower skin crack and the left wing lower skin doubler crack in photographs provided by the DER. In addition, the DER who designed the July 1999 major repair to N142PA's lower left wing skin stated that N142PA had an area of corrosion around the fuel sump drain and a 14-inch crack that emanated from the forward edge of the corrosion to a point that was 9 inches forward. He also stated that the left wing aft spar attachment point showed evidence of grinding in some areas, the right wing aft spar attachment point had corrosion, and extensive corrosion was present on other areas of the airplane.

Even though the airplanes in Chalk's Ocean Airways' fleet were not subject to the fatigue evaluation requirements in 14 CFR 25.571,[81] and the aging aircraft inspection and records review performed under 14 CFR 121.368 was not designed to detect fatigue cracking, the company was still responsible for maintaining its airplanes in an airworthy condition. The Chalk's Ocean Airways maintenance supervisor stated that he was given all of the resources (parts and personnel) that he needed to maintain the company's airplanes in an airworthy condition and that he did not sense "any pressure from upper management to keep the airplanes flying no matter what." However, in a January 2005 letter to the company's director of maintenance, a former company captain stated that the most common reaction to a maintenance problem that could not be quickly fixed was for the mechanic to ask the captain of that airplane if he would fly it anyway and that the second most common reaction was for the mechanic to sign off that the airplane was fixed when it was not actually fixed.

The Safety Board concludes that the failure of Chalk's Ocean Airways to identify and properly repair fatigue cracks in the accident airplane's wing structure and the numerous maintenance-related problems found on the accident airplane and another company airplane demonstrate that the company's maintenance program and practices were deficient, and these deficiencies were causal to the accident.

2.4 Federal Aviation Administration Oversight of the Chalk's Ocean Airways Maintenance Program

The Chalk's Ocean Airways PMI was responsible for overseeing the company's maintenance program plan and the maintenance performed on the airplanes in the company's fleet. During a postaccident interview, the PMI stated that he was "comfortable" with the maintenance being conducted on Chalk's Ocean Airways' airplanes, and he did not convey any concerns about the quality of the maintenance program. The PMI also noted that the company's maintenance program plan met all FAR requirements.

As part of his oversight duties, the PMI conducted the 14 CFR 121.368 aging aircraft inspection and records review for Chalk's Ocean Airways on October 7, 2005. A review of the paperwork for the PMI's aging aircraft inspection and records review indicated that, for the accident airplane, major repairs to the rear spar upper spar cap at right WS 34 and to the lower wing skin at left WS 34 were accomplished on April 13 and May 6, 1992, respectively. However, the paperwork did not include the July 6, 2000, major repair to the rear Z-stringer at right WS 50.5, even though maintenance records for this repair were available. Also, the paperwork did not include the major repair to the lower wing skin at right WS 34.

[81] As mentioned in section 1.16.1, the Safety Board notes that Chalk's Ocean Airways electively employed a fatigue- and damage-tolerance-based approach for the August 2005 repair to the right wing on N142PA.

Because 14 CFR 121.368 does not specifically include requirements for inspecting airplane structures that are susceptible to fatigue cracking, a thorough aging aircraft inspection alone would not likely detect the multiple-element fatigue cracking on the accident airplane's right wing and the significant fatigue crack on the airplane's left wing front spar lower spar cap. However, the Safety Board is concerned that the PMI's aging aircraft inspection and records review for Chalk's Ocean Airways did not include a repair that was undocumented in the maintenance records but was known to company maintenance personnel.

As previously discussed, the purpose of Chalk's Ocean Airways' CASS program was to identify and correct deficiencies in the company's maintenance program plan, and the PMI was responsible for monitoring the company's CASS program. Records showed that the Chalk's Ocean Airways PMI did not attend the July and September 2005 CASS meetings, each of which included discussions of fuel leak issues on the accident airplane. However, according to the PMI's annual work plan, he was responsible for reviewing all information related to the company's CASS program, including the CASS meeting minutes, so he should have been aware of the repetitive fuel leaks on the accident airplane.

As stated previously, the fuel leak discrepancies on the accident airplane were repeated indicators of wing structural damage issues that the Chalk's Ocean Airways maintenance program did not effectively address. Because the PMI had information that the fuel leaks were recurring and that a DER's evaluation of leaks on N142PA led to extensive structural repairs of that airplane's wing structure in August 2005, the PMI should have realized that the skin and sealant repair methods being applied to the accident airplane were not sufficient. However, no evidence indicated that the PMI investigated the cause of the repetitive fuel leaks or discussed these issues with company management.

2.4.1 Importance of Program Oversight for Aircraft With Limited Support

The Safety Board has long recognized that effective FAA oversight of air carriers serves as an important safety function to help prevent accidents. For example, during its investigations of the May 11, 1996, ValuJet Airlines accident[82] and the August 7, 1997, Fine Airlines accident,[83] the Board noted that FAA oversight activities did not detect systemic deficiencies at each airline that were related to the circumstances of each accident. As a result, the Board issued Safety Recommendation A-98-51 on July 10, 1998, which asked the FAA to determine why certain oversight procedures failed to detect

[82] National Transportation Safety Board, *In-flight Fire and Impact With Terrain, ValuJet Airlines Flight 592, DC-9-32, N904VJ, Everglades, Near Miami, Florida, May 11, 1996,* Aircraft Accident Report NTSB/AAR-97/06 (Washington, DC: NTSB, 1997).

[83] National Transportation Safety Board, *Uncontrolled Impact With Terrain, Fine Airlines Flight 101, Douglas DC-8-61, N27UA, Miami, Florida, August 7, 1997,* Aircraft Accident Report NTSB/AAR-98/02 (Washington, DC: NTSB, 1998).

systemic safety problems at ValuJet Airlines and Fine Airlines and to modify those procedures.[84]

The Safety Board has also long recognized the value of engineering services in assisting operators to periodically evaluate and improve their maintenance practices. For example, on July 21, 1989, the Board issued Safety Recommendation A-89-61,[85] which asked the FAA to require that air carrier maintenance departments use the engineering services available from the manufacturer or other sources to periodically evaluate their maintenance practices.[86] In response to the recommendation, the FAA stated, "present association between the manufacturers' engineering organizations and the air carriers' maintenance organizations is adequate," and "air carrier engineering departments maintain a close liaison with their counterparts in the manufacturers' organizations and their maintenance department liaison with the manufacturers' service representatives."

However, in the case of Chalk's Ocean Airways, neither the airplane's manufacturer nor the current type certificate holder provided engineering services, and Chalk's Ocean Airways did not have an engineering department. Engineering support for Chalk's Ocean Airways was provided by individual contracts with multiple DERs. This type of support does not provide the comprehensive understanding of the operator's fleet that sole-source engineering support could provide. In addition, a structural repair manual was not issued for the G-73 because one was not required at the time the airplane was manufactured.

The Safety Board notes that, because of the limited availability of engineering services and manufacturer support for the G-73T airplanes, effective FAA oversight of the Chalk's Ocean Airways maintenance program plan was important to ensure that the program addressed the airworthiness issues of such a fleet. However, although the program plan met FAR requirements and the PMI performed his required oversight activities, these activities did not result in the detection and correction of the systemic

[84] Safety Recommendation A-98-51 specifically asked that the FAA do the following: "Review its national aviation safety inspection program and regional aviation safety inspection program inspection procedures to determine why inspections preceding these accidents failed to identify systemic safety problems at ValuJet and Fine Air[lines] and, based on the findings of this review, modify these inspection procedures to ensure that such systemic indicators are identified and corrected before they result in an accident." On March 12, 2001, the Safety Board classified Safety Recommendation A-98-51 "Open—Unacceptable Response" because the FAA did not answer why the inspections failed to identify systemic safety problems at ValuJet and Fine Airlines and did not address how the program modifications ensure that such systemic indicators are identified and corrected before they result in an accident.

[85] Safety Recommendation A-89-61 was issued as part of the Safety Board's final report on the April 28, 1988 Aloha Airlines flight 243 accident. The airplane experienced an explosive decompression and structural failure at 24,000 feet while en route from Hilo to Honolulu, Hawaii. About 18 feet of cabin skin and structure aft of the cabin entrance door and above the passenger floorline separated from the airplane. For more information, see National Transportation Safety Board, *Aloha Airlines, Flight 243, Boeing 737-200, N73711, Near Maui, Hawaii, April 28, 1988*, Aircraft Accident Report NTSB/AAR-89/03 (Washington, DC: NTSB, 1989).

[86] On September 22, 1992, the Safety Board classified Safety Recommendation A-89-61 "Closed—Acceptable Alternate Action" as a result of the implementation of several FAA initiatives to reinforce the requirements of the existing regulation (14 CFR 121.373) and to provide assurance that operator maintenance programs were satisfactory.

deficiencies in the maintenance program that led to this accident. Thus, the Safety Board concludes that the Chalk's Ocean Airways maintenance program plan was inadequate to maintain the structural integrity of its aircraft fleet. Further, the Safety Board concludes that the FAA's procedures for maintenance program oversight, when applied to commercial operators of aircraft with limited manufacturer or engineering support, such as Chalk's Ocean Airways, are insufficient to ensure the adequacy of such programs' structural airworthiness plans and, thus, the safety of such aircraft operations and that the FAA's failure to identify the inadequacy of the Chalk's Ocean Airways maintenance program was causal to the accident. Therefore, the Board believes that the FAA should identify the systemic deficiencies in the maintenance program oversight procedures that led to this accident and modify those procedures to ensure that the maintenance program plans for commercial operators are adequate to ensure the continued airworthiness, both structural and otherwise, of the operator's fleet.

2.4.2 Continuing Analysis and Surveillance System Program Guidance

Inspector guidance for ensuring that an operator's CASS meets the necessary requirement for certification or revision is currently found in FAA Order 8300.10, *Airworthiness Inspector's Handbook*, volume 2, chapter 65, "Evaluate Continuing Analysis and Surveillance Program." Inspector guidance for monitoring the CASS program is currently found in FAA Order 8300.10, volume 3, chapter 37, "Monitor Continuing Analysis and Surveillance Program." These handbook sections were developed in the early 1990s.

In March 2003, the FAA issued AC 120-16D, "Continuous Airworthiness Maintenance Programs," which indicated that an air carrier's CASS program should detect and correct air carrier maintenance program deficiencies through a closed-loop, continuous cycle of surveillance and investigations, data collection and analysis, corrective actions, and monitoring and feedback. AC 120-16D stated that an air carrier's CASS program should include detailed policy and procedures for determining whether an air carrier needed to amend its maintenance program and for making such amendments. In addition, the guidance stated, "proactive surveillance and analysis forecasts faults in your [the air carrier's] maintenance program … through the collection and analysis of a wide variety of data. It corrects those faults, including human factors issues, in advance of any specific event, accident, or incident."

In April 2003, the FAA published AC 120-79, "Developing and Implementing a Continuing Analysis and Surveillance System," which was a comprehensive guide for the development of CASS programs. The AC provided information on many CASS-related topics and described model CASS programs for air carriers in three different size ranges.

On March 5, 2004, the Safety Board issued Safety Recommendation A-04-14 as part of its investigation into the January 2003 Air Midwest flight 5481 accident in Charlotte, North Carolina.[87] Safety Recommendation A-04-14 asked the FAA to "include the Continuing Analysis and Surveillance System guidance from Advisory Circular (AC) 120-16D, 'Continuous Airworthiness Maintenance Programs,' and AC 120-79, 'Developing and Implementing a Continuing Analysis [and] Surveillance System,' in Federal Aviation Administration Order 8300.10, *Airworthiness Inspector's Handbook.*"

On June 18, 2004, the FAA stated that it would include a reference to AC 120-16D and AC 120-79 in FAA Order 8300.10 and that it anticipated that the order would be revised by October 2004. On October 12, 2005, the Safety Board stated that a May 2005 check of FAA Order 8300.10 on the FAA's Web site did not find this revision. The Board stated that, pending issuance of a revised FAA Order 8300.10 that incorporates the reference to the ACs, Safety Recommendation A-04-14 was classified "Open—Acceptable Response."

In December 2006, the FAA notified the Safety Board that the *Airworthiness Inspector's Handbook* had been revised in October 2005 to include references to AC 120-16D and AC 120-79. However, the Board's review of the handbook found that the references to both ACs only appeared in a chapter that discussed outsourcing maintenance (volume 2, chapter 69). In addition, the Board found that (1) a reference to only AC 120-79 was added to volume 2, chapter 95 of the handbook, which discusses an operator's use of a Coordinating Agencies for Supplier Evaluation audit to satisfy the operator's surveillance requirement under 14 CFR 121.373 and that (2) a reference to only AC 120-16D was added to volume 3, chapter 134 of the handbook, which discusses the evaluation of an outsource maintenance organization's facility.

For the handbook chapters that discuss evaluating and monitoring a CAMP (volume 2, chapter 64, and volume 3, chapter 36, respectively), a reference to only AC 120-16D appears. Also, for the handbook chapters that discuss evaluating and monitoring a CASS program (volume 2, chapter 65, and volume 3, chapter 37, respectively), a reference to only AC 120-16D appears. To effectively assess the adequacy of an operator's CASS program, a PMI needs to consider the guidance in AC 120-79 in addition to the guidance in AC 120-16D. Also, for all of the CASS guidance references, only the AC number and the AC title appear. The handbook contains no specific information to inform the PMI of the purpose and contents of each AC. Such information would help PMIs to evaluate and monitor a company's CASS.

The Safety Board concludes that updating FAA Order 8300.10, *Airworthiness Inspector's Handbook*, with the latest CASS guidance and an explanation of this guidance would help FAA aviation safety inspectors ensure that CASS programs are being effectively implemented at 14 CFR Part 121 air carriers. Therefore, the Board reiterates

[87] National Transportation Safety Board, *Loss of Pitch Control During Takeoff, Air Midwest Flight 5481, Raytheon (Beechcraft) 1900D, N233YV, Charlotte, North Carolina, January 8, 2003*, Aircraft Accident Report NTSB/AAR-04/01 (Washington, DC: NTSB, 2004).

Safety Recommendation A-04-14. Further, the Board classifies Safety Recommendation A-04-14 "Open—Unacceptable Response."

2.4.3 Other Indicators of Potential Safety Deficiencies

During the investigation of this accident, a number of cues from several sources served as indicators of potential safety deficiencies at Chalk's Ocean Airways. In 2004 and 2005, Chalk's Ocean Airways received and responded to repeated correspondence from the DOT regarding the DOT's concerns with the economic fitness of the air carrier. The DOT sent copies of this correspondence to the POI. Although the DOT Air Carrier Fitness Division's role does not include assessing air carrier safety, the correspondence served to notify the POI that Chalk's Ocean Airways was exhibiting financial difficulties. The Safety Board notes that the financial distress of an operator can be an indicator that additional surveillance may be warranted.[88]

In addition, the DOT correspondence indicated that the POI expressed concerns that company managers were too busy with their flight duties to effectively attend to their compliance and management duties. The accident captain was a full-time line pilot but also served as the company's director of safety, a position that required FAA approval for her to perform. During postaccident interviews, the husband of the accident captain reported that, in the year before the accident, she was becoming exhausted and stressed by work demands.

Also, for an airline with a small fleet, there were a number of maintenance-related events that compromised flight safety. In November 2004, an in-flight emergency occurred on a company airplane when an elevator cable failed in flight. Chalk's documented this event and informed the FAA by means of a service difficulty report. Also, a landing-gear fatigue failure incident in 2001 was attributed to unserviceable parts installed on the airplane by Chalk's maintenance personnel. Further, through the CASS meetings and minutes, the PMI was made aware of repetitive maintenance issues, such as wing fuel leaks on the accident airplane. These leak issues continued to persist, even after the FAA was made aware that another company airplane received a major structural wing repair to fully address its fuel leak issues.

The Safety Board is concerned that the FAA received cues from a number of sources that, when looked at in aggregate, served as indicators of potential safety

[88] On December 28, 1988, the Safety Board issued Safety Recommendation A-88-155, which asked that the FAA provide POIs of operators under 14 CFR Parts 135 and 121 with similar indicators of financial distress and rapid growth; these indicators suggest when increased surveillance of those operations is warranted. On May 23, 1989, the Safety Board classified Safety Recommendation A-88-155 "Closed—Acceptable Action" after the FAA responded that it issued an action notice and guidance materials for POIs with regard to requested action. Subsequently, the FAA incorporated a "Financial Condition Assessment Decision Aid" into FAA Order 8300.10. The recommendation resulted from the Board's investigation of the February 19, 1988, fatal accident involving a Fairchild Metro III operated as AvAir, Inc., flight 3378. For more information, see National Transportation Safety Board, *AvAir Inc., Flight 3378, Fairchild Metro III, SA227 AC, N622AV, Cary, North Carolina, February 19, 1988,* Aircraft Accident Report NTSB/AAR-88/10 (Washington, DC: NTSB, 1988).

deficiencies at Chalk's Ocean Airways. However, there is no evidence that the FAA conducted any meaningful increase in surveillance in response to the aggregate information. In fact, the FAA principal inspectors expressed no concerns with the company's operations and maintenance. Therefore, the Safety Board concludes that the FAA received sufficient cues from a number of sources to alert it of potential safety deficiencies at Chalk's Ocean Airways and that these cues should have prompted heightened vigilance and additional surveillance of the operator.

2.5 Certification Issues

The accident airplane's right wing was designed in accordance with the applicable certification requirements in Part 4aT of the *Civil Air Regulations*, dated November 1, 1943, and amended March 8, 1944. The Safety Board's review of certification documents revealed no faulty methods or invalid assumptions for the wing structure certification basis. However, the Board notes that the certification requirements included a static strength analysis but not a fatigue analysis. No requirements for a fatigue analysis existed at the time of the G-73's original certification because such an analysis had not yet been developed.

In August 1968, when Frakes Aviation applied for the STC to increase the gross weight of the G-73 and replace its piston engines with turbopropeller engines, 14 CFR 21.19, "Changes Requiring a New Type Certificate," was in effect. Paragraph (b)(2) of the regulation stated that a new application for a type certificate was required for transport-category airplanes if the proposed change involved engines using different principles of operation. However, the FAA granted Frakes Aviation the option to perform the analysis for the modifications according to the original type certificate, which was issued more than 20 years earlier.

As mentioned in section 1.18.1, the practice of applying former regulations instead of new regulations is known as grandfathering. This practice is generally employed when a type certificate or STC applicant is developing derivative aircraft (those for which changes in the type design are considered minor)[89] as long as the omission of current regulations does not have a negative impact on structural integrity, continued airworthiness, or safety of flight. A major change in type design may, in some cases, be accomplished without applying the most recent requirements at the time of type certificate or STC application (as demonstrated by the G-73's increase in gross weight and conversion from piston to turbopropeller engines).

Because the FAA allowed Frakes Aviation to use the original certification basis for the modifications, the analysis to support the modifications for the STC considered only static loading. A review of the Frakes Aviation STC, as approved by the FAA and applied to the accident airplane, revealed that, on the basis of the static strength analysis performed in support of the STC, the increase in gross weight and the conversion from

[89] A minor change is one that has no appreciable effect on the weight, balance, structural strength, reliability, operational characteristics, or other characteristics affecting the airworthiness of the product.

piston to turbopropeller engines for the accident airplane did not contribute to the circumstances of the accident. The accident airplane's wing structure did not fail because of static loading but rather because of multiple-element fatigue damage that reduced the residual strength capability of the wing structure.

However, had the FAA not allowed Frakes Aviation to use the original certification basis for the STC modification, Frakes Aviation would have had to apply for a new type certificate in 1968. As part of that process, Frakes Aviation would have most likely[90] been required to perform a fatigue analysis, according to 14 CFR 25.571, "Fatigue Evaluation of Flight Structure," which was enacted more than 3 years earlier. Such a fatigue analysis would have included an evaluation of the strength, design, and fabrication of those parts of the structure, including the wings, whose failure could result in catastrophic failure of the airplane. Also, this analysis likely would have included a determination of a safe operating life for the wing structure that would have been used as the basis for inspection and retirement requirements.

Because no fatigue analysis was performed, no information is available for the dynamic loading experienced by the G-73 wing before or after the incorporation of the Frakes Aviation STC. Without the results of a complete fatigue analysis of the wing before and after the time of the STC, it is not possible to determine whether the fatigue damage and locations of fatigue cracks in the accident airplane's wing structure were what could have been expected. Also, without a fatigue analysis, there was no existing information for the safe operating life of the G-73T wing structure that could have been used as the basis for inspection and retirement requirements. Therefore, the Safety Board concludes that the FAA missed an opportunity to recertify the Grumman Mallard G-73T airplane with a new type certificate that would likely have included a fatigue analysis of the airplane. Such a fatigue analysis likely would have included a determination of a safe operating life for the wing structure that would have been used as the basis for inspection and retirement requirements that could have prevented the accident. The Board notes that, according to the current FARs pertaining to type certificates and STCs, an operator can no longer accomplish such major modifications of primary structural elements without first conducting a detailed assessment of the certification basis and the analysis necessary to support such design changes, including, but not limited to, static, fatigue, and/or damage-tolerance analyses.[91]

The Safety Board further notes that the accident airplane was not subject to the supplemental damage-tolerance-based inspections and procedures required by

[90] Although fatigue requirements were in place at the time, applicants could negotiate the certification basis with the FAA.

[91] The current version of 14 CFR 25.571 was revised when damage-tolerance regulations were enacted in December 1978; the section's name changed to "Damage-Tolerance and Fatigue Evaluation of Structure." The regulation requires, in part, that an applicant must perform a damage-tolerance evaluation to include a determination of the probable locations and modes of damage due to fatigue, corrosion, or accidental damage; repeated load and static analyses supported by test evidence and (if available) service experience; and special consideration for widespread fatigue damage. The regulation also states that an applicant must demonstrate with sufficient full-scale fatigue test evidence that widespread fatigue damage will not occur within the design service goal of the airplane.

14 CFR 121.370a, "Supplemental Inspections," because of FAA exemptions.[92] As a result, Chalk's Ocean Airways was not required to account for the adverse effects that repairs, alterations, and modifications might have on fatigue cracking and the inspection of the airplane structure.

Because of its concerns about the FAA exemptions to 14 CFR 121.370a, on July 24, 2006, the Safety Board issued Safety Recommendation A-06-52 to recommend that the FAA require records reviews, aging airplane inspections, and supplemental inspections for all airplanes operated under Part 121.[93] The Board notes that the actions proposed by the safety recommendation would identify potential failures of structures in airplanes, like the G-73T, that are not currently subject to 14 CFR 121.370a. In its November 20, 2006, response to this recommendation, the FAA stated that it would not include, in the final rule requiring damage-tolerance-based supplemental inspections, airplanes that were type-certificated before 1958 and had a maximum passenger seating capacity of fewer than 30 seats because it would be cost prohibitive to do so. The Board strongly encourages the FAA to reconsider its position and take expeditious action on Safety Recommendation A-06-52.

[92] According to the February 2005 final rule, 14 CFR 121.370a applies only to transport-category, turbine-powered airplanes that were type-certificated after January 1, 1958, and that had a maximum passenger seating capacity of 30 or more seats or a maximum payload of 7,500 pounds.

[93] In addition to all airplanes operated under Part 121, the safety recommendation included all U.S.-registered airplanes operated under Part 129 and all airplanes used in scheduled operations under Part 135. This would include those airplanes operated under Part 135 that carry nine or fewer passengers and those that are operated in scheduled cargo service.

3. Conclusions

3.1 Findings

1. The captain and the first officer were properly certificated and qualified under Federal regulations. No evidence indicated any medical or behavioral conditions that might have adversely affected their performance during the accident flight. There was no evidence of flight crew fatigue.

2. The accident airplane was certificated and equipped in accordance with Federal regulations. The recovered components showed no evidence of any system or powerplant failures but showed evidence of multiple failures of wing structural components.

3. The fire damage to the fuselage and empennage was a result of the failure of the right wing and the subsequent breach in the wing fuel tank.

4. The accident was not survivable. The emergency response was timely.

5. There was no evidence from the performance or appearance of the airplane that would have provided warning to the flight crew of the right wing's imminent failure, and there was nothing that the crew could have done to regain control of the airplane after the in-flight separation of the right wing.

6. The right wing separated from the accident airplane at wing station 34 because of preexisting fatigue fractures and cracks in the rear Z-stringer, lower skin, and rear spar lower spar cap, and this multiple-element fatigue damage reduced the residual strength capability of the wing structure and caused the fatigue failure of the wing during normal flight operations.

7. The repetitive fuel leaks near the area where the accident airplane's right wing separated from the fuselage were indicators of structural damage inside the right wing.

8. Chalk's Ocean Airways most likely performed the doubler repair to the accident airplane's lower skin at right wing station 34, and this repair should have been reflected in the company's maintenance records.

9. The doubler repair to the accident airplane's lower wing skin at right wing station 34 was ineffective because the doublers did not restore the load-carrying capability of the skin in the area of the fuel sump drain and the repair did not properly address the underlying cause of the skin cracking, which was the cracked or fractured rear Z-stringer.

10. The establishment of repair thresholds in all maintenance programs would help ensure that repeated occurrences of a specific discrepancy are sufficiently evaluated.

11. On the basis of the repetitive nature of the fuel leaks on the accident airplane and the structural damage that was found during the fuel leak inspection of another company airplane that led to the August 2005 replacement of that airplane's lower right wing skin and stringers, Chalk's Ocean Airways should have performed a comprehensive inspection of and maintenance on the wing structures of the airplanes in its fleet.

12. The failure of Chalk's Ocean Airways to identify and properly repair fatigue cracks in the accident airplane's wing structure and the numerous maintenance-related problems found on the accident airplane and another company airplane demonstrate that the company's maintenance program and practices were deficient, and these deficiencies were causal to the accident.

13. The Chalk's Ocean Airways maintenance program plan was inadequate to maintain the structural integrity of its aircraft fleet.

14. The Federal Aviation Administration's (FAA) procedures for maintenance program oversight, when applied to commercial operators of aircraft with limited manufacturer or engineering support, such as Chalk's Ocean Airways, are insufficient to ensure the adequacy of such programs' structural airworthiness plans and, thus, the safety of such aircraft operations, and the FAA's failure to identify the inadequacy of the Chalk's Ocean Airways maintenance program was causal to the accident.

15. Updating Federal Aviation Administration (FAA) Order 8300.10, *Airworthiness Inspector's Handbook*, with the latest Continuing Analysis and Surveillance System (CASS) guidance and an explanation of this guidance would help FAA aviation safety inspectors ensure that CASS programs are being effectively implemented at 14 *Code of Federal Regulations* Part 121 air carriers.

16. The Federal Aviation Administration received sufficient cues from a number of sources to alert it to potential safety deficiencies at Chalk's Ocean Airways, and these cues should have prompted heightened vigilance and additional surveillance of the operator.

17. The Federal Aviation Administration missed an opportunity to recertify the Grumman Mallard (G-73T) airplane with a new type certificate that would likely have included a fatigue analysis of the airplane. Such a fatigue analysis likely would have included a determination of a safe operating life for the wing structure that would have been used as the basis for inspection and retirement requirements that could have prevented the accident.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the in-flight failure and separation of the right wing during normal flight, which resulted from (1) the failure of the Chalk's Ocean Airways maintenance program to identify and properly repair fatigue cracks in the right wing and (2) the failure of the Federal Aviation Administration to detect and correct deficiencies in the company's maintenance program.

4. Recommendations

4.1 New Recommendations

As a result of the investigation of this accident, the National Transportation Safety Board makes the following recommendations to the Federal Aviation Administration:

> Verify that the maintenance programs of commercial aircraft operators include stringent criteria to address recurring or systemic discrepancies to include, if necessary, further analysis of the discrepancies through a comprehensive engineering evaluation. (A-07-39)

> Identify the systemic deficiencies in the maintenance program oversight procedures that led to this accident and modify those procedures to ensure that the maintenance program plans for commercial operators are adequate to ensure the continued airworthiness, both structural and otherwise, of the operator's fleet. (A-07-40)

4.2 Previously Issued Recommendation Reiterated and Classified in This Report

The Safety Board reiterates the following recommendation to the Federal Aviation Administration:

> Include the Continuing Analysis and Surveillance System guidance from Advisory Circular (AC) 120-16D, "Continuing Airworthiness Maintenance Programs," and AC 120-79, "Developing and Implementing a Continuing Analysis [and] Surveillance System," in Federal Aviation Administration Order 8300.10, *Airworthiness Inspector's Handbook*. (A-04-14)

Further, Safety Recommendation A-04-14 (previously classified "Open—Acceptable Response") is classified "Open—Unacceptable Response" in section 2.4.2 of this report.

4.3 Previously Issued Recommendation Resulting From This Accident Investigation

As a result of the investigation into this accident, the Safety Board issued the following recommendation to the FAA on July 24, 2006:

> Require records reviews, aging airplane inspections, and supplemental inspections for all airplanes operated under 14 *Code of Federal Regulations* (CFR) Part 121, all U.S.-registered airplanes operated under 14 CFR Part 129, and all airplanes used in scheduled operations under 14 CFR Part 135. This would include those airplanes operated under 14 CFR Part 135 that carry nine or fewer passengers and those that are operated in scheduled cargo service. (A-06-52)

For more information about this recommendation, see sections 1.18.2.1 and 2.5 in this report.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

MARK V. ROSENKER
Chairman

ROBERT L. SUMWALT
Vice Chairman

DEBORAH A. P. HERSMAN
Member

KATHRYN O. HIGGINS
Member

STEVEN R. CHEALANDER
Member

Adopted: May 30, 2007

Member Hersman filed the following concurring statement on June 6, 2007, joined by Vice Chairman Sumwalt and Member Higgins. Member Higgins filed the following statement on June 6, 2007, and was joined by Member Hersman.

Board Member Statements

Member Hersman, Concurring:

While this accident was primarily the structural failure of a very old airplane, the facts surrounding the accident and the operation of Chalk's shine a light on an important underlying consideration for any accident involving a financially strapped operator, that of economic fitness. In the past several years, we have watched several major airlines slide into bankruptcy protection, while others closed their hangar doors permanently. It has been clear that those airlines which continue to operate under bankruptcy protection are carefully scrutinized by FAA to ensure that their financial straits do not lead to a dangerous reduction of operational and maintenance safety measures. My concern about Chalk's and other small, financially challenged small operators is two-fold: 1) that their operational and maintenance practices receive a heightened degree of scrutiny by FAA just like the large carriers, and 2) that the added scrutiny begins during that delicate time *before* a company declares bankruptcy, when its managers may begin taking dangerous risks in a last-ditch effort to stay out of bankruptcy.

In the case of Chalk's, the signs of serious financial difficulties were noted by the U.S. Department of Transportation (DOT) more than 18 months before the accident. In 2004, DOT initiated a fitness review of Chalk's for the first time since the airline was reorganized under new management in 1999. DOT contacted Chalk's in a letter dated April 14, 2004,[1] to acquire additional information about the financial state of the company. The letter raised concerns about Chalk's financial position as well as the significant sub-servicing arrangements with various carriers when Chalk's airplanes were unavailable due to scheduled or unscheduled maintenance. DOT sent a courtesy copy of the letter to FAA's POI assigned to Chalk's.

In 1988, the Safety Board recommended that FAA issue guidance to POIs to assist them in recognizing when a carrier was experiencing financial distress, meriting increased surveillance.[2] In a positive response to the Safety Board's recommendation, FAA issued guidance to its inspectors about reviewing the state of an airline that is in financial distress.[3] The guidance is clear and comprehensive. It specifies many indicators that a principle inspector should look for, for example:

- *Changes in support staff positions such as quality control, analysis, training or middle management* – The accident captain was made Director of Safety in August 2005; the Chief Pilot was named July, 2005; the general manager assumed that role in February, 2005 and was also Director of Operations;

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[1] In addition to the April 14, 2004 letter from the Chief of DOT's Air Carrier Fitness Division to Chalk's General Manager (cc'd to the FAA POI for Chalk's), there was also a follow-up letter to the same parties on January 5, 2005 stating similar concerns. DOT was also in communication with FAA's POI via telephone and e-mail.

[2] A-88-155, AvAir Inc., Flight 3378, Cary, North Carolina, February 19, 1988.

[3] Order 8300.10 CHG 23, *Airworthiness Inspector's Handbook*, Federal Aviation Administration.

- *Shifts in contractors or contractual arrangements* – Chalk's entered into multiple sub-service agreements during 2002, 2003, and 2004, and 284 flights were sub-serviced in an 18-month period;

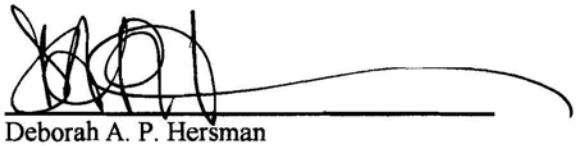
- *Noticeable turnover of personnel; labor unrest* – Three of six captains resigned approximately one year prior to the accident;

- *Non-payment of debts* – There were records of unpaid debts, including payments to the U.S. Department of Agriculture for international user fees;

- *A showing by CASS that there is a rising trend in performance, inspection and maintenance deficiencies* – Maintenance issues relevant to the accident aircraft (including repeated reports of leaking fuel in the wings) were the topic of CASS meetings.

If this guidance had been utilized in the case of Chalk's once the FAA received DOT's correspondence outlining its concerns, perhaps the poor maintenance practices uncovered by this accident investigation could have been documented before the accident occurred. Unfortunately, and for no reason our investigators could discern, the guidance was not applied to Chalk's and the operator did not receive heightened safety scrutiny, despite significant concerns stated by DOT about the operator's financial condition.

It is not clear from this investigation whether this lack of action was the lapse of only one or two people in FAA, or whether the letter from DOT was not considered by FAA to be sufficient warning to trigger heightened safety scrutiny of the carrier. Our discussion at the May 30 board meeting pointed out that there is a general lack of understanding about how and when FAA invokes the use of its thorough and helpful guidance. My concern is that there may be other small, financially challenged carriers that continue to fly under FAA's radar possibly to the detriment of flying public's safety. For this reason, I am very pleased that the Safety Board staff agreed to conduct a study about the economic fitness component of airline safety to learn when it becomes a significant factor for FAA in its effort to ensure the safety integrity of financially struggling airlines. I look forward to reviewing that report next January.



Deborah A. P. Hersman
June 6, 2007

Member Kathryn O'Leary Higgins, Concurring in part:

I concur with nearly all of this report documenting the tragic consequences of the failure to fully detect and repair fatigue cracks that led to the inflight failure and separation of the right wing of the aircraft, killing 18 passengers and 2 flightcrew members. The staff has done a fine job determining what happened in this avoidable accident. I wish we had gone further in our investigation to understand why this accident happened.

Chalk's Ocean Airways was a small Part 121 operation, without the safety programs and systems, safety culture, and safety oversight that are part of larger Part 121 operations. The lack of these important elements enabled an environment where the mystique of the "oldest operating airline in the country" may have overshadowed the reality of an inadequate maintenance program to protect the structural integrity of its aircraft fleet. Even a Chalk's captain, who wrote a 7-page resignation letter documenting the continued and repetitive maintenance discrepancies, was enamored of his opportunity to be a part of this iconic airline and its iconic aircraft.

There were any number of warning signs that should have been seen as cause for concern both by Chalk's management and by the FAA – fuel leaks and other recurring problems with the aircraft; cutbacks in maintenance staff; maintenance concerns raised by pilots with management; resignation of pilots because of their concerns about inadequate maintenance; financial information indicating that Chalk's was losing sufficient money to adversely affect their continued economic viability. Why didn't anyone with oversight responsibility connect all these facts? Why didn't anyone look more carefully at this operation? Why didn't anyone act before this accident? What can be done to assure that another accident clearly waiting to happen is prevented?

I am particularly troubled that the pilots – who identified a number of serious problems with the Chalk's operation – did not share their concerns with the FAA after Chalk's management failed to fully address those concerns. It is clear that there are avenues available to the public and airline personnel to raise concerns about safety: the FAA's safety hotline, the FAA's whistleblower program, the DOT Inspector General hotline. Why weren't they used? Why didn't we ask that question as part of our investigation?

As our investigators have said in this investigation, the "airplane was talking" – and it was talking not only to the airline's management, airline's maintenance personnel and the FAA inspectors, but it also was talking to the pilots. While the pilots may not have been maintenance experts, they were certainly familiar with the machines that they flew day in and day out, and they knew there were problems. We will never know why

the numerous avenues available to them to report their serious concerns were not used. And nothing we can do or say will change the outcome of this accident. But we can learn from this accident, and take action to try to prevent something similar from happening again.

Our reports are widely read. Because of that, I believe we have an obligation to help those interested readers understand how to avoid a similar accident in the future. With the privilege of holding certificates from DOT to transport passengers in our national airspace system comes a responsibility to help ensure the highest levels of safety. Reminding employees that they can and should report problems that threaten safe operations and that are not otherwise resolved would seem to be a small but important step in maintaining the excellent aviation safety record we enjoy.

As I have noted in other accident investigations, I am very concerned that Chalk's not only continues to operate through other air carriers but also is offering "new" air services through other air carriers. Chalk's has been criticized by DOT for "sub-servicing" passenger operations. Yet, it seems as if Chalk's now continues to do the same thing on its website – booking paying passengers on other not well-disclosed airlines.

It is ironic that Chalk's part 121 certificate has been suspended but they still seem to represent themselves as an airline – they are booking passengers, accepting money, and continuing to hold themselves out as the oldest operating airline in the country. There is nothing on their website to suggest to the traveling public that the passengers are flying on anything other than Chalk's Ocean Airways. Is this advertising false and misleading? How is the public to make an informed decision about the airline? Who is providing safety oversight? And, finally, who is held accountable? My concern here is that nothing has really changed. The relationship between the regulators and the regulated seems even more attenuated. If that's true, this important report has not greatly changed the safety equation.

Kathryn O'L Higgins 6/6/07

KATHRYN O'LEARY HIGGINS Date

5. Appendixes

Appendix A
Investigation and Hearing

Investigation

The National Transportation Safety Board was initially notified of this accident during the afternoon of December 19, 2005. A go-team was assembled, which departed for Miami about 1900 and arrived on scene about 2200. Accompanying the team to Miami was Acting Chairman Mark Rosenker.[1]

The following investigative teams were formed: Aircraft Operations, Human Performance, Aircraft Structures, Aircraft Systems, Powerplants, and Maintenance Records. While the investigative team was in Miami, a specialist was assigned to transcribe the cockpit voice recorder at the Safety Board's laboratory in Washington, D.C. Also, specialists in the areas of survival factors and witnesses, video/imaging, and materials assisted in the investigation.

Parties to the investigation were the Federal Aviation Administration, Chalk's Ocean Airways, Frakes Aviation, Grumman Mallard Owners Association, and Hartzell Propellers. In accordance with the provisions of Annex 13, paragraph 5.18, to the Convention on International Civil Aviation, the Transportation Safety Board of Canada participated in the investigation as the representative of the State of Design and Manufacture of the powerplants. Accordingly, Pratt & Whitney Canada participated in the investigation as a technical advisor to the Transportation Safety Board of Canada. In accordance with the provisions of Annex 13, paragraph 5.27, to the Convention on International Civil Aviation, the Bahamas Ministry of Transport participated in the investigation as the representative of the State with special interest in the accident by virtue of fatalities to its citizens.

Public Hearing

No public hearing was held for this accident.

[1] Mark Rosenker served as acting chairman from March 2005 until August 11, 2006, when he was sworn in as the 11th chairman of the National Transportation Safety Board.