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Dubrovnik-bound Flight Crew's Improperly Flown Nonprecision Instrument Approach Results in Controlled-flight-into-terrain Accident

Special CFIT Safety Report

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Cover: *Wreckage of aft fuselage and empennage at crash site of U.S. Air Force CT-43A (Boeing 737-200), Dubrovnik, Croatia, April 3, 1996. Photo: AP/Wide World Photos*

Foreword

In 1991, Flight Safety Foundation (FSF) launched an international campaign to reduce the number of controlled-flight-into-terrain (CFIT) accidents, which was expanded later to include approach-and-landing accidents. An FSF-led task force, in counsel with the International Air Transport Association (IATA) and the International Civil Aviation Organization (ICAO), was formed and set as its goal to reduce by 50 percent the number of CFIT accidents by 1998. The FSF CFIT Task Force, which in 1994 received an *Aviation Week & Space Technology* Aerospace Laurel award for its work, includes representatives from airlines, equipment manufacturers, airframe manufacturers, professional aviation organizations and other technical and research organizations (see page iii).

CFIT accidents are the leading cause of commercial aviation fatalities. According to FSF CFIT Task Force statistics, CFIT and approach-and-landing accidents accounted for more than 80 percent of the fatalities in commercial transport accidents between 1979 and 1991. According to statistics compiled by McDonnell Douglas (see page 30), there were four commercial jet transport CFIT accidents in 1995. Approach-and-landing accidents in 1995 continued to be prominent among commercial jet transport accidents, with 20 such accidents worldwide.

As part of the overall CFIT-reduction plan, the FSF CFIT Task Force has developed several products including:

- An "FSF CFIT Safety Alert" distributed to thousands of operators worldwide at no cost to recipients that emphasized the importance of immediate and aggressive "pull-up" actions, unless circumstances (visual meteorological conditions and flight well-above flat terrain, for example) explicitly determined that a ground-proximity warning system (GPWS) warning was false. Early FSF CFIT Task Force findings had determined that flight crews in CFIT accidents often ignored GPWS warnings; delayed recommended pull-up procedures while trying to evaluate the accuracy of the GPWS warning; or failed to respond with sufficient aggressive pull-up action.

- An "FSF CFIT Checklist," which helps pilots assess CFIT risks for specific flights and operations. To date, more than 30,000 copies of the FSF CFIT Checklist (reproduced following page 25) have been distributed by the Foundation worldwide with the help of sponsorships from FlightSafety International, Scandinavian Airlines System (SAS) and SimuFlite Training International at no cost to the recipients. The English version remains available at no charge. Additional sponsorships are being sought to distribute Chinese, Russian, French, Spanish and Arabic versions of the CFIT Checklist, which were translated by ICAO.

- A video training aid, *CFIT: Awareness and Prevention*, which examines several CFIT accidents and presents cockpit voice recorder (CVR) data and simulation to illustrate accident reduction strategies. More than 6,000 copies of the video were distributed worldwide in 1995 (4,500 at no cost, with major funding from Associated Aviation Underwriters (AAU), Gulfstream Aerospace and Jeppesen Sanderson). Copies of *CFIT: Awareness and Prevention* are available from the Foundation for US$30; and,

- The *CFIT Education and Training Aid*, a two-volume training package developed under the auspices of the FSF CFIT Task Force and produced by the Boeing Commercial Airplane Group. Scheduled for release in late 1996, the training aid examines a number of CFIT accidents and focuses on human factors and management issues. The comprehensive training aid, which contains data to design simulator escape-maneuver training, is intended to be a resource for developing policies, procedures and CFIT-avoidance standards. The training aid also includes the video *Controlled Flight into Terrain: An Encounter Avoided*, which analyzes a jet transport CFIT accident in detail and shows how such accidents can be avoided. A price for the *CFIT Education and Training Aid* has not been determined, but it is designed to be an affordable training product for a wide range of aviation operators.

The FSF CFIT Task Force has also made eight recommendations to ICAO. A recommendation to broaden requirements for the use of GPWSs has been adopted by ICAO, and the others are under review. The new GPWS standards, effective Dec. 31, 1998, require GPWS in all aircraft used in “international commercial and general aviation operations, where the MCTM [maximum certified takeoff mass] is in excess of 5,700 kilograms [12,500 pounds] ... or that are authorized to carry more than nine passengers.”

ICAO officials have indicated their support for the pending recommendations, which include:

- A call for color-shaded depictions of terrain altitude on instrument-approach charts;
- A warning against the use of three-pointer and drum-pointer altimeters;
- A recommendation that all countries adopt the use of hectopascals for altimeter settings;
- A call for the replacement of early-model GPWS equipment;
- A recommendation for the improved design and presentation of nonprecision instrument approach procedures with a standard three-degree approach slope, except where prohibited by obstacles;
- A call for the use of automated altitude call-outs; and,
- A recognition of the important CFIT-avoidance benefits provided by the global positioning system/global navigation satellite system (GPS/GNSS).

CFIT accidents involving commercial operators were examined in detail in a special April–May 1996 double issue of the *Flight Safety Digest*. The research focused on 156 CFIT accidents that occurred from 1988 through 1994. The report, “An Analysis of Controlled-flight-into-terrain (CFIT) Accidents of Commercial Operators, 1988 through 1994,” concluded that 75 percent of the 108 accident aircraft (for which data were available) were not equipped with a GPWS and that landing (descent)-phase and landing (approach)-phase accidents together accounted for nearly 70 percent of all CFIT accidents studied. The report also noted that nearly 60 percent of landing (approach)-phase accidents involved aircraft flying nonprecision approaches. Twenty-five percent of the approaches were very high frequency omnidirectional radio range (VOR) DME approaches.

Another FSF report, prepared for the Directorate-General of Civil Aviation of the Netherlands and published in the March 1996 *Flight Safety Digest*, determined that there was a “five-fold increase in accident risk among commercial aircraft flying nonprecision approaches compared to those flying precision approaches.” The report, “Airport Safety: A Study of Accidents and Available Approach-and-landing Aids,” said that the “chance for error by the crew is probably greater during a nonprecision approach compared to a precision approach, resulting from the increased workload and additional need to maintain situational awareness.” According to FSF CFIT Task Force statistics for the period 1988 through 1995, 15 CFIT accidents involved distance-measuring equipment (DME) stepdown approaches. The FSF CFIT Task Force concluded that such nonprecision approaches are unnecessarily hazardous.

The Foundation’s CFIT accident–reduction campaign, like other FSF-led efforts in the areas of wind shear accident avoidance and fatigue countermeasures, was designed to bring the resources of the industry together to work toward the common goal of improving an already admirable safety record.

— Stuart Matthews
Chairman, President and CEO
Flight Safety Foundation

FSF CFIT Task Force

Following is a list of companies whose representatives launched the initial FSF CFIT Task Force. Since its formation, many additional companies and individuals have participated in the task force's work.

Aeroformation
Aerospatiale Inc. (now Aero International Regional)
Air Canada
Air Line Pilots Association (ALPA)
Air Traffic Control Association (ATCA)
Airbus Industrie
Airclaims Group Ltd.
All Nippon Airways (ANA) Co. Ltd.
Allegheny Airlines Inc.
AlliedSignal Aerospace
American Express Bank Ltd.
Atlantic Southeast Airlines (ASA)
Australian Airlines
Avions de Transport Regional
BA Acrad
Beechcraft
The Boeing Co.
Britannia Airways Ltd.
British Airways
Canada 3000 Airlines Inc.
Cessna Aircraft Co.
Comair Inc.
Continental Airlines Inc.
de Havilland Inc.
Delta Air Lines Inc.
Dresser Industries
Douglas Aircraft Co.
U.S. Federal Aviation Administration (FAA)
Finnair Oy
Flight Safety Foundation
Flight Safety Foundation-CIS
FlightSafety International
Gulfstream Aerospace Corp.
International Air Transport Association (IATA)
International Civil Aviation Organization (ICAO)
International Federation of Air Line Pilots Associations (IFALPA)
International Federation of Air Traffic Controllers' Association (IFATCA)
Japan Airlines
Jeppesen Sanderson Inc.
KLM—Royal Dutch Airlines
The Kroger Co.
Lockheed Martin Corp.
Lufthansa German Airlines
Middle East Airlines
Monsanto Co.
U.S. National Aeronautics and Space Administration (NASA) — Ames Research Center
National Business Aircraft Association (NBAA)
Netherlands National Aerospace Laboratory (NRL)
Pakistan International Airlines Corp.
Raytheon Co.
SimuFlite Training International
Smiths Industries Aerospace
Sundstrand Corp.
United Airlines
Varig S.A.
Vereiningung Cockpit E.V.

Additional CFIT-related Reading from FSF Publications

“Helicopter Strikes Water on Approach After Pilots Lose Altitude Awareness,” *Helicopter Safety* Volume 22 (July-August 1996).

“Different Altimeter Displays and Crew Fatigue Likely Contributed to Canadian Controlled-flight-into-terrain Accident,” *Accident Prevention* Volume 52 (December 1995).

“Commuter Crew’s Loss of Situational Awareness During Night Takeoff Results in Controlled Flight into Terrain,” *Accident Prevention* Volume 52 (October 1995).

“Crew’s Failure to Monitor Terrain Clearance After Night Takeoff Results in Collision with Mountain,” *Accident Prevention* Volume 52 (September 1995).

“Poorly Flown Approach in Fog Results in Collision with Terrain Short of Runway,” *Accident Prevention* Volume 52 (August 1995).

“Failure to Intercept Final Approach Course, Improperly Performed IFR Approach Cited in Fatal Collision with Terrain,” *Helicopter Safety* Volume 21 (May-June 1995).

“Aircraft Descended Below Minimum Sector Altitude and Crew Failed to Respond to GPWS as Chartered Boeing 707 Flew into Mountain in Azores,” *Accident Prevention* Volume 52 (February 1995).

“Breakdown in Coordination by Commuter Crew During Unstabalized Approach Results in Controlled-flight-into-terrain Accident,” *Accident Prevention* Volume 51 (September 1994).

“Lack of Management Oversight Cited in Controlled-flight-into-terrain Accident of FAA Aircraft,” *Accident Prevention* Volume 51 (August 1994).

“Captain Stops First Officer’s Go-around, DC-9 Becomes Controlled-flight-into-terrain (CFIT) Accident,” *Accident Prevention* Volume 51 (February 1994).

“Cockpit Coordination, Training Issues Pivotal in Fatal Approach-to-Landing Accident,” *Accident Prevention* Volume 51 (January 1994).

“Fatal Commuter Crash Blamed on Visual Illusion, Lack of Cockpit Coordination,” *Accident Prevention* Volume 50 (November 1993).

“Anatomy of a Mountain Crash: Error Chain Leads to Tragedy,” *Accident Prevention* Volume 49 (October 1992).

Dubrovnik-bound Flight Crew's Improperly Flown Nonprecision Instrument Approach Results in Controlled-flight-into-terrain Accident

An analysis of the terrain profile, accident aircraft configuration and flight profile determined that the accident aircraft's ground-proximity warning system would not have provided a warning to the crew, the official U.S. Air Force report said.

FSF Editorial Staff

On April 3, 1996, the crew of the U.S. Air Force CT-43A (Boeing 737-200) was flying a nondirectional radio beacon (NDB) approach in instrument meteorological conditions (IMC) to Runway 12 at the Cilipi Airport, Dubrovnik, Croatia, when the aircraft collided with a 701-meter (2,300-foot) mountain. All six crew members and all 29 passengers were killed in the accident.

As the aircraft crossed the final approach fix (FAF), it had an airspeed of approximately 209 knots (387 kilometers per hour), which was 30 knots (56 kilometers per hour) faster than the airspeed recommended in the airplane's flight manual for crossing the FAF.

As they flew the approach, the crew did not track the final-approach course of 119 degrees, but instead tracked a course of 110 degrees. They maintained this course until the aircraft collided with the mountain, 1.8 nautical miles (NM) (3.4 kilometers) north of the threshold of Runway 12.

A U.S. Air Force Accident Investigation Board concluded in its final accident report that the accident was caused by "a failure of command, air crew error and an improperly designed approach procedure."

The accident aircraft was not equipped with either a cockpit voice recorder (CVR) or a flight data recorder (FDR), the report said.

The accident flight crew and aircraft were assigned to the Air Force 76th Airlift Squadron (76 AS), 86th Operations Group (86 OG), 86th Airlift Wing (86 AW) at Ramstein Air Base (AB), Germany. The crew's mission was to transport U.S. Department of Commerce Secretary Ronald H. Brown and a delegation of U.S. industry executives from Zagreb, Croatia, to various locations in Bosnia-Herzegovina and Croatia during a three-day period. The accident occurred on the first day, on the fourth leg of a five-leg trip.

The itinerary was changed four times before the flight began. The crew planned the mission on April 1 (two days before the accident flight), based on the information in Change 1 to their itinerary. A stop in Dubrovnik was not listed in the change.

The pilot of the flight "was known for very thorough mission planning and briefing," the report said. "Mission planning typically included flight plan preparation and review of approaches in accordance with squadron policy; however, the squadron mission briefing guide did not specifically include approach review. The crew would not have flight-planned for the Dubrovnik leg, because Dubrovnik was not part of the Change 1 mission," the report said.

At 1945 hours local time that same day, Change 2 to the itinerary was transmitted to the 76 AS. This change added Dubrovnik as a stop on the first day's itinerary. "It could not be confirmed if the [accident] pilots received the information

Photo: AP/Wide World Photos

Wreckage of the U.S. Air Force CT-43A that crashed near Dubrovnik, Croatia, on April 3, 1996, killing U.S. Department of Commerce Secretary Ron Brown and all 34 others on board.

concerning Change 2 that night," the report said. "The [accident] copilot's spouse testified that the copilot received a phone call that evening from the [accident] pilot who requested that the copilot report to the squadron earlier than planned the next morning, possibly due to a mission change."

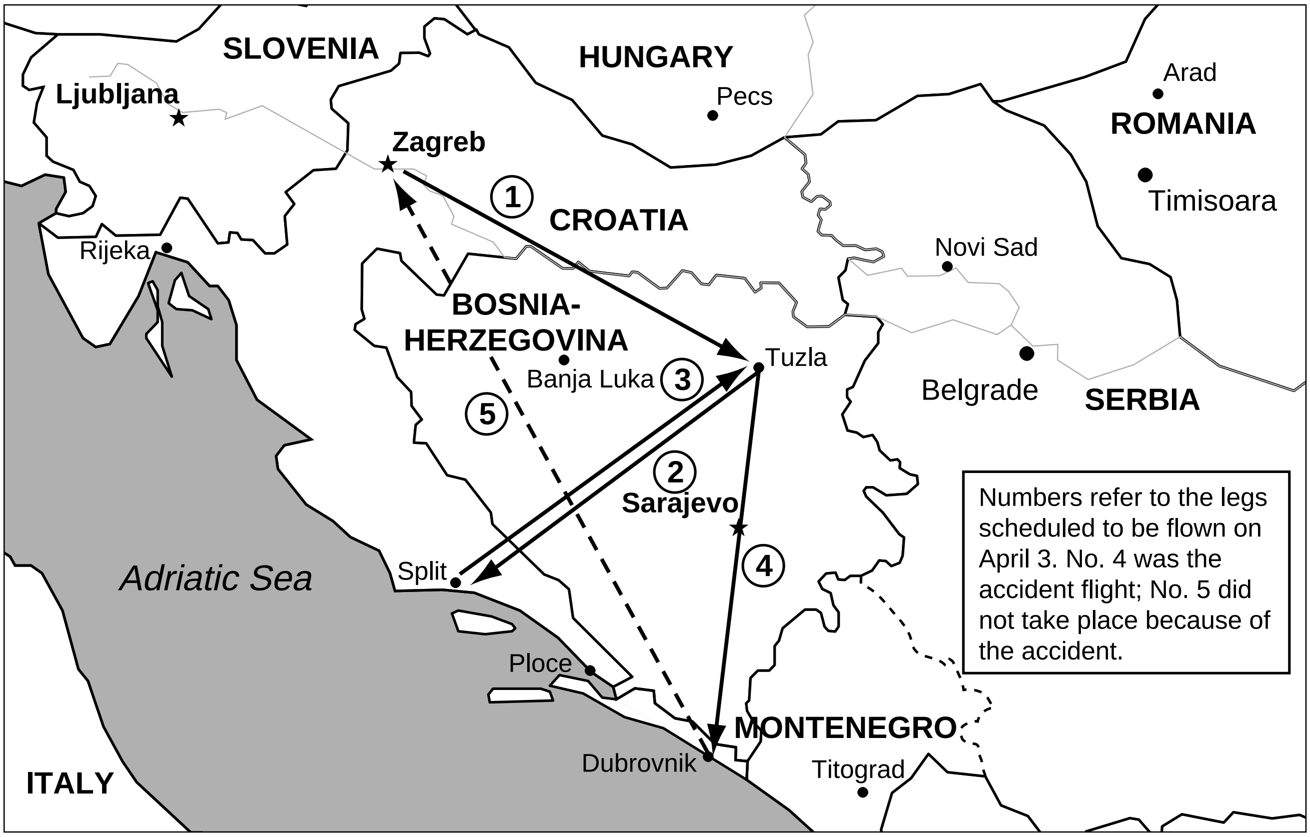
On the morning of April 2 (the day before the accident flight), the crew prepared for their mission at the squadron, before departing on a pre-positioning flight to Zagreb. During their planning, the copilot requested a change (Change 3) to the second day's itinerary, which was approved. [That change would allow the crew to return to Zagreb while the commerce secretary's group was in Sarajevo.] "The copilot also asked a squadron flight planner to build flight plans for the Dubrovnik stop," the report said. "This indicates the pilots were aware of Change 2 before they departed for Zagreb. They also may have had the opportunity to secure mission planning information for Dubrovnik before they departed Ramstein AB on April 2, 1996," the report said.

The crew departed on another aircraft (flown by another flight crew) from Ramstein AB at 1232 and arrived in Zagreb at 1400. They arrived at approximately 1500 at the hotel where they would remain overnight. Their planned departure time was between 0330 and 0400 on the morning of April 3. At approximately 2200, the copilot called the operations center at Ramstein AB and asked for the latest mission change. "He was verbally briefed on Change 4 and was faxed a copy of Change 4; however, he received only the cover sheet," the report said.

Change 4 resulted in the following itinerary for the first day's mission: Zagreb to Tuzla, Bosnia; Tuzla to Split, Croatia; Split to Tuzla; Tuzla to Dubrovnik; and Dubrovnik to Zagreb (Figure 1, page 3). This change added Split to the itinerary, which was required because there was not enough ramp space at Tuzla for the accident aircraft to stay on the ground for the scheduled time of seven hours and 20 minutes. Thus, the crew would drop off their passengers in Tuzla, fly to Split and return later to pick up their passengers in Tuzla before continuing.

While the crew rested in Zagreb, their aircraft was en route from Cairo, Egypt. The pilot of the Cairo flight had received information on the latest change to the accident crew's mission, the report said. "The Cairo pilot performed some mission preparation for the next day's missions during this flight, because he knew the [accident] crew was already in crew rest," the report said. "He [the Cairo pilot] did not know whether they had already received Change 4 and believed he could help with the planning."

Itinerary for U.S. Air Force CT-43A, April 3, 1996



Source: U.S. Air Force

Figure 1

The report continued: "The Cairo pilot prepared flight plan information that included proposed routing for three of the five legs (including Tuzla to Dubrovnik). He also provided communications information … and removed the Dubrovnik approach procedure, published by Jeppesen Sanderson Inc., from the aircraft's publications kit. He planned to deliver these to the [accident] crew when he met with them in Zagreb."

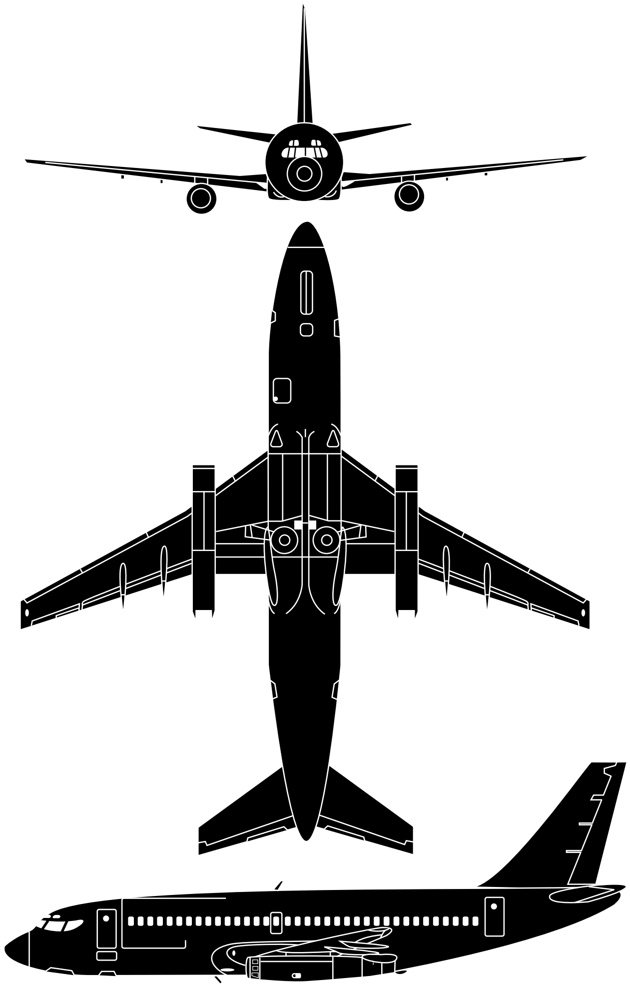
The accident aircraft arrived in Zagreb at 2320. The Cairo pilot went to the hotel where the accident crew was staying, arriving there between approximately 0030 and 0100 [April 3]. "He [the Cairo pilot] called the [accident] copilot's room to arrange for the delivery of the copilot's personal clothing items [which were stowed on board the aircraft from Cairo], as well as the mission change information, planning data and the Dubrovnik instrument-approach procedure," the report said.

The report noted: "The Cairo pilot testified that he believed the [accident] copilot was asleep when he called. After he called, the Cairo pilot delivered the information to the copilot's room. The Cairo pilot said the copilot was dressed in his jeans but looked as if he had just awoke. The Cairo pilot gave the copilot his clothing and the paperwork he had prepared, especially noting the unusually high weather requirements (4,800 meters [approximately three miles] visibility) for the approach to Dubrovnik."

The accident copilot told the Cairo pilot that "he had received a mission change by fax to the hotel earlier, but he had received only the fax cover sheet, with no attached information. They talked for about five minutes," the report said.

On April 3 (the day of the accident flight), the accident crew assembled in the hotel at approximately 0330, so that they could report to the aircraft at 0400. The crew contacted the operations center at Ramstein AB and was verbally given Change 4. "A fax containing this change was retransmitted to the hotel," the report said.

At 0403, a weather briefing was faxed from the Ramstein AB weather station to the hotel. "The weather briefing included Tuzla, Dubrovnik and Zagreb," the report said. "The forecast weather for Dubrovnik was: wind 140 degrees at 10 knots [18.5 kilometers per hour], unrestricted visibility, ceiling broken at 2,500 feet [762 meters] and broken at 8,000 feet [1.5 statute miles (SM)/2.4 kilometers], with temporary conditions of rain. It is not known if the crew received this weather briefing prior to departure from the hotel," the report said.



Boeing 737-100/200

The short-/medium-haul Boeing 737 first entered service in 1967. The 737-100 seated 115, which was increased to 130 with the introduction of the 737-200. The twin-turbofan 737 (U.S. Air Force designation T-43A), has a maximum takeoff weight of 52,390 kilograms (115,500 pounds) and a maximum cruising speed of 462 knots (856 kilometers per hour). It has a range of 1,855 nautical miles (2,136 miles/3,437 kilometers) with 115 passengers cruising at 33,000 feet (10,060 meters).

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

After the crew arrived at their aircraft, they contacted the U.S. Air Force Europe (USAFE) Meteorological Service (METRO) via high-frequency radio at 0440, the report said. They received a briefing on the weather for Tuzla (the first leg of their itinerary) and Zagreb (their alternate for the first leg).

Operating with a call sign of "IFO21," the accident aircraft departed Zagreb at 0624. "This was 24 minutes later than the planned departure, because the [Department of] Commerce party arrived late," the report said.

The 51-minute flight to Tuzla was uneventful, but "while flying the approach at Tuzla, the approach controller notified the crew that they were well left of the final-approach course," the report said. "The crew responded that they were correcting. After joining the final-approach course, the crew requested a 360-degree turn in order to 'lose a couple thousand feet,'" the report said.

The crew landed at Tuzla at 0715. The passengers deplaned, and the aircraft departed 37 minutes later, at 0752. The departure was 32 minutes behind schedule.

At 0832, the aircraft arrived at Split and the crew had the aircraft refueled. "They departed Split at 1156, four minutes ahead of schedule; however, the scheduled 40-minute return flight to Tuzla actually took 51 minutes," the report said. "The extra time was required because the crew flight-planned into Bosnia-Herzegovina through a closed corridor." The corridor that the crew was required to use added 90 NM (167 kilometers) to the flight.

At 1247, the aircraft landed at Tuzla, where the passengers reboarded. "The [Department of Commerce] added two Croatian nationals to the party, bringing the total passengers to 29," the report said.

The accident flight departed Tuzla for Dubrovnik at 1355. "After takeoff, the [accident] crew checked in with Tuzla Departure Control, who cleared them to flight level (FL) 160 (16,000 feet [4,880 meters]), following the filed standard instrument departure," the report said. "The crew also asked Tuzla departure for approval to turn left to avoid thunderstorms."

The report continued: "At 1402, radar service for IFO21 was terminated by Tuzla Departure Control, and IFO21 was instructed to contact Zagreb NATO [North Atlantic Treaty Organization] Air Traffic Control (ATC) and monitor MAGIC (the call-sign for a NATO E-3 Airborne Early Warning [AEW] aircraft). They checked in with Zagreb NATO ATC at 1406 and were cleared to FL 190 [19,000 feet (5,795 meters)], then to FL 250 [25,000 feet (7,625 meters)]."

IFO21 also established contact with the NATO E-3 AEW aircraft, the report said. Good radio communications and radar contact were established with the AEW aircraft (which was responsible for flight monitoring and threat warning in Croatia and Bosnia-Herzegovina airspace). "The responsibilities of NATO E-3 AEW aircraft do not include course correction when an aircraft is flying an approach to an airfield," the report said.

At 1404, IFO21 contacted the operations center at Ramstein AB. "[The accident crew] reported their takeoff time from Tuzla and asked if there were any mission changes beyond Change 4," the report said. "They were informed there were no additional mission changes and were cautioned about the possibility of fog at the Dubrovnik airport." The crew acknowledged the weather information and terminated the contact.

The accident crew then contacted USAFE METRO and requested the forecast at Dubrovnik for their planned arrival time of 1440. "USAFE METRO provided them with the following weather information: wind 110 degrees at 12 knots [22 kilometers per hour], ceiling at 500 feet [152 meters] broken, 2,000 feet [610 meters] overcast, 8,000 feet [2,440 meters] overcast, altimeter 29.85 inches of mercury, pressure altitude +609 feet [186 meters], temperature +[52 degrees F (11 degrees C)], [approximately five SM (8,000 meters)] visibility and rain," the report said. "IFO21 made a pilot weather report to the USAFE METRO, reporting overall cloudy conditions with little indication of thunderstorm activity."

As the aircraft flew through Bosnia-Herzegovina airspace en route to Croatia airspace, the AEW aircraft called the crew and advised that they were going out of the approved corridor. Under Bosnia-Herzegovina flight regulations, there were only three corridors that aircraft were permitted to use, and one of those — the BEAR corridor — was open only at specific times. The BEAR corridor, which the flight crew had selected as part of their route, was closed at the time of IFO21's flight. "The crew's original flight plan and their request for the [closed] corridor indicate they were unfamiliar with the corridor times of operation," the report said.

"The crew's original flight plan and their request for the [closed] corridor indicate they were unfamiliar with the corridor times of operation."

IFO21 asked Zagreb NATO ATC to provide a radar vector to the approved corridor. After receiving an initial vector, IFO21 resumed navigation along the approved corridor. "This unplanned routing added approximately 15 [minutes]–16 minutes to IFO21's flight time," the report said.

As the accident crew approached the Bosnia-Herzegovina border, "Zagreb NATO ATC transferred control of IFO21 to Croatian Zagreb Center civilian controllers (Zagreb Center)," the report said. Then IFO21 was cleared direct to the Split very high frequency omnidirectional radio range (VOR). "Zagreb Center cleared the [accident flight] to descend to [FL] 210 (21,000 feet [6,405 meters]), to be level 25 NM [46 kilometers] before Split," the report said.

IFO21 crossed Split at 1434 and was cleared to descend from FL 210 to FL 140 (14,000 feet [4,270 meters]). "[The accident crew] started a normal descent and received further descent clearance from FL 140 to FL 100 [10,000 feet (3,050 meters)] at 1439," the report said. "After the aircraft reached FL 100 at 1445, south of Split VOR, Zagreb Center transferred control to Dubrovnik Approach/Tower, a nonradar approach facility. The Dubrovnik Approach/Tower provides air traffic control services based on vertical, lateral or longitudinal separation, rather than radar monitoring," the report said.

IFO21 contacted Dubrovnik Approach/Tower at 1446 and was cleared direct to the Kolocep (KLP) NDB [15.9 kilometers (9.9 miles) from the Cavtat (CV) NDB, 11.8 NM from runway threshold]. After opposite-direction traffic had been cleared, IFO21 was cleared to descend to 5,000 feet (1,525 meters). The accident flight began a descent from 10,000 feet approximately 16 NM (30 kilometers) from KLP.

"Calculations from groundspeed data indicate the pilot flew approximately 224 [knots]–243 knots [414 kilometers per hour–450 kilometers per hour] indicated airspeed during this descent," the report said. "Although there are no flight manual performance charts that depict this specific descent speed, the charts for 250 knots [463 kilometers per hour] indicate this descent would take approximately 16 NM with idle power and landing gear up."

The report noted: "Engine anti-ice was 'on' at impact. When engine anti-ice is on, the operating manual requires an increased power setting. Use of speed brakes would offset the effect of the increased power setting. Landing gear down would have increased the rate of descent; however, the tracking data shows the aircraft descended in approximately the distance and time that would indicate the landing gear was up. The crew leveled the aircraft for about one minute, where the speed slowly decelerated, possibly indicating the power remained reduced in an attempt to slow the aircraft for [approach] configuration."

At 1452, the crew told Dubrovnik Approach/Tower that they were 16 NM from the airport. "They were cleared to descend to 4,000 feet [1,220 meters] and told to report crossing the KLP beacon," the report said. "They began the descent and descended through 4,100 feet [1,250 meters] as they crossed KLP. They were still [flying] too fast to fully configure with landing flaps before beginning the final approach, as required by Air Force directives," the report said.

At 1450, the pilot of a Croatian aircraft on the ground at Dubrovnik radioed the accident crew and asked the crew to contact him on a frequency of 123.47 megahertz (MHz). (This was a different frequency from the one being used for the approved tower communication.) The accident aircraft was equipped with two very high frequency (VHF) communication transceivers; therefore the crew could communicate with the pilot on the ground and simultaneously monitor the tower frequency.

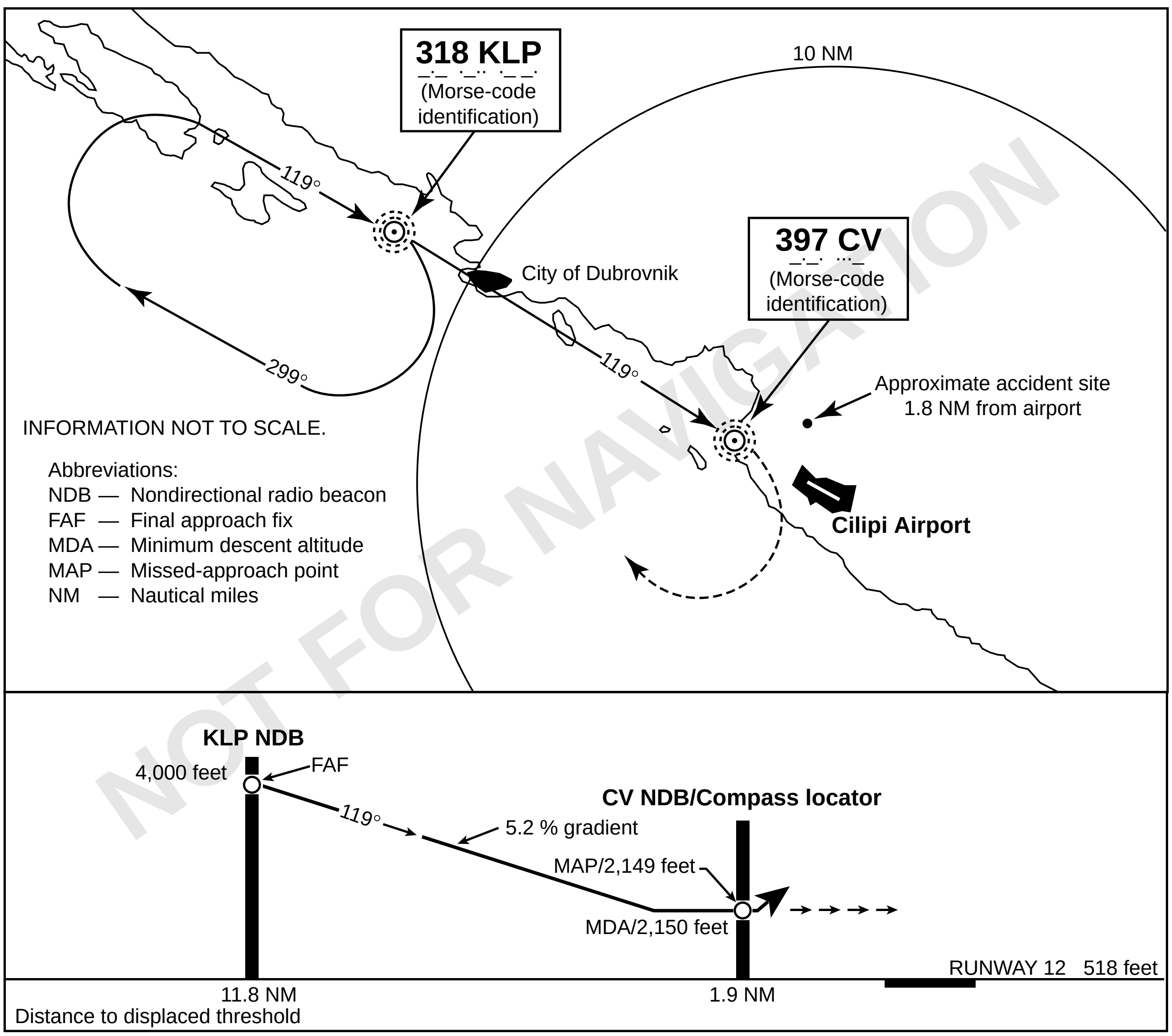
The pilot on the ground at Dubrovnik had landed one hour earlier with the U.S. Ambassador to Croatia and the Prime Minister of Croatia, who were awaiting the arrival of Secretary Brown. The pilot later testified that he told the accident crew that he had landed one hour earlier, and the weather was at the minimum required for the approach. "He [the pilot on the ground] also testified that he told the IFO21 pilot that if he had to execute a missed approach, he should proceed to Split," the report said. "The [Dubrovnik] pilot testified [that] he conversed with the IFO21 pilot for not more than 20 seconds. [He] also testified that IFO21 acknowledged the conversation."

The report added: "Other testimony indicated that [the Dubrovnik pilot] contacted IFO21 two times and told the [accident] crew about a circling procedure that [he] had used to land. This procedure was not published in the Jeppesen approach procedure." [Although a special circling procedure was not depicted on the Dubrovnik NDB Runway 12 approach chart, the Jeppesen chart package for Dubrovnik included a special circling procedure to Runway 30. This procedure had the same minimums as the NDB approach procedure. Minimums for the NDB Runway 12 approach were: minimum descent altitude 2,150 feet (656 meters) and visibility three SM (4.8 kilometers).]

Investigators could not determine whether the accident pilot or the flight mechanic answered the Dubrovnik pilot's call concerning the special circling procedure. "Testimony from the [Dubrovnik] pilot indicated that it was not the same voice that was making radio calls on the tower frequency," the report said. "Other testimony indicated that the mishap copilot was talking on the tower frequency."

At the time of the accident, the NDB approach to Runway 12 (Figure 2) was the only instrument-approach procedure

Illustration of NDB Approach to Runway 12, Cilipi Airport, Dubrovnik, Croatia



Source: Adapted from *Accident Investigation Board Report United States Air Force CT-43A 3 April 1996 Dubrovnik, Croatia.*

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Figure 2

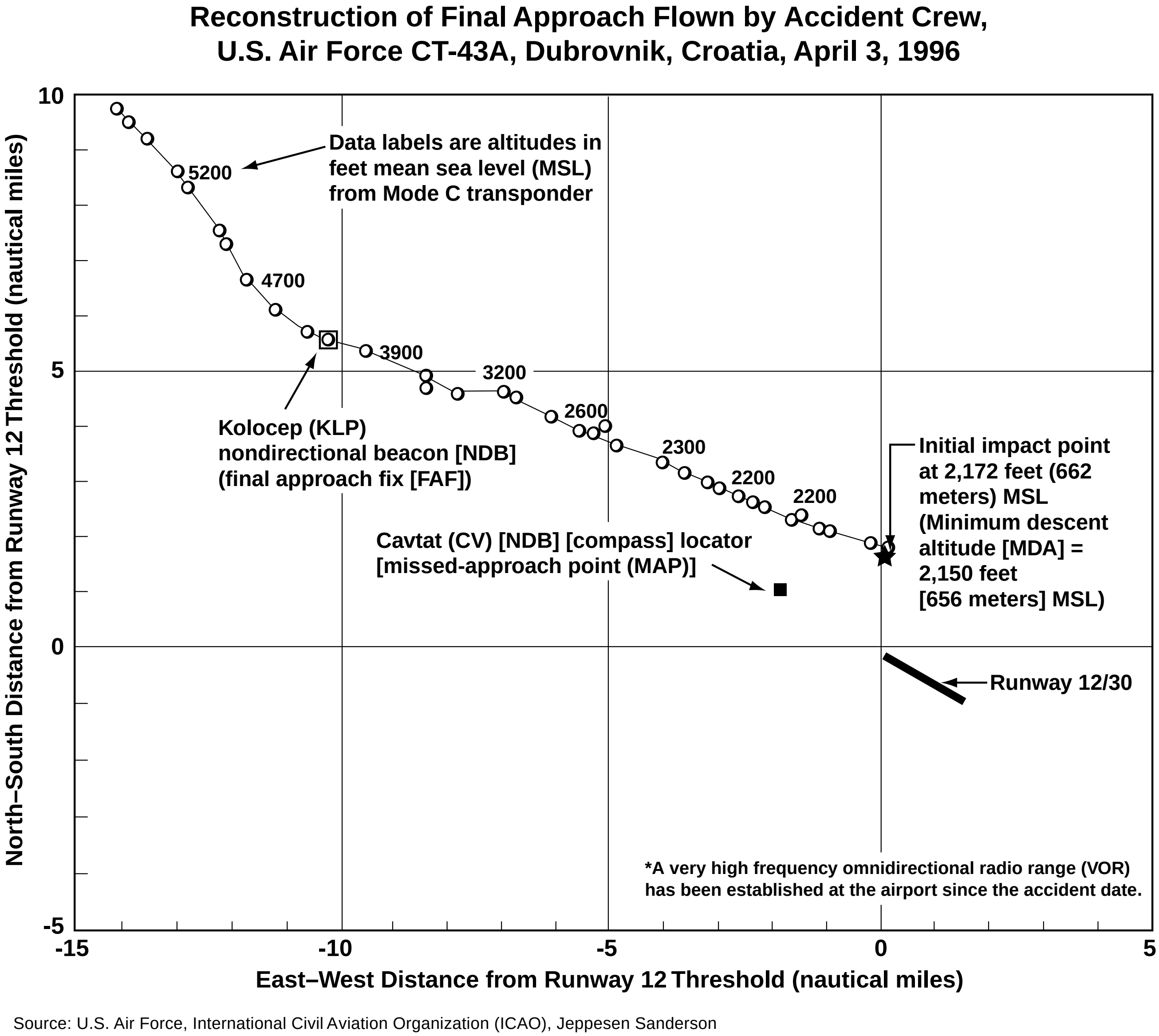


Figure 3

available at Dubrovnik. The approach uses the KLP NDB to fly the final-approach segment and the CV NDB to define the missed-approach point.

The report noted: "In order to fly the approach, the air crew must be able to maintain positive course guidance and determine the missed-approach point. For this approach, timing may not be used as the primary method to determine the missed-approach point, in accordance with the Jeppesen approach chart legend; however, timing is recommended as a backup in the event of problems with the primary method," the report said.

Because Dubrovnik Approach/Tower is a nonradar facility and because the accident aircraft was not equipped with a CVR or FDR, the final approach flown by the crew (Figure 3) was reconstructed using radar surveillance data from Zagreb Center and two NATO E-3 AEW aircraft.

Data indicate that, at 1453, the accident aircraft crossed KLP, the FAF, at 1,251 meters (4,100 feet) "and began the approach without approach clearance from Dubrovnik [Approach/] Tower," the report said. "A tower transmission to [the pilot on the ground] indicated [that] the tower controller expected IFO21 to hold at KLP. However, this transmission was in the Croatian language, and the crew would not have understood," the report said.

Just after IFO21 crossed KLP, another military aircraft asked Dubrovnik Approach/Tower for the current weather. "The weather reported to [the other aircraft] was: wind 120 degrees at 12 knots [22 kilometers per hour], visibility [5 SM (eight kilometers)], 492 feet [150 meters] broken, 1,969 feet [600 meters] overcast, altimeter setting 1010 millibars [29.83 inches of mercury], temperature [54 degrees F (12 degrees C)], dew point [52 degrees F (11 degrees C)],” the report said.

Tracking data from the NATO E-3 AEW aircraft “[indicate that] IFO21 crossed the [FAF] at approximately 210 knots [389 kilometers per hour] groundspeed,” the report said. “The Zagreb Center radar shows the aircraft crossing the FAF at 230 knots [426 kilometers per hour] groundspeed. Corrections for altitude and wind data (180 degrees at 30 knots [56 kilometers per hour]) result in an indicated airspeed of approximately 209 knots [387 kilometers per hour] based on the NATO E-3 [AEW] aircraft tracking data and 228 knots [422 kilometers per hour] based on the Zagreb radar data,” the report said.

The report noted: “The flight manual also requires an aircraft to be fully configured with landing gear down and landing flaps extended when crossing the [FAF].” Based on these indicated airspeeds and the maximum flap airspeeds found in the flight manual, the [accident] aircraft’s flaps were not set for landing and would have been between the zero and 10 flap setting (normal setting for landing is flaps at 30).”

At 1454, the copilot of IFO21 called Dubrovnik Approach/Tower and said, “We’re inside the locator, inbound,” the report said. IFO21 was then cleared for the approach.

Radar data indicate that IFO21 tracked a course of 110 degrees after crossing KLP, instead of tracking the published course of 119 degrees. The aircraft maintained this track from KLP to the point of impact.

Radar data indicate that IFO21 tracked a course of 110 degrees after crossing KLP, instead of tracking the published course of 119 degrees.

The accident aircraft descended to 2,200 feet (671 meters), “which is consistent with the published minimum descent altitude [MDA] of 2,150 feet [656 meters] on the Jeppesen approach procedure,” the report said. When the aircraft leveled at the MDA, it slowed to 140 knots [259 kilometers per hour] groundspeed, which was later calculated as an indicated airspeed of 150 knots [278 kilometers per hour]. Flight manual procedures called for the aircraft to be slowed to final-approach airspeed before crossing the FAF, the report said. “The final-approach target speed from the flight performance manual calculated for this approach is 133 knots [246 kilometers per hour],” the report said.

At 1457, “IFO21 impacted a rocky mountainside approximately 1.7 NM [3.1 kilometers] to the left (northeast) of the extended runway centerline and 1.8 NM [3.3 kilometers] north of the approach end of Runway 12 at Dubrovnik Airport,” the report said.

Four minutes after the accident, Dubrovnik Approach/Tower personnel made numerous radio calls in an attempt to locate the aircraft. “After receiving no response, they contacted Dubrovnik City Police, the Croatian Military and the Dubrovnik Port Authority,” the report said. “The tower gave general instructions asking for ships, boats and personnel to conduct the search. Because the approach is over water, this was where the search began.”

At 1520, Zagreb Center notified Zagreb NATO ATC that IFO21 was overdue. Ten minutes later, Zagreb NATO ATC notified the NATO Combined Air Operations Center (CAOC) in Vincenza, Italy, that IFO21 was probably lost in the Dubrovnik area. The CAOC asked several NATO aircraft in the area to attempt radio contact with IFO21. Those radio calls went unanswered.

At approximately 1600, the CAOC contacted a French military helicopter unit in Ploce, Croatia, which had the nearest available helicopters. “The CAOC requested the French helicopters prepare to launch and conduct a search of the area,” the report said. “The French commander called his headquarters at Mostar for permission, a process that normally takes two hours. For this [accident], approval took less than an hour. The Croatians did not have helicopters equipped for search-and-rescue (SAR) in the Dubrovnik area.”

The report added: “The local police at Cavtat, Croatia, began their search using two police patrols and one patrol boat. SAR forces searched in the area between the suspected crash site at Kolocep Island and the coast between the city of Dubrovnik and the airport. Zagreb Center notified Zagreb NATO ATC that an unidentified Croatian civilian source reported a possible aircraft accident on the southern tip of Lopud Island. This location was different, but it was only two NM [3.7 kilometers] from the original position of the suspected accident site. The [French] helicopter crews were advised of the updated location.”

At 1655, three French helicopters were airborne. When they arrived in the Dubrovnik area, “the initial search area was Kolocep Island, the location of the [KLP NDB],” the report said. “Although they searched the island, the helicopters were unable to reach the highest point, which was obscured by fog. Ceilings were 200 [feet]–300 feet [61 meters–91 meters]. Unable to see any wreckage in the vicinity of the island, the helicopters searched Lopud Island, two NM away, and the area between [KLP NDB] and the airfield,” the report said.

The helicopters then searched the area of the instrument approach to the airfield and the missed-approach route along the coast. “The mountains were obscured by a ceiling at 300 feet, making it impossible to search inland by helicopter,” the report said. “The French aircraft had the capability to detect emergency locator beacons, but never received any transmissions from the crash site."

As the French helicopters conducted their search, two U.S. military helicopters and an airborne tanker aircraft launched from Brindisi, Italy (about a one-hour flight from Dubrovnik). The U.S. helicopter crew had received information that the downed aircraft was a T-34 (a small single-engine U.S. Navy training aircraft). "As the helicopters crossed the Adriatic Sea, they still believed the aircraft was a T-34," the report said. "They learned [the downed aircraft] was a T-43 after they arrived in the search area."

The U.S. helicopter crews were not given any information about the downed aircraft's activities before the accident. "[One of the helicopter pilots] testified that it would have been helpful to have known the [downed] aircraft was on final approach to Dubrovnik," the report said. "Also, if they had known the aircraft was making an approach, they would have planned the search to start at the airport and expand to the last known position. The [U.S. helicopters] arrived off the coast of Dubrovnik at 1830," the report said.

The accident aircraft was equipped "with a crash position indicator (CPI) system [a radio beacon] that broadcasts on 243.0 MHz, with a range of approximately 80 NM [148 kilometers]," the report said. "The receiving aircraft must be within 50 NM [93 kilometers] to be able to determine the direction of the signal."

At 1920, five local police located the crash site and radioed police headquarters.

At 1735, a military aircraft that had been appointed to be the airborne mission commander received a weak signal on 243.0 MHz, without directional indication, and reported this to the CAOC. This same aircraft reported a stronger signal at 1755.

The two U.S. helicopters began searching the islands off the coast of Dubrovnik. One of the helicopters received a strong signal "because there were no terrain obstructions between [the helicopter's] location and the [accident] site," the report said.

The second helicopter received only a sporadic signal because of obstructions between the helicopter's location and the accident site. "Although both [helicopters] had direction-finding capability to locate the beacon, they were unable to fly toward the indicated beacon location, because the weather was too bad. The Dubrovnik Approach/Tower had a VHF radio only and was not equipped to receive a beacon broadcasting on UHF [ultra high frequency]," the report said.

At 1845, "the local police received a call that [a Croatian] civilian had seen the [accident] site and had identified the location on top of a mountain … ," the report said. The civilian had spotted the wreckage from his house at the base of the mountain where the accident occurred.

The civilian "had heard an explosion at 1500, but did not see the wreckage because of poor visibility, which he estimated at 33 feet [10 meters]," the report said. "He had heard the sound of an airplane and then an explosion, but [he] believed the explosion was probably a grenade or maybe [the noise of a flying NATO jet]. Because of the poor visibility, he was unable to see the wreckage until 1800. The [civilian] lived in a remote area and did not have a phone. He began a 30-minute drive on a narrow mountain road in the fog and rain to reach a phone," the report said.

At 1920, five local police located the accident site and radioed police headquarters. "Because it was dark and the terrain rough, it took an additional 15 [minutes] to 20 minutes to reach the site," the report said. "[The police] were the first ones on the scene. After they reached the area near the tail section, they found four bodies. The police began looking for survivors. The tail section was intact; the main part of the plane was so scattered and so burned that they believed there could be no survivors. Since they did not have any special equipment, they called the fire department and ambulance," the report said.

At 1948, the two U.S. military helicopters landed at Dubrovnik to refuel. "Weather was extremely bad with torrential rain, lightning and estimated 100-foot [31-meter] ceilings," the report said. After landing, one of the helicopter crews "recommended that the search be called off until the weather improved," the report said. "The [CAOC] did not agree and directed [that] the search would continue."

After the helicopters had been refueled, the coordinates of the accident site were given to the crews. "The two helicopters remained at the airport waiting for the clouds covering the mountains to lift; they faced torrential rain, lightning and very low ceilings," the report said. "As the ceiling would rise a few hundred feet, they could see blue lights flashing from the emergency vehicles at the base of the mountain, then the ceiling would drop again. The ceiling kept them from getting to the [accident] site," the report said.

Between 1950 and 2010, 90 additional police arrived at the crash site, set up security and continued looking for survivors. At 2030, "despite burning aircraft parts, smell of kerosene, poor weather and safety concerns, the Croatian police cleared a path to the main wreckage," the report said. "They saw two individuals in the tail section under debris. After they cleared the debris, an airport police officer checked their pulses and felt none. He testified that he was not well informed on how to do this [checking for a pulse]," the report said.

At 2130, "one of the individuals in the tail section made a breathing sound and had a weak pulse," the report said. "In consultation with a medical team down below the mountain, the police administered first aid; they placed a bandage on her [the survivor's] bleeding leg, turned her on her side to prevent choking, covered her and placed her on a stretcher. The police did not want to move her down the mountain, because the weather was so terrible, and they did not want to risk further injury on the steep path. They believed the best way to move her would be by air," the report said.

Between 2215 and 2230, the crew of one of the U.S. helicopters was told about the survivor. A Croatian major (whose affiliation was not further identified in the report) told the crew, "We have an American female; she has a broken spine, and she needs immediate medical attention," the report said. The major added, "We are afraid to touch her because we know she will die if we try to walk her off the mountain." The CAOC did not want the helicopter to depart until it was certain that the crew was not in any danger, the report said.

At 2236, "one [helicopter] launched with the Croatian major on board to attempt to reach the site," the report said. "The aircraft made multiple attempts to reach the site, but clouds and fog were still obscuring the area, making it impossible to get close enough to put the rescue team on the ground. Unable to reach the site, [the helicopter] returned to Dubrovnik Airport," the report said.

The U.S. helicopter pilot told the Croatian major that they would have to get the survivor off the mountain some other way. "The Croatians began to transport the survivor down the mountain," the report said. "There were no indications of life (no breathing) at this time. At the base of the mountain, the [survivor] was put in an ambulance and transported to Dubrovnik Hospital. At 2355, a Croatian emergency room physician from the Dubrovnik Hospital, who accompanied [the survivor] in the ambulance, pronounced her dead," the report said.

An autopsy performed by the U.S. Armed Forces Institute of Pathology revealed that "the cause of death for all but one of the [accident aircraft] passengers and crew was blunt force injuries," the report said.

At 0050, the U.S. helicopter crew made multiple unsuccessful attempts to reach the accident site. Finally, at 0145, the helicopter "got close enough to drop the three members of the Special Tactics Squad (STS) by rope near the site," the report said. "It took an additional 45 minutes for the STS team to hike to the site, where visibility was reported as less than 10 feet (three meters). The [team] spent the next several hours looking for survivors. There were none."

Other U.S. military personnel arrived at the base of the mountain via ground vehicles at 0400 and set up a communications link and base camp. "It took one hour and 15 minutes to walk from the base camp to the [accident] site," the report said. "Visibility was so bad that when [the soldiers] finally were able to see the aircraft tail, they were only [six meters (20 feet)] away."

At 0450, "the [search team] reported 20 bodies had been located and marked," the report said. "No ... survivors were found." It took less than 24 hours to recover the remains of the aircraft occupants and transport them to a field morgue set up at Dubrovnik Airport.

An autopsy performed by the U.S. Armed Forces Institute of Pathology revealed that "the cause of death for all but one of the [accident aircraft] passengers and crew was blunt force injuries," the report said. "One crew member died of thermal inhalation injuries." An autopsy performed on the cabin crew member who survived the accident but later died revealed that she "had extensive and multiple internal, spinal and extremity injuries," the report said. "Any one of several of these injuries could have been fatal, alone."

On April 5, the U.S. Air Force accident investigation team arrived at the accident site and began documenting the wreckage. It was determined that the aircraft "impacted with a groundspeed of approximately 138 knots [255 kilometers per hour]," the report said. "IFO21 was in a slight right bank (approximately 11 degrees), configured with flaps set at 30 and landing gear down. Exact aircraft pitch attitude could not be determined, but is estimated to have been near level flight. Flight control analysis of the elevators was inconclusive. Evidence indicates that the [accident] pilot hand-flew (autopilot disengaged) the approach to the impact point from the left seat," the report said.

When examining the wreckage, investigators found "all major structural components were located in a debris field approximately 219 meters (718 feet) long and 141 meters (463 feet) wide," the report said. "Ground and aerial compass readings indicated that the airplane's initial ground impact marks were oriented along a magnetic heading of approximately 120 degrees."

Investigators found parts of the fuselage "throughout the wreckage debris field, but most [of it] had been destroyed by fire," the report said. "Most of the cockpit structure was found near the middle of the debris field and had been destroyed or severely damaged by fire. A portion of the left fuselage/cockpit was found near this location and included the pilot's aft window frame … and the forward entry door. The door was in the closed position," the report said.

The empennage was located and found "upslope from the initial impact area and oriented on a heading of approximately 90 degrees," the report said. "It was upright but resting on its left side and the left horizontal-stabilizer tip due to the incline of the hill. This section [extended] from the forward break … (near the third fuselage window from the back) to the tailcone, which remained attached."

A 3.4-meter (11-foot) section of the left wing, beginning at the tip, was found beside the empennage. The inboard section of the wing, "approximately [9.2 meters (30 feet)] long was found adjacent to the similar right-wing section," the report said. "Except for the inner cylinder and wheels, most of the [left-main landing gear] remained attached to this left-wing section."

A 4.6-meter (15-foot) section of the right wing, beginning at the tip, "was found upslope from the initial impact area and right engine," the report said. "The wing section had been damaged by impact and fire. An inboard wing section approximately [9.2 meters] long was one of the last large pieces of wreckage in the debris field. Much of the lower skin had torn away, and a portion of the leading-edge flaps and slats, spoilers and aileron had burned away," the report said.

Examination of the wreckage revealed fire damage that was characteristic of postimpact fire. Fractured surfaces exhibited characteristics of overload that were consistent with high-energy impact with the ground. There was no preimpact failure or separation of the aircraft structure. Evidence of fatigue or corrosion that could have precipitated preimpact failure was not found on any major component."

An analysis of the crash forces determined that the accident was nonsurvivable. "Forensic analysis of injuries estimates the decelerative forces in the forward portion of the aircraft were approximately 100 [Gs]–150 Gs (one G is a unit measuring the inertial stress applied against a body by the force of Earth's gravity), and the decelerative forces in the tail section, experiencing the least amount of force, to be approximately 50 [Gs]–80 Gs, the upper limit of survivability," the report said.

The report noted: "There was no evidence of emergency egress or use of life support equipment; all injuries were fatal or incapacitating."

Investigators reviewed the history and maintenance records of the accident aircraft, which was one of two CT-43As in the U.S. Air Force inventory that were originally used for training navigators. In 1992, the accident aircraft was modified to carry 53 passengers and assigned to the 76 AS at Ramstein AB. "A crew of six normally operates the aircraft: two pilots, a flight mechanic and three in-flight passenger service specialists," the report said.

The accident aircraft "was a U.S. government aircraft operated as a public use aircraft and, therefore, was exempt from U.S. Federal Aviation Regulation[s], Part 121, *Certification and Operation: Domestic, Flag, Supplemental Air Carriers and Commercial Operators of Large Aircraft*," the report said. As a result, the accident aircraft was not required to be equipped with either a CVR or an FDR.

The report noted that if the accident aircraft had been equipped with a CVR and an FDR, "both may have enabled the investigators to more clearly identify crew actions during the final phases of flight," the report said.

When reviewing the maintenance records of the accident aircraft, investigators determined that "maintenance forms from March 29 [1996] to April 3, were on board the aircraft at the time of the [accident]," the report said. Some of the forms, severely burned and fragmented, were recovered from the wreckage.

Investigators found three fragments of maintenance write-ups on the accident aircraft. "On April 2, 1996, there was a notation of what appears to be static on the flight [mechanic's] interphone," the report said. "On April 3, 1996, there was a notation of what appears to be 'a [pitot] static light problem.' There was an additional maintenance notation for April 3, 1996, that was unreadable. In each of these three cases, the corrective action side of the [form] was destroyed or otherwise unreadable."

A review of other maintenance records on the accident aircraft for 12 months prior to the accident indicated no discrepancies related to the accident.

A review of other maintenance records on the accident aircraft for 12 months prior to the accident indicated no discrepancies related to the accident. "A thorough review of the spare-parts request report (a logbook for tracking parts) revealed no significant trends or recurring maintenance malfunctions for the [accident] aircraft," the report said. "The engine-condition monitoring program revealed no abnormalities in engine performance. Aircraft historical records indicated no recurring maintenance problems with engine, airframe or avionics systems."

The accident aircraft had been maintained by Boeing contractors based at Ramstein AB since 1992. "A review of personnel records revealed that all contractor personnel were U.S. Federal Aviation Administration (FAA)–certified airframe and powerplant technicians and were authorized to clear aircraft grounding discrepancies," the report said. "All initial and recurring training was current. Interviews with the [maintenance] manager and lead mechanic at Ramstein AB revealed a high level of attention to detail and sound maintenance practices."

The report noted: "The [accident] aircraft flew a total of 103.5 hours and 48 sorties with a 98.6 percent mission-capable rate since its last inspection. A review of unscheduled maintenance for February 1996 indicated the contractor replaced a pressure controller … and a vertical gyro … . The contractor reported seven discrepancies in March 1996, none of which showed any correlation to the [accident].”

Both engines from the accident aircraft were recovered and examined. “Engine analysis indicated both engines were running at similar speeds, significantly above idle,” the report said. “Analysis of the engine number one fuel-control unit indicates a high power setting was selected for the number one (left) engine.”

The report said that the damage to both engines “appears similar in magnitude between the two engines, indicating a proportionate level of rotor speed between the two engines. … There was no indication of preimpact malfunction. There were no indications of fire external to the engine or burn on any visible case. There were no indications of bird remains in the engines. Both engine thrust reversers were found in the stowed position, indicating they did not deploy in flight.”

The report noted that the high engine power at impact “might indicate one of three things: The crew may have been initiating a missed approach, the crew [may have been] responding to visual recognition of the terrain or the crew was responding to an aural signal from the ground-proximity warning system [GPWS],” the report said.

“A thorough review of the spare-part request and maintenance documentation revealed no discrepancies for the [GPWS] control display and receiver/transmitter from August 1992 to April 1996,” the report said. “The GPWS control panel and receiver/transmitter were sent to Rockwell Collins for teardown and analysis. These items were burned and damaged. Physical evidence provided no definite conclusions for the GPWS control display. The GPWS receiver/transmitter suffered extensive internal damage, prohibiting any functional testing of mechanical parts from which to derive data,” the report said.

An analysis was conducted to determine if the GPWS could have warned the accident crew about the terrain proximity. “The [accident] flight profile indicates a groundspeed of 140 knots [259 kilometers per hour] with the aircraft in level flight at an altitude of [668 meters (2,191 feet)] above the terrain,” the report said. “The relevant portion of the receiver/transmitter circuitry was simulated using a computer-based program … .”

The report concluded: “Analysis showed the warning profile was never penetrated — with the terrain profile, aircraft configuration and flight path as described, no warning from the GPWS would have been produced. This is consistent with the GPWS’s design.”

A review of the accident aircraft’s maintenance records for the 12 months preceding the accident flight revealed no discrepancies in the aircraft’s attitude heading reference system (AHRS). The AHRS provides continuous attitude (pitch and roll) and heading information for display on the:

- Pilot’s attitude direction indicator (ADI);
- Pilot’s horizontal situation indicator (HSI);
- Pilot’s radio magnetic indicator (RMI);

CT-43A Ground-proximity Warning System (GPWS) Warning Profiles Were Not Activated

Based on the flight path, terrain profile and the accident aircraft’s configuration and groundspeed, Rockwell-Collins engineers concluded that the none of the GPWS’s six warning profiles would have been activated. Following are the warning modes of the Rockwell-Collins model FPC-75 GPWS and conclusions about why each mode did not activate:

Mode 1. Excessive barometric altitude sink rate: No warning profile penetration because the aircraft was in level flight;

Mode 2A. Excessive closure rate with flaps not in landing configuration: No warning profile penetration because the flaps were in the landing configuration;

Mode 2B. Excessive closure rate, flaps in the landing configuration: No warning profile penetration because 2,000 feet [610 meters] per minute is the lowest closure rate warned by the device. The rate of increasing terrain was determined to be between 519 meters and 549 meters [1,700 feet and 1,800 feet] per minute, and never reached the 2,000-feet-per-minute warning limit;

Mode 3. Excessive barometric altitude sink rate or loss with flaps and gear not in the landing configuration: No warning profile penetration because the flaps and gear were in the landing configuration;

Mode 4. Insufficient height above terrain without flaps and gear in the landing configuration: No warning profile penetration because the flaps and gear were in the landing configuration; and,

Mode 5. Excessive below-glideslope deviation: No warning profile penetration because no glideslope signal was available.

“This was an unfortunate set of circumstances that defeated the design and utility of the GPWS,” said Roger Southgate, a Rockwell-Collins engineer who helped conduct the post-accident investigation of the GPWS. “GPWS does have the ability to provide valid and timely warning for terrain avoidance and clearance, but it is not a predictive device, it cannot see ahead of the aircraft.”♦

Photo: AP/Wide World Photos

U.S. Army investigators walk toward wreckage of rear fuselage and empennage of U.S. Air Force CT-43A that crashed on approach to Dubrovnik, Croatia.

- Pilot's bearing distance heading indicator (BDHI); and,
- Copilot's BDHI.

The cockpit instruments recovered from the wreckage had sustained severe fire damage. Nevertheless, investigators were able to determine the aircraft's heading, roll and bearing information from the recovered instrumentation. "Nothing was noted during analysis that indicated instrument or instrument system failure prior to impact or loss of input signal," the report said.

When examined, "the ADI indicated a right-wing bank of approximately five degrees," the report said. "The pilot's HSI and BDHI showed a course bearing between 115 degrees and 119 degrees. The RMI front glass, bezel, switch knobs, compass card and bearing pointers were missing. The teardown revealed the RMI needle was either 115 degrees or 295 degrees … ."

The report noted: "The mach/airspeed indicator, altimeters, radio altimeters and other instruments were severely damaged by impact and postimpact fire and provided no useful information. A complete teardown analysis of all recovered instruments was accomplished."

The accident aircraft was equipped with two inertial navigation systems (INSs) "that derived present position, groundspeed, heading and other flight parameters from display on two separate control/display units (CDUs) located in the pilot's forward control panel," the report said. "Operation of each INS is controlled by a mode selector unit and a CDU. Display of position and other flight parameters plus system operating status [are] displayed on the CDU," the report said.

Investigators recovered and examined both CDU and INS units. When the first CDU was examined, an analysis determined that "the display selector switch was set to the cross-track/track-angle error position and the automatic manual remote (AMR) switch was on the automatic (A) position," the report said. The second CDU was examined and "the display selector switch was set to the heading/drift-angle position and the AMR switch was set to the 'A' position."

The first INS unit was examined and declared completely destroyed. The second INS unit was examined and found to

A Primer: the Nondirectional Radio Beacon (NDB)

Two nondirectional radio beacons (NDBs) were the primary navigational aids (NAVAIDs) for the instrument-approach procedure to land on Runway 12 at Cilipi Airport, Dubrovnik, Croatia, the destination of the U.S. Air Force CT-43A accident airplane.

An NDB is a ground-based radio NAVAID that transmits radio frequency (rf) energy on the low-frequency (30 kilohertz [kHz]–300 kHz) or medium-frequency (300 kHz–3000 kHz) portions of the radio spectrum. (In the United States, NDBs operate on frequencies between 190 kHz and 535 kHz; in Europe, the frequency can be as high as 625 kHz).

Developed in the late 1920s, the NDB is one of the oldest NAVAIDs in use. Although modern NDBs are more technologically advanced than those of the 1920s, they all operate on the same basic principle: A transmitter converts electrical energy into rf energy and delivers the rf energy to an omnidirectional broadcasting antenna. A modern automatic direction finder (ADF) aircraft receiver determines the direction to the NDB and conveys that information by a pointer on the face of a round display instrument surrounded by an adjustable compass rose. (In the early days of NDB navigation, the pilot hand-cranked the aircraft's receiving antenna to determine the direction of the NDB in relation to the aircraft).

By following the direction of the needle, the pilot can fly the aircraft to a specific beacon, which is identified by a Morse-code identifier transmitted by the NDB. Nevertheless, the pilot usually must adjust the aircraft's heading to the NDB to compensate for the effects of wind, so that the most direct course is maintained. Otherwise, rather than following a direct course to the NDB, the aircraft's course can curve as the pilot "homes" on the NDB radio signal.

The NDB radio signal is also subject to interference created by weather conditions, the presence of other radio transmitters and by geographically induced phenomena associated with mountainous terrain or large expanses of water, all of which can produce erroneous needle indications.

An NDB can be an en route NAVAID, and by using a second NDB radio signal (or the signal from another radio NAVAID), the pilot can "fix" the aircraft's position in relation to the two signals.

A pilot can also fly an NDB instrument approach, which specifies various procedures, including altitudes, turns, radio frequencies and so forth, that the pilot must follow to land an aircraft in instrument meteorological conditions (IMC). The NDB approach does not provide precision vertical guidance for the descent or precision horizontal (lateral) guidance for runway alignment. Thus, situational awareness by the pilot is especially important in an NDB approach.

In elementary terms, the objective of an NDB instrument approach — as is that of other types of instrument approaches during conditions of restricted visibility — is to allow the pilot to descend the aircraft to the lowest possible safe altitude (which is determined by factors such as terrain and the type of instrument approach) so that the pilot has the best opportunity to visually identify the airport, continue the approach and land the aircraft. After descending to the lowest safe altitude (minimum descent altitude [MDA] on an NDB instrument approach), if the pilot does not visually identify the airport by the time the missed-approach point (MAP) is reached, then the pilot must follow specific procedures to abandon the approach. In the Dubrovnik accident, a second NDB identified the MAP. Where authorized in other NDB procedures, timing can be used to identify the MAP based on a specific groundspeed from the final approach fix to the MAP.

have been operating for one hour and 12 minutes before impact. The geographical coordinates stored in this unit at the time of power loss were recovered and indicated that "the inertial navigation equipment on the [accident] aircraft was performing satisfactorily and within specifications (maximum allowable drift of two NM [3.7 kilometers] per hour in the navigation mode) at the time of impact," the report said.

The accident aircraft was equipped with one low-frequency radio automatic direction finder (ADF) system. "Circuits in the [ADF] receiver determine the bearing of radio stations and transmit the information to the pilot's [RMI]," the report said. "The RMI is located on the pilot's forward instrument panel."

Investigators analyzed the ADF receiver to determine the frequency selected at the time of impact. "The tuning synchro, which is directly slaved from the ADF control panel, indicated a tuned frequency of 316 kilohertz [kHz]," the report said. "(KLP frequency is 318 kHz.) The output synchro to the pilot's RMI indicated the bearing needle was pointing at 174 degrees from the top of the case, i.e., six degrees right of the six o'clock position, confirming that the ADF was tuned to the KLP [NDB] at the time of impact," the report said. [The difference between 316 kHz and 318 kHz was not considered to have significantly affected reception of the KLP NDB for navigation purposes.]

The aircraft was also equipped with a compass adapter, which "receives digital inputs from the [AHRS] and the [INS] and converts them to analog outputs for the pilot's HSI, RMI, BDHI and the copilot's BDHI and autopilot," the report said. "Teardown inspection of the compass adapter indicated the aircraft heading was between 116.1 [degrees] and 116.4 degrees. These outputs correspond with RMI, HSI and BDHI teardown reports that suggested, from physical evidence, the heading at impact was between 115 [degrees] and 119 degrees."

A CPI was also installed on the aircraft. "The CPI system consists of a control panel on the cockpit forward overhead panel, four external sensing switches, a radio beacon dispenser located on the vertical tail section and an airfoil containing a radio beacon, batteries and transmitting antenna," the report said.

When investigators examined the CPI on the accident aircraft, they found that it had partially deployed. "It [the CPI] remained attached to the vertical portion of the tail during the accident," the report said.

The report noted: "The resulting location of the CPI after the accident placed it between a steep section of the mountain to the south and southwest and the vertical section of the aircraft tail to the north and northeast. This blocked the CPI signal in every direction except to the northwest and the southeast. An interview with the [SAR helicopter] pilot confirmed the CPI emitted a distress signal on the international emergency frequency."

Investigators also performed a teardown analysis of the CPI battery pack and found it in good condition. "The battery's power was depleted, indicating that it activated the airfoil release mechanism," the report said. "After charging the unit overnight, it was tested and passed all operational criteria."

The background and qualifications of the flight crew were reviewed. The accident pilot had 2,942 total flying hours, with 582 hours in the CT-43A. His flight times in the CT-43A during the 30-, 60- and 90-day periods prior to the accident flight were 37.0 hours, 77.5 hours and 87.6 hours, respectively.

The pilot completed his undergraduate pilot training instrument check in 1987. He then "upgraded from KC-135Q [the military tanker version of the Boeing 707] copilot through aircraft commander, instructor and evaluator pilot positions over the next six years," the report said. "The pilot had approximately 464 instructor hours and 36 evaluator hours in the KC-135."

The pilot received his initial T-43 qualification in 1994, and was assigned to the 76 AS at Ramstein AB. "The squadron commander in place at the time the pilot arrived at Ramstein [AB] in 1994 indicated the pilot did not display adequate procedural knowledge for upgrade to aircraft commander," the report said.

The squadron commander "did not upgrade the pilot during the eight months they were both assigned to the 76 AS. However, he [the squadron commander] did not document his concerns and did not note substandard performance in

Table 1
Nondirectional Radio Beacons (NDBs)
By World Region

Region	Number of NDBs*
Africa	1,821
Canada (including Alaska)	1,284
Eastern Europe	2,681
Europe	2,734
Latin America	268
Middle East	919
Pacific	634
South America	1,204
South Pacific	1,219
United States	3,738
Total	**16,502**

* Includes Terminal, Approach and En-route NDBs.
Source: Jeppesen Sanderson Inc.

Table 2
Nondirectional Radio Beacon (NDB)
Approaches, by World Region

Region	Number of NDB Approaches*
Africa	60
Canada	237
Eastern Europe	177
Europe	287
Latin America	54
Middle East	68
Pacific	71
South America	200
South Pacific	81
United States	1,578
Total	**2,813**

* Individual procedure
Source: Jeppesen Sanderson Inc.

NDBs are grouped by power-output range, with the power output determining the distance that the signal can be received reliably, ranging from less than 25 watts and 15 nautical miles (NM) for compass locators, to 2,000-watt, high-power transmitters that have service ranges of 75 NM.

Statistics supplied by Jeppesen Sanderson Inc., based on data in "NavDat," the company's electronic navigation data base, indicate that there are 16,502 NDBs (most are designated for en route navigation) located throughout the world, with 3,738 of them located in the United States. Some 2,813 individual NDB approach procedures are identified worldwide, with 1,578 of them located in the United States. In each category, data show the United States with the greatest numbers.

NDB statistics by world region are shown for NAVAIDs in Table 1 and for approaches in Table 2.

Many pilots do not fly NDB approaches frequently. As part of a 1995 study conducted by Earl L. Wiener, Ph.D., and Rebecca D. Chute, and sponsored by the U.S. National Aeronautics and Space Administration (NASA), 147 commercial transport pilots who were transitioning to the Boeing 757 airplane were asked to report the number of NDB approaches that they had conducted in the previous calendar year. Nearly 60 percent of the pilots who responded said that they had not flown an NDB approach within the previous calendar year. Of those who responded, only 10 percent had conducted six or more NDB approaches during that period.

Some airports use an NDB as the primary approach NAVAID or as a supplementary approach NAVAID because NDBs are less expensive to purchase and less difficult to maintain than precision landing systems. Charles Whitney, chief engineer of Southern Avionics Co., which manufactures NDBs, said that "NDBs are used for backup," in countries where instrument landing system (ILS) facilities are subject to frequent breakdowns or disruptions. He said that as much as 85 percent of the company's NDB products are exported to other countries from the company's plant in Beaumont, Texas, U.S.

An NDB system costs between US$20,000 and $40,000, depending on the transmitter's power output, in addition to installation costs, Whitney said.

An ILS is preferable to an NDB-based approach because, unlike the NBD, the ILS provides *precision* approach guidance. An ILS provides precise information about the aircraft's position in relation to the glideslope (vertical guidance) and the localizer (horizontal guidance), which are displayed as vertical and horizontal cross-bars on a single instrument display, respectively.

The pilot operates the flight controls to center the cross-bars. Undesired deviations are indicated by the localizer and glideslope crossbars and alert the pilot to make the appropriate corrections. Moreover, the aircraft's autopilot can be coupled to the aircraft's ILS receiver and other aircraft systems, so that the autopilot will fly most of the approach, and the pilot will land the aircraft. With additional equipment on the ground and on the aircraft, and the appropriate pilot training, a transport-category airplane can be landed automatically — without a pilot touching the controls.

An ILS usually permits the pilot to descend the aircraft to a lower — but still-safe — altitude than an NDB approach, thus providing a better opportunity to visually identify the runway in restricted-visibility conditions. The precise ILS guidance also reduces pilot workload during a critical and demanding phase of flight. The very high frequency of the radio spectrum used by the ILS is also less vulnerable to weather-related interference than the NDB, and careful design of each ILS aims to reduce the likelihood of problems caused by other rf interference and geographical influences. Nevertheless, despite the advantages of an ILS approach, an NDB approach is safe when performed properly.

A basic ILS — with a low-power glideslope and localizer — costs $65,000 to $70,000, in addition to installation costs, according to Rich Viets, manager of technical marketing at Wilcox Electric Inc., Kansas City, Missouri, U.S., which manufactures ILSs. Viets said that a much more advanced ILS system could cost between $500,000 and $1,000,000, excluding installation. — **Editorial Staff**

the pilot's performance reports. This squadron commander also selected the pilot for the 76 AS Pilot of the Quarter, and did not tell his replacement about his concerns," the report said.

The report noted: "A CT-43A instructor/evaluator pilot who flew with the [accident] pilot from the time the [accident] pilot arrived at the 76 AS until February 1996 noted no problems during the [accident] pilot's normal upgrade programs. He felt the [accident] pilot had consistently improved since his arrival at Ramstein [AB]."

In 1995, the pilot was upgraded to aircraft commander. He was granted a waiver in January 1996, "to upgrade to instructor with less than the required 100 hours minimum flying time as an aircraft commander," the report said. In February 1996, the pilot was granted a second waiver and was allowed to upgrade to evaluator pilot.

The pilot's training records were reviewed for proficiency at NDB approaches. During his initial qualification in 1994, he performed three NDB approaches satisfactorily. "At Ramstein, during both first pilot and instructor pilot upgrade training programs, the pilot flew [NDB] approaches to proficiency," the report said. "Additionally, [an NDB] instrument approach was evaluated during the pilot's first evaluation [in] October 1995."

The report concluded: "The pilot was fully qualified for the flying activities he was performing at the time of the [accident]."

The accident copilot had 2,835 total flying hours, with 1,676 hours in the CT-43A. His flight times in the 30-, 60- and 90-day periods prior to the accident were 20.4 hours, 57.2 hours and 70.7 hours, respectively. The copilot completed his undergraduate pilot training in 1989. In 1990, he completed qualification in the CT-43A "and upgraded to aircraft commander over the next two years," the report said.

In 1993, the copilot was qualified in the C-141B and flew 960 hours in that aircraft. "Following assignment to the 76 AS, the copilot completed a local first pilot requalification [in] 1995," the report said. "During the series of flights planned from April 3–5, 1996, the copilot was scheduled for a checkride to complete his upgrade to aircraft commander. However, his training records indicate he had not completed the 76 AS level 2 upgrade training book as required. The 76 AS training manager could not say whether this training had been completed but not documented," the report said.

The copilot's training records were reviewed for proficiency at NDB approaches. "[NDB] instrument-approach training was documented during requalification training flights [in 1995] in which [NDB] approaches were flown to proficiency," the report said. "The copilot was fully qualified for the flying activities he was conducting at the time of the [accident]."

The activities of the flight crew prior to the accident were reviewed. "Associates and immediate family members of the flight-deck crew did not indicate any unusual habits, behavior or stress," the report said. "Specifically, there were no known problems or peculiarities with diet, alcohol or medication use, sleep/wake cycle, change in usual physical activities, unusually stressful situations at home or work, indications of fatigue or unusual changes in moods."

A postmortem toxicology analysis of the crew was "negative for medications, illicit drugs or alcohol," the report said. "There were no significant pre-existing diseases in the air crew."

When investigators reviewed the rest periods for the crew, they found that "complete crew rest histories for the crew could not be determined," the report said. "Prior to departure from Ramstein AB, both pilots received their usual amount of sleep. The crew arrived in Zagreb (there are no time zone changes between Ramstein and Zagreb) via a … pre-positioning flight on April 2, 1996, at 1400 and entered crew rest. Afternoon and evening activities, as well as the times the crew went to sleep, are unknown," the report said.

"A postmortem toxicology analysis of the crew was "negative for medications, illicit drugs or alcohol."

The report noted: "However, according to testimony, when air crews on the road had a planned morning departure the next day, they would typically eat dinner and go to sleep about 2100 or 2200."

The copilot had two interruptions during his rest period. The first occurred when he called the Ramstein operations center for mission changes at 2200. "A second interruption occurred when, at the copilot's request, the Cairo flight pilot contacted the copilot between 0030 and 0200," the report said.

The report added: "There was no indication the pilot's crew rest was interrupted. Air crews would typically begin the next crew-duty day when they assembled at the hotel two and one-half hours prior to the planned takeoff. Therefore, for a planned takeoff of 0600, the [accident] crew would have begun the crew duty day at 0330, affording them an opportunity for at least 12 hours of crew rest."

The accident crew would have been limited to 18 hours from the scheduled crew reporting time to engine shutdown time. "At the time of the [accident], the crew was 11 hours and 27 minutes into their duty day based on a reporting time of 0330," the report said. "The total planned crew-duty time for the day was 13-1/2 hours (0330 show time at Zagreb to a planned 1700 landing at Zagreb)."

The weather conditions during the accident flight were reviewed. On the day of the flight, "a low-pressure system dominated the Mediterranean region," the report said. "The low pressure caused widespread cloudy conditions throughout the area with light rain, rain showers and very isolated thunderstorms. The European Meteorological Satellite … image … shows most of the former Yugoslavia under dense cloud cover. The image shows some enhanced cloud tops indicating thunderstorms."

The weather briefing faxed by the Ramstein AB weather station to the accident crew's hotel forecast overall cloudy skies for their entire route, "isolated thunderstorms with maximum tops of 35,000 feet [10,675 meters], moderate clear air turbulence from surface to 10,000 feet, light rime/mixed icing from 10,000 feet to 18,000 feet [5,490 meters] and occasional rain or snow showers," the report said.

The forecast for Dubrovnik for the accident crew's estimated time of arrival was: "forecast winds — 140 degrees at 10 knots [18.5 kilometers per hour]; visibility — unrestricted; sky condition — broken at 2,500 feet [762 meters] (ceiling) and broken at 8,000 feet [2,440 meters]; altimeter setting — 29.58 inches of mercury; pressure altitude of [+] 860 feet [262 meters]; temperature — [54 degrees F (12 degrees C)]; and temporary conditions of rain," the report said.

While en route to Dubrovnik, the accident crew transmitted a pilot report (PIREP) to USAFE METRO. "The PIREP coincides with all other data," the report said. "The crew reported conditions as overall cloudy and wet with little indication of thunderstorm activity. The IFO21 crew then asked if METRO expected any changes in the future weather. USAFE METRO reported little change expected."

Investigators reviewed thunderstorm activity that occurred during the accident flight. "Lightning stroke data from 1500 shows weak thunderstorm activity (two [strokes]–three strokes from 1430–1500) to the north and south of Dubrovnik," the report said. "This would be consistent with the reports of thunderstorms by some eyewitnesses. There were differing reports concerning wind, clouds, thunderstorm activity and the amount and intensity of rain. The reports range from a light rain to a storm locals called the worst in years."

The weather observations for Dubrovnik from 1200 to 1400 indicated that a rain shower had passed through the area with thunderstorm clouds. "The tower controller at Dubrovnik never saw lightning [or] heard thunder," the report said.

The official weather observation for Dubrovnik at the time of the accident was: "winds 120 degrees at 12 knots; visibility … of [five SM] with light rain; sky condition — 400 feet [122 meters] broken … overcast at 2,000 feet … ; temperature — [54 degrees F (12 degrees C)]; dew point temperature — [52 degrees F (11 degrees C)]; altimeter setting: 29.83 inches of mercury," the report said.

The weather deteriorated significantly in the hour following the accident, the report said. "At 1600, the Dubrovnik official observation was: Winds 120 degrees at 16 knots [30 kilometers per hour]; visibility [0.6 SM (1,000 meters)] with rain showers; sky condition 300 feet [91.5 meters] overcast. The conditions changed little over the next few hours," the report said.

Investigators also reviewed the upper-air wind data for the Dubrovnik area during the time of the accident flight. The wind data were based "on the Brindisi, Italy, upper-air sounding and interpretation of all available data," the report said. "The difference from Brindisi is due to the local effects of the mountains near Dubrovnik. Winds: 110 feet [33.5 meters] — 130 degrees at 13 knots [24 kilometers per hour]; 400 feet — 150 degrees at 21 knots [39 kilometers per hour]; 3,000 feet [915 meters] — 160 degrees at 25 knots [46 kilometers per hour]; 5,000 feet [1,525 meters] — 170 degrees at 24 knots [44 kilometers per hour]. There were no reports [or] indication of wind shear … ," the report said.

The accuracy of the navigational aids (NAVAIDs) used for the instrument-approach procedure at Dubrovnik was reviewed. Five days after the accident, U.S. Federal Aviation Administration (FAA) flight-check inspectors conducted a special flight inspection of both the KLP and CV radio beacons. Both NAVAIDs were found to be satisfactory.

The investigation also reviewed the possibility that the following types of electromagnetic environmental effects might have contributed to the accident: "High-intensity radiation fields (HIRF); lightning effects; coastal bending of the [KLP] 318 [kHz] or [CV] 397 [kHz] [NDB] signals; electromagnetic interference (EMI) sources; NDB signal reflection either by small-aperture reflectors or terrain; and mistakenly tuning to an NDB other than KLP or CV," the report said.

In reviewing the area for HIRF, investigators examined the possibility that high-power transmitters in the vicinity of the final-approach course interfered with the accident aircraft's avionics. "An examination of available information indicates that the most powerful emissions in the vicinity of Dubrovnik are associated with local television transmissions," the report said. "The emissions from these transmitters along the IFO21 flight path are present for all other aircraft approaching Runway 12 at Dubrovnik, and no HIRF problems have been reported."

The report noted: "No effects from the local radio frequency environment were observed during any of the flight tests at Dubrovnik. There are no indications that HIRF contributed to the IFO21 accident."

The possibility that lightning could have interfered with the accident aircraft's ADF receiver was examined. "Due to the straight flight path of IFO21 for the extended period of the final approach, an external short-term electrical disturbance, such as lightning, in the vicinity of the flight path of IFO21 would not explain the extended course variation," the report said.

Investigators examined the possibility that coastal bending could have affected the quality of the signals transmitted from both the KLP and CV radio beacons. "Ground waves from a transmitter that pass over sea water incur less loss than waves that pass over land areas," the report said. "As a result, in the vicinity of the transition region between land and water (at the coast line), the wave front will no longer be perpendicular to a line joining the transmitter and receiver, due to the increased loss over land. This phenomenon is termed coastal bending."

The report continued: "Coastal bending can manifest itself in the form of bearing error in an ADF system. This type of anomaly could exist near the accident area due to the location of the coastline of the Adriatic Sea. This anomaly was seen in a small needle shift crossing the [CV NDB]. However, propagation anomalies would not explain the specific straight route of flight taken by the crew of IFO21."

Possible sources of EMI from on board the accident aircraft were examined. "Emissions from portable electronic devices

"FSF CFIT Checklist"

Flight Safety Foundation (FSF) has designed a controlled-flight-into-terrain (CFIT) risk-assessment safety tool as part of its international program to reduce CFIT accidents. Listed below are some of the risk factors that were identified in the "FSF CFIT Checklist" (following page 25) that are applicable to the Dubrovnik accident:

- No radar coverage available for the approach;
- Airport located in or near mountainous terrain;
- Nondirectional radio beacon approach;
- Controllers and pilots speak different primary languages;
- Nonscheduled operation;
- Arrival airport in Eastern Europe; and,
- Instrument meteorological conditions during approach.♦

(PEDs), such as notebook computers, CD [compact disc] players, cellular telephones and hand-held computer games were considered as a possible on-board source of EMI," the report said. "At least one PED (a notebook computer) was found in the accident debris. Analysis, ground testing and flight testing indicated that PED emissions did not interfere with the CT-43A navigational aids."

EMI sources from outside the accident aircraft were considered. These EMI sources were "electrical disturbances associated with an electrical power plant near the accident site and signals from other [NDBs] either behind (up-range) IFO21 or in front (down-range) of IFO21," the report said. "Potential interference to the ADF receiver from three mechanisms [was] examined: corona discharge, power-line carrier signaling and reradiation of the NDB signal by the power lines. There is no indication that these phenomena affected the CT-43A navigational equipment. It was observed that the distances were too far, the frequencies too dissimilar or both. During flight tests, no [EMI] was observed."

The possibility that the CV NDB signal could have reflected off a microwave antenna near the accident site or off the mountain was examined. "In either case, the reflected signal would have been too weak in comparison to the signal received directly from CV to have contributed to the accident," the report said. "Flight tests supported this determination; no interference was observed."

Investigators also considered the possibility that the accident crew might have mistakenly tuned their only on-board ADF receiver to a frequency other than KLP or CV. "An examination of the frequencies of other [NDBs] in the area and their expected signal strength showed that several [were] capable of being received along the flight path of IFO21," the report said. "An examination of the aircraft's actual route of flight prior to KLP passage shows an obvious transition from navigation via the Split [VOR] to navigation via the KLP NDB shown by the right turn and radial flight to KLP, direct passage over KLP, followed by an outbound radial directly to the impact point."

The report concluded: "The route of flight taken and the condition of instruments examined after the accident indicated KLP was successfully tuned on the ADF."

The NDB approach flown by the accident crew was the only instrument-approach procedure available for Dubrovnik. "The Dubrovnik airport was formerly served by an instrument landing system (ILS) for precision approaches, a [VOR] for nonprecision approaches and a third NDB [in addition to KLP and CV]," the report said. "The Croatian authorities reported the VOR, ILS and one NDB were stolen or destroyed during the conflict period between 1992 and 1995. The stolen NDB was later replaced."

Investigators reviewed the instrument-approach chart used by the accident crew during its approach and the design of the instrument-approach procedure. "Jeppesen Sanderson Inc. publishes instrument-approach procedures from the host-nation procedures after reformatting and translating," the report said. "Jeppesen also adds terrain data, as necessary. However, they do not review or approve the adequacy, reliability, accuracy or safety of the procedures. The mountain struck by the aircraft was depicted on the approach procedure by Jeppesen Sanderson Inc."

The report described the approach procedure: "The instrument-approach procedure identifies the [KLP NDB] as the primary navigational aid for this approach. KLP defines the final-approach holding fix [FAF] and the final-approach course. The final-approach course is the 119-degree bearing (southeast) from KLP to the runway. … The missed-approach point for the Dubrovnik approach is defined by the [CV] locator. The missed-approach procedure requires an immediate right turn and a climb to 4,000 feet."

An aircraft must have two ADF receivers to fly the approach, the report said. "One ADF must be tuned to the [KLP NDB] to identify the [FAF] and provide continuous course guidance to the runway," the report said. "Simultaneously, another ADF must be tuned to the [CV] locator to identify the missed-approach point. With this configuration, the pilot can continuously monitor the final-approach course and also identify the location of the missed-approach point. The aircraft did not have the two ADF receivers required to fly the Dubrovnik approach in instrument conditions."

An aircraft must have two ADF receivers to fly the Dubrovnik approach.

The report noted: "The Jeppesen approach procedure for Dubrovnik does not specifically indicate what type of equipment is necessary to fly the entire procedure. However, [U.S.] Air Force pilots are responsible for recognizing the factors which go into an approach and determining if the aircraft is properly equipped. If the crew had accurately reviewed the approach procedure, they would have recognized that two ADF receivers were required."

Investigators were unable to determine how the accident crew had planned to identify the missed-approach point, but they believed the crew might have used timing as a back-up. The pilot's clock was recovered from the wreckage. "The minute recording hand and the sweep second hand … were stopped at five minutes and 50 seconds, indicating the pilot may have attempted to time to the missed-approach point," the report said.

The report noted that "the actual time from the [FAF] to the impact point was approximately four minutes, indicating the pilot started the clock before the [FAF]."

Investigators also reviewed the possibility that the crew could have used one of the two INS units to identify the missed-approach point. "The two INS selector switches were found in the heading/drift-angle and cross-track distance/track-angle error selections," the report said. "The information provided by the INS displays in these selections could not have been used to determine the missed-approach point."

In reviewing the design of the Dubrovnik NDB approach procedure, investigators found that the Republic of Croatia Air Traffic Services Authority used the International Civil Aviation Organization (ICAO) "Procedures for Air Navigation Services — Aircraft Operations (PANS-OPS)" criteria for constructing instrument-approach procedures, the report said.

The report concluded: "During review of the [NDB] approach to Runway 12 at Dubrovnik, a number of nonstandard applications of ICAO criteria were found. The host country misapplied missed-approach criteria in the development of the final-approach segment, failed to correctly identify the controlling obstacle and did not compute the correct [MDA]. The host country did not make adjustments to the required obstacle clearance for the excessive length of the final-approach segment and did not make the appropriate height adjustment to the [MDA]."

"Correct application of both the U.S. and [ICAO] standards would result in a higher [MDA] than published by the host nation … . "

The chart for the NDB approach to Runway 12 at Dubrovnik depicts the KLP NDB as the primary NAVAID on which the approach is based and from which the final-approach course guidance is provided. "However, based on testimony, the host-nation specialist who developed the approach intended for the pilot to receive final-approach guidance from the [CV] locator," the report said.

The report noted: "The depiction also required a note on the depiction, 'timing not authorized for defining the missed-approach point,' when timing is not authorized. The warning is not indicated on the procedure; however, the Jeppesen legend clearly states that if no timing block is published, timing is not authorized."

Using ICAO criteria, investigators computed the MDA, first using KLP as the primary NAVAID for the approach then using CV as the primary NAVAID for the approach. The MDA computed using KLP as the primary NAVAID was 860 meters (2,822 feet) and the MDA computed using CV as the primary NAVAID was 790 meters (2,592 feet) (Figure 4, page 21). "Other computations provided by the [FAA using U.S. criteria] were slightly lower, but were well above [701 meters (2,300 feet)]," the report said. "No correct computation using ICAO criteria was found that duplicated the host nation–published MDA."

The report concluded: "Correct application of both the U.S. and [ICAO] standards would result in a higher [MDA] than published by the host nation … . If the flight had used this higher minimum altitude, it would have been above the high terrain [rather than] where it impacted."

Investigators reviewed U.S. Air Force Instruction (AFI) 11-206 regarding the use of instrument-approach procedures. AFI 11-206 requires that "any instrument-approach procedure not published in a U.S. Department of Defense (DOD) or [U.S.] National Oceanic and Atmospheric Administration (NOAA) flight information publication be reviewed by the major command terminal instrument procedures (TERPs) specialist before it can be flown by [U.S.] Air Force crews," the report said.

There is an exception within the AFI that allows U.S. Air Force crews to use a non-DOD/NOAA approach chart if the weather conditions meet the minimums required to conduct a visual flight rules (VFR) approach and landing. "The [U.S.] Air Force makes this distinction, because procedures from another source may not meet [U.S.] Air Force criteria," the report said. "Additionally, the [U.S.] Air Force cannot ensure [that] the navigational aids (e.g., [NDB] or [ILS]) supporting the procedures are regularly inspected for accuracy or that obstacle data used for the procedure [are] accurate and complete."

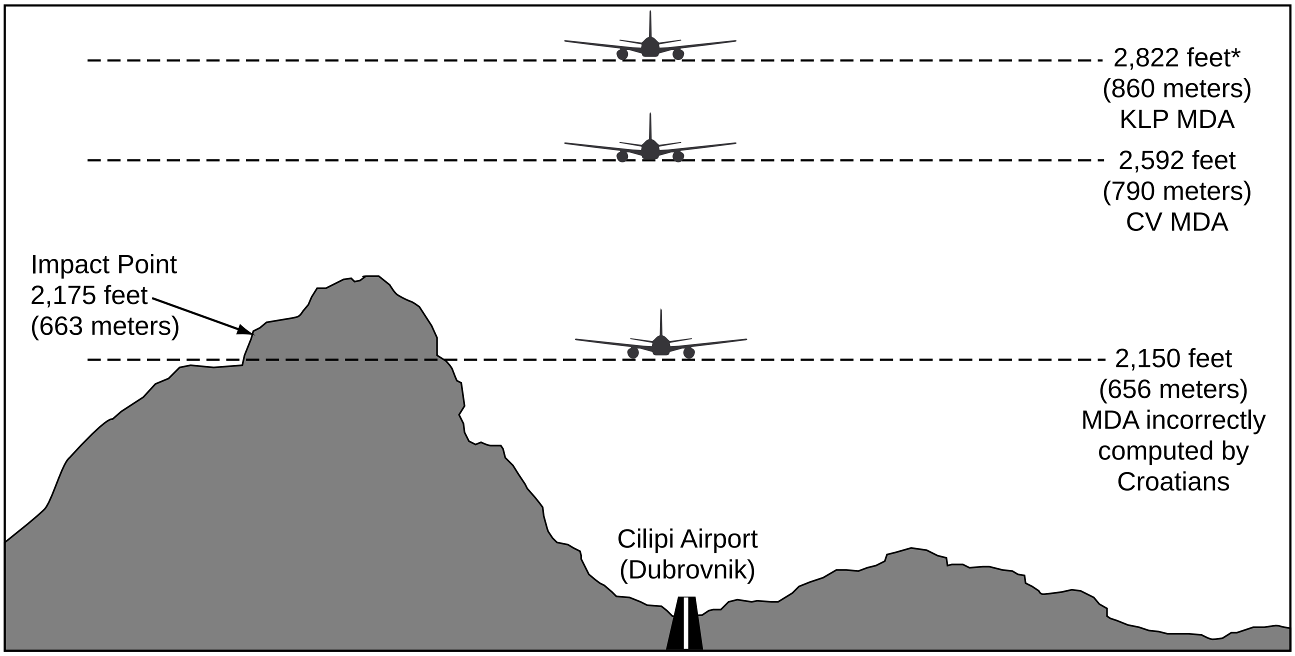
The report noted: "In a TERPs review, a TERPs specialist examines the procedure to determine whether it meets [U.S.] Air Force criteria. The specialist also reviews obstacle data and navigational aid information to ensure the procedure is safe. The USAFE TERPs chief testified it takes six hours or longer to complete a TERPs review."

Because Jeppesen published the only approach charts for Dubrovnik, the crew should not have flown the NDB approach in other-than-VFR conditions until the approach procedure had been reviewed by a USAFE TERPs specialist, the report said.

During the investigation, investigators reviewed [a U.S.] Air Force regulation that conflicted with AFI 11-206 and authorized the use of Jeppesen approach charts without restriction and without a TERPs review. "This conflicting guidance on the use of Jeppesen approach procedures caused confusion among the USAFE staff and 86 AW air crew members," the report said.

In 1995, a supplement to AFI 11-206 was issued by USAFE that allowed non-DOD approach charts to be used without a TERPs review if the weather was better than a 1,500-foot (457-meter) ceiling and 3.1-SM (5,000-meter) visibility, the report said.

Minimum Descent Altitudes (MDAs) Based on ICAO Criteria



* KLP and CV MDAs correctly computed by accident investigators using International Civil Aviation Organization (ICAO) criteria. [Editorial note: KLP and CV are nondirectional radio beacons (NDBs).]

Source: U.S. Air Force, International Civil Aviation Organization

Figure 4

When AFI 11-206 and the USAFE supplement were released, "the 86 OG commander realized the adverse impact these restrictions would have on the 86 AW's mission," the report said. "The 86 AW lands at many airfields where the only published approach is a Jeppesen [approach chart]; they could no longer land at these airfields unless the weather was 1,500 feet and 5,000 meters, because none of these procedures had been reviewed by a TERPs specialist."

The 86 OG commander sent an electronic-mail (e-mail) message to the USAFE director of operations "identifying the difficulty in meeting this requirement and its impact on the 86 AW's mission," the report said. "[The 86 OG commander] requested a blanket waiver to allow the 86 AW to fly Jeppesen approaches to the published weather minimums without TERPs review — contrary to both the USAFE supplement and AFI criteria."

A USAFE action officer contacted the Air Force Flight Standards Agency (AFFSA) to request a waiver to AFI 11-206. "The action officer testified that he believed he had obtained a verbal waiver for flying Jeppesen approaches without review from AFFSA during this conversation," the report said. "The AFFSA action officer testified that no such waiver was requested by or granted to USAFE. Additionally, testimony from branch chiefs and the director of operations at AFFSA indicated that such waivers are only provided in writing and are formally recorded. According to these witnesses, giving a 'verbal' waiver for an AFI does not follow any standard agency operating practice."

After the telephone conversation, "the USAFE action officer sent an e-mail to his supervisor indicating he had obtained a verbal waiver from AFFSA," the report said. As a result, a flight crew information notice (which informs flight crews of special flying requirements) was issued to all 86 OG flight crews stating that a verbal waiver from AFFSA had been received, "allowing air crews to fly Jeppesen approaches without complying with AFI 11-206 requirement for TERPs review or the USAFE Supplement 1,500-foot ceiling and [1,525-foot (5,000-meter)] visibility weather restriction," the report said.

In January 1996, an e-mail message was sent from U.S. Air Force headquarters (HQ Air Force) to the USAFE director of operations that disapproved the waiver to fly Jeppesen approaches to published minimums without a TERPs review, the report said. A portion of the message stated: "AFI 11-206 guidance on the use of Jeppesen products is sound," the report said. "Jeppesen is essentially a 'publishing house' for instrument-approach procedures — they do not guarantee the safety and/or accuracy of their product. In fact, Jeppesen publishes a disclaimer specifically stating they do not review or approve the adequacy, reliability, accuracy or safety of the approach procedures they publish."

"Proper approach development is one factor air crews 'take for granted' every time they fly an instrument approach. When planning an approach, our aviators assume if they fly the procedure as depicted, they will have adequate obstacle/terrain clearance. The requirements outlined in [AFI] 11-206 will help us maintain that high level of confidence — we should keep them as they are."

As a result of this message, the USAFE director of operations staff told the 86 OG commander that "86 AW air crews will have no authorized Jeppesen approaches to fly," the report said. The 86 OG commander then requested that his squadron commanders "forward names of airfields that required Jeppesen approaches so they could receive a review at USAFE TERPs within the Air Operations Squadron," the report said. The 86 OG commander concluded his request with the following: "My view on this: Safety is not compromised if we continue flying ops [operations] normal until approaches have been reviewed — then we rescind [the waiver to AFI 11-206]."

After receiving this message, the 86 AW commander sent the following message back to the 86 OG commander with copies to the squadron commanders: "[86 OG commander], come see me ref [reference] this. … let's step back and use common sense. … these approaches have been used for years and years … what do we have to do to get this ok'd? … safety first … thanks," the report said.

The 86 OG commander discussed the continued use of Jeppesen approaches during a staff meeting. "The consensus from the squadron commanders and [the 86 OG commander's] chief of standardization and evaluation was that safety was not compromised, and Jeppesen approaches could be continued to be flown pending TERPs review," the report said. "The 86 AW safety officer was also present during this discussion; no one at the staff meeting voiced any objections or raised any safety concerns."

The report noted: "The 86 OG commander then elected to fly 'ops normal' and did not rescind [the waiver to AFI 11-206] [which] continued to authorize 86 AW air crews' unrestricted use of Jeppesen approaches down to published weather minimums. He understood at the time that the 86 AW was not following the letter of the [AFI]. … The 86 OG commander believed that the entire chain of command knew of this action and was not directing him to act otherwise."

The report also noted that "with the extremely high operations tempo [of the 86 AW], the Jeppesen approach issue was pushed to a lower priority and 'dropped off [86 AW's] radar scope.'"

In February 1996, "a representative from 17 AF [Air Force] Standardization and Evaluation learned that the 86 AW was still flying Jeppesen approaches to published weather minimums in violation of [previous requirements]," the report said. "[The representative] then called the 86 OG chief of standardization and evaluation and told him the 86 AW had to rescind [the waiver to AFI 11-206] and stop using Jeppesen approaches until reviewed."

The report concluded: "The 86 OG chief of standardization and evaluation did not ensure these actions were taken. The 17 AF standardization and evaluation officer did not later ensure compliance, nor did he inform 17 AF senior officials."

Investigators discovered that there were four conflicting directives regarding the use of Jeppesen approaches and weather minimums (Table 1) at the time of the accident, the report said. AFI 11-206 required that the accident crew be able to fly the approach and land in VFR conditions. The Dubrovnik weather did not meet requirements for VFR operations during the accident crew's approach.

Table 1
Comparison of Applicable Weather Minimums

U.S. Air Force Applicable Directives	Weather Minimums for Dubrovnik NDB Runway 12	Did Dubrovnik Weather Meet Minimums?
AFI 11-206, paragraph 8.4.2	Visual conditions at KLP	No
AFI 11-206, USAFE Supp 1, paragraph 8.4.2	1,500-foot [458-meter] ceiling and 5,000-meter [3.1-SM] visibility	No
MCR 55-121, paragraph 6.74.5.1	4,800-meter (three-SM) visibility	Yes
86 OG FCIF 95-20	4,800-meter (three-SM) visibility	Yes

NDB — Nondirectional radio beacon
USAFE — U.S. Air Force Europe
86 OG — 86th Operations Group
FCIF — Flight Crew Information File
AFI — Air Force Instruction
MCR — Multi-command Regulation
KLP — Kolocep NDB
SM — statute mile

Source: U.S. Air Force

The USAFE Supplement to AFI 11-206 required U.S. Air Force crews to have at least a 1,500-foot ceiling and 1,525-foot visibility to fly the approach at Dubrovnik. The weather at Dubrovnik was below these minimums during the accident crew's approach.

A U.S. Air Force regulation, Multi-Command Regulation (MCR) 55-121, and the 86 OG waiver to AFI 11-206, Flight Crew Information File (FCIF) 95-20, required the accident crew to have at least [three-SM (4,800-meter)] visibility to fly the approach at Dubrovnik. At the time of the accident crew's approach, visibility at Dubrovnik was better than three SM.

The report noted: "The AFI 11-206 restriction … is the only valid requirement, because it is published at the highest level ([U.S.] Air Force) and is the most restrictive provision."

The waiver to AFI 11-206 was rescinded on April 4, 1996, the day after the accident. "From January–April 1996, 86 AW missions used Jeppesen approaches without restriction, in violation of AFI 11-206 and contrary to the [January 1996] message from HQ Air Force," the report said.

The investigation also revealed that the USAFE operations staff had not implemented a "cockpit/crew resource management (CRM) program" that was required by an AFI, the report said. "The 76 AS had recently developed a squadron CRM program that the [accident] pilots had not yet attended. Tenets taught in the resource management program are designed to help crews avoid mishaps like the one experienced by IFO21 by improving skills for managing workload, air crew decision making and enhanced situational awareness," the report said.

Investigators reviewed the qualifications of personnel and supervision within 86 AW. "The 86 AW commander had not flown the CT-43A in his 10 months of command prior to the accident," the report said. "The 86 OG commander assumed command in 1995. He had flown the CT-43A once in his year of command prior to the accident. The 86 OG commander had previous experience flying [Lockheed Martin] C/EC-130s. Just prior to assuming command of the 86 OG, he commanded a T-1 specialized undergraduate pilot training squadron from 1993 to 1995."

The report added: "Both the 86 AW commander and the 17 AF director of operations testified that, in their opinion, the 86 OG commander did not have enough experience to command the 86 OG."

The 76th Airlift Squadron is part of the 86th Airlift Wing. "The 86 AW commander, vice commander and operations group commander receive daily schedules and updates for 76 AS missions; however, these agencies exercise no operational control over these sorties," the report said.

Investigators reviewed the number of operations flown by the 76 AS. "The busiest months were February and March 1996, when the air crews flew 84 sorties in a 60-day period," the report said. "This usage rate can be compared to the two-month period from October to November 1995, when only 46 sorties were flown. During the 10-day period from March 27 to April 5, 1996, the CT-43A was scheduled to fly all eight days, all supporting high-level distinguished visitors (DVs), including the First Lady [wife of the U.S. President] (DV-1), the secretary of defense (DV-2) and the secretary of commerce (DV-2)," the report said.

The report noted: "The 76 AS commander, the former commander, the operations officer and the assistant operations officer all are very experienced in DV airlift operations."

The oversight of 76 AS missions was examined. "After the mission is assigned to an air crew, actual supervisory oversight by the European Operations Center (EOC) is limited to flight following and message exchange, unless the air crew specifically requests assistance," the report said.

Investigators found that squadron supervision had intervened "on at least two occasions to assist air crews flying DV missions," the report said. On one mission, "a squadron supervisor intervened to determine the suitability of an airfield that was not listed in the European airport directory. During another mission, a [U.S.] Congressman insisted on takeoff when weather conditions were unsuitable for landing at the destination, and the squadron commander intervened on behalf of the crew, resulting in a flight delay."

The investigation reviewed the possibility of external pressures on the accident crew to fly the mission as planned. Investigators found that "external pressures to successfully fly the planned mission were present, but testimony revealed [that the accident crew] would have been resistant to this pressure and would not have allowed it to push them beyond what they believed to be safe limits," the report said. "Specifically, the [accident] crew would not have begun the approach into Dubrovnik unless they thought they had the proper minimums for weather and had the required aircraft instrumentation."

"For the [accident] flight, it is unknown what pressures may have been generated by the [Department of] Commerce party."

The report continued: "The 76 AS former commander stated that both the [accident] pilot and copilot had occasions within the last few months where they were required to say no to a DV request. In fact, the [accident] pilot transported the presidents of Croatia, Serbia and Bosnia-Herzegovina after the signing of the Dayton Peace Accord and initially could not land at Sarajevo as planned. The [accident] pilot told the presidents they could not land."

The report added: "For the [accident] flight, it is unknown what pressures may have been generated by the [Department of] Commerce party. On two previous occasions, the secretary of commerce flew with the 76 AS. On the most recent occasion, April 2, 1996, the 76 AS pilot indicated there were no problems; this flight was completed without disruptions to the schedule. In 1993, the secretary of commerce flew with the 76 AS on a C-20 [Gulfstream III] from Ramstein to Saudi Arabia. On this occasion, scheduling difficulties were encountered, and a member of the [Department of] Commerce party attempted to pressure the pilots."

Investigators also found that the four changes to the mission itinerary contributed to the possibility of inadequate mission planning, the report said.

The accident crew were described as "the two best pilots in the flight," the report said. Nevertheless, on the day of the accident, "the crew demonstrated several behaviors uncharacteristic of the normal professionalism then attributed to these pilots, behaviors indicative of a reduced capacity to cope with the normal demands of the mission," the report said.

The report noted that these errors included "misplanning the flight plan from Tuzla to Dubrovnik; flying outside the protected corridor outbound from Tuzla; excessive speed and not having the aircraft configured by the [FAF] at KLP; and beginning the approach from KLP to Dubrovnik without formal approval from the tower and without a way to identify the missed-approach point."

Investigators reviewed factors that would have distracted the crew during the accident flight. "During the flight from Tuzla to Dubrovnik, the crew's misplanning of the route caused a 15-minute delay in the planned arrival time," the report said. "Pressure may have begun to mount for the crew to make the scheduled landing time, especially because responsibility for the delay now rested with the crew."

There were two additional distractions as the accident flight neared the FAF: "A delay in clearance to descend from 10,000 feet and external communication with [the pilot of the aircraft on the ground at Dubrovnik]," the report said. "The crew did not have the aircraft properly configured by the [FAF]. This indicated a disruption of normal crew habit patterns, which may have further rushed other crew actions."

The report noted: "Instead of gaining additional time to slow down the apparent rush of events, by entering into a holding pattern at KLP, the crew pressed on. The crew steadily flew approximately nine degrees to the left of the required course. During this time, the crew could have been further distracted by trying to identify the missed-approach point. This would have consumed additional attentional resources, raised the workload and increased the likelihood of channelized attention and the resulting loss of situational awareness."

"Instead of gaining additional time to slow down the apparent rush of events, by entering into a holding pattern at KLP, the crew pressed on."

Investigators reviewed the passenger manifest for the accident flight and the process by which the manifest was established. "Interviews with members of the 76 AS indicate an extensive lack of understanding as to how the passenger manifest is completed and tracked," the report said. "On the day of the [accident], the flight plan annotation indicated the passenger manifest was located at USAFE EOC, [but] the actual passenger manifest for the accident aircraft was not available at the EOC."

The report noted: "An actual passenger manifest could not be located and a passenger list had to be constructed by the U.S. Embassy at Zagreb following the [accident]. This is contrary to the governing guidance in AFI 11-206, which requires the filing of a passenger manifest with the flight plan or at least a reference to where such a document can be found."

Investigators reviewed the utilization and qualification of the CT-43A flight mechanic program. "Former squadron supervisors indicated that the CT-43A flight mechanic program in the 76 AS grew from a flying crew chief program, and was progressing into what was beginning to resemble a flight engineer program," the report said. "The flight manual states the forward crew [pilots] normally accomplish in-flight checklists, [but] the CT-43A flight mechanics would not only read checklists in flight, but also change switch positions during emergency situations."

The report noted: "The one remaining CT-43A flight mechanic felt he was not well trained and that he relied mostly on his on-the-job training. The flight mechanic's formal training is based upon his duties as a maintenance crew chief."

As a result of its investigation, the U.S. Air Force Accident Investigation Board concluded that the following areas did not substantially contribute to the accident: "Aircraft maintenance, aircraft structures and systems, crew qualifications, navigational aids and facilities, and medical qualifications," the report said. "Although the weather at the time of the [accident] required the air crew to fly an instrument approach, the weather was not a substantially contributing factor to this [accident]."

The report concluded that the accident was caused by "a failure of command, air crew error and an improperly designed instrument-approach procedure," the report said. In reviewing the failure of command, the report concluded that "command failed to comply with AFI 11-206. Commanders failed to comply with governing directives from higher authorities. [AFI] 11-206 required major commands to review non-DOD approach procedures prior to their being flown."

The report added: "The approach flown by the [accident] crew had not been reviewed by the major command and, in accordance with AFI 11-206, should not have been flown."

The report also faulted U.S. Air Force command for failing "to provide adequate theater-specific training," the report said. "This was a substantially contributing factor in the [accident]. Knowing operational support airlift crews in Europe were routinely flying into airfields using non-DOD–published instrument-approach procedures, commanders did not provide adequate theater-specific training on these instrument-approach procedures," the report said.

The report concluded: "Pilots with a thorough understanding of these non-DOD instrument-approach procedures would have identified the requirement to have two [ADFs] to fly the

[NDB] approach into Dubrovnik — one for final-approach guidance and one for identifying the missed-approach point. The CT-43A was equipped with only one ADF. Proper training would have enabled the air crew to recognize they could not fly the Dubrovnik approach with the navigational equipment on the aircraft. They should not have attempted to do so."

The report also concluded that errors committed by the flight crew in planning and executing the flight combined to cause the accident. During mission planning, "although the flight crew had known for approximately 36 hours that their mission would take them into Dubrovnik, the pilots' review of the approach procedure failed to determine the approach could not be flown with only one ADF receiver," the report said. "Additionally, the air crew improperly planned their route. This error added 15 minutes to their planned flight time."

Because of their planning error, the flight crew was late arriving at Dubrovnik. "The pilots rushed their approach and did not properly configure the aircraft prior to commencing the final segment of the approach," the report said. "They crossed the [FAF] without clearance from the Dubrovnik tower and were 80 knots [148 kilometers per hour] above final-approach airspeed [and not] in accordance with the flight manual. They did not enter holding at the [FAF], which was required because they had not received approach clearance from the tower. Additionally, holding would have allowed them to slow and fully configure the aircraft."

The report concluded that the crew was distracted from adequately monitoring the final-approach course because of the rushed approach, improper aircraft configuration and the call from the pilot on the ground at Dubrovnik. "They [the accident crew] flew a course that was nine degrees left of the correct course," the report said. "The following possible reasons for the course deviation were ruled out: Equipment malfunction, performance of the navigational aids and lightning or other electromagnetic effects."

The most significant error by the accident crew was their failure "to identify the missed-approach point and execute a missed approach," the report said. "If the pilots had not been able to see the runway and descend for a landing, they should have executed a missed approach no later than the missed-approach point. Had they executed a missed approach at the missed-approach point, the aircraft would not have impacted the high terrain, which was more than one NM [1.9 kilometers] past the missed-approach point [Figure 3, page 7]."

With regard to the improperly designed approach at Dubrovnik the report said, "[The instrument-approach procedure] did not provide sufficient obstacle clearance in accordance with internationally agreed-upon criteria," the report said. "Additionally, the [chart] depiction reflected the [KLP NDB] as the [NAVAIDs] providing the primary approach guidance, but the approach was designed using both KLP and CV for approach guidance. Had the approach been properly designed, the MDA would have been higher."

The report noted: "The aircraft descended to the incorrectly designed MDA and impacted the terrain. A properly designed MDA would have placed the aircraft well above the point of impact, even though the air crew flew nine degrees off course."

As a result of the investigation, two generals and 14 other officers were disciplined. The two generals, the 86 AW commander and the 86 OG commander, were relieved of command in May 1996. The USAFE director of operations and the 86 AW vice-commander received letters of reprimand.♦

Editorial note: This article was adapted from a report prepared by the U.S. Air Force Accident Investigation Board regarding the crash of U.S. Air Force CT-43A, 73-1149, April 3, 1996, Dubrovnik, Croatia. The 7,174-page report includes diagrams and illustrations.