Left Behind

BY MARK LACAGNINA

The ATR 42 pilots were unaware of current procedures for recovering from an ice-induced upset.

The airline's failure to promptly update its standard operating procedures (SOPs) was among organizational deficiencies that contributed to the loss of control of an ATR 42-320 during an encounter with severe icing conditions the morning of Sept. 14, 2005, said the Accident Investigation Board of Norway (AIBN).

In its final report on the serious incident, the board said that the airline, Coast Air, had only recently distributed revisions to severe-icing emergency procedures that had been issued two years earlier by the aircraft manufacturer. "The pilots received this [information] close to the time at which the incident occurred and had not had time to become familiar with its content," the report said.

The flight crew struggled to regain control of this ATR 42 after an ice-induced stall.

Coast Air operated two ATR 42s and six British Aerospace Jetstream 31s and 32s on scheduled flights between nine airports in Norway. The airline issued SOPs for the ATR 42 when it received its air operator certificate early in 2000; the last revision was dated Sept. 13, 2002.

In October 2003, the manufacturer revised the ATR 42 airplane flight manual to require pilots to memorize the following six actions on the "Severe Icing" emergency checklist:

- Increase the "red bug" minimum icing speed by 10 kt[1];
- Apply maximum continuous torque;
- Disengage the autopilot while firmly holding the control wheel;
- Escape from the severe icing conditions; and,
- Notify air traffic control (ATC).

A notation following these memory items says that if any unusual roll response or uncommanded roll control movement occurs, the control wheel must be pushed firmly forward and the flaps extended to 15 degrees. These actions, however, are not designated as memory items. ATR told investigators that roll excursions will not occur if the actions that *are* designated as memory items are completed correctly upon encountering severe icing conditions.

The report said that shortly before the incident, a newly hired flight operations manager "discovered by coincidence" the two-year-old revisions and told the chief pilot to distribute the information. An "OPS INFO" document outlining the revised procedures was issued to the company's ATR 42 pilots the day before the incident. The airline did not have a system to monitor the receipt and review of OPS INFO documents. The pilots told investigators that they remembered retrieving the documents from their mailboxes either the day before, the same day or the day after the incident. "However, they had not picked up particularly on details of the content or reflected in any concrete way on what the changes meant," the report said.

Moreover, the OPS INFO document did not include the following notice that the manufacturer had added to the "Severe Icing" emergency checklist:

> *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 buildup on unprotected surfaces exceeding the capability of the ice protection system or may result in ice forming aft on the protected surfaces. This ice may not be shed using the ice protection systems and may seriously degrade the performance and controllability of the airplane.*

"In *severe icing*, therefore, it is necessary to change course and/or altitude instantaneously since the aircraft's anti-ice and deice systems cannot handle these conditions," the report said. "A characteristic of severe icing is said to be ice formation on the side windows and/or an unexpected decrease in speed and climb rate. Water which splatters and streams on the front windshield and ice buildup at the back of the spinner and on the airframe in places where ice does not normally collect are given as secondary indications. In addition, it is stated that visible rain and large droplets with an outside temperature of around 0° C [32° F] could lead to severe icing."

Strong Cold Front

The aircraft was being operated as Flight 602 from Stord, an island off the southwestern coast of Norway, to Oslo, about 170 nm (315 km) east. The pilots and the flight attendant reported for duty at 0615 local time.

Noting that a strong cold front had passed through the area overnight, the report said, "The weather was the subject of conversation that morning. There had been a landslide in Bergen [north of Stord] during the night, and precipitation records had been set at several locations in the western part of Norway."

The three crewmembers visited the airport's flight information service facility to gather

weather information and notices to airmen. "The weather forecast was a moderate risk of local icing in the western part of Norway up to Flight Level (FL) 180 (approximately 18,000 ft), which is normal for this time of year," the report said.

Before departing with 24 passengers at 0710, the flight crew activated the anti-ice systems for the probes and windshields (Figure 1). The first officer, 29, was the pilot flying. He had been employed by Coast Air in 2003 and earned an ATR 42 type rating the same year. He had 2,980 flight hours, including 1,350 hours in type.

The commander, 39, had been employed by Coast Air as a Jetstream pilot in 1999. He earned an ATR 42 type rating in 2000 and upgraded to commander in type the next year. He had 7,850 flight hours, including 2,800 hours in type.

The flight attendant, 29, had been employed by the company in 2001.

The aircraft entered icing conditions shortly after takeoff, and the crew activated the anti-icing systems for the aileron, elevator and rudder horns, propellers and side windows. Activation of the horn ice protection system also armed the stick shaker (stall warning) system to activate — and cause the autopilot to automatically disengage — at a lower-than-normal angle-of-attack: 11 degrees instead of 18 degrees with flaps retracted.

The flight proceeded east, toward the cold front and rising terrain. The crew did not use the weather radar system during the climb. "This may indicate that the crew had a low level of awareness of the importance of using the weather radar as an aid for avoiding severe icing," the report said, noting that the airline did not have a written policy about using the equipment. "Information from the weather radar could have made it possible for the crew to plan their route outside the cells with the heaviest precipitation at greatest hazard of severe icing."

'Impression of Complacency'

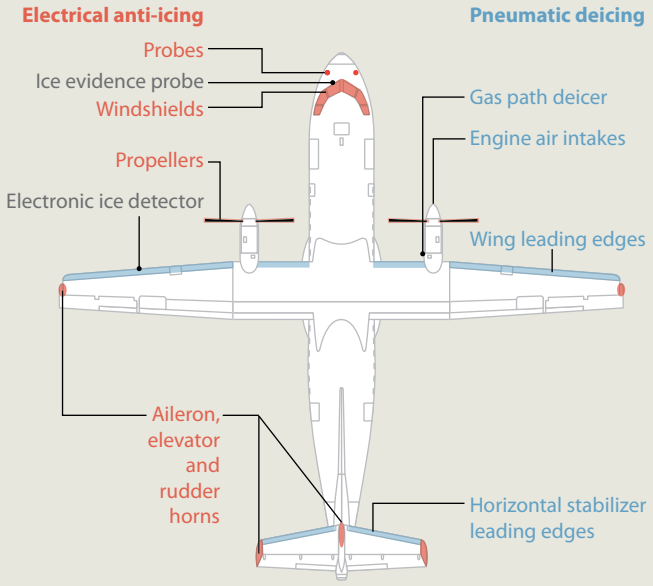
The aircraft was climbing through FL 100 when the "ICING" warning light illuminated. This indicated that the electronic ice detector sensed that ice was accumulating on the wing and that the appropriate ice protection systems had not been activated. In response, the crew activated the deicing systems for the wing and horizontal stabilizer leading edges, and the engine nacelles.

"The crew is certain that the systems were functioning as intended," the report said. However, ice continued to accumulate rapidly. Neither pilot realized that the aircraft had entered severe icing conditions.

"The commander has stated that they gradually went into heavy rain, with large drops that splattered on the front windshield while the outside temperature (static air temperature, SAT) was minus 10° C [14° F]," the report said. "He saw significant ice formation on the evidence probe outside his window and assessed the icing as more or less the same as the worst case he had experienced during the course of his six years of flying this aircraft type."

That "worst case" had been resolved when the aircraft exited the icing conditions. "It may appear that the flight crew also anticipated that the problems here would resolve themselves by their exiting the icing area in time, which is something that gives the impression of complacency," the report said. "Both pilots were experienced and had

ATR 42 Ice Protection Systems



Source: Accident Investigation Board of Norway/Susan Reed

Figure 1

flown the route between Stord and Oslo in icing conditions countless times with no problems. The pilots were used to the aircraft's systems handling moderate icing conditions. … Another important element is that the hazard of icing was not given particular emphasis in the company's program for training and flight safety."

Ice covered the cockpit side windows, but the pneumatic deice boots on the wings appeared to be shedding ice from the leading edges. "From the cockpit, it was not possible to see whether there was ice further back on the upper and lower sides of the wings," the report said. "Neither the commander nor the first officer remembered afterwards whether they saw ice on the propeller spinners."

The crew said that the aircraft climbed normally until reaching FL 120. Climb performance then decreased significantly. "When they approached FL 140, the climb was marginal," the report said. The first officer, who was flying the aircraft with the autopilot engaged in the airspeed-hold mode, adjusted the commanded airspeed from 160 kt to between 150 and 155 kt in an attempt to increase the climb rate.

The crew had set the red speed bugs on their airspeed indicators to 143 kt, the minimum airspeed specified for flight in "standard" icing conditions. "Both the commander and the first officer were of the opinion that they had sufficient margins when they were at least 7 kt above [minimum] icing speed," the report said. According to the emergency checklist, however, the correct speed bug setting for severe icing conditions was 153 kt. "The crew therefore did not have the safety margin they assumed since they had allowed the speed to drop to 150–155 kt," the report said.

The pilots discussed the possibility that the aircraft's performance was being affected by mountain wave activity, which indicates that they did not associate the performance deficiency with severe icing. The airspeed reduction did not result in the anticipated climb rate improvement; instead, it resulted in the contaminated wing nearing the critical — stall — angle-of-attack, the report said.

ATR 42-320

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The Avions de Transport Régional (ATR) program was launched in 1981 when Aérospatiale and Alenia agreed to combine their efforts to design a twin-turboprop regional airplane. Deliveries of the first model, the ATR 42-300, began in 1985. The airplane has 1,342-kw (1,800-shp) Pratt & Whitney Canada PW120 engines. The ATR 42-320, introduced in 1987, has 1,566-kw (2,100-shp) PW121 engines, which improve performance at high altitude and with high ambient temperature.

Basic seating capacity is for 42 passengers. Maximum takeoff weight is 16,700 kg (36,817 lb). Maximum operating altitude is 25,000 ft. At a maximum cruising speed of 267 kt at 17,000 ft, range with reserves is 4,481 km (2,420 nm). Stall speeds are 104 kt with flaps up and 81 kt with flaps extended 30 degrees.

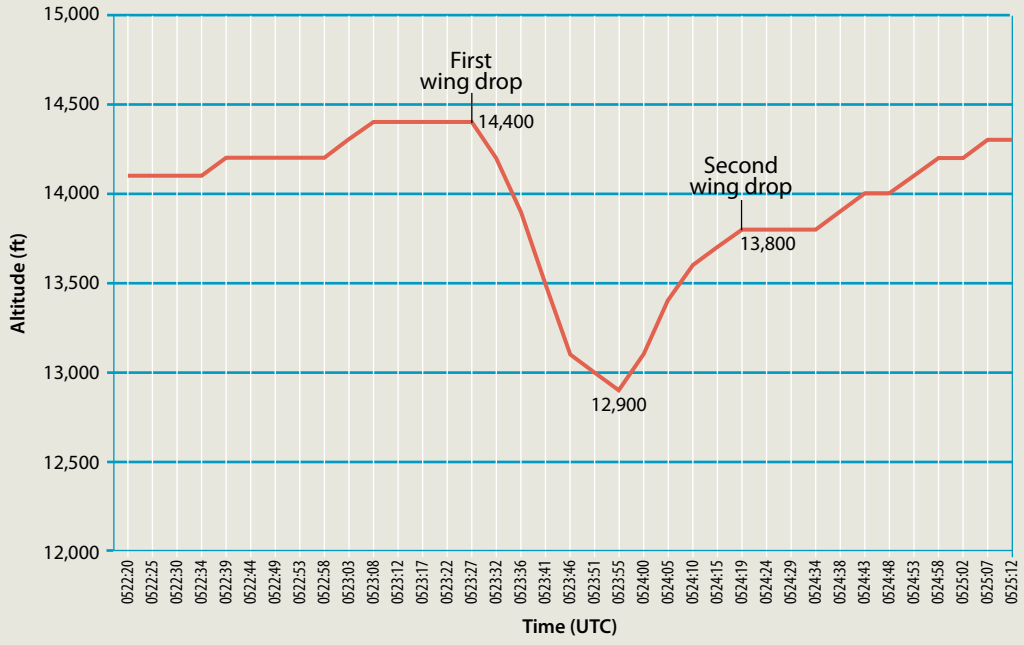
Production of the ATR 42-300 and -320 was phased out in 1996. ATR became a corporate entity in 2001 and currently produces the ATR 42-500 and the ATR 72-500.

Source: *Jane's All the World's Aircraft*

Struggle for Control

The aircraft stopped climbing at 14,400 ft. The first officer placed his hand on the control column and felt the stick shaker activate. He was about to disengage the autopilot when it disengaged automatically. "A second or two after this, the aircraft suddenly rolled, uncommanded, approximately 45 degrees to the right at the same time the nose dropped to approximately 7–8 degrees below the horizon," the report said (Figure 2, p. 36).

Flight Profile



UTC = coordinated universal time

Source: Accident Investigation Board of Norway

Figure 2

The first officer said that he pushed the control column forward to keep the nose down while setting the engine controls to achieve maximum continuous torque. He did not extend the flaps 15 degrees. "He struggled to regain control of the aircraft and tried to rectify the bank angle," the report said. "The bank angle moved from the right straight over to the left before it gradually allowed itself to be straightened up."

The commander's decision not to take control when the upset occurred was not faulted. "The best the commander could have contributed in the critical situation … would probably have been to extend the flaps in time," the report said. "Control would have been regained more quickly. By only pushing the stick forward, the speed would have to increase more before the angle-of-attack dropped below the critical value."

Recorded ATC radar data indicated that the upset had begun at 0723 (0523 coordinated universal time) and that the aircraft had descended 1,500 ft before the first officer regained control. "It is equivalent to an average descent speed of approximately 3,200 fpm for the 28 seconds that passed before the aircraft again commenced climbing," the report said. "At its steepest, the descent was around 5,000 fpm."

Terrain clearance, however, was not a factor. The aircraft was over a glacier about 35 nm (65 km) east of Stord, where the minimum safe altitude was 7,000 ft. With the wings leveled and airspeed increasing to about 175 kt, the first officer pulled the control column back to stop the descent. The aircraft then entered a relatively steep climb. "According to the radar readings, it climbed 700 ft in the first 15 seconds, which corresponds to 2,800 fpm," the report said. "The fact that the crew did not register that the pull-out from the dive was excessive can be explained by the fact that they were shaken by the experience in addition to the fact that they were in cloud and had to correct a most abnormal aircraft attitude based on information from the aircraft's instruments," the report said.

Angle-of-attack again exceeded the critical value, and the aircraft stalled and rolled left. "This wing drop was almost as powerful as the first, and the first officer has stated that he used the same procedure to regain control," the report said. During this time, the aircraft had exited from the clouds.

After the first upset, the commander had set the red airspeed bug at 160 kt and told ATC that they were having icing problems and were requesting FL 150 as their final cruising altitude. After the second upset, he told ATC that they were unable to maintain FL 150 and requested, and received,

clearance to fly within an altitude block between FL 130 and FL 150.

All the passengers had been seated during the upsets. The flight attendant, who was placing empty bottles in the cargo compartment at the rear of the aircraft, lost her balance and fell into the cargo compartment. Uninjured, she returned to the galley and held onto an unsecured service cart until the aircraft was returned to controlled flight.

The flight attendant then entered the cabin and found the passengers sitting still; none had been injured. "She spoke for a little while with a woman who, before takeoff, had told her she was afraid of flying," the report said. "The commander gave a passenger announcement, [stating] that they had moved into some bad weather involving turbulence and icing, but that this was now over, so the flight would continue to Oslo as normal."

The ATR 42 was flown between cloud layers and out of icing conditions, and was landed without further incident in Oslo at 0804.

Although AIBN requires prompt notification of a severe icing encounter involving a loss of altitude, Coast Air's manuals contained "extremely old" information about reporting requirements. The airline reported the incident to the Civil Aviation Authority of Norway (CAA) almost two weeks after it occurred. The CAA forwarded the report to the AIBN. By then, voice and flight data recorded in the aircraft during the incident no longer were available.

'Organizational Incident'

Coast Air had experienced major changes in its ownership, key personnel and route structure.[2] The report said that the CAA had found deficiencies in the airline's quality system and flight safety program but had not ensured that they were corrected. Chief among the persistent deficiencies were an unsatisfactory document-management system and inadequate collection and dissemination of information about hazards and preventive measures.

Among deficiencies that related directly to what the report characterized as an "organizational incident" was inadequate pilot training for flight in icing conditions. "Pressure to keep down cost levels within the company may have contributed to reducing the quality of flight crew training," the report said.

The airline had contracted with Finnair to use its ATR 42 flight simulator to train Coast Air pilots for type ratings and to conduct six-month proficiency checks. The training was performed by Coast Air instructors. The proficiency checks comprised four hours in the simulator. Among the procedures reviewed was stall recovery in various aircraft configurations.

"The first items in the procedure when the stick shaker actuated in a clean configuration (gear up, flaps zero degrees) was that the person flying should say, 'Stalling,' immediately advance power, level the aircraft's nose 2–3 degrees above the horizon and say, 'Set max power, flap 15,'" the report said. "The second pilot should do the manual actions and respond, 'Max power set, flaps 15 selected.' … The training manager has stated that it was common for the pilots to forget to extend the flaps in conjunction with this exercise."

Noting that the French accident-investigation bureau also has found that ATR 42 pilots generally are not familiar with the requirement to extend flaps to 15 degrees, the AIBN recommended that the action be designated as a memory item on the emergency checklist.

The report also said that the stall-recovery training in the flight simulator was not related to icing conditions. The airline's training manager was not aware that the flight simulator was programmed to provide four icing scenarios — two related to inadequate preflight deicing, and two related to encounters with standard icing conditions and severe icing conditions without the appropriate ice protection systems activated. "Coast Air first became aware of the opportunity to train on realistic icing scenarios in the simulator as a result of this incident," the report said.

The incident aircraft was not equipped with an aircraft performance monitoring (APM) system, which ATR introduced as an option in 2005. The system monitors icing intensity and its effect on aircraft performance, and generates several different visual and aural advisories and warnings. For example, an "INCREASE SPEED" warning light illuminates and a chime sounds if airspeed decreases below red bug speed plus 10 kt. The AIBN recommended that the APM system be required aboard all ATR 42s and 72s.

This article is based on AIBN Report SL 2009/02, "Report on the Serious Incident Over Glacier Folgefonna, Norway, on 14 September 2005 with ATR 42-320, LN-FAO, Operated by Coast Air AS."

Notes

1. The "red bug" is an adjustable marking on the airspeed indicator.
2. Coast Air filed for bankruptcy in January 2008.

Further Reading

Rosenkrans, Wayne. "Surveillance Without Surprises." *ASW* Volume 2 (April 2007): 42–46.

Dow, John P. Sr. "Understanding the Stall-Recovery Procedure for Turboprop Airplanes in Icing Conditions." *Flight Safety Digest* Volume 24 (April 2005): 1–17.