FLIGHT SAFETY FOUNDATION
Accident Prevention
Vol. 51 No. 1 *For Everyone Concerned with the Safety of Flight* January 1994

Cockpit Coordination, Training Issues Pivotal in Fatal Approach-to-Landing Accident

The crash of an Indian Airlines Airbus A320 underscored safety issues ranging from cockpit resource management to airport emergency procedures.

Editorial Staff Report

The Indian Airlines Airbus A320 was on final approach to Bangalore Airport in southern India when it struck a golf course embankment less than one-half mile (.8 kilometer) from the runway threshold, bounced over a ravine and road and exploded in flames just outside the airport's boundary wall.

The aircraft was destroyed by the impact and post-impact fire. The two pilots, two cabin attendants and 86 passengers were killed in the Feb. 14, 1990, accident. There were 56 survivors.

The accident occurred at 1303 hours local time in visual meteorological conditions. Visibility was reported as 6.2 miles (10 kilometers) with winds 120 degrees at five knots. The aircraft's crew reported sighting the runway from seven miles (11.2 kilometers). An instrument landing system (ILS) had not been installed at Bangalore Airport, so the crew executed a non-precision VOR-DME (Very high frequency omnidirectional radio range-distance-measuring equipment) step-down approach. The approach runway was served with three-bar visual approach slope indicator (VASI) lights. No defects were found in the VASI lights during a routine check on the morning of the accident, and there were no cockpit reports of malfunctioning VASI lights.

An accident investigation report prepared for the Indian Director General of Civil Aviation (DGCA) said that the aircraft "descended below the normal approach path and its wheels contacted the ground."

"The aircraft initially touched softly on the golf course ground on its main wheels [about 2,300 feet (701.5 meters) from the runway threshold]," the report said. "[The] aircraft then bounced and remained in [the] air for about 230 feet [70.1 meters] and thereafter touched the ground more firmly on its main landing gear followed by its nose landing gear.

"At this stage, the right engine also touched a raised portion of the ground. Immediately after this, the aircraft hit an approximately 12-foot [3.6-meter]-high embankment leading to the separation of both engines,

undercarriage and [causing] extensive damage to [the] front fuselage. [The wings also struck trees on the embankment.]

"The aircraft in this condition hopped over the adjacent nullah [ravine] and the road, covering a distance of about 26 feet [8 meters] and fell down in a grassy and rocky area close to the airport boundary wall. [A] huge fire engulfed the forward fuselage. Many passengers escaped through [the] rear left door, which was opened by one of the cabin crew members."

The report said the aircraft skidded for 170 feet before it came to rest about 150 feet from the airport boundary wall.

The report said that the aircraft skidded for 170 feet (52 meters) before it came to rest about 150 feet (45.7 meters) from the eight-foot (2.4-meter)-high airport boundary wall at the approach-end of Runway 09.

The pilot/captain occupying the left seat and flying the approach was undergoing his "first route check for command endorsement'' under supervision of the company's A320 check pilot, who occupied the right seat. The check pilot was commander of the flight, the report said.

The A320 check pilot, 44, was authorized for pilot-in-command status for the aircraft in September 1989 and was exempted from a rule requiring 100 hours of flying experience as first officer. He had flown a total of 48 hours as first officer in the A320 and had logged 212 flight hours as pilot-in-command of the aircraft. He had also served as captain on Boeing 737s and Hawker-Siddley HS-748s. He had logged a total of 10,339 flight hours.

The Indian report said that the check pilot in June 1989 had undergone conversion training for the A320 aircraft in France and that his training evaluations there had been "generally good, except for certain advisory remarks to show [areas of necessary] improvement in ECAM [electronic centralized aircraft monitor] actions and radial tracking during VOR approach[es]."

- June 19, 1989: "Good session, but use of ECAM and [call outs] should be improved."
- June 27, 1989: "Good session, ECAM calls to be improved. Mistakes during abnormal procedures."
- June 28, 1989: "Sometimes forgets the check lists. Good handling during single engine procedure."
- June 30, 1989: "Have to improve the ECAM actions during abnormal procedure. Do not forget to select APPR mode."
- July 3, 1989: "Procedures and actions during non-precision approach are very slow. Poor radial tracking during VOR approach."
- July 5, 1989: "Ready for FFS [full flight simulator], have to improve ECAM reading and FMGS [flight management guidance system] actions."
- July 7, 1989: "Handling is correct, Improve FMGC use, on the whole satisfactory."
- July 11, 1989: "Good session, Hydraulic … O.K. after discussion."

[The FMGS is an interactive system that provides autopilot control, flight director commands, autothrust control, rudder commands, flight envelope computation, information display management and other functions.]

The pilot undergoing the check route, 46, had a total of 68 flight hours as first officer in the A320. He had previously served as captain on Boeing 737s and HS-748s and had logged a total of 9,307 flying hours, of which 5,175 were as pilot-in-command.

Remarks on his A320 conversion training in 1989 in France included:

- Nov. 11, 1989: "Some difficulty with pitch and yaw control during single engine exercises. Improvement noted. Otherwise satisfactory progress."
- Nov. 13, 1989: "This was not a good period for Capt.___. Dual hydraulic failure approach procedure repeated. Auto Thrust was disconnected upon glideslope interception.Thrust Reverser lock engaged and when Thrust Levers were moved, aircraft accelerated to 220 Knots. Approach was abandoned. Thrust levers were closed and eventually, because of mishandling, aircraft stalled. After briefing, repeat was satisfactory. Numerous small errors and omissions with FMGS and ECAM. Single engine handling still erratic. There has been some regression with progress. Improvement must be noted in subsequent periods or additional training will be required."
- Nov. 14, 1989: "Great improvement noted today in all areas."
- Nov. 17, 1989: "Not satisfactory. Engine failure after takeoff. Positive action on the wrong side, Cat-II approach — try to go around after touchdown and single engine operation. A bit slow on

FMGS. One remedial session is required focusing on Single Engine control and CAT-2 Procedure. Spare time will be used for FMGS training."

- Nov. 18, 1989: "Useful practice of instrument scanning was made so flight path accuracy and speed control improved. FMGS control still rather hesitant."

The captain was "found fit for command endorsement" the next day.

The report said that when the DGCA granted the A320 type endorsement to the captain, the DGCA advised the airline that his performance be "positively monitored in operation of FMGS, single-engine handling and procedures and single-engine non-precision approach[es], which require improvement and reports on his performance in these areas may specifically be raised. These shall be taken into consideration at the time of issue of Pilot-in-Command endorsement to Capt.___.

"Indian Airlines had, however, intimated that the performance of Capt.___ in operating FMGS will be monitored, while he is undergoing Pilot-in-Command route check, and the remaining recommendations of DGCA will be acted upon, during his next IR/LR check after commissioning of A-320 simulator. DGCA has also advised that the next six monthly proficiency checks of Capt.___ are to be endorsed in DGCA headquarters only."

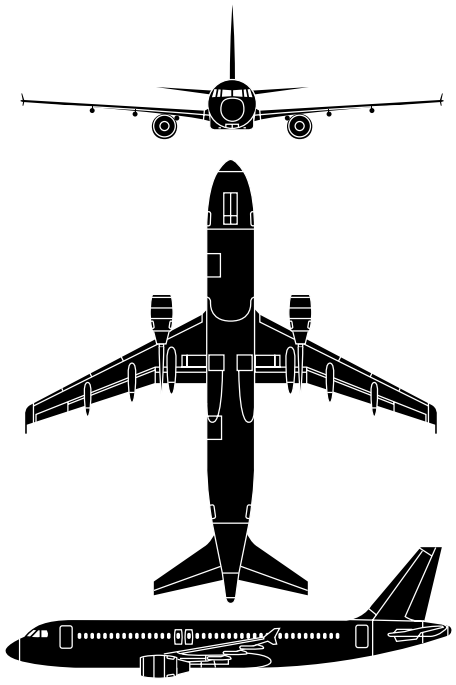
The accident flight departed Bombay at 1158. At 1259, Bangalore air traffic control (ATC) cleared the flight to descend to 4,600 feet (1,403 meters) at 10 miles (16.1 kilometers) from touchdown.

The report said that air traffic control tapes "clearly show that the aircraft did not report any abnormality or emergency to Bangalore ATC."

An examination of cockpit voice recorder (CVR) and digital flight data recorder (DFDR) information indicated that the aircraft was descending in an "open descent mode," and that the autopilot was disconnected when the aircraft reported the runway in sight.

"At 1301:33 hours, 'altitude capture mode' was activated and 'Speed alt-star' was called out twice by [the check pilot] at 1301:36 and 1301:40 hours. The 'altitude capture mode' was activated at 4,938 feet [1,506 meters] altitude, which indicates that an altitude of 4,600 feet [1,403 meters] was selected on the flight control unit [FCU] during the 'open descent mode.' ... The approach path of the aircraft indicates that it was about 600 feet [183 meters] higher than the normal path when the 'altitude capture mode' was activated. Normally, 700 feet [213.5 meters] per minute rate of descent is required to maintain the final approach path, but in this case the aircraft was higher and [the pilot flying] had asked for a 1,000 feet [305 meters] per minute rate of descent.

"Accordingly, as per CVR recordings, 'vertical speed mode' was selected with 1,000 feet per minute rate of descent. The actual rate of descent maintained after this selection, however, was around 2,000 feet [610 meters] per minute initially, then reducing to approximately 1,300 feet [396.5 meters] per minute. Due to this higher rate of descent, [the aircraft's speed] increased to about 148 knots, whereas 'approach target speed' of 132 knots was required to be maintained. However, when landing clearance was given, the aircraft was almost in the proper 'approach path,' but its speed was about nine knots higher than the required speed."



Airbus A320

The twin-engine Airbus A320 was first flown in 1987. The short/medium range jetliner is built jointly by Aerospatiale in France, Deutsche Airbus in Germany, British Aerospace in the United Kingdom, Belairbus in Belgium and CASA in Spain. The A320 uses a fly-by-wire control system and side stick controls in place of the usual control columns in the cockpit. Its range with CFM56 engines and 150 passengers is 3,302.4 miles (5,318 kilometers).

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

Nevertheless, the report said, "it is evident that the aircraft had descended properly, and its initial approach profile, even though slightly higher, is considered to be normal. The aircraft was almost in profile when it was 1,000 feet above ground level (AGL) and had obtained landing clearance. The aircraft was also in proper landing configuration at this time."

The aircraft was cleared to land at 1302:17 when it had reported short final at an altitude of 1,000 feet AGL. The aircraft [at this stage] was descending in "vertical speed mode" with autothrust in [the proper] "speed mode," the report said.

"At 1302:41, the DFDR data clearly show that 'altitude acquisition mode' became active at 3,341 feet [1019 meters] altitude. This activation of 'altitude acquisition mode' can only take place when there is a selection of lower reference altitude on the FCU [flight control unit] panel. The activation at 3,341 feet indicates that this reference altitude selection on the FCU panel was probably close to minimum descent altitude (MDA) of 3,270 feet [997 meters] [for the VOR-DME approach to Bangalore [instead of 6,000 feet go-around altitude. Go-around altitude was not set during the final approach checks.]. One second later ... the pilot flying said, 'OK, 700 feet [213.5 meters] rate of descent,' and immediately thereafter the aircraft had gone into an 'open descent mode,' which the check pilot realized at 1302:53 [and who remarked], 'You are descending on idle open descend ha, all this time!'"

Improper selection of the altitude on the FCU resulted in "open descent mode," which led to "autothrust mode" changing from "speed mode" to "thrust idle mode," the report said.

The report said that there were some garbled words at 1302:42 after the check pilot said, "Missed approach is … ." Because the open descent mode was actually engaged and there was conversation between the two pilots that suggested an FCU selection was being made, investigators believe an inadvertent selection of an altitude lower than the aircraft altitude was made.

"As soon as the open descent mode got engaged, the aircraft speed started falling below the approach target speed of 132 knots and the aircraft started coming below the approach path. The DFDR data clearly show that at this stage, the nose of the aircraft was being pitched up, and its speed was steadily falling below 130 knots. The nose-up change of pitch angle was probably as a direct result of the side stick input being given by [the pilot flying in the left seat] to keep the aircraft in profile. But [because] the engines were maintaining only idle power due to open descent mode, the speed of the aircraft was being washed away and the aircraft [was descending] below the profile required for a normal landing.

"[The pilot flying] continued to fly the aircraft, which was going down much below the required profile until he realized at 1303:10 that he may not be able to land at the proper place and said, 'Hey, we are going down!' He then pulled back fully the side stick, activating 'alpha floor protection' at 1303:11. The aircraft was then at 135 feet [41.2 meters] AGL. Activation of alpha floor protection [designed as wind shear protection that activates if certain parameters are exceeded] generated an EPR [engine pressure ratio] command for full power to both engines. Around two seconds later both the throttle levers were also pushed to the TOGA [takeoff/go-around] position by the crew. Engine power started building, but could not develop adequate power to arrest the descent. The aircraft touched the ground and hit the embankment of the golf course."

An examination of the engines determined that both were developing power and "set for high power" at the time of impact, the report said.

The report said that "if the thrust levers would have been moved to TOGA position simultaneously when [the pilot flying] initiated [the] side stick movement backwards at 1303:08, then [the] engines would have got [an] additional three seconds to accelerate and would have attained go-around power. In such a case, the accident could have been avoided."

The CVR indicated that about 21 seconds before the crash, the check pilot asked the pilot flying, "You want the FDs [flight directors] off now?" The flying pilot replied, "Yes, OK, I already put it off." The check pilot then replied, "But you did not put off mine."

"DFDR data reveal that at least one of the FDs remained engaged up to the time of [the] crash. The autothrust mode logic states that if neither autopilot nor FD is engaged, the autothrust will be active in 'speed mode' only. Since in [this case] the aircraft never went into the 'speed mode' during this [last] phase, it corroborates that the FD of [the check pilot] was not disengaged [until] the time of [the] crash.

"If the flight director of [the check pilot] would have been disengaged at that stage, the autothrust mode would have changed from thrust (idle) mode to speed mode, which is the proper mode for landing. In that case, engine power would have started building up power from that instant to restore speed, and the accident could have possibly been averted."

An examination of the engines determined that both were developing power and "set for high power" at the time of impact, the report said.

Despite the severity of the impact, the aircraft's wings remained attached, the report said. The front part of the fuselage was "severely crushed by impact with [the] embankment, causing extensive breakage in the fuselage structure. The rear fuselage behind the wings, however, remained in shape [until] the fire erupted."

The report said that fire engulfed the forward part of the fuselage and moved toward the rear. The starboard wing tank ruptured, and leaking fuel fed an intense fire near the starboard wing root, the report said.

The report said that a series of events delayed arrival of fire trucks and emergency personnel at the crash site.

Tower controllers alerted airport fire and rescue personnel by sounding an "emergency buzzer" after seeing smoke near the end of the runway. The buzzer signaled a "declared emergency" [A bell signaled "aircraft accident/fire."]

"Since there was no voice communication between [the] tower and [the] fire station, the fire crew moving out did not know ... the nature of [the] emergency. So they proceeded to the ramp position, which is located in front of the tower and [about] 5,000 feet [1,525 meters] from the beginning of runway 09. From the ramp position, the fire crew could see smoke and proceeded toward" the crash site, said the report.

There was no telephone link between the tower and the fire station or emergency vehicles, the report said. A portable radio receiver that was provided for communication between the tower and the fire station did not operate, and the tower did not have a crash siren to alert personnel to emergencies. Communications were also inadequate between the airport officials and the city fire brigade, the report said.

The report said that the airport fire station is surrounded by tall buildings and trees and that "it is not possible to maintain a watch on aircraft movements at or in the vicinity of the aerodrome from any position" from the fire station.

The approach road beyond the runway threshold "passes over a hump three-feet (.9-meter)-high. Underneath the hump is the channel for [the] barrier cable. The road passing over the hump is broken and rough and has a steep gradient. To cross over this hump, a vehicle has to slow down to walking speed."

There was only one gate in the boundary wall in the area of the crash site. The key for the gate lock was supposed to be available in the fire station and on each fire truck, the report said. It said that fire officials stated that the "key had never been made available to [the] aerodrome fire station or any of the fire fighting vehicles.

"On reaching the [eight-foot (2.4 meter)-high] boundary wall, the fire crew saw that the security gate was locked," the report said. "So they went near the wall and saw the thick smoke just outside the boundary wall. According to witnesses' statements, the crash fire tenders had reached the boundary wall five to six minutes after the occurrence of the accident."

"On seeing the smoke and fire within the range of throw of foam from the crash fire tenders, the firemen began discharging foam onto the smoke. From within the aerodrome boundary wall, the foam jet could not cover all the aircraft portions [that] got engulfed in the fire [the aircraft was about 150 feet from the wall]. Therefore, it did not have the desired effect. [It discharged all its foam from within the boundary wall.]

According to witness reports, fire trucks did not reach the crash site until 10 to 20 minutes after the accident.

"In the meantime, two crew members from [a second airport fire truck] had taken the power cutter from the vehicle to cut the security gate lock. After removing the lock, the door having rusted and jammed, it was pushed open by about 20 persons to let the crash fire tenders pass through."

Airport fire crews had not been briefed in training on the Airbus A320 to help facilitate rescue operations, the report said. "They [fire and rescue crews] do not have the emergency chart of this aircraft available to them."

A total of 18 of a complement of 21 firemen were on duty on the day of the accident.

[The report said that the manager of the airport fire department had been employed seven months "but had not yet been provided with the uniforms. It is essential for every fireman to be in his uniform for it provides immediate identification of his profession and involvement in the event of fire."]

According to witness reports, fire trucks did not reach the immediate crash site until 10 to 20 minutes after the accident. One fire truck became stuck in soft ground and "had to be pushed" to the crash site, but "as it had already discharged some [most] of its foam from inside the boundary wall, there was not much foam left when it reached the crash site. According to eyewitnesses, it was not able to fight the fire properly."

Final Minutes of 'India 605'*

Time	Source	Content
1300:42	CP:	*Runway in sight.* (Autopilot disconnect "cricket" sound three times.)
1300:46	ATC:	*Resume own navigation No. 1 contact tower. 123.5.*
1300:48	PF:	*Flap 4.*
1300:51	CP:	*123.5, thank you, good day.*
	CP:	*There she is.*
	PF:	*OK landing checks.*
	CP:	*Coming, changing over to tower.*
	PF:	*OK.*
1301:08	CP:	*Bangalore tower India 605 good morning.*
1301:11	ATC:	*Good morning. Report short finals.*
1301:13	CP:	*Roger.*
1301:20	PF:	*Landing checks completed?*
	CP:	*Negative, I will give you at 1,400 AGL.*
1301:23	PF:	*OK.* (Coughing sound thrice.) *I am sorry.*
1301:36	CP:	*Speed, alt star.*
1301:40	CP:	*Speed, alt star.*
	PF:	*OK, give me go around.*
	CP:	*Go around you want?*
1301:48	PF:	*6,000.*
	CP:	*Or you want vertical speed.*
1301:54	PF:	*Vertical speed.*
	CP:	*How much?*
1301:56	PF:	*Thousand.*
	CP:	*Thousand.*
1302:08	CP:	*Tower, 605, confirm cleared to land?*
	PF:	*Go around, 6,000.*
1302:11	ATC:	*605, report short finals*
1302:13	CP:	*We are short finals.*
1302:17	ATC:	*Roger, cleared to land.*
1302:19	CP:	*Cleared to land, 605.*
	PF:	*OK, landing checks.*
1302:23	CP:	*OK, landing gear is down, three greens, release signs are on, spoilers are armed, flaps are full, landing checks are complete.*
1302:34	CP:	*Crew at your stations for landing.*
1302:42	PF:	*OK, 700 feet rate of descent.*
	CP:	*Missed approach is ...*
1302:49		(RA [radio altimeter] call out *"four hundred."*)
1302:53	CP:	*You are descending on idle open descend ha, all this time.* (RA call out *"three hundred."*)
1302:56	CP:	*You want the FDs [flight directors] off now?*
1302:57	PF:	*Yes.*
	PF:	*OK, I already put it off.*
1303:00	CP:	*But you did not put off mine.*
1303:03		(RA call out *"two hundred."*)
1303:07	CP:	*You are on the autopilot still?*
1303:09	PF:	*No.*
	CP:	*It's off.*
1303:10	PF:	*Hey, we are going down.*
1303:11	CP:	*O Chit.* [sic] (RA call out *"one hundred."*)
	PF:	*Captain.*
1303:12	PF:	*Captain still going.*
1303:13		(Sink rate warning.)
1303:14		(Chime.)
1303:15		(Sink rate warning and RA call out *"fifty."*)
1303:16		(Sink rate warning and RA call out *"ten."*)
1303:17		(Crash sounds.)

CP = Check Pilot
ATC = Air Traffic Control
PF = Pilot Flying

*Transcript from aircraft's cockpit voice recorder.

Source: Indian Director General of Civil Aviation

The report said that the third fire truck was discribed as an "old rattling vehicle. It had regular starting trouble. On the day of the accident, it was the last vehicle to reach the scene." It discharged its foam [only 160 liters of the total 1600-liter capacity of the three trucks] at the crash site. The report said that the fire "was erupting again and again." It added: "With the limited fire fighting capacity available, the fire could not be brought under control. Also there were very limited means [locally] of refilling water [in the fire trucks] and no means of refilling at the site of the crash."

The city fire department was informed of the crash at 1309, about six minutes after the accident, the report said, and city fire trucks arrived at 1320.

Three flight attendants were seated in the rear of the cabin when the aircraft struck the embankment. On impact, one attendant was thrown to the floor and injured. Another flight attendant struck her head on a lavatory bulkhead. The third flight attendant "was alert to the situation and as soon as the aircraft came to a stop she opened the left hand rear door."

The report said that many passengers "had impacted the seats in front of them causing various injuries, dizziness and shocks. Some seats in [the] middle to forward section of the cabin had also broken. Immediately thereafter, smoke started emanating from the front portion of the cabin. One emergency window reportedly opened by itself, and some passengers egressed through that emergency window on their own. However, smoke and heat started spreading backwards inside the cabin.

"After opening the rear door, [two flight attendants] shouted at the passengers to leave the aircraft immediately, since the smoke ... was spreading fast toward the rear. According to the [flight attendants] the passengers were slow in reacting to their announcement, probably due to shock or injuries. [The flight attendants] had to help some passengers to exit the aircraft. Some passengers also helped other passengers to come [exit] the aircraft.

"The two flight attendants then went up in the cabin to help other passengers, but due to thick smoke they found it difficult to breathe and ... had to return and leave the aircraft. While leaving the aircraft they saw [the injured third flight attendant] in a dazed condition [and] ... helped her out of the aircraft.

"Some passengers were seen coming out in inverted position ... head first out from underneath the damaged nose [section]. They were helped out by local people who pulled them out of the wreckage. One person while trying to come out from there was caught up by the fire and was seen dying there.

"Some persons, undaunted by the fire, went inside the cabin from [the] rear left-hand door and pulled out the injured passengers until they were prevented [from continuing to help] by smoke and suffocation."

The report said that the two flight attendants managed to obtain water from local people, and gave it to the passengers. They also helped the passengers board buses, which had been "passing along the road round the crash site," to the hospital.

"The injured passengers who could escape or who were helped out of the aircraft ... were not given any first-aid treatment at the crash site," the report said. "Such first-aid facilities were not available on the spot. An [airport fire and rescue] ambulance reached the crash site after about seven minutes but did not have the medical attendant on board, and there was no other medical aid available nearby."

The ambulance was equipped with "two beds, one stretcher, and a first-aid box," the report said.

The report noted that ATC was equipped with a 45-channel recorder to tape radio frequency traffic. The report said that an investigation determined that the device was only recording the tower and approach control frequencies. A time signal was also not recorded, making it impossible to establish the exact time of tower and approach channel transmissions.

An airport emergency plan for Bangalore Airport was drafted and discussed in 1988, the report said. "Following the discussion, a revised draft plan was circulated among the concerned agencies for their opinions for adoption of the plan to make it operative. There was no response from those agencies and the matter was not followed up by the aerodrome authorities at Bangalore."

The report added: "It is mandatory ... to establish an emergency plan at an aerodrome, commensurate with aircraft operations in order to provide for the coordination of actions to be taken in an emergency occurring at an aerodrome or in its vicinity. The plan is to coordinate the response or participation of all existing agencies [that] could be of assistance in responding to an emergency. To ensure effectiveness of [the] plan, procedures are to be established for testing the plan and reviewing the results at least once a year."

Following the investigation, the accident inspector made the following recommendations:

- "A protection should be available to ensure that the open descent mode is not engaged below 1,000 feet on radio altimeter;
- "Crashable gates in the boundaries near the end of the runways should be provided so that fire-fighting vehicles can have immediate access to effectively carry out fire fighting [of] accidents in the approach funnel areas; and,
- "Airport authorities should ensure proper recordings of all channels on ATC tapes."♦

Editorial Note: The preceding article was adapted from *Report on Accident to Indian Airlines Airbus A-320 Aircraft VT-EPN at Bangalore on 14th Feb., 1990*, a special report prepared at the request of the Indian Director General of Civil Aviation, March 1990. The 99-page report includes appendices and illustrations.

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6th Annual European Corporate and Regional Aircraft Operators Safety Seminar (ECARAOSS)

Amsterdam, Netherlands
February 28 through March 2, 1994

For more information contact J. Edward Peery, FSF.

ACCIDENT PREVENTION

Staff: Roger Rozelle, director of publications; Girard Steichen, assistant director of publications; Kate Achelpohl, editorial assistant; and Monique Kohly, production consultant

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