National Transportation Safety Board
Washington, D.C. 20594

Safety Recommendation

Date: January 27, 2000

In reply refer to: A-00-7 through -18

Honorable Jane F. Garvey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On August 6, 1997, about 0142:26 Guam local time,[1] Korean Air flight 801, a Boeing 747-3B5B (747-300), Korean registration HL7468, operated by Korean Air Company, Ltd., crashed at Nimitz Hill, Guam.[2] Flight 801 departed from Kimpo International Airport, Seoul, Korea, with 2 pilots, 1 flight engineer, 14 flight attendants, and 237 passengers[3] on board. The airplane had been cleared to land on runway 6L at A.B. Won Guam International Airport, Agana, Guam, and crashed into high terrain about 3 miles southwest of the airport. Of the 254 persons on board, 228 were killed,[4] and 23 passengers and 3 flight attendants survived the accident with serious injuries. The airplane was destroyed by impact forces and a postcrash fire. Flight 801 was operating in U.S. airspace as a regularly scheduled international passenger service flight under the Convention on International Civil Aviation and the provisions of 14 Code of Federal Regulations (CFR) Part 129 and was on an instrument flight rules flight plan.[5]

The National Transportation Safety Board determined that the probable cause of this accident was the captain's failure to adequately brief and execute the nonprecision approach and

[1]All times in this letter are Guam local time, based on a 24-hour clock.

[2] The island of Guam is a U.S. territory in the Pacific Ocean and is part of the Mariana Islands. Guam has an elected governor and a 21-member unicameral legislature. U.S. Naval and Air Force installations make up 35 percent of the island's area.

[3] Six of the passengers were Korean Air flight attendants who were "deadheading," that is, traveling off duty.

[4] Three passengers (including one deadheading flight attendant) initially survived the accident with serious injuries but died within 30 days after the accident. According to 14 Code of Federal Regulations (CFR) Section 830.2, such fatalities are to be included in the total number of fatal injuries. A passenger with serious injuries died at the U.S. Army Medical Center in San Antonio, Texas, on October 10, 1997, but is not officially listed as a fatality because the passenger's death occurred more than 30 days after the accident.

[5] For more detailed information, see National Transportation Safety Board. 2000. *Controlled Flight Into Terrain, Korean Air Flight 801, Boeing 747-300, HL7468, Nimitz Hill, Guam, August 6, 1997.* Aircraft Accident Report NTSB/AAR-00/01. Washington, DC.

the first officer's and flight engineer's failure to effectively monitor and cross-check the captain's execution of the approach. Contributing to these failures were the captain's fatigue and Korean Air's inadequate flight crew training. Contributing to the accident was the Federal Aviation Administration's (FAA) intentional inhibition of the minimum safe altitude warning (MSAW) system[6] at Guam and the agency's failure to adequately manage the system.

Description of the Approach

The instrument landing system (ILS)[7] glideslope inoperative,[8] or localizer-only, approach to runway 6L at Guam International Airport required the flight crew to maintain at least 2,000 feet from the FLAKE intersection (7 DME from the UNZ VOR)[9] to the GUQQY (outer marker) final approach fix (FAF), which was located 1.6 DME from the UNZ VOR. After passing GUQQY, the crew was required to maintain at least 1,440 feet mean sea level (msl) until passing the UNZ VOR. After passing the UNZ VOR, the next step-down fix was to 560 feet (the minimum descent altitude [MDA]), and the flight crew was required to maintain at least this altitude while counting up to 2.8 DME (the missed approach point [MAP]) from the UNZ VOR.

The Captain's Performance of the Approach

Approach Briefing

Korean Air cockpit procedures call for an approach (landing) briefing[10] before descent. Also, company training instructs the flying pilot to conduct an approach briefing before descent. According to the Korean Air 747 landing briefing checklist card and testimony by Korean Air officials during the Safety Board's public hearing,[11] this briefing should include a discussion of weather conditions, a review of the instrument approach procedure, details of the approach's execution (including the minimum safe altitude, approach frequency and approach course, the

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[6] The purpose of the ground-based MSAW system is to provide air traffic controllers with a visual and an aural warning whenever an airplane descends, or is predicted to descend, below a prescribed minimum safe altitude. This information can then be relayed to the pilots so they can take remedial action.

[7] The ILS is a precision approach system that provides lateral guidance (localizer) and vertical alignment (glideslope) with the runway. The system uses ground-based radio transmitters that provide both the localizer and the glideslope signals.

[8] FAA Form 6030-1, "Air Traffic Control Facility Maintenance Log," showed that the glideslope portion of the ILS was taken out of service on July 7, 1997, for extensive reconstruction. The reconstruction work included the replacement of the glideslope's equipment shelter and all cabling and the upgrade of the power systems and grounding. A Notice to Airmen issued by the FAA that same day indicated that the glideslope would remain out of service until September 12, 1997. The complete ILS system was flight checked, certified, and returned to service on August 31, 1997. The Safety Board's review of the facility maintenance log revealed no entries of pilot reports regarding the ILS or related navigation systems from July 7 to August 6, 1997.

[9] DME stands for distance measuring equipment and is expressed in miles. VOR stands for very high frequency omnidirectional radio range.

[10] The approach briefing is called a "landing briefing" on the Korean Air checklist card.

[11] The Safety Board held a public hearing on this accident from March 24 to 26, 1998, in Honolulu, Hawaii. Five issues were addressed at this hearing: controlled flight into terrain (CFIT) accidents, operation of navigational devices at the Guam airport, MSAW systems and practices related to these systems, search and rescue operations, and U.S. and foreign government oversight of foreign air carriers operating into the United States.

runway touchdown zone elevation, and the missed approach procedure), crew actions and callouts, and any abnormal configurations or conditions.

Cockpit voice recorder (CVR) information indicated that the captain briefed a visual approach in his approach briefing, which he referred to as a "short briefing." However, the captain also briefed some elements of the localizer-only ILS approach, indicating that he intended to follow that approach as a supplement or backup to the visual approach. Specifically, the captain's briefing included a reminder that the glideslope was inoperative, some details of the radio setup, the localizer-only MDA, the missed approach procedure, and the visibility at Guam (stated by the captain to be 6 miles). However, the captain did not brief other information about the localizer-only approach, including the definitions of the FAF and step-down fixes and their associated crossing altitude restrictions or the title, issue, and effective dates of the approach charts to be used. The Safety Board notes that the landing briefing checklist did not specifically require the captain to brief the fix definitions, crossing altitudes, or approach chart title and dates,[12] although it would have been good practice to do so.

Further, according to public hearing testimony by a Korean Air instructor pilot, company pilots were trained to conduct a more detailed briefing than the one specified in the landing briefing checklist for a nonprecision approach, such as the localizer approach to runway 6L at Guam. According to the instructor pilot, this more detailed briefing included a discussion of the "instrument approach in detail" and a discussion of the "step-down altitudes and how they were determined." The Safety Board notes that this information is essential for a nonprecision approach briefing.

The Safety Board also notes that the captain did not brief the first officer and flight engineer on how he would fly the descent (including his planned autopilot/flight director [FD] modes and his plan to fly either a constant angle of descent or a series of descents and level-off altitudes associated with the step-down fixes), and he did not discuss go-around decision criteria. Further, although not specifically required, it would have been prudent for the captain to note the need for special caution in the UNZ VOR area (which he had described as a "black hole" in his approach briefing to another first officer on a July 4, 1997, flight into Guam).

The Safety Board further notes that, in this case, a thorough briefing was especially important because the accident captain and first officer were flying together for the first time, which is a situation that has been linked to flight crew-involved accidents.[13] According to recent human factors research, a good briefing is important to develop a "shared mental model" to ensure "that all crew members are solving the same problem and have the same understanding of priorities, urgency, cue significance, what to watch out for, who does what, and when to perform certain activities."[14] The Safety Board concludes that, by not fully briefing the instrument

[12] Testimony by Korean Air officials at the Safety Board's public hearing indicated that these items were taught in company flight crew training.

[13] National Transportation Safety Board. 1994. *A Review of Flightcrew-Involved Major Accidents of U.S. Air Carriers, 1978 Through 1990.* Safety Study NTSB/SS-94/01. Washington, DC, pp. 40-41.

[14] Orasanu, J. "Decision-making in the Cockpit." In *Cockpit Resource Management.* 1993. Ed. E.L. Weiner, B.G. Kanki, and R.L. Helmreich. San Diego: Academic Press, p. 159.

approach, the captain missed an opportunity to prepare himself, the first officer, and the flight engineer for the relatively complex localizer-only approach and failed to provide the first officer and flight engineer with adequate guidance about monitoring the approach; therefore, the captain's approach briefing was inadequate.

Expectation of a Visual Approach and Role of the Guam Airport Familiarization Video

The Safety Board notes that, when the captain flew to Guam about 1 month before the accident, he executed a routine ILS approach to runway 6L in good visibility, with a scattered cumulous buildup. Further, the most current automatic terminal information service (ATIS) information available to the accident flight crew indicated that visual conditions (scattered cloud decks and 7-mile visibility) existed at the airport.[15] Korean Air's Guam airport familiarization video,[16] which the captain and first officer had viewed in July 1997, noted that weather conditions in Guam allowed visual approaches most of the year and that, even though instrument meteorological conditions (IMC) are likely during the rainy season from June to November, "you [the pilot] will be guided from over Apra Harbor to the localizer. You will then perform a visual approach…." Thus, the captain may have assumed that conditions for the flight 801 approach would be similar to those he experienced about 1 month earlier. The captain's anticipation of a visual approach probably became a strong expectation after the flight crew's early visual sighting of Guam.[17] Although the captain would likely have recognized the possibility of flight through clouds as the airplane descended from its cruise altitude, he may have assumed that the visual approach slope indicator (VASI) system would be in sight after the flight was vectored onto final approach by the Guam Combined Center/Radar Approach Control (CERAP) controller. The VASI system would have provided visual guidance for a constant angle of descent that safely cleared obstacles.

As previously discussed, the captain's landing briefing included references to his expectation of visual conditions at the airport as well as an abbreviated and inadequate briefing for the localizer-only approach. The Safety Board concludes that the captain's expectation of a visual approach was a factor in his incomplete briefing of the localizer approach. The Board is aware that it is a common practice among air carrier pilots to abbreviate the briefing for a backup instrument approach when a visual approach is expected. Although there may be little benefit to fully briefing a backup instrument approach in daylight conditions when no appreciable possibility of encountering IMC exists, the Safety Board concludes that, for flights conducted at night or when there is any possibility that IMC may be encountered, the failure to fully brief an available

[15] The CVR indicated that, about 0122:06, the Combined Center/Radar Approach Control (CERAP) controller informed the flight 801 crew that ATIS information Uniform was current.

[16] Korean Air stated that, in June 1997, it established an airport familiarization program that used audio-visual presentations (purchased from Japan Airlines) to prepare pilots for operations into designated airports. Korean Air requires pilots to view an airport familiarization videotape if the company or the FAA list that airport as a special airport. Title 14 CFR Section 121.445 defines special airports as those that require a special airport qualification for pilots in command because of "surrounding terrain, obstructions, or complex approach or departure procedures." Guam International Airport was not classified by Korean Air or the FAA as a special airport; thus, the accident flight crew was not required to view this familiarization tape.

[17] According to the CVR, the flight engineer stated "it's Guam, Guam" about 0126:25.

backup instrument approach compromises safety. Therefore, the Safety Board believes that the FAA should require principal operations inspectors (POI) assigned to U.S. air carriers to ensure that air carrier pilots conduct a full briefing for the instrument approach (if available) intended to back up a visual approach conducted at night or when IMC may be encountered.

The Safety Board notes that, although Guam was not a designated special airport requiring special training or familiarization by flight crews, Korean Air encouraged its flight crews to view the airport familiarization video. However, the Guam familiarization video gave only a generalized description of the topography of the island of Guam. Although the video mentioned some of the obstacles near the approach course, it did not specifically state that the UNZ VOR was located on a hill, the DME was not colocated with the localizer, or the final approach segment was over hilly or mountainous terrain.

Even though the airport familiarization video accurately identified some landmarks and advised pilots not to fly over a residential area and a Naval hospital (for noise abatement), the Safety Board also notes with concern that the video contained no discussion of factors that made operations into Guam challenging, such as the high terrain along the approach course or in the vicinity of the airport. Further, the presentation did not describe the complexity of the Guam nonprecision approaches, including the multiple step-down fixes, the use of two separate navigation facilities (the localizer and the VOR), and the countdown/count up DME procedure.

The Safety Board concludes that the Korean Air airport familiarization video for Guam, by emphasizing the visual aspects of the approach, fostered the expectation by company flight crews of a visual approach and, by not emphasizing the terrain hazards and offset DME factors, did not adequately prepare flight crews for the range of potential challenges associated with operations into Guam.[18]

The Safety Board addressed the issue of the classification of special airports and approaches to certain airports in connection with its investigation of the October 19, 1996, accident involving Delta Air Lines flight 554, an MD-88, at LaGuardia Airport in New York.[19] On August 25, 1997, the Board issued Safety Recommendations A-97-92 through -94, asking the FAA to develop and publish "specific criteria and conditions" for the classification of special airports (including special runways and/or special approaches) and use these criteria to evaluate all airports and "update special airport publications."

On November 13, 1997, the FAA responded that it was revising Advisory Circular (AC) 121.445, "Pilot-in-Command Qualifications for Special Area/Routes and Airports," and that the revision would address the issues discussed in the safety recommendations. On August 17, 1998,

[18] In its report on this accident, the Safety Board recommended that the Korean Civil Aviation Bureau (KCAB) require Korean Air to revise its video presentation for Guam to emphasize that instrument approaches should also be expected and describe the complexity of such approaches and the significant terrain along the approach courses and in the vicinity of the airport. The KCAB, a division within the Korean Ministry of Construction and Transport, is responsible for overseeing the Korean civil airlines.

[19] National Transportation Safety Board. 1997. *Descent Below Visual Glidepath and Collision With Terrain, Delta Air Lines Flight 554, McDonnell Douglas MD-88, N914DL, LaGuardia Airport, New York, October 19, 1996*. Aircraft Accident Report NTSB/AAR-97/03. Washington, DC.

the Safety Board classified Safety Recommendations A-97-92 through -94 "Open—Acceptable Response" pending completion of the AC. On September 21, 1999, the FAA stated that AC 121.445 was undergoing internal coordination and should be published in the *Federal Register* by November 1999. The FAA indicated that it would proceed with issuing the flight standards handbook bulletin as soon as the AC was completed. According to the FAA, both documents were expected to be issued by February 2000. The Board recognizes that the FAA's eventual evaluation of Guam against the newly developed criteria might result in its classification as a special airport.

The Safety Board further recognizes that, because the captain flew into Guam and viewed the Guam airport familiarization video during July 1997, he would have been authorized to conduct the accident flight even if Guam had been classified as a special airport. Nonetheless, the Safety Board concludes that the challenges associated with operations to Guam International Airport support its immediate consideration as a special airport requiring special pilot qualifications. Therefore, the Safety Board believes that the FAA should consider designating Guam International Airport as a special airport requiring special pilot qualifications.

Confusion About Status of Glideslope

Despite several indications that the flight crew was aware that the glideslope was inoperative, in the last 2 ½ minutes of the flight (beginning shortly after the airplane was established on the approach), the CVR recorded a series of conflicting flight crew comments concerning the operational status of the glideslope. About 0139:55, the flight engineer asked, "is the glideslope working?" The captain responded, "yes, yes it's working." About 0139:58, an unidentified voice in the cockpit stated, "check the glideslope if working?" One second later, an unidentified voice in the cockpit stated, "why is it working?" About 0140:00, the first officer responded, "not useable." About 0140:22, an unidentified voice in the cockpit stated, "glideslope is incorrect," followed by the captain's statement, "since today's glideslope condition is not good, we need to maintain one thousand four hundred forty [feet]." However, about 0141:46, after the airplane crossed the GUQQY outer marker (1.6 DME from the VOR), the captain again stated, "isn't glideslope working?"

The Safety Board considered whether the flight crew might have misinterpreted some cockpit instrumentation indications as a valid glideslope capture signal. During the localizer approach into Guam, both pilots' horizontal situation indicators (HSI) would have appeared centered; the captain's would have captured the localizer, and the first officer's would have captured the VOR radial. With VOR/LOC (localizer) selected, the localizer captured, and the pitch commands set to VERT (vertical) SPEED (the most likely setting), the captain's FD command bars would have shown some vertical and horizontal movement, similar to an FD that was responding to a captured localizer and glideslope. However, the raw data glideslope needles on the attitude director indicator (ADI) and HSI would not have been affected by the VERT SPEED setting; therefore, the captain's ADI and HSI glideslope needles should have been covered by "off" flags.[20] Further, there would have been no glideslope capture annunciator on the

[20] The Safety Board notes that the raw data localizer and glideslope needles and off flags on the first officer's ADI and HSI would have been out of view because his navigation receiver was tuned to the VOR.

GS (glideslope) bar of the flight mode annunciator (FMA) on top of the captain's and first officer's instrument panels.

The Safety Board also considered whether the flight crewmembers might have observed intermittent movement of the glideslope needles during the approach, thereby creating or adding to their confusion about the glideslope. An FAA navigation expert testified at the Board's public hearing that spurious radio signals could cause a sporadic or intermittent glideslope indicator deviation in the absence of a valid glideslope signal. However, he stated that the glideslope off flag would still appear on the HSI and ADI glideslope needles and that, when the off flag appears, any movement of the glideslope needle should be considered unreliable. Postaccident testing by Korean Air and the Korean Civil Aviation Bureau (KCAB) confirmed that an airplane's glideslope receiver could be affected by spurious radio signals when no valid glideslope signal was being transmitted.[21] The tests demonstrated that spurious signals could cause movement of the glideslope needle and that, when the receiver was subjected to a steady signal, retraction of the off flag was also possible. However, the Safety Board notes that these tests were conducted with an airplane on the ground and that the airplane's navigational receiver was subjected to extreme signal modulations transmitted very near the airplane's antenna. These conditions are not likely to be encountered by an airplane on an actual instrument approach.

The Safety Board also notes that the flight crew of a Boeing 727 reported glideslope anomalies on August 5, 1997, while executing the localizer-only approach to runway 6L at Guam.[22] (The purpose of the flight was to test a newly installed global positioning system [GPS].) However, the captain of the 727 stated that he thought the glideslope anomaly might have been caused by the GPS wiring installation. Further, the first officer stated that he and the captain "never thought twice" about the glideslope indications because they knew that the glideslope was inoperative. The Board's investigation into the 727's maintenance history indicated that, in the weeks after the test flight, several cockpit navigational displays, including the first officer's HSI and ADI, were repeatedly removed and replaced by maintenance personnel because of anomaly reports written up by flight crews. The maintenance documents indicated that the cockpit display problems were the result of integrating the new GPS with the existing cockpit displays.

Although it is possible that spurious radio signals caused some erratic movement of the glideslope needles on the accident captain's HSI and ADI, it is unlikely that the accident airplane's navigation receivers could have been subjected to a steady spurious signal of a duration that would have resulted in a continuous glideslope needle activation and flag retraction over a period of minutes and several miles of aircraft motion. Thus, the presence of the off flags over the glideslope needles at some times and the absence of FMA glideslope capture indicators on the captain's and first officer's instrument panels should have been sufficient to convince the flight

[21] The KCAB and Korean Air conducted a series of independent tests on a Boeing 747 to determine if spurious radio-frequency energy could induce an abnormal ("false") glideslope indication. These tests were not intended to represent conditions at the time of the accident; rather, the tests were designed to explore ILS system sensitivity to spurious signals.

[22] The Boeing 727 flight crew stated that no glideslope flags were visible and that the ADI glideslope needle was "centered."

801 flight crew to disregard the glideslope indications. Even if the flight crewmembers did see a continuous glideslope needle activation and flag retraction, it would not have been prudent or reasonable for them to rely on a glideslope signal of any sort when the glideslope had been reported to be unusable. (Korean Air officials stated that flight crews were trained not to use navigational aids, including glideslopes, that were reported to be unreliable or unusable). Therefore, the Safety Board concludes that, although the captain apparently became confused about the glideslope's status, the flight crew had sufficient information to be aware that the glideslope was unusable for vertical guidance and should have ignored any glideslope indications while executing the nonprecision localizer-only approach.

The Safety Board notes that, when a glideslope signal is not generated by the transmitter (resulting in an open frequency channel), an airborne glideslope receiver will continue to seek a glideslope signal, although navigation receiver filters are designed to block most spurious radio signals. The postaccident testing conducted by Korean Air and the KCAB involved the glideslope receiver; however, the Safety Board concludes that navigation receivers, including glideslope receivers, may be susceptible to spurious radio signals. Therefore, the Safety Board believes that the FAA should disseminate information to pilots, through the Aeronautical Information Manual, about the possibility of momentary erroneous indications on cockpit displays when the primary signal generator for a ground-based navigational transmitter (for example, a glideslope, VOR, or nondirectional beacon [NDB] transmitter) is inoperative. Further, this information should reiterate to pilots that they should disregard any navigation indication, regardless of its apparent validity, if the particular transmitter was identified as unusable or inoperative.

Summary of Captain's Performance on the Approach

As the approach progressed without encountering the visual conditions the captain had anticipated, the captain likely experienced increased stress because of his inadequate preparation for the nonprecision approach, which made the approach increasingly challenging.[23] CVR and flight data recorder (FDR) data indicated that, shortly after the captain appeared to become preoccupied with the status of the glideslope, he allowed the airplane to descend prematurely below the required intermediate altitudes of the approach. Thus, the captain may have failed to track the airplane's position on the approach because he believed that he would regain visual conditions, the airplane was receiving a valid glideslope signal, and/or the airplane was closer to the airport than its actual position.[24]

Regardless of the reason for failing to track the airplane's position, the captain conducted the approach without properly cross-referencing the positional fixes defined by the VOR and

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[23] Human factors research has shown that a common decision-making error, especially in high stress and workload situations, is for people to tend to ignore evidence that does not support an initial decision. Human "operators tend to seek (and therefore find) information that confirms the chosen hypothesis and to avoid information or tests whose outcome could disconfirm it," which produces an "inertia which favors the hypothesis initially formulated." See Wickens, C. (1992). *Engineering Psychology and Human Performance,* 2nd Edition. Columbus, Ohio: Charles E. Merrill.

[24] In its report on this accident, the Safety Board concluded that the captain might have mistakenly believed that the airplane was closer to the airport than its actual position; however, if the captain conducted the flight's descent on this basis, he did so in disregard of the DME fix definitions shown on the approach chart.

DME with the airplane's altitude. Therefore, the Safety Board concludes that, as a result of his confusion and preoccupation with the status of the glideslope, failure to properly cross-check the airplane's position and altitude with the information on the approach chart, and continuing expectation of a visual approach, the captain lost awareness of flight 801's position on the ILS localizer-only approach to runway 6L at Guam International Airport and improperly descended below the intermediate approach altitudes of 2,000 and 1,440 feet, which was causal to the accident.

Flight Crew Monitoring of the Approach

CVR evidence indicated that the flight crew seemed confused about, and did not react to, a series of audible ground proximity warning system (GPWS) alerts during the final approach. The first audible GPWS callout occurred about 0141:42, with the "one thousand [feet]" altitude call. A second GPWS callout of "five hundred [feet]" occurred about 0142:00 (when the airplane was descending through about 1,200 feet msl, to which the flight engineer responded in astonishment, "eh?" However, FDR data indicated that no change in the airplane's descent profile followed, and the CVR indicated that the flight engineer continued to complete the landing checklist. Similarly, no flight crew discussion followed the GPWS callout of "minimums" about 0142:14, and the first officer dismissed a GPWS "sink rate" alert 3 seconds later by stating "sink rate okay." About 0142:19, the flight engineer called "two hundred [feet]," followed immediately by the first officer saying "let's make a missed approach." The flight engineer immediately responded "not in sight," followed by the first officer repeating "not in sight missed approach." According to the CVR, a rapid succession of GPWS altitude callouts down to 20 feet followed, as the flight crew attempted to execute the missed approach.

The GPWS "minimums" callout occurred about 12 seconds before impact, when the airplane was descending through about 840 feet msl. The first officer's first statement suggesting the execution of a missed approach occurred about 6 seconds before impact. The captain initiated a missed approach and thrust began increasing about 4 seconds before impact. However, no significant nose-up control column inputs were made until just before initial impact. Analysis of FDR data indicated that, if a missed approach had been initiated 12 seconds before impact (at the GPWS "minimums" callout), it is likely that the airplane would have successfully cleared terrain by about 450 feet. Analysis of the FDR data also indicated that, if an aggressive missed approach had been initiated 6 seconds before impact (when the first officer made the first missed approach challenge), it is possible that the airplane might have cleared the terrain.

The Safety Board notes that the flight crew would have been gauging the airplane's height above the MDA by referring to the airplane's barometric altimeter (which displays altitude above sea level) and not the radio altimeter (which senses altitude above ground level, and upon which the GPWS minimums callout was based) and that the MDA of 560 feet msl was never reached. Nevertheless, the GPWS callouts were a salient cue that should have caused the flight crew to question the airplane's position and the captain to act conservatively and choose to execute a missed approach. The Safety Board concludes that the first officer and flight engineer noted the GPWS callouts and the first officer properly called for a missed approach, but the captain's failure to react properly to the GPWS minimums callout and the direct challenge from the first officer precluded action that might have prevented the accident.

Although the first officer properly called for a missed approach 6 seconds before impact, he failed to challenge the errors made by the captain (as required by Korean Air procedures)[25] earlier in the approach, when the captain would have had more time to respond. Significantly, the first officer did not challenge the captain's premature descents below 2,000 and 1,440 feet.

The Safety Board was unable to identify whether the absence of challenges earlier in the approach stemmed from the first officer's and the flight engineer's inadequate preparation during the approach briefing to actively monitor the captain's performance on the localizer approach, their failure to identify the errors made by the captain (including the possibility that they shared the same misconceptions as the captain about the glideslope status/FD mode or the airplane's proximity to the airport), and/or their unwillingness to confront the captain about errors that they did perceive.

The Safety Board notes that the captain's failure to brief the localizer approach to back up the expected visual approach could have adversely affected the flight crew's preparation for monitoring the approach. If the captain had briefed the details of the approach, including the various navigational fix definitions and associated altitude constraints, he would have enhanced the flight crew's ability to monitor the approach and challenge any errors he made.

Even if the first officer was attempting to monitor the approach, his ability to identify errors made by the captain would have been impaired by the requirement that he tune his navigation receiver to the UNZ VOR, thus forcing him to look across the cockpit to the captain's instruments to monitor the glideslope/FD status, any indications of glideslope capture on the captain's ADI and HSI, and the airplane's lateral position on the localizer. However, the first officer would have had information on his own HSI and radio magnetic indicator about the airplane's position relative to the VOR (the step-down fix for the descent to 560 feet) and the DME readings that defined the remaining fixes of the approach.

The first officer's ability to monitor the captain was also possibly hindered by the likelihood that he was using a different instrument chart than the captain for the localizer approach. The Safety Board found an out-of-date chart for this approach (dated January 19, 1996) in the cockpit. On the basis of the captain's comments on the CVR, it appears that the captain was using the correct chart (dated August 2, 1996), which included different definitions and names of DME fixes and different crossing altitudes than the out-of-date chart. Thus, if the first officer was using the out-of-date chart, he would have been hindered in monitoring the captain's compliance with the altitude constraints at the fixes.

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[25] Korean Air's cockpit training procedures instructed the pilot flying a nonprecision approach (with the autopilot engaged) to program the autopilot/FD controls, including VERT SPEED and ALT SEL (altitude select), unless that pilot directed the nonflying pilot to do so. In addition, flight crews were trained that, while executing the approach profile, the flying pilot was to initiate all heading, course, and altitude changes, including selection of the step-down altitudes. The role of the nonflying pilot was to monitor and challenge if the flying pilot failed to follow proper procedures.

Although the precise reason(s) for the lack of monitoring by the flight crew could not be determined, the Safety Board concludes that the first officer and flight engineer failed to properly monitor and/or challenge the captain's performance, which was causal to the accident.

Problems associated with subordinate officers challenging a captain are well known. For example, in its study of flight crew-involved major air carrier accidents in the United States,[26] the Safety Board found that more than 80 percent of the accidents studied occurred when the captain was the flying pilot and the first officer was the nonflying pilot (responsible for monitoring). Only 20 percent of the accidents occurred when the first officer was flying and the captain was monitoring. This finding is consistent with testimony at the Safety Board's public hearing, indicating that controlled flight into terrain (CFIT) accidents are more likely to occur (on a worldwide basis) when the captain is the flying pilot. The Board's study found that the failure of first officers to challenge errors (especially tactical decision errors) made by a flying captain was a frequent factor in accidents involving such errors. In addition, the study noted that, while monitoring and challenging a captain's tactical decision error, "a first officer may have difficulty both in deciding that the captain has made a faulty decision, and in choosing the correct time to question the decision." The study concluded that a first officer "may be concerned that a challenge to a decision may be perceived as a direct challenge to the captain's authority."

The Safety Board is concerned that the use of the nonflying pilot in a passive role, while the flying pilot is responsible for the approach procedure, programming the autopilot/FD controls, and monitoring the aircraft flightpath, places an inordinately high work load on the flying pilot and undertasks the nonflying pilot. The Board is also concerned that, when the nonflying pilot has a passive role in the approach, the flying pilot may erroneously consider the lack of input from the nonflying pilot as confirmation that approach procedures are being properly performed. The Board is aware that some international air carriers use the nonflying pilot in a more interactive role during the performance of a nonprecision approach, in which that pilot leads or prompts the flying pilot through the approach procedure by stating the next procedural change, including course, heading, altitude, time, visual contact, or MAP. The Board is also aware that some air carriers employ a "monitored approach" method, with the first officer as the flying pilot and the captain as the monitoring, nonflying pilot until just before landing.

The Safety Board notes that the monitored approach method provides for more effective monitoring by the nonflying pilot because captains are more likely to be comfortable offering corrections or challenges to first officers than the reverse situation. Thus, the Safety Board concludes that monitored approaches decrease the workload of the flying pilot and increase flight crew interaction, especially when experienced captains monitor and prompt first officers during the execution of approaches. However, the Board also notes that, when there are differences in aircraft handling skills between captains and first officers and the approach is not flown using the autopilot, a monitored approach with the captain as the nonflying pilot may not always be appropriate. Therefore, the Safety Board believes that the FAA should conduct or sponsor

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[26] *A Review of Flightcrew-Involved Major Accidents of U.S. Air Carriers, 1978 Through 1990,* pp. 47-49 and 55-59.

research to determine the most effective use of the monitored approach method and the maximum degree to which it can be safely used and then require air carriers to modify their procedures accordingly.

Pilot Training

The Safety Board examined Korean Air's Boeing 747 pilot training and proficiency checking program to determine what effect, if any, it may have had on the performance of the flight crew of flight 801. In training its pilots to fly the 747-200 and -300 series airplanes, Korean Air conducted 10 4-hour simulator sessions in which pilots were taught various maneuvers, emergencies, and scenarios, followed by a proficiency check in which pilot performance of certain maneuvers was assessed. The profile for each simulator training session outlined the specific airport, runway, weather, and airplane malfunction to be expected and whether the flight would result in a landing or missed approach. The training curriculum was not varied. Korean Air's Director of Academic Training testified at the Safety Board's public hearing that, at the time of the accident, the company's practice was to follow simulator scenarios exactly as outlined in the training curriculum and that instructors were not permitted to vary the scenarios. The director also indicated that the proficiency checks used the same approaches that had been practiced in the previous simulator training sessions.

Further, the only nonprecision approach practiced throughout the simulator sessions that used DME information was the VOR/DME approach to runway 32 at Seoul's Kimpo Airport. However, the DME at that airport is located on the field, unlike at Guam. No scenario was presented in which pilots were required to count down to and fly past the DME and then count up to the MAP, which was required for the Guam approach.[27] Further, according to the airline's training syllabus, the VOR/DME approach to runway 32 at Kimpo was the only nonprecision approach that Korean Air flight crews were required to perform on their check ride.

The Safety Board notes that proper training in the execution of nonprecision approaches is essential to safe operations. The complexity of such approaches and the absence of precise vertical guidance create more demands on pilot skills and cognitive performance than precision approaches. An expert on CFIT accidents testified the following at the Board's public hearing:

> Nonprecision approaches generally are much more complex than precision approaches. For many pilots, they are less familiar. They are more error-prone. They require [a] more comprehensive briefing. They need particularly careful and accurate monitoring, and it is possible for complex step-down procedures for steps to be missed or to be taken out of step. In other words, to get one step ahead of the airplane could be fatal. Such approaches also need much more carefully managed airplane crew and checklist

[27] During training, Korean Air pilots performed two different NDB approaches; each was performed once, and neither incorporated DME. The pilots also performed the localizer approach to runway 14 at Kimpo once and the VOR/DME approach to runway 32 at Kimpo five times. The localizer and VOR/DME approaches used a DME that was colocated and frequency paired with approach navigational facilities located on the airport. Thus, the pilots were exposed to four nonprecision approaches during their training, and the VOR/DME approach to runway 32 at Kimpo was the only approach performed more than once.

management, and it is a characteristic of many CFIT accidents that they occur when the crew is preoccupied or distracted by other tasks.

The Safety Board notes that the Air Line Pilots Association (ALPA), in its submission regarding this accident, estimated that air transport pilots typically conduct one to three nonprecision approaches a year and practice these approaches "just as infrequently" in the simulator. In its investigation of the November 12, 1995, accident involving American Airlines flight 1572, an MD-83 that crashed in East Granby, Connecticut, while on final approach to Bradley International Airport in Windsor Locks, Connecticut,[28] the Board found that even relatively minor errors in the monitoring of the execution of a nonprecision approach can lead to an accident.[29]

The Safety Board is concerned that the repeated presentation of a single nonprecision approach scenario throughout simulator training (to the exclusion of all other kinds of nonprecision approaches) provides insufficient training in nonprecision approaches. Specifically, the repetition limits pilots' opportunity to understand and practice the flying techniques necessary to perform the different kinds of nonprecision approaches and limits their ability to successfully apply these techniques to novel situations or unusual approach configurations encountered in line operations, such as the localizer approach at Guam. Further, Korean Air's reliance on the same approach for both training and checking resulted in an inadequate evaluation of a flight crew's ability to execute the varied nonprecision approaches that might be encountered in line operations.[30] Therefore, the Safety Board concludes that Korean Air's training in the execution of nonprecision approaches was ineffective, which contributed to the deficient performance of the flight crew.

In addition, on the basis of the history of similar accidents involving U.S. air carriers, the Safety Board concludes that U.S. air carrier pilots would benefit from additional training and practice in nonprecision approaches during line operations (in daytime visual conditions in which such a practice would not add a risk factor). Therefore, the Safety Board believes that the FAA should issue guidance to air carriers to ensure that pilots periodically perform nonprecision approaches during line operations in daytime visual conditions in which such practice would not add a risk factor.

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[28] National Transportation Safety Board. 1996. *Collision With Trees on Final Approach, American Airlines Flight 1572, McDonnell Douglas MD-83, N566AA, East Granby, Connecticut, November 12, 1995.* Aircraft Accident Report NTSB/AAR-96/05. Washington, DC.

[29] The Safety Board found similar nonprecision approach-related factors in its investigation of the 1995 accident involving an American Airlines Boeing 757 on a nonprecision approach to Cali, Colombia; the 1990 accident involving a Markair Boeing 737 on a nonprecision approach to Unalakleet, Alaska; the 1989 accident involving a Flying Tigers Boeing 747 that crashed while executing an NDB approach to Kuala Lumpur, Malaysia; and the 1989 incident involving a USAir Boeing 737 executing a localizer backcourse approach to Kansas City, Missouri.

[30] The Safety Board notes the Korean Air simulator training now incorporates a variety of approach scenarios, including approaches in which the DME is not colocated with an on-airport navigational facility and approaches involving countdown/count up DME procedures. Also, the simulator training now includes approaches likely to be encountered in the airline's domestic and international operations.

Air Traffic Controller Performance

Safety Board investigators evaluated the performance of the CERAP and Agana tower controllers to determine whether their performance played a role in the circumstances of the accident. FAA Order 7110.65, "Air Traffic Control," prescribes the air traffic control (ATC) procedures that controllers are required to follow. The investigation revealed three deviations from those procedures on the part of the CERAP controller.

The CERAP controller failed to provide the flight crew with a position advisory relative to a fix on the final approach course when he cleared flight 801 for the approach. If such a position advisory had been given, as required by paragraph 5-9-4, the pilots might have been prompted to cross-check their radar position with the cockpit DME and other navigational aid indications, thereby improving their situational awareness. In addition, the CERAP controller did not inform the flight crew or the tower controller that he had observed a rain shower (described by the CERAP controller as a "cell" during a postaccident interview with Safety Board investigators) on the final approach path, as required by paragraph 2-6-4. Although the pilots should have been aware of the weather situation because they were using on-board weather radar, their decision-making might have been aided if the CERAP controller had provided his weather observations.

The CERAP controller also failed to monitor the flight after the frequency change to the tower controller.[31] As a result, the CERAP controller did not immediately recognize that the airplane was overdue. (Paragraph 10-3-1 states that a controller who has any reason to believe that an aircraft is overdue should immediately take appropriate action.) If the CERAP controller had been properly monitoring the flight on one or both of the radar displays he had available to him (the en route display and/or the terminal display), he might have observed flight 801 disappear on final approach. Also, the controller might have noticed the approach path warning (low-altitude MSAW alert) that was generated on the en route radar display,[32] which began about 6 seconds before impact and continued until at least 23 seconds afterward. These actions would have resulted in an earlier notification of the accident to emergency rescue personnel and possibly an earlier emergency response.

Further, if the CERAP controller had been monitoring the flight on the terminal radar display, which was located to his immediate right and would have been clearly visible to him,[33] he might have seen the airplane descend prematurely toward high terrain and have been able to alert the flight crew and prevent the accident. This radar display would have shown the flight

[31] The controller was required to continue monitoring the flight because radar service had not been terminated in accordance with paragraph 5-1-13.

[32] The CERAP controller was monitoring the En route Automated Radar Tracking System (EARTS) radar scope, which had a functioning MSAW capability. However, this MSAW capability was based on a different algorithm than the disabled Automated Radar Terminal System (ARTS) IIA MSAW system. The ARTS IIA MSAW system compares the airplane's trajectory with the ILS glideslope. The EARTS system uses a single altitude (based on the lowest MDA for all nonprecision approaches to the runway) from the FAF to the point at which MSAW processing terminates (usually 1 mile from the runway threshold).

[33] The Safety Board recognizes that the en route radar display was set to a range of 265 nautical miles and therefore could not be used for effectively monitoring the final approach. The terminal radar display was set to a range of 60 nautical miles and displayed the final approach course for runway 6L.

descending through 2,000 feet msl while almost 7 miles from the airport and outside of the outer marker. The radar display would have also shown the airplane crossing the outer marker almost 800 feet lower than the established crossing altitude of 2,000 feet.[34]

Although the CERAP controller told Safety Board investigators that he did not continue to monitor the flight because he was engaged in other duties about the time of the accident, the ATC transcripts indicated no activity during that time. The transcripts indicated that the controller instructed the flight crew, about 0140:42, to contact the Agana tower. The controller then made a radio transmission to another aircraft about 0140:54. From about 0141:14 to 0141:30, the controller had a conversation with another controller at a different center, and about 0142:05, he acknowledged a transmission from another aircraft. However, the transcripts indicated no further activity until 0143:49, when the CERAP controller called the Agana tower with a flight plan. Thus, the ATC transcripts indicated no activity during the time period beginning 21 seconds before and continuing until 1 minute 23 seconds after the flight 801 crash (which occurred about 0142:26). Therefore, the CERAP controller should have been able to monitor the flight during this time. If the controller had done so, he would have had an opportunity to warn the flight crew of the flight's premature descent and possibly prevent the accident.

The Safety Board concludes that the CERAP controller's performance was substandard in that he failed to provide the flight crew with a position advisory when he cleared the flight for the approach, inform the flight crew or the Agana tower controller that he had observed a rain shower on the final approach path, and monitor the flight after the frequency change to the tower controller. It could not be determined whether the absence of the CERAP controller's procedural errors, singularly or in any combination, would have prevented the accident or reduced its severity. However, the Safety Board concludes that strict adherence to ATC procedures by the CERAP controller may have prevented the accident or reduced its severity. Therefore, the Safety Board believes that the FAA should develop a mandatory briefing item for all air traffic controllers and ATC managers, describing the circumstances surrounding the performance of the CERAP controller in this accident to reinforce the importance of following ATC procedures.

Constant Angle of Descent Nonprecision Approaches

Some airlines have adopted a "constant angle of descent" technique for nonprecision approaches. This technique involves descending on a constant descent angle toward the runway and meeting all of the crossing restrictions of the nonprecision approach procedure while avoiding intermediate level-offs. For this technique, the crossing altitudes depicted on the approach chart are used only as the bottom portion of a window through which the airplane passes as it descends. In most cases, the descent angle is about 3º, except in instances in which terrain or obstructions

[34] Although the CERAP controller told Safety Board investigators that his last observation of the target of flight 801 on the terminal radar display was when the airplane was 7 miles from the airport at an altitude of 2,600 feet, FDR and radar data do not support his statement. The data indicated that, when the CERAP controller instructed the flight to contact the Agana tower, the airplane was at an altitude of about 2,200 feet and maintained a continual descent. Therefore, the airplane was probably farther than 7 miles from the airport when the CERAP controller last observed the flight.

require a steeper descent. Because of terrain factors, some currently approved nonprecision approaches are not amenable to being flown with a constant angle of descent method.

One method for flying a constant angle of descent, in the absence of a ground-based glideslope signal, involves the use of on-board flight management system (FMS) or GPS equipment that provides electronic guidance for a constant angle of descent. This method uses the same flight instrument and FD displays as with an ILS approach. The FMS or GPS equipment, one or both of which is widely installed in newer airplanes, provides precise, real-time information about airplane position.

Under FAA Order 8260.47, "Barometric Vertical Navigation Instrument Procedures Development," issued May 26, 1998, some airlines have received approval to use preprogrammed FMS/GPS approaches that include three-dimensional navigation guidance to the MAP, which is expressed as a barometric decision altitude. The advantages of this method include greater precision, lower pilot workload, and the ability to obtain FD guidance and couple the autopilot to fly the approach automatically. Pilots are not required to use step-down fixes, which removes the chance for misinterpreting the distance to the runway or the proper altitude for that distance and provides for a stabilized approach throughout the descent. The Safety Board concludes that, by providing vertical guidance along a constant descent gradient to the runway, the use of on-board FMS- and/or GPS-based equipment can provide most of the safety advantages of a precision approach during a nonprecision approach. Therefore, the Safety Board believes that the FAA should require that all air carrier airplanes that have been equipped with on-board navigational systems capable of providing vertical flightpath guidance make use of these systems for flying nonprecision approaches whenever terrain factors allow a constant angle of descent with a safe gradient.

The Safety Board notes that it is likely that most air carrier airplanes will be equipped with on-board FMS and/or GPS equipment over the next several years and that the lack of such equipment may ultimately result in the loss of approach capability to certain runways for those airplanes not so equipped. Further, the Board acknowledges that terrain along the approach courses to some runways may preclude a constant angle of descent with a safe gradient, thus resulting in the loss of approach capability to certain runways. However, on the basis of the safety advantages of the constant angle of descent with vertical guidance versus step-down approaches, as demonstrated in the circumstances of this accident, the Safety Board believes that the FAA should require, within 10 years, that all nonprecision approaches approved for air carrier use incorporate a constant angle of descent with vertical guidance from on-board navigation systems.

For those airplanes not yet equipped with on-board navigational systems capable of providing vertical flightpath guidance, an alternative method allows pilots to approximate a constant angle of descent. This method requires using a published approach procedure that incorporates a defined point along the final approach course to begin a constant angle descent to the runway of about 3º; this descent point and descent angle also fulfill the minimum crossing altitudes at each step-down fix of the nonprecision approach. If pilots are provided a tabular means of cross-referencing the distance from the runway (measured by DME) and the proper altitude for that distance, they can adjust the airplane's rate of descent to approximate a constant angle. The advantages of this method include greater awareness of the airplane's position on the approach path and a more stabilized approach, but there is additional workload involved in the cross-referencing of altitude and distance.

In Safety Recommendation A-96-128, issued on November 13, 1996, the Safety Board asked the FAA for the incorporation of constant angle descents instead of step-down criteria. The FAA indicated that it has made progress in providing some of the information pilots need to approximate a constant angle of descent (descent angles and gradients to the runway from a defined starting point). However, the FAA continues to provide insufficient information on approach charts to cross-reference DME distances and altitudes.

Thus, the Safety Board concludes that the safety of executing a nonprecision approach using the constant angle of descent, or stabilized descent technique, would be enhanced by adding to approach charts the cross-referenced altitudes versus distance from the airport. Therefore, the Safety Board believes that the FAA should include, in nonprecision approach procedures, tabular information that allows pilots to fly a constant angle of descent by cross-referencing the distance from the airport and the barometric altitude.

Terrain Depiction on Approach Charts

Approach chart vendors use various methods of depicting obstructions and high terrain on approach charts. On the plan view,[35] some vendors use contour lines and color shading for various height gradients and symbols for high obstructions, and others use broader colored areas with the minimum sector altitude for obstacle clearance printed over each area. However, no chart vendor depicts terrain or obstructions on the profile view,[36] which depicts the inbound approach course descent profile from an initial approach fix to a landing or missed approach. Other than the depiction of certain obstruction heights, there is no FAA requirement or standardized format to depict terrain on approach charts. The Safety Board notes that Nimitz Hill was not depicted on the Guam runway 6L ILS approach chart.

During an instrument approach, pilots generally refer to the plan view until they are established on the inbound approach course, usually on the intermediate and final approach segments. Once on the inbound approach course, pilots generally shift their attention on the approach chart from the plan to the profile view. Thus, the Safety Board concludes that terrain depiction on the profile view of approach charts could result in increased flight crew awareness of significant terrain on the approach path. The Board recognizes that logistical problems may be associated with obtaining and including this information and that not all users agree that obstacle depiction on the profile view is necessary and helpful. Nevertheless, the Safety Board believes that the FAA should evaluate the benefits of depicting terrain and other obstacles along a specific approach path on the profile view of approach charts and require such depiction if the evaluation demonstrates the benefits.

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[35] The plan view shows the approach viewed from above.

[36] The profile view shows the approach viewed from the side.

User Review of Instrument Procedures

Charting companies that publish instrument procedures receive the pertinent information from the FAA on its Form 8260. This form includes data for the terminal area as well as final approach and missed approach standards for a specific instrument procedure. The manager of the FAA's Western Flight Procedures Development Branch testified at the Safety Board's public hearing that, when an approach procedure is completed but before it is published, the procedure is distributed to industry user groups, including ALPA, the Air Transport Association, the Aircraft Owners and Pilots Association, and airport operators, for review. The manager stated that the purpose of this user review is to ensure that the final product is safe, accurate, and intelligible. The Safety Board agrees with and endorses this practice. However, the Board notes that the FAA does not provide user groups with the approach procedure in its final, graphical form as it will be published and used. Rather, user groups are only given FAA Form 8260, which describes the approach in words and numbers.

Industry user groups, including ALPA (according to its submission to the Safety Board regarding this accident), have stated that the format of FAA Form 8260 makes it difficult for them to evaluate the procedure. Thus, the Safety Board concludes that valuable user group reviews of proposed new instrument procedures are hampered by the format in which the information is disseminated; thus, user groups may not be able to effectively evaluate whether a procedure is safe, accurate, and intelligible. Therefore, the Safety Board believes that the FAA should provide user groups, along with Form 8260, draft plan and profile views of instrument procedures to assist the groups in effectively evaluating proposed new procedures.

Oversight of Korean Air and Assessment of the Korean Civil Aviation Bureau

The FAA issues operations specifications to foreign air carriers operating into the United States pursuant to 14 CFR Part 129. The FAA also assigns a POI to each foreign air carrier to provide oversight to that carrier. The POI for Korean Air at the time of the accident stated that oversight of foreign carriers under Part 129 included inspections of trip records and facilities in the United States and ramp inspections of airplanes and crews when they were in the United States or its territories. However, the POI stated that the FAA did not inspect, approve, or oversee a foreign airline's training program or any of its manuals or accomplish line checks or en route inspections on board foreign airlines. (There is no requirement that a foreign carrier provide the FAA POI with flight operations or training manuals.) The POI also stated that there was no formal interaction between the KCAB and the FAA regarding their respective oversight activities relating to Korean Air.

The Safety Board notes that the purpose of the FAA's International Aviation Safety Assessment (IASA) program is to ensure that foreign air carriers operating in the United States are receiving adequate oversight by their respective civil aviation authority (CAA). The FAA developed this program in response to an identified need to oversee foreign carriers operating to the United States; however, the FAA's assessment under that program is limited to an evaluation of the foreign CAA's ability to provide oversight in accordance with International Civil Aviation

Organization (ICAO) Annex 6 standards. The FAA does not directly assess whether foreign carriers are receiving such oversight or are complying with Annex 6. When the FAA assessed the KCAB in 1996, the FAA concluded that the KCAB was capable of overseeing Korean air carriers in accordance with ICAO safety standards, and Korea was therefore given a Category I rating (the highest rating of the three IASA categories).[37] The FAA indicated that it would reassess a country that has air carriers operating into the United States if there was any reason to question whether that country was meeting its international safety oversight obligations.

The substantial number of Korean Air crew-related accidents and incidents, the deficiencies in Korean Air's pilot training program, and the lack of documented cockpit procedures suggest that Korean Air had not fully complied with the intent of paragraph 9.3.1 of ICAO Annex 6, which states that operators "shall establish and maintain a ground and flight training program...which ensures that all flight crew members are adequately trained to perform their assigned duties. [The training program] shall also include training in knowledge and skills related to human performance and limitations...[and] shall ensure that all flight crew members know the functions for which they are responsible and the relation of those functions to the functions of other crew members."

The reliability of the FAA's assessment and rating of a country's CAA under the IASA program is becoming ever more important in light of increases in code-sharing and other alliances involving U.S. and foreign carriers. U.S. carriers are likely to view a positive assessment by the FAA and the resulting Category I rating as an indication that the country's airlines are receiving adequate oversight and are therefore maintaining an adequate level of safety. However, even though Korea had received and maintained a Category I rating, the evidence developed in this investigation (including that only two operations inspectors were assigned to Korean Air and that neither was type rated for the 747, as well as the deficiencies in the KCAB's oversight of Korean Air)[38] and Korean Air's accident and incident record (both before and after the flight 801 crash)[39] suggest that the FAA's IASA program was not adequate in its scope and depth to determine the capacity of the KCAB to fully assess Korean Air's level of safety or ensure that Korean Air was receiving adequate oversight. The Department of Transportation Office of Inspector General's (DOT/IG) audit report, titled *Aviation Safety Under International Code Share Agreements*,[40] reached a similar conclusion. The DOT/IG report noted that the FAA's assessment under the IASA program "is quite different from a judgment about the safety practices of an individual carrier." The report further noted that the "FAA is itself a civil aviation authority that meets international standards, but that is materially different from a conclusion that all U.S. carriers therefore follow sound safety practices."

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[37] As a result of its investigation into this accident, however, the Safety Board determined that the KCAB was ineffective in its oversight of Korean Air's operations and pilot training programs.

[38] The Safety Board acknowledges that KCAB operations inspectors now assigned to Korean Air have type ratings for the 747. However, at the time of the flight 801 accident, there were signs suggesting systemic problems within Korean Air's operations and pilot training programs that indicated the need for a broad assessment of these programs. No such assessment was carried out by Korean Air or the KCAB before the accident.

[39] Korean Air experienced a series of accidents (beginning before and continuing after the Guam accident) involving crew coordination and performance.

[40] DOT/IG Report No. AV-1999-138, September 30, 1999.

The Safety Board concludes that the FAA's IASA program (which evaluates a foreign CAA's ability to provide adequate oversight for its air carriers) is not adequate to determine whether foreign air carriers operating into the United States are maintaining an adequate level of safety. The Board notes that the DOT/IG's audit report recommended that U.S. carriers perform safety assessments of foreign carriers as a condition of approval to enter into code share agreements and that the FAA should consider the results of those assessments when performing IASA reviews. Further, the Safety Board believes that the FAA should consider the accident and incident history of foreign air carriers as a factor when evaluating the adequacy of a foreign CAA's oversight and whether a reassessment may be warranted.

Therefore, the National Transportation Safety Board makes the following recommendations to the Federal Aviation Administration:

> Require principal operations inspectors assigned to U.S. air carriers to ensure that air carrier pilots conduct a full briefing for the instrument approach (if available) intended to back up a visual approach conducted at night or when instrument meteorological conditions may be encountered. (A-00-7)
>
> Consider designating Guam International Airport as a special airport requiring special pilot qualifications. (A-00-8)
>
> Disseminate information to pilots, through the Aeronautical Information Manual, about the possibility of momentary erroneous indications on cockpit displays when the primary signal generator for a ground-based navigational transmitter (for example, a glideslope, VOR, or nondirectional beacon transmitter) is inoperative. Further, this information should reiterate to pilots that they should disregard any navigation indication, regardless of its apparent validity, if the particular transmitter was identified as unusable or inoperative. (A-00-9)
>
> Conduct or sponsor research to determine the most effective use of the monitored approach method and the maximum degree to which it can be safely used and then require air carriers to modify their procedures accordingly. (A-00-10)
>
> Issue guidance to air carriers to ensure that pilots periodically perform nonprecision approaches during line operations in daytime visual conditions in which such practice would not add a risk factor. (A-00-11)

Develop a mandatory briefing item for all air traffic controllers and air traffic control (ATC) managers, describing the circumstances surrounding the performance of the Combined Center/Radar Approach Control controller in this accident to reinforce the importance of following ATC procedures. (A-00-12)

Require that all air carrier airplanes that have been equipped with on-board navigational systems capable of providing vertical flightpath guidance make use of these systems for flying nonprecision approaches whenever terrain factors allow a constant angle of descent with a safe gradient. (A-00-13)

Require, within 10 years, that all nonprecision approaches approved for air carrier use incorporate a constant angle of descent with vertical guidance from on-board navigation systems. (A-00-14)

Include, in nonprecision approach procedures, tabular information that allows pilots to fly a constant angle of descent by cross-referencing the distance from the airport and the barometric altitude. (A-00-15)

Evaluate the benefits of depicting terrain and other obstacles along a specific approach path on the profile view of approach charts and require such depiction if the evaluation demonstrates the benefits. (A-00-16)

Provide user groups, along with Federal Aviation Administration Form 8260, draft plan and profile views of instrument procedures to assist the groups in effectively evaluating proposed new procedures. (A-00-17)

Consider the accident and incident history of foreign air carriers as a factor when evaluating the adequacy of a foreign civil aviation authority's oversight and whether a reassessment may be warranted. (A-00-18)

Chairman HALL, Vice Chairman FRANCIS, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

Original Signed

By: Jim Hall
Chairman