Home > Accident Investigations > Reports

AIRCRAFT ACCIDENT REPORT

Descent Below Visual Glidepath and Impact With Seawall, Asiana Airlines Flight 214

San Francisco, California
July 6, 2013

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EXECUTIVE SUMMARY

On July 6, 2013, about 1128 Pacific daylight time, a Boeing 777-200ER, Korean registration HL7742, operating as Asiana Airlines flight 214, was on approach to runway 28L when it struck a seawall at San Francisco International Airport (SFO), San Francisco, California. Three of the 291 passengers were fatally injured; 40 passengers, 8 of the 12 flight attendants, and 1 of the 4 flight crewmembers received serious injuries. The other 248 passengers, 4 flight attendants, and 3 flight crewmembers received minor injuries or were not injured. The airplane was destroyed by impact forces and a postcrash fire. Flight 214 was a regularly scheduled international passenger flight from Incheon International Airport, Seoul, Korea, operating under the provisions of 14 Code of Federal Regulations Part 129. Visual meteorological conditions prevailed, and an instrument flight rules flight plan was filed.

The flight was vectored for a visual approach to runway 28L and intercepted the final approach course about 14 nautical miles (nm) from the threshold at an altitude slightly above the desired 3° glidepath. This set the flight crew up for a straight-in visual approach; however, after the flight crew accepted an air traffic control instruction to maintain 180 knots to 5 nm from the runway, the flight crew mismanaged the airplane's descent, which resulted in the airplane being well above the desired 3° glidepath when it reached the 5 nm point. The flight crew's difficulty in managing the airplane's descent continued as the approach continued. In an attempt to increase the airplane's descent rate and capture the desired glidepath, the pilot flying (PF) selected an autopilot (A/P) mode (flight level change speed [FLCH SPD]) that instead resulted in the autoflight system initiating a climb because the airplane was below the selected altitude. The PF disconnected the A/P and moved the thrust levers to idle, which caused the autothrottle (A/T) to change to the HOLD mode, a mode in which the A/T does not control airspeed. The PF then pitched the airplane down and increased the descent rate. Neither the PF, the pilot monitoring (PM), nor the observer noted the change in A/T mode to HOLD.

As the airplane reached 500 ft above airport elevation, the point at which Asiana's procedures dictated that the approach must be stabilized, the precision approach path indicator (PAPI) would have shown the flight crew that the airplane was slightly above the desired glidepath. Also, the airspeed, which had been decreasing rapidly, had just reached the proper approach speed of 137 knots. However, the thrust levers were still at idle, and the descent rate was about 1,200 ft per minute, well above the descent rate of about 700 fpm needed to maintain the desired glidepath; these were two indications that the approach was not stabilized. Based on these two indications, the flight crew should have determined that the approach was unstabilized and initiated a go-around, but they did not do so. As the approach continued, it became increasingly unstabilized as the airplane descended below the desired glidepath; the PAPI displayed three and then four red lights, indicating the continuing descent below the glidepath. The decreasing trend in airspeed continued, and about 200 ft, the flight crew became aware of the low airspeed and low path conditions but did not initiate a go-around until the airplane was below 100 ft, at which point the airplane did not have the performance capability to accomplish a go-around. The flight crew's insufficient monitoring of airspeed indications during the approach resulted from expectancy, increased workload, fatigue, and automation reliance.

When the main landing gear and the aft fuselage struck the seawall, the tail of the airplane broke off at the aft pressure bulkhead. The airplane slid along the runway, lifted partially into the air, spun about 330°, and impacted the ground a final time. The impact forces, which exceeded certification limits, resulted in the inflation of two slide/rafts within the cabin, injuring and temporarily trapping two flight attendants. Six occupants were ejected from the airplane during the impact sequence: two of the three fatally injured passengers and four of the seriously injured flight attendants. The four flight attendants were wearing their restraints but were ejected due to the destruction of the aft galley where they were seated. The two ejected passengers (one of whom was later rolled over by two firefighting vehicles) were not wearing their seatbelts and would likely have remained in the cabin and survived if they had been wearing their seatbelts.

After the airplane came to a stop, a fire initiated within the separated right engine, which came to rest adjacent to the right side of the fuselage. When one of the flight attendants became aware of the fire, he initiated an evacuation, and 98% of the passengers successfully self-evacuated. As the fire spread into the fuselage, firefighters entered the airplane and extricated five passengers (one of whom later died) who were injured and unable to evacuate. Overall, 99% of the airplane's occupants survived.

The safety issues discussed in the report relate to the need for the following:

- **Adherence of Asiana pilots to standard operating procedures (SOP) regarding callouts.** The flight crew did not consistently adhere to Asiana's SOPs involving selections and callouts pertaining to the autoflight system's mode control panel. This lack of adherence is likely the reason that the PF did not call out "flight level change" when he selected FLCH SPD. As a result, and because the PM's attention was likely on changing the flap setting at that time, the PM did not notice that FLCH SPD was engaged.
- **Reduced design complexity and enhanced training on the airplane's autoflight system.** The PF had an inaccurate understanding of how the Boeing 777 A/P and A/T systems interact to control airspeed in FLCH SPD mode, what happens when the A/T is overridden and the throttles transition to HOLD in a FLCH SPD descent, and how the A/T automatic engagement feature operates. The PF's faulty mental model of the airplane's automation logic led to his inadvertent deactivation of automatic airspeed control. Both reduced design complexity and improved systems training can help reduce the type of error that the PF made.
- **Opportunity at Asiana for new instructors to supervise trainee pilots in operational service during instructor training.** The PM was an experienced 777 captain who was on his first flight as an instructor pilot supervising a trainee captain gaining operating experience. The PM did not have the opportunity during his instructor training to supervise and instruct a trainee during line operations while being observed by an experienced instructor. Such an opportunity would have improved the PM's awareness of the

dynamic and often unpredictable challenges that an instructor must deal with when supervising a trainee during line operations.

- **Guidance for Asiana pilots on use of flight directors during a visual approach.** During the accident flight, after the A/P was disconnected, the PM loosely followed Asiana's informal practice, which was to turn both flight directors (F/Ds) off and then turn the PM's F/D back on when conducting a visual approach. However, the two F/D switches were not both in the off position at the same time. If they had been, the A/T mode would have changed to speed mode and maintained the approach speed of 137 knots. In addition, during a visual approach, F/D pitch and roll guidance is not needed and can be a distraction.

- **More manual flight for Asiana pilots.** Asiana's automation policy emphasized the full use of all automation and did not encourage manual flight during line operations. If the PF had been provided with more opportunity to manually fly the 777 during training, he would most likely have better used pitch trim, recognized that the airspeed was decaying, and taken the appropriate corrective action of adding power. Federal Aviation Administration (FAA) guidance and a recent US regulatory change support the need for pilots to regularly perform manual flight so that their airplane handling skills do not degrade.

- **A context-dependent low energy alert.** The airplane was equipped with a low airspeed alerting system that was designed to alert flight crews to low airspeed in the cruise phase of flight for the purpose of stall avoidance. However, this accident demonstrates that existing low airspeed alert systems that are designed to provide pilots with redundant aural and visual warning of impending hazardous low airspeed conditions may be ineffective when they are developed for one phase of flight (e.g., cruise) and are not adequately tailored to reflect conditions that may be important in another phase of flight (e.g., approach). During the approach phase of flight, a low airspeed alert may need to be designed so that its activation threshold takes airspeed (kinetic energy), altitude (potential energy), and engine response time into account.

- **Research that examines the injury potential from significant lateral forces in airplane crashes and the mechanism that produces high thoracic spinal injuries.** In this accident, the dynamics were such that occupants were thrown forward and experienced a significant lateral force to the left during the impact sequence. One passenger sustained serious head injuries as a result of striking the arm rest of the seat that was in front of and to his left. While current FAA dynamic seat certification requirements do include testing row/row seat interactions with seats positioned slightly off the longitudinal axis, they would not likely approximate the forces encountered in this accident. Further, there was a high number of serious injuries to the high thoracic spine in this accident, and the mechanism that produces these injuries is poorly understood.

- **Evaluation of the adequacy of slide/raft inertia load certification testing.** The forces experienced by the slide/rafts during the impact sequence far exceeded their certification limits, leading to overload failures of the slide/raft release mechanisms on the 1R and 2R slide/rafts. Given the critical nature of these evacuation devices and their proximity to essential crewmembers, slides and slide/rafts must be certified to sufficient loads so that they will likely function in a survivable accident. Although this exact accident scenario is unlikely to occur again, the data obtained during this accident investigation could prove useful for future slide/raft design.

- **Aircraft rescue and firefighting (ARFF) training for officers placed in command of an aircraft accident.** The arriving incident commander placed an officer in charge of the fire attack who had not received ARFF training, and this individual made decisions that reflected his lack of ARFF training. Although no additional injuries or loss of life could be attributed to the fire attack supervisor's lack of ARFF training, it demonstrates the potential strategic and tactical challenges associated with having nonARFF trained personnel in positions of command at an airplane accident.

- **Guidance on when to pierce the fuselage of a burning airplane with a skin-piercing nozzle.** The airport's fire department had two vehicles equipped with high-reach extendable turrets (HRETs) that were not used to the best of their capabilities in the initial attack. This was partially the result of departmental guidance that discouraged penetration of the fuselage using the skin-piercing nozzles on the HRETs until all of the occupants were known to have evacuated the airplane. Current FAA guidance provides information on how to pierce but does not include any guidance on when to pierce.

- **Integration of the medical supply buses at SFO into the airport's preparation drills.** Although the airport's emergency procedures manual called for airport operations personnel to deliver the airport's two emergency medical buses to the accident site, neither of the medical buses arrived. Further, the monthly emergency drills conducted by the airport did not include deployment of the buses either as a matter of routine or as part of the unique scenario being evaluated. This lack of integration of the medical buses into the airport's preparation drills likely played a part in their lack of use in the initial response to the accident.

- **Guidance or protocols for ensuring the safety of passengers and crew at risk of being struck or rolled over by a vehicle during ARFF operations.** In this case, only one passenger was at significant risk for a vehicle strike due to her close proximity to the burning airplane; however, there are other accident scenarios in which many injured or deceased persons could be located near an accident airplane. There is currently no guidance or any recommended protocols for ensuring the safety of passengers and crew at risk of being struck or rolled over by a vehicle during ARFF operations.

- **Requirements for ARFF staffing.** Seven ARFF vehicles and 23 ARFF personnel from SFO's fire department were involved in the initial response to the accident. This equipment level exceeded the FAA-required minimum of three vehicles, and there is currently no FAA-required minimum staffing level. Because of the amount of available ARFF vehicles and personnel, the airport firefighters were able to perform exterior firefighting and send firefighters into the airplane who rescued five passengers who were unable to self-evacuate amid rapidly deteriorating cabin conditions. Due to the lack of an FAA-required minimum staffing level, passengers involved in an aviation accident at a smaller airport may not be afforded the same level of protection that the passengers of flight 214 had.

- **Improvements in emergency communications at SFO.** Numerous problems with communications occurred during the emergency response, the most critical being the inability for responding mutual aid units to speak directly with units from the airport on a common radio frequency. Although some of the communications difficulties encountered during the emergency response, including the lack of radio interoperability, have been remedied, others, such as the breakdown in communications between the airport and city dispatch centers, should be addressed.

- **Increased FAA oversight of SFO's emergency procedures manual.** Although the airport had submitted, and the FAA had approved in December 2012, an updated emergency procedures manual, the airport had not yet distributed or trained personnel on the updated manual when the accident occurred and was still actively operating with the manual approved by the FAA in December 2008.

As a result of this investigation, the NTSB makes safety recommendations to the FAA, Asiana Airlines, Boeing, the Aircraft Rescue and Firefighting Working Group, and the City and County of San Francisco.

Probable Cause

The National Transportation Safety Board (NTSB) determined that the probable cause of this accident was the flight crew's mismanagement of the airplane's descent during the visual approach, the PF's unintended deactivation of automatic airspeed control, the flight crew's inadequate monitoring of airspeed, and the flight crew's delayed execution of a go-around after they became aware that the airplane was below acceptable glidepath and airspeed tolerances. Contributing to the accident were (1) the complexities of the autothrottle and autopilot flight director systems that were inadequately described in Boeing's documentation and Asiana's pilot training, which increased the likelihood of mode error; (2) the flight crew's nonstandard communication and coordination regarding the use of the autothrottle and autopilot flight director systems; (3) the PF's inadequate training on the planning and execution of visual approaches; (4) the PM/instructor pilot's inadequate supervision of the PF; and (5) flight crew fatigue, which likely degraded their performance.

Resources

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