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Failure to Comply With Nonprecision Approach Procedure Sets Stage for Regional Jet CFIT at Zürich

The flight crew did not have visual contact with the runway or with the approach lights when they continued descent below the published minimum descent altitude. The airplane struck terrain soon after the crew began a missed approach.

FSF Editorial Staff

At 2206 local time Nov. 24, 2001, the flight crew of a British Aerospace (now BAE Systems) Avro 146-RJ100 operated by Crossair was conducting the very-high-frequency omnidirectional radio/distance-measuring equipment (VOR/DME) approach to Runway 28 at Zürich (Switzerland) Airport in nighttime instrument meteorological conditions (IMC) when the airplane struck terrain. The two pilots, one cabin crewmember and 21 passengers were killed; one cabin crewmember and four passengers received serious injuries; and one cabin crewmember and three passengers received minor injuries or no injuries.

The Swiss Aircraft Accident Investigation Bureau (AAIB; Büro für Flugunfalluntersuchungen) said, in its final report on the accident, that the following were causal factors:

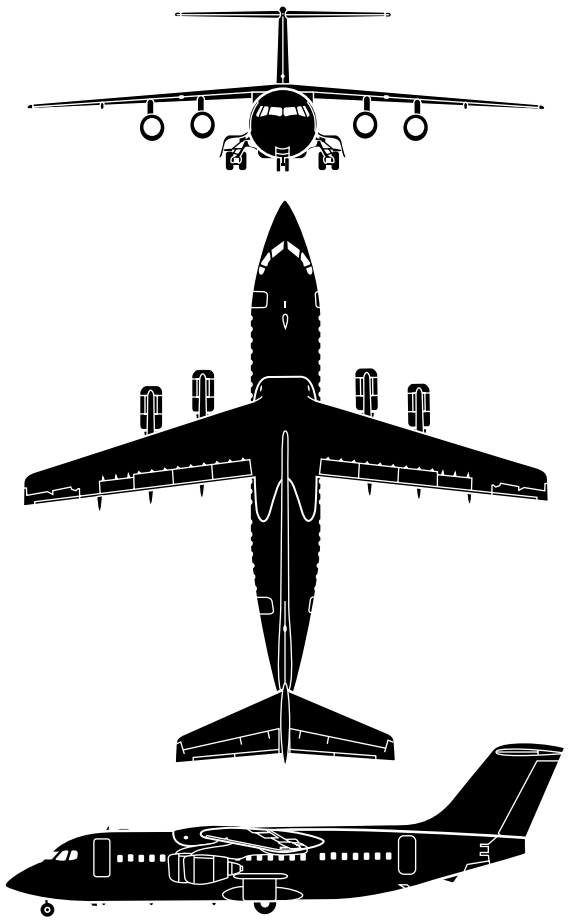
- "The commander deliberately descended below the minimum descent altitude (MDA) of the standard VOR/DME approach … without having the required visual contact [with] the approach lights or the runway; [and,]
- "The copilot made no attempt to prevent the continuation of the flight below the [MDA]."

The report said that the following factors contributed to the accident:

- "In the approach sector of Runway 28 at Zürich Airport, there was no system available which triggers an alarm if a minimum safe altitude is violated (minimum safe altitude warning — MSAW);
- "Over a long period of time, the responsible persons of the airline did not make correct assessments of the commander's flying performance. Where weaknesses were perceptible, they did not take appropriate measures;
- "The commander's ability to concentrate and take appropriate decisions, as well as his ability to analyze complex processes, were adversely affected by fatigue;
- "Task-sharing between the flight crew during the approach was not appropriate and did not correspond to the required procedures [of] the airline;
- "The range of hills which the aircraft came into contact with was not marked on the approach chart used by the flight crew;
- "The means of determining the meteorological visibility at the airport was not representative for the approach sector [of] Runway 28 because it did not correspond to the actual visibility; [and,]

- "The valid visual minimums at the time of the accident were inappropriate for a decision to use the standard VOR/DME [Runway 28] approach."

At the time of the accident, Crossair was engaged in regional airline service, operated more than 80 airplanes — including Avro 146-RJ85/100s, Boeing MD-83s, Embraer EMB-145s and Saab 2000s — and had about 3,500 employees.



British Aerospace Avro 146-RJ100

British Aerospace (BAe) Regional Aircraft (now part of BAE Systems) introduced the BAe 146 short-range transport airplane in 1983. The Avro 146-RJ100, a lengthened version of the airplane assembled by Avro International Aerospace, has four AlliedSignal (now Honeywell) LF507 turbofan engines, each producing 31.14 kilonewtons (7,000 pounds static thrust).

The airplane accommodates two flight crewmembers, two cabin crewmembers or three cabin crewmembers, and 85 passengers to 112 passengers.

Maximum takeoff weight is 46,040 kilograms (101,500 pounds). Maximum landing weight is 40,144 kilograms (88,500 pounds). Long-range cruising speed at 35,000 feet is 389 knots. Range with maximum payload is 2,130 kilometers (1,150 nautical miles). Stall speed with 33 degrees of flap is 95 knots.♦

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

The commander, 57, held an airline transport pilot license and had 19,555 flight hours, including 287 flight hours in type. He began his flying career as a flight instructor and charter pilot. He was employed by Crossair as a Swearingen Metroliner pilot in 1979 and by Horizon Swiss Flight Academy as a part-time flight instructor in 1981.

"At his own request, he left Crossair on 31 May 1982," the report said. "The commander's performance was assessed by Crossair as above average."

After leaving Crossair, the commander flew a Saab 340 as a contract pilot and as a part-time pilot for the company. On Jan. 1, 1994, he returned to full-time employment with Crossair. He continued to work as a contract flight instructor for Horizon Swiss Flight Academy. The report said that the commander occasionally conducted instructional flights for the academy in the morning and line flights for the airline in the afternoon.

The Crossair operations manual required that flight time and duty time accumulated by flight crewmembers during service with other companies be included in calculations of flight time and duty time for the airline.

"Neither Crossair nor the Horizon Swiss Flight Academy carried out any supervision of flying time and rest time across different companies," the report said.

In 1995 and in 1996, the commander failed conversion courses for the McDonnell Douglas MD-80. The report said that he had difficulty using the MD-80's digital flight guidance system and that he demonstrated inadequate manual control of the airplane and "a limited ability to analyze and to take decisions at the appropriate time."

The report said that a review of the commander's career at Crossair showed that "he did not always strictly adhere to standard operating procedures." The following incidents were cited:

- The commander erroneously had believed that a Saab 340's landing gear could not be retracted with the airplane's weight on its wheels. While conducting an aircraft-systems-training session on Feb. 21, 1990, the commander selected the landing-gear-lever downlock-release button, and the student pilot moved the landing-gear lever to the retract position. The landing gear retracted, and the airplane was destroyed. The airline relieved the commander of his instructor's duties;

- During a route check on June 25, 1991, the commander did not comply with an air traffic control (ATC) airspeed restriction and flew the airplane into wake turbulence

from a Boeing 747. He also omitted the approach check and before-landing check, and landed the airplane with a flight attendant standing in the cabin;

- A copilot told investigators that in December 1995, he conducted an instrument approach in IMC with the commander in which a descent rate of 4,000 feet per minute and an airspeed of 200 knots were maintained to 300 feet radio altitude. The overspeed-warning system and the ground-proximity warning system (GPWS) had been disengaged before the approach was begun; and,

- After the accident in Zürich, Crossair learned about an incident on March 21, 1999, in which the commander conducted a visual approach in mountainous terrain to an airport in Italy that was 50 kilometers (27 nautical miles) south of the destination in Germany. On final approach, passengers observed road signs in Italian. The commander conducted a go-around and flew the airplane through a mountain pass to the scheduled destination.

In 2001, the commander completed a conversion course for the Avro 146-RJ100. The report said that the proficiency check forms completed by instructors during the conversion course and route training contained only positive comments about the commander's performance.

"No mistakes were pointed out, and no items were mentioned that the commander could have improved," the report said.

The report said that the different evaluations of the commander's performance during his conversions and attempted conversions to different airplanes indicated that "certain experts and flying instructors from the operator applied different benchmarks and did not recognize the deficits which were present. The operator also did not really manage to put the various occurrences during the commander's career into a broader context, to recognize common features and basic patterns or to take appropriate measures."

The copilot, 25, held a commercial pilot license and had 490 flight hours, including 348 flight hours in type. He was employed by Crossair after he earned his commercial pilot license at Horizon Swiss Flight Academy in 2000. The commander had conducted instrument-training flights with the copilot when the copilot was a student at the academy.

From 0715 to 0957 the day before the accident, the commander conducted two instrument-training flights with student pilots for the Horizon Swiss Flight Academy. From 1202 to 2101, he conducted four scheduled flights for Crossair and was off duty at 2131. The commander was on duty for 15 hours and 31 minutes that day.

After a rest period of 10 hours and 59 minutes, the commander returned to the airport at 0830 and conducted instrument training flights with student pilots for the academy from 1034 to 1327.

"On the two days preceding the accident, the commander had clearly exceeded the permitted maximum duty times and had slightly undercut the prescribed rest time the night before the accident," the report said. "The accident happened at the end of a day in which the commander had been awake for 15 hours [and] on duty for more than [13.5] hours. … The bad weather may have further increased the strain throughout the day and led to greater fatigue."

The copilot began duty for Crossair at 1250 the day before the accident. He conducted four scheduled flights for Crossair and was off duty at 2305. The copilot was on duty for 10 hours and 15 minutes that day.

"The copilot's spouse stated that the copilot described this working day as very stressful and had felt very exhausted," the report said.

"On the two days preceding the accident, the commander had clearly exceeded the permitted maximum duty times."

After a rest period of 18 hours and 15 minutes, the copilot began duty for Crossair at 1720 on the day of the accident. The flight crew was scheduled to conduct a flight from Zürich to Berlin, Germany, and then to return to Zürich. The scheduled departure time from Zürich was 1820; the actual departure time was 1854. The crew landed the airplane in Berlin at 2025.

"No refueling took place since the aircraft still had 5,650 kilograms [12,456 pounds of] fuel on board (actual block fuel)," the report said. "For the return flight [to Zürich], according to the flight plan, a fuel amount of 4,893 kilograms [10,787 pounds] (minimum block fuel) was required."

A ramp-handling agent who conversed briefly with the commander said that the commander's behavior was normal, with "no signs of stress or urgency."

The crew received taxi instructions from ATC at 2056. While holding on a taxiway, the crew was told to taxi the airplane onto the runway and to hold for takeoff clearance. The taxiway stop bar lights remained illuminated, however, and the crew refused to taxi onto the runway until the lights were extinguished. The crew began the takeoff at 2101.

The commander, the pilot flying, used the automatic flight control system (AFCS). Digital flight data recorder (DFDR) data showed that the AFCS functioned normally throughout the flight.

The copilot conducted radio communications with ATC in English. The pilots conversed in Swiss German. The

cockpit voice recorder (CVR) recording began at 2136, when the airplane was in cruise flight at Flight Level (FL) 270 (approximately 27,000 feet). The pilots discussed automatic terminal information service (ATIS) information "Kilo," which said that the instrument landing system (ILS) approach to Runway 14 was being used at Zürich Airport, surface winds were from 190 degrees at four knots, visibility was 3,000 meters (9,843 feet) in light snow and there were a few clouds at 500 feet above ground level (AGL), scattered clouds at 1,500 feet AGL and a broken ceiling at 2,200 feet AGL.

The crew did not receive ATIS information "Lima," which said that the VOR/DME Runway 28 approach was being used. Weather conditions were the same as those reported by ATIS information Kilo.

At 2140, ATC told the crew to descend to FL 240. At 2142, ATC told the crew to continue the descent to FL 160. The commander briefed the copilot on the ILS Runway 14 approach and told the copilot to set up the navigation radios for the ILS approach.

During the approach briefing, the copilot told the commander that indicated airspeed was increasing toward the maximum limit (redline).

"I believe that our speed is going somewhat into the red," the copilot said.

"Yes, it ran away," the commander said. "Sorry. Have to bring it back a bit."

At 2144, ATC told the crew to reduce airspeed to 240 knots and to descend to FL 130. At 2147, the crew was told to establish radio communication with Zürich Arrival East.

During his first radio transmission to Zürich Arrival East, the copilot said that the crew had received ATIS information Kilo. The controller did not tell the crew that ATIS information "Mike" was current but said that the crew could expect to conduct the VOR/DME Runway 28 approach.

At 2150, ATIS information "November" was broadcast. Visibility had increased to 3,500 meters (11,484 feet), and the base of the broken ceiling had lowered to 1,500 feet AGL.

"These changes were not communicated to the crew by the Zürich Arrival East sector air traffic controller," the report said.

At 2151, the crew began to fly a holding pattern over a navigation fix north of the airport. While holding, the commander briefed the copilot on the VOR/DME Runway 28 approach. The copilot told the commander that he had conducted the approach "a couple of times."

At 2153, ATC issued vectors to the Zürich East (ZUE) VOR, which is northeast of the airport, and told the crew to descend to 6,000 feet.

The VOR/DME Runway 28 approach procedure required the flight to cross the ZUE VOR and then to track the ZUE VOR 178-degree radial outbound at 5,000 feet until intercepting the final approach course — 275 degrees inbound to the Kloten (KLO) VOR, which is on the airport.

While conducting an approach check at 2157, the pilots set and cross-checked their altimeter settings and altimeter indications. The copilot told the commander that the fuel-panel gauges indicated that 3,200 kilograms (7,055 pounds) of fuel remained in the fuel tanks.

At 2158, ATC cleared the crew to conduct the VOR/DME Runway 28 approach and to reduce airspeed to 180 knots. Soon thereafter, the crew was told to establish radio communication with Zürich Tower. At the time, the crew was conducting a descent to 4,000 feet (per the published approach procedure) and a right turn to intercept the final approach course. The airplane was approximately 11 nautical miles (20 kilometers) east of the airport.

During the turn, the commander told the copilot that he had visual contact with the ground.

During the turn, the commander told the copilot that he had visual contact with the ground. The report said that this statement indicated that the pilot "was looking outside the cockpit for at least some of the time [rather than] controlling the aircraft using instruments."

The published minimums for the VOR/DME Runway 28 approach were 2,390 feet (974 feet above runway touchdown zone elevation) and 2,000 meters runway visual range (RVR). The report said that the cloud bases near the airport were not uniform. Pilot reports indicated that there were scattered clouds east of the airport at 500 feet above airport elevation and a broken ceiling at 1,000 feet above airport elevation; airport elevation was 1,416 feet.

"When flying just below the main cloud base, forward visibility from the cockpit was greatly restricted because of the patches of stratus," the report said. "Below the cloud layers, meteorological visibility was approximately 4.0 kilometers [2.5 statute miles]; in light precipitation and near the cloud base, it was reduced to about 2.0 kilometers [1.2 statute miles]."

Pilot reports indicated that moderate icing conditions existed below FL 140 and that severe icing conditions existed from FL 120 to FL 80. The surface temperature was slightly above freezing, and precipitation in the form of snow mixed with rain was observed in the area.

At 2203, the crew of an EMB-145 landed the airplane on Runway 28 and told the tower controller that weather

conditions were "pretty minimum" and that they had acquired visual contact with the runway about 2.2 nautical miles (4.1 kilometers) from the KLO VOR (about 1,700 meters [5,578 feet] from the runway approach lights).

"This aircraft was the first that evening to execute the standard [i.e., not radar-vectored by ATC] VOR/DME approach [to Runway] 28," the report said. "The commander of the accident flight was aware of this report from [the EMB-145 crew]."

The final approach fix (FAF) was 8.0 nautical miles (14.8 kilometers) DME from the KLO VOR. After crossing the FAF, a descent from 4,000 feet to 3,360 feet was authorized by the published approach procedure. After crossing the 6.0-nautical-mile (11.1-kilometer) DME fix, a descent to the MDA — 2,390 feet — was authorized. The missed approach point was at the 2.0-nautical-mile (3.7-kilometer) DME fix.

At 2204, the copilot said, "We're coming to eight miles, so we can leave four thousand." The commander acknowledged the information and told the copilot to set 6,000 feet, the altitude required by the published missed approach procedure, in the mode-control panel (MCP). The commander also told the copilot to extend the landing gear and to extend the flaps to 24 degrees.

Company procedure at the time required flight crews to set the missed approach altitude in the MCP soon before crossing the FAF.

"In former times, … the MDA was set on the MCP during the final approach," the report said. "This [former] procedure established a safety net, because an automatic level-off at the MDA was executed, without pilot intervention, provided the autopilot was engaged."

A terrain awareness and warning system (TAWS) would have detected an excessive terrain-closure rate and would have warned the crew of the hazard.

At the beginning of the descent, the Avro's indicated airspeed was 160 knots and its rate of descent was 1,000 feet per minute. The rate of descent later was increased to 1,200 feet per minute and was maintained at 1,200 feet per minute until just before the airplane struck terrain.

The descent rate was not sufficient to trigger a GPWS excessive-sink-rate warning or a GPWS excessive-terrain-closure-rate warning. The report said that a terrain awareness and warning system (TAWS) would have detected an excessive terrain-closure rate and would have warned the crew of the hazard.[1]

"If the aircraft in landing configuration approaches the ground too far away from the runway, a visual [warning] and acoustic warning are generated," the report said. "This is possible because the TAWS has access to a topographical database of the area around the airport."

At 2205:21, the first officer told the tower controller that the airplane was established on the VOR/DME final approach course. At the time, the airplane was crossing the 6.0-nautical-mile DME fix at 3,240 feet. The commander said, "Six miles, three three [3,300 feet] is checked."

The report said that the commander either did not observe that the airplane was 120 feet lower than the published minimum altitude for that segment of the approach or considered that the altitude deviation was tolerable.

"This was probably the beginning of an at least partial loss of awareness of the situation," the report said.

There was no further discussion by the flight crew of the airplane's distance from the VOR.

At 2205:36, the commander told the copilot to extend the flaps to 33 degrees.

At 2205:55, the commander said, "Two four [2,400 feet]. We have ground contact."

The copilot said, "Yes."

The commander said, "Someone [i.e., the EMB-145 crew] said he saw the runway late here. Approaching minimum descent altitude. Here, we've got some ground contact."

The EMB-145 was one of two Crossair airplanes that had been landed while the accident crew was conducting the approach.

"It cannot be excluded that this fact generated a certain pressure to succeed or at least encouraged the hope that a landing was possible under the prevalent weather conditions," the report said.

At 2206:10, as the airplane was descending through the MDA, the commander said, "Two four, the minimum. I have ground contact. We're continuing at the moment. It appears we have ground contact. We're continuing on." At the time, the airplane was 4.4 nautical miles (8.1 kilometers) from the VOR and 3.5 nautical miles (6.5 kilometers) from the runway threshold.

"The recordings of the [CVR] prove that communication and cooperation between the commander and the copilot took place calmly and professionally," the report said. "The pronounced calmness which the commander exhibited almost continuously had very probably created in the copilot the impression of an experienced superior who was acting prudently and consciously. This may have been one of the main reasons why the copilot did not intervene when … the commander continued the descent below the minimum altitude for the approach."

The Crossair operations manual said that pilots could continue a nonprecision approach below MDA if one of the following visual references was "distinctly visible" and "identifiable":

- "Elements of the approach lights system;
- "[Runway] threshold;
- "Threshold marking;
- "Threshold lights;
- "Threshold identification lights;
- "Visual glide [path] indicator;
- "Touchdown zone or touchdown zone markings;
- "Touchdown zone lights;
- "Runway edge lights; [or,]
- "Other visual reference as published in [the route manual]."

The report said that the crew used a Jeppesen approach chart that did not depict two obstacles that were shown on the Swiss *Aeronautical Information Publication* (*AIP*) approach chart.

"[The airplane] collided with the most northerly of these two obstacles, a hill with an obstacle light at 1,880 feet," the report said. "It cannot be excluded that the commander would have reconsidered his decision to descend below the MDA without sufficient visual references if these obstacles had been visible on the approach chart."

The airport … did not have MSAW equipment to help controllers monitor approaches to Runway 28.

The airplane was at 2,150 feet at 2206:22, when the GPWS announced 500 feet radio altitude. The commander voiced an expletive and said, "Two miles, he said, he sees the runway." At the time, the airplane was 3.1 nautical miles (5.7 kilometers) from the runway threshold. The report said that the crew would not have been able to see the runway environment and that the captain likely did not have visual contact with the ground.

"It is highly probable that in this phase, the commander was trying to re-establish visual contact with the ground," the report said. "Since he did not mention further visual references, it must be assumed that he no longer had any."

The controller told investigators that he observed the airplane on his radar display when the airplane was nine nautical miles (17 kilometers), six nautical miles (11 kilometers) and about four nautical miles (seven kilometers) from the runway threshold. The controller observed the airplane's altitude readout only once — when the airplane was six nautical miles from the runway threshold at about 3,600 feet.

The controller told investigators, "I did not carry out any more altitude checks later. I merely monitored the continuing flight path. The reason I did not carry out any deliberate altitude checks was that the aircraft was using its own navigation [to conduct the approach] and, in my opinion, in this status, there was no need for me to carry out such altitude checks as part of radar-monitoring."

The report said that although the ATC facility duty plan called for four approach controllers and four airport controllers to be on duty, one approach controller and two airport controllers were on duty at the time.

The airport had MSAW equipment to help controllers monitor approaches to Runway 14 and to Runway 16 but did not have MSAW equipment to help controllers monitor approaches to Runway 28. MSAW equipment provides a visual warning and an aural warning when an aircraft descends below specific minimum altitudes during an approach.

At 2206:31, the commander said, "Two thousand." The GPWS then announced "minimums" when the airplane was at 300 feet radio altitude, the decision height that had been selected on the commander's radio altimeter.

The controller cleared the crew to land the airplane on Runway 28. The report said that while the copilot was acknowledging the clearance, the commander said quietly, "Make a go-around?" Two seconds later, at 2206:34, the commander said, "Go around."

The copilot said, "Go around."

The CVR recorded the sound of the autopilot being disengaged; the autothrottle system remained engaged. DFDR data indicated that engine speed began to increase one second before the CVR began recording the sounds of impact at 2206:36. The CVR recording ended soon thereafter.

The airplane was in landing configuration, the pitch attitude had been changed from two degrees nose-down to five degrees nose-up, and the rate of descent had decreased from 1,200 feet per minute to zero feet per minute when the airplane struck treetops near the summit of a hill. The airplane then struck the ground, broke into several pieces and began to burn.

"Because of this intense fire, the accident was survivable only by chance," the report said.

The debris path extended about 1,000 meters (3,281 feet) from the point of initial contact with the trees.

"The impact and the subsequent intense fire destroyed the cockpit, the front part of the fuselage, the central part of the fuselage and large sections of both wings," the report said. "Only the aft section of the fuselage, which was torn off complete with the elevator unit and rudder unit, was not affected by the fire."

The report included the following statements from survivors:

- "The aircraft flew into trees, a wing broke off, and the aircraft caught fire. But then, it gently hit the ground, shook, made a 'bang' and came down at an angle";

- "Suddenly, there was a thud … . On the right side, I noticed a fireball outside the aircraft. Up to that moment, I thought everything was going normally. Then it rumbled and jolted like a roller coaster. Suddenly, it went quiet";

- "There was a sudden crash, and a fireball came at us at great speed from the nose"; and,

- "Suddenly, a loud crashing noise could be heard, and the aircraft shook violently. I immediately looked forward and saw through the open cockpit door and the cockpit windscreens that outside the aircraft, a real shower of sparks was rising. Next moment, there was a massive impact."

Based on the findings of the accident investigation, AAIB on Oct. 2, 2003, made the following recommendations to the Swiss Federal Office for Civil Aviation (FOCA; Bundesamt für Zivilluftfahrt); [as of June 4, 2004, responses by FOCA to the recommendations were pending]:

- "The visual descent point (VDP) is the point at the [MDA] of a nonprecision approach from which a normal visual approach to the runway is possible. If a glide path indicator (e.g., a precision approach path indicator [PAPI]) is present, the VDP is the intersection point of this glide path with the MDA. In the case of a nonprecision approach, only the missed approach point is defined. … [FOCA] should check the extent to which a [VDP] should be added to the approach charts for nonprecision approaches;

- "The investigation has shown that the minimum visual ranges in force at the time of the accident for the standard VOR/DME approach [to Runway] 28 are not appropriate. … A minimum visual range can only be termed appropriate if it makes it possible to carry out the final approach with the necessary visual references from the [VDP]. … [FOCA] should check the extent to which the valid minimum visual ranges for nonprecision approaches should be adapted, so that a final approach with the necessary visual references is possible from the [VDP];

- "Many [airports] in Switzerland have rises in the terrain in their immediate environment which are clearly above the reference height of the [airport]. Obstacles on approach can be made more apparent by using a side-view representation of the terrain along the approach path. … [FOCA] should check whether the terrain profile along the approach path should be entered in the approach charts for all categories of instrument approach;

- "On the day before the accident, the commander was on duty for 15 hours [and] 31 minutes because he had already completed two IFR [instrument flight rules] training flights before flying the four sectors for the operator. The prescribed rest time was not complied with. At the time of the accident, the commander had already been on duty for 13 hours and 37 minutes because he had made three IFR training flights prior to the accident flight. The flying duty records show that this combination of training activity and assignment as an air transport pilot on the same day was not a rarity. No inter-company check on crew times was carried out. As the accident shows, the commander of the aircraft involved in the accident exhibited signs of fatigue in his behavior. … [FOCA], together with the operator, should check how a complete check on total flying duty time and rest time can be guaranteed;

- "The investigation showed that even before the accident, there were crews who did not follow guidelines and procedures. The operator's efforts in the area of flight safety, as well as the monitoring measures of [FOCA], were not adequate to detect and prevent these occurrences. Within the framework of the quality systems required according to the provisions of the Joint Aviation Authorities JAR-OPS [Joint Aviation Requirements — Operations] 1.035 on the commercial carriage of persons and goods in aircraft, [FOCA] should demand procedures from the operators which indicate and eliminate deficits in the behavior and working practices of flight crews by means of internal company measures, and should monitor these procedures; [and,]

- "The investigation showed that for a long period, the operator did not manage to determine the actual capabilities of a crewmember. The experts responsible for administering skill tests, proficiency checks and line checks, [and] who were employed by the operator and who carried out these tests on behalf of [FOCA], were in the majority not able to detect deficits and weaknesses, so these were able to have an influence on the accident. … [FOCA] should arrange for qualifications [checks] and proficiency checks to be administered, at least on a random-sample basis, by inspectors or independent experts from [FOCA]."

The report said that Crossair, which became part of Swiss International Air Lines in 2002, established a program to reduce approach-and-landing risks based on criteria developed by Flight Safety Foundation.[2] The program included 81 actions, including revisions of operating manuals, installation of improved aircraft equipment and changes to crew-training procedures and crew-testing procedures. The airline also established a safety advisory board to evaluate its operating standards and practices.[3]♦

[FSF editorial note: This article, except where specifically noted, is based on the English translation of the Swiss Aircraft Accident Investigation Bureau (AAIB; Büro für Flugunfall-untersuchungen) *Investigation Report of the Aircraft Accident Investigation Bureau on the accident to aircraft AVRO 146-RJ100, HB-IXM, operated by Crossair under flight number CRX 3597, on 24 November 2001 near Bassersdorf/ZH*. The 161-page report contains illustrations and appendixes.]

Notes

1. *Terrain awareness and warning system* (*TAWS*) is the term used by the European Joint Aviation Authorities and the U.S. Federal Aviation Administration to describe equipment meeting International Civil Aviation Organization standards and recommendations for ground-proximity warning system (GPWS) equipment that provides predictive terrain-hazard warnings; *enhanced GPWS* and *ground collision avoidance system* are other terms used to describe TAWS equipment.

2. Flight Safety Foundation (FSF) criteria for reducing approach-and-landing risks are included in the FSF *Approach-and-landing Accident Reduction (ALAR) Tool Kit*. The tool kit provides on compact disc (CD) a unique set of pilot briefing notes, videos, presentations, risk-awareness checklists and other tools designed to help prevent approach-and-landing accidents (ALAs) and controlled flight into terrain (CFIT). The tool kit is the culmination of the Foundation-led efforts of more than 300 safety specialists worldwide to identify the causes of ALAs and CFIT, and to develop practical recommendations for prevention of these accidents. The FSF *ALAR Tool Kit* is a compilation of work that was begun in 1996 by an international group of aviation industry volunteers who comprised the FSF ALAR Task Force, which launched the second phase of work begun in 1992 by the FSF CFIT Task Force. CFIT occurs when an airworthy aircraft under the control of the flight crew is flown unintentionally into terrain, obstacles or water, usually with no prior awareness by the crew. This type of accident can occur during most phases of flight, but CFIT is more common during the approach-and-landing phase, which begins when an airworthy aircraft under the control of the flight crew descends below 5,000 feet above ground level (AGL) with the intention to conduct an approach and ends when the landing is complete or the flight crew flies the aircraft above 5,000 feet AGL en route to another airport.

3. Members of the Swiss International Air Lines safety advisory board included: Christian Josef Krahe, a former engineering test pilot for Airbus; Karel Ledeboer, a former executive with KLM Royal Dutch Airlines; and Stuart Matthews, FSF president and CEO. The work of the independent safety advisory board is ongoing.

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