Automation exceptions and flight path management

by Roger Cox

Discussions about automation over-reliance often focus on what happens when an automatic feature fails. In the Asiana 214 accident in San Francisco last year, the automation worked exactly as designed but the crew misunderstood it and failed to take over manually in time to prevent the accident. I was the NTSB's operational factors investigator in the investigation of the Asiana 214 accident in San Francisco last year, and I am writing this short article to discuss the crew's misunderstandings and mindset in managing the automation.

The flight was high on a visual approach to runway 28L and the pilot flying (PF) put the airplane into an idle power descent on final approach. The thrust levers remained in idle for one minute ten seconds as the airplane descended from 1,500 ft. to 86 ft. and as the airspeed dropped from 169 knots to 109 knots. Coincidentally, the flight passed through the 500 foot stabilised approach window very close to on speed and on path, but it was descending too fast and the crew made no adjustments. The pilot monitoring (PM) finally advanced the throttles to attempt a go-around, but he was too late. The airplane struck the seawall, bounced and pirouetted down the runway, and caught fire shortly after it stopped.

The three pilots in the cockpit were shaken up but survived. Shortly after the accident they each told investigators they believed the autothrottle should have engaged automatically and maintained the selected approach speed. None of the pilots could remember where the thrust levers were positioned or what the engine power settings were during the last minutes of the approach as they sank lower and lower below the proper approach path. They made an incorrect assumption about how the autothrottle worked and they didn't have a plan for what to do if their assumption was wrong.

The Boeing 777, which was the type involved in the accident, has a full time autothrottle (A/T). It is designed to be used either paired with the autopilot or when the airplane is being flown manually by the pilot. The A/T has an automatic engagement feature commonly referred to as "A/T wakeup." The feature will engage the A/T automatically if the airspeed is detected to be below a minimum threshold for one second. According to Boeing, at flaps 30, the minimum threshold is 8 knots below Vref. If it had engaged on the accident flight it would have returned the airspeed to 137, the selected approach speed. However, the feature does not function in all circumstances. There is an automation exception.

When the autothrottle is in a mode known as "hold," its servos are disengaged and engine thrust is controlled by where the pilot positions the throttles. Boeing created this exception to the full time autothrottle to give the pilot added control and flexibility. In older models when the pilot wanted to make a temporary adjustment to engine thrust he had to disengage the autothrottle. With the advent of hold mode, the autothrottle senses when the pilot adjusts the throttles and relinquishes

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control; it notifies the pilot it is doing so by announcing HOLD in green on a coloured electronic display[49] located in front of each pilot. Unfortunately, when the PF put the airplane in hold mode, he didn't see the annunciation and didn't realise he was telling the autothrottle to relinquish control. Even though he had completed most of his training on the 777 he didn't understand the built-in automation exception.

The PF wasn't alone in his misunderstanding. Many of the 777 pilots investigators spoke with did not realise the autothrottle could effectively become dormant. There were several reasons for this. First, the Boeing flight crew operations manual (FCOM) was less than clear about the exception. Second, the presentation slides used in training did not mention the exception. Finally, the simulator training demonstrating the wakeup feature did not show how the exception could prevent wakeup from taking place. Ironically, one company instructor who had experienced the exception during approaches several times himself taught his students, including the accident PF, about it, but his message was never incorporated in company manuals or passed back to Boeing for clarification.

Given that the three pilots in the cockpit did not understand the automation exception, what is hard to understand is why none of them took timely action to prevent the accident. The day was sunny and clear, the runway was in full view, and there were multiple cues, including a PAPI[50] and a VDI[51] in the cockpit to show them they were getting low and slow. From the time the airspeed first dropped below the selected approach speed of 137 knots until the throttles were advanced, 28 seconds elapsed. It would seem there was ample time to act. Had the crew simply intervened at 500 feet and pushed the thrust up to the normal setting for an approach they would have landed safely.

An examination of the company's policies and actual practices with regard to use of automation showed they wanted pilots to use the highest level of automation available. The company 777 chief pilot confirmed this, saying the airline recommended using as much automation as possible. Pilots were expected to turn the A/P and A/T on as soon as possible on departure and leave it on until at or near the completion of the flight. The accident pilots had good records and clearly had complied with the company's policy throughout their careers. They trusted the automation and relied on it, as they were taught.

In a study[52] published in 2013, the PARC/CAST Flight Deck Automation Working Group found that although automated systems had contributed significantly to safety for many years, pilots sometimes relied too much on automated systems and might be reluctant to intervene. The first point made under the report's recommendation 9 was "the policy should highlight and stress that the responsibility for flight path management remains with the pilots at all times. Focus the policy on flight path management, rather than automated systems."

In order for pilots to be able to focus on flight path management, they need the flexibility to move between different levels of automation, from fully engaged to semi-automatic to manual flight. Excessively rigid automation policies inhibit that flexibility. The FAA recognised this in 2013 when it issued SAFO 13002, "Manual Flight Operations" and when it revised air carrier rules to increase manually flown manoeuvres in training.

The accident crew encountered an automation exception they did not understand. Regardless of why the autothrottle stopped functioning, the crew's first priority should have been correcting the flight path and energy state. In its accident report, the NTSB made 16 findings and 13 recommendations related to operations and human performance. One of those recommendations, A-14-55, made to the airline, says "modify your automation policy to provide for manual flight, both in training and line operations, to improve pilot proficiency." Implicit in this recommendation is the need for pilots to better recognise when the automation is not working as they expect and to have a plan for taking over and using semi-automatic or manual methods to control the flight path and energy state of the airplane when necessary.

49- The display is called flight management annunciator , or FMA.
50- Precision approach path indicator
51- Vertical deviation indicator
52- 'Operational use of Flight Path Management systems," Final Report of the Performance-based operations Aviation Rulemaking Committee/ Commercial Aviation Safety Team Flight Deck Automation Working Group, September 5, 2013