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NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C.

Operations Group Chairman's Factual Report

(45 Pages)

NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington, D.C. 20594

September 10, 2009

Group Chairman's Factual Report

OPERATIONS

CEN09MA142

A. ACCIDENT

Location:	Lubbock, Texas
Date:	January 27, 2009
Time:	1253 Central Standard Time (CST)
Aircraft:	Empire Airlines ATR-42-320, N902FX

B. OPERATIONS GROUP

Todd G. Gunther
Air Safety Investigator
National Transportation Safety Board

Guilhem Nicolas
Safety Investigator
Bureau d'Enquetes et d'Analysis

Gordon D. Morris
Aviation Safety Inspector, Operations
Federal Aviation Administration

Jerome Bonetto
Flight Instructor
ATR

Steven J. Martini
Chief Pilot
Empire Airlines

C. SUMMARY

On January 27, 2009, at approximately 0437 central standard time (CST), N902FX, an Aerospatiale Alenia ATR-42-320, operating as Empire flight 8284, sustained substantial damage when it collided with terrain short of the runway while executing the Instrument Landing System (ILS) RWY 17R approach at Lubbock Preston Smith International Airport (LBB), Lubbock, Texas. The airplane was registered to Federal Express Corporation, Memphis, Tennessee, and operated by Empire Airlines, Hayden, Idaho. The airline transport pilot rated captain was seriously injured and the commercial rated first officer sustained minor injuries. An instrument flight rules flight plan was filed for the flight that departed Fort Worth Alliance Airport (AFW), Fort Worth, Texas, at approximately 0319 CST. Instrument meteorological conditions prevailed for the supplemental cargo flight operated under 14 Code of Federal Regulations (CFR) Part 121.

D. DETAILS OF INVESTIGATION

The National Transportation Safety Board (NTSB) was notified of the accident on January 27, 2009.

The Operations Group was formed on January 29, 2009 and began gathering reference manuals, witness statements, and pertinent documents from Empire Airlines (Empire), Federal Express Corporation (FedEx), and the Federal Aviation Administration (FAA).

The Operations Group also traveled to the Lubbock Flight Standards District Office (FSDO) and reviewed the Lubbock Air Traffic Control Tower (ATCT) recorded voice data for the local control, and tower radar, positions. The group also received draft transcripts of this data.

The Operations Group additionally conducted a survey of the accident airplane's flight deck and recovered the cockpit paperwork for both the accident flight, and the previous legs that were operated by the flight crew.

Interviews with the flight crew were conducted that afternoon.

On January 30, 2009, the Operations Group reconvened at the FSDO. On this date the Operations Group examined and photo documented the cockpit paperwork and company provided operational guidance that was recovered.

On February 24 and 25, 2009 the Operations Group conducted interviews with Empire Airlines personnel and personnel from the FAA.

On March 30, 31, and April 1, 2009 the Operations Group conducted qualitative simulator testing at ATR's facilities in Toulouse, France.

On August 11 and 12, 2009 the operations group along with an NTSB human performance investigator interviewed the director of safety and compliance and re-interviewed the flight crew at Empire Airlines headquarters, in Hayden, Idaho.

On August 19 and 20, 2009, the operations group conducted interviews at Flight Safety International, Houston Texas.

1.0 HISTORY OF FLIGHT

Historically the trip had been operated with an Fokker F27 however, at the time of the accident the F27 fleet was in the process of being phased out by the operator, and since January 5, 2009 the trip sequence was being covered by ATR 42s utilizing flight crews from other crew bases while the F27 flight crews were being trained to operate the ATR.

The flight was originally scheduled to depart from the Midland International Airport (MAF), Midland, Texas, at 1955, on January 26, 2009. It would have arrived at LBB at 2038 and after the transloading process, it would have continued on to AFW at 2225. After arrival at AFW at 2337 all of the cargo would have been unloaded, and the cargo destined for LBB and MAF would have been placed onboard. The airplane would then have departed for LBB at 0325 on January 27, 2009. It would have arrived at LBB at 0449, completed the transload process, and then would have departed for MAF where the cargo would have been off loaded and the flight would have terminated.

According to the captain however, prior to departing MAF he was advised of a reroute to El Paso International Airport (ELP), El Paso, Texas to drop off his cargo as the CE208s would have been unable to operate into LBB because of the "freezing drizzle." The flight departed for ELP at 1945 on January 26, 2009 and arrived at 2113. After unloading the cargo, the flight then departed empty for AFW at 2230 with 609 pounds of ballast onboard to maintain the center of gravity within the allowable limits. It arrived at AFW at 0018 on January 27, 2009. After the cargo was loaded the flight departed for LBB at 0313 with the first officer as the flying pilot.

After departure the flight encountered rime ice which the captain described as being "moderate, bordering on severe" at FL180. He selected Level Three icing protection, which includes engine continuous ignition. The Captain stated that normally they indicate two hundred to two hundred ten knots at cruise, but were only indicating one hundred eighty knots during the encounter. The captain requested a descent down to 14,000 feet MSL and was in the clear. He stated substantial amounts of ice came off the aircraft.

During the descent from 14,000 feet MSL He received Automated Terminal Information Service (ATIS) Papa for LBB. The ice light on the memo panel began to flash after five minutes and he deselected Level Three ice protection. The ATIS reported rapidly changing weather and advised that the current weather could be obtained from Approach Control.

Fort Worth Center handed off the flight to LBB approach control and cleared them to descend to 6,000 feet MSL. LBB approach informed them of "light freezing drizzle" conditions in LBB. The weather was reported to the flight as also having a five hundred foot overcast ceiling with two miles visibility, and a ten-knot tail wind. They were then cleared for the ILS Approach to runway 17R, cleared to descend to 5,000 feet MSL, and were vectored for the approach to runway 17R. The captain stated that approach control had to give additional vectors due to a wind shift during the descent from 6,000 feet to 5,000 feet MSL. The captain briefed the approach, in anticipation

of having to fly it, as he had some concerns that the first officer might be "high minimums" but found out shortly there after that the visibility would not be a problem and the first officer could fly the approach.

The first officer called for "Flaps 15, gear down, and landing check." The captain selected flaps 15 degrees, the crew did the pre-landing checklist and the first officer reduced power on both engines. The captain then realized that there was a problem with the flaps. He said he repositioned the flap handle several times and checked the circuit breakers with a flash light while they were descending on the final approach. He then placed the flap handle in the up or retracted position, as he did not want the flaps to inadvertently travel during the approach. The captain stated that he did not do the reduced flaps landing procedure, did not reset the speeds for a no flap approach, and continued despite the first officer's suggestion to go around. The captain stated he based this decision on the runway conditions, icing conditions, and the flap problem. He stated, "I just wanted to land as soon as possible."

According to the captain, they were still carrying ice from their first encounter when they started to descend into LBB. The first officer stated they began to accrete ice once again as they descending through 6,000 feet MSL and received an ice aural warning chime. She stated Level Three ice protection was again activated. She stated the Icing Light came on and a chime was heard. She could see icing on the spinner. The stick shaker then activated at an approximate altitude of 1,000 feet above ground level, and the autopilot disengaged.

The captain in the meantime looked over and noticed that the airplane was drifting off the localizer and saw the first officer flying the approach when the airplane should have been coupled to the ILS. He was confused as to why the autopilot had disconnected, and stated that he had not heard an aural alert. The first officer asked the captain if they should go around. The captain said no and then asked the first officer if she wanted him to take the flight controls. She responded yes and advised that shortly thereafter, the airplane became uncontrollable. The captain stated that the stick shaker then activated, so he added power. Moments later the TAWS (Terrain Avoidance Warning System) issued a "PULL UP" warning and the first officer advised that she had the runway in sight. The stick shaker then activated two more times, and the captain called for maximum RPM. He realized that he had no lateral control, and then, the controls were almost "snatched" out of his hands. Moments later the airplane impacted the ground.

At no time during the approach did the non-flying pilot call out localizer, glide slope, speed, or vertical speed deviations, and there was no reaction to the "PULL UP" warning.

2.0 Meteorological Information

A weather observation taken about 16 minute after the accident, recorded the wind as 020 degrees at 11 knots, gusting to 18 knots, visibility 2 miles in light freezing drizzle and mist, ceiling overcast at 500 feet, temperature minus 08 degrees Celsius, dew point minus 09 degrees Celsius, and an altimeter setting of 30.13 inches of mercury.

3.0 Flight Crew Information

According to the accident flight crew the two crewmembers had never flown together before this flight pairing. During the impact sequence the captain was seriously injured and the first officer received minor injuries.

3.1 The Captain

The captain held an airline transport pilot certificate with ratings for airplane single-engine land and multi-engine land. His most recent FAA first-class medical certificate was issued on September 19, 2008. He reported 13,200 total hours of flight experience on that date.

Empire Airlines hired him on May 9, 1988. He was based in Salt Lake City, Utah and Resided in Portland, Oregon.

He began his trip sequence by deadheading to Midland International Airport (MAF), Midland, Texas on January 24, 2009 and was scheduled to end his 5-day trip on January 30, 2009.

A review of the captain's Employee Training Events record provided by the operator revealed that he had completed a recurrent proficiency check ride and line check on September 22, 2008. He advised the Operations Group that he had accrued approximately 13,000 hours total time, of which 6,600 hours of flight time had been in the CE208 (some of which was as a check airman), 2,500 hours had been in the F27 (of which 600 hours were as a first officer), and 1,500 hours had been in the ATR.

The captain had been previously employed as a 14 CFR Part 135 pilot for Union Flights and had flown both Beech 18, and CE208 for that operator.

A review of FAA and company records revealed no previous accidents, incidents, or disciplinary action involving the captain.

Flight Experience according to Empire Airlines records:

Flight Time	**Hours**
Total	13,828
Pilot In Command (PIC)	12,742
Total ATR PIC Time	2,080
Last 24 Hours	4.7
Last 30 Days	12.6
Last 90 Days	58.3
Last 12 months	362.7

Pertinent training and checks:

Part 121 Training/Checks	**Date**
Upgraded/Transitioned to a 121 Captain position	F27: April 5, 2002 ATR: January, 8, 2005
Initial Operating Experience (IOE) For the ATR	January 8, 2005

Type Rating on the ATR	December 30, 2004
Most Recent Recurrent Ground School (ATR Systems)	March 29, 2008
Most Recent Proficiency Check	September 22, 2008
Most recent PIC Line Check	September 22, 2008

3.2 Captain's 72-Hour History

On January 24, 2009 the captain awoke about 0800 CST, showered, had breakfast, and was driven to the airport. He boarded Southwest flight 2535 and departed for Las Vegas, Nevada at approximately 1015. He then arrived in Las Vegas had about a 1-hour layover and departed for MAF at 1325. The flight arrived in MAF at 1535. The first officer picked up the captain and they drove to the hotel where he checked in, and visited with her for approximately an hour. He then went to the store and purchased some groceries for the next few days, as there was a microwave and refrigerator in his hotel room. He then ate dinner in his hotel room, watched some television and about 2300 went to bed.

He awoke on January 25, 2009 at approximately 0800. He ate breakfast in the hotel, and exercised in the hotel fitness center. After taking a shower in his hotel room, he then read the newspaper and called a fellow co-worker to confirm dinner plans for the evening. At approximately 1200 the captain ate a light lunch, drove around town, and did some light shopping. Later that evening, both he and the first officer drove to the co-workers home for dinner. They completed dinner at approximately 2130 drove back to the hotel and went to bed at 2200.

On January 26, 2009, the captained awoke at 0400 and watched some television, made and ate a small snack, and read a book. At 0600 he went to the hotel lobby and had breakfast. He then worked out in the hotel fitness center and sat in the spa next to the pool for approximately 25 minutes. At 0730 he went back to his room, showered, dressed, and did some paperwork. He also read the newspaper and watched television. At 1000 the captain went to the store and purchased lunch for his trip that evening and then returned to the hotel. He went to bed at 1100, and woke at 1630. He then had a meal, showered, packed his lunch, and prepared to go to work. He met the first officer in the lobby at 1820, drove to the airport and began their flight crew duties at 1845. At 1945 they departed MAF for ELP and arrived at ELP at 2115. Then at 2230 departed ELP for AFW.

On January 27, 2009 they arrived at AFW at approximately 0030. After closing out the flight with Empire's dispatch, the captain ate lunch and watched television. At 0230 he arrived back at the airplane and resumed flight crew duties and departed AFW at 0313 for LBB. After arriving at LBB the accident occurred at 0437.

3.3 The First Officer

The first officer held a commercial pilot certificate with ratings for airplane single-engine land, multi-engine land, and instrument airplane. Her most recent FAA first-class medical certificate

was issued on December 4, 2008. She reported 2,000 total hours of flight experience on that date.

She was hired on July 25, 2008. She was based in Salt Lake City, Utah and Resided in Fife, Washington

The week before the accident flight, the first officer deadheaded to MAF from Seattle, Washington on January 18, 2009. She then flew the trip sequence with another captain completing the trip pairing on January 23, 2009.

The first officer picked up the captain of the accident flight at the passenger terminal at MAF on January 24, 2009 and commenced the accident flight's trip pairing on January 26, 2009. She was scheduled to end her 5-day trip on January 30, 2009.

A review of the first officer's Employee Training Events record provided by the operator revealed that she had completed her initial proficiency check ride on September 10, 2008. She advised the Operations Group that she had accrued approximately 2,000 total hours of flight time, of which approximately 100 hours had been in the ATR 42.

The first officer had been previously employed as a flight instructor for Spanaflight in Puyallup, Washington and had flown the Cessna 172, Beech Duchess, and the Piper Arrow.

A review of FAA and company records revealed no previous accidents, incidents, or disciplinary action involving the first officer.

Flight Experience according to Empire Airlines records:

Flight Time	**Hours**
Total	2,055
PIC	1925
Total Second In Command (SIC) Time	130
Total ATR Time	130
Last 24 Hours	4.7
Last 30 Days	29.8
Last 90 Days	87.9
Last 12 months (At Empire Airlines)	130.2

Pertinent training and checks:

Part 121 Training/Checks	**Date**
IOE (For the ATR)	September 26, 2008
Initial Ground School (ATR)	August 29, 2008
Most Recent Proficiency Check	September 10, 2008

3.4 First Officer's 72-Hour History

On January 24, 2009, the first officer went to bed at 0600 CST. She awoke at 1430 and drove to the airport to pick up the captain at approximately 1600. At 1700, she worked out at the hotel fitness center for about an hour. She then went to the store about 1900, and then returned to the hotel.

After remaining awake the previous evening, she went to bed at 0600 on January 25, 2009. She awoke about 1400, and then she and the captain went to a coworker's home for dinner and left for the hotel at 2200.

She once again remained awake overnight, and went to bed on the morning of January 26, 2009. She woke up about 1500 and got ready for her trip and reported for the trip with her captain at approximately 1845.

At 1945 they departed MAF for ELP and arrived at ELP at 2115. Then at 2230 departed ELP for AFW.

On January 27, 2009 they arrived at AFW at approximately 0030. After a break, she arrived back at the airplane At 0220 to resume her flight crew duties and they departed AFW at 0313 for LBB. After arriving at LBB the accident occurred at 0437.

4.0 Aircraft Information

The accident airplane was an ATR 42-320 twin-turboprop short haul regional airliner, which was manufactured in France and Italy in 1989 and had conducted its first flight on January 15, 1990. It had been converted for use in freight operations. It was constructed of both metal and composite materials and was powered by Pratt & Whitney PW-121 powerplants. The airplane was pressurized and its maximum certificated operating altitude was flight level 250. It was registered to FedEx and operated by Empire Airlines. The airplane's most recent inspection was completed on January 9, 2009. At the time of the accident, the airplane had accrued 28,768.0 total hours of operation and 32,379.0 cycles.

4.1 Weight and Balance Information

The FedEx Feeder Aircraft Load Control Sheet, and the Empire Airlines ATR 42 LC/SC Cargo Load Manifest, were reviewed by the Operations Group. Weight and Balance Information from these documents, was then entered by the group into the accident airplane's CG calculator and the weight and balance calculations produced, were verified. No anomalies with the accident airplane's calculated weight and balance, was discovered.

MANUFACTURER'S PUBLISHED AIRPLANE WEIGHT LIMITATIONS	
	WEIGHT (Pounds)
Taxi Weight	37,633
Takeoff Weight	37,258
Landing Weight	36,155
Zero Fuel Weight	34,259

WEIGHTS AS ENTERED ON THE LOAD MANIFEST	
	WEIGHT (Pounds)
Zero Fuel Weight	30,187
Fuel Weight	4,500
Taxi Weight	34,687
Taxi Fuel Burn	200
Takeoff Weight	34,487
Fuel Burn (To Accident Site)	1,770
Estimated Landing Weight	32,717

5.0 Equipment and Systems

The following systems information was taken from the ATR 42 Flight Crew operating Manual (FCOM).

5.1 Electronic Flight Information System

The airplane was equipped with an Electronic Flight Information System (EFIS). Information was displayed by the EFIS system through the use of Cathode Ray Tubes (CRTs) for each pilot. Dual Electronic Attitude Director Indicators (EADI) were used to indicate Pitch and roll and a mechanical ADI located on the center instrument panel was used for backup.

The EADI sphere, which was displayed, moved relative to the airplane symbol to indicate pitch and roll attitudes. The portion of the sphere that represented the sky was blue and the lower half was brown. The pitch scale was marked in 5-degree intervals. The roll scale was marked at 0, 10, 20, 30, 45, and 60 degrees. Red chevrons, which pointed toward the horizon, were shown above +45 degrees of pitch and below –30 degrees of pitch to assist in recovery from unusual attitudes. The tip of the chevron below the horizon would become visible at approximately 10" nose down. In addition to the chevrons, an "Eyelid" of either blue or brown, representing the horizon would remain in view in extreme pitch attitudes to facilitate pilot orientation.

The EADI was also equipped with a FAST/SLOW indicator on the left hand side. A green scale would indicate the difference between speed selected by the pilot using the internal speed bug on their related airspeed indicator, and the airplane's actual speed. A white index would move up (FAST) or down (SLOW) according to the deviation from the selected speed.

5.2 Ice Evidence Probe

Some ATR airplanes came equipped with an optional ice evidence probe (IEP) installed near the left side cockpit window. When encountering icing conditions, ice would build up on the leading edge of this IEP allowing visual detection of the accretion and when leaving icing conditions, the IEP would assist in determining when the critical surfaces of the airplane were free of ice prior to resetting icing AOA (instead of a propeller spinner visual check). An integrated light controlled by the NAV LIGHT switch was also included for night operations.

According to ATR, on new production airplanes, the IEP had been installed on serial numbers 315, 321 and subsequent, and ATR had provided all operators with the service bulletin and kit necessary for installation of the IEP on airplanes already delivered.

Examination of the accident airplane revealed that it was not equipped with an IEP.

5.3 Ice Detection

An Anti-icing Advisory System (AAS) was installed on the ATR 42. It included:

- An Ice detector
- ICING (Amber) light
- ICING AOA (green) light
- DE ICING blue light

The system was designed to remind the flight crew on the need to apply procedures and checklists when flying in icing conditions. These include:

- Increase in the minimum maneuvering speed/operating speeds.
- Selection of anti-icing system when entering icing conditions (selection of horns anti-icing lowers the AOA stall warning threshold and triggers illumination of the ICING AOA light).
- Selection of de-icing system at first indication of ice accretion.
- When ice does not build up anymore on the airframe ("DE-ICING" flashing), checking if the de-icing system should be switched off.

The ice detector, located under the left wing of the airplane, alerts the flight crew as soon as and as long as the probe senses ice accretion. This will illuminate the amber ICING light in the cockpit. The manufacturer cautions that the ice detector indicates ice accretion is "building up" on the airplane. Therefore, extinguishing of the ICING light must be regarded as an end of ice accretion, and not as an absence of ice on the airplane. Consequently a visual check must be performed by the flight crew to assure that the airplane is clear of ice after having encountered ice accretion conditions and prior to the reset of the ICING AOA green light.

The manufacturer also cautioned that ice accretion on the airplane under certain conditions may sublimate, and if the ice accretion rate is low, the balance between accretion/sublimation may tend to be low or nil. Under those circumstances, the ice detector may not detect ice accretion, as sublimation is much faster on the ice detector than on the airframe.

Additionally, the manufacturer cautioned that freezing rain is a precipitation composed of large super cooled water droplets which may be transformed into clear ice when impacting the airplane's skin in negative temperature conditions. Nevertheless, if the Standard Air Temperature (SAT) is slightly negative, these large droplets may not freeze immediately when impacting, clear ice can build up behind the leading edge, and the ice detector may become inefficient.

5.4 Operation of the Ice Protection System

According to the manufacturer, Atmospheric Icing Conditions exist when the outside air temperature (OAT) on the ground and for takeoff is at or below 5 degrees Celsius (C) or when the total air temperature (TAT) in flight is at or below 7 degrees C and visible moisture in any form is present (such as clouds, fog, with visibility of less than one mile, rain, snow, sleet and ice crystals).

The leading edges of the wings, horizontal stabilizers, and vertical stabilizer on the ATR 42 were deiced by pneumatic boots (which inflate perpendicular to the airfoil span), and the engine intakes were protected by annular, pneumatic boots.

The manufacturer advised that with this type of pneumatic boots, that there is no need to wait for ice accretion on the airframe before selecting the system on, and that the system should be selected on as soon, and as long, as ice accretion develops on the airframe.

The propeller blades, windshields, probes, and flight control horns were electrically heated.

For operation in atmospheric icing conditions the airplane was to be configured as follows:

- Np [Propeller speed] 86%
- The Horns, propellers, side windows and engine anti-icing must be selected ON.
- The Eng [ine] start rotary selector must be placed to CONT [inuous] RELIGHT.

The AFM outlines the use of the anti-ice/deice systems. Three different levels of equipment have been defined. These three equipment levels are as follows:

Level One:

- Probe HTG [Heat]
- Windshield HTG [Heat]

Level Two:

- **Level One** items plus,
- Propellers 1 & 2 Heat
- Flight Control Horns L & R Heat
- Side Windows L & R Heat
- Engine 1 & 2 (inertial separator & pneumatic boot)
- Minimum Propeller RPM 86%
- Angle of Attack (AOA) Light illuminated
- Icing Speeds bugged and observed

Level Three:

- **Level Two** items plus

- Continuous Relight [engine ignition]
- Airframe deicing ON (pneumatic boots)

Level One ice protection must be selected for all flight operations.

For all takeoffs and flight operations in atmospheric icing conditions, **Level Two** protection must be selected in addition to **Level One**.

Anytime ice is building on the airframe, **Level Three** protection must also be selected.

When **Level Three** protection is desired, airframe deicing is selected by pushing the AIRFRAME button. Pockets in the boot system inflate in sequence and deice the leading edges without further flight crew input or attention.

5.5 Flight Controls

The primary flight controls included conventional mechanically operated ailerons, elevators and rudder.

The trailing-edge flaps and roll spoilers were hydraulically operated. There were three electrically controlled trim tabs on each of the three axes. The ailerons, elevators, and rudder had "horns" which acted as counterweights and served to balance the flight controls. The horns were anti-iced when level II ice protection was selected.

Vortex generators were installed on the upper surface of the wings, forward of each aileron to insure aileron response when operating at low airspeeds.

The trailing-edge flaps were double-slotted, fowler type, with inboard and outboard panels. They were electrically controlled and hydraulically positioned.

The selectable flap positions were: RET[ract] 0 degrees, TO (takeoff)/APP [roach] 15 degrees, LDG (landing) 30 degrees (which actually corresponded to 27 degrees), and 45 degrees (to be used only in the event of an emergency).

The lever and flaps position would automatically control the flap value, which would hydraulically actuate the four flap actuators.

In the event that a possible asymmetry was detected between the right inboard and left inboard flaps, the maximum asymmetry allowed by the system was between 8 and 10 degrees, and then the electrical supply to the flap control system would be isolated, the flaps would stay at their current position, and the flap control lever would have no further effect on the system until a maintenance action was performed.

System indication was also provided in the event of untimely flaps retraction and uncoupled flaps. Indication of flap untimely retraction was made available to the flight crew through illumination of a red FLAP UNLOCK warning light, master warning light, and a continuous chime. The purpose of the unlock warning was to inform the pilot of the untimely flap retraction

and induce him to take appropriate action so that rapid development of a stall configuration was avoided.

5.6 Automatic Flight Control System

The airplane was equipped with an Automatic Flight Control System (AFCS). It provided autopilot (AP), yaw damper (YD), flight director (FD), and altitude alert functions.

A flight director mode could be selected prior to autopilot engagement. Bank could be selected at High (27 degrees) or Low (15 degrees). The ATR-42 AFM indicated that pilots were expected to operate in the LO bank mode for takeoff but could be selected to High after takeoff depending on speed.

Manual disengagement of the autopilot would occur when the quick disconnect button on the wheel is pressed, the normal or standby pitch trim is activated, The AP button on the AFCS panel is pressed, the YD button is pressed, The go around button is pressed on the power levers, or pilot force on the rudder pedals is in excess of 66 pounds.

Automatic disengagement would occur when one of the engagement conditions of the AP or YD was no longer met, stall warning indicator threshold was achieved, there was a disagreement between the two Attitude Heading Reference Systems (AHRS) or between the two Air Data Computers (ADC), or there was a mismatch between the two pitch trims.

Both aural warnings (cavalry charge), and visual indications (AP OFF, AP DISENGAGED) on the Advisory Display Unit (ADU), and an AP MSG on the primary flight display were generated in the event of manual or automatic disengagement of the autopilot.

If an autotrim failure or mistrim condition occured, a "PITCH TRIM FAIL" or "PITCH MISTRIM" message would be displayed on the ADU, and an "AP MSG." Would be displayed on the primary flight displays. According to the manufacturer, in the event this occurs, "The crew has to disengage the AP and manually fly the airplane."

Aberrancy in roll would generate an "RETRIM ROLL R(L) WING DN," "AILERON MISTRIM," messages on the ADU. According to the manufacturer, in the event of "RETRIM ROLL R(L) WING DN," the aileron trim should be operated accordingly. In the event of "AILERON MISTRIM" the control wheels should be held firmly, the AP should be disconnected, and the lateral trims should be adjusted. The autopilot may then be reengaged.

Elevator hinge moment could be affected by external conditions such as takeoff with ice remaining on the tail plane (de/anti-icing hold overtime exceeded) or severe icing. Aileron forces could be affected by external conditions such as prolonged exposure to severe icing or the de/anti-icing hold over time being exceeded

The AFM also stated that since the autopilot may mask tactile cues that indicate adverse changes in handling characteristics, use of the autopilot is prohibited when the severe icing exists, or when unusual lateral trim requirements or autopilot trim warnings are encountered while the airplane is in icing conditions.

5.7 Low Speed Warning System

The airplane was not equipped with a low speed warning system nor was one required by regulation.

Some later models of the ATR 42 and 72 are equipped however with an Aircraft Performance Monitoring (APM) system. This system was developed by ATR on a voluntary basis in response to several aviation investigation authorities recommendations to develop onboard detectors that could warn flightcrews when the airplane was in severe icing conditions. The main objective of the development of the APM was to give evidence to the flightcrew of severe ice effects on the airplane's performance and alert the flight crew about compliance with the minimum required indicated airspeed as indications were, that cues and procedures established for severe icing encounters were not always recognized or followed by flight crews. Recent recommendations also asked for the installation of low speed warning devices.

During flight, the APM calculates the actual performance of the airplane and compares it to what is expected, computes the actual minimum icing and severe icing speeds for the given flight condition, and will warn the flight crew to increase speed if the cruise speed is low, or the performance of the airplane has been degraded.

5.8 Stall Protection System

To generate a stall alert (cricket and stick shaker), the airplane was fitted with two angle of attack (AOA) probes, one on each side of the forward fuselage.

In the event that the airplane would reach a critical AOA of 12.5 degrees, this would be detected by the AOA probe, an aural alert (cricket), would be generated and the stick shaker would be activated. If the angle of attack continued to increase to 15 degrees, stick pusher activation would then occur.

The critical AOA for activation of the aural alert (cricket), and the stick shaker would be reduced to 7.5 degrees when selecting the horns anti-icing.

5.9 Terrain and Traffic Collision Avoidance System

The airplane was equipped with a T²CAS (Terrain and Traffic Collision Avoidance System). T²CAS is an integrated system that combines both terrain avoidance (TAWS) and traffic avoidance (TCAS) In a single unit.

During the final approach, the system generated a "Pull Up" warning to the flight crew. At the point of the "PULL UP", the aircraft was approximately 1.5 miles from the runway threshold, slightly west of the extended centerline. The data recording indicated that at a radio altitude of 488 ft and a vertical speed of -2050 ft/min the warning was generated.

According to the TAWS Event Analysis Report which was produced on behalf of the Safety Board by Aviation Communications and Surveillance systems, the rapid change in vertical speed

combined with the low radio altitude value resulted in an immediate Mode 1 Warning without a preceding Caution. The annunciation to the flight crew at that point consisted of an aural "PULL UP, PULL UP" in conjunction with the illumination of the red TAWS Warning annunciator.

6.0 Airport and Approach Information

LBB had three runways, oriented in an 8/26 and 35/17 configuration. At the time of the accident, the runway complex was covered in ice and runway 8/26 was closed. Runway 17R was concrete, grooved, and in good condition It was equipped with an Instrument Landing System with Distance Measuring Equipment (ILS/DME), a 1,400 foot long, medium intensity approach lighting system with runway alignment indicator lights (MALSR), high intensity runway edge lights, and precision markings. The total length of the runway was 11,500 feet, and its width was 150 feet.

7.0 Company Information

Empire Airlines holds Air Carrier Certificate number COEA135A for all cargo operations conducted under 14 CFR Parts 135 and 121. Company headquarters are located in Hayden, Idaho. The Chief Executive Officer (CEO), Board of Directors (BOD), Chief Pilot, Director of Operations, Director of Maintenance, and the Director of Safety are employed at that location.

On April 12, 1977 the company was first established as Clearwater Flying Service (CFS) in Orofino, Idaho. On May 1, 1977 they hired an individual who became their first flight instructor and manager.

By 1979, The Company had expanded and they were operating fire patrol flights, were transporting outfitters into remote areas, operating air ambulance flights, air pollution monitoring flights, charter flights, and were providing flight instruction.

On November 1, 1980 they acquired West Air Inc. at Coeur d'Alene, Idaho and expanded their business to include aircraft sales and maintenance. They also changed their name to Empire Airways.

In 1986 Empire began contracting with a Colorado company to run shuttle flights between ski resorts.

In 1987, they once again expanded and entered into a contract with Hughes Corporation to fly employees between offices in three California locations and were awarded a contract to operate flights in Alaska on behalf of the Naval Arctic Research Laboratory. Later that same year they signed a contract with FedEx to fly and maintain Cessna CE208 "Caravans," out of Portland, Oregon, Spokane, Washington, and Seattle Washington, to numerous locations in the Pacific Northwest.

In 1989, Empire became a 14 CFR Part 121 operator, after the purchase of Pacific Alaska and two Fairchild F27 airplanes. In August of that year, Empire began F27 service on behalf of FedEx and changed their name to Empire Airlines.

In 1990, Empire added more cargo routes and performed their first heavy maintenance check on a Fairchild F27.

In 1992, Empire assisted Mahalo Airlines startup in Hawaii, and began to operate BAE 146 jets for Silverwing Holidays out of Vancouver, British Columbia.

Starting in 1993, Empire became a sustaining member of CASE (Coordinating Agency for Supplier Evaluation).

In 1995, Empire moved it's corporate office to Coeur d'Alene, Idaho and ended passenger service to focus on cargo operations, aircraft maintenance, and airline startups. They also began sending technical representatives to Conair, during their heavy maintenance checks on Fokker 27s.

In January of 1995, A Cessna 208 Caravan operated by Empire Airlines on a 14 CFR Part 135 cargo flight from Flagstaff, Arizona to Phoenix Sky Harbor International Airport crashed about 1.3 miles south-southeast of Flagstaff Pulliam Airport. While returning to the airport, the "fuel selector off" warning horn was heard. The pilot was killed. The probable cause of the accident was determined to be pilot's failure to properly configure the fuel system prior to takeoff.

In 1998, Empire added the Shorts Brothers SD360 to their fleet and began to both fly and maintain them, and entered into a partnership agreement to startup Express Air, to serve FedEx in Europe.

In 1999, Empire began to do heavy maintenance checks on the F27.

In March of 2000, Empire appointed a new CEO. On December 31, 2000 Express Air began flying independently.

In October of 2000, a Cessna 208 Caravan operated by Empire Airlines under 14 CFR Part 135, impacted terrain on Lummi Island, Washington during a, VFR cargo flight, from Bellingham, Washington, to Orcas Island, Washington. The pilot was killed. The probable cause of the accident was determined to be pilot's flying into adverse weather and not maintaining proper terrain clearance.

In 2001, Empire received its 14 CFR Part 145 repair station certificate.

In 2002, Empire purchased freight forwarder Reliant Logistics, as a wholly owned subsidiary.

In 2003, Empire's first ATR 42 arrived in Spokane, Washington, and was converted to a freighter. Empire's BOD also accepted the State of Idaho's proposal for a new hangar and offices at the Coeur d'Alene airport.

In 2004, Empire moved into its new hangar and office building. The first ATR was put on Empire's certificate and it made its first revenue flight for FedEx.

In 2005, Empire Aerospace performed heavy maintenance on the first ATR 72 imported from Germany by FedEx.

In 2006, Empire Aerospace received and signed Operations Specifications to allow the performance of heavy maintenance on ATR 72s and Fokker F27s. Empire aerospace also added Dehavilland Dash 8 –100, -200, -300, and Q-400 capabilities to their Operations Specifications.

In 2007, Empire Aerospace signed a contract with Horizon Air to support a line of Q-400 airplanes for reliability and performance upgrade modifications.

At the time of the accident, Empire was operating 35 CE208s, 10 ATR 42s, and 3 ATR, 72s, serving 51 destinations on behalf of FedEx. All the airplanes were owned by FedEx and leased to Empire. Its flight and maintenance operations were staffed by approximately 250 employees, of which 108 were pilots.

8.0 Provided Guidance and Icing Information

A review of operational guidance and icing information from the airline, manufacturer, and FAA was reviewed by the operations Group.

8.1 Stabilized Approach Criteria

According to the Empire Airlines, they had established procedures for ensuring that each approach was accomplished using standardized procedures.

A review of the GOM revealed that stabilized approach and approach standardization was mentioned and that the airline had established procedures for each type of airplane.

Review of the airline's Flight Training Manual (FTM) revealed that the information was contained in the "ATR 42/72 Flight Profiles and Briefings" section and was also in the Empire Airlines ATR Pilot Handbook, which was issued to the company's pilots.

According to the FTM, Approaches should be stabilized by 1000' height above touchdown (HAT) in IMC and by 500' HAT in VMC.

The approach would be considered stabilized when all of the following criteria were met:

The aircraft is on the correct track (correct track is one for which the correct localizer, radial, or other track guidance has been set, tuned, and identified, and is being followed by the flight crew);

- Only small changes in heading and pitch were required to maintain the correct track.
- The bank angle was not more than 30 degrees.
- The rate of descent was, +/- 300 fpm deviation from target.
- The aircraft speed was not more than the required approach speed +20 knots and not less than the required approach speed.
- The aircraft was in the proper approach configuration.

- The sink rate was a maximum of 1000 FPM, if an approach required a sink rate greater than 1000 FPM, a special briefing should be performed.
- The power setting was appropriate for the configuration.
- All briefings and checklists had been performed.

8.2 Flight Profiles and Briefings

According to the Empire Airlines ATR 42 Pilot Handbook (PH) and FTM, during an Instrument Landing System (ILS) approach, the non flying pilot was to provide standard calls and procedures, keep the flying pilot advised of any deviations in altitude, airspeed, or course, and to provide a progressive brief on the approach.

According to the Descent And Approach Awareness procedure contained in the PH and FTM, the non flying pilot was to call out any deviations from normal, altitude, airspeed, or descent rates throughout the approach, touchdown or missed approach, and specifically during the descent and approach, the non flying pilot was required to:

- Call out through FL180, set and crosscheck altimeters.
- Call out through 10,000 feet, Landing and ice inspection lights on, approach checks.
- Call out 1000 feet above and below assigned altitudes. Call out star (asterisk) indication for both altitude and navigation acquisitions. ALT*, VOR*, BC*, LOC*, GS*, as appropriate.
- On the approach, check and monitor approach plates for frequencies, airport elevation, MDA or DH, missed approach procedures, descent rates, etc.
- Call "RAD ALT ALIVE" when the radio altimeter began to indicate.
- At the Final fix inbound to cross check the instruments and check the correct altitude at glideslope interception.
- Call out 1,000 feet above minimums. Instruments and altimeters crosschecked. No flags.
- Call out 500 feet above minimums. Instruments and altimeters crosschecked. No flags.
- Call out 200 feet above minimums.
- Call out 100 feet above minimums.
- Call out at minimums.
- Call out lights or runway "In sight" or "No contact."
- Captain calls "missed approach," if necessary.

Additionally, the Descent And Approach Awareness procedure required that, the proper mode and glideslope during coupled and/or flight director approaches be confirmed, and that the final landing checklist be completed prior to or as soon as practicable after passing the final fix.

8.3 Terrain Avoidance Warning Procedure

According to the Empire Airlines General Operations Manual (GOM), In response to a terrain avoidance warning system (TAWS) warning/alert, except in daylight visual meteorological conditions (VMC), when the flight crew can immediately and without doubt confirm that an impact with the ground, water, or an obstacle will not take place, react immediately to the TAWS warning or alert.

Specifically if the crew receives a "Pull Up warning," they should:

- Advance to go around power
- Disconnect the autopilot
- Level the wings and simultaneously execute a positive pull up
- Set Flaps to go around postion
- Retract the landing gear
- Maintain Vmlb (in the ATR) until terrain clearance is assured using all available information

8.4 Emergency and Abnormal Guidance

According to the Empire Airlines General Operations Manual (GOM), in an emergency situation that requires immediate decision and action, the pilot in command could take any action that he or she considered necessary under the circumstances and could deviate from prescribed operations procedures and methods, weather minimums, FAA regulations, and guidelines to the extent required in the interest of safety.

There was no guidance however, in the GOM regarding abnormal situations, and no guidance regarding the prioritization of abnormal and emergency situations.

The Manufacturer's FAA approved Airplane Flight Manual (AFM) contained specific guidance regarding emergency and abnormal procedures. This information was also contained in the Quick Reference Handbook (QRH), and the Flight Crew Operating Manual (FCOM)

Review of both the AFM and the QRH revealed that in the event of a wing flaps failure, guidance was provided. Guidance in both documents included procedures for unlocked flaps, jammed flaps, uncoupled flaps, and flap asymmetry conditions.

Information was also provided for a reduced flaps landing.

8.5 Guidance Regarding Component Failure

According to the Empire Airlines GOM, when a "failure of any component of the aircraft materially affected the safety of the flight" or if there had been some kind of structural damage (due to bird strike, etc.), the flight crew would have been required to assess the damage to the aircraft after the emergency was under initial control.

The assessment should have included:

(1) Analysis of the affected component(s)
(2) Notification of ATC of the situation

The captain also was required to:

A. Obtain the condition of all intermediate fields in the sector, weather conditions in the vicinity of these fields and airway traffic in the area.
B. Notify Maintenance Control. Arrange for direct radio communications between Maintenance Control and the flight if desired.

8.6 FAA Icing Guidance

At the time of the accident, information regarding meteorological and weather information products and services were available from the FAA in form of two advisory circulars; Aviation Weather AC 00.6A and Aviation Weather Services AC 00.45F Change 1. These two documents were advisory in nature only, and the information contained in them was not provided to the flight crews by the airline, nor was it required to be.

Aviation Weather AC 00.6A provides information on conditions favorable to the formation of structural icing. It stated:

"The condition most favorable for very hazardous icing is the presence of many large, supercooled water drops. Conversely, an equal or lesser number of smaller droplets favors a slower rate of icing."

"Small water droplets occur most often in fog and low-level clouds. Drizzle or very light rain is evidence of the presence of small drops in such clouds; but in many cases there is no precipitation at all"

Aviation Weather Services AC 00.45F Change 1, provided a table of icing intensities, which classified each intensity according to its operational effect on aircraft. It defined these as follows.

Trace:

Ice becomes perceptible. Rate of accumulation slightly greater than rate of sublimation. It is not hazardous even though deicing/anti-icing equipment is not used unless encountered for an extended period of time (over one hour). The rate of accumulation may create a problem if flight is prolonged in this environment (over one hour).

Light:

Occasional use of deicing/anti-icing equipment removes/prevents accumulation. It does not present a problem if the deicing/anti-icing equipment is used.

Moderate:

The rate of accumulation is such that even short encounters become potentially hazardous and use of deicing/anti-icing equipment or diversion is necessary.

Severe:

The rate of accumulation is such that deicing/anti-icing equipment fails to reduce or control the hazard. Immediate diversion is necessary.

Rime:

Rough milky opaque ice formed by the instantaneous freezing of small supercooled water droplets.

Clear:

A glossy, clear or translucent ice formed by the relatively slow freezing of large supercooled water droplets.

Pilots are expected to use this terminology when making pilot reports (PIREPS) concerning icing conditions. This terminology makes knowledge of the reporting aircraft's anti-ice/deice capabilities requisite to a pilot's understanding the report's impact on his or her flight. Light icing conditions for a turbojet or turboprop aircraft such as the L-382, L-188, *CV-580,* CV-600, may exceed the anti-ice/de-ice capabilities of a regional turboprop.

8.7 Company Provided Icing Guidance

Empire Airlines possessed an FAA approved Aircraft Deicing Program (ADP) to provide for release of their airplanes in icing conditions. The program was designed in accordance with 14 CFR 121.69 and conformed to the guidance contained in AC 120-60B to assure that none of their airplanes was released for flight in icing conditions without determining that the airplane had been deiced/ant-iced prior to takeoff.

The ADP contained holdover tables as a guideline on the amount of time that deicing/anti-icing fluid would protect the airplane's critical surfaces from frozen contaminants in the specified icing conditions of: active frost, freezing fog, snow, snow grains, freezing drizzle, light freezing rain, and rain on cold soaked wings.

In addition to Empire Airline's FAA approved ADP that was distributed to the flight crews and provided guidance for ground de-icing, the GOM also contained information regarding flight in icing conditions.

The GOM stated on page 8-9 that, " When light freezing rain, light to moderate freezing drizzle, or light, moderate snow is falling, aircraft may takeoff, provided it is prepared in accordance with approved deicing procedures."

The GOM also stated that, " When light freezing rain, light or moderate freezing drizzle, or light, moderate, or heavy snow is falling aircraft may land."

According to Empire Airlines Director of Operations, this guidance was generated by the airline by using the titles from the holdover tables from the airline's approved ground deicing program in response to flight crewmembers requests for operational guidance regarding operations in icing.

The company also provided their flight crews a two volume Pilot Handbook (PH). A Review of the PH revealed that it contained the manufacturer provided icing information but, the PH was not required by the airline to be in the flight crew's possession while they were on duty.

8.8 Manufacturer Provided Icing Guidance

Information regarding operations in icing conditions was provided in the AFM. This information contained, limitations which including a warning, that stated, "Severe icing may result from environmental conditions outside of those for which the airplane is certificated. Flight in freezing rain, freezing drizzle, or mixed icing conditions (supercooled liquid water and ice crystals) may result in ice build-up on protected surfaces exceeding the capability of the ice protection system or may result in ice forming aft of the protected surfaces. This ice may not shed using the ice protection systems and may seriously degrade the performance and controllability of the airplane."

This guidance also included information to identify severe icing, and both normal and emergency procedures for flight in icing conditions.

Information regarding operations in icing conditions was also provided by the manufacturer in their "Be Prepared for Icing," document. This document advised that icing is a major concern for commuter aircraft particularly during takeoff and landing despite anti-icing and de-icing systems and that due to their flight level and speed, turboprop aircraft fly where icing conditions are most likely to occur. The document goes on to advise that pilots of turboprops must pay attention to clues leading to ice accretion. They must keep in mind that adverse weather conditions play significant causal roles in nearly one third of all aircraft accidents, including general aviation. Among them more than 20 percent are directly related to icing. Additionally, it also provided information regarding the icing meteorological phenomena, the systems available to prevent and to control the ice accumulation, the performance loss due to ice contamination on the aerodynamic surfaces of the airplane, and the procedures to apply on the ground and during flight when facing icing conditions.

8.9 Samples of Multiple Operator's Icing Guidance

A cursory survey of operators icing guidance (Both 14 CFR Part 121 and 135) revealed, that a wide disparity existed in the guidance provided to flight crews. Review of the guidance provided, revealed conflicting operational statements even between operators who operated the same or similar equipment, with statements ranging from absolute prohibition of flight in conditions that would result in operation outside of the airplane's certification envelope such as:

- "Takeoffs in freezing rain and freezing drizzle is not approved."
- "Flight in freezing rain and freezing drizzle is prohibited."
- "Pilots will not takeoff, land, or operate company aircraft in conditions of freezing drizzle, freezing rain, known or forecast severe icing."

To ones that only warned that:

- "Flight in freezing rain, freezing drizzle, or mixed icing conditions (supercooled liquid water and ice crystals) may result in ice build up on protected surfaces exceeding the capability of the ice protection system or may result in ice forming aft of the protected surfaces."
- "The following weather conditions may be conducive to severe inflight icing: Visible rain at temperatures below 0 degrees C ambient air temperature."

To ones that allowed operations in conditions outside the certification envelope of the airplane or advised to delay activation of the deicing boots:

- "Aircraft may operate when light freezing rain, light to moderate freezing drizzle, or light to moderate snow is falling, the aircraft may takeoff, provided it is prepared in accordance with approved deicing procedures."
- " When light freezing rain, light or moderate freezing drizzle, or light, moderate or heavy snow is falling aircraft may land."
- "For most effective deicing operation, allow at least 1 to 1 ½ inches of ice to form before attempting ice removal. Very thin ice may crack and cling to the boots instead of shedding. Subsequent cyclings of the boots will then have a tendency to build up a shell of ice outside the contour of the leading edge, thus making ice removal efforts ineffective."

9.0 FAA Oversight

The Empire Airlines operating certificate was managed by the FAA at the Spokane Flight Standards District Office (FSDO) in Spokane, Washington and was administered under the FAA's Air Transportation Oversight System (ATOS)

ATOS began with ten air carriers in 1998 and since that time, all 14 CFR Part 121 carriers have been transitioned to ATOS. The FAA expects that all Part 135 operators will be transitioned to the system by 2013.

According to the FAA, the purpose of the system is to provide a means of oversight that allows carriers to meet and address all regulatory requirements, for FAA inspectors to develop methodology for continued operational safety, and to provide FAA inspectors and carriers the ability to manage risk.

ATOS is based on system safety concepts and three major functions further define the oversight system: design assessment, performance assessment, and risk management.

- Design assessment ensures an air carrier's operating systems comply with regulations and safety standards.
- Performance assessments confirm that an air carrier's operating systems produce intended results, including mitigation or control of hazards and associated risks.
- Risk management process identifies and controls hazards and manages FAA resources according to risk-based priorities.

A review of FAA records revealed that at the time of the accident the carrier had two enforcement actions pending. Neither directly related to Empire Airline's flight operations.

A review of the ATOS program's "System/Subsystem/ Element Chart – Operations and Cabin Safety Elements" table revealed, that as part of the program, the FAA was required to provide oversight of the carrier in multiple areas including; the content of the airline's manuals and the training of its flight crewmembers.

10.0 Dispatch Information

Empire operated a centralized communications center at their headquarters in Hayden, Idaho. It consisted of Dispatch, Maintenance Control, and Crew Scheduling.

Dispatch, had flight following responsibility for Empire's fleet of 48 airplanes. Empire Airlines was not required as a 14 CFR Part 121 Supplemental carrier to use licensed dispatchers for flight following however, dispatch was staffed with 7 flight followers, all of whom were licensed dispatchers with the exception of one, new hire employee. The flight followers typically worked an 8-hour schedule alternating between night and day shifts.

To accomplish the required FAA flight following functions, communications with the company's flight crews was done through the use of telephones, fax machines, and Aeronautical Radio, Incorporated's (ARINC) network of air to ground radio stations, and lease line telephone connections.

Maintenance Control was staffed by three maintenance controllers. At the hub stations, the airplanes were maintained by Empire maintenance personnel. Airplane maintenance at out stations was provided through the use of contract maintenance personnel.

Crew scheduling at headquarters was responsible for pilot scheduling for the Part 121 operation (ATRs). Crew scheduling for the Part 135 operation (CE208s) was accomplished at the individual crew bases and reviewed by crew scheduling at the company headquarters.

According to Empire Airlines, the typical "flight release flow" was as follows:

- 2 to 4 hours prior to scheduled departure time the flight releases were printed and filled out with the flight crew, aircraft, and other information as needed.
- Preliminary weather would than be reviewed and alternates selected.
- Fuel burns would then be calculated using DUATS and dispatch procedures for destination, alternates, and holding if necessary.
- 70 to 90 minutes prior to scheduled departure "fresh weather" is downloaded. Any necessary changes to destinations, alternates, fuel burns, holding, etc. are made.
- No later than 70 minutes prior to scheduled departure time, the flight release along with the weather package is faxed to the flight crew at the station.
- 45 to 60 minutes prior to the scheduled departure time the crew checks in and opens the flight release with dispatch. Any weather concerns are discussed if needed. If changes are needed based on flight crew requests, these are accomplished and either re-faxed or a pen

and ink change occurs. After agreement that all is in order, the fuel on board is recorded along with the time that the captain signed the release.

- After the flight the dispatch copy of the flight release is filed until the original is received back from the flight crew about 1 week later. The original is then filed when received and the dispatch copy is removed and discarded.

11.0 Cockpit Examination

Guidance provided to the pilots in the cockpit included the QRH, which was derived from manufacturers data and published by Empire Airlines, The AFM, the GOM, The Deicing Manual, the TCAS Pilot's Guide, the Normal and Emergency Checklists, the GPS Pilots Guide, the Emergency Response Guidebook, the Policy and Procedures Manual, the Fueling Manual, the Aircraft Performance Data, and the Minimum Equipment List.

During examination of the cockpit by the Operations Group, two copies of the QRH were discovered in the side pockets of the center console. A company supplied hard-sided aircraft documents case was also discovered to be stored against the cockpit bulkhead behind the captain's seat. Its lid was closed and latched. A copy of the AFM along with a copy of the Minimum Equipment List (MEL) was discovered inside. According to Empire Airlines this was the usual storage location for the AFM and MEL.

12.0 Company Provided Aeronautical Charting

According to Empire's Operations Specifications (A009) as the certificate holder, Empire was required to "obtain, maintain, and distribute current aeronautical data for the airports it uses."

A009 also referenced Jeppesen enroute and instrument approach procedures as the primary source of aeronautical data, which is "maintained and distributed to the flight crews by the company." United States Government and Transport Canada terminal procedures and enroute charts are also authorized.

According to the Empire's chief pilot, flight crews where instructed to purchase charts of their choosing (Jeppesen or United States Government), and they would be reimbursed by Empire.

Examination of the flight deck revealed numerous photocopies of United States Government approach plates, on the floor of the airplane as well as in the side pockets of the center pedestal. Further examination revealed that no approach plates or charts were clipped to any of the four chart holders installed in the airplane.

13.0 Airspeed Bugs

The airspeed indicators in the accident airplane were equipped with movable indices (airspeed bugs), which were mounted on the circular bezels surrounding the periphery of the airspeed indicators. The three colored bugs (yellow, white, and red) enabled the flightcrew to manually set predetermined speeds for operation of the airplane.

A speed selector knob mounted on the airspeed indicators would move an internal bug, which was used to select a desired speed during a given phase of flight (i.e. final approach speed, cruise speed, etc.). The selected speed was indicated by an internal speed bug and it would control the reference on the EADI FAST/SLOW scale.

Examination of the cockpit revealed that the ATR 42-320 Eng PW121, V speed card pack was open to the page for 33,000 pounds. A review of the V Speed card revealed that for a normal flaps 30 landing in icing conditions at 33,000 pounds the airspeed bugs would have been set as follows:

- The Internal Bug, which is the minimum approach speed and target touchdown speed at landing, should have been set to 116 KTS.

- The Yellow Bug, which is the approach speed not considering wind effect plus 5 knots, should have been set to 121 KTS.

- The White Bug, which is the minimum airspeed for flap retraction to flaps 0 (takeoff phase), and the minimum airspeed to operate the airplane with flaps 0 (cruise and approach phases) in non-icing conditions, should have been set for 123 KTS.

- The Red Bug, which is the minimum airspeed for flap retraction to flaps 0 (takeoff phase), and the minimum airspeed to operate the airplane with flaps 0 (cruise and approach phases) in icing conditions, should have been set to 143 KTS.

At the time of the accident, Empire Airlines had no policy for setting the internal bug in cruise for a visual indication of degraded performance (speed loss) and no crosscheck confirmation policy for setting the airspeed bugs.

Examination of both Airspeed Indicators revealed, that the airspeed bugs were in the following positions:

Captain's Airspeed Indicator

- Internal Bug: 109 KTS
- Yellow Bug: 110 KTS
- White Bug: 124 KTS
- Red Bug: 145 KTS

First Officer's Airspeed Indicator

- Internal Bug: 106 KTS
- Yellow Bug: 112 KTS
- White Bug: 126 KTS
- Red Bug: 144 KTS

14.0 Training

According to 14 CFR Part 121.419 (Pilots and Flight Engineers: Initial, Transition, and Upgrade Ground Training), initial, transition, and upgrade ground training for pilots and flight engineers must include instruction in at least the following as applicable to their assigned duties:

(1) General subjects—

(i) The certificate holder's dispatch or flight release procedures;

(ii) Principles and methods for determining weight and balance, and runway limitations for takeoff and landing;

(iii) Enough meteorology to insure a practical knowledge of weather phenomena, including the principles of frontal systems, icing, fog, thunderstorms, and high altitude weather situations;

(iv) Air traffic control systems, procedures, and phraseology;

(v) Navigation and the use of navigation aids, including instrument approach procedures;

(vi) Normal and emergency communication procedures;

(vii) Visual cues prior to and during descent below DA/DH or MDA;

(viii) Approved crew resource management initial training; and

(ix) Other instructions as necessary to ensure his competence.

(2) For each airplane type—

(i) A general description;

(ii) Performance characteristics;

(iii) Engines and propellers;

(iv) Major components;

(v) Major airplane systems (i.e., flight controls, electrical, hydraulic); other systems as appropriate; principles of normal, abnormal, and emergency operations; appropriate procedures and limitations;

(vi) Procedures for—

(A) Recognizing and avoiding severe weather situations;

(B) Escaping from severe weather situations, in case of inadvertent encounters, including low-altitude windshear, and

(C) Operating in or near thunderstorms (including best penetrating altitudes), turbulent air (including clear air turbulence), icing, hail, and other potentially hazardous meteorological conditions;

(vii) Operating limitations;

(viii) Fuel consumption and cruise control;

(ix) Flight planning;

(x) Each normal and emergency procedure; and

(xi) The approved Airplane Flight Manual.

(b) Initial ground training for pilots and flight engineers must consist of at least the following programmed hours of instruction in the required subjects specified in paragraph (a) of this section and in §121.415(a) unless reduced under §121.405:

(1) Group I airplanes—

(i) Reciprocating powered, 64 hours; and

(ii) Turbopropeller powered, 80 hours.

(2) Group II airplanes, 120 hours.

14.1 Flight Training Manual

The Empire Airlines Flight Training Manual (FTM) was used to provide a standardized course of training for Empire Airlines crewmembers, dispatchers, and flight followers

The FTM constituted the Empire Airlines FAA approved Fight Training Program. According to the FAA, it met the regulatory requirements of 14 CFR Parts 61, 91, 107, 108, 119, 121, 135 and SFAR 58 and was compliant with the guidance set forth in FAA Order 8400.10, the Air Transportation Operations Inspector's Handbook. It stated Empire's policies and procedures concerning training of flight operations personnel, and gave training personnel information and instructions to guide and assist them in their duties.

Review of the ground training curriculum segment outline revealed that it required that instruction be given in abnormal and emergency procedures for flight controls and that instruction be given for adverse weather recognition, avoidance, and escape, including icing.

As part of the curriculum, a review of the ATR publication, Cold Weather Operations (Be Prepared for Icing), was required along with a review of meterological conditions likely to cause freezing drizzle, freezing rain or SCDD.

Identification of weather information sources and their use relative to in-flight icing was also required, as well as discussion of procedures, including Company and Air Traffic Control (ATC) procedures, for pilot weather reports (PIREP) on severe icing to include reporting procedures, content, and use of PIREPS.

Additionally, discussion of information provided to flight crewmembers was required, including identification of severe icing conditions, freezing rain and freezing drizzle, exit procedures (should severe icing conditions be encountered) and ATC procedures.

14.2 New Hire Training

Under Operations Specification A031, Empire Airlines was authorized to make arrangements with specified training centers listed in order to conduct instruction and/or evaluations.

Typical new hire pilots would be trained in accordance with Empire Airlines FAA approved training program.

This consisted of one week of basic indoctrination and company orientation at Empire's headquarters in Hayden, Idaho.

According to the chief pilot, In "Basic Indoc," the pilots would review the ADP, FAA's Handbook of Meteorology, the NASA tailplane icing video, operations in icing for corporate aircraft video, and handouts of flight releases to familiarize the pilots with the format.

The new hire pilot would then be sent to Flight Safety International (FSI) in Houston, Texas which was a 14 CFR Part 142 Training Center permitted to conduct initial, transition and upgrade training on behalf of Empire Airlines for both the ATR 42 and ATR 72.

This training consisted of two weeks of ground school, two weeks of simulator training, and a check ride. The new hire pilot would then receive an additional two days of flight training in the actual airplane, followed by another checkride. The new hire pilot would then receive 20 hours of initial operating experience (IOE) with a line check airman before being released to the line.

14.3 Upgrade Training

For upgrade training (moving from first officer to captain), the pilot would be given 2 days of general operations ground school at Empire's headquarters in Hayden, Idaho. This was followed by 2.5 days of systems training at FSI, 4 simulator sessions, and a checkride. The pilot would then receive 2 training sessions in the actual airplane followed by a checkride. The pilot would then receive 20 hours of IOE with a line check airman before being released to the line.

14.4 Transition Training

For transition training (moving from one airplane type to another), the pilot would be given 2 days of general operations differences ground school at Empire's headquarters in Hayden, Idaho. This was followed by 2 weeks of systems training at FSI, 2 weeks of simulator training, and a checkride. The pilot would then receive 2 training sessions in the actual airplane followed by a checkride. The pilot would then receive 20 hours of IOE with a line check airman before being released to the line.

14.5 Line Oriented Flight Training

At the time of the accident, Empire Airlines did not conduct Line Oriented Flight Training (LOFT).

14.6 Flight Crew Winter Operations Training

Prior to the winter flying season Empire Airlines would make available the Winter Operations On-Line Test. Both flight crews, and dispatchers were required to review the materials and take the on-line test. According to Empire Airlines, the Winter Operations On-Line Test subject areas and questions were derived from the airline's ADP and would cover the elements of the ADP such as:

- The use of holdover tables
- Aircraft deicing/antiicing procedures
- Aircraft surface contamination and critical area identification
- Types, purpose, characteristics, and effectiveness of deicing and ant-icing fluids

None of the materials however included operations in the inflight icing environment.

15.0 Personnel Interviews

In addition to the interviews of the accident airplane's flightcrew, Personnel from the FAA, Empire Airlines, and FSI were interviewed by the Operations Group. Descriptions varied between statements in regard to techniques that would be employed during different abnormal or emergency scenarios however, the preponderance of statements were that the airplane should be operated in accordance with FAA, Empire Airlines, and manufacturers guidance.

15.1 FAA Interviews

Both the Principal Operations Inspector (POI) and the Assistant POI were interviewed.

The POI advised that pilots should know what the severe icing cues were and to "pull the emergency checklists," when they experienced these cues. He stated that "During a flap malfunction a crew should go to the QRH" and that when entering icing, the "entering icing checklist," should be verbalized and the crew should emphasize the minimum speed in icing.

He also stated that he was the POI when the approval to operate in freezing drizzle was approved and that the GOM was the FAA approved manual, and that Empire's PH is "accepted."

15.2 Empire Airlines Interviews

Eighteen personnel were interviewed from Empire Airlines, These personnel included line pilots, check airman, and dispatchers.

When questioned by the Operations Group, the preponderance of statements from the personnel indicated that an approach should be stabilized, that during a flap malfunctions a delay/go-around was warranted, and that checklists/QRH should be utilized.

Questions regarding super cooled large droplets (SLD), and super cooled drizzle droplets (SCDD) revealed that only a few personnel were aware of or understood the phenomena, and when asked about operations in freezing drizzle or freezing rain answers varied from no or little concern to the impression that it was undesirable and that if they met the requirements of the ground deicing program that they were good to go.

15.3 FSI Interviews

Seven personnel where interviewed from FSI. These personnel included ground instructors, simulator instructors, check airmen, the director of training, and program managers.

When questioned by the Operations Group, the preponderance of statements from the personnel indicated that if an approach became unstabilized or the stick shaker activated that a go-around should occur. They taught use of the QRH and abnormal and emergency procedures. Checking of the circuit breakers was not taught. They would also do flap malfunctions during training and checkrides.

They would not do multiple failures (more than one simulated failure at one time) and when simulating icing problems would not give any other failure or emergency at the same time.

Questions regarding SLD, and SCDD revealed that only a few of FSI's personnel were aware of or understood the phenomena, and when asked about operations in freezing drizzle or freezing rain the answers varied regarding what the phenomena meant to a pilot and if it should be avoided. Comments ranged from "an as you see it kind of thing" to "you don't negotiate with freezing rain." When asked if they distributed the ATR publication "Be Prepared for Icing," they advised that they did not distribute the document but instead referred the students to the ATR website.

16.0 Simulator Testing

On March 30, 31, and April 1, 2009, the Operations Group conducted qualitative simulator testing to assess pilot workload, and to evaluate the airplane/simulator handling qualities with a flap asymmetry and ice accretion.

The testing was conducted in ATR's Full-Flight Simulators (FFS) in Toulouse, France, which had been validated for pilot training by comparing simulator performance with actual airplane performance. This was done by ATR using the Royal Aeronautical Society's International Qualification Test Guide (IQTG) based on ICAO Doc 9625 AN/938: Manual of Criteria for the Qualification of Flight Simulators.

The simulator as configured could not produce the accident drag levels without introducing unrealistic lift, pitching moment, yawing moment, and rolling moment effects due to ice. As a result, "Normal Icing – Boots On" ice levels were used (as a function of angle-of-attack) with the knowledge that the drag effect was underestimated.

Simulator testing revealed that after autopilot disconnect, the pilot workload that resulted from flight into icing conditions, a 10-knot tailwind, and asymmetric flap deployment was significant. However, even with this pilot workload, a go around (missed approach) could be successfully conducted.

No dedicated asymmetry indicator was installed, however aberrancy in roll due to the flap asymmetry would generate an A/P MSG on the EADI and a "RETRIM LEFT WING DOWN"

message on the ADU and a visible displacement of the control wheels to the left. This was shortly followed by a flashing "AILERON MISTRIM" message. Re-trimming the airplane, re-engaging the autopilot per the "Aileron Mistrim" checklist in the QRH, and setting power to maintain the minimum safety speed would, however, result in a successful outcome. But when the approach was flown in the FFS without re-trimming the airplane, and at a speed lower than the minimum safety speed, the controllability of the airplane during the approach was often similar to the accident flight.

During the simulator testing approximately 20 degrees of left control wheel was required to counter the flap asymmetry. Analysis by the performance group revealed that this was equivalent to about 20 pounds of wheel force.

17.0 The Presence of Ice

Initial examination of the wreckage by FAA inspectors revealed the presence of ice on the right aileron. The captain also stated to company personnel that the airplane had been picking up ice on the approach.

Review of performance data by the Performance Group revealed that while at FL180 at the beginning of the cruise portion of the accident flight, the airplane had a cruise speed that was 10 knots lower than nominal and at the end of the cruise portion of the flight the cruise speed was 20 knots lower than nominal. This corresponded to a drag increase of 80 counts or approximately 15% of total power.

The accident airplane's performance was once again nominal until descending below 5,000 ft. At this point, the drag began to increase beyond nominal levels again. Airplane performance indicated that an additional 120 counts was present when the flap asymmetry occurred. This was equivalent to approximately 23% of total power.

The Airplane Performance Group concluded that the FDR data do not show behavior consistent with an airplane stall, loss of lateral control, or a sudden change in aileron hinge moment. The stick shaker triggered at the appropriate local angle-of-attack and airspeed on the FDR and, as a result, provided sufficient stall margin. The bank angle followed the commanded wheel and aileron deflections throughout the approach and landing.

The FDR data and ATR simulation analysis of the accident also indicated that, the ice accretion during portions of the flight was significant but that it never exceeded the control authority of the ATR-42. However, significant ice accretion will degrade the flying qualities of any airplane design. The full extent of Empire Airlines Flight 8284's degradations could not be determined.

17.1 Previous Icing Incidents and Accidents

After departure the accident flight encountered what the captain reported as rime ice, which he described as being "moderate, bordering on severe" at FL180. During the descent and approach the flight subsequently flew into an area of reported light freezing drizzle.

A review of the type certificate data by Safety Board investigators revealed that The ATR 42 and 72 had been certificated for flight into known icing conditions under 14 CFR Part 25, Appendix C and additionally in the case of the ATR 72 also JAR Special Conditions B6. These regulations detail the type of icing exposures for which an aircraft is to be tested and certificated.

The standards prescribe various exposure time periods as a function of both air temperature and water droplet size. Current standards include average drop size of up to approximately 50 microns in diameter.

While the Appendix C icing envelope includes a vast majority of the icing conditions encountered, it does not cover all possible conditions. Specifically, it does not include freezing drizzle where droplets have a diameter of between 50 and 500 microns or freezing rain where the droplets exceed 500 microns.

During icing tanker testing and natural icing testing of the ATR it was demonstrated that droplets larger than those covered by 14 CFR Part 25 Appendix C, yet smaller in size than precipitation drops, could accrete in the areas aft of the 7 percent chord on the wing. The precise location along the chord at which these drops would impact the surface and potentially begin formation of a ridge of ice, is a function of a number of factors including droplet size, temperature, and liquid water content. This ridge if allowed to build, could result in a separation of the airflow over the aileron area at relatively low angles of attack.

At its earliest stages, the flow separation would result in the ailerons becoming extremely light and sensitive, a condition that pilots could interpret as lateral instability. If the angle of attack was further increased for any reason, it could result in the control wheel deflecting itself in one direction, much as the airplane might respond in a strong lateral out of trim condition. This condition is known as an aileron hinge moment reversal, sometimes referred to by pilots as an "aileron snatch." This is a very unsteady condition due to the turbulent airflow over the control surface, which has generated the condition. In this condition the aileron forces keep changing abruptly and eventually reverse direction. This will continue as long as the angle of attack remains above the trigger threshold.

One of the more recent examples of an icing accident was the fatal accident of a Trans Asia Airways (TNA) ATR-72, which occurred on December 21, 2002, in the waters of the Taiwan Strait. The airplane, configured to carry cargo, encountered severe icing while cruising at 18,000 feet some 30 minutes into the two and a half-hour night flight from Taipei to Macau. It took approximately 18 minutes from the first indication of icing, to the impact. Only two minutes separated the crew's first mention of severe icing to the sound of the stall warning and stick shaker.

The accident was investigated by the Aviation Safety Council (ASC) of Taiwan, with the Bureau d'Enquetes et d'Analysis (BEA) as an accredited representative, and ATR as their technical advisor. The ASC had earlier issued a safety bulletin calling on operators worldwide to reinforce proper crew responses to flight in icing conditions. ASC and ATR analysis of the accident revealed evidence of a drag increase of up to 500 drag counts, which induced about a 40 knot speed decay and subsequent stall warning activation.

In a transcript of the cockpit voice recorder (CVR), the two pilots knew their speed was bleeding off and a "big chunk" of ice was observed on the ice evidence probe located just outside the captain's left window.

On April 22, 2005 the ASC released the factual report.

The ASC stated that the crew unknowingly flew into severe icing conditions and may have been late taking precautions.

Weather reports reviewed by the crew before their departure from Taipei's Chiang Kai Shek International Airport on the nightly cargo run (flight GE791) to Penghu, Macau, advised of rain but made no mention of icing. The significant weather chart - SIGWX - generated by Taiwan had no indication of moderate icing, although it was mentioned in SIGWX reports generated at Hong Kong and Naha, Okinawa. Severe icing had not been observed and was not forecast.

About a half-hour into the flight, the airplane's ice detector alerted. The alert occurred about two minutes after the crew first noticed ice on the airplane. Airframe de-icing was activated, from local time 0134 to 0137, a brief period of about three minutes. A four-minute gap followed, when the airplane was flying in icing conditions with the de-icing system turned off. Airframe de-icing was then turned back on, from time 0141 until some 11 minutes later, when the flight data recorder (FDR) ceased functioning.

Until the final moments of the flight, when numerous alarms sounded, the crew continued the flight on autopilot. In previous icing-related accidents, crews flying on autopilot have been lulled by nil apparent degradation of flying qualities as the autopilot silently worked to maintain its prescribed parameters. In this case the crew kept the autopilot on as speed slowed below the minimum for icing conditions, and even as speed slowed below the minimum for severe icing conditions.

Following the fatal January 19, 1997 accident involving a Comair EMB-120RT twin-turboprop in icing conditions at Monroe, Michigan, the Safety Board recommended that pilots should disengage the autopilot whenever anti-icing systems are activated as manual flying can provide tactile cues to the airplane's handling characteristics, and certainly by getting the autopilot out of the "altitude hold" mode, it would not automatically trim nose-up.

In May 1999 ATR issued a number of updated changes to the airplane flight manual dealing with operation in icing conditions. The procedures and limitation were explicit, and made a number of essential points. They included adding a 10-kt. speed margin, activating anti-ice systems until the aircraft was clear of ice, turning off the autopilot, and exiting the icing conditions as soon as possible.

The GE791 crew had added 10-knots to the airplane's target cruising speed, as called for when flying in icing conditions but it did not appear that they performed the other actions required, although 28 seconds before the stall warning and stick shaker activated, the captain urged the first officer to radio a request to air traffic control [ATC] for an immediate descent from 18,000 feet to 16,000 feet.

"Down, down, down, down, down, notify them quickly," the captain stated.

"Do you see that? It's severely iced up," he stated moments before the airplane rolled beyond a 60-degree bank angle, spun, and impacted the water.

It was the first fatal accident in icing conditions for the ATR-72 since the 1994 accident in Roselawn, Indiana. In the period in between, ATR had modified the flight manual to more explicitly caution crews about the airplane's limitations in icing, and ATR redesigned the wing de-icing boots to extend further back on the wing, from seven percent of the wing chord to 12.5 percent. The TransAsia Airways ATR-72 had been outfitted with the larger wing boots.

After the GE791 accident, ATR conducted a number of flight simulations to assay the circumstances surrounding the loss, and in a report to the ASC, ATR cited "non-compliance by the crew of the icing speeds led the aircraft to attitudes where, on wings polluted by severe ice, aerodynamic anomalies occur."

The ATR analysis concluded that it was way late in the sequence when the crew finally established the relationship between ice on the airplane and its decaying speed.

On Dec. 5, 2002, just 16 days before the GE 791 accident, ATR issued a worldwide reminder to its customers of winter operations, and a number of icing events in which ATR-42 and ATR-72 crews had not followed necessary procedures. Continuous "situational awareness" and "an accurate compliance with established procedures" are necessary to prevent a recurrence of "such undesired icing reports," the ATR reminder said.

The ATR reminder also mentioned that aircraft are not certified to cope with severe icing, notably supercooled drizzle drops (SCDD). At temperatures near freezing, the drops do not necessarily freeze on impact, but run back along the surface and freeze. This process accelerates the adverse effects, since droplets hitting within the protected part of the leading edge of the wing run back and form ice aft of the boot.

"Please ask your pilots to pay the most possible care in watching and detecting conditions which could exceed the certification standards and have to be escaped/avoided when inadvertently encountered," the ATR note advised.

Ice from SCDD is characterized by rapid accumulation of large droplets. For a turboprop, which flies at altitudes where SCDD can occur, the accumulation of a coat of thin, rough ice can impose severe aerodynamic penalties. Those penalties take the form of as much as a 25 percent increase in stall speed and hence a reduced stall margin, increased drag requiring either a huge increase in engine power to sustain flight or increased angle of attack (AOA) if excess thrust is not available. The higher AOA may exceed the new iced stall angle and cause a change in section of the tailplane due to the changed airflow over it.

On the night of the accident involving GE791, the weather reports indicated the conditions were conducive to SCDD.

18.0 Special Certification Review

Following the Roselawn accident, the FAA convened a special certification review (SCR) of the ATR 42/72. The SCR report concluded that SCDD icing is outside the envelope of icing types for certification purposes, and that "these conditions may not be as infrequent as commonly

believed and that accurate forecasts of SCDD conditions do not have as high a level of certitude as other precipitation."

The SCR posed two options: (1) the airplane "must be shown to be free from any hazard due to an encounter of any duration" with the SCDD environment, or (2) the pilots need "a positive method of identifying when the airplane has entered SCDD, and their airplane must be able to operate safely in that regime long enough to identify and safely exit the condition."

Presently, neither condition applies. The certification standards for flying in icing conditions still have not been expanded to cover SCDD.

Relying on the accuracy of weather forecasts (or forecasters) and pilot discretion when assessing the likelihood of a medium-altitude encounter with freezing precipitation is problematic. The SCR suggested that the ability of airframes and engines to handle icing conditions needs to be designed into turboprop aircraft, because they fly at intermediate levels where icing is likely to be encountered.

19.0 Events Timeline

According to a conservative review of our database, since 1982 the Safety Board has investigated 44 icing related loss of control occurrences in turbine powered airplanes, and icing accidents have resulted in 201 deaths and 16 serious injuries.

The following timeline summarizes significant events and recommendations made by the Safety Board since the 1994 ATR accident in Roselawn, Indiana. Note: It does not include all of the accidents that the Safety Board has investigated since 1982 where icing was a factor.

- October 31, 1994, the Roselawn accident occurred. 68 killed. American Airlines subsequently moved operations of the ATR to the Caribbean and southern U.S.

- July 9, 1996: the NTSB Aircraft Accident Report regarding Roselawn was released. The probable cause was a "loss of control, attributed to a sudden and unexpected aileron hinge moment reversal that occurred after a ridge of ice accreted beyond the deice boots."

- August 8, 1996: The Safety Board Issued Safety Recommendations A-96-48 through A-96-69. Among these were Recommendations A-96-54 and A-96-56, which read as follows:

  "Revise the icing criteria published in 14 Code of Federal Regulations (CFR), Parts 23 and 25, in light of both recent research into aircraft ice accretion under varying conditions of liquid water content, drop size distribution, and temperature, and recent developments in both the design and use of aircraft. Also, expand the Appendix C icing certification envelope to include freezing drizzle/freezing rain and mixed water/ice crystal conditions, as necessary. (A-96-54)."

  "Revise the icing certification testing regulation to ensure that airplanes are properly tested for all conditions in which they are authorized to operate, or are otherwise shown to be capable of safe flight into such conditions. If safe operations cannot be

demonstrated by the manufacturer, operational limitations should be imposed to prohibit flight in such conditions and flightcrews should be provided with the means to positively determine when they are in icing conditions that exceed the limits for aircraft certification. (A-96-56)."

- August 20, 1997: The Safety Board classified the FAA's response to A-96-54 and A-96-56 as "Open-Acceptable" after FAA created an Aviation Rulemaking Advisory Committee (ARAC) to develop certification criteria for the safe operation of aircraft in icing conditions.

- January 27, 2003: The Safety Board wrote a letter to FAA regarding the work of the ARAC, saying it is concerned about the "slow pace of the [the ARAC's work]." The Safety Board stated, "Although the FAA, through its referral of this work to the ARAC, is responding to these recommendations, the Safety Board remains concerned that in the 6 years since these recommendations were issued, the work has not been completed. The Board would like the FAA to provide a schedule for completion of the recommended actions."

- May 19, 2003: FAA responded to the Safety Board's concerns, stating that, "The FAA will publish a notice of proposed rulemaking based on these recommendations by June 2004."

- November 9, 2004: After a Safety Board meeting regarding "Most Wanted Recommendations," the Safety Board classified Recommendations A-96-54 and A-96-56 as "Open-Unacceptable."

- February 15, 2005: A Cessna Citation 560, owned by Circuit City Stores, Inc. crashed in Pueblo, CO 4 miles east of Pueblo Memorial Airport. 8 people were killed. The Safety Board stated the probable cause as: "the flight crew's failure to effectively monitor and maintain airspeed and comply with procedures for deice boot activation on the approach, which caused an aerodynamic stall from which they did not recover. Contributing to the accident was the Federal Aviation Administration's failure to establish adequate certification requirements for flight into icing conditions, which led to the inadequate stall warning margin provided by the airplane's stall warning system."

- May 10, 2006: Two years after the FAA's own deadline for action, the Safety Board issued a statement again lamenting the lack of action: "There does not appear to have been any progress since the FAA previously informed the Board of the status of this recommendation on September 15, 2003."

- February 27, 2007: From a Safety Board update on FAA action regarding the Recommendations: "The FAA has still not received the recommendations from [its working group studying deicing certification], prepared regulatory analyses, issued the NPRM, analyzed comments, or completed the many other tasks involved in issuing new regulations."

- On August 3, 2009, the FAA published a final rule, which became effective on September 2, 2009. The rule only applies to new transport aircraft designs. The new rule does not address existing airplane designs, the FAA is considering similar rulemaking that would cover those designs. Under the revised certification standards, new transport aircraft designs must have one of three methods to detect icing and to activate the airframe ice protection system:

  1. An ice detection system that automatically activates or alerts pilots to turn on the ice protection system;
  2. A definition of visual signs of ice buildup on a specified surface (e.g., wings) combined with an advisory system to alert the pilots to activate the ice protection system; or
  3. Identification of temperature and moisture conditions conducive to airframe icing that would tip off pilots to activate the ice protection system.

  The standards further require that after initial activation, the ice protection system must operate continuously, automatically turn on and off, or alert the pilots when the system should be cycled.

20.0 Open Icing Recommendations

At the time of this report, there were 16 open recommendations regarding icing.

From the ATR accident in Roselawn, Indiana: A-96-051 concerns reporting of icing conditions, A-96-60 concerns the definition of severe icing. A-96-54 and A-96-56 are on the Most Wanted List and concern certification for flight into supercooled large droplet conditions. A-96-58 concerns aileron hinge moment reversals.

From the EMB120 accident in Monroe, Michigan: A-98-89 and A-98-102 concern flight procedures in icing conditions. A-98-96 concerns increasing the stall warning margin in icing conditions.

From a number of serious incidents with Saab 340 aircraft involving loss of control due to low air speed in in-flight icing conditions, several recommendations were issued, including A-06-49 which concerns modified stall protection logic in Saab 340 airplanes, and A-06-51 which concerns a requirement for all pilots of turbopropeller-driven airplanes to disengage the autopilot and fly the airplane manually when operating in icing conditions, except during intermittent periods of high workload.

From The Cessna Citation accident in Pueblo, Colorado: A-07-12 concerns training for icing conditions, A-07-13 concerns pilot monitoring and cross checking, A-07-14 concerns activation of deicing boots as soon as you enter icing conditions, A-07-15 concerns automatic cycling of the boots, A-07-16 concerns testing already certified airplanes in icing conditions once the certification conditions have changed, and A-07-17 concerns stall warning margin.

Safety Recommendations A-96-54 and -56, as well as A-07-14 and -16 are on the Most Wanted List.

21.0 Corrective Actions

The following corrective actions were taken by the parties to the investigation.

21.1 Empire Airlines Corrective Actions

On March 17, 2009 Empire Airlines advised the Safety Board that they initiated the following changes to training and procedures.

- Empire increased the amount of time spent in ground training for all categories to include special emphasis icing training for all ATR pilots and dispatchers. The curriculum contains the following:
    - Review of ATR Cold Weather Operations document
    - The NASA/FAA tailplane icing video
    - The Part 25 Appendix C icing certification envelope
    - Review of SLD, severe icing, icing reports, icing forecast from NOAA's aviation digital data service (ADDS), icing advisories, AIRMETS and SIGMETS
    - Review of aircraft performance with contaminated runways and the recommended maximum crosswind / tailwind components with contaminated runways
- Flight Operations Bulletin 09-04 was issued, prohibiting takeoff and landing operations in known or reported FZRA or FZDZ. It also references the procedures to be followed for an in-flight severe icing encounter and expands on the procedure of how to use the severe icing checklist to continue an approach and landing after an inadvertent encounter with freezing drizzle, freezing rain, or severe icing.
- Service Bulletin kits were ordered for the installation of the Icing Evidence Probe (IEP) on the airplanes not so equipped.
- The airline is considering the options of either common charting or the use of Electronic Flight Bags (EFBs) for flightcrew use. The airline is currently discussing how to most efficiently implement this policy. Once a policy has been modified, operations specification A006 will be revised to reflect this change.
- The maintenance department implemented a fleet campaign directive to remove the lids from the document cases in order to provide more effective access to the publications therein.
- Flight Information Bulletin 09-01 was sent to all ATR crewmembers explaining the proper determination and setting of airspeed bugs for flight in icing conditions. The airline also added expanded procedures to the ATR Pilot Handbook for flightcrews to be

aware of errors in setting airspeed bugs, and added a procedure for setting and readback of the bugs during departure briefing and approach briefing.

- The airline devised a method on how to annotate the flight release to show if either crewmember is high minimums. This procedure should be implemented before the end of March 2009.

- The following guidance was sent out to all Empire checkairmen and to the Flight Safety International ATR program manager:

  "In the course of conducting flight training or checking in the ATR (Airplane or Simulator) and specifically while executing flap malfunction and reduced flap landing, do not let the crew think that you want them to continue the approach without taking the time to complete the QRH procedure(s), reset the speed bugs, rebrief the approach, etc."

  "Depending on where the crew recognizes the flap problem, they should probably ask ATC (instructor/checkairman) for a delay vector or hold while they complete the QRH before continuing the approach. The point is we don't want to train or check differently than we want the crew to fly the aircraft. We should expect them to delay the approach until all the QRH procedures and briefs are complete."

- A General Operations Manual (GOM) policy change was implemented to require all ATR flights to be released under Part 121 except for training/checkride or operational check flights. Specific guidance for conducting training/checkride or operational check flights is also contained in the GOM.

- ATR provided Empire with a copy of their Flight Crew Training Manual, which contains task sharing, and priority management guidance. Empire adopted the ATR guidance and published it in their ATR Pilot Handbook.

21.2 FedEx Feeder Corrective Actions

- In April 2009, FedEx facilitated a safety "summit" with their four in-house operators (Empire, Mountain Air, Morningstar in Canada and Air Contractors in Dublin, Ireland) to address many of the findings from the accident and look for improvement and "best practices."

- FedEx also reviewed the training curriculum, primarily the flight portion. Negotiations are underway with Flight Safety (for their domestic operators) to gradually bring most, if not all of the training "in-house"

- Mountain Air Cargo--in conjunction with their POI--performed stick shaker/pusher evaluations of additional ATR icing scenarios in Flight Safety's simulator in Atlanta, Georgia in June 2009. This information will be incorporated into the training curriculum and will consist of both recognition and recovery technique. It will also become part of a "LOFT" module that the operators will be adding.

- ATR training will be enhanced by extending the training by eight hours. Half of this time will be dedicated to systems and half to flight training.

- ATR simulator training will be enhanced by extending the initial simulator training duration by two sessions. Upgrade simulator training will be increased by one session.

- All operators have incorporated a system of ensuring airspeed bugs are properly configured for all phases of flight. With only minor variations, each operator has developed a system in which each crewmember identifies and calls out the appropriate speed settings using the V-Speed cards, sets the bugs, and then cross-checks the settings.

- Ice evidence probes have been ordered and will be installed on all FedEx Feeder ATRs.

21.3 Manufacturer Corrective Actions

ATR advised the Safety Board that they were initiating the following changes to training and procedures:

- They will add photographs of normal icing (compared to severe icing) to the next revision of the "Be Prepared for Icing" document.
- They provided their DGAC approved training manual to the operator to assist in improving the operator's training program.

21.4 FAA Corrective Actions

On May 5, 2009, The FAA issued an Information for Operators (INFO) letter to ensure that all pilots of pneumatic de-icing deicing boot-equipped airplanes understand and receive training on proper operation of those systems and on maintaining an appropriate airspeed in icing conditions.

This INFO was generated as a result of a fatal accident involving a Cessna Citation 560 (CE-560) during an approach in icing conditions. The Safety Board determined that the probable cause of the accident was the flightcrew's failure to effectively monitor and maintain airspeed and comply with the procedures for activating the deicing boots on approach. This led to an aerodynamic stall from which they did not recover. As a result, the NTSB issued Safety Recommendations A-07-12 and A-07-13.

The INFO was published as part of the FAA's response to the Safety Board's Recommendations and to reinforce the need for flightcrews to be trained to properly follow all icing-related operating limitations and operating procedures specified in the Aircraft Flight Manual (AFM) or FAA approved operator's manual. The INFO however, was advisory in nature only.

The INFO advised that Pilots should follow the boot activation and operating procedures specified in the AFM or FAA approved operator's manual for the airplane they are flying and should be aware of the following additional information:

- If icing has been encountered during the flight, boots should be cycled prior to approach and landing.

- If the AFM does not have specific boot operation procedures or if ice thickness is difficult to judge, pilots should not be reluctant to cycle modern boots at the first sign of ice accretion and then as needed. Boots with less than 1.75 inch diameter tubes, operating pressures of 15 psig or greater, and fast inflation/deflation times are considered modern. If the airplane was certificated after 1960, it likely has modern boots.

- Residual ice accretion on boots can be minimized with the proper application of an ice adhesion inhibitor recommended by the boot or airplane manufacturer (e.g., ICEX II for Goodrich Corporation deicing boots). Any other product, such as wax, can damage the boots and may cause more ice accretion.

- Many airplanes certificated for operation in icing conditions before 2001 (both part 23 and 25 certificated airplanes) do not have a mode that will automatically continue to cycle the deicing boots once the system has been energized. In this case, continual monitoring and operation of the deicing boots increases the pilots' workload. Pilots should be alert to the need to recycle the boots as necessary during flight in icing conditions.

- Inter-cycle and residual ice is inherent in pneumatic boot operation, and can lead to a significant increase in stall speeds.

The INFO also advised that for many airplanes with pneumatic deicing boots, operating limitations require the flightcrew to exit severe icing conditions. These limitations provide the flightcrew with cues to recognize severe icing and procedures for exiting the severe icing conditions.

Also that, for many airplanes with pneumatic deicing boots, operating limitations require the flightcrew to exit severe icing conditions. These limitations provide the flightcrew with cues to recognize severe icing and procedures for exiting the severe icing conditions.

Additionally, it discussed the Safety Board's recommendation that flight training in the CE-560 airplane emphasize the AFM requirements that pilots increase airspeed and operate the deice boots during approaches when ice is present on the wings and that:

- For other aircraft whose AFM or operator's procedures do not contain minimum icing airspeeds, to use the non-ice stall speed multiplied by 1.5 as a minimum airspeed while operating in icing conditions.

- That pilots should not accept an airspeed assigned by air traffic control (ATC) that is lower than that required by their manuals, the airplane manufacturer's recommended airspeed, or the 50% margin recommended above, as applicable. Training should also emphasize that this increased airspeed, if maintained to the runway threshold in a stabilized approach configuration, may also require increased landing distance. Airspeed losses in icing, particularly of turbopropeller-powered airplanes, can be hazardous, and pilots of turbopropeller-powered airplanes should follow the guidance in Safety Alert for Operators (SAFO) 06016, In-Flight Icing, Turbo Propeller Powered Airplanes.

The INFO concluded by Recommending that to ensure safe operations in icing conditions, the following actions should be taken. Parts 61, 91, 91K, 121, 135, 141, and/or 142 personnel who have responsibility over training and checking (e.g., Director of Operations, Chief Flight Instructor) should:

- Modify training and checking programs as necessary to reflect the airplane's operating limitations and operator's procedures for flight in icing conditions, as well as information provided in this InFO. If icing Airworthiness Directive (AD) procedures are applicable, modify training to reflect them.

- Modify training and checking programs to ensure that they include training on ice accumulation, shedding, and ice-bridge formation per the current edition of AC 91-74, Pilot Guide: Flight Icing Conditions.

- Modify training and checking programs to ensure that they include emphasis on maintaining and monitoring the appropriate airspeed in icing conditions.

- Modify training and checking programs to ensure that there is special emphasis training on operation of the pneumatic deicing boots in accordance with the AFM or FAA approved operator's manual.

- Modify training and checking programs to teach and emphasize monitoring skills and workload management (CRM/SRM skills) during operations in icing conditions.

Checking of personnel conducting operations under parts 61, 91, 91K, 121, 135, 141, and 142 (e.g., Training Center Evaluator, Check Airman) should include the following:

- During any flight check or practical test (e.g., Section 135.297 proficiency check, instrument rating practical test, type rating practical test), the pilot must demonstrate knowledge and use of pneumatic deicing boots, including ice accumulation, shedding, and ice bridge formation per AC 91-74.

- During any operational approval flight-check, the pilot must demonstrate the appropriate use of the deicing boot system and flight management including appropriate monitoring, speed requirements and workload management in icing conditions.

22.0 Supporting Documentation

All interviews, statements, and pertinent documents obtained during the investigation by the Operations Group have been included as attachments to this document, and are included in the NTSB's Public Docket.

22.1 Attachments To Group Chairman's Factual Report

Attachment 1: Flight Crew Training Events Summary and Issued Documents
Attachment 2: Flight Crew Flight Time & Duty Time Record
Attachment 3: Empire Airlines January 2009 ATR Trip Pairings

Attachment 4: Witness Statements (Including Empire Dispatch Log Information)
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Attachment 7: Interview Summaries of Empire Airlines Dispatch Personnel
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Attachment 51: ATOS System / Subsystem / Element Chart (Operations)
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Attachment 53: ATR Cold Weather Operations Guide (Be Prepared for Icing)
Attachment 54: Empire Airlines Descent and Approach Awareness Procedure
Attachment 55: Empire Airlines Flight Profile and Briefing (Normal ILS Approach)
Attachment 56: Empire Airlines ATR Go Around Procedure
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Todd Gunther
Air Safety Investigator