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Nonadherence to Standard Procedures Cited in Airbus A320 CFIT in Bahrain

The report said that spatial disorientation likely was involved in the flight crew's controlled flight into terrain (CFIT) during an attempted go-around. The ground-proximity warning system generated nine warnings before the aircraft struck the sea.

FSF Editorial Staff

About 1930 local time on Aug. 23, 2000, an Airbus A320 operating as Gulf Air Flight GF-072 struck water in the Arabian Gulf about three nautical miles (six kilometers) northeast of Bahrain International Airport in Muharraq, Bahrain, during an attempted go-around in night visual meteorological conditions. The two pilots, six cabin crewmembers and 135 passengers were killed. The aircraft was destroyed.

The Bahrain Accident Investigation Board (AIB) said, in its final report, that the following individual factors contributed to the accident:

- "Nonadherence to standard operating procedures (SOPs) by the captain;
- "The first officer not drawing the attention of the captain to the deviations of the aircraft from the standard flight parameters and profile;
- "The spatial disorientation and information overload experienced by the flight crew; and,
- "The non-effective response by the flight crew to the ground-proximity warnings."

The report said, "Systemic factors that could have led to these individual factors were: a lack of a crew resource management (CRM) training program; inadequacy in some of the airline's A320 flight crew training programs; problems in the airline's flight-data-analysis system and flight safety department … ; organizational and management issues within the airline; and safety-oversight factors by the regulator."

Gulf Air is the national carrier of four countries: Abu Dhabi, Bahrain, Oman and Qatar. At the time of the accident, the airline operated 32 jet transport airplanes and employed 485 pilots.

The captain, 37, held an airline transport pilot certificate and had 4,416 flight hours, including 86 flight hours as an A320 captain and 997 flight hours as an A320 first officer. He had 2,402 flight hours as a Lockheed L-1011 flight engineer.

The captain was employed by Gulf Air as an engineer cadet in December 1979 and was promoted to flight engineer in 1989. He served as an L-1011 flight engineer and as an L-1011, Boeing 767 and A320 first officer until he was promoted on June 17, 2000, to A320 captain.

"Gulf Air pilots [who] had flown with the captain were interviewed and used the following words to describe his personality: responsible, knowledgeable, open to suggestions, happy, very helpful, professional, and sharp," the report said.

"Pilots interviewed varied in terms of their description of the captain's confidence in his abilities. One interviewee noted that the captain was confident but not dominant or overconfident. Another interviewee stated that the captain was slightly overconfident but not overpowering or dominant, while another interviewee indicated that the captain was a little loud and confident to the extent that he may have bordered on overconfidence and was somewhat boastful of his knowledge of aircraft systems."

The first officer, 25, held a commercial pilot certificate and had 608 flight hours, including 408 flight hours as an A320 first officer. He was employed by Gulf Air as a training cadet in July 1999 and was promoted to A320 first officer on April 20, 2000.

"The first officer failed his initial proficiency check in the A320 on October 29, 1999," the report said. "He received marks of 'D' on the following: LOC/DME [localizer/distance measuring equipment] approach, VOR [very-high-frequency omnidirectional radio]/DME approach, normal landing, crosswind landing, landing from nonprecision approach, automation and technology, and engine-failure procedures."

(Gulf Air designated examiners grade pilots during proficiency checks on a scale from "A" through "E," with E as a failing grade and three Ds constituting a failing grade.)

After receiving additional training, the first officer passed his A320 proficiency check in November 1999 and began line training.

"Several Gulf Air captains [who] had flown with the first officer were interviewed and used the following words to describe the personality of the first officer: timid, meek, mild, polite, disciplined, shy and reserved in social situations, and keen to learn (i.e., inquisitive)," the report said. "While most of the captains interviewed stated that they did not think that the first officer's reserved nature would hinder him from speaking up during flight operations, others felt that he might have been too reserved to speak up or challenge a captain.

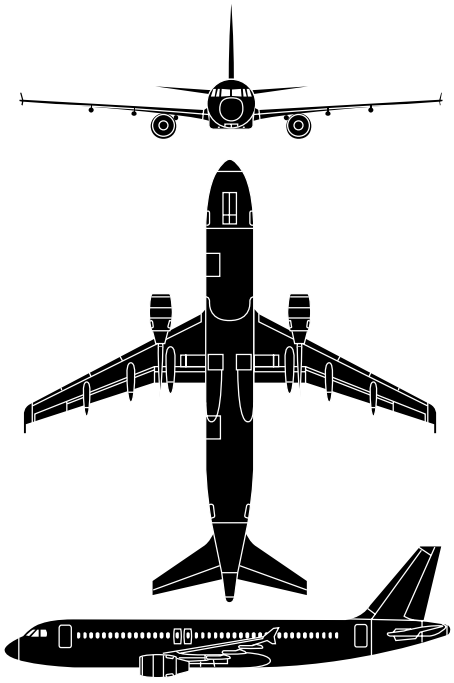
"One designated examiner/simulator training captain recalled that during a training session, he intentionally exceeded the 30-knot taxi-speed limit specified in Gulf Air [SOPs] and the first officer failed to challenge him regarding this."

The captain and the first officer had not flown together before they began a four-day trip on Aug. 19, 2000. On Aug. 22, they landed the accident aircraft in Cairo, Egypt, at 1350 local time (Cairo and Bahrain are in the same time zone in summer). They left their hotel at 1440 on Aug. 23 to continue the trip.

The flight to Bahrain was scheduled to depart from Cairo at 1600. Actual departure time was 1652. The captain was the pilot flying.

Investigators did not determine whether the captain conducted an approach briefing, as required by the airline's SOPs, before beginning the descent from cruise altitude. An approach briefing was not recorded by the cockpit voice recorder (CVR) during the last 30 minutes of the flight.

At 1921, the aircraft was being flown through approximately 14,000 feet on descent about 30 nautical miles (56 kilometers)



Airbus A320

Development of the Airbus A320 twin-jet airliner began in 1984. Deliveries of the A320-100 and the A320-200 began in 1988. The A320-200 (now called the A320) has wing-tip fences, higher maximum takeoff weights and optional wing-center-section fuel tanks.

The A320 is the first subsonic commercial aircraft with major primary structures manufactured from composite materials, a "fly-by-wire" control system and sidestick manual controls. The airplane accommodates two flight crewmembers and up to 180 passengers.

Airplanes built in 1988 have CFM International CFM56-5A1 turbofan engines, each producing 111.2 kilonewtons to 120.1 kilonewtons (25,000 pounds to 27,000 pounds static thrust). A320s built from 1998 through 2002 have either 120.1-kilonewton CFM56-5B4/P engines or 117.9-kilonewton (26,500-pounds-static-thrust) International Aero Engines V2527E-A5 engines.

Standard fuel capacity is 23,859 liters (6,304 gallons). Two wing-center-section fuel tanks can hold 2,900 liters (766 gallons) each. Maximum standard takeoff weight is 73,500 kilograms (162,038 pounds). Maximum standard landing weight is 64,500 kilograms (142,197 pounds).

Maximum operating speed is 0.82 Mach. Optimum cruising speed is 0.78 Mach. Service ceiling is 39,000 feet. Range in standard configuration is 4,807 kilometers (2,596 nautical miles).♦

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

northwest of the Bahrain airport when a Dammam Approach controller said, "Gulf Air zero seven two, self navigation for runway one two is approved. Three point five [3,500 feet] as well approved, and Bahrain Approach one two seven eight five approved."

The captain told the controller, "Gulf Air zero seven two, confirm we can go for runway one two."

The controller said "affirmative."

The captain told the first officer to establish radio communication with Bahrain Approach and to ask the controller for confirmation that they could expect to land on Runway 12. The first officer complied with the instruction, and the Bahrain Approach controller told the crew that they were "cleared [for] self position and as you're cleared by Dhahran" and to "confirm three thousand five hundred feet."

The report said that the captain believed that they had been cleared by air traffic control to descend to 7,000 feet. He told the first officer to tell the controller that they were cleared to 7,000 feet. The first officer complied, and the controller told the crew to continue their descent to 3,500 feet.

The flight crew was conducting the "Approach" checklist at 1923 when the controller told them to continue their descent to 1,500 feet and to report when they were established on the final approach course for the VOR/DME approach to Runway 12.

The airport is on the northern coast of Bahrain and has one runway that is 3,956 meters (12,980 feet) long and 60 meters (197 feet) wide with high-intensity approach lights and high-intensity runway lights. Airport elevation is six feet.

At the time of the accident, the automatic terminal information service (ATIS) reported weather conditions as "CAVOK" (i.e., ceiling and visibility OK, indicating that there were no clouds below 5,000 feet above ground level [AGL] and that visibility was at least 10 kilometers [six statute miles]). Surface winds were from 090 degrees at seven knots. Temperature was 35 degrees Celsius (95 degrees Fahrenheit); dew point was 29 degrees Celsius (84 degrees Fahrenheit).

At 1925, the aircraft was about 7.7 nautical miles (14.3 kilometers) from Runway 12 — about 2.7 nautical miles (5.0 kilometers) from the final approach fix (FAF) — when the captain told the first officer to "call established."

At the time, airspeed was 272 knots. The report said that airspeed was excessive throughout the approach and that an airspeed restriction below 10,000 feet was not specified by the regulations governing the airspace in which the aircraft was being flown or by the airline's SOPs. (After the accident, Gulf Air specified an airspeed limit of 250 knots below 10,000 feet during normal operations.)

The report said that the airline's SOPs specified that before reaching the FAF, the aircraft must be established on the final approach course (121 degrees) and at the published FAF crossing altitude (1,500 feet), and be configured for the approach — with landing gear extended, flaps fully extended and at the selected approach airspeed, which was 136 knots. (The A320 "FLAPS" lever has five positions — "0," "1," "2," "3" and "FULL" — and controls the position of the wing leading-edge slats as well as the trailing-edge flaps.)

"Although the aircraft was established on [the final approach course] at the FAF, the other parameters were far from the standard," the report said. "The speed was 223 knots, instead of 136 knots; the flaps position was '1,' instead of 'FULL'; and the altitude was 1,662 feet, instead of 1,500 feet.

"One of the reasons for not achieving the required configurations was excessive speed, compared to the standard. At this stage of flight, the SOPs define 'deviation from standard' to be when the speed varies by plus 10 [knots] or minus zero knots and/or [when] altitude varies by 100 feet."

After the first officer told the controller that the aircraft was established on the final approach course, the controller cleared the crew to conduct the VOR/DME approach and told them to call Bahrain Tower.

At 1926, the first officer told Bahrain Tower that the aircraft was "eight DME, established." The tower controller cleared the crew to land and said that the surface wind was from 090 degrees at eight knots.

The aircraft was at 1,678 feet and 224 knots when the captain told the first officer "flaps one" and "gear down."

The captain then said "OK, visual with airfield" and disengaged the autopilot and the flight director; the autothrottles remained engaged (see Figure 1, page 4).

The aircraft was about 2.8 nautical miles (5.2 kilometers) from the runway at 976 feet AGL and 207 knots when the captain said, "Have to be stabilized by five hundred feet." The airline's SOPs required that a visual approach be stabilized before the aircraft was flown to 500 feet AGL.

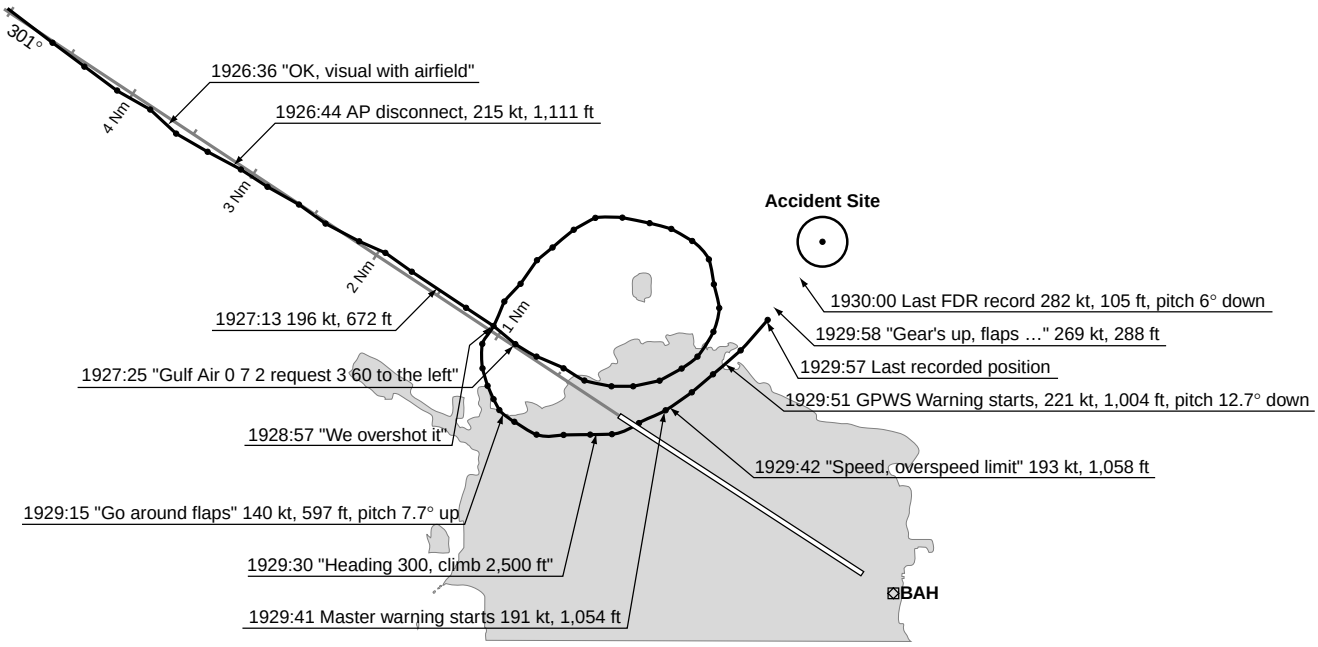
The crew selected the flaps "2" position.

At 1927:06, the captain said, "We're not going to make it." He repeated the statement six seconds later.

"These remarks showed that the captain believed that from that point in the approach, a successful landing could not be achieved," the report said. "The SOPs call for a 'go-around' action at this stage."

The captain told the first officer to request clearance to conduct a 360-degree left turn. The controller approved the crew's request.

Flight Path of Gulf Air Airbus A320 and Selected Cockpit Voice Recorder Data and Flight Data Recorder Data; Muharraq, Bahrain; Aug. 23, 2000



Note: All times are local.

Nm = Nautical miles kt = Knots ft = Feet AP = Autopilot GPWS = Ground-proximity warning system FDR = Flight data recorder
BAH = Bahrain VOR/DME (very-high-frequency omnidirectional radio/distance-measuring equipment)

Source: Bahrain Accident Investigation Board

Figure 1

The report said that the controller should have told the flight crew to conduct the missed approach procedure because the crew neither had told the controller that they had acquired visual contact with the airport nor had canceled their instrument flight rules (IFR) flight plan.

The report said that the captain apparently decided to conduct the turn to reduce altitude and airspeed.

"The captain performed this unsafe act without prior briefing [of] his first officer and in the absence of any valid operational necessity, such as an unexpected emergency," the report said.

The aircraft was about 0.9 nautical mile (1.7 kilometers) from the runway and at 584 feet AGL when the captain began the turn. Airspeed was 177 knots. Recorded flight data recorder (FDR) data indicated that the flap configuration was changed from flaps "2" to flaps "3" and then to flaps "FULL" during the turn.

The report said that selection of the flaps "FULL" position was not appropriate.

"Flaps 'FULL' is a flap setting intended only for the final phases of flight: approach and landing," the report said. "It is generally selected when a landing can be accomplished. Due to the associated drag, flaps 'FULL' is not a setting for maneuvering."

About 1928:17, the captain called for the "Landing" checklist. Eleven seconds later, the first officer said that the "Landing" checklist was complete.

"FDR data showed that the airplane's altitude during the left turn ranged from 965 feet [AGL] to 332 feet AGL and that the airplane's bank angle reached a maximum of about 36 degrees," the report said.

The report said that the captain apparently used external visual cues, rather than the information displayed on the aircraft's flight instruments, to control aircraft attitude and bank angle. Standard rate of turn is three degrees per second; the accident aircraft's average rate of turn was four degrees per second.

"The SOPs require [the pilot not flying to] make call-outs in respect of flight parameters," the report said. "However, despite a number of deviations from standard — particularly in attitude, bank angle and altitude — the CVR showed no evidence of such call-outs or any other relevant comments from the first officer."

The tower controller told investigators that the turn appeared to be "very tight."

"He stated that he had never seen that kind of approach before, and he asked his tower colleague to 'look at this,'" the report said.

An approach controller told investigators that the turn appeared unusual and tight.

"He indicated that he has seen other 360-degree turns but that they are usually not done so tight or so close to the runway threshold," the report said.

At 1928:57, the captain rolled the aircraft wings-level on a heading of about 211 degrees. At the time, the aircraft was crossing the extended runway centerline. The captain said, "We overshot it." He then rolled the aircraft into a left turn, and engine power was increased.

About 1929:07, the captain told the first officer to tell the controller that they were "going around." The autothrottles were disengaged, and takeoff/go-around (TOGA) power was selected.

SOPs for a go-around include increasing the aircraft pitch attitude to 15 degrees nose-up. FDR data indicated that the aircraft's pitch attitude initially reached nine degrees nose-up but decreased to about five degrees nose-up over the next 25 seconds.

The controller asked the crew if they wanted radar vectors to establish the aircraft on the final approach course. The first officer said yes. The controller then told the crew to fly a heading of 300 degrees and to climb to 2,500 feet.

"During this time, the flaps were moved to position '3' and the [landing] gear was selected up," the report said. "FDR data showed that the gear remained retracted until the end of the recording."

The captain flew the aircraft in a shallow climb to 1,054 feet AGL. The aircraft was crossing the runway wings-level and on a heading of 040 degrees at 1929:41, when the aural flap-overspeed warning sounded. Airspeed was 191 knots; the limit airspeed is 185 knots for flaps position "3."

The first officer said "speed, overspeed limit."

At this time, the aircraft was being flown toward the gulf. There was no moonlight, and no lights were visible on the horizon.

"Thus, the visual horizon was unlikely to be distinguishable over the sea," the report said.

FDR data indicated that, beginning at 1929:43, the captain's sidestick control was held forward of the neutral position for about 11 seconds. The report said that deflection of the control reached 9.7 degrees; maximum forward (and aft) deflection is 16 degrees.

"During this time, the airplane's pitch attitude decreased from about five degrees nose-up to about 15.5 degrees nose-down, the recorded vertical acceleration decreased from about +1.0 g [i.e., standard gravitational acceleration] to about +0.5 g, and the airspeed increased from about 193 knots to about 234 knots," the report said.

The report said that when the captain applied forward sidestick, he likely was experiencing a strong but false physical sensation that the aircraft was pitching up.

"Even though the aircraft's instruments were displaying its true pitch attitude, this information was not utilized by the captain," the report said. "It was effectively this nose-down sidestick input that set in train the final sequence of events leading to the accident."

About 1929:51, the aircraft was descending through 1,004 feet AGL at 221 knots, when the ground-proximity warning system (GPWS) generated an aural "sink rate" warning.

"There should have been an instant response from the captain — 'pull up to full-back stick and maintain' — in accordance with the SOP," the report said. "The A320 FCOM [flight crew operating manual] further states, 'During night or IMC (instrument meteorological conditions), apply the procedure immediately. Do not delay reaction for diagnosis.'"

At 1929:52, the GPWS generated an aural "whoop whoop, pull up" warning. The warning was repeated once each second for the next nine seconds.

"Gulf Air procedures for response to a GPWS warning of 'whoop whoop, pull up' stipulate that full back stick is to be employed and maintained, and that during night conditions, the response should be immediate," the report said.

At 1929:52, the captain said "flaps up." FDR data indicated that the captain's sidestick then was moved aft of the neutral position to a maximum deflection of 11.7 degrees.

"However, the FDR data showed that this nose-up command was not maintained and that subsequent movements never exceeded 50 percent of full-aft availability," the report said. "FDR data indicated no movement from the first officer's sidestick throughout the approach and accident sequence."

SOPs require that if a captain does not respond appropriately to a GPWS warning, the first officer should assume that the captain is incapacitated and take control of the aircraft.

"In this case, it appears that … the captain as well as the first officer did not comprehend the criticality of the aircraft's attitude and increasing proximity to the ground," the report said.

The aircraft continued to descend.

At 1929:59, the captain said "flaps all the way."

The first officer said "zero." This was the last crew statement recorded by the CVR.

"The FDR data showed continuous movement of the flap position toward the '0' position after the captain's 'flaps up' command," the report said. The last flap position recorded on the FDR was about two degrees of extension. The last recorded pitch attitude was about six degrees nose-down, and the last recorded airspeed was about 282 knots.

"FDR data indicated that TOGA selection and corresponding maximum engine thrust remained until the end of the recording."

The aircraft broke into several pieces on impact. Autopsies and toxicological tests indicated that all the occupants died of blunt-force trauma.

"There was no evidence of any thermal injuries or carbon-monoxide inhalation," the report said.

Most of the wreckage was recovered from about three meters (10 feet) of water, and there was no indication of structural failure, flight-control failure or fire before impact. Both engines were producing power on impact.

The FDR and CVR were recovered the day after the accident; the underwater-locator beacons had separated from both recorders during impact.

The digital aircraft integrated data system recorder (DAR) also was recovered but contained no flight data.

"The DAR provides easy access for downloading data for condition monitoring and trend analysis," the report said. "Although the DAR is not 'crash-protected' like FDRs and CVRs, the unit from GF-072 was recovered in relatively good condition with only impact marks to the case.

"However, subsequent examination revealed that no data had been recorded on the [DAR] tape, and the tape was found at the beginning of the track."

The report said that Flight Safety Foundation research on CFIT accidents identified several common factors, including night conditions, limited-visibility conditions, unstabilized approaches, loss of situational awareness and uncertainty about altitude.

"Nearly all these factors were present in the accident to GF-072," the report said.

The report said that the airline's pilot-training programs at the time of the accident were deficient in CFIT prevention, response to GPWS warnings and spatial disorientation, and that the airline's flight-data-analysis program "was not functioning satisfactorily."

The report said that although Airbus A320 pilot-training materials include a GPWS pull-up demonstration, the airline did not require a GPWS pull-up demonstration during pilot training at the time of the accident.

During post-accident tests that replicated the accident flight in an A320 flight simulator, pilots moved the sidestick either fully aft or halfway aft when the GPWS warning sounded and maintained the sidestick deflection to recover from the dive. The report said that with the sidestick moved fully aft, about 300 feet of altitude was lost during recovery; with the sidestick moved halfway aft, about 650 feet of altitude was lost during recovery.

"In another scenario, a recovery was performed by the copilot after he verified that the captain took no action to recover from the GPWS 'whoop whoop, pull up' alert," the report said. "The copilot depressed the priority button on his sidestick, announced his control override and applied full-aft sidestick input. In this scenario, the simulator recovered with about 400 feet of altitude loss."

In another test, instead of rolling the aircraft out of the turn on a heading of 211 degrees, the pilots continued the turn at a "moderate" bank angle to align the aircraft with Runway 12 and continue the approach and landing.

"In these demonstrations, the pilots were able to successfully land on Runway 12 from the 360-degree turn," the report said. "However, the pilots noted that the approach was not stabilized and a short amount of time was available to successfully complete the final approach and landing."

The report said that the captain apparently experienced high workload, a high level of stress and information overload while conducting "an unplanned and unpracticed maneuver at low altitude with negligible external visual references and in a high-drag aircraft configuration." The captain's workload further was increased by the necessity to respond to the flap-overspeed warning.

"Under this very high workload and stressful situation, and with his conscious attention focused on the flap overspeed in the last moments before impact, the captain did not possess sufficient spare information-processing capacity to perceive and respond to the information from the aircraft's instruments," the report said. "Information from the instruments was filtered out. The overall lack of situational awareness demonstrated by the captain was evidence of information overload on the part of the captain."

A study conducted by the U.S. Naval Aerospace Medical Research Laboratory indicated that the captain experienced a somatogravic illusion while he focused his attention on responding to the flap-overspeed warning during the go-around. Although the aircraft's pitch attitude was five degrees,

the captain perceived that the pitch attitude was approximately 12 degrees.

"In this illusion, the absence of visual cues combined with rapid forward acceleration creates a powerful pitch-up sensation," the report said. "The somatogravic illusion has been identified as a significant factor in numerous dark-night takeoff/go-around accidents. In these accidents, the aircraft involved were typically accelerating into an area of total blackness.

"Under such conditions, the somatogravic illusion induced by the aircraft's acceleration under TOGA power causes the pilot to perceive that the aircraft is pitching up, and he responds by making a nose-down input on the controls. As a result, the aircraft descends and thereafter flies into the ground or water."

At the time of the accident, the airline required an air safety report to be submitted after a go-around (missed approach) was conducted.

"Although Gulf Air stated that its policy was not to take action against any pilot who had conducted a missed approach, it was apparent that, at the time of the accident, a perception existed on the part of some company pilots that a missed approach would be regarded unfavorably by company operational management," the report said.

After the accident, the airline issued a fleet instruction that said, "No disciplinary action whatsoever will be taken against any crew that elects to carry out a go-around for safety-related reasons, including inability, for whatever reason, to stabilize an approach by the applicable minimum height." Gulf Air also prohibited 360-degree turns and "other maneuvers for descent-profile adjustments" on final approach.

The report said that the CVR transcript indicated an absence of CRM by the accident pilots; the captain conducted the final portion of the flight as if it were a single-pilot operation, and the first officer was not assertive.

"The captain did not utilize effectively the first officer, a valuable resource," the report said. "The first officer performed routine procedural functions and made little significant contribution to the conduct of the last critical phases of the flight. … He deferred to all of the captain's decisions and actions, even though they involved the violation of SOPs."

At the time of the accident, Gulf Air was developing CRM training programs. The report said that, as of May 2001, the airline had implemented a generic CRM ground school program for flight crew and cabin crew but had not implemented type-specific CRM flight simulator training and line-oriented flight training (LOFT) for A320 flight crew.

"Gulf Air [said] that these [training programs] are expected to be introduced along with the annual recurrent CRM training program during the year 2002," the report said.

Gulf Air's flight safety department was staffed by one person from 1998 to the time of the accident.

"He did not report directly to the highest executive level within the company," the report said. "This lack of resources within the flight safety department and its inappropriate corporate status within the company [were] serious organizational [deficiencies]."

The report said that the airline's participation in regular meetings conducted by the International Air Transport Association (IATA) Safety Committee (SAC) was interrupted during an unspecified number of years preceding the accident.

"This greatly restricted the airline's awareness of new information and developments in areas such as accident investigation case studies, safety and risk-management programs, CRM and LOSA [line operations safety audit] training, safety information systems and safety management programs," the report said.

The report said that after the accident, the airline resumed participation in IATA SAC meetings.

The Oman Directorate General of Civil Aviation and Meteorology (DGCAM) was responsible for regulatory oversight of the airline.

"A review of correspondence between DGCAM and Gulf Air revealed numerous letters citing a lack of compliance with [civil aviation regulations]," the report said. "The evidence indicated that in some safety areas, Gulf Air did not effect timely changes when problems were identified by DGCAM."

Based on these findings, the AIB made the following recommendations to the DGCAM:

- "Review whether safety oversight surveillance is adequate to ensure airlines' timely compliance with all critical regulatory requirements;

- "Ensure that Gulf Air updates the [CRM] program by integrating it in [LOFT] in accordance with DGCAM regulatory requirements, and consider implementing a [LOSA] program;

- "Ensure that Gulf Air reviews and enhances, in accordance with DGCAM regulatory requirements, the A320 flight crew training programs to ensure full compliance with the [SOPs] and increase the effectiveness of the first officer. The training in 'CFIT avoidance and GPWS responses' should be augmented by including it in the recurrent training program, with a detailed syllabus in accordance with DGCAM requirements. The *Approach-and-landing Accident Reduction (ALAR) Tool Kit*, produced by Flight Safety Foundation with extensive airline-industry input, could be a key element in the updated training program;

- "Ensure that Gulf Air company's training and evaluation of flight crew performance consistently meets the required DGCAM standards;

- "Consider requiring Gulf Air to include in its flight crew training programs (initial as well as recurrent) comprehensive information on spatial disorientation;

- "Ensure that Gulf Air reviews and improves the functioning and utilization of the A320 flight data analysis system, in accordance with DGCAM regulatory requirements; [and,]

- "Consider requiring Gulf Air to augment [its] accident-prevention strategies and adopt programs, such as the Procedural Event Analysis Tool (PEAT [a software-based analytic tool developed by Boeing Commercial Airplanes to help identify factors contributing to flight crew nonadherence to SOPs]), and implement a comprehensive integrated safety and risk management program."

The AIB made the following recommendations to Abu Dhabi, Bahrain, Oman and Qatar:

- "Ensure that the civil aviation regulatory authority for Gulf Air (DGCAM) [has your] full and continuing support … in implementing regulatory compliance by the airline; and,

- "Ensure that the management of Gulf Air complies with civil aviation regulatory requirements effectively and expeditiously."

The AIB recommended that Bahrain Civil Aviation Affairs "enhance guidance to air traffic controllers for addressing requests from pilots to execute non-standard maneuvers (such as an orbit [i.e., 360-degree turn]) during the final approach. When on final approach, requests from pilots to conduct non-standard maneuvers should only be approved by controllers after they have ascertained the required safety parameters."

The AIB made the following recommendations to the International Civil Aviation Organization (ICAO):

- "Consider making the following a standard applicable in all classes of airspace: a speed limit of 250 knots below 10,000 feet AMSL [above mean sea level]; [and,]

- "Consider prohibiting non-standard maneuvers (such as orbit) when an aircraft is on the final approach, unless safety considerations demand otherwise."♦

[FSF editorial note: This article, except where specifically noted, is based on the Bahrain Accident Investigation Board (AIB) *Accident Investigation Report: Gulf Air Flight GF-072, Airbus A320-212, Reg. A40-EK, on 23 August 2000 at Bahrain*. The 126-page report contains illustrations and appendixes.]

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Contact Ann Hill, director, membership and development,
by e-mail: hill@flightsafety.org or by telephone: +1 (703) 739-6700, ext. 105.

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