# Loss of Control and Crash
# Marlin Air
# Cessna Citation 550, N550BP
# Milwaukee, Wisconsin
# June 4, 2007


## Accident Report

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**National Transportation Safety Board**

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National Transportation Safety Board

490 L'Enfant Plaza, S.W.
Washington, D.C. 20594

**National Transportation Safety Board. 2009.** ***Loss of Control and Crash, Marlin Air Cessna Citation 550, N550BP, Milwaukee, Wisconsin, June 4, 2007.*** **Aircraft Accident Report NTSB/AAR-09/06. Washington, DC.**

**Abstract:** This report describes the circumstances of an accident involving a Cessna Citation 550, which impacted Lake Michigan shortly after departure. The safety issues discussed include pilot actions and coordination, the need for image recording equipment on airplanes not equipped with flight data recorders, autopilot panel design, control yoke wiring installations, identification of circuit breakers for use in emergencies, aural and visual alerts to pitch trim-in-motion, aileron trim power and sensitivity, human factors in airplane design, Federal Aviation Administration (FAA) appointment of check airmen, the scope of Regional Aviation Safety Inspection Program inspections, avenues for expressing safety concerns to Federal authorities, and the safety ramifications of operators' financial health. Safety recommendations to the FAA and the American Hospital Association are included.

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# Abbreviations

| | |
|---|---|
| AAMS | Association of Aeromedical Services |
| AC | advisory circular |
| AD | airworthiness directive |
| AFM | airplane flight manual |
| agl | above ground level |
| AHA | American Hospital Association |
| ALJ | administrative law judge |
| ATC | air traffic control |
| ATCT | air traffic control tower |
| ATP | airline transport pilot |
| CAMTS | Commission on Accreditation of Medical Transport Services |
| CFM | company flight manual |
| CFR | *Code of Federal Regulations* |
| cg | center of gravity |

| | |
|---|---|
| CRM | crew resource management |
| CVR | cockpit voice recorder |
| EDT | eastern daylight time |
| EMS | emergency medical services |
| EUROCAE | European Organization for Civil Aviation Electronics |
| FAA | Federal Aviation Administration |
| FBO | fixed-base operator |
| FDR | flight data recorder |
| FSDO | flight standards district office |
| FSI | Flight Safety International |
| IFR | instrument flight rules |
| KIAS | knots indicated airspeed |
| MKE | General Mitchell International Airport |
| msl | mean sea level |
| MVFR | marginal visual flight rules |
| NASIP | National Aviation Safety Inspection Program |

| | |
|---|---|
| NPRM | notice of proposed rulemaking |
| NTSB | National Transportation Safety Board |
| OIG | Office of Inspector General |
| OSIP | Office Safety Inspection Program |
| POI | principal operations inspector |
| PRIA | Pilot Records Improvement Act |
| RASIP | Regional Aviation Safety Inspection Program |
| SAIB | special airworthiness information bulletin |
| SB | service bulletin |
| TSO | technical standard order |
| UM | University of Michigan |
| YIP | Willow Run Airport |

# Executive Summary

On June 4, 2007, about 1600 central daylight time, a Cessna Citation 550, N550BP, impacted Lake Michigan shortly after departure from General Mitchell International Airport, Milwaukee, Wisconsin (MKE). The two pilots and four passengers were killed, and the airplane was destroyed. The airplane was being operated by Marlin Air under the provisions of 14 *Code of Federal Regulations* Part 135 and departed MKE about 1557 with an intended destination of Willow Run Airport, near Ypsilanti, Michigan. At the time of the accident flight, marginal visual meteorological conditions prevailed at the surface, and instrument meteorological conditions prevailed aloft; the flight operated on an instrument flight rules flight plan.

The National Transportation Safety Board determined that the probable cause of this accident was the pilots' mismanagement of an abnormal flight control situation through improper actions, including failing to control airspeed and to prioritize control of the airplane, and lack of crew coordination. Contributing to the accident were Marlin Air's operational safety deficiencies, including the inadequate checkrides administered by Marlin Air's chief pilot/check airman, and the Federal Aviation Administration's (FAA) failure to detect and correct those deficiencies, which placed a pilot who inadequately emphasized safety in the position of company chief pilot and designated check airman and placed an ill-prepared pilot in the first officer's seat.

The safety issues discussed in this report include pilot actions and coordination, the need for image recording equipment on airplanes not equipped with flight data recorders, autopilot panel design, control yoke wiring installations, identification of circuit breakers for use in emergencies, aural and visual alerts to pitch trim-in-motion, aileron trim power and sensitivity, human factors in airplane design, FAA appointment of check airmen, the scope of Regional Aviation Safety Inspection Program inspections, avenues for expressing safety concerns to federal authorities, and the safety ramifications of an operators' financial health.

# 1. Factual Information

## 1.1 History of the Flight

On June 4, 2007, about 1600 central daylight time,[1] a Cessna Citation 550, N550BP, impacted Lake Michigan shortly after departure from General Mitchell International Airport, Milwaukee, Wisconsin (MKE). The two pilots and four passengers were killed, and the airplane was destroyed. The airplane was being operated by Marlin Air under the provisions of 14 *Code of Federal Regulations* (CFR) Part 135, and departed MKE about 1557 with an intended destination of Willow Run Airport (YIP), near Ypsilanti, Michigan. At the time of the accident flight, marginal visual meteorological conditions prevailed at the surface and instrument meteorological conditions prevailed aloft; the flight operated on an instrument flight rules (IFR) flight plan.[2]

On the day of the accident, the pilots reported for duty at YIP about 1000 eastern daylight time (EDT) for an 1100 EDT departure for MKE. The accident flight was a medical/air ambulance flight under contract to the University of Michigan (UM) Health System and was transporting a medical transplant team to MKE so they could harvest an organ and return to YIP for an organ transplant at UM Medical Center. According to the cockpit voice recorder (CVR),[3] as the airplane approached MKE, the first officer stated that he would request weather information from MKE air traffic control tower (ATCT) personnel, and the captain replied, “no, no, because if they give us…below minimums then we’re…really screwed.”[4] When the pilots were instructed to contact MKE ATCT, the captain reminded the first officer not to ask about the weather.

The pilots checked in at the MKE fixed-base operator (FBO) about 1153. According to FBO personnel, the pilots helped the medical transplant team to a waiting van and then ate lunch and awaited the team’s return. A pilot who had interviewed for a job with Marlin Air encountered the accident pilots at the MKE FBO while they waited for the medical team to return. He stated that the pilots appeared relaxed and in good spirits; they talked about future business prospects for Marlin Air, and the accident captain indicated that he hoped to acquire more airplanes for the company. The pilot stated that the captain received a telephone call advising him (in his capacity as Marlin Air’s chief pilot) that the other Marlin Air/UM charter flight scheduled for that day had

[1] Unless otherwise indicated, all times are central daylight time, based on a 24-hour clock.

[2] The public docket for this accident (National Transportation Safety Board identification number CHI07MA160) is available online at <http://dmssvr/dms/public/search>.

[3] The CVR recorded the last 30 minutes and 57 seconds of cockpit communications before the accident. See appendix B for a transcript of the CVR recording.

[4] Federal regulations do not permit a flight operating under 14 CFR Part 135 to begin an instrument approach unless the latest weather report indicates conditions at or above the authorized IFR minimums for that airport. Therefore, the pilots would not have been able to initiate the approach to MKE if they had received a weather report indicating conditions that were below instrument landing requirements. Thus, they would have had to deviate to an alternate airport. Despite the captain’s concerns, surface weather observations showed that conditions at MKE were above the authorized minimums at the time of the flight’s arrival.

been canceled because of mechanical problems and a ferry permit would be needed to return the airplane for maintenance. (For additional information, see section 1.17.2.)

The medical team returned to MKE with the transplant organ about 1530, and the pilots prepared for departure. About 1546, the pilots received an IFR clearance for the flight from MKE to YIP. The pilots taxied to the departure runway (runway 1L). According to the CVR transcript, the pilots discussed some tasks that were on preflight checklists but did not perform a formal challenge-response checklist procedure as they were leaving MKE.[5] About 1556:36, the pilots received clearance for takeoff, with instructions to climb to 2,000 feet mean sea level (msl) and then turn right to a heading of 050°. The National Transportation Safety Board's (NTSB) review of CVR evidence showed that, about 1557:34, the airplane accelerated on the runway and rotated. About 4 seconds later, the captain stated, "positive rate gear up," and the first officer confirmed, "yup."

About 1557:40, the CVR recorded the captain stating, "lights off, yaw damper on." About 1557:51, while the first officer radioed MKE controllers to advise them that the pilots were starting the airplane's turn from the runway heading to the air traffic control- (ATC)-assigned heading of 050°, the captain asked, "why am I fighting the controls here?" At 1557:57, the captain again stated, "I'm fighting the controls…" as the CVR recorded the first officer stating, "[unintelligible word] I had it on." Then, the captain confirmed with the first officer that the landing gear was up and instructed him to retract the flaps.

About 1558:07, the captain made his third mention of an unspecified control problem, stating, "what the [expletive]'s going on? I'm fighting the controls." About 1558:13, the first officer asked, "how's your trim set? Is that the way you want it?" About 1558:21, the captain began to describe the control problem more specifically, stating, "I'm fighting the controls. It wants to turn hard left," and the first officer again asked, "how's your trim down here?" The captain's response, which began, "trim has nothing…" was interrupted when the first officer erroneously responded to an ATC transmission intended for another airplane.

About 1558:45, the CVR recorded the captain stating, "… something is wrong with the trim…the rudder trim…" The captain questioned the altitude clearance, the first officer stated they were cleared to 3,000 feet msl, and the captain stated, "all right, something is wrong with our rudders. And I don't know what." At 1559:04, the first officer asked the captain what he wanted to do; then, at 1559:07, the first officer asked, "how's that, any better?" The CVR recorded the captain stating, "huh, no, we got a trim problem…[sound of grunt[6]]…tell 'em we got to come back and land." At 1559:19, the CVR recorded the captain saying, "she's rolling on me. Help me, help me," and the first officer responded, "I am." At 1559:24, the captain asked the first officer to pull the autopilot circuit breakers, and the first officer responded, "where is it?"

About 1559:29, the CVR recorded the captain stating, "tell 'em we got a control problem," and at 1559:30, the first officer advised the MKE departure controllers that they had

[5] During postaccident interviews, the owner of Marlin Air described the accident captain as being "quick with the checklist," and a company pilot described the captain as "working on getting unnecessary callouts/chatter removed from some of the checklists."

[6] The NTSB's investigation showed that when this sound was recorded, the airplane had accelerated to about 245 knots.

"a control problem, we've got to come back in." The first officer used an incorrect airplane identification number on this transmission, and the captain promptly corrected him. At 1559:44, the first officer transmitted, "Milwaukee, we got…a runaway trim, we got an emergency."

According to the CVR transcript, about 1559:50, the first officer asked, "what circuit breakers?" About 1559:57, the CVR recorded the captain telling the first officer, "answer her…" in response to an ATC query, and "keep turning." The captain then advised the MKE departure controller, "zero bravo pap[a] declaring an emergency, yes." About 1600:12, the first officer repeated that they were "coming back to Milwaukee," and the captain added, "landing any runway at…Milwaukee. Guide us in please, zero bravo pap[a]."

At 1600:26, the captain transmitted to MKE, "I don't know what's wrong," then, at 1600:30, the captain stated to the first officer, "I don't know what's wrong…I see the airport. Keep [unintelligible words]." At 1600:36, the CVR recorded the captain stating, "you hold it, I'm gonna try to pull circuit breakers…" Beginning at 1600:40, the captain stated, "…we're not…holding it." The first officer stated, "I'm pulling," and, at 1600:43, the CVR recorded the captain stating, "awww [expletive]…" The CVR recording ended at 1600:45.

The fragmented airplane wreckage was recovered from Lake Michigan during multiple dives. Physical evidence indicated that the airplane impacted Lake Michigan at a speed of about 243 knots, in a steep (about 42°) nose-down, left-wing-low attitude. Figure 1 shows the accident airplane's ground track, based on radar data, from liftoff to impact, with selected CVR quotes shown.

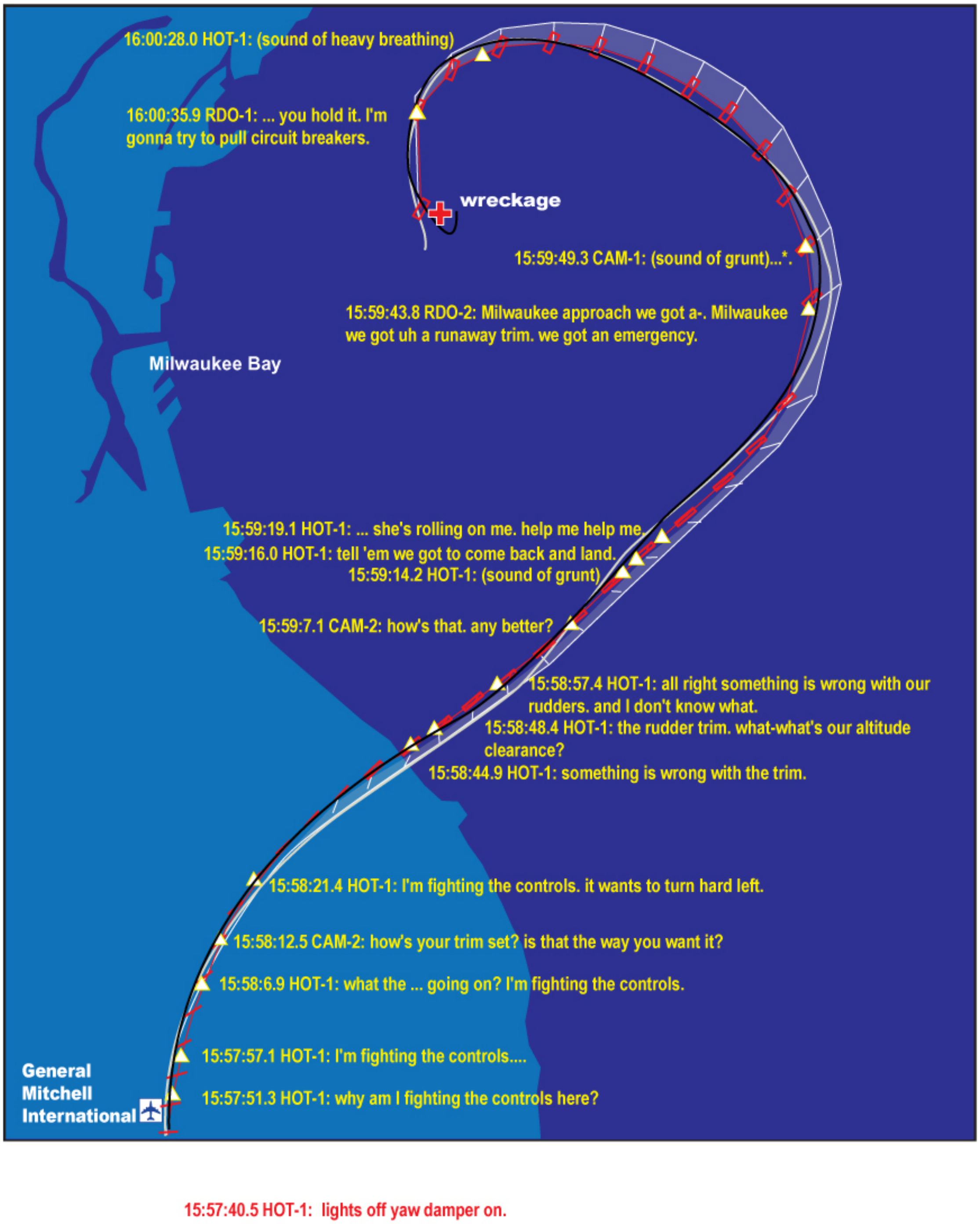


**Figure 1.** The accident airplane's ground track from liftoff to impact, based on radar data. Selected CVR excerpts are shown. (Figure not to scale.)

## 1.2 Injuries to Persons

**Table 1.** Injury chart.

| Injuries | Flight Crew | Cabin Crew | Passengers | Other | Total |
|---|---|---|---|---|---|
| Fatal | 2 | 0 | 4 | 0 | 6 |
| Serious | 0 | 0 | 0 | 0 | 0 |
| Minor | 0 | 0 | 0 | 0 | 0 |
| None | 0 | 0 | 0 | 0 | 0 |
| Total | 2 | 0 | 4 | 0 | 6 |

## 1.3 Damage to Airplane

The airplane was destroyed when it impacted Lake Michigan.

## 1.4 Other Damage

No other damage was reported.

## 1.5 Personnel Information

### 1.5.1 The Captain

The captain, age 59, applied for Marlin Air's chief pilot position[7] on February 7, 2005, and was hired by Marlin Air as a line pilot on February 21, 2005. Marlin Air management subsequently designated him the company's chief pilot and then, effective August 15, 2005, he was appointed by the Federal Aviation Administration (FAA) as Marlin Air's check airman in Cessna Citation 500/550 airplanes.[8] He held a multiengine airline transport pilot (ATP) certificate with type ratings in the Citation 500, 550, and 650 airplanes and the McDonnell-Douglas DC-9.[9] He completed his most recent 14 CFR Part 135 recurrent training at a commercial flight training facility that provided simulator-based training in November 2006, and he completed his most recent Part 135 proficiency and line checks in a Marlin Air Citation

[7] According to documents describing Marlin Air's organization, the chief pilot's duties included supervising company line pilots; establishing and maintaining ground and flight training programs; assisting and advising the company's director of operations in managing flight operations; and maintaining company manuals.

[8] A check airman is authorized to conduct proficiency or competency checks, line checks, and special qualification checks; to supervise the reestablishment of landing currency; and to supervise the initial operating experience requirements of 14 CFR 121.434 and 135.244. A check airman may conduct flight training in the operator's approved program.

[9] The captain's Citation 650 type rating provided second-in-command privileges only.

on April 24, 2007. The captain held a first-class FAA airman medical certificate, dated March 29, 2007, with the restrictions that he "must wear corrective lenses for distant vision," and "not valid for any class after March 31, 2008."[10]

According to FAA and Marlin Air records,[11] at the time of the accident, the captain had flown about 14,000 total hours, including about 12,000 hours as a professional pilot in a variety of airplanes, including the Learjet, Citation, Mitsubishi MU-2, DC-8 and -9, and Airbus 320. The captain's total flight time included about 300 hours in Citation 500/550 airplanes. Marlin Air records show that the captain had flown about 206, 51, and 31 hours in the 90, 60, and 30 days, respectively, before the accident. Company records showed that the captain was off duty on May 30, May 31, and June 1. On June 2, he was on duty from 0000 to 0330, during which time he flew 1.5 hours. On June 3, he was on duty from 1000 to 1900, during which time he flew about 1.5 hours. As previously stated, the captain reported for duty about 1000 on June 4, in preparation for the flight from YIP to MKE that preceded the accident flight.

A search of FAA records revealed that, on August 13, 1987, the FAA issued an Order of Revocation against the captain's commercial pilot certificate because of the captain's March 27, 1987, conviction for "conspiracy to import methaqualone" into the United States from Canada in violation of federal law.[12] The Order of Revocation was upheld on appeal before an NTSB administrative law judge (ALJ) on February 12, 1991. In September 1992, while appealing the ALJ's decision upholding the revocation order, the captain successfully completed the required tests and was issued an ATP certificate.[13] On July 9, 1993, the NTSB Board Members affirmed the earlier ALJ decision and upheld the FAA's Order of Revocation. The captain's subsequent petition that the NTSB reconsider its decision was denied in NTSB Order EA-4015, dated November 4, 1993; however, in accordance with existing procedures, the pilot was allowed to apply for new pilot certificates after he surrendered the revoked certificates.

FAA records show that the captain surrendered his pilot certificates to the FAA on December 8, 1993. At the time of the captain's conviction, regulations did not dictate permanent certificate revocation under these circumstances.[14] Therefore, after the captain surrendered his pilot certificates to the FAA, new certificates were issued to him after he successfully completed the required practical tests. On December 17, 1993, the captain applied for and was issued a student pilot certificate. On December 19, 1993, the captain was issued private and commercial pilot certificates with instrument and multiengine land ratings after he successfully completed the required practical tests. On May 6, 1994, the captain successfully completed the applicable practical tests and was issued an ATP certificate.

[10] The captain had an authorization for special issuance of a medical certification for his diabetes, controlled on oral medications, that required annual follow-up.

[11] The captain's current pilot logbook was likely on the accident airplane, and it was not found in the wreckage.

[12] The captain was convicted of piloting an airplane containing about 2,100 pounds of methaqualone into the United States from Canada on the night of October 13-14, 1981, and was sentenced to 28 months in prison as a result.

[13] A pilot can obtain additional certificates while a case is under appeal.

[14] Current federal regulations specify a lifetime revocation of pilot privileges for a criminal conviction involving transportation of controlled substances.

Records show that, on June 12, 2001, the captain applied for a Citation 500 type rating, which was initially denied because he "ran off [the] runway" while demonstrating a crosswind takeoff during the simulator checkride. The captain subsequently reapplied for the type rating the same day, successfully demonstrated a crosswind takeoff, and was issued an ATP certificate with a Citation 500 type rating.

Records further indicate that, on June 8, 2004, the captain applied for a DC-9 type rating, which was initially denied because he was unable to successfully complete the weight and balance portion of the practical test oral exam. On June 21, 2004, the captain successfully completed the practical tests and was issued a DC-9 type rating.

Marlin Air management personnel told investigators that when they hired the captain in February 2005, they obtained background information about the captain in accordance with the Pilot Records Improvement Act (PRIA) of 1996, which requires operators to obtain and evaluate safety-related background information regarding prospective pilots. The PRIA information should include airman and medical certification records, closed enforcement actions within the previous 5 years, and all past or current certificate revocations.[15]

FAA records showed that, on March 29, 2006, the captain failed a 14 CFR Part 135 proficiency checkride after he deployed the thrust reversers prematurely during landing, causing the airplane to become airborne again after touchdown. The inspector who conducted the proficiency checkride commented that the captain did not have the knowledge of the airplane's systems needed for a check airman. The inspector also noted that the captain did not demonstrate an acceptable understanding of IFR operations and requirements. The captain subsequently successfully completed a retest on the same day.[16]

Records indicate that, on October 18, 2006, the captain applied for and successfully completed the practical test for a Citation 650 type rating with second-in-command privileges.

During postaccident interviews, several pilots who had flown with the captain indicated that although he was a capable pilot, the captain lacked in-depth airplane systems knowledge and did not always adhere to company procedures or comply with regulations. Several former Marlin Air pilots commented that the captain seemed to focus on business issues rather than on flight operations and safety. One pilot stated that, as Marlin Air's chief pilot, the captain wanted company pilots to stay longer at higher altitudes to save fuel. Another pilot stated that he had flown with the captain once when the captain intentionally took off, and subsequently landed, in an airplane that was loaded beyond allowable takeoff and landing weight limits because he was "tankering" inexpensive fuel.[17] On another occasion, after experiencing a mechanical problem

[15] Review of the documentation provided by the PRIA vendor showed that the information given to Marlin Air accurately reflected the captain's background and certificate revocation. However, Marlin Air personnel stated that they were unaware of the captain's background and certificate revocation.

[16] Federal regulations (14 CFR Part 135.301[b]) do not prohibit a pilot who fails any of the required maneuvers during a Part 135 checkride from practicing and then being retested on the failed maneuver. However, the regulations restrict that pilot from acting as a flight crewmember in Part 135 operations until he or she has satisfactorily completed the checkride.

[17] The term "tankering" refers to the practice of loading the airplane with more fuel than needed for an intended flight by buying from less expensive vendors and then carrying that fuel onboard until it is needed.

(collapsed landing gear strut) on a flight, the captain proposed flying the return leg of the trip with the landing gear extended to avoid contract penalties that would be incurred if another company completed the trip.

In addition, several pilots stated that the captain was actively trying to expand the company and was trying to obtain another airplane for charter operations. (During the investigation, NTSB investigators reviewed a partnership agreement that the first officer proposed to the owner of Marlin Air. The draft agreement proposed that the first officer would purchase 49 percent of Marlin Air stock at a price to be determined and that the captain would receive company stock from the owner and the first officer, such that the captain would have a 25-percent stake in the company at the end of 5 years.)[18]

The NTSB examined records for the three most recent training flights conducted by the captain. These flights included a company pilot training flight on May 4 and proficiency checkrides for the accident first officer and another newly hired pilot on May 23 and June 2, respectively. The training times recorded on all three training records (3.5, 3.1, and 1.5 hours, respectively) differed from the times recorded by the airplanes' hour-recording meters (0.8, 0.6, and 0.3 hours, respectively). Marlin Air and FAA personnel were unable to explain these discrepancies. During postaccident interviews, the newly hired pilot involved in the June 2 training at first stated that he had never flown with the accident captain/chief pilot and then later indicated that he had flown briefly with the accident captain, to perform a "couple of takeoffs and landings." This pilot held a Citation type rating but indicated that he had not flown a Citation in years.

A search of the National Driver Register found no record of driver's license suspension or revocation.

### 1.5.2 The First Officer

The first officer, age 65, was not a full-time professional pilot but, rather, was a businessman who flew commercially part time. Records showed that he had previously worked as a part-time pilot for Marlin Air between December 1998 and August 2002 and was subsequently rehired by Marlin Air during the weeks before the accident. The first officer held a multiengine ATP certificate with type ratings in the Citation 500 and 550, Mitsubishi MU-300, and Raytheon Beechcraft BE-400. He also held a first-class FAA airman medical certificate, dated August 7, 2006, with the restriction that the "[h]older shall wear correcting lenses while exercising the privileges of his airman certificate."

According to FAA and Marlin Air records, the first officer had flown about 9,200 total hours, including about 420 hours in Citation 500/550 airplanes.[19] Company records indicate that

[18] Marlin Air personnel stated that, although the first officer had proposed an investment agreement, the company had not taken any action with regard to that agreement at the time of the accident.

[19] This calculation of the first officer's Citation 500/550 flight time was based on a June 2000 pilot record form for Marlin Air's insurance provider; no updated documentation regarding his flight in the accident make and model was available.

the first officer completed basic indoctrination training related to his rehire with Marlin Air on May 15, 2007, and that the accident captain, acting in his role as FAA-designated check airman, administered the first officer's subsequent flight training and checkride in a Marlin Air Citation on May 23, 2007. (The first officer's most recent simulator-based training was accomplished in May 2006, in a King Air simulator at a commercial flight training facility. His most recent Citation-specific simulator training occurred in November of 2001.) The associated FAA airman checkride documentation provided to the NTSB after the accident showed a checkride flight time of 2.5 hours;[20] however, the airplane records showed that the airplane was actually flown a total of 0.6 hour flight time during the flight training and checkride. The first officer had flown about 1.1 hours since that logged training flight, all on the day of the accident. He had not flown during the 3 days before the day of the accident. He worked at a business not related to aviation on Friday, June 1, then remained near home over the weekend and reportedly arrived for duty well rested on Monday, June 4. He had been on duty about 7 hours when the accident occurred.

FAA records indicated that, in December 2002, the first officer was involved in an accident involving a loss of electrical power on takeoff.[21] The NTSB's investigation of this accident revealed that the first officer inadvertently took off with the electrical generator switches in the "off" position and did not follow approved emergency landing gear extension procedures during the resultant (gear-up) forced landing.[22]

The NTSB conducted postaccident interviews with several pilots who had flown with the first officer during his previous employment with Marlin Air. One of these pilots characterized the first officer as "a nice guy who had no idea how the airplane operated" and added that he would act without thinking. These interviews revealed that the first officer would get overloaded easily and had difficulty flying a stabilized approach without coaching. One interviewed pilot recalled an occurrence in which the first officer was unable to properly tune the airplane's radios. He stated that the first officer did not know which radio he was transmitting on or with which ATC facility he was communicating. Two other pilots who had flown with the first officer during his previous employment with the operator reported that the first officer inadvertently turned off the airplane's avionics while attempting to switch the engine ignition settings from "on" to "norm" in accordance with after-takeoff procedures. (The ignition and avionics power switches were located adjacent to each other on the panel.)

According to two former Marlin Air pilots, when the first officer left the company in August 2002, he was in captain upgrade training and was not performing to the required standards; they had informed Marlin Air's owner that they could not recommend the first officer for the captain checkride. One of these pilots stated that the first officer was subsequently enrolled in upgrade training at Flight Safety International (FSI), and one of the FSI instructors

[20] The checkride documentation showed that the first officer had satisfactorily completed all required tasks, including airwork, such as steep turns, approaches to stalls, emergency procedures, and two instrument approaches (one precision, one nonprecision).

[21] This accident occurred on December 15, 2002, in Jackson, Michigan. Additional information about this accident, NTSB identification number CHI03LA039, can be found on the NTSB's website at <http://www.ntsb.gov/ntsb/query.asp>.

[22] Marlin Air's principal operations inspector (POI) was the FAA inspector who reexamined the first officer after the 2002 accident. The POI subsequently rented one of the helicopters owned by the first officer when the POI wanted to take his son for a helicopter ride.

did not believe that the first officer would successfully complete that program. Subsequently, the first officer was not upgraded to a captain position.

The accident trip was the first officer's first revenue flight since Marlin Air rehired him. CVR evidence indicates that he did not act as the flying pilot on either the outbound or return leg of the trip. The CVR also recorded the first officer being unaware that he had selected an improper standard instrument departure page (about 1547:35), being confused about taxi instructions (1549:30; 1550:03; and 1552:15), responding to an ATC communication for another aircraft (1558:08.3), and misstating the accident airplane's call sign during three radio communications (1546:41; 1547:16; and 1559:38).

A search of the National Driver Register found no record of driver's license suspension or revocation.

## 1.6 Airplane Information

### 1.6.1 General

The accident airplane, serial number 550-246, was manufactured by Cessna in 1981. In April 2003, after numerous ownership changes and modifications to the avionics and structure, the airplane was purchased by Toy Air, Inc. Toy Air made additional avionics and structural modifications[23] and then leased the accident airplane to Marlin Air, Inc. At the time of the accident, the airplane had accumulated about 4,402 total flight hours. The airplane was equipped with two Pratt & Whitney Canada JT-15D-4 turbofan engines, both of which had been operated about 4,000 total hours.

According to postaccident calculations, the airplane's takeoff weight for the accident flight (assuming nominal fuel burn on the flight from YIP to MKE) was about 12,310 pounds and the calculated center of gravity (cg) was 280.5 inches; both parameters were within the required limits.

### 1.6.2 Airplane Systems

#### 1.6.2.1 Flight Control Trim Systems

The accident airplane had separate trim control systems for pitch (elevator), roll (aileron), and yaw (rudder). Each system included a manual hand-wheel in the cockpit and control cables attached to trim tabs at the related flight control surfaces. Each trim system had two cable loops,

[23] The airplane records showed that modifications to the accident airplane included strengthening the landing gear, cutting the fuselage for a wider cabin door (for stretcher accessibility) and the installation of the CVR, an enhanced ground proximity warning system, a global positioning system, a satellite telephone, and emergency locator systems.

one connecting the hand-wheel in the cockpit to the trim control surface and one connecting the trim control surface to its trim position indicator in the cockpit.

#### 1.6.2.1.1 Pitch Trim System Information

The pitch trim system is the only Citation 550 flight control trim system that is equipped with an electric servomotor and offers pilots the option of adjusting the elevator trim setting manually or electrically. The manual pitch trim mechanism is a large, black, vertically oriented wheel located along the left side of the throttle console, next to the captain's right knee. (Figure 2 shows the pitch trim control wheel and the white position indicator as viewed from the captain's seat in a Citation 550 airplane similar to the accident airplane.)

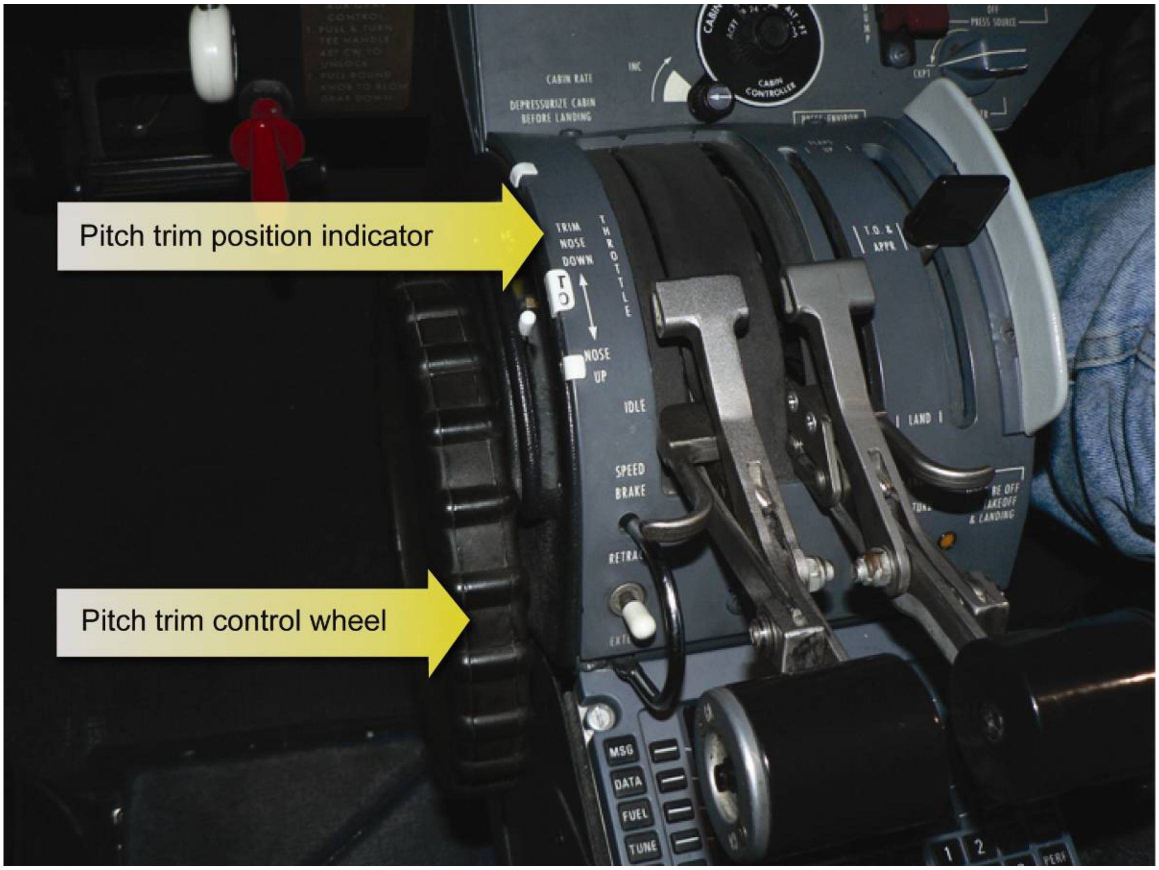


**Figure 2.** Photograph showing the pitch trim control wheel and the white pitch trim position indicator on the left side of the throttle console of a representative Citation, as viewed from the captain's seat.

Either pilot could input electrical pitch trim commands through a toggle switch on his control yoke.[24] After engagement of the autopilot, the autopilot computer could also make pitch

[24] Activation of the electric pitch trim system requires both a switched source of power and a switched path to ground. The single toggle button on each control yoke actuates a set of double-pole double-throw switches to achieve the required power and ground paths.

trim inputs through a relay to relieve the load on the electric autopilot servomotor. Once engaged, the autopilot would disconnect if either pilot used their electric pitch trim switch.[25]

Marlin Air's Citation 550 pilots' abbreviated checklist contained the following item on the taxi checklist: "electric elevator [pitch] trim—check." Marlin Air's Citation 550 airplane flight manual (AFM) further described this taxi checklist item as follows:

> Electric Elevator Trim – CHECK; operate electric elevator trim nose up and push AP/TRIM DISC switch. Verify elevator trim wheel stops rotating. Repeat check for nose down trim.

The CVR recorded no evidence that the pilots performed these system checks during the accident airplane's ground operations.[26] During postaccident investigations in a representative airplane, it was noted that the captain's right knee or his right hand or arm while gripping the right side of the control yoke could obstruct his vision of pitch trim wheel movement. The pitch trim wheel was painted black, and movement of the wheel was largely inconspicuous. Investigators also noted that the electric pitch trim operated quietly and that an aural trim-in-motion warning is not required by the FAA.

The "Abnormal Procedures" section of the Citation 550 AFM included the following instructions for a jammed elevator trim condition during a takeoff or go-around maneuver:

> Reduce power as necessary to maintain 120 [knots indicated airspeed] or less. Do not change flap position…Do not retract landing gear. Land as soon as practical.

#### 1.6.2.1.2 Aileron Trim System Information

During postaccident discussions, Cessna personnel initially indicated that the Citation 550 aileron trim, which has +/- 20° of authority, was designed to relieve control wheel forces in the event of an engine failure. However, Cessna personnel recognized that, because of the Citation's design (low-wing with fuselage-mounted engines) and rudder and aileron effectiveness, this amount of aileron trim authority is not needed to counter an engine failure. Cessna personnel subsequently stated that the airplane's aileron trim capability was originally designed for some other failure condition but that records from the time of the design did not identify that condition.

The Citation 550 aileron trim system is mechanical, without an electric trim or autopilot function. It consists of a trim knob mechanism in the cockpit that is connected by cables to jackscrews located forward of the ailerons in the wings. The cockpit aileron trim knob is a relatively small, knobbed wheel that is vertically oriented on the aft face of the throttle console and is oriented perpendicularly to the airplane's longitudinal axis. Clockwise or counterclockwise movement of the trim knob results in right-wing-low or left-wing-low aileron trim tab adjustments, respectively. The aileron trim indicator slot is 2.5 inches wide and has an

[25] The autopilot could also disconnect if its internal monitoring system detected an uncommanded servomotor engagement.

[26] Between 15:55:15 and 15:57, the CVR recorded the pilots citing some checklist items that were on the airplane's abbreviated checklist; however, the cited items were incomplete and not in the listed order.

associated 0.20-inch wide white position indicator tab. (Figure 3 shows the aileron and rudder trim wheels and indicators on the aft face of a Cessna 550 throttle console.)

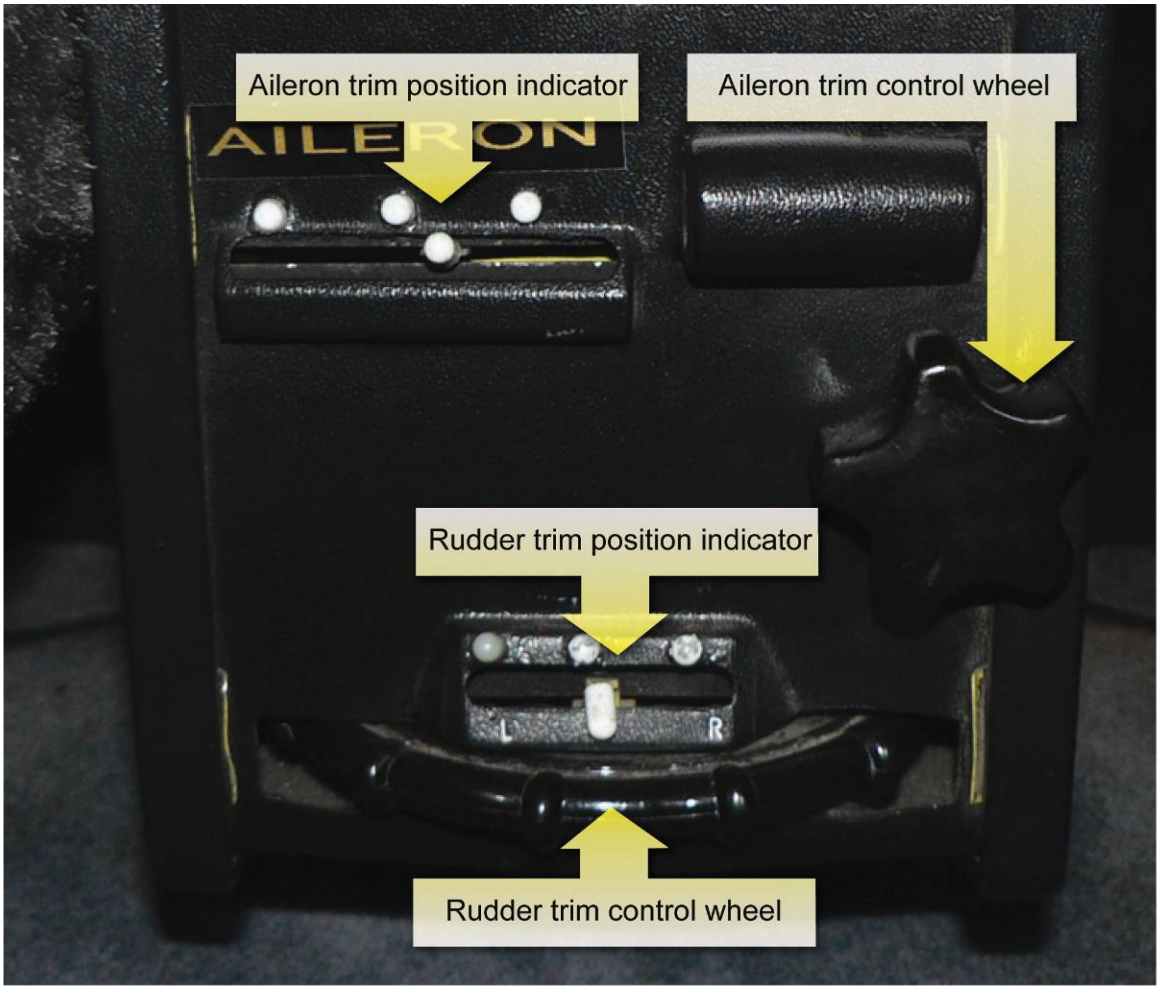


**Figure 3.** Photograph showing the aileron and rudder trim wheels and indicator tabs on the aft face of a representative Cessna 550 throttle console.

Based on postaccident observations in a similar airplane, investigators noted that a centered aileron trim indicator would appear not to be centered when viewed from either pilot's seat, due to parallax.[27] For additional information regarding Cessna Citation aileron trim, see section 1.18.4.

#### 1.6.2.1.3 Rudder Trim System Information

The Citation 550 rudder trim system is mechanical, without an electric trim or autopilot function. It consisted of cables that connect a hand-wheel mechanism in the cockpit to sets of

[27] Parallax is when an object seems to change direction because the observer has changed position and, thus, has a new line of sight.

jackscrews in the vertical stabilizer. The cockpit rudder trim wheel is a horizontal, knobbed wheel that is located in a slot on the aft face of the throttle console, below the aileron trim indicator slot; movement of the hand-wheel adjusts the rudder trim tab accordingly. The rudder trim indication slot is 1.70 inches wide and has an associated 0.20-inch wide, white position indicator tab. (See figure 3.) As they had with the aileron trim indicator, investigators noted that a centered rudder trim indicator in a similar airplane would appear not to be centered when viewed from either pilot's seat, due to parallax.

#### 1.6.2.2 Autopilot System

The accident airplane was equipped with a Honeywell SPZ-500 integrated autopilot system, which used a computer to collect information from various sensors and control inputs and then to position electric-clutched servomotors at each of the primary flight controls (elevator, aileron, and rudder). When engaged, the autopilot computer could also provide input to the electric pitch trim system to relieve a sustained load on the autopilot's pitch servomotor. The rudder servomotor and an internally segregated portion of the autopilot computer also functioned as the yaw damper, providing a limited amount of rudder authority to the rudder servomotor to offset minor yaw motions.

The individual-toothed faces of the servomotor clutch discs (which resemble poker chips) are held apart by springs until the autopilot system is engaged, at which time the servomotor clutch assembly brings the two discs together and the disc teeth mesh. When engaged, the autopilot servomotors can provide limited amounts of force to the primary flight controls, based on inputs from the autopilot computer.[28] If the flight guidance system is not coupled to the autopilot computer when the autopilot is initially activated, the autopilot computer's default settings engage in the "magnetic heading hold/pitch attitude hold" mode. While engaged in this mode, the autopilot could apply up to the motor's limits of force to resist any effort to change the airplane's heading or pitch. However, according to Cessna and Honeywell, the electrical motor selected for the Citation autopilot servos limited the amount of force that each could generate, allowing a pilot to overpower the full force produced by a servomotor with relative ease in the event of a malfunction.[29]

The Citation 550 autopilot control panel is located on the aft surface of the center control console in the cockpit, between the pilots' seats, aft of the seats' forward edges. The two buttons that are used to either fully or partially engage the autopilot system (the autopilot and yaw damper buttons, respectively) are located on the aft portion of this control panel almost directly above the aileron and rudder trim indicators. The autopilot and yaw damper buttons are directly adjacent to each other on the panel and are identical except for their left/right orientation and the labeling text beneath them (AP and YD, respectively). Figure 4 is a photograph of a representative Citation 550 cockpit, with the autopilot control panel and the pilots' control-yoke-

[28] Pilots can provide control inputs to the autopilot directly through knobs on the autopilot control panel or through inputs to the flight guidance system. The autopilot computer can provide control inputs to the autopilot through its interpretation of flight guidance system information and inputs.

[29] Flight test data showed that (at an altitude of 12,000 feet msl and 150 knots) 25, 30, and 70 pounds were required to overpower the aileron, elevator, and rudder servomotors, respectively.

mounted autopilot disconnect buttons indicated. Figure 5 is a closer view of the autopilot control panel at the aft end of the console's upper surface, between the pilots' seats. (This photograph also shows the aileron and rudder trim control wheels and position indicators.)


**Figure 4.** Photograph of a representative Citation 550 cockpit, with the autopilot control panel and the pilots' control-yoke-mounted autopilot disconnect buttons indicated.

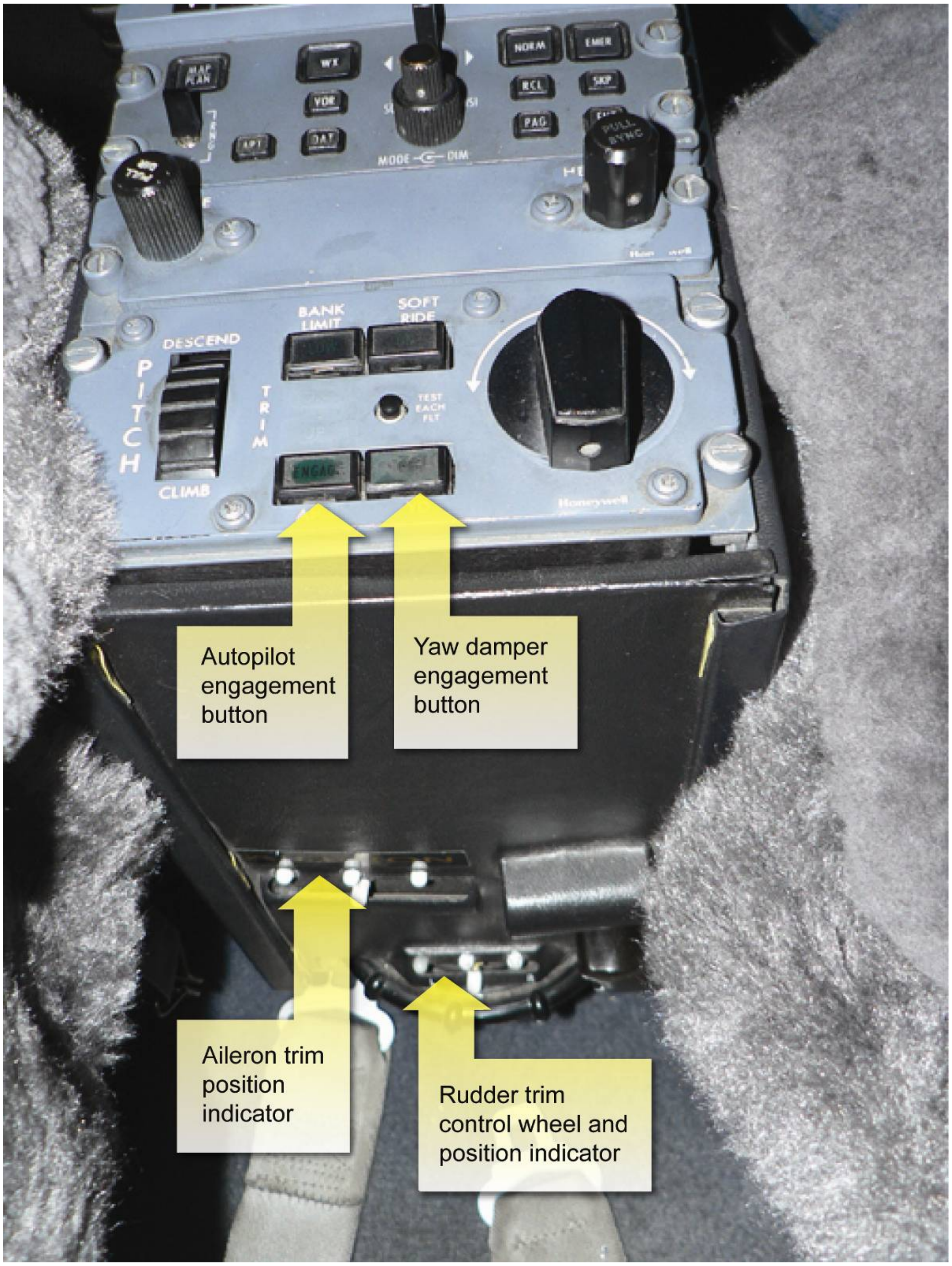


**Figure 5**. Photograph showing a closer view of the autopilot control panel at the aft end of the center console's upper surface, between the pilots' seats.

During the investigation of this accident, several Citation 550 pilots told NTSB investigators of times when they had inadvertently engaged the autopilot instead of the yaw damper. The NTSB previously addressed the issue of inadvertent autopilot activation in its report on the October 25, 2002, accident involving a King Air A100 in Eveleth, Minnesota. The Eveleth investigation showed that the selection of the autopilot instead of the yaw damper after a previous takeoff resulted in an unanticipated control response (abrupt nose-down pitch), which might have had dramatic consequences if the problem had gone unrecognized by the pilots.[30]

The ability to differentiate among controls has safety implications. As described in *Human Factors in Engineering and Design*,[31] "[a]lthough the correct identification of controls is not critical in some circumstances, there are some situations…in which their correct and rapid identification is of major consequence—even life or death…. One characteristic of a good control system is that every control must be detectable and discernable from other controls." FAA airworthiness standards in 14 CFR 25.777, "Cockpit Controls," require that cockpit controls be located and arranged for easy access and operation and to prevent confusion and inadvertent operation. Section 25.781, "Cockpit Control Knob Shape," requires specific control shapes for engine, landing gear, and flap controls to provide for tactile identification of controls as a secondary identification method beyond the visual.

Marlin Air's Citation 550 pilots' abbreviated checklist contained the following item on the taxi checklist: "autopilot—check." Marlin Air's Citation 550 AFM further described this taxi checklist item as follows:

> Autopilot—check; engage autopilot; check pitch and roll command, heading mode, and altitude mode. Push autopilot test button and hold. The AP TORQUE annunciator will illuminate, the AUTOPILOT OFF annunciator will illuminate and the autopilot disconnect horn will sound. If all annunciators do not illuminate, autopilot may not be functional.

The Citation AFM stated that the autopilot and yaw damper were to be off for takeoff and landing.

Marlin Air's Citation 550 checklists also included in the after-takeoff—climb checklist: "yaw damper—as required"[32] and included in the before-landing checklist: "autopilot and yaw damper—off."[33] Marlin Air's Citation 550 checklists reflected the more detailed guidance contained in the Citation AFM and Operating Manual. The CVR recorded no evidence that the pilots performed any of these autopilot or yaw damper system checks during the accident airplane's ground operations.

The Citation AFM outlined procedures for autopilot malfunctions involving an autopilot servomotor failure to high torque and an autopilot hardover;[34] in both cases, the procedures

[30] For additional information, see *Loss of Control and Impact with Terrain, Aviation Charter, Inc., Raytheon (Beechcraft) King Air A100, N41BE, Eveleth, Minnesota. October 25, 2002*, Aviation Accident Report NTSB/AAR-03/03 (Washington, DC: National Transportation Safety Board, 2003).

[31] M.S. Sanders and E.J. McCormick, *Human Factors in Engineering and Design.* (New York: McGraw Hill 1987).

[32] According to the Citation Operating Manual, "with the yaw damper engaged, airplane control is improved and passenger comfort is enhanced."

[33] The Citation Operating Manual stated, in part, "If the yaw damper is not turned off it will attempt to override pilot rudder input during touchdown and roll out. Utilize the APTRIM DISC button on either control [yoke]."

[34] An autopilot hardover is defined as any autopilot failure that results in rapid and sustained displacement of an aircraft aerodynamic control surface.

required the pilots to disconnect the autopilot using the AP/TRIM DISC switch on the control yoke.

According to the Citation 550 operations manuals, the autopilot is normally disengaged by:

- depressing the AP/TRIM DISC switch on either control yoke;
- electrically trimming the elevator trim system; or
- depressing the go-around button on the throttle lever.

The manuals stated that, if the autopilot is disengaged by any of these methods, a warning tone sounds for 1 second and the amber AUTOPILOT OFF indicator light on the instrument panel illuminates for 1 second. The manuals further stated that, if the pilots disengage the autopilot by any method other than the normal disengagement procedures listed above, the warning tone will still sound for 1 second but the amber AUTOPILOT OFF indicator light will illuminate and remain illuminated.[35] In addition, the autopilot servomotor engagement clutches can be temporarily disengaged by holding down the touch control steering button on either pilots' control yoke. This method of disengagement would not result in a warning tone or instrument panel indicator light; however, the autopilot engagement light in the autopilot panel pushbutton would remain lit while the control yoke switch was held down.

The autopilot cannot be disengaged by applying an overriding force to the control yoke; however, as previously noted, the engaged autopilot servomotors require a maximum force of 25, 30, and 70 pounds to overpower the aileron, elevator, and rudder servomotors, respectively, which a pilot would be able to counter easily.

## 1.7 Meteorological Information

On the day of the accident, National Weather Service surface analysis charts showed a deep low-pressure system and associated cold fronts moving across the region, producing an area of IFR to marginal visual flight rules (MVFR) conditions[36] with rain showers and thunderstorms. Surface weather observations from MKE showed MVFR conditions with rain and multiple cloud layers, with a broken ceiling at 3,000 feet above ground level (agl) and an overcast cloud layer at 3,500 feet agl reported at the time of the accident.

[35] Other methods that might be used to disengage the autopilot included pulling the circuit breakers for the autopilot computer, autopilot clutch, or pitch trim; or removing generator power or otherwise interrupting signals from required system components.

[36] IFR conditions are defined as a ceiling or lowest layer of clouds reported as broken or overcast, or the vertical visibility into a surface-based obscuration of less than 1,000 feet above ground level (agl) and/or visibility less than 3 statute miles. MVFR conditions are defined as a ceiling between 1,000 and 3,000 feet agl inclusive and/or visibility 3 to 5 miles inclusive. Based on the accident site weather observations, the pilots would not have had visual reference to the ground when the airplane was above 3,000 feet during the accident flight.

## 1.8 Aids to Navigation

No problems with any navigational aids were reported.

## 1.9 Communications

No communications problems were reported.

## 1.10 Airport Information

MKE is located about 5 miles south of Milwaukee, Wisconsin, at an elevation of about 723 feet. Runway 1L, the active runway at the time of the accident, is 9,690 feet long by 200 feet wide.

## 1.11 Flight Recorder Information

### 1.11.1 Cockpit Voice Recorder

The accident airplane was equipped with a solid-state Universal CVR-30B designed to record the most recent 30 minutes of cockpit audio information obtained from four channels.[37] The CVR was sent to the NTSB's laboratory in Washington, DC, for examination, readout, and evaluation. Although the CVR exhibited external structural damage, audio information from the four channels was downloaded successfully. The accident CVR contained fair and good quality[38] audio information. The recording started at 1138:26, and it captured the inbound portion of the airplane's arrival at MKE, including the approach, landing, and ground operations; the recording ended at 1600:45.5, after the accident departure. (The airplane was not powered for about 3 hours and 51 minutes between flights, and during that time, the CVR was not operating.) Review of the CVR indicated that the captain was the flying pilot on both the inbound and outbound flights. A transcript was prepared of the 30-minute, 57-second recording and is available in appendix B.

[37] The four channels of audio information recorded by the accident CVR included one channel for each flight crewmember, the cockpit area microphone, and a duplicate of the captain's channel.

[38] The NTSB uses the following categories to classify the levels of CVR recording quality: excellent, good, fair, poor, and unusable. A fair quality recording is one in which the majority of crew conversations were intelligible, and a good quality recording is one in which most of the flight crew conversations could be accurately and easily understood. The audio information recorded on the three pilots' channels was fair, whereas that recorded on the cockpit area microphone was good.

### 1.11.2 Flight Data Recorder

The airplane was not equipped, and was not required to be equipped, with a flight data recorder.[39]

## 1.12 Wreckage and Impact Information

As previously noted, physical evidence indicates that the airplane impacted Lake Michigan at a high speed, in a steep nose-down, left-wing-down attitude. The recovered wreckage was severely fragmented; however, in general, the damage observed on the recovered wreckage was more severe on the left side of the airplane than the right. Recovered debris included an airspeed indicator that exhibited impact marks extending from the center of the indicator to an airspeed indication of about 243 knots, and a partially-crushed standby attitude indicator that indicated an attitude of about 42° nose down, with about 115° left roll. The angle of the observed impact damage corresponded to this roll attitude, which would have resulted in the airplane's left wingtip and nose striking the water almost simultaneously. The airplane wreckage was located in water about 62 feet deep east of Milwaukee, Wisconsin. After the wreckage was recovered from the lake, it was initially documented on a dock at the U.S. Coast Guard Station in Milwaukee and then transported to an airport hangar for reconstruction and lay-out. There was no evidence of lack of flight control continuity before impact. Physical examination of the flight control wreckage indicated that the elevators were generally positioned with the trailing edge down (airplane nose down) at impact; the ailerons were generally in a left-wing-down orientation, and the rudder trailing edge was left of its center, or streamlined, position.

Wreckage examination indicated that the landing gear and flaps were in their retracted positions and the engines were producing power at impact. None of the airplane's master warning annunciation light bulbs contained stretched or deformed filaments.[40]

### 1.12.1 Airplane Systems Wreckage Information

#### 1.12.1.1 Airplane Trim Systems

The NTSB examined the recovered trim systems, including their jackscrews, and related cockpit trim position indicators.[41] Examination of the recovered aileron (roll) trim system revealed that the recovered black housing from around the white aileron trim position indicator had a white smear that extended from a half-needle width left of the center of the indicator slot,

[39] According to 14 CFR Part 91.609(c)(1), an approved flight recorder is required for multiengine, turbine-powered airplanes manufactured after October 11, 1991, that have passenger seating configurations of 10 or more. The accident airplane was equipped with 8 passenger seats.

[40] Tungsten filaments in a hot light bulb are malleable and may be stretched or deformed if illuminated at impact, unlike cold filaments, which are brittle.

[41] Impact forces that result in flight control cable separation (as occurred in this case) can render jackscrew positions and cockpit indications inconclusive.

which correlated to about 7-percent left wing down input. (Postaccident tests in another Citation showed that this trim position appeared to be centered when viewed from the first officer's seat.) The cable-driven aileron trim jackscrew was found extended 1.2 inches, near its full left-wing-down extension.

Examination of the recovered rudder (yaw) trim system revealed that the rudder trim jackscrew (recovered from the tail section) and the rudder trim cockpit indicator showed nearly identical indications of about 50 percent of full left rudder travel. Examination of the recovered rudder showed that it had impacted the airplane's vertical stabilizer to the left of center.

Examination of the recovered pitch trim system components revealed that the cockpit pitch trim indicator was found at the forward end of the range of travel, indicating a full nose-down position, with corresponding scratches on the side of the adjacent pedestal structure. The trim tab on the right elevator was twisted and bent but generally oriented in an airplane nose-down position. Pitch trim jackscrew measurements also indicated that the pitch trim was at or near its full nose-down position. There was no evidence of preimpact mechanical malfunction; however, the pitch trim wiring showed evidence of a short circuit. (For additional information, see section 1.12.2.)

### 1.12.1.2 Autopilot System Components

The autopilot servomotor clutches that were connected to the primary control cables for the aileron, rudder, and elevator (pitch) systems were recovered and examined. The elevator autopilot servomotor clutch's polymer gear teeth revealed no visible impact-related markings and showed little visible wear. Examination of the aileron autopilot and rudder servomotor clutches revealed damage to the clutch gear teeth that was consistent with an event that occurred while the clutch teeth were separated (disengaged). Some evidence of wear and repeated rubbing was observed at the roots of the aileron and rudder autopilot servomotor clutch gear teeth.

Examination of the light bulbs that were in the recovered autopilot control panel from the throttle console revealed that the filament light bulb associated with the TRIM UP status light had stretched filaments that were partially wrapped around the support post within the bulb. This stretched filament indicated that the autopilot control panel (and the autopilot computer, which provided power to the autopilot control panel) was powered and functioning at impact.[42] However, the autopilot pilot engaged light bulb filaments were not stretched; this bulb was tested and found functional after the accident. Examination of the yaw damper engaged bulb filaments revealed that they were more stretched than the AP ENGAGE status bulb filaments.

[42] Although the stretched light bulb filaments indicated that the autopilot control panel was powered and functioning (and thus performing continuous self-checks for proper operation) at impact, they did not indicate whether the servomotors were engaged. According to the autopilot's design, if a servomotor had engaged when the light was illuminated, it should have resulted in a nose-up force on the pitch controls.

### 1.12.2 Control Yoke and Related Switches

The left and right side (captain's and first officer's, respectively) control yokes, with some associated switches and wiring, were recovered. Visual examination of the control yoke mounting shafts revealed that the shaft in the right side (first officer's) control yoke had a sooty blackened appearance that was not evident in the shaft in the captain's control yoke. (Figure 6 shows the sectioned first officer's control yoke and mounting shaft with associated wiring.)

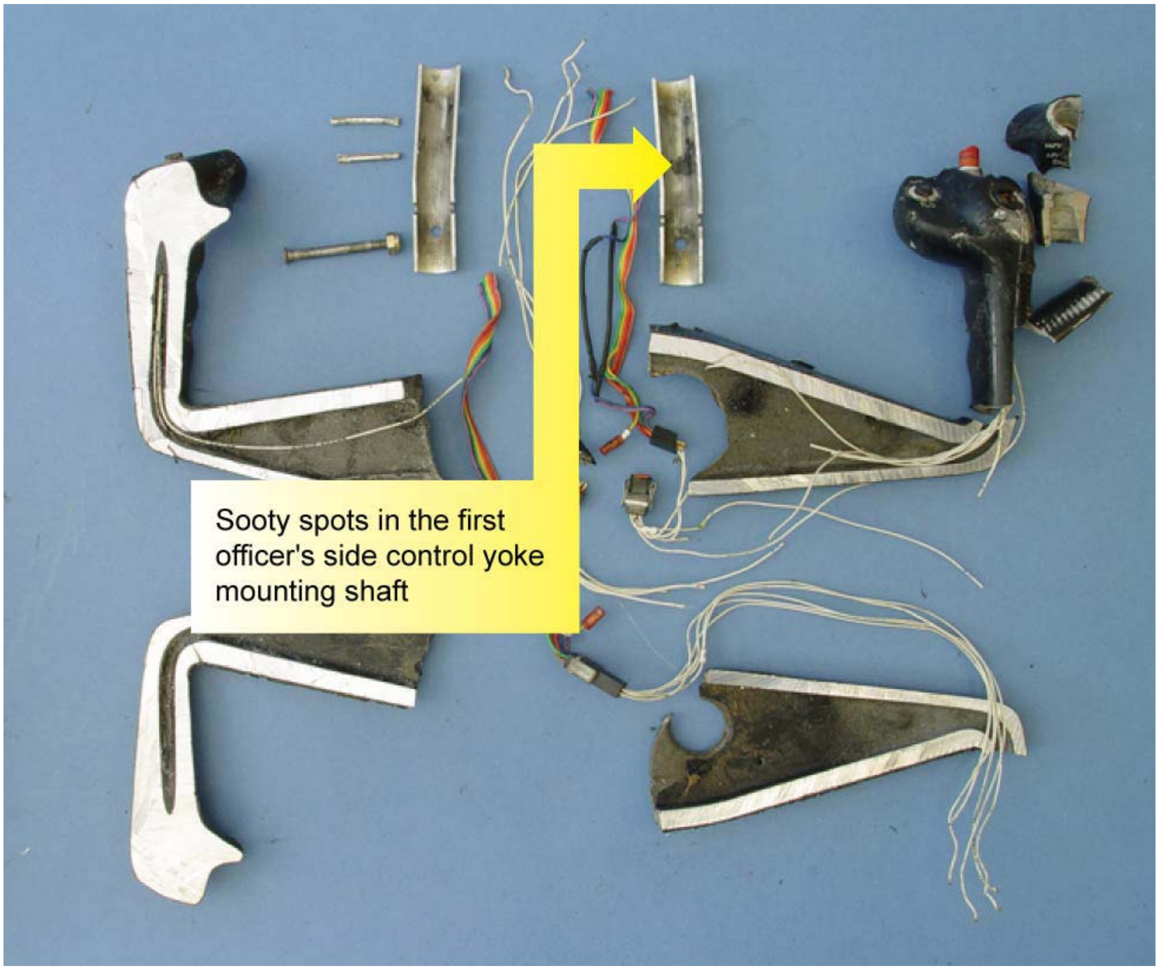


**Figure 6.** Photograph of the sections of the first officer's control yoke and mounting shaft with associated wiring.

The NTSB examined the control yoke-mounted switches (including the pitch trim and autopilot switches) and wiring from the recovered control yokes and mounting shafts. Each control yoke-mounted pitch trim system comprised a handgrip-mounted switch that had a plastic toggle to operate two double-pole double-throw internal microswitches[43] and associated wiring. For the pitch trim motor to operate, two circuits needed to be completed: one providing power to

[43] The microswitches, each of which had two sets of three contacts, could create nose-up or nose-down pitch trim commands, depending on the movement of the center reed and its subsequent contact with either the electrical contacts on either side of the reed. Depending on which direction the reed moved, such contact would result in either nose-down or nose-up commands.

the motor, the other to a ground path for the motor. Wreckage examination also showed that, sometime before the accident, at least two short circuits occurred in a bundle of wires in the first officer's control yoke/column. Investigators also found evidence of heat damage consistent with the short circuits and found chafing on some unrelated wires in this area.[44] One of the short circuits occurred between the pitch trim power supply wire and the adjacent steel surface of the first officer's control yoke shaft;[45] the recovered wires were chafed around the area where the exposed wire had become welded to the steel of the control shaft. In addition, a possible ground path was found in the pitch trim microswitch assembly from the first officer's control yokes. Although one of the normally-fixed contacts was found bent toward the center reed and the switch appeared to be closed when visually inspected, after rinsing silt from the switch, electrical tests found no continuity.

### 1.12.2.1 Control Column/Yoke Electrical Wiring

Investigators recovered wires from both control yokes/columns. Examination of the wires revealed some wires that were enclosed in sleeves where repairs had previously been accomplished and several instances of damaged, chafed, or punctured wire insulation. Damage was observed on individual wires, as well as wires contained in flat ribbon cable bundles that were 0.38-inches wide and 0.07-inches thick. Two such ribbon cables were routed through each of the control yoke mounting shafts, along with individual wires. In addition, two mounting bolts passed through the control yoke mounting shaft at its widest point, restricting the available space in that part of the shaft to less than the 0.38-inch dimension of the ribbon wire, creating at least four potential chafe locations. (Figure 7 is an illustration of the wiring and bolts in the control yoke mounting shaft.)

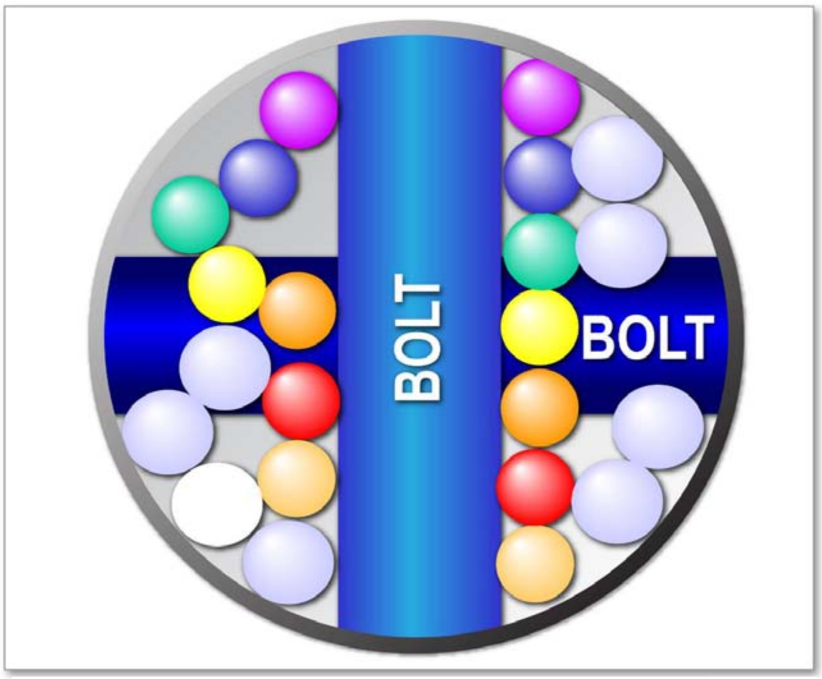


**Figure 7**. Illustration of the wiring and bolts in the control yoke mounting shaft. (Figure not to scale.)

Postaccident examination also revealed some individual wires that had been folded back among the wires and pressed into the shafts, apparently when they were reinstalled after

[44] Evidence and maintenance records showed at least two instances in which the wires in the first officer's control yoke/column had been previously repaired.

[45] There was also evidence of a short circuit on the power wire for the autopilot clutches.

maintenance. (Anecdotal information indicates that such wiring installations in control shafts are common.) Other recovered wires were found stretched and severed at the ends of the shafts. The observed wiring installations were inconsistent with the wiring practices described in FAA Advisory Circular (AC) 43.13-1B and -2A.

After the right side control yoke and shaft were bisected, detailed examination revealed several areas of damaged wiring and that remnants of copper wire had adhered to the interior of the steel yoke mounting shaft. For example, the pitch trim system power wire had an extensive area of exposed copper core that had previously melted and resolidified, with some missing copper strands, signs of a mechanical imprint, and a kink that was not observed in other wires from that area. This portion of the pitch trim system power wire was found near an area of copper deposits, similar in shape and appearance, that had adhered to the inner wall of the steel mounting shaft. Additionally, wires adjacent to this portion of the pitch trim system power wire exhibited extensive insulation damage.

In addition, the autopilot clutch power wire that was routed to the first officer’s control yoke exhibited two types of damage: 1) localized “poke-type” damage that penetrated the insulation and 2) a more wide-spread area of damage that contained a surface scratch, ripped insulation, torn copper strands, and three distinct areas of previously melted and resolidified copper, but none were as extensive as the damage to the pitch trim wire.

## 1.13 Medical and Pathological Information

Toxicology tests were performed by the FAA’s Civil Aeromedical Institute on tissue specimens from both pilots. The tests detected low levels of ethanol in both pilots’ specimens, which were consistent with postmortem ethanol production. The specimens tested negative for a wide range of drugs, including major drugs of abuse such as marijuana, cocaine, phencyclidine, amphetamines, and opiates.

The Milwaukee County Medical Examiner determined that the cause of death for the airplane occupants was multiple blunt force injuries.

## 1.14 Fire

No evidence of an in-flight or a postcrash fire was found.

## 1.15 Survival Aspects

The accident was not survivable due to impact forces.

## 1.16 Tests and Research

### 1.16.1 Airplane Simulation and Performance Studies

The NTSB conducted an airplane performance study to determine the accident airplane's approximate flightpath, orientation, airspeed, and other performance parameters throughout the accident flight. Performance calculations were largely based on MKE airport surveillance radar data (with some support from two distant radar sites), and local weather information.

The NTSB also conducted simulator tests to recreate two potential accident scenarios: runaway pitch trim and inadvertent autopilot activation. The NTSB's airplane performance study noted that all of the pilots who attempted to fly the accident airplane's flight scenario in the simulator indicated that a reduction in power (and resultant reduction in airspeed) was required to successfully control the airplane during the return to the airport. The study stated that without the power reduction, control forces were excessive and the aural overspeed warning sounded as the airplane's airspeed exceeded its limits. The airplane performance study indicated that a power reduction shortly after the pilots declared an emergency and began to turn back to MKE was consistent with the accident airplane's flightpath.[46]

#### 1.16.1.1 Pitch Trim Runaway

According to the airplane performance study, during a nose-down pitch trim runaway event, the pilots would have had to counter peak column forces as high as 140 pounds and average forces of about 80 pounds during the last minute of flight. The NTSB performance study indicated that, although the airplane would have been controllable in the event of a pitch trim runaway, it would have required a significant physical effort by both pilots working together to keep the airplane upright for the last minute of flight.

#### 1.16.1.2 Inadvertent Autopilot Engagement

If the pilots had inadvertently engaged the autopilot instead of the yaw damper after takeoff, the autopilot would have attempted to hold the airplane heading that existed when the autopilot was engaged, which was likely close to the runway's magnetic heading of 009°. Trying to fly the airplane manually with the autopilot engaged would result in dynamically changing airplane handling characteristics. The NTSB's performance study showed that during an inadvertent autopilot engagement, the pilots may have encountered control wheel forces of about 25 pounds right wing down during the first 2 minutes or so of the accident flight, with increased forces during the last minute of flight.

The effectiveness of airplane trim surfaces is a function of the airplane's airspeed squared. Thus, the tendency of aileron or rudder trim to roll the airplane would increase with

[46] Such a power reduction was not detected by the NTSB's CVR Sound Spectrum Study, nor did the CVR record the aural overspeed warning.

speed. According to the performance study report, in an inadvertent autopilot engagement accident scenario, a pilot beginning to experience unexpectedly high roll-control forces while trying to manually control the airplane under these circumstances might add aileron trim in an attempt to ease those forces. The study also noted that the Citation's aileron trim is highly sensitive and effective and that the effect of the added trim would increase as the airplane accelerated.

### 1.16.2 Assessment of Likely Aileron Trim Inputs and Forces

As a result of this accident, simulator and flight tests were conducted to evaluate possible aileron trim inputs and their effects during the accident sequence. The tests revealed that aileron trim inputs resulted in a dramatic airplane-rolling tendency. Both simulator and flight-test data showed that the Citation 550 aileron trim is highly sensitive and effective.

After examining the aileron trim test data,[47] Cessna engineers estimated pilot wheel forces of 150 to 160 pounds for full aileron trim input at 250 knots. federal certification requirements limit wheel forces to 5 and 50 pounds for prolonged and temporary application, respectively.

## 1.17 Organizational and Management Information

### 1.17.1 Marlin Air General Information

Marlin Air provided on-demand air taxi and air medical transportation services under 14 CFR Part 135, as authorized by the FAA. The company was privately owned, and the owner/president served as the director of operations. At the time of the accident, the company employed nine pilots, including the accident captain. Of those pilots, five were employed full time, and four part time. Five pilots were assigned to the UM Survival Flight contract.

Marlin Air operated two Cessna Citation 550 airplanes (N435UM and N550BP) and one Beech C-90 King Air. The accident airplane, N550BP, was owned by Toy Air and made available to Marlin Air on a dry lease[48] arrangement. In addition to on-demand charters, the accident airplane was used as a back-up aircraft for UM Medical Center's organ procurement flights. Citation N435UM was owned by Marlin Air and leased under contract to the UM Medical Center. This airplane was configured in a medical transport configuration and was available for the exclusive use of UM Medical Center.

[47] Examination of the aileron trim test data revealed that at 150 knots, the maximum aileron trim deflection of 20° resulted in a wheel force of approximately 50 pounds. At 90 percent of maximum aileron trim, or 18°, and 200 knots, 70 pounds of wheel force was measured. Only about 50 percent, or 11.5°, of aileron trim was introduced at 250 knots. At this speed, the recorded wheel force was 65 pounds.

[48] A dry lease involves the lease of the basic aircraft without insurance, crew, maintenance, or other services.

### 1.17.2 Marlin Air and University of Michigan Information

Marlin Air had provided medical transport services for the UM Survival Flight Program under successive contracts for about 19 years before the accident. The current Marlin Air/UM contract was effective beginning October 1, 2004, and was scheduled to terminate on September 30, 2009.[49] (The contract was terminated after the accident because of clauses for termination based on injuries to UM personnel and Marlin Air's failure to perform.) During postaccident interviews, UM personnel told investigators that in the past they had felt comfortable with the operator and had confidence in Marlin Air's pilots; however, they stated that, about 1½ years before the accident, UM management began to hear complaints about Marlin Air from UM medical crews. In general, these complaints reflected concerns about safety of flights and the number of maintenance-related cancellations. (At the time of the accident, UM also had an emergency medical services (EMS) contract with a hospital-based helicopter operator, and UM management personnel told investigators that maintenance-related cancellations with that operator were relatively rare.)

UM's Marlin Air program manager was responsible for EMS dispatch functions, and her main point of contact with Marlin Air was the captain/chief pilot. The individual selected as UM's program manager had experience in critical care nursing and health care management; however, she was not familiar with flight operations. In addition, UM personnel, including the UM Marlin Air program manager, were not aware of the FAA safety hotline or that they could bring concerns about an operator to the attention of the overseeing FAA principal operations inspector (POI).

The UM Marlin Air program manager told investigators that she had been concerned about Marlin Air's financial condition before the accident, in part because upgrades requested by the University (for example, upgrades to the stretcher system and an intercom system to ease communications between pilots and medical crews) were not accomplished. Additionally, Marlin Air attempted to obtain additional revenue from UM by adding various supplemental charges to the contract.

Further, UM's program manager told investigators that she was disturbed to learn shortly before the accident that Marlin Air had not renewed its membership with the Association of Aeromedical Services (AAMS). She stated that she believed that Marlin Air's lack of membership in AAMS could jeopardize the accreditation and standing of the UM Survival Flight Program in industry programs.

### 1.17.3 Marlin Air Financial Information

The investigation revealed indications that Marlin Air had been experiencing financial difficulties in recent years.[50] For example, a representative of a YIP-based fuel supplier that had

[49] Postaccident interviews indicated that one of the other bidders for this contract was a start-up operator composed of former Marlin Air pilots with whom UM personnel were at least equally familiar and comfortable. However, UM management ultimately renewed the contract with Marlin Air because of financial considerations.

[50] As a result of its investigation of the December 2005 Chalk's Ocean Airways accident, the NTSB examined the association between an operator's safety and its financial condition. The NTSB specifically evaluated the FAA's

contracted with Marlin Air for about 6 years stated that his company terminated its contract with Marlin Air about 2 or 3 years before the accident because the operator was behind in its payments. The representative stated that Marlin Air's payments had been irregular for "a couple of years" before the contract was terminated but that Marlin Air subsequently repaid most of what was owed, and the fuel supplier wrote off the remaining balance. After that fuel contract was canceled, Marlin Air purchased fuel from a second YIP-based fuel supplier. A representative from this company stated that Marlin Air was initially billed on a monthly basis; however, when the operator began to miss required payments, the fuel vendor required immediate credit card payment for all purchases. They reported no further payment issues.

In addition, two of the Marlin Air pilots interviewed after the accident reported experiencing problems with company paychecks being returned because of insufficient funds during the year before the accident.

Further, on October 19, 2006, a landlord-tenant judgment related to nonpayment of hangar rent at Marlin Air's YIP facility was entered against the operator. Marlin Air agreed to make an initial payment toward unpaid rent, with the promise of a subsequent payment within 90 days but defaulted on the subsequent 90-day payment.

### 1.17.4 Federal Aviation Administration Oversight

#### 1.17.4.1 Operational Oversight of Marlin Air

The Detroit flight standards district office (FSDO) was responsible for oversight of Marlin Air's operations;[51] like Marlin Air, the FSDO offices were located at YIP. Marlin Air's POI had been assigned to the company's certificate for about 8 years. The POI stated that he was required to observe all check airmen under his surveillance in performance of their duties at least once every 2 years. Records showed that the POI observed a checkride performed by the accident captain/check airman once, in June 2006.[52] (Although FAA inspectors had performed about 20 percent of the Marlin Air checkrides during the 2 years preceding the accident,[53] the POI did not recall whether FAA inspectors observed any checkrides conducted by the check airman during that time.)

oversight of operators experiencing financial difficulty. For additional information, see *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,* Aviation Accident Report NTSB/AAR-07/04 (Washington, DC: National Transportation Safety Board, 2007).

[51] The Detroit FSDO provided oversight for Marlin Air's maintenance and operations; however, this section only addresses oversight of the company's operations because the investigation did not reveal any maintenance program deficiencies.

[52] During postaccident interviews, the POI stated that because Marlin Air did not notify the FAA of upcoming check airman-conducted checkrides, the POI did not have an opportunity to spontaneously observe such checkrides. The POI also stated that this was typical of the Part 135 operators he surveilled and that he had not addressed the issue with Marlin Air personnel.

[53] Records indicated that of the Marlin Air checkrides conducted during the 2 years preceding the accident, FAA inspectors performed about 20 percent, Marlin Air check airmen performed about 40 percent, and outside training centers performed the remaining about 40 percent.

At the time of the accident, the POI was responsible for 15 operator certificates (including Marlin Air), all of which were local operators. During postaccident interviews, the POI told investigators that it was a challenge to manage the 15 certificates and characterized his workload as "busy."[54] He estimated that he devoted about 5 percent of his time to routine surveillance of Marlin Air and stated that he would only provide additional oversight to any operator as a result of an incident or accident or in response to complaints alleging safety issues or regulation violations. The POI stated that his normal points of contacts within Marlin Air were the chief pilot and director of operations; he did not routinely talk with Marlin Air's line pilots nor did he conduct checkrides for Marlin Air pilots because he was not current in the Cessna Citation.

During postaccident interviews, the POI stated that he was uncertain about Marlin Air's pilots' workload, the competitiveness of pilot compensation, or the financial condition of the company. Specifically, the POI told investigators that he was unaware of the financial issues revealed during the investigation; he added that FAA inspectors would not typically inquire about an operator's financial condition unless such an inquiry was prompted by discussions with the operator's management or with outside parties.[55]

The POI's supervisor at the FSDO stated that the POI was performing his oversight duties well; he had satisfactorily completed all of the inspection items on the Marlin Air work program, and the supervisor had received no complaints from or about the company. There had been no enforcement actions against Marlin Air in the 5 years before the accident, and the POI had not brought any issues related to Marlin Air to his supervisor's attention. The supervisor, who was a point of contact for FAA hotline complaints, indicated that he was aware of no hotline complaints regarding Marlin Air.

### 1.17.4.2 Appointment of Marlin Air's Check Airman

About 2 years before the accident, Marlin Air's POI reviewed a nomination letter requesting that the accident captain be appointed as a check airman for Marlin Air. The POI stated that he verified the captain's pilot and medical certificate qualifications as required by FAA procedures. The POI stated that during the verification process he noted the captain's prior airman certificate revocation; although the FAA's database provided contact information for anyone interested in additional information regarding the nature and circumstances of the revocation, the POI did not pursue additional information because he did not believe it was necessary. The POI told investigators that he assumed that the revocation was the result of a personal issue with prescription medications. He did not seek to clarify the issue with the captain nor did he contact anyone within the FAA for additional information.[56]

[54] During postaccident interviews, the FAA's manager of the Flight Standards Certification and Surveillance Division stated that it would be a challenge for a POI to manage 15 certificates and that this workload would result in a limited depth of FAA surveillance.

[55] For additional information as to how outside parties might communicate operator-related concerns to pertinent FAA personnel, see section 1.17.4.4.

[56] The POI further stated that he recalled thinking that if FAA authorities had re-issued the captain's pilot certificates, it would not be necessary to pursue the issue further.

During postaccident interviews, an FAA Great Lakes region investigator told NTSB investigators that, in his opinion, because a pilot with a history of pilot certificate revocation related to a felony drug conviction would not be qualified to be hired as an FAA inspector, such a pilot should not be authorized to represent the FAA as a check airman. For information on official guidance regarding FAA appointment of check airmen, see section 1.18.2.

#### 1.17.4.3 Pre and Postaccident FAA Inspections of Marlin Air

In March 2002, the FAA conducted an Office Safety Inspection Program (OSIP) of Marlin Air and the UM's hospital-based helicopter operator. Although the OSIP identified issues related to Marlin Air's operating manual and recording of pilot flight times, the issues were corrected immediately, and both operators passed the audit.

A Regional Aviation Safety Inspection Program (RASIP) was conducted after the accident.[57] The RASIP team was made up of three inspectors from the FAA's Great Lakes regional office and the three principal inspectors (operations, maintenance, and avionics) who were assigned to Marlin Air at the time of the accident. The inspection focused on Marlin Air's policies and procedures and was conducted with input from the company's director of operations and assistant chief pilot.[58] Although the RASIP inspection report stated that "[training] records for all pilots were reviewed," the RASIP team did not have access to the accident pilots' training records. According to the RASIP inspectors, Marlin Air personnel told them that training records for the accident captain and first officer had been provided to the NTSB as a result of the ongoing investigation and were, thus, not available to RASIP inspectors.

The RASIP report identified one adverse operational finding[59] and indicated that there were no adverse findings in the area of pilot training. The NTSB's postaccident review of Marlin Air records revealed three training discrepancies. One of these discrepancies (the improper recording of the first officer's training flights and times) involved the accident pilots, and the related training documents were in the possession of the NTSB and, therefore, unavailable to the RASIP team. The two other training discrepancies (dated May 4 and June 2, 2007) identified by the NTSB and not identified during the RASIP involved other Marlin Air pilots whose training documents were available to the RASIP team.

During postaccident interviews, an FAA Great Lakes regional inspector told investigators that the RASIP was intended to provide a "second set of eyes" on the operator. Because, according to the RASIP team leader, the inspection was not assessing the quality or adequacy of the FAA oversight by the operator's principal inspectors, the operator's principal inspectors were included on the RASIP team. (For additional information regarding postaccident inspections conducted by the FAA, see section 1.18.1.5.)

[57] The FAA has since replaced its RASIP inspection program with a similar regional inspection program.

[58] Marlin Air's line pilots were not often available during the RASIP investigation because Marlin Air operations had been suspended after the accident.

[59] The operational finding involved a Marlin Air operation that required two pilots but was operated with only one pilot.

#### 1.17.4.4 Available FAA Alert Programs

During postaccident interviews, an FAA management and program analyst described the following four programs that the UM might have used to report concerns about or request additional surveillance of Marlin Air:

1) Administrator's hotline.[60] Developed in the late 1980s, this hotline provides FAA employees and outside organizations a way to raise issues to the FAA administrator. The FAA's Flight Standards Division has 30 to 60 days to react to complaints received on this hotline. Callers who identify themselves will be advised of subsequent actions. Anonymous callers are not so advised.

2) Customer Service Initiative. The UM could have described safety concerns and lodged a complaint with the local FSDO. The FSDO would then have been required to investigate and, if possible, substantiate the complaint. If not satisfied by the FSDO's response, the UM could have appealed to FAA regional management, the director, or the administrator. (This mechanism is typically used by operators rather than the public.)

3) Office of Inspector General (OIG) hotline. Used by the public, this hotline normally accepts information related to crimes, but it also accepts safety information. In the past 2 years, the OIG hotline was active in pursuing safety concerns related to the Southwest Airlines certificate. This hotline also pursued a complaint from a nurse involving a helicopter emergency medical services operator. She complained that the operation used by her hospital was unsafe. The FAA region sent in two teams and replaced the POI.

4) Safety hotline, Office of Accident Investigation. Complaints received through the safety hotline are typically received from pilots and are acted on by local regional offices and FSDOs.

## 1.18 Additional Information

### 1.18.1 Previously Issued Safety Recommendations

#### 1.18.1.1 Crew Resource Management

Between 1980 and 2003, the NTSB repeatedly recommended that the FAA revise 14 CFR Part 135 requirements to require on-demand charter operators that conduct operations with aircraft requiring two or more pilots to establish an FAA-approved crew resource management

[60] Safety concerns may be reported to the administrator's hotline by telephone at 1-800-255-1111 or 1-866-835-5322 (866-TELL-FAA) or online at <http://www.faa.gov/contact/safety_hotline> or <http://www.faa.gov/about/office_org/headquarters_offices/avs/cust_service>.

(CRM) training program for their flight crews. Most recently, on December 2, 2003, the NTSB issued Safety Recommendation A-03-52 as a result of its investigation of the November 18, 2003, accident in which an Aviation Charter, Inc., King Air A100 airplane lost control and impacted terrain in Eveleth, Minnesota.[61] Safety Recommendation A-03-52 asked the FAA to require that 14 CFR Part 135 on-demand charter operators that conduct dual-pilot operations establish and implement an FAA-approved CRM training program for their flight crews in accordance with 14 CFR Part 121, subparts N and O. Safety Recommendation A-03-52 was added to the NTSB's Most Wanted List of Transportation Safety Improvements in November 2006.

In April 2004, the FAA indicated that an aviation rulemaking committee had been tasked to revise Part 135 requirements, including a requirement for CRM training for Part 135 operators of airplanes with two pilots. The NTSB classified Safety Recommendation A-03-52 "Open—Acceptable Response" pending completion of the revisions to Part 135. However, as a result of its investigation of the November 28, 2004, Canadair, Ltd., accident in Montrose, Colorado, during which the NTSB determined that the captain and first officer demonstrated poor CRM, the NTSB reiterated Safety Recommendation A-03-52 and, as a result of the FAA's continuing delays in addressing this issue, classified it "Open—Unacceptable Response" on May 2, 2006. In an April 3, 2008, letter, the FAA indicated that it had initiated a notice of proposed rulemaking (NPRM) to revise Part 135 requirements to include a requirement for CRM training for Part 135 operators of airplanes.

On May 1, 2009, the FAA published in the *Federal Register* an NPRM titled "Crew Resource Management Training for Crewmembers in Part 135 Operations," which proposed a rule that would require all Part 135 operators to include instruction in CRM in pilot and flight attendant training programs. The proposed rule requires initial and recurrent CRM training for crewmembers working for Part 135 on-demand operators. The proposed rule also specifies the minimum course content required for an approved CRM training program. However, the proposed rule exempts operators from providing initial training to those who have already completed training with another company. In comments submitted to the docket for this NPRM, the NTSB stated that it was supportive of the proposed rule, apart from that exemption because conditions and the specifics of training vary across operators such that crews should be trained by each operator with whom they work. The NTSB believed that, without this exception, the proposed rule would largely meet the intent of Safety Recommendation A-03-52. Pending issuance of appropriate revisions to Part 135, Safety Recommendation A-03-52 remains classified "Open—Unacceptable Response."

#### 1.18.1.2 Pitch Trim Issues

The NTSB previously addressed issues related to Cessna Citation pitch trim, such as the need for an aural trim-in-motion warning, better visual trim-in-motion cues, and a collared pitch

[61] Aircraft Accident Report NTSB/AAR-03/03. For information on additional CRM-related safety recommendations, see Safety Recommendations A-80-42, A-94-196, and A-02-12, which are available on the NTSB website at <http://www.ntsb.gov>.

trim circuit breaker,[62] in a recommendation letter concerning the July 22, 2003, accident involving a Citation 525 that ditched in the waters of Penn Cove, in Coupeville, Washington, after a loss of elevator trim control that resulted in an uncommanded nose-down pitch attitude.[63] The recommendation letter stated the following:

> Because the Cessna Citation 525 is not equipped with a clear indication or warning for an electric elevator trim runaway (such as an aural[[64]] or visual trim-in-motion warning), the accident pilot had only indirect indications to assist in identifying the condition, and these indications were insufficient to allow timely recognition of the problem…
>
> The [NTSB] is concerned that, when the Citation 525 is in autopilot mode, the available cues for an electric elevator trim runaway…do not provide pilots with a salient and reliable means to detect this unsafe condition in a timely manner….it is critical to alert a pilot to a trim runaway condition before the associated control forces exceed what a single pilot can manage.

On September 13, 2007, the NTSB issued Safety Recommendations A-07-52 and-54, which asked the FAA to do the following:

> Require Cessna to modify the Citation 525 to incorporate an aural trim-in-motion warning and the addition of contrasting color bands on the pitch trim wheel to provide the pilot with more timely recognition of a trim runaway condition before control forces become unmanageable. (A-07-52)
>
> Require Cessna to replace the pitch trim circuit breaker on the Citation 525 with a collared circuit breaker to aid the pilot in quickly identifying it if necessary. (A-07-54)

In its response letter, dated November 20, 2007, the FAA indicated that it believes that the combination of the normal cues of undesired trim motion and the issuance of Airworthiness Directive (AD) 2004-14-20 (which addressed the specific failure mode identified in the Penn Cove accident investigation by requiring the replacement of the trim printed circuit board) correct the unsafe conditions identified during the investigation of the July 22, 2003, Penn Cove accident, rendering the action recommended in Safety Recommendations A-07-52 and -54 unnecessary.

The NTSB's response letter, dated June 11, 2009, disagreed with the FAA's assertion that no action was required. With regard to Safety Recommendation A-07-52, the NTSB's letter

[62] The NTSB also discussed clear identification of critical circuit breakers in its report on the July 10, 2007, Cessna 310 accident in Sanford, Florida. For more information, see *In-flight Fire, Emergency Descent, and Crash in a Residential Area, Cessna 310R, N501N, Sanford, Florida, July 10, 2007,* Aircraft Accident Summary Report NTSB/AAR-09/01 (Washington, DC: National Transportation Safety Board, 2008)

[63] The brief for this accident, NTSB identification number SEA03FA147, can be found on the NTSB's website at <http://www.ntsb.gov/ntsb/query.asp>.

[64] Several manufacturers equip their airplanes with aural alerts for stabilizer or pitch trim motion.

stated that, had the Penn Cove pilot received conspicuous warning of the pitch trim runaway condition earlier in the accident sequence, he would have been able to complete the related checklist procedure and pulled the pitch trim circuit breaker before the pitch control forces became unmanageable. Pending action by the FAA to require Cessna to incorporate an aural trim-in-motion warning and the addition of contrasting color bands on the pitch trim wheel, the NTSB classified Safety Recommendation A-07-52, "Open—Unacceptable Response."

With regard to Safety Recommendation A-07-54, the FAA agreed with the NTSB's belief that a collared pitch trim circuit breaker would improve a pilot's ability to quickly locate the pitch trim circuit breaker in an emergency situation but indicated that the FAA lacked sufficient basis for regulatory action on the issue. As an alternative response to this safety recommendation, the FAA proposed issuing guidance, such as a special airworthiness information bulletin (SAIB), on the subject. Pending issuance of an SAIB or similar guidance recommending replacement of the pitch trim circuit breaker on the Citation 525 with a collared circuit breaker to aid the pilot in quickly identifying it if necessary, the NTSB classified Safety Recommendation A-07-54, "Open—Acceptable Alternate Response."

#### 1.18.1.3 Human/Aircraft Interface Issues

In its 2006 study of the aircraft certification process,[65] the NTSB made the following two recommendations to the FAA concerning human/aircraft issues in the certification of aircraft:

> Amend the advisory materials associated with 14…[CFR] 25.1309 to include consideration of structural failures and human/airplane system interaction failures in the assessment of safety-critical systems. (A-06-37)
>
> Require a program for the monitoring and ongoing assessment of safety-critical systems throughout the life cycle of the airplane. … Once in place, use this program to validate that the underlying assumptions made during design and type certification about safety-critical systems are consistent with operational experience, lessons learned, and new knowledge." (A-06-38)

In its September 12, 2007, response, the FAA indicated that it was incorporating more standardized consideration of human factors into new certification projects and planned to develop new regulations and advisory materials and a human factors design guide. Additionally, the FAA stated that it intended to formalize a process for monitoring and assessing safety critical systems throughout the life cycle of an airplane. Pending the FAA's related actions, the NTSB has classified Safety Recommendations A-06-37 and -38, "Open—Acceptable Response."

[65] *Safety Report on the Treatment of Safety-Critical Systems in Transport Airplanes*, Safety Report NTSB/SR-06/02 (Washington, DC: National Transportation Safety Board, 2006).

### 1.18.1.4 Recording Information on Aircraft

The NTSB has issued numerous recommendations addressing the need to record information on all turbine-powered, nonexperimental airplanes that are not required to be equipped with a flight data recorder (FDR) and are operating under 14 CFR Part 135 (such as the accident airplane). In addition, the NTSB included "automatic information recording devices" on its Most Wanted List from 2001 to 2008 and has included "require image recorders" on its Most Wanted List for 2009. Most recently, the NTSB noted these issues in its report on the July 27, 2007, midair collision involving electronic news gathering helicopters in Phoenix, Arizona.[66]

Because the FAA had not yet taken appropriate action in response to the NTSB's earlier recommendations, in its January 2009 report on the Phoenix midair collision, the NTSB classified several previous safety recommendations,[67] "Closed—Unacceptable Action/Superseded," superseding them with updated recommendations, including Safety Recommendation A-09-11, which asked the FAA to do the following:

> Require all existing turbine-powered, nonexperimental, nonrestricted-category aircraft that are not equipped with a [FDR] and are operating under 14 [CFR] Parts 91, 121, or 135 to be retrofitted with a crash-resistant flight recorder system. The crash-resistant flight recorder system should record cockpit audio (if a cockpit voice recorder is not installed), a view of the cockpit environment to include as much of the outside view as possible, and parametric data per aircraft and system installation, all to be specified in European Organization for Civil Aviation Equipment document ED-155, "Minimum Operational Performance Specification for Lightweight Flight Recorder Systems," when the document is finalized and issued. (A-09-11)

On April 17, 2009, the FAA issued a response letter, which described the FAA's participation in two proof-of-concept studies that evaluated the installation of image recorders on (1) an FAA airplane that was compliant with European Organization for Civil Aviation Electronics (EUROCAE) document ED-112 and (2) a transport-category Boeing 737 flight simulator. The findings that resulted from these studies provided valuable information on the potential uses of cockpit image recording systems on airplanes that are currently not required to carry any type of data-recording equipment. The working group incorporated this information into EUROCAE document ED-155, "Minimal Operational Performance Specification for Lightweight Flight Recorder Systems," which was published in August 2009. Pending the FAA's issuance of a technical standard order (TSO) that includes the specifications of ED-155, Safety Recommendation A-09-11 is classified "Open—Acceptable Response."

[66] For additional information, see *Midair Collision of Electronic News Gathering Helicopters, KTVK-TV Eurocopter AS350B2, N613TV, and U.S. Helicopters Eurocopter AS350B2, N215TV, Phoenix, Arizona, July 27, 2007*, Aviation Accident Report NTSB/AAR-09/02 (Washington, DC; National Transportation Safety Board, 2009).

[67] Safety Recommendations A-03-62, -64, and –65 were classified "Closed—Unacceptable Action/Superseded" in this report.

The NTSB notes that the accident airplane was not required to have an FDR installed; however, had the FAA implemented previous NTSB recommendations, the airplane would have been subject to the requirements for a cockpit image recorder.

#### 1.18.1.5 FAA Postaccident Inspections

The NTSB has issued several safety recommendations regarding the quality of inspections conducted by the FAA and the need for an evaluation of an operator's principal inspectors during such inspections. For example, on July 21, 1989, as a result of the 1988 Aloha Airlines accident,[68] the NTSB issued Safety Recommendation A-89-64, recommending that the FAA "[e]valuate the quality of FAA surveillance provided by the principal inspectors as part of the National Aviation Safety Inspection Program [NASIP]."

In its response, dated June 21, 1991, the FAA indicated that NASIPs regularly resulted in an evaluation of FSDO personnel responsible for surveillance of inspected operators. On July 13, 1991, the NTSB classified Safety Recommendation A-89-64, "Closed—Acceptable Action" but also indicated that the FAA should consider issuing formal documentation of its related policies to ensure their consistent and continued implementation.

On July 23, 1991, as a result of a fatal runway collision involving two Northwest Airlines airplanes,[69] the NTSB issued Safety Recommendation A-91-65, recommending that the FAA do the following:

> Require that an assessment of local FAA surveillance effectiveness be a formal part of NASIP inspections, so that NASIP findings can be used to correct observed deficiencies of local inspectors as well as those of the airline.

In its response, dated October 25, 1993, the FAA stated that its existing procedures involved routine internal evaluations of certificate-holding FSDOs to determine the effectiveness of the office surveillance programs and that any related NASIP results would be used in conjunction with this evaluation. On March 9, 1994, the NTSB classified Safety Recommendation A-91-65, "Closed—Acceptable Alternate Action."

Most recently, on April 8, 2005, as a result of a fatal accident involving an Air Sunshine Cessna 402C,[70] the NTSB issued Safety Recommendation A-05-08, recommending that the FAA do the following:

[68] For additional information, see *Aloha Airlines, Flight 243, Boeing 737-200, 73711, near Maui, Hawaii, April 28, 1988,* Aviation Accident Report NTSB/AAR-89/03 (Washington, DC; National Transportation Safety Board, 1989).

[69] For additional information, see *Northwest Airlines, Inc. Flights 1482 and 299, Runway Incursion and Collision, Detroit Metropolitan/Wayne County Airport, Detroit, Michigan, December 3, 1990,* Aviation Accident Report NTSB/AAR-91/05 (Washington, DC; National Transportation Safety Board, 1991).

[70] For more information, see *In-Flight Engine Failure and Subsequent Ditching, Air Sunshine, Inc., Flight 527, Cessna 402C, N314AB, About 7.35 Nautical Miles West-Northwest of Treasure Cay Airport, Treasure Cay, Great Abaco Island, Bahamas, July 13, 2003*, Aircraft Accident Report NTSB/AAR-04/03 (Washington DC; National Transportation Safety Board, 2004).

> Review the procedures used during its oversight of Air Sunshine, including those for the Surveillance and Evaluation Program and [RASIP], to determine why the inspections failed to ensure that operational and maintenance issues that existed at the company were corrected. On the basis of the findings of this review, modify 14 [CFR] Part 135 inspection procedures to ensure that such issues, including maintenance record keeping and practices, are identified and corrected before accidents occur.

In its response letter dated August 15, 2005, the FAA indicated that it would review FAA inspector procedures and programs and revise inspector handbooks and FAA orders as necessary. In subsequent responses, the FAA indicated that its southern region conducted a focused oversight inspection of Air Sunshine. As a result of this inspection, the FAA revised its oversight procedures for Air Sunshine and revised the following related sections of FAA Order 8900.1:

- Volume 2, Chapter 1, Section 2, "Assignment of Federal Aviation Administration Responsibilities" (paragraph 2-30)
- Volume 6, Chapter 2, Section 32, "Inspect Part 91 Subpart K Program Manager or Part 135 (Nine or Less) Air Carrier"
- Volume 6, Chapter 2, Section 35, "Inspect Section 135.422(a)(1) Operator's Maintenance Records"

On August 27, 2009, as a result of the FAA's actions, the NTSB classified Safety Recommendation A-05-08, "Closed—Acceptable Action."

### 1.18.1.6 Check Airman Program Guidance

On October 9, 1986, as a result of its investigation of three commuter air carrier accidents, the NTSB issued Safety Recommendation A-86-108, asking the FAA to do the following:

> Issue an Air Carrier Operations Bulletin-Part 135, requesting [POIs] to put special emphasis on their check airmen program to assure that company pilots are evaluated properly and that check airmen apply the training and checkride standards in a strict and standardized manner.

On August 31, 1990, the FAA issued change 4 to its Handbook 8400.10, "Air Transportation Operations Inspector's Handbook." This change contained direction and guidance concerning the check airman program for Part 121 and 135 operators, including the role and purpose of the check airman, the regulatory requirements, qualifications, functional responsibilities, and the approval process and training requirements for check airmen. On August 1, 1991, based on these actions, the NTSB classified Safety Recommendation A-86-108, "Closed—Acceptable Action."

### 1.18.1.7 Airplane Upset Recovery Training Aid

On October 18, 1996, as a result of three upset-related air carrier accidents, the NTSB issued Safety Recommendation A-96-120, asking the FAA to do the following:

> Require 14 [CFR] Part 121 and 135 operators to provide training to flight crews in the recognition of and recovery from unusual attitudes and upset maneuvers, including upsets that occur while the airplane is being controlled by automatic flight control systems, and unusual attitudes that result from flight control malfunctions and uncommanded flight control surface movements.

The NTSB recognized that although pilots receive unusual attitude and upset training during all phases of basic pilot training, pilots would benefit from additional and recurrent training related to airplane attitudes and/or control system failures not normally associated with air carrier flight operations. In a response letter dated August 11, 1999, the FAA expressed agreement with the intent of the recommendation and indicated that it would initiate an NPRM proposing revision of 14 CFR Part 121, Subparts N and O, to include the recommended training. However, the FAA took no regulatory action for more than 8 years after this safety recommendation was issued (and had never proposed revision of 14 CFR Part 135 regulations, as recommended). Thus, in October 2004, the NTSB classified Safety Recommendation A-96-120 "Open—Unacceptable Response."

Although the FAA has not taken regulatory action regarding upset recovery training, an industry team, in response to an FAA request,[71] developed an airplane upset recovery training aid designed to "increase the ability of pilots to recognize and avoid situations that can lead to airplane upsets and to improve their ability to recover control of an airplane that has exceeded the normal flight regime. This will be accomplished by increasing awareness of potential upset situations and knowledge of aerodynamics…." Although this aid was originally developed to address operations involving airplanes with 100 seats or more, the information it contains is directly applicable to most jet airplanes operating in environments similar to those used by Part 121 operators.

The airplane upset recovery training aid indicates that there are myriad potential situations that pilots can experience while flying and that pilots should first gain control of the airplane and then determine and eliminate the cause of the upset. Specifically, the aid indicates that every upset recovery should include managing the energy (airspeed), arresting any flightpath divergence, and recovering to a stabilized flightpath. The airplane upset recovery training aid also states that there "could be confusion on the flight deck as to what exactly happened to cause the original upset" and that "inappropriate control inputs during one upset recovery can lead to a different upset situation."

On January 12, 2009, the FAA issued an NPRM titled, "Qualification, Service, and Use of Crewmembers and Aircraft Dispatchers," which, if adopted as a rule, would require minimum

[71] The Upset Recovery Industry Team included representatives from airplane manufacturers, airlines, pilot associations, flight training organizations, and government and regulatory agencies. The upset recovery training aid was originally released in 1998, with a recommendation that it be incorporated into all air carrier training programs to improve aviation safety. Subsequent revisions were released in 2004 and 2008.

standards for Part 121 flight crewmember upset and loss of control training that references the airplane upset recovery training aid. The comment period for this NPRM closed on August 10, 2009. In its comments on this NPRM, the NTSB indicated that it is pleased that the NPRM includes Part 121 training on recognizing and recovering from sudden or unexpected aircraft upsets. The NTSB further noted that the special hazards training section of the NPRM addresses issues related to airplane malfunctions and human performance. However, the NTSB's response stated that similar action for Part 135 operators will be needed before Safety Recommendation A-96-120 can be classified "Closed—Acceptable Action."

### 1.18.2 FAA Check Airman Appointment Information

According to FAA Order 8900.1, Flight Standards Information Management System, Chapter 20, titled, "Check Airman, Instructor, and Supervisor Programs for 14 CFR Parts 121 and 135 Certificate Holders," a check airman is an airman who is approved by the FAA to perform the following functions for an operator: 1) ensure that a flight crewmember has met competency standards before that crewmember is released from training, and 2) ensure that those standards are maintained while the crewmember remains in service with the operator. According to the provisions of 14 CFR Part 135, a check airman is authorized to conduct proficiency or competency checks, line checks, and special qualification checks and to supervise the initial operating experience training within the operator's approved program.

According to FAA Order 8900.1, the check airman appointment process consists of the following five phases:

1) Operator familiarization with check airman requirements. (A check airman candidate must have the appropriate training, experience, and demonstrated ability to evaluate and to certify the knowledge and skills of other company airmen. Additionally, a check airman candidate must have achieved and maintained a favorable record as a flight crewmember.)

2) The operator submits the appropriate nominating documentation to the FAA.

3) The FAA reviews the nominating documentation.

4) The FAA evaluates the check airman candidate.

5) If appropriate, the FAA approves the check airman candidate for check airman status.

FAA Order 8900.1 specifically stated that the approving POI will verify the check airman candidate's pilot certificates and background using the Flight Standards Information System and that all required training must have been satisfactorily completed. Order 8900.1 does not contain any guidance regarding POI actions in the event that the background check contained negative information. However, the guidance stated that, once approved, a check airman's manner and professional reputation should always reflect positively on the operator and the FAA.

### 1.18.3 Related Wiring Issues and Cessna Service Bulletin

Postaccident review of Marlin Air's maintenance documents for its other Citation revealed a repair similar to those observed on the ribbon cables recovered from the accident airplane's control column shafts. Subsequent interviews with avionics technicians and the NTSB's review of related FAA service difficulty reports revealed that similar repairs to address damaged wiring/cables in control column shafts were common.

At its widest point, the control yoke mounting shaft had an inside diameter of 0.625 inches. At that same point, the shaft had two 0.187-inch diameter bolts passing through it in a cross, which effectively reduced the inside diameter to less than 0.3 inch. (See figure 7 in section 1.12.2.1.) There was no chafe protection or physical restraint for the wires where they passed by the bolts. The design of the ribbon cable installations required lengthwise folds to fit past the bolts in the shaft, as was the case in the accident airplane. The wires within the control yoke shaft would not have been visible to flight crews or even to maintenance personnel without extensive disassembly.

As a result of previous reports of failures of the wiring within Cessna Citations control column shafts, Cessna issued Service Bulletin (SB) 550-24-14, on January 17, 1992, advising Citation operators to replace the flat ribbon cable installed inside the control column shafts (which were found folded and damaged in the accident airplane control column) with a rounded type of sheathed wire bundle that would fit better and be better protected within the shaft. SB 550-24-14 had not been accomplished on the accident airplane. Compliance with SBs (which are issued by the manufacturer) is not mandatory as is compliance with FAA-issued ADs. According to FAA personnel, the agency did not issue an AD on this issue because it considered wiring short circuits a minor recurring service issue and because an unlikely double failure (for example, short circuits on the power and ground paths) would be necessary to elevate the problem beyond what it considered to be a nuisance level.

According to Cessna representatives, after SB 550-24-14 was issued, Cessna had received seven customer reports of short circuits and cut wires in bundles of original control column wiring in various Citation models.

### 1.18.4 Aileron Trim Requirements

Federal regulations require "powered" trim systems—systems in which an electric or hydraulic motor can drive the trim surface deflections—to be protected against the possibility of a runaway trim condition. AC 25-7A, "Flight Test Guide for Certification of Transport Category Airplanes," provides guidance for demonstrating compliance with aileron trim system design standards. According to AC 25-7A, the aileron flight control forces experienced by the pilot must not exceed those defined in 14 CFR 25.143(d): 50 pounds for temporary application and 5 pounds for prolonged application.

Because the Citation 550 aileron trim is an "unpowered" system (meaning that the only means of deflection are the manual inputs made by the pilots), the FAA does not require tests of surface deflections during airplane certification activities. However, during postaccident flight tests conducted in July 2007, pilot control wheel forces in excess of 50 pounds were recorded when only 50 percent of the available aileron trim was applied at an airspeed of 250 knots. Cessna estimated that full aileron trim input would have resulted in pilot control wheel forces in excess of 150 pounds.

### 1.18.5 Previous Citation 550 Aileron Trim Events

The NTSB's investigation revealed several instances in which other Citation 550 pilots have experienced aileron trim-related control problems, as shown in the following examples:

1) The owner of the accident airplane told a NTSB investigator that when he flew the accident airplane just after maintenance a few months before the accident, control of the airplane during the takeoff roll and departure was "very challenging" even though the trim indicators appeared at first to be centered. He stated that he was able to counteract the challenging control forces by adjusting the aileron trim control knob and complete the flight without further incident. However, he noted that relatively minor adjustments of the aileron trim wheel resulted in control inputs that could be challenging to control and stated that those inputs would have been harder to control as the airplane's speed increased.

2) On August 27, 2007, the pilots of a Cessna Citation declared an emergency and received vectors back to the departure airport after experiencing an uncommanded right roll during climbout. The captain reported that he had to use substantial pressure, using both of his hands and assistance from the first officer, to correct the uncommanded roll. A postflight inspection revealed that a mistrim in the roll axis resulted in an uncommanded roll at high speed when the autopilot disengaged.

# 2. Analysis

## 2.1 General

The captain and first officer were properly certificated and qualified under federal regulations to act in their respective roles during the accident flight. There was no evidence of any medical conditions that might have adversely affected the pilots' performance during the accident flight.

Although the captain's pilot certificates had previously been revoked because of a felony conviction involving the illegal transport of drugs into the United States, the FAA had reissued his pilot certificates, and they were valid at the time of the accident.

The accident airplane was properly certificated, was equipped and maintained in accordance with industry practices (except for the wiring installed in the pilots' control yokes), and was within weight and cg limits. Evidence of preimpact electrical failures in the first officer's control yoke is discussed in section 2.2.2.2.

The following analysis discusses the accident flight, including possible accident scenarios; pilot actions and coordination; image recording equipment on airplanes not equipped with FDRs; autopilot panel design; control yoke wiring installations; identification of circuit breakers for use in emergencies; aural and visual alerts to pitch trim-in-motion; aileron trim power and sensitivity; FAA appointment of check airmen; the scope of RASIP inspections; avenues for expressing safety concerns to federal authorities; and the safety ramifications of an operators' financial health.

## 2.2 Accident Flight Sequence

According to the CVR recording, the captain recognized a flight control problem almost immediately after takeoff from MKE (about 1557:35), as he began to turn right from the runway heading of 009° toward the assigned departure heading of 050°. Beginning about that time (1557:51), the CVR recorded repeated comments indicating that the captain was struggling with a flight control problem. The captain repeatedly stated that he was "fighting the controls" (about 1557:51; 1557:57; 1558:07) and confirmed with the first officer that the landing gear had been retracted (about 1558:03). About 1558:21, the captain again stated that he was "fighting the controls," this time adding, "It wants to turn hard left."

The captain allowed the airplane to accelerate and climb after takeoff consistent with the airplane's assigned departure heading and altitude while he and the first officer tried to troubleshoot the control anomaly. Comments recorded by the CVR indicated that the pilots did not consult an emergency or abnormal procedure checklist.[72] Further, CVR evidence indicated that, on at least one occasion, it is likely that the first officer made an unrequested trim input. About 1559, at the captain's request, the first officer advised MKE air traffic controllers that they had a control problem and would be returning to the airport. For the remainder of the flight, the CVR recorded both pilots communicating on the radio. The CVR also recorded several instances in which the captain asked the first officer to help him maintain control of the airplane; the last such instance occurred about 1600:36, when the captain asked the first officer to hold the airplane's flight controls so that he could try to pull circuit breakers. The last radar return was recorded moments later (just before 1601), about 8 to 9 seconds before the airplane hit the water in a steep nose-down, left-wing-low attitude.

### 2.2.1 Possible Initiating Event Accident Scenarios

The NTSB evaluated several possible explanations for the initiating event experienced by the pilots and found that two of those possible explanations were most consistent with the abnormal control situation: 1) an inadvertent autopilot engagement, or 2) a runaway electric pitch trim. Examination of the available evidence, including the items described below, both supports and contradicts these scenarios.

Without an FDR or image recorder on board, it was not possible to determine the exact cause of the initiating event or the pilots' actions during the accident sequence. If the accident airplane had been equipped with crash-protected data- or image-recording equipment,[73] the NTSB would also have had useful information regarding many other unresolved issues in this accident, including whether checklists were silently followed (partially or completely), whether and when the trim controls were used, and any other actions and flight control movements made by the pilots during the event. In Safety Recommendation A-09-11, issued in January 2009 as a result of the July 27, 2007, midair collision involving electronic news gathering helicopters in Phoenix, Arizona,[74] the NTSB addressed the need for image recording equipment on aircraft that are not required to be equipped with an FDR and are operating under 14 CFR Part 135 (such as the accident airplane). In its April 17, 2009, response letter, the FAA described its participation in two studies that evaluated the installation of image recorders on an airplane and a flight simulator. Based on the results of these studies, the working group developed EUROCAE document ED-155, "Minimal Operational Performance Specification for Lightweight Flight Recorder Systems," which was published in August 2009. Pending the FAA's issuance of a TSO that includes the specifications outlined in ED-155, Safety Recommendation A-09-11 is classified "Open—Acceptable Response." The NTSB concludes that if the accident airplane had been equipped with a recorder system that captured cockpit images and parametric data,

[72] The pilots could have consulted the autopilot hardover or jammed elevator trim tab checklists, which would have called for pressing the autopilot/trim disengage switch or maintaining a reduced airspeed, respectively. There was no specific rudder-related emergency or abnormal procedure checklist.

[73] The airplane involved in the Milwaukee accident was not required to have an FDR or image recorder installed; however, it would have been subject to the requirements for a cockpit image recorder had the FAA implemented previous safety recommendations.

[74] For additional information, see *Midair Collision of Electronic News Gathering Helicopters, KTVK-TV Eurocopter AS350B2, N613TV, and U.S. Helicopters Eurocopter AS350B2, N215TV, Phoenix, Arizona, July 27, 2007,* Aviation Accident Report NTSB/AAR-09/02 (Washington, DC; National Transportation Safety Board, 2009).

investigators would have been better able to determine the circumstances that led to this accident.

#### 2.2.1.1 Inadvertent Autopilot Engagement Scenario

The NTSB considered the possibility that the autopilot was inadvertently activated instead of, or at the same time as, the yaw damper, initiating the accident sequence. As previously noted, the autopilot and yaw damper engage buttons are identical and are located adjacent to each other on the autopilot console, and anecdotal evidence indicates that inadvertent activation of the autopilot when activation of the yaw damper is intended is not an uncommon occurrence.[75] If the first officer had inadvertently engaged the autopilot instead of the yaw damper (which is not inconsistent with his limited proficiency in the accident airplane) and the situation went unnoticed (and, therefore, uncorrected) by the captain, the autopilot would have tried to hold the heading and climb pitch attitude on which it was engaged; the associated heading was likely on or about the runway's magnetic heading of 009°. The autopilot inputs would result in a control wheel force toward that heading whenever the pilots tried to turn the airplane in a different direction.

It is likely that, at some time during the accident sequence, the first officer manipulated the aileron and/or rudder trim in an effort to help the captain with the control problems he was experiencing. The CVR recorded several trim-related comments made by the first officer.[76] The last of these comments, "how's that. Any better?" occurred about 90 seconds after takeoff and after the captain complained about the trim and could plausibly have referred to an effort he made to assist the captain. The NTSB's airplane performance study indicated that the airplane banked sharply after this statement. The CVR then recorded a grunting noise made by the captain, and the performance study indicated that the airplane subsequently returned to its previous heading. The CVR evidence indicates that the pilots did not coordinate with each other regarding trim inputs, and it is likely that the first officer's trim inputs aggravated, rather than ameliorated, the situation. Almost immediately, the captain told the first officer to advise ATC that they were returning to MKE. (Pilot coordination will be discussed in section 2.3.)

Because the captain would normally have hand-flown the initial portion of a flight, he would not have expected the autopilot to be engaged. Additionally, because he did not request trim adjustments, the captain would not have anticipated having to counter trim-related forces while haphazardly troubleshooting the problem. As a result, the captain's troubleshooting during the accident sequence was confused. According to the NTSB's performance study, the lateral and directional handling problems that would result from inadvertent autopilot activation and mistrim under these circumstances would result in control forces that were light at first and larger as the airplane accelerated and turned further from the runway extended centerline heading. The effects

[75] The Citation 550 pilots involved with the simulator testing during the investigation stated that each, at one time in their careers, had inadvertently pushed the autopilot instead of the yaw damper buttons.

[76] About 35 seconds after takeoff, after the captain made his third mention of an unspecified control problem, the first officer stated, "how's your trim set? Is that the way you want it?" About 12 seconds later, after the captain stated that the airplane wanted to "turn hard left," the first officer asked, "how's your trim down here?" Finally, about 1 ½ minutes after takeoff, the first officer asked, "how's that, any better?"

of the autopilot turning the airplane toward the runway's magnetic heading and the forces resulting from the mistrimmed condition ultimately would have demanded strenuous inputs from both pilots to maintain control.

The performance study results were consistent with many aspects of this interpretation of the accident sequence. For example, the captain first complained of a control problem just moments after the airplane would have begun to turn from the initial autopilot engagement heading in accordance with the departure clearance, when an inadvertently activated autopilot would have been trying to return the airplane to the initial autopilot engagement heading. About 1 1/2 minutes later, after the control problem had escalated (likely as a result of the first officer's trim inputs and the captain allowing the airplane to accelerate while he dealt with the unidentified control problem), the captain decided to declare an emergency and return to MKE. The final loss of control began about 1 minute later, just after the captain transferred the controls to the first officer to look for the autopilot circuit breaker. The performance study showed that the transfer of control occurred when the airplane was heading back towards MKE and passed through and moved away from the autopilot engagement heading, which, according to this scenario, would have resulted in dynamically changing forces on the control wheel as the autopilot reversed the direction of its input in an attempt to return to the runway heading.

Other evidence was inconsistent with this scenario, however. For example, examination of the recovered autopilot servomotor clutches and the unstretched filaments in the cockpit autopilot-engaged light bulb (which was not illuminated at impact) suggested that, although the autopilot did have power at impact, it was likely not engaged at impact.[77] Some stretching was observed in the yaw-damper-engaged bulb filaments. If the autopilot had been engaged, similar stretching should have been observed in the autopilot-engaged bulb filaments.

#### 2.2.1.2 Runaway Pitch Trim Scenario

Because of evidence of short circuits in the first officer's control column wiring that could have affected the airplane's pitch trim, the NTSB also considered the possibility that a runaway pitch trim resulted in uncommanded nose-down inputs,[78] initiating the accident sequence. This scenario interprets the captain's reactions as consistent with an increasing control force and efforts to decrease that force. These efforts would have been complicated by the first officer's trim inputs. Actuation of the accident airplane's electric pitch trim required completion of circuits providing power to the motor and to a ground path. Wreckage examination did reveal physical evidence that, sometime before impact, at least two short circuits occurred in a bundle of wires in the first officer's control yoke/column. Investigators also found evidence of heat

[77] Examination of the autopilot servomotor clutches indicated that they were not engaged at impact. Manufacturer testing showed that new servomotor clutches disengage within about 50 milliseconds, which was within the estimated 85 milliseconds that elapsed during the impact sequence. However, the servomotor clutch disengage times would degrade with time and use; therefore, it is likely that the accident airplane's servomotor clutches would take longer than 50 milliseconds to disengage.

[78] Physical evidence indicated that the airplane's pitch trim was in the full nose-down position at impact. Because an engaged and normally functioning autopilot can also provide inputs to the electric pitch trim motor, this evidence could be consistent with either scenario.

damage consistent with the short circuits and chafing on some of the wires in this area.[79] One of the short circuits occurred between the pitch trim power supply wire and the adjacent steel surface of the first officer's control yoke shaft;[80] the recovered wires were chafed around the area where the exposed wire had become welded to the steel of the control shaft. This short circuit exposed the cores of multiple wires, providing a potential source of power to the pitch trim motor. This short circuit would also have caused the pitch trim circuit breaker to trip, which would render the electric pitch trim system unavailable for normal use by the pilots. Because the CVR recorded no pitch-trim-related complaints by the pilots during their approach to MKE, it is likely that this short circuit occurred after the pilots' last use of the electric pitch trim during the airplane's landing at MKE.

Examination of the wreckage also revealed that a contact in one of the two switches in the first officer's pitch-trim control was bent inward, eliminating the space between it and the center reed. In normal pitch trim operations, the center reed moves outward and contacts the fixed contact to complete the ground path circuit; this condition might have provided the pitch trim motor with the nose-down latent ground path. (Impact damage precluded positive identification of the ground path.)

Other evidence is inconsistent with this scenario. For example, previous NTSB investigations involving pitch control problems[81] indicate that pilots are typically immediately aware of the nature of pitch-related problems and struggle to keep the airplane upright.[82] Because the captain would have routinely adjusted the pitch trim with each configuration change and in response to any unwanted trim forces experienced during departure, it is likely that he would have recognized a runaway pitch trim situation shortly after it began. Further, in this scenario, the pilots would have been struggling to keep the airplane from nosing over during the accident flight, yet there was no specific reference to "pitch" or "pull" by either pilot until about 5 seconds before impact.

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[79] Evidence and maintenance records showed at least two instances in which the wires in the first officer's control yoke/column had been previously repaired.

[80] There was also evidence of a short circuit on the power wire for the autopilot clutches.

[81] For example, see (a) *Loss of Control and Impact with Pacific Ocean, Alaska Airlines Flight 261, McDonnell Douglas MD-83, N963AS, About 2.7 miles north of Anacapa Island, California, January 31, 2000,* Aircraft Accident Report NTSB/AAR-02/01, (Washington, DC: National Transportation Safety Board, 2002); (b) *Loss of Control on Takeoff, Emery Worldwide Airlines, Flight 17, McDonnell Douglas DC-8-71F, N8079U, Rancho Cordova, California, February 16, 2000,* NTSB/AAR-03/02 (National Transportation Safety Board: Washington, DC, 2003); (c) Colgan Air (dba USAirways), Beechcraft 1900D, N240CJ, Yarmouth Massachusetts, August 26, 2003, NTSB/AAR-04/01 (National Transportation Safety Board: DC, 2001); and (d) *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 (National Transportation Safety Board: DC, 2004); (e) The factual report and probable cause statement for a September 1, 2008, accident (NTSB identification number CHI08MA270), available on the NTSB website at <http://www.ntsb.gov/ntsb/query.asp>.

[82] In addition, during investigation-related simulation sessions, pilots indicated that a natural first response to a pitch-related problem would be to press the autopilot/trim disconnect button. No autopilot disconnect chime was recorded by the CVR.

#### 2.2.1.3 Accident Scenario Analysis and Discussion

Although these two scenarios were the most likely explanations for the initiating flight control event, neither scenario was completely consistent with the investigative evidence. Therefore, the NTSB concludes that the accident sequence initiated as a result of a control problem that was related to either an inadvertent autopilot activation or a pitch trim anomaly, the effects of which were compounded by aileron and/or rudder trim inputs; however, it was not possible to determine the exact nature of the initiating event.

Regardless of what the initiating event was, evidence from Cessna flight test records, postaccident simulator tests, and the NTSB's postaccident performance study indicated that the result would have been controllable if the captain had not allowed the airspeed and resulting control forces to increase while he tried to troubleshoot the problem. Evidence showed that, despite the abnormal control situation, the captain was able to maintain control of the airplane without much exertion when the airplane was operating at a relatively slow airspeed shortly after takeoff, but he increasingly struggled as the airplane accelerated and the control forces increased. By allowing the airplane's airspeed to increase while engaging in haphazard and poorly coordinated troubleshooting efforts, the pilots allowed an abnormal situation to escalate to an emergency. Therefore, the NTSB concludes that, regardless of the initiating event, if the pilots had simply maintained a reduced airspeed while they responded to the situation, the aerodynamic forces on the airplane would not have increased significantly; at reduced airspeeds, the pilots should have been able to maintain control of the airplane long enough to either successfully troubleshoot and resolve the problem or return safely to the airport.

If the accident pilots had sought guidance for either of the potential scenarios in the airplane's checklists or manuals, they would not have found it, because no such guidance existed. However, AFM guidance for a different control anomaly (a jammed elevator trim) suggests that, in the face of an unexpected and unidentified control problem, a pilot should maintain a configuration and airspeed already proven to be controllable.[83]

In partial response to an NTSB safety recommendation issued after a series of upset-related air carrier accidents (A-96-120), an industry team developed an airplane upset recovery training aid designed to "increase the ability of pilots to recognize and avoid situations that can lead to airplane upsets and to improve their ability to recover control of an airplane…." The FAA has issued an NPRM, which,[84] if adopted as a rule, would require minimum standards for 14 CFR Part 121 flight crewmember upset and loss of control training that references the airplane upset recovery training aid. Although this aid was originally developed to address operations involving airplanes with 100 seats or more, the information it contains is directly applicable to most jet airplanes, such as the accident airplane, operating in environments similar to those used by Part 121 operators. In its comments on the NPRM, the NTSB stated that similar action for Part 135 operators will be needed before Safety Recommendation A-96-120 can be classified "Closed—Acceptable Action."

[83] The Citation 550 AFM guidance for a jammed elevator trim condition during takeoff condition advised pilots to maintain an airspeed of 120 knots or less, not to change the airplane's configuration, and to land as soon as practical. Given enough time, the pilots might have consulted the AFM and discovered this procedure.

[84] The NPRM was issued on January 12, 2009, and comments were due by August 10, 2009.

The NTSB recognized that although pilots receive unusual attitude and upset training during all phases of basic pilot training, pilots would benefit from additional and recurrent training related to airplane attitudes and/or control system failures not normally associated with air carrier flight operations.

Therefore, the NTSB concludes that pilots would benefit from training and readily accessible guidance indicating that, when confronted with abnormal flight control forces, they should prioritize airplane control (airspeed, attitude, and configuration) before attempting to identify and eliminate the cause of the flight control problem. Therefore, the NTSB recommends that the FAA require all 14 CFR Part 91K and Part 135 operators to incorporate upset recovery training (similar to that described in the airplane upset recovery training aid used by many Part 121 operators) and related checklists and procedures into their training programs.

Investigation of both possible initiating event scenarios identified safety issues that will be discussed in the remainder of this report.

### 2.2.2 Safety Issues

#### 2.2.2.1 Autopilot Panel Design

As previously noted, the yaw damper and autopilot engage buttons are identical in size, shape, type of operation (on/off pushbutton), and amount of force necessary to activate. Further, because of their physical location (adjacent to each other near the aft end of the cockpit center console, out of a pilot's normal field of vision), the difference between the yaw damper and autopilot engage buttons may not always be readily apparent to pilots.

Anecdotal evidence indicates that inadvertent activation of the autopilot when attempting to engage the yaw damper is not an uncommon occurrence. This would especially be of concern during times of competing visual demands and high pilot workload, such as takeoffs and landings. As discussed in section 2.2.1.1, if the first officer had inadvertently activated the autopilot when intending only to activate the yaw damper, it would likely have resulted in unanticipated, and possibly dramatic, consequences.

FAA airworthiness standards require cockpit controls to be located and identified to prevent confusion and inadvertent operation. Additionally, human factors engineering principles indicate that, in a well-designed control system, every control must be detectable and discernable from other controls. The current design configuration of the Citation yaw damper/autopilot control push-button switches appears contrary to this standard. The switches present identical size, texture, mode of operation (on/off pushbutton), and actuation pressure to the pilot. Further, they are located immediately adjacent to each other, outside of the pilots' normal range of vision, without an intervening divider or partition. In periods of high workload or other distractions, a pilot might be inclined to activate the yaw damper by feel and location; under such circumstances, it would be easy for a pilot to select the wrong switch.

The NTSB concludes that the design and location of the yaw damper and autopilot switches on Cessna Citation series airplanes do not adequately protect against inadvertent activation of a system, which could have disastrous consequences. Therefore, the NTSB recommends that the FAA require Cessna to redesign and retrofit the yaw damper and autopilot switches on the autopilot control panel in Citation series airplanes to make them easily distinguishable and to guard against unintentional pilot activation. Further, because other airplanes may be equipped with similarly designed autopilot control panels and, therefore, may also be susceptible to inadvertent autopilot activation,[85] the NTSB recommends that the FAA identify airplanes other than the Cessna Citation with autopilot control panel designs that may lead to inadvertent activation of the autopilot and require manufacturers to redesign and retrofit the autopilot control panels to make the buttons easily distinguishable and to guard against unintentional activation.

#### 2.2.2.2 Airplane Wiring

This investigation revealed documentation of previous instances in which the Cessna Citation series of airplanes had experienced failures of the wiring within the control column shafts.[86] As a result of these wiring failures, Cessna issued SB 550-24-14 on January 17, 1992, advising Citation operators to replace the flat ribbon cable installed inside the control column shafts with a rounded type of sheathed wire bundle that would fit better and be better protected within the shaft. None of the accident airplane’s owners and/or operators since SB 550-24-14 was issued had accomplished the replacement suggested in SB 550-24-14; compliance with SBs is not mandatory. The flat ribbon cable installed in the accident airplane’s control column shaft was found in the wreckage, folded and damaged, with evidence of prior repairs.

According to Cessna representatives, after SB 550-24-14 was issued, Cessna had received numerous customer reports of short circuits and cut wires in control columns in various Citation models. In each case where sufficient data were available, analysis indicated that the actions suggested in SB 550-24-14 would likely have alleviated the situation. The NTSB concludes that a rounded type of sheathed wire bundle would fit better and be better protected within the control column shaft than the currently installed flat ribbon cable; replacement of the flat ribbon cable with a rounded type of sheathed wire bundle could result in fewer short circuits and other electrical events. Therefore, the NTSB recommends that the FAA issue an AD mandating compliance with Cessna SB 550-24-14, “Control Wheel Electrical Cable Replacement,” which was issued on January 17, 1992.

[85] For example, the NTSB’s investigation of the October 25, 2002, accident involving a King Air A100 in Eveleth, Minnesota, revealed that, on a previous flight, the King Air’s pilot had inadvertently activated the autopilot instead of the yaw damper after takeoff, which resulted in an abrupt nose-down pitch.

[86] Review of documentation for these other instances revealed that in some cases multiple wires were damaged; however, there was no documentation of a dual failure (as may have occurred on the accident airplane) or resulting inappropriate pitch trim function.

#### 2.2.2.3 Runaway Pitch Trim

The NTSB's accident and incident database contains at least eight accidents involving Cessna Citation pitch trim or related failures. For example, the NTSB previously addressed runaway pitch trim issues as a result of the July 22, 2003, accident involving a Citation 525 that ditched in the waters of Penn Cove, Coupeville, Washington, after a loss of elevator trim control that resulted in an uncommanded nose-down pitch attitude. Based on this accident, the NTSB issued Safety Recommendations A-07-52 and -54, asking that the FAA require Cessna to equip its Citation 525 airplanes with an aural trim-in-motion warning, better visual trim-in-motion cues (for example, contrasting color bands) on the pitch trim wheel, and collars on the pitch trim and autopilot circuit breakers to provide pilots with the means for recognizing and correcting a runaway pitch trim condition before control forces become unmanageable. (Postaccident examination of Marlin Air's other Citation 550 revealed that it had identification collars on the starter and alternating current inverter circuit breakers, but not on the pitch trim or autopilot circuit breakers. Investigators also noted that the Citation's uncollared circuit breakers were difficult to grasp and pull and that the circuit breakers with identification collars were much easier to grasp and pull.)

In its response letter, dated November 20, 2007, the FAA indicated that it believed that the combination of the normal cues of undesired trim motion and the issuance of AD 2004-14-20 (which addressed the specific single-point failure mode identified in the Penn Cove accident investigation by requiring the replacement of the trim printed circuit board) correct the unsafe conditions identified during the investigation of the July 22, 2003, Penn Cove accident, rendering the action recommended in Safety Recommendation A-07-52 unnecessary. The NTSB's June 11, 2009, response letter disagreed with the FAA's position, stating that, had the Penn Cove pilot received conspicuous warning of the pitch trim runaway condition earlier in the accident sequence, he would have been able to complete the related checklist procedure and pulled the pitch trim circuit breaker before the pitch control forces became unmanageable. Therefore, on June 11, 2009, the NTSB classified Safety Recommendation A-07-52, "Open—Unacceptable Response."

The NTSB notes that not only has the runaway trim problem not been satisfactorily addressed with regard to the Citation 525 model airplane involved in the Penn Cove accident, it also exists in other Citation model airplanes, such as the Citation 550 involved in the MKE accident. In a representative airplane, investigators observed that the movement of the large, black pitch trim wheel, which was located on the left side of the throttle console adjacent to the captain's right leg, was not always apparent. The addition of contrasting color bands, as recommended in Safety Recommendation A-07-52, would facilitate a pilot's recognition of the wheel's movement during a runaway pitch trim situation. Additionally, if a pitch trim anomaly were the initiating event in either the Penn Cove or MKE accidents, an aural trim-in-motion warning would have allowed the pilots to promptly identify the nature of the problem and correct it.[87]

[87] An aural pitch trim-in-motion would also have been recorded by the CVR and, therefore, would have benefited the accident investigation as well.

Therefore, the NTSB concludes that the incorporation of an aural pitch trim-in-motion warning and contrasting color bands on the pitch trim wheel in all Cessna Citation series airplanes would help pilots of those airplanes to more promptly recognize and correct runaway pitch trim situations before control forces become unmanageable. Therefore, the NTSB recommends that the FAA require Cessna to modify all Citation series airplanes by incorporating an aural pitch trim-in-motion warning and contrasting color bands on the pitch trim wheel to help pilots recognize a runaway pitch trim condition before control forces become unmanageable. This recommendation supersedes Safety Recommendation A-07-52, which the NTSB reclassifies, “Closed—Unacceptable Action/Superseded.”

As an alternative response to the actions proposed in Safety Recommendation A-07-54, the FAA proposed issuing guidance recommending replacement of the pitch trim circuit breaker on the Citation 525 with a collared circuit breaker to aid the pilot in quickly identifying it if necessary. Pending the FAA’s issuance of such guidance, on June 11, 2009, the NTSB classified Safety Recommendation A-07-54, “Open—Acceptable Alternate Response.”

The MKE accident demonstrates that identification-collared circuit breakers on critical systems that a pilot might need to access during an abnormal or emergency situation would also benefit pilots operating Citation models not affected by the single-point failure identified in the Penn Cove accident. Filament analysis of autopilot computer-related annunciator lights and evidence inferred from the CVR transcript indicated that the MKE accident first officer was not able to immediately locate and identify critical (possibly autopilot and pitch trim) circuit breakers during the accident sequence. In part, this may have been due to his lack of familiarity with the airplane; however, these critical circuit breakers were not easily distinguishable from the many other circuit breakers on the panel.

As previously noted, postaccident examination of another Marlin Air Citation 550 revealed that it had identification-collared circuit breakers on the starter and the alternating current inverter. If the accident airplane had been equipped with identification-type collars on the autopilot and pitch trim circuit breakers, the accident pilots would have been better able to identify those breakers. In addition, after the pilots located those circuit breakers, the identification collars would have made the breakers easier to grasp and pull. Therefore, the NTSB concludes that if circuit breakers that a pilot might need to quickly access during an abnormal or emergency situation were equipped with identification collars, pilots would be able to locate them more readily and pull them more easily during such a situation. Therefore, the NTSB recommends that the FAA require Cessna to replace all Citation series airplanes’ pitch trim, autopilot, and any other circuit breakers for critical systems that a pilot might need to access during an emergency situation with easily identifiable and collared circuit breakers to aid a pilot in quickly identifying and easily pulling those circuit breakers if necessary. This recommendation supersedes Safety Recommendation A-07-54, which the NTSB reclassifies Safety Recommendation A-07-54, “Closed—Unacceptable Action/Superseded.”

Additionally, because pilots should be able to easily identify and pull critical circuit breakers during an abnormal or emergency situations in any airplane, the NTSB recommends that the FAA require airplane manufacturers to develop guidance on the identification of circuit breakers that pilots need to identify quickly and pull easily during abnormal or emergency situations and to provide such guidance, once developed, to operators of those airplanes. Further, the NTSB recommends that the FAA require operators to implement the manufacturer's guidance asked for in recommendation A-09-119 regarding which circuit breakers pilots need to identify quickly and pull easily during abnormal or emergency situations in their airplanes.

#### 2.2.2.4 Human Factors in Aircraft Design

Several of the safety issues identified during this investigation (the autopilot panel design and the aileron trim sensitivity are two examples) reflect a lack of attention to human/airplane system interactions that was typical when the Citation cockpit was designed and certificated. However, the aviation industry has learned much about human factors issues in the years since the Citation was certificated, and it is now clear that areas of the airplane's design would benefit from that knowledge. It is likely that many other aircraft that were designed and certificated in the last 3 decades would benefit from similar review and application of human factors principles.

In its 2006 study of the aircraft certification process, the NTSB made two recommendations (Safety Recommendations A-06-37 and -38) to the FAA concerning human/aircraft issues in the certification of aircraft. In response to these recommendations, the FAA indicated that it was incorporating more standardized consideration of human factors into new certification projects and planned to develop new regulations and advisory materials and a human factors design guide. Additionally, the FAA stated that it intended to formalize a process for monitoring and assessing safety critical systems throughout the life cycle of an airplane. Pending the FAA's related actions, the NTSB classified Safety Recommendations A-06-37 and -38, "Open—Acceptable Response" on September 12, 2007.

This accident investigation revealed numerous human factors issues with the Citation cockpit design. Although this investigation revealed that many Citation pilots were aware of some of these issues (such as the potential for inadvertently pressing the wrong button when engaging the autopilot or yaw damper), the NTSB is not aware of any plans by Cessna or the FAA to change the design to address these issues. The FAA indicated to the NTSB that it was developing guidance on human factors issues in aircraft for use by its certification staff; however, the NTSB is not aware that this new guidance has been developed and distributed, nor that it would address the many issues identified in this accident. Therefore, the NTSB concludes that the circumstances of this accident demonstrate the importance of a program for the FAA to monitor and conduct ongoing assessments of safety-critical systems throughout the life cycle of an airplane; the FAA did not perform this task adequately for the Cessna Citation. Because the numerous human factors issues identified in the accident airplane's cockpit design may have been identified and corrected if current human factors principles were applied even after certification, the NTSB reiterates Safety Recommendations A-06-37 and –38 and classifies both "Open—Unacceptable Response."

#### 2.2.2.5 Aileron Trim Sensitivity and Responsiveness

As previously noted, the Citation 550 aileron trim system is a manual (unpowered) trim system in which small inputs on the manual trim wheel in the cockpit can have a disproportionate effect on aileron movement. Additionally, the trim position indicator may not accurately reflect the aileron trim surface position.

Postaccident interviews indicated that many Citation pilots have been surprised by the disproportionate sensitivity and responsiveness of the Citation aileron trim control system. In addition, numerous Citation pilots (including the owner of the accident airplane)[88] reported problems or even declared an emergency as a result of aileron trim issues. The anecdotal evidence indicates that it is easy to set the Citation aileron trim inappropriately, possibly resulting in a hazardous out-of-trim condition. The disproportionate sensitivity and responsiveness of this system would likely have compounded any aileron trim inputs made by the first officer during the accident flight and exacerbated an already challenging troubleshooting effort.

The FAA's certification requirements contained in 14 CFR 25.143(c) protect against a trim runaway for powered surfaces (no more than 50 pounds of force for temporary applications). However, the Citation's aileron trim tab is unpowered, and the certification requirements do not protect against the forces that might result from excessive manual inputs. During accident-related flight tests, control wheel forces in excess of 50 pounds were measured when half of the available aileron trim was applied at an airspeed of 250 knots. Cessna estimated that application of full aileron trim at 250 knots would have resulted in control wheel forces in excess of 150 pounds. Therefore, the NTSB concludes that the control wheel forces resulting from adjustments to the Cessna Citation's unpowered aileron trim could exceed the control force limits specified by regulations for powered aileron trim surfaces.

The NTSB is concerned that the design of the Citation's aileron trim system allows for trim forces that far exceed those needed during an emergency, such as a loss of engine power. Additionally, because of the relative sensitivity of the small aileron trim control knob, even a small aileron trim adjustment could result in trim forces that would require excessive control wheel inputs to counteract and keep the airplane's wings level. Therefore, the NTSB concludes that limiting the deflection of the Cessna Citation's manually operated aileron trim tab to the deflection certification limit for powered trim tabs and reducing the Citation's aileron trim sensitivity (the unexpectedly significant aileron trim deflection that results from a relatively small amount of trim knob input) would help pilots avoid sudden and excessive aileron trim deflections. However, during postaccident interviews, Cessna personnel indicated that the Citation's aileron trim capability was originally designed for a failure condition, but that records from the time of the design did not identify that failure condition. Therefore, the NTSB recommends that the FAA require Cessna to evaluate and limit the maximum aileron trim deflection on Citation series airplanes to that required to meet the certification control requirements for powered trim tabs, unless there is a design-justification to exceed those requirements. In addition, the NTSB recommends that the FAA require Cessna to reduce the aileron trim sensitivity (the unexpectedly significant aileron trim deflection that results from a relatively small amount of trim knob input) on Citation series airplanes to avoid sudden and

[88] The owner of the accident airplane told investigators that months before the accident he experienced a "very challenging" aileron trim-related control situation just after takeoff during a postmaintenance flight. He stated that he was never concerned about losing control during the flight and was able to correct the situation with a half-turn of the aileron trim control wheel but added that a larger aileron mistrim would have been "really hard to control…as speed built you may not be able to [control the airplane]."

excessive aileron trim deflections. (Safety Recommendations A-06-37 and -38, reiterated in this report, address this issue for other future-built airplanes.)

These recommended changes to the Citation aileron trim system will take time to develop and implement. In the meantime, Citation pilots who are unaware of the aileron trim system's potentially excessive sensitivity and responsiveness might unintentionally exacerbate an abnormal flight control situation. The NTSB concludes that if Cessna Citation pilots and operators were informed of the potential hazards related to the sensitivity and responsiveness of the airplane's aileron trim system, they would be better able to avoid problematic aileron trim inputs until a more permanent solution (an aileron trim system retrofit) is in place. Therefore, the NTSB recommends that the FAA, as an interim measure (pending an available aileron trim system retrofit), notify Citation pilots and operators of the potential hazards related to the sensitivity and responsiveness of the airplane's aileron trim system.

## 2.3 Pilot Communications and Coordination

The CVR recorded the later portion of the flight inbound to MKE (including the approach, landing, and taxi to the FBO) and the entire accident flight. The CVR evidence showed that the captain performed the flying pilot duties during both flights and portrayed an instructor-student pilot atmosphere, with the captain routinely correcting the first officer, during both flights.[89] The CVR transcript revealed a casual and undisciplined cockpit environment during both flights, with no indication that either pilot routinely referenced checklists.

Further, neither pilot referenced a checklist for assistance in resolving the control anomaly during the accident flight. Rather, CVR evidence indicates that the pilots engaged in a haphazard and confusing troubleshooting process, which was often hindered by the pilots' inadequate coordination and communication and the first officer's lack of familiarity with the airplane. According to the CVR, when the captain decided to return to the departure airport, he stated again that the airplane was rolling on him and asked the first officer to pull the autopilot circuit breakers. The first officer could not find the circuit breakers and asked the captain where they were located. The captain did not respond to the first officer's question; instead he instructed the first officer to declare an emergency and advise ATC of their intention to return to MKE. The first officer subsequently used an incorrect aircraft call sign in his radio transmission, and the captain corrected him.

About 10 seconds before the end of the recording, the captain instructed the first officer to take control of the airplane while he, the captain, tried to pull circuit breakers. Seconds later, the captain stated, "…we're not holding it," and about 5 seconds later the recording ended. Performance data suggest that almost immediately after the first officer took control, the airplane rolled to the left and descended into the lake. It is clear that the captain had at least marginal

[89] For example, when the pilots were inbound to MKE, the captain told the first officer, "Don't hesitate to ask a question…" When the first officer began to prematurely complete the before-landing checklist, the captain told him twice to wait until he talked with the control tower. Additionally, the captain coached the first officer to get the instrument landing system approach properly displayed on his flight instruments; then, during the landing rollout, the captain stated that they would forego the use of spoilers, indicating, "I should have called for 'em. I didn't want you being confused on it." As they taxied to the FBO after landing, the captain asked the first officer to call the FBO to announce the flight's arrival; the first officer asked, "What switch do I use for com two?" The captain replied, "Number two. Turn your knob. There you go."

control of the airplane, and the airplane had successfully reversed course to return to the airport until the captain transferred control to the first officer. It is possible that the captain believed that pulling circuit breakers was the best course of action to avert a loss of control. However, the captain's efforts to maintain control of the airplane had been successful to that point, and he could have significantly eased the ongoing and increasing control problem by reducing airspeed.

The first officer provided little or no support to the captain during either flight and was arguably a distraction because the captain had to monitor the first officer's actions as well as perform flying pilot duties. In addition, as the emergency escalated, the captain began to take over the radio calls while he continued to handle the airplane and troubleshoot the control problem. Although these distractions might have been benign during a normal flight, they were critical during the accident sequence, especially the later stages. The NTSB concludes that, as a result of the first officer's poor flying skills, his lack of airplane systems knowledge, and both pilots' lack of communication and coordination, the first officer provided little help to, and likely hindered, the captain during his attempts to deal with the flight control anomalies during the accident flight.

The NTSB has repeatedly recommended that the FAA revise Part 135 requirements to require on-demand charter operators to establish an FAA-approved CRM training program for their flight crews, similar to CRM training programs required for Part 121 operators. The most recent related safety recommendation, Safety Recommendation A-03-52,[90] was added to the NTSB's Most Wanted List in November 2006. On May 1, 2009, the FAA published an NPRM in the *Federal Register* titled "Crew Resource Management Training for Crewmembers in Part 135 Operations," which proposed a rule to require all Part 135 operators to include instruction in CRM in pilot and flight attendant training programs. The proposed rule would require initial and recurrent CRM training for crewmembers working for Part 135 on-demand operators. The proposed rule also specifies the minimum course content required for an approved CRM training program. The proposed rule would also exempt operators from providing initial training to crew who have already completed training with another operator. In comments submitted to the docket for this NPRM, the NTSB stated that it was supportive of the proposed rule but not the exception because operations are sufficiently different from one another to require tailored training. The response stated that the NTSB believed that the rule, without the exception, would largely meet the intent of Safety Recommendation A-03-52.

Postaccident interviews with FAA inspectors and pilots who had previously flown with the accident pilots indicated that both pilots lacked procedural knowledge and familiarity with the airplane's systems. Several pilots who had previously flown with the first officer indicated that he did not understand airplane systems, would act without thinking, and would get overloaded easily. In addition, postaccident interviews indicated that the captain did not always adhere to procedures or comply with regulations, focused on business rather than safety concerns, and routinely abbreviated checklists. CVR evidence from the accident airplane support these assertions. Therefore, the NTSB concludes that the pilots' lack of discipline, in-depth

[90] Safety Recommendation A-03-52 was issued as a result of its investigation of the November 18, 2003, accident in which an Aviation Charter, Inc., King Air A100 airplane lost control and impacted terrain in Eveleth, Minnesota. For additional information, see Aircraft Accident Report NTSB/AAR-03/03. For information on additional CRM-related safety recommendations, see Safety Recommendations A-80-42, A-94-196, and A-02-12, which are available on the NTSB's website at <http://www.ntsb.gov>.

systems knowledge, and adherence to procedures contributed to their inability to cope with anomalies experienced during the accident flight. The NTSB further concludes that Marlin Air's selection of the accident captain (who routinely failed to comply with procedures and regulations) to the positions of company chief pilot and check airman, with responsibility for supervision and training of all company pilots, contributed to an inadequate company safety culture that allowed an ill-prepared first officer to fly in Part 135 operations.

## 2.4 FAA Oversight

### 2.4.1 Check Airman Appointment Guidance

As previously stated, the POI appointed the captain as Marlin Air's designated check airman about 2 years before the accident. The FAA defines a check airman as an airman approved by the FAA who has the appropriate training, experience, and demonstrated ability to evaluate and to certify the knowledge and skills of other airmen. The roles of a check airman, as described previously, are (1) to ensure that the flight crewmember has met competency standards before the crewmember is released from training, and (2) to ensure that those standards are maintained while the crewmember remains in line service. A check airman candidate must have achieved and maintained a favorable record as a flight crewmember. Once approved, a check airman's manner and professional reputation should always reflect positively upon the employer and the FAA.

When Marlin Air nominated the captain for check airman appointment, the POI reviewed the nomination letter and verified the captain's pilot and medical certificate qualifications as required by FAA procedures.[91] The captain was eligible under federal regulations to serve as the company's chief pilot and as an FAA-designated check airman, and the POI approved the designation. The POI stated that during his review process, he noticed that the captain had previously had his pilot certificates revoked because of a drug violation; however, the POI did not seek further information regarding the nature or circumstances of the revocation. He stated that he assumed the revocation was related to a personal issue with prescription medications. The POI further stated that he did not believe it would be necessary for him to pursue the issue because the FAA had reviewed the situation and reissued the captain's pilot certificates. FAA guidance regarding appointment of check airmen requires POIs to verify the check airman candidate's "certificates and background." Additionally, all required training must be completed, and the airman's training records must show satisfactory completion of initial, transition, or upgrade training, as applicable. The guidance does not specifically address POI actions when the background evaluation discloses negative information. This lack of guidance can result in the

[91] In October 1986, as a result of its investigations into three commuter air carrier accidents, the NTSB issued Safety Recommendation A-86-108, asking the FAA to issue guidance regarding oversight of check airmen to all POIs for Part 135 operators. In response to this recommendation, on August 31, 1990, the FAA issued change 4 to its Handbook 8400.10, "Air Transportation Operations Inspector's Handbook." This change contained specific direction and guidance concerning the check airman program for Part 121 and 135 operators, including the role and purpose of the check airman, the regulatory requirements, qualifications, functional responsibilities, and the approval process and training requirements for check airmen. In March 1991, the NTSB classified Safety Recommendation A-86-108, "Closed—Acceptable Action."

appointment of check airmen who do not adhere to standards, possibly jeopardize flight safety, and generally do not represent the FAA well (as was the case with the accident captain).

The FAA could address this issue by establishing procedures requiring POIs to provide heightened surveillance during a probationary period (and at other times if deemed necessary based on routine surveillance) for any check airman whose background or performance reveals negative information. The heightened surveillance would provide a check airman with an opportunity to demonstrate that they had reformed and would represent the FAA well, while providing the approving POIs with an opportunity to scrutinize the individuals' manner and performance to ensure that they are consistent with the FAA's standards for check airmen. In this case, the captain might have established the habit of operating according to proper standards as a check airman because he was aware of the scrutiny, or the POI might have noticed the captain's tendency to be slipshod and rescinded the check airman appointment.

The NTSB concludes that if the FAA guidance regarding check airman appointments and oversight contained procedures for POIs to follow (such as heightened surveillance) in cases where review of the pilot's background or performance reveals negative information, checkride failures, or other performance-related deficiencies, the agency might prevent inadequate and/or undisciplined pilots from being appointed or retained as check airmen. The NTSB therefore recommends that the FAA revise check airman approval and oversight procedures to incorporate heightened surveillance during a probationary period and at other times, as warranted, for check airmen whose background evaluation uncovers a history of criminal convictions, certificate revocations, check-ride failures, or other performance-related deficiencies.

### 2.4.2 Regional Aviation Safety Inspection Program Guidance and Procedures

The FAA's postaccident RASIP of Marlin Air involved an inspection team that included three inspectors from the FAA's Great Lakes Regional office and the three principal inspectors assigned to the operator at the time of the accident. The Marlin Air RASIP team leader told NTSB investigators that RASIP inspections were not intended to assess the quality or adequacy of the principals' oversight, but rather to provide additional surveillance of the operators. In the case of the Marlin Air RASIP, the FAA decided to include the principal inspectors on the RASIP team because their familiarity with the operator's policies and procedures could facilitate the inspection.

The Marlin Air RASIP was focused on the operator's policies and procedures, including training. Because Marlin Air's operations had been suspended at that time due to the accident, the RASIP team did not interview any company line personnel, but rather coordinated with the director of operations and the assistant chief pilot. The inspection revealed one finding related to operation of an airplane requiring two pilots under the operations specifications by only one pilot.[92]

[92] As previously noted, the only other recent FAA inspection of Marlin Air was an OSIP that was accomplished in March 2002, more that 5 years before the accident. The OSIP findings were minor and were immediately corrected by Marlin Air.

Although the RASIP report indicated that the team reviewed training records for all Marlin Air pilots, Marlin Air personnel advised the RASIP team that the only copies of the accident pilots' records had been furnished to NTSB investigators. Because Marlin Air did not retain copies of the pilots' records (or obtain copies from the NTSB to fully comply with the RASIP team's request), these records were not available for the RASIP team's review. Yet the RASIP team's report indicated that "records for all pilots were reviewed," and issued no adverse findings. The RASIP report did not qualify its findings by indicating that some of the pilot records were not reviewed nor did it indicate that the team was unable to assess Marlin Air's day-to-day operations because the company's operations were suspended after the accident. Furthermore, it is understandable that the RASIP report did not reveal the training form irregularities for the first officer's recent checkride approval if the inspection team had no information regarding him; however, it is not clear why the RASIP investigators did not discover the irregularities in two recent checkride forms pertaining to other Marlin Air pilots, irregularities that were subsequently discovered during the NTSB's investigation.

The NTSB has previously issued safety recommendations reflecting its concerns about the quality of inspections conducted by the FAA, repeatedly recommending that the FAA issue formal documentation to ensure consistent and continued implementation of these policies. The most recent of these recommendations, Safety Recommendation A-05-08, was issued in April 2005, as a result of a fatal accident involving an Air Sunshine Cessna 402C. In response to Safety Recommendation A-05-08, the FAA's southern region conducted a focused oversight inspection of Air Sunshine. As a result of that inspection, the FAA revised its oversight of Air Sunshine and revised several related sections of FAA Order 8900.1. On August 27, 2009, the NTSB classified Safety Recommendation A-05-08, "Closed—Acceptable Action."

The NTSB concludes that the RASIP inspection conducted after this accident failed to uncover evidence of training irregularities and did not evaluate the quality of FAA surveillance provided before the accident. Therefore, the NTSB recommends that the FAA conduct a detailed review of the oversight provided to Marlin Air to determine why the oversight system failed to detect (before and after the accident) and correct Marlin Air's operational deficiencies, particularly in the areas of pilot hiring, training, and adherence to procedures. Further, the NTSB recommends that the FAA, based on the review described in Safety Recommendation A-09-125, revise the oversight system and FAA Order 8900.1 as needed.

### 2.4.3 Mechanisms for Alerting the FAA to Potential Operator Problems

Complaints from outside the FAA may alert the FAA to a variety of operator-related safety issues that the FAA can pursue through a formal investigation or increased oversight. This investigation revealed that although UM Survival Flight program personnel had felt comfortable with Marlin Air for most of the 19 years they had contracted with the operator, UM personnel had increasing reservations regarding Marlin Air's operations in the couple of years preceding the accident. UM personnel stated that they began to hear complaints about Marlin Air and their pilots and had concerns related to the number of Marlin Air flights cancelled due to mechanical issues. According to the UM program manager, the number of trip cancellations had increased in the year preceding the accident and medical personnel were beginning to think that Marlin Air was unsafe. However, UM personnel did not relay any of these concerns to the FAA before the accident because they were not aware of the FAA safety hotline or other methods by which they might make their concerns known.

An FAA representative of its Executive Office for Flight Standards stated that there were several FAA programs that might have been beneficial to the UM personnel in raising safety concerns. These included the Customer Service Initiative administered through the local FSDO or regional offices, the Safety Hotline administered by the Office of Accident Investigation, and the Administrator's Hotline. Had the FAA been aware of UM's concerns, FAA staff could have responded with increased oversight or a formal investigation.

The NTSB concludes that customers (such as UM) who contract with aviation operators may not understand the FAA's role in aviation safety or know how to contact FAA personnel when safety concerns arise. Therefore, the NTSB recommends that the FAA require all 14 CFR Part 135 and Part 91K operators to provide their customers, when a business agreement or contract is finalized, with FAA contact information identified as specifically for use in expressing concerns about flight safety thus providing customers with a clear means of communicating any safety concerns to the FAA.

The American Hospital Association (AHA) is another source for updated medical/air ambulance industry information.[93] AHA currently has more than 37,000 health care members and routinely publishes newsletters addressing current healthcare issues. The NTSB recommends that AHA inform its members, through its website, newsletters, and conferences, of the FAA's role in aviation safety with respect to medical/air ambulance services and provide FAA contact information. Further, AHA should urge its members to communicate any safety concerns related to medical/air ambulance services to the FAA.

## 2.5 Operators with Financial Difficulties

Marlin Air exhibited many signs of financial difficulties before the accident. For example, about 7 months before the accident, a court judgment was entered against Marlin Air for nonpayment of hangar rent. The company made an initial payment against the rent due but subsequently defaulted on the second payment. Additionally, a supplier that had previously provided Marlin Air with fuel on a contract basis terminated its contract with the company about 2 to 3 years before the accident because the operator fell behind in account payments. Another fuel supplier terminated its credit arrangement with Marlin Air due to nonpayment but continued to provide fuel, with payment required at the time of purchase.

Postaccident interviews and CVR evidence showed that the captain occasionally focused on business issues at the expense of flight safety. For example, as previously stated, the captain intentionally took off, and subsequently landed, in an airplane that was loaded beyond allowable takeoff and landing weight limits because he was "tankering" inexpensive fuel to avoid paying for more expensive fuel elsewhere. In addition, CVR evidence showed that, during the accident airplane's approach to MKE in marginal weather conditions, the captain advised the first officer

[93] The AHA is the national organization that represents and serves all types of hospitals, health care networks, and their patients and communities.

not to ask for current weather information. Although asking for the most current weather conditions immediately before an instrument approach is not required by regulation, a specific decision not to do so is consistent with a willingness to attempt an approach to an airport that may be below minimums, thus decreasing the level of safety for the operation. Concerns about the cost of a go-around or diversion to another airport might have played a part in that decision.

The UM program manager stated that the financial condition of Marlin Air appeared troubled before the accident because requested upgrades were not accomplished. The program manager was disturbed to learn shortly before the accident that Marlin Air had failed to pay its recent renewal dues to the AAMS. She felt this failure could potentially jeopardize the accreditation and standing of the UM program.

The examples above clearly indicate that the operator was experiencing financial difficulties. However, current federal regulations and procedures require only Part 121 operators to report financial information to the FAA. The FAA detected none of the signs of Marlin Air's financial hardship during the FAA's routine surveillance of that company's Part 135 operations. The POI and local FSDO management personnel reported that they were unaware of Marlin Air's financial situation; had they known, they said they would have scrutinized the company's operations more closely.

The NTSB concludes that had FAA personnel been aware of Marlin Air's financial situation, the FAA would have had an opportunity to increase surveillance of the company. Therefore, to provide inspectors with an opportunity to increase their oversight of operators who appear to be in financial distress, the NTSB recommends that the FAA require all 14 CFR Part 91K and Part 135 operators to notify the assigned POIs of specific adverse financial events, such as bankruptcy, court judgments related to nonpayment of recurring expenses, or termination of a credit agreement or contract by a vendor for reasons of late payment or nonpayment. Upon receipt of such information, inspectors should increase their oversight of operators who appear to be in financial distress.

# 3. Conclusions

## 3.1 Findings

1. The captain and first officer were properly certificated and qualified under federal regulations to act in their respective roles during the accident flight. There was no evidence of any medical conditions that might have adversely affected the pilots' performance during the accident flight.

2. Although the captain's pilot certificates had previously been revoked because of a felony conviction involving the illegal transport of drugs into the United States, the Federal Aviation Administration had reissued his pilot certificates, and they were valid at the time of the accident.

3. The accident airplane was properly certificated, was equipped and maintained in accordance with industry practices (except for the wiring installed in the pilots' control yokes), and was within weight and center of gravity limits.

4. If the accident airplane had been equipped with a recorder system that captured cockpit images and parametric data, investigators would have been better able to determine the circumstances that led to this accident.

5. The accident sequence initiated as a result of a control problem that was related to either an inadvertent autopilot activation or a pitch trim anomaly, the effects of which were compounded by aileron and/or rudder trim inputs; however, it was not possible to determine the exact nature of the initiating event.

6. Regardless of the initiating event, if the pilots had simply maintained a reduced airspeed while they responded to the situation, the aerodynamic forces on the airplane would not have increased significantly; at reduced airspeeds, the pilots should have been able to maintain control of the airplane long enough to either successfully troubleshoot and resolve the problem or return safely to the airport.

7. Pilots would benefit from training and readily accessible guidance indicating that, when confronted with abnormal flight control forces, they should prioritize airplane control (airspeed, attitude, and configuration) before attempting to identify and eliminate the cause of the flight control problem.

8. The design and location of the yaw damper and autopilot switches on Cessna Citation series airplanes do not adequately protect against inadvertent activation of a system, which could have disastrous consequences.

9. A rounded type of sheathed wire bundle would fit better and be better protected within the control column shaft than the currently installed flat ribbon cable; replacement of the flat ribbon cable with a rounded type of sheathed wire bundle could result in fewer short circuits and other electrical events.

10. The incorporation of an aural pitch trim-in-motion warning and contrasting color bands on the pitch trim wheel in all Cessna Citation series airplanes would help pilots of those airplanes to more promptly recognize and correct runaway pitch trim situations before control forces become unmanageable.

11. If circuit breakers that a pilot might need to quickly access during an abnormal or emergency situation were equipped with identification collars, pilots would be able to locate them more readily and pull them more easily during such a situation.

12. The circumstances of this accident demonstrate the importance of a program for the Federal Aviation Administration to monitor and conduct ongoing assessments of safety-critical systems throughout the life cycle of an airplane; the FAA did not perform this task adequately for the Cessna Citation.

13. The control wheel forces resulting from adjustments to the Cessna Citation's unpowered aileron trim could exceed the control force limits specified by regulations for powered aileron trim surfaces.

14. Limiting the deflection of the Cessna Citation's manually operated aileron trim tab to the deflection certification limit for powered trim tabs and reducing the Citation's aileron trim sensitivity (the unexpectedly significant aileron trim deflection that results from a relatively small amount of trim knob input) would help pilots avoid sudden and excessive aileron trim deflections.

15. If Cessna Citation pilots and operators were informed of the potential hazards related to the sensitivity and responsiveness of the airplane's aileron trim system, they would be better able to avoid problematic aileron trim inputs until a more permanent solution (an aileron trim system retrofit) is in place.

16. As a result of the first officer's poor flying skills, his lack of airplane systems knowledge, and both pilots' lack of communication and coordination, the first officer provided little help to, and likely hindered, the captain during his attempts to deal with the flight control anomalies during the accident flight.

17. The pilots' lack of discipline, in-depth systems knowledge, and adherence to procedures contributed to their inability to cope with anomalies experienced during the accident flight.

18. Marlin Air's selection of the accident captain (who routinely failed to comply with procedures and regulations) to the positions of company chief pilot and check airman, with responsibility for supervision and training of all company pilots, contributed to an inadequate company safety culture that allowed an ill-prepared first officer to fly in Part 135 operations.

19. If the Federal Aviation Administration guidance regarding check airman appointments and oversight contained procedures for principal operations inspectors to follow (such as heightened surveillance) in cases where review of the pilot's background or performance reveals negative information, checkride failures, or other performance-related deficiencies, the agency might prevent inadequate and/or undisciplined pilots from being appointed or retained as check airmen.

20. The Regional Aviation Safety Inspection Program inspection conducted after this accident failed to uncover evidence of training irregularities and did not evaluate the quality of Federal Aviation Administration surveillance provided before the accident.

21. Customers (such as the University of Michigan) who contract with aviation operators may not understand the Federal Aviation Administration's (FAA) role in aviation safety or know how to contact FAA personnel when safety concerns arise.

22. Had Federal Aviation Administration (FAA) personnel been aware of Marlin Air's financial situation, the FAA would have had an opportunity to increase surveillance of the company.

## 3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the pilots' mismanagement of an abnormal flight control situation through improper actions, including failing to control airspeed and to prioritize control of the airplane, and lack of crew coordination. Contributing to the accident were Marlin Air's operational safety deficiencies, including the inadequate checkrides administered by Marlin Air's chief pilot/check airman, and the Federal Aviation Administration's failure to detect and correct those deficiencies, which placed a pilot who inadequately emphasized safety in the position of company chief pilot and designated check airman and placed an ill-prepared pilot in the first officer's seat.

# 4. Recommendations

## 4.1 New Recommendations

As a result of this investigation, the National Transportation Safety Board makes the following recommendations:

**To the Federal Aviation Administration:**

Require all 14 *Code of Federal Regulations* Part 91K and Part 135 operators to incorporate upset recovery training (similar to that described in the airplane upset recovery training aid used by many Part 121 operators) and related checklists and procedures into their training programs. (A-09-113)

Require Cessna to redesign and retrofit the yaw damper and autopilot switches on the autopilot control panel in Citation series airplanes to make them easily distinguishable and to guard against unintentional pilot activation. (A-09-114)

Identify airplanes other than the Cessna Citation with autopilot control panel designs that may lead to inadvertent activation of the autopilot and require manufacturers to redesign and retrofit the autopilot control panels to make the buttons easily distinguishable and to guard against unintentional activation. (A-09-115)

Issue an airworthiness directive mandating compliance with Cessna Service Bulletin 550-24-14, “Control Wheel Electrical Cable Replacement,” which was issued on January 17, 1992. (A-09-116)

Require Cessna to modify all Citation series airplanes by incorporating an aural pitch trim-in-motion warning and contrasting color bands on the pitch trim wheel to help pilots recognize a runaway pitch trim condition before control forces become unmanageable. (A-09-117) (This recommendation supersedes Safety Recommendation A-07-52 and is classified “Open—Unacceptable Response.”)

Require Cessna to replace all Citation series airplane pitch trim, autopilot, and any other circuit breakers for critical systems that a pilot might need to access during an emergency situation with easily identifiable and collared circuit breakers to aid a pilot in quickly identifying and easily pulling those circuit breakers if necessary. (A-09-118) (This recommendation supersedes Safety Recommendation A-07-54 and is classified “Open—Unacceptable Response.”)

Require airplane manufacturers to develop guidance on the identification of circuit breakers that pilots need to identify quickly and pull easily during abnormal or emergency situations and to provide such guidance, once developed, to operators of those airplanes. (A-09-119)

Require operators to implement the manufacturer's guidance asked for in recommendation A-09-119 regarding which circuit breakers pilots need to identify quickly and pull easily during abnormal or emergency situations in their airplanes. (A-09-120)

Require Cessna to evaluate and limit the maximum aileron trim deflection on Citation series airplanes to that required to meet the certification control requirements for powered trim tabs, unless there is a design-justification to exceed those requirements. (A-09-121)

Require Cessna to reduce the aileron trim sensitivity (the unexpectedly significant aileron trim deflection that results from a relatively small amount of trim knob input) on Citation series airplanes to avoid sudden and excessive aileron trim deflections. (A-09-122)

As an interim measure (pending an available aileron trim system retrofit), notify Citation pilots and operators of the potential hazards related to the sensitivity and responsiveness of the airplane's aileron trim system. (A-09-123)

Revise check airman approval and oversight procedures to incorporate heightened surveillance during a probationary period and at other times, as warranted, for check airmen whose background evaluation uncovers a history of criminal convictions, certificate revocations, check-ride failures, or other performance-related deficiencies. (A-09-124)

Conduct a detailed review of the oversight provided to Marlin Air to determine why the oversight system failed to detect (before and after the accident) and correct Marlin Air's operational deficiencies, particularly in the areas of pilot hiring, training, and adherence to procedures. (A-09-125)

Based on the review described in Safety Recommendation A-09-125, revise the oversight system and Federal Aviation Administration Order 8900.1 as needed. (A-09-126)

Require all 14 *Code of Federal Regulations* Part 135 and Part 91K operators to provide their customers, when a business agreement or contract is finalized, with Federal Aviation Administration (FAA) contact information identified as specifically for use in expressing concerns about flight safety, thus providing customers with a clear means of communicating any safety concerns to the FAA. (A-09-127)

Require all 14 *Code of Federal Regulations* Part 91K and Part 135 operators to notify the assigned principal operations inspectors of specific adverse financial events, such as bankruptcy, court judgments related to nonpayment of recurring expenses, or termination of a credit agreement or contract by a vendor for reasons of late payment or nonpayment. Upon receipt of such information, inspectors should increase their oversight of operators who appear to be in financial distress. (A-09-128)

**To the American Hospital Association:**

> Inform your members, through your website, newsletters, and conferences, of the Federal Aviation Administration's (FAA) role in aviation safety with respect to medical/air ambulance services and provide FAA contact information. Urge your members to communicate any safety concerns related to medical/air ambulance services to the FAA. (A-09-129)

## 4.2 Previously Issued Recommendations Reiterated and Reclassified in This Report

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

> Amend the advisory materials associated with 14 *Code of Federal Regulations* 25.1309 to include consideration of structural failures and human/airplane system interaction failures in the assessment of safety-critical systems. (A-06-37)

> Adopt Society of Automotive Engineers [Aerospace Recommended Practice] 5150 into 14 *Code of Federal Regulations* Parts 21, 25, 33, and 121 to require a program for the monitoring and ongoing assessment of safety-critical systems throughout the life cycle of the airplane. Once in place, use this program to validate that the underlying assumptions made during design and type certification about safety-critical systems are consistent with operational experience, lessons learned, and new knowledge." (A-06-38)

Safety Recommendations A-06-37 and -38 are reiterated in section 2.2.2.4 of this report. In addition, Safety Recommendations A-06-37 and -38 are reclassified "Open—Unacceptable Response."

## 4.3 Previously Issued Recommendations Classified in This Report

The following previously issued recommendations are classified in this report:

- Safety Recommendation A-07-52 (previously classified "Open—Unacceptable Response") is classified "Closed—Unacceptable Action/Superseded" (replaced by Safety Recommendation A-09-117) in section 2.2.2.3 of this report.

- Safety Recommendation A-07-54 (previously classified "Open—Acceptable Alternate Response") is classified "Closed—Unacceptable Action/Superseded" (replaced by Safety Recommendation A-09-118) in section 2.2.2.3 of this report.

## BY THE NATIONAL TRANSPORTATION SAFETY BOARD

**DEBORAH A.P. HERSMAN**
Chairman

**ROBERT L. SUMWALT**
Member

**CHRISTOPHER A. HART**
Vice Chairman

**Adopted: October 14, 2009**

# 5. Appendixes

# Appendix A

## Investigation and Public Hearing

**Investigation**

The National Transportation Safety Board (NTSB) was notified about the accident on June 4, 2007, shortly after it occurred. A partial go-team was launched, with an Investigator-in-Charge and specialists in Operations and Maintenance/Maintenance Records/Airworthiness.

The following investigative groups were formed during this investigation: Maintenance/Maintenance Records/Airworthiness, Meteorology, Operations/Human Performance, Airplane Performance, and Cockpit Voice Recorder.

In accordance with Annex 13 to the Convention on International Civil Aviation, an accredited representative from the Transportation Safety Board of Canada and advisors from Transport Canada and Pratt and Whitney Canada participated in this investigation.

Parties to the investigation were the Federal Aviation Administration, Marlin Air, Cessna Aircraft Company, and Honeywell International. The NTSB received submissions regarding this accident from Marlin Air, Cessna Aircraft Company, and Honeywell International.

**Public Hearing**

No public hearing was held for this accident.

# Appendix B

## Cockpit Voice Recorder Transcript

The following is a transcript of the Universal CVR-30B cockpit voice recorder (CVR) installed on the accident airplane, a Cessna 550 (Citation 550), N550BP, which impacted Lake Michigan shortly after it departed the General Mitchell International Airport (MKE), Milwaukee, Wisconsin on June 4, 2007.

**LEGEND**

| | |
|---|---|
| **CAM** | Cockpit area microphone voice or sound source |
| **HOT** | Flight crew audio panel voice or sound source |
| **RDO** | Radio transmissions from N550BP |
| **TAWS** | Sound identified as the terrain awareness and warning system |
| **TCAS** | Sound identified as the traffic collision and avoidance system |
| **-1** | Voice identified as the captain |
| **-2** | Voice identified as the first officer |
| **-3** | Voice of unidentified passenger |
| **-?** | Voice unidentified |
| ***** | Unintelligible word |
| **#** | Expletive |
| @ | Non-pertinent word |
| **[ ]** | Editorial insertion |

Note 1: Times are expressed in central daylight time (CDT).

Note 2: Generally, only radio transmissions to and from the accident aircraft were transcribed.

Note 3: Words shown with excess vowels, letters, or drawn out syllables are a phonetic representation of the words as spoken.

Note 4: A non-pertinent word, where noted, refers to a word not directly related to the operation, control or condition of the aircraft.

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| 11:38:26<br>**START OF RECORDING**<br>**START OF TRANSCRIPT** | | | |
| 11:38:26<br>**CAM-1** | *** anti-ice. | | |
| 11:38:35<br>**CAM-2** | six thousand feet to go.  gonna be in the clouds all the way. | | |
| 11:38:41<br>**CAM-1** | sixty five *. | | |
| 11:38:53<br>**CAM-?** | three thousand *. | | |
| 11:39:17<br>**CAM-1** | ***. | | |
| 11:39:21<br>**CAM-2** | I'll check. | | |
| 11:39:27<br>**HOT-2** | I'll get—.  I'll ask 'em. | | |
| 11:39:28<br>**HOT-1** | naw that's all right.  don't worry about it. | | |
| 11:39:29<br>**HOT-2** | no when I go to tower I'll ask what the current weather is. | | |
| 11:39:33<br>**HOT-1** | no no because if they give below minimums then we're—.  we're really screwed. | | |
| 11:39:36<br>**HOT-2** | okay. | | |

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| 11:39:39 **HOT-1** | anti-ice is coming off. | | |
| | | 11:39:43 **RDO-2** | two fifty—. two fif—. uh four thousand two fifty on the heading zero bravo pap. |
| 11:39:48 **HOT-1** | four thousand? | | |
| 11:39:51 **HOT-1** | all right get ahead of this stuff. | | |
| 11:39:52 **HOT-1** | no. too dark out. too dark. | | |
| 11:39:59 **HOT-1** | okay down to four thousand. we're still armed on the alt—altitude. | | |
| 11:40:06 **CAM-2** | yes. | | |
| 11:40:09 **HOT-1** | can't hear you. what? | | |
| 11:40:09 **HOT-2** | * speed. | | |
| 11:40:10 **CAM** | [sound similar to altitude alert tone] | | |
| 11:40:16 **HOT-1** | darn me. okay we are doing uh. I'll show you something else here too if I can find it. | | |
| 11:40:24 **HOT-1** | DH here. up here. DH is two hundred feet above the ground. | | |

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| 11:40:36 **HOT-1** | okay. comin' through ten thousand feet seatbelt sign's on. I'd put the extra lights on if I need it— if I thought it would do any good but it won't. and we are seventeen miles from CUTMO. down to four let's get her down. | | |
| 11:40:58 **HOT-1** | normally I don't get down this fast but I want to be set up for this approach. | | |
| 11:41:09 **HOT-1** | put the air conditioner back on. | | |
| 11:41:15 **HOT-1** | ** cold back there. | | |
| 11:41:50 **HOT-2** | set the radar altimeter. | | |
| 11:41:55 **HOT-1** | yeah two hundred feet. we don't need no damn turbulence right now either. | | |
| 11:42:20 **HOT-1** | * we'll flatten out the descent a little bit. | | |
| 11:42:28 **HOT-1** | six for four now. | | |
| 11:42:43 **HOT-1** | you keep—. | | |
| | | 11:42:46 **RDO-2** | two seven zero five five zero bravo pap. |
| 11:42:52 **HOT-1** | two seven zero. okay you keep me honest now. | | |
| 11:42:58 **CAM-2** | okay. | | |

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| 11:42:58 **HOT-1** | don't hesitate to ask a question. just try to keep it calm. I'm pretty comfortable with the airplane so—. | | |
| 11:43:06 **HOT-1** | out of five for four. | | |
| 11:43:07 **CAM** | [sound similar to altitude alert] | | |
| 11:43:08 **CAM-2** | one to go. | | |
| 11:43:10 **HOT-1** | startin' to get the right signals here. there's the glideslope. um. | | |
| 11:43:35 **HOT-1** | okay altitude's captured. she'll level at four. | | |
| 11:43:48 **HOT-1** | very good. yeah that's our missed. okay we'll slow to about two twenty. we get our vector I'll slow a little more. | | |
| 11:43:50 **CAM-2** | right. | | |
| 11:44:03 **HOT-1** | we're six miles from the fix. | | |
| | | 11:44:09 **RDO-2** | down to twenty-six hundred zero bravo pap. |
| 11:44:12 **HOT-1** | set it for me. armed. | | |
| 11:44:31 **HOT-1** | thousand feet to go. | | |
| 11:44:33 | | | |

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| **CAM** | [sound similar to altitude alert] | | |
| 11:44:35 **HOT-1** | now we're going below the glide slope which we should be doing. | | |
| | | 11:44:52 **RDO-2** | okay two six zero maintain two thousand six hundred till CUTMO five zero bravo pop. |
| 11:45:01 **HOT-1** | cleared for the approach we arm it on both sides. | | |
| 11:45:05 **CAM-2** | two ninety the heading *. | | |
| 11:45:08 **HOT-1** | say what. | | |
| | | 11:45:11 **RDO-2** | zero four zero five zero bravo pap. |
| 11:45:16 **HOT-1** | all we need is a bad vector. approach flaps. approach flaps there one notch. | | |
| 11:45:21 **CAM** | [sound similar to flap lever actuation] | | |
| 11:45:22 **CAM-2** | speed check approach flaps out. | | |
| 11:45:25 **HOT-1** | just what we need is a bad vector. | | |
| 11:45:47 **HOT-1** | okay we're stable. flaps are out we're good. next call's gonna be gear but don't worry about it right now. ignitors are on that's a pre landing check. okay localizer's alive again. yup and captured. | | |
| 11:45:55 | | | |

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| **CAM-2** | *. | | |
| 11:46:00 **CAM-2** | you want the approach mode armed at all? | | |
| 11:46:02 **HOT-1** | say what no? * I can't hear you @. | | |
| 11:46:05 **HOT-2** | I'm sorry approach mo— mode armed? | | |
| 11:46:07 **HOT-1** | yeah we're all set. | | |
| 11:46:08 **HOT-2** | okay I'm sorry. | | |
| 11:46:09 **HOT-1** | good catch good catch. | | |
| 11:46:14 **HOT-1** | okey doke. | | |
| | | 11:46:27 **RDO-2** | 'kay over to tower lifeguard zero bravo pap. thanks for the help. |
| 11:46:37 **HOT-1** | damn it. | | |
| 11:46:43 **HOT-1** | don't ask her the weather. | | |
| 11:46:44 **CAM-2** | I'm not. one dot gear up. | | |
| 11:46:46 **HOT-1** | I see it. landing gear down. | | |
| 11:46:49 **CAM** | [sound similar to landing gear handle actuation] | | |

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| 11:46:49 **CAM** | [sound of increasing background noise] | | |
| 11:46:59 **HOT-1** | landing flaps?  landing checklist? | | |
| 11:47:06 **HOT-2** | landing gear's down landing gear's down.  * are on.  landing lights on.  flaps flaps—. | | |
| 11:47:09 **HOT-1** | three green.  yes. | | |
| 11:47:10 **HOT-1** | no wait talk to tower now. | | |
| 11:47:13 **HOT-1** | talk to tower.  @ talk to tower. | | |
| | | 11:47:17 **RDO-2** | * tower lifeguard uh five five zero bravo pap's on the ILS one zero. |
| 11:47:23 **CAM** | [sound similar to switch being flipped] | | |
| 11:47:25 **CAM** | [sound similar to altitude alert] | | |
| | | 11:47:30 **RDO-2** | five zero bravo pap. |
| 11:47:32 **HOT-1** | okay we're cleared to land lights are on go ahead with checklist. | | |
| 11:47:36 **HOT-2** | landing lights? | | |
| 11:47:37 **HOT-1** | on. | | |

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| 11:47:38 **HOT-2** | okay gear's down ignition's on. | | |
| 11:47:40 **HOT-1** | correct. | | |
| 11:47:40 **HOT-2** | flaps landing lights? | | |
| 11:47:42 **HOT-1** | on on on. | | |
| 11:47:43 **HOT-2** | flaps autopilot yaw damper? | | |
| 11:47:44 **HOT-1** | autopilot's comin' off in a minute. | | |
| 11:47:46 **HOT-2** | okay. | | |
| 11:47:47 **HOT-1** | okay I need you inside and out now okay @. let's get you armed and join me here. | | |
| 11:47:50 **HOT-2** | okay. | | |
| 11:47:51 **HOT-1** | oh # for some reason it didn't—. the one over here anything. no go to nav yeah go to nav go to nav. now hit the two buttons. armed. | | |
| 11:48:02 **HOT-1** | okay. all right you've got a good ILS with a glideslope. okay we're shooting for nine oh four. we got a thousand feet to go or less. that—. that agrees there. that agrees here. okay autopilot's comin' off. | | |

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| 11:48:05 **HOT-2** | right. | | |
| 11:48:15 **CAM** | [sound similar to autopilot disconnect tone] | | |
| 11:48:17 **HOT-2** | speed one thirty-five. | | |
| 11:48:18 **HOT-1** | want to keep that pretty much all the way down. | | |
| 11:48:20 **CAM-2** | okay. | | |
| 11:48:24 **HOT-1** | just bleed it off very slowly.  we got plenty of runway and we're going to the far end anyway. | | |
| 11:48:32 **HOT-1** | I need you in and out real good okay…. | | |
| 11:48:33 **HOT-2** | I'll do the best I can. | | |
| 11:48:34 **HOT-1** | good man good man. | | |
| 11:48:35 **HOT-2** | I show you on glideslope on localizer. | | |
| 11:48:38 **HOT-1** | we're tryin' we're tryin'. | | |
| 11:48:39 **HOT-2** | speed one thirty-five. | | |
| 11:48:48 **HOT-1** | gettin' darker that's a good sign. | | |

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| 11:48:58 **HOT-2** | okay I show you three hundred feet to minimums. | | |
| 11:49:00 **HOT-1** | thank you. | | |
| 11:49:02 **TAWS** | five hundred. | | |
| 11:49:04 **HOT-1** | that's above the ground.  that's fine. | | |
| 11:49:05 **HOT-2** | right. | | |
| 11:49:10 **HOT-2** | on glideslope on localizer.  a little high— a little low rather. | | |
| 11:49:13 **HOT-1** | workin' on it. | | |
| 11:49:17 **HOT-1** | bleed the speed of a little bit with ground contact in my peripheral vision there. | | |
| 11:49:18 **HOT-2** | okay. | | |
| 11:49:24 **HOT-1** | comin' up on minimums.  look for the runway please. | | |
| 11:49:27 **HOT-2** | I got the lights straight ahead. | | |
| 11:49:28 **HOT-1** | okay I'm flying.  I'm landing.  got your sight—.  runway in sight. | | |
| 11:49:30 **CAM** | [sound of unknown tones] | | |

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| 11:49:31 **CAM-2** | airspeed one thirty-five. | | |
| 11:49:33 **HOT-1** | okay we'll bleed the speed off nice and slow. | | |
| 11:49:36 **HOT-2** | three green no red. | | |
| 11:49:37 **HOT-1** | okey doke. | | |
| 11:49:40 **HOT-1** | right down the chute.  almost like I knew what I was doing. | | |
| 11:49:41 **HOT-2** | fifty feet. | | |
| 11:49:43 **CAM-2** | hey good job…. | | |
| 11:49:50 **HOT-1** | do a little float routine down here gotta go all the way to the end anyway. | | |
| 11:49:55 **CAM** | [sound of unknown tones] | | |
| 11:49:58 **HOT-1** | nice soft landing. | | |
| 11:50:00 **HOT-1** | trying here. | | |
| 11:50:11 **HOT-2** | your speed is ninty-five. | | |
| 11:50:14 **CAM** | [sound similar to touchdown] | | |

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| 11:50:15 **HOT-2** | ninety. | | |
| 11:50:17 **HOT-2** | six lights. | | |
| 11:50:18 **HOT-1** | we could get some spoilers out but don't worry about it I should have called for 'em. I didn't want you being confused on it. | | |
| 11:50:25 **HOT-2** | Signa—. Signature. | | |
| | | 11:50:32 **RDO-2** | 'kay left at the end over to ground. |
| 11:50:39 **CAM** | [sound of unknown tones] | | |
| 11:50:40 **HOT-1** | we never called…with an inbound sorry. I should have. no big deal. yeah you got a frequency for them. go ahead I'll watch ground. ground is twenty-one eight. yeah I'll get the ground you just—. don't wor—. its on the flightplan actually too. thirty-one something or 'nother. | | |
| 11:50:55 **CAM-2** | thirty-one twenty. | | |
| 11:50:56 **HOT-1** | thirty-one zero. left at the end is what she told us. | | |
| 11:50:58 **CAM** | [sound of unknown tones] | | |
| 11:51:02 **HOT-1** | Signature's right here anyway. | | |
| 11:51:13 **CAM** | [sound of unknown tones] | | |

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| 11:51:14 **CAM-2** | what switch do you use for com two? | | |
| 11:51:17 **HOT-1** | number two.  turn your knob. | | |
| 11:51:19 **HOT-1** | there you go. | | |
| | | 11:51:22 **RDO-2** | and…lifeguard five five zero bravo pap. |
| 11:51:25 **CAM** | [sound similar to switches being flipped] | | |
| | | 11:51:30 **RDO-1** | ground five five zero bravo pap clear of uh zero one at the end going to Signature. |
| | | 11:51:39 **RDO-1** | zero bravo pap. |
| | | 11:51:40 **RDO-2** | and…lifeguard five five zero bravo pap is taxiing in. |
| 11:51:43 **HOT-1** | we have an ambulance.  there should be an ambulance or a cab or something waiting for them. | | |
| 11:51:50 **CAM-2** | they're not answering.  where do you want—. | | |
| 11:51:54 **HOT-1** | they didn't answer.  all right it looks like they heard us coming or something.  there's a guy walking out.  see the guy in the raincoat. I don't know where he's gonna park us but—. | | |
| 11:52:01 **CAM-2** | yup. | | |

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| 11:52:02 **CAM** | [sound of unknown tones] | | |
| 11:52:05 **HOT-1** | see if you can figure out what direction he wants us to turn. looks like we're gonna get front line parking here next to the Citation. yeah I see it okay I got 'em facing east right. I shut right engine down. | | |
| 11:52:11 **HOT-2** | yup see him over there. | | |
| 11:52:15 **HOT-2** | okay. | | |
| 11:52:16 **CAM** | [sound similar to decreasing engine rpm] | | |
| 11:52:19 **HOT-1** | we can turn the fan and defog switch off. | | |
| 11:52:23 **CAM** | [sound similar to switches being flipped] | | |
| 11:52:24 **CAM** | [sound of unknown tones] | | |
| 11:52:54 **HOT-1** | nosewheel nice and straight. | | |
| 11:53:00 **CAM** | [sounds consistent with aircraft power down] | | |

**[Break in CVR recording while the airplane was unpowered at Milwaukee.]**

| | | | |
|---|---|---|---|
| 15:44:32.0 **CAM** | [sound similar to switches being flipped] | | |
| 15:44:34.0 | | | |

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| **HOT-1** | okay. ATIS is still on here correct? | | |
| 15:44:41.4 **CAM** | [sound similar to switches being flipped] | | |
| 15:45:11.7 **CAM** | [sound of unknown tones] | | |
| 15:45:25.4 **HOT-1** | here's what I do. put destination in here. | | |
| 15:45:28.5 **HOT-2** | uh huh. | | |
| 15:45:31.4 **HOT-1** | get this *. | | |
| 15:46:15.7 **HOT-1** | okay I'm gonna get the clearance | | |
| 15:46:17.4 **HOT-2** | I'll get it for you if you want me to. | | |
| 15:46:18.3 **HOT-1** | all right number one's ready for it. | | |
| 15:46:19.6 **HOT-2** | okay. | | |
| 15:46:20.1 **HOT-1** | make sure you're switched on to it. down no down on you num— knob too. turn it no—. knob down. speaker down. down no next one. okay you got clearance on top radio. | | |
| 15:46:26.4 **HOT-2** | okay. oop— that one. | | |
| 15:46:30.9 **HOT-2** | okay. | | |

| INTRA-COCKPIT COMMUNICATION TIME and SOURCE | CONTENT | AIR-GROUND COMMUNICATION TIME and SOURCE | CONTENT |
|---|---|---|---|
| | | 15:46:34.9 **RDO-2** | Milwaukee clearance lifeguard five five zero bravo pap. |
| | | 15:46:40.8 **RDO-2** | zero pap has got to pick up an IFR clearance to yankee india papa. and we have uh quebec. |
| 15:47:12.4 **CAM-2** | what was the squawk? Three two one—. | | |
| 15:47:14.2 **HOT-1** | three two five one. | | |
| | | 15:47:16.1 **RDO-2** | okay five five papa papa is cleared Br— Brew Three departure Grand Rapids Lansing Spartan arrival five thousand eight— nineteen uh nineteen sixty-five thirty-two fifty-one. |
| 15:47:31.4 **HOT-1** | okay man. you got the Brew Three pulled? | | |
| | | 15:47:32.1 **RDO-2** | zero pap. |
| 15:47:33.3 **CAM-2** | yup. | | |
| 15:47:34.5 **HOT-1** | all right that's not it. | | |
| 15:47:37.6 **HOT-1** | there it is. okay. cool. all right I'm ready to taxi. let's turn to ground. | | |
| 15:47:41.3 **CAM-2** | you want what runway? | | |
| 15:47:42.5 **HOT-1** | we're on it. | | |

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| 15:47:43.3 **HOT-1** | we haven't been assigned a runway yet. winds are—. winds are a little—. we can't take that runway. winds are too strong. all right tell her we're ready to taxi. wherever she sends us we'll go. | | |
| 15:47:45.4 **CAM-2** | *** okay. | | |
| | | 15:47:53.9 **RDO-2** | * ground lifeguard five five zero bravo pap at Signature with quebec like taxi. |
| | | 15:48:09.7 **RDO-2** | one left by zulu echo tango romeo. |
| | | 15:48:27.9 **RDO-2** | okay that's foxtrot delta bravo romeo and want to get the progressive as we go thanks. |
| | | 15:48:37.6 **RDO-2** | okay **. |
| 15:48:41.4 **HOT-1** | yeah and uh you can try to pick it up somewhere. we're on the north side here so—. I see foxtrot there. | | |
| 15:48:48.5 **CAM-2** | this is foxtrot here. | | |
| 15:48:50.2 **HOT-1** | yeah we're on—. I guess we're on foxtrot. so foxtrot what? | | |
| 15:48:55.2 **CAM-2** | delta down here. | | |
| 15:48:57.9 **HOT-1** | okay. | | |
| 15:49:02.1 **HOT-1** | got a long taxi here. all right just keep an eye on it. you can | | |

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| | figure it out. | | |
| 15:49:07.3 **CAM-2** | we're clear off to the right. how we doin' on the left. | | |
| 15:49:09.5 **HOT-1** | uh we're clear as far as I can see. we are crossing—. | | |
| 15:49:15.3 **CAM-2** | crossing runway. | | |
| 15:49:16.4 **HOT-1** | okay foxtrot to what? | | |
| 15:49:18.1 **CAM-2** | delta. | | |
| 15:49:18.8 **HOT-1** | uh is that delta up ahead or do we turn here? | | |
| 15:49:20.6 **CAM-2** | yup delta up ahead. | | |
| 15:49:23.1 **HOT-1** | okay. | | |
| | | 15:49:27.2 **RDO-2** | left turn *. |
| 15:49:30.3 **HOT-1** | where? is this—. which one. you sure? this says charlie. | | |
| 15:49:31.6 **CAM-2** | no keep going. no this is delta. | | |
| 15:49:37.1 **HOT-1** | this is charlie. | | |
| | | 15:49:44.2 **RDO-1** | okay **. okay we'll turn left on charlie then left again here. |

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| | | 15:50:02.6 **RDO-2** | zero bravo pap. |
| 15:50:03.1 **HOT-1** | all right keep an eye on things. come on @. you're worse than uh @. | | |
| 15:50:09.3 **HOT-1** | ***. let's get the fans on here. | | |
| 15:50:16.5 **HOT-1** | stay on charlie. okay I'm following the lines. | | |
| 15:50:19.8 **CAM-2** | * charlie. okay that'll take us to bravo. | | |
| 15:50:23.5 **HOT-1** | she said cross some runway up here. | | |
| 15:50:25.2 **CAM-2** | yup. crossing seven left. | | |
| 15:50:28.6 **HOT-1** | turn your uh radar altimeter knob get that light off. yup right there. the other way. all the way to zero. there you go. no yellow lights. me no like 'em yellow lights. | | |
| 15:50:45.5 **HOT-1** | okay she said cross seven left. | | |
| 15:50:47.6 **CAM-2** | okay. | | |
| 15:50:47.9 **HOT-1** | I don't see any taxiway on the other end. | | |
| 15:50:49.1 **CAM-2** | clear to the right. this is bravo here. | | |

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| 15:50:56.0 **HOT-1** | there's nobody around. | | |
| 15:50:59.6 **CAM-2** | turn right.  take bravo right. | | |
| 15:51:02.9 **HOT-1** | okay. | | |
| 15:51:03.2 **CAM-2** | take bravo to romeo. | | |
| 15:51:05.9 **HOT-1** | if you say so. | | |
| 15:51:07.3 **CAM-2** | ** bravo to romeo. | | |
| 15:51:10.2 **HOT-1** | some of our guys would stop.  they'd stop. | | |
| 15:51:14.8 **CAM-2** | **. | | |
| 15:51:19.0 **CAM-2** | blocked off here.  bravo's off this way. | | |
| 15:51:22.3 **HOT-1** | okay.  yup.  looks like it to the right.  I'll follow.  its gonna be on—on the terminal area.  its through the terminal here.  its in there somewhere. | | |
| 15:51:32.2 **CAM-2** | *. | | |
| 15:51:50.3 **HOT-1** | um what's the Brew Three while we're doing this now? | | |
| 15:52:03.2 **CAM-2** | runway heading to two thousand. | | |

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| | | 15:52:04.7 **RDO-1** | zero bravo pap. |
| 15:52:05.8 **HOT-1** | okay runway heading to two thousand feet. got it. | | |
| 15:52:08.1 **CAM-2** | okay. | | |
| 15:52:09.2 **HOT-1** | then what? | | |
| 15:52:10.1 **CAM-2** | turn to assigned heading. okay that's it. | | |
| 15:52:12.9 **CAM-2** | ** join. | | |
| 15:52:14.5 **HOT-1** | uh left at delta she said? you're not paying attention @. | | |
| 15:52:17.9 **CAM-2** | bravo romeo. bravo—. | | |
| 15:52:20.1 **HOT-1** | no she changed it. she said due to a— due to an aircraft pushback. | | |
| 15:52:23.3 **CAM-2** | I didn't catch that. | | |
| 15:52:24.4 **HOT-1** | uhhh gotta see where. | | |
| 15:52:27.0 **CAM-2** | * pushback. | | |
| 15:52:28.0 | | | |

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| **HOT-1** | yeah but she wants us going left somewhere. | | |
| | | 15:52:35.9 **RDO-2** | okay kilo then right turn on echo zero bravo pap. |
| 15:52:40.9 **CAM-2** | here all the way down. | | |
| 15:52:41.5 **HOT-1** | yup and that should take us all the way down. okay now you can look at the departure. | | |
| 15:52:44.8 **CAM-2** | the departure basically two thousand feet to assigned heading. | | |
| 15:52:47.1 **HOT-1** | okay put your intercom on. | | |
| 15:52:49.3 **HOT-2** | okay I'm sorry. two thousand feet turn to assigned heading. okay? | | |
| 15:52:49.4 **HOT-1** | I'm getting old stand here. okay. | | |
| 15:52:55.7 **CAM-1** | okay and what altitude? is there a fix you can put in? what's our first fix from the clearance? go ahead and put that in there. | | |
| 15:52:59.4 **HOT-2** | well—. okay its Lansing. Grand Rapids rather. | | |
| 15:53:03.3 **HOT-1** | all right. put Grand Rapids in. there there you're already there. just keep plug it. start plugging. | | |
| 15:53:07.1 **HOT-2** | there? | | |
| 15:53:08.3 | | | |

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| **HOT-1** | nope up now turn the little knob and plug in Grand Rapids. G no no no K. Just the G-R-R. | | |
| 15:53:09.8 **HOT-2** | all right. G-R-R? | | |
| 15:53:15.6 **HOT-1** | yup. | | |
| 15:53:21.3 **HOT-1** | okay. | | |
| | | 15:53:29.3 **RDO-1** | zero bravo pap. |
| 15:53:32.0 **HOT-2** | okay. | | |
| 15:53:33.9 **CAM-1** | okay and then after Grand Rapids what's there? | | |
| 15:53:35.6 **HOT-2** | Lansing. | | |
| 15:53:36.0 **CAM-1** | all right well. let's get back. just put it in over yip. put the cursor over yip. | | |
| 15:53:41.0 **HOT-2** | pardon. | | |
| 15:53:44.0 **CAM-1** | damn it. | | |
| 15:53:46.7 **CAM-1** | okay put Lansing. | | |
| 15:53:56.2 **CAM-1** | that's good enough. now go ahead and enter—. yup. enter set yeah. that's good. now we'll plug— we’ll program the rest later | | |

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| 15:54:04.1 **HOT-2** | right okay. check the Spartan arrival after Lansing. | | |
| 15:54:13.7 **CAM-1** | okay uh look on your taxi chart and get tower frequency—. | | |
| 15:54:15.9 **HOT-2** | I can't hear you…. | | |
| 15:54:18.5 **HOT-1** | look on your tow— uh taxi chart and get a tower frequency there. | | |
| 15:54:21.6 **HOT-2** | okay. | | |
| 15:54:22.3 **HOT-1** | get ready for that. | | |
| 15:54:28.8 **HOT-2** | okay. | | |
| 15:54:29.5 **HOT-1** | look on your taxi chart. taxi chart ground control frequency— or tower frequency. | | |
| 15:54:34.4 **HOT-2** | okay tower is one nineteen one. | | |
| 15:54:47.0 **HOT-2** | we tell 'em we're ready to go at the end? | | |
| | | 15:54:53.6 **RDO-2** | okay number one and monitor tower thanks for your help today. |
| 15:54:57.4 **HOT-1** | okay put your tower in monitor them and put your departure frequency in the bottom. no just monitor them is all she said. | | |
| 15:54:57.9 | | | |

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| **CAM-2** | yup. yup. | | |
| 15:55:06.0 **HOT-1** | departure you wrote down haven't you? | | |
| 15:55:08.6 **HOT-1** | okay the squawk is in. what is the squawk? | | |
| 15:55:11.2 **CAM-2** | three two five one. | | |
| 15:55:12.0 **HOT-1** | three two five one is here. | | |
| 15:55:13.5 **CAM-2** | okay. | | |
| 15:55:15.1 **HOT-1** | I'm gonna put the transponder on. that's part of the checklist before takeoff. | | |
| 15:55:17.9 **CAM-2** | okay right **. | | |
| 15:55:22.4 **HOT-1** | that's way down at the bottom but—. | | |
| 15:55:23.6 **CAM-2** | flaps you want at ten right? | | |
| 15:55:24.6 **HOT-1** | flaps are good. they— they're fifteen actually. | | |
| 15:55:31.3 **CAM-2** | exterior lights transponder. engine switch. | | |
| 15:55:35.1 **HOT-1** | he said we were number one and now he says traffic will hold in position. he hasn't told us to hold yet. we will find out. | | |

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| 15:55:36.7 **CAM-2** | right. | | |
| 15:55:44.8 **CAM-2** | he knows we're ready to go? | | |
| | | 15:55:52.1 **RDO-2** | okay position and hold five zero bravo pap. |
| 15:55:56.0 **HOT-1** | yeah she said monitor tower so we don't have to call and tell 'em we're ready.  you know be careful at busy airports like that New York and uh Chicago and all that.  when they monitor tower just be ready when they call.  yeah. | | |
| 15:56:02.9 **CAM-2** | uh huh.  just listen. | | |
| 15:56:07.1 **HOT-1** | all set back there? | | |
| 15:56:08.4 **CAM-3** | yes sir. | | |
| 15:56:09.9 **HOT-1** | they're eatin' away man.  they don't care.  hey see if you can hand me my straps?  am I sitting on them or what? | | |
| 15:56:12.8 **CAM-2** | all right. | | |
| 15:56:17.0 **CAM-2** | you get 'em both? | | |
| 15:56:23.7 **HOT-1** | okay we got position and hold.  you can go to final items on the checklist. | | |
| 15:56:28.5 **HOT-1** | damn things [sound of grunt].  that's all right it just doesn't work. | | |

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| | | 15:56:36.4 **RDO-2** | okay two thousand zero five zero cleared for takeoff five zero bravo pap. |
| 15:56:41.9 **HOT-1** | okay final items for takeoff. | | |
| 15:56:43.6 **CAM-2** | okay final items. p-heat? transponder? on. | | |
| 15:56:46.2 **HOT-1** | its on. | | |
| 15:56:46.9 **CAM-2** | okay * ignition? | | |
| 15:56:50.0 **HOT-1** | put your PA. put your intercom on. | | |
| 15:56:50.8 **HOT-2** | ignition? | | |
| 15:56:51.8 **HOT-1** | they're on. | | |
| 15:56:52.5 **HOT-2** | pitot heat? | | |
| 15:56:53.9 **HOT-1** | who? pitot heat's on. | | |
| 15:56:54.4 **HOT-2** | pitot heat. | | |
| 15:56:55.2 **HOT-2** | anti-skid? | | |
| 15:56:56.4 **HOT-1** | anti-skid is gonna get—. I'll get it in a second. | | |

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| 15:56:58.9 **HOT-2** | annunciators clear? | | |
| 15:56:59.6 **HOT-1** | annunciators gonna be clear when I get anti-skid. | | |
| 15:57:02.1 **HOT-2** | okay. | | |
| 15:57:04.0 **HOT-1** | okay here comes anti-skid.  we're clear to go two thousand feet we're turning right to zero five zero. | | |
| 15:57:08.2 **HOT-2** | right. | | |
| 15:57:09.3 **HOT-1** | okay here we go.  you're watching my power ninety-six three or less. | | |
| 15:57:12.6 **CAM** | [sound similar to increasing engine rpm] | | |
| 15:57:15.2 **HOT-1** | okay you got it. | | |
| 15:57:19.9 **HOT-2** | power set.  airs—.  airspeed—.  airspeed alive. | | |
| 15:57:22.8 **HOT-1** | okay. | | |
| 15:57:26.8 **HOT-2** | eighty knots. | | |
| 15:57:31.7 **HOT-2** | V one. | | |
| 15:57:33.4 | | | |

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| **HOT-2** | rotate. | | |
| 15:57:37.3 **HOT-1** | positive rate gear up. | | |
| 15:57:38.3 **HOT-2** | yup. | | |
| 15:57:39.0 **HOT-1** | lights. | | |
| 15:57:39.4 **CAM** | [sound similar to switches being flipped] | | |
| 15:57:40.5 **HOT-1** | lights off yaw damper on. | | |
| | | 15:57:51.0 **RDO-2** | okay zero five zero and start my turn and thanks for the help. |
| 15:57:51.3 **HOT-1** | why am I fighting the controls here?  damn it. | | |
| 15:57:57.1 **HOT-1** | I'm fighting the controls @. | | |
| 15:57:58.5 **CAM-2** | ** I had it on. | | |
| 15:58:01.3 **TCAS** | traffic traffic. | | |
| 15:58:03.2 **HOT-1** | gear up. | | |
| 15:58:03.9 **CAM-2** | gear's up. | | |
| 15:58:05.0 **HOT-1** | flaps up. | | |

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| 15:58:06.9 **HOT-1** | what the hell's going on? I'm fighting the controls. | | |
| 15:58:12.5 **CAM-2** | how's your trim set? is that the way you want it? | | |
| 15:58:21.4 **HOT-1** | I'm fighting the controls. it wants to turn left hard. | | |
| 15:58:24.3 **CAM-2** | how's— how's your trim down here? | | |
| 15:58:26.1 **HOT-1** | trim is— *. | | |
| 15:58:26.3 **CAM** | [sound similar to altitude alert] | | |
| 15:58:27.4 **HOT-1** | trim has nothing—. I—. I—. | | |
| | | 15:58:31.1 **RDO-2** | we'll take a one eighty two thirty uh * twenty three for three. |
| 15:58:33.9 **HOT-1** | all right you talk. | | |
| 15:58:39.1 **HOT-1** | that's not us. | | |
| | | 15:58:39.6 **RDO-2** | negative on that. wrong aircraft. |
| 15:58:44.9 **HOT-1** | something is wrong with the trim. | | |
| 15:58:47.6 **CAM** | [sound similar to altitude alert] | | |

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| 15:58:48.4 **HOT-1** | the rudder trim. what— what's our altitude clearance? | | |
| 15:58:52.1 **CAM-2** | three thousand three thousand. | | |
| 15:58:57.4 **HOT-1** | all right something is wrong with our rudders. and I don't know what. | | |
| 15:59:02.7 **HOT-1** | damn it. | | |
| 15:59:03.8 **HOT-1** | @. | | |
| 15:59:04.3 **CAM-2** | hey what do you want to do. | | |
| 15:59:05.6 **HOT-1** | huh. | | |
| 15:59:07.1 **CAM-2** | how's that. any better? | | |
| 15:59:09.4 **HOT-1** | huh no we got a trim problem. | | |
| 15:59:14.2 **HOT-1** | [sound of grunt] | | |
| 15:59:16.0 **HOT-1** | tell 'em we got to come back and land. | | |
| 15:59:18.2 **HOT-1** | #. | | |
| 15:59:19.1 **HOT-1** | @ she's rolling on me. help me help me. | | |

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| 15:59:22.4 **CAM-2** | I am. | | |
| 15:59:24.1 **HOT-1** | the autopilot is—. pull circuit breakers on autopilot. | | |
| 15:59:27.4 **CAM-2** | where is it? | | |
| 15:59:28.6 **HOT-1** | tell 'em we got a control problem. | | |
| 15:59:30.0 **CAM-2** | I am. | | |
| | | 15:59:30.2 **RDO-2** | Milwauk—. eh approach Citation one bravo tango has got a control problem we've got to come back in. |
| 15:59:34.9 **HOT-1** | …. | | |
| 15:59:37.5 **CAM** | [sound of high frequency tone that lasts 16 seconds] | | |
| | | 15:59:38.3 **RDO-2** | one bravo tango. |
| 15:59:39.9 **HOT-1** | zero bravo pap. | | |
| | | 15:59:43.8 **RDO-2** | Milwaukee approach we got a—. Milwaukee we got uh a runaway trim. we got an emergency. |
| 15:59:49.3 **CAM-1** | [sound of grunt] @ *. | | |
| 15:59:50.4 **CAM-2** | which circuit breakers? | | |

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| 15:59:52.7 **CAM-1** | zero bravo pap. | | |
| | | 15:59:54.3 **RDO-1** | zero bravo pap. |
| 15:59:57.0 **CAM-1** | yes ma'am. answer her @. keep turning *. | | |
| 16:00:03.5 **CAM-2** | **. | | |
| 16:00:03.7 **CAM-1** | yes. | | |
| | | 16:00:05.0 **RDO-1** | zero bravo pap declaring an emergency yes. |
| 16:00:06.2 **HOT-1** | we're coming back to Milwaukee. | | |
| 16:00:08.2 **CAM** | [sound similar to altitude alert] | | |
| | | 16:00:12.5 **RDO-2** | coming back to Milwaukee. |
| | | 16:00:13.5 **RDO-1** | landing any runway at uh at Milwaukee. guide us in please. zero bravo pap. |
| | | 16:00:26.1 **RDO-1** | I don't know what's wrong. |
| 16:00:28.0 **HOT-1** | [sound of heavy breathing] | | |
| 16:00:30.1 **HOT-1** | I don't know what's wrong @. I see the airport. keep **. son of a | | |

| INTRA-COCKPIT COMMUNICATION | | AIR-GROUND COMMUNICATION | |
|---|---|---|---|
| **TIME and SOURCE** | **CONTENT** | **TIME and SOURCE** | **CONTENT** |
| | bitch. | | |
| | | 16:00:35.9 **RDO-1** | @ you hold it I'm gonna try to pull circuit breakers. |
| 16:00:37.3 **CAM-2** | ***. | | |
| | | 16:00:40.0 **RDO-1** | @ we're not—. |
| 16:00:40.1 **HOT-1** | holding it. | | |
| 16:00:40.6 **CAM-2** | I'm pulling. | | |
| 16:00:42.8 **CAM-1** | awww #. | | |
| 16:00:45.4 **CAM-1** | no—. | | |
| 16:00:45.5 **END OF TRANSCRIPT END OF RECORDING** | | | |