Absence of Reasonableness

A 100-tonne takeoff weight error eluded several checks.

BY MARK LACAGNINA

The Airbus A340 was 100,000 kg (220,460 lb) heavier than the takeoff weight entered into its computers and did not respond to normal control pressure at the calculated rotation speed. When the first officer, the pilot flying, increased back pressure on the sidestick, the aircraft rotated but still was moving too slowly to lift off. The captain realized that something was not right and applied full power. The A340 finally became airborne after running off the runway and destroying several lights and localizer antennas. Damage was substantial, but there were no injuries.

During its investigation of the March 20, 2009, accident at Melbourne Airport, the Australian Transport Safety Bureau (ATSB) found similarities to several other recent occurrences in which flight crews apparently were unable to perform "reasonableness checks" that likely would have revealed gross errors in the data used for calculating takeoff performance parameters such as V-speeds and thrust settings (see InfoScan, p. 53).

"Equally significant was that the degraded takeoff performance [resulting from the gross errors] was generally not detected by the flight crews until well into the takeoff run, if at all," the bureau said.

The data-entry error that set up the accident at Melbourne led to calculations of a thrust

This A340 was substantially damaged in a tail strike and overrun at Melbourne Airport.

Australian Transport Safety Bureau

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setting and V-speeds that were too low. In its report on the accident, ATSB said that distractions and "the effect of expectation" rendered ineffective several subsequent checks and cross-checks of the takeoff weight and performance calculations. Further, the flight crew's ability to gauge the "reasonableness" of the calculations was found to have been affected in part by large variations in the size and performance of the aircraft that they routinely flew.

The report also cited the limited ability of humans to perceive acceleration, especially at night, as a significant factor in the crew's late recognition of the aircraft's relatively sluggish performance.

Ahead of Schedule

The aircraft was being operated as Emirates Flight EK407, with 257 passengers and 18 crewmembers bound for Dubai, United Arab Emirates (UAE). The flight had begun that morning in Auckland, New Zealand. The leg from Auckland to Melbourne had been flown by other members of the augmented flight crew. "The flight was several minutes ahead of schedule, and there were no time pressures affecting the flight crew," the report said.

Both pilots assigned to the leg from Melbourne to Dubai regularly flew the A330-243 and the A340-313K, as well as the accident aircraft, an A340-541 registered in the UAE as A6-ERG. The captain had 8,195 flight hours, including 1,372 hours in the A340-541. The first officer had 8,316 flight hours, including 425 hours in the -541.

"The pre-departure preparation included the use of an electronic flight bag laptop computer (EFB) to calculate the performance parameters (takeoff reference speeds and flap and engine settings) for the takeoff from Runway 16," the report said. Among the data required to be entered into the EFB were wind speed and direction, outside air temperature and takeoff weight (Figure 1, p. 14).

The loadsheet showed a takeoff weight of 361.9 tonnes. "So that flights were not unnecessarily delayed [due to last-minute changes such as late passenger arrivals], the operator permitted the flight crew to make minor alterations to the weight and balance information on the loadsheet without the need to issue a new loadsheet," the report said. Accordingly, the first officer added 1,000 kg (1 tonne, or 2,200 lb), the maximum alteration allowed by Emirates.

"When entering the takeoff weight into the EFB, however, the first officer inadvertently entered 262.9 tonnes, instead of the intended 362.9 tonnes, and did not notice that error," the report said. In human factors terminology, the data-entry error was a *slip*. "Most likely, the first officer made a typing slip, where the '2' key was accidently pressed instead of the adjacent '3' key," the report said.

The first officer transcribed the takeoff weight and calculated performance parameters from the EFB onto the master flight plan while discussing an apparently confusing aspect of an assigned departure procedure with the captain. The weight error again went unnoticed.

The first officer then handed the EFB to the captain, so that he could check the data per standard operating procedure (SOP). "There was a lot of activity in the cockpit at that time, and it is likely that the associated distractions degraded the captain's checks," the report said, noting that there were several people in the cockpit and in the forward galley area, including maintenance technicians, flight attendants and the other members of the augmented flight crew.

The captain might have been further distracted from a thorough check of the EFB data by the first officer's radio communication with air traffic control (ATC) regarding the departure clearance, and thus another opportunity to detect the erroneous takeoff weight was lost, the report said.

Company SOP did not require available non-operational flight crewmembers to check performance calculations. "Although not required by the operator's procedures, had the augmenting captain had the opportunity to perform his own check of the takeoff performance calculations, he may have detected the takeoff weight entry error," the report said.

'Just Numbers'

The inadvertent entry of 262.9 tonnes into the EFB had yielded calculations of 143 kt for V_1, which the report defined as "decision speed," and 145 kt for V_R, rotation speed. (The correct speeds for the actual takeoff weight, 362.9 tonnes, were 149 kt and 161 kt, respectively.)

Based on the incorrect takeoff weight, the EFB also provided a flex temperature — an assumed temperature used in calculations for a reduced-thrust takeoff — of 74 degrees C. (The correct temperature was 43 degrees C.)

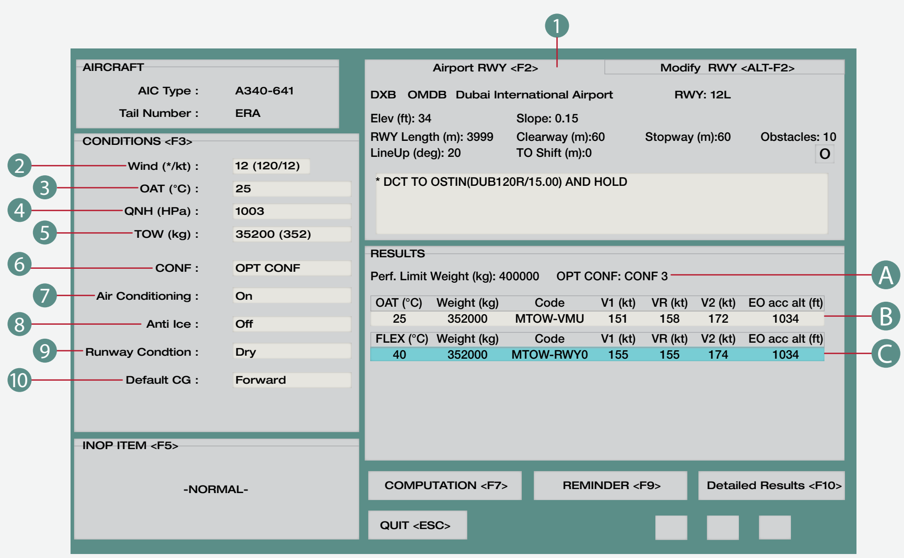
The first officer later told investigators that the flex temperature calculated by the EFB "looked high" and that he intended to check it. However, he "became distracted by other tasks and believed that subsequent checks would detect whether the figure was inaccurate," the report said.

The captain entered the EFB performance figures into the aircraft's flight management guidance system (FMGS) and began a silent check of the data. However, "while completing this check, he became distracted by other tasks and activities in the cockpit," the report said. "This diverted his attention away from checking the EFB for a short period."

The captain momentarily engaged in a discussion with the first officer about the departure clearance and in a nonpertinent conversation with another person in the cockpit. The pilots then verbally cross-checked the takeoff performance calculations that had been entered by the captain into the FMGS against those that the first officer had recorded on the master flight plan. They did not realize that both sets of figures were based on an incorrect takeoff weight.

Except for the first officer's momentary concern about the flex temperature, the calculations did

EFB Takeoff Performance Screen (example)



1. Desired runway
2. Wind speed and direction
3. Outside air temperature
4. Altimeter setting
5. Proposed takeoff weight
6. Flap configuration
7. Air conditioning status
8. Anti-ice selection
9. Runway surface conditions
10. Aircraft center of gravity position

EFB = electronic flight bag

Note: Selection of the COMPUTATION button calculated the takeoff performance data and displayed (A) performance-limited takeoff weight and optimum flap configuration for the selected runway and entered conditions; (B) takeoff speeds and the engine-out acceleration altitude for the proposed takeoff weight using full takeoff thrust at the actual outside air temperature; and (C) takeoff speeds and engine-out acceleration altitude for the proposed takeoff weight using less than full takeoff thrust based on a computed flex takeoff thrust temperature value.

Source: Australian Transport Safety Bureau

Figure 1

not seem unreasonable to the crew. They were accustomed to seeing takeoff reference speeds that varied by up to 50 kt in the aircraft they flew: the A340-541, with a maximum takeoff weight of 372 tonnes; the A340-313K, 275 tonnes; and the A330-243, 230 tonnes. The takeoff weights of the aircraft that the crew had flown in the two months preceding the accident had ranged from 150 to 370 tonnes.

"The flight crew reported observing a wide range of takeoff performance parameters during normal operations, as well as significant variations in passenger loads across routes and aircraft types," the report said. "Both the captain and the first officer reported that this resulted in the takeoff performance figures losing significance and becoming 'just numbers.'"

Tail Strike

Visibility was greater than 10 km (6 mi) and there were no clouds below 5,000 ft when the crew began the takeoff from Runway 16 at 2230 local time. The pilots recalled that the takeoff seemed normal until the aircraft was 1,043 m (3,422 ft) from the departure end of the 3,657-m (11,999-ft) runway and the captain called "rotate."

"The first officer, who was the pilot flying, applied a back-stick (nose up) command to the sidestick, but the nose of the aircraft did not rise as expected," the report said. "The captain again called 'rotate,' and the first officer applied a greater back-stick command. The nose began to rise, but the aircraft did not lift off from the runway."

The A340 was 57 m (187 ft) from the end of the runway when the captain applied takeoff/go-around (TO/GA) thrust. The aircraft was accelerating through 157 kt as it overran the runway, the 120-m (394-ft) clearway and the 60-m (197-ft) stopway.

"The aircraft became airborne three seconds after the selection of TO/GA, but before gaining altitude it struck a Runway 34 lead-in sequence strobe light and several antennas, which disabled the instrument landing system for Runway 16," the report said, noting that the outcome might have been far more serious if the captain had not applied full thrust.

A cockpit annunciator and a radio call from ATC alerted the crew that a tail strike had occurred. The captain declared an urgency and coordinated with ATC to jettison fuel before returning to the airport. When the crew retrieved the EFB to make landing performance calculations, they noticed the 100-tonne takeoff weight error.

The A340 was landed on Runway 34 at 2336 and, after a brief inspection by aircraft rescue and fire fighting personnel, was taxied to the terminal, where the passengers disembarked normally. Examination of the aircraft revealed severe abrasion of skin panels on the bottom of the rear fuselage, deformation of fuselage frames and stringers in the area, and a cracked rear pressure bulkhead.

Gauging Acceleration

The flight crew told investigators that they had perceived the aircraft's acceleration during the takeoff roll as typical of a heavy A340. "They did not realize that there was a problem with the aircraft's acceleration until they had nearly reached the end of the runway and the red runway end lights became more prominent," the report said. "Both [pilots] reported that during operations from some runways at other airports, it was common to see the red runway end lights as the aircraft lifted off."

Performance certification standards and takeoff performance calculations *assume* that an aircraft will accelerate sufficiently, the report said. Over the years, several attempts to develop cockpit takeoff performance monitoring systems have been abandoned due to the complexity of the systems and the excess workload they would impose on the flight crew.

"At the time of the accident, there was no means available to the flight crew to monitor the performance of the aircraft during the takeoff roll," the report said. "The safety of the takeoff relied on the accuracy of the takeoff performance calculations and on the flight crew detecting any degraded performance during the takeoff roll."

Lacking a quantitative method of measuring acceleration, pilots must rely on previous experience to judge an aircraft's takeoff performance, the report said. "A human's ability to determine acceleration is neither an accurate nor reliable means to assess takeoff performance. Furthermore, that accuracy and reliability are further degraded in darkness."

During the accident investigation, ATSB queried the European Aviation Safety Agency (EASA) and the U.S. Federal Aviation Administration (FAA) on progress toward the development of takeoff performance monitoring systems. EASA replied that it is cooperating with the European Organisation for Civil Aviation Equipment on reviewing "state of the art options" that might lead to the establishment of standards for developing such systems. The FAA said that although it had found the idea of such systems "with all their inherent complexity to be more problematical than reliance on adequate airmanship," it nevertheless "would be happy … to revisit the issue in the light of new information or ideas."

This article is based on ATSB Transport Safety Report AO-2009-012, "Tailstrike and Runway Overrun; Melbourne Airport, Victoria; 20 March 2009; A6-ERG, Airbus A340-541," Dec. 16, 2011. The report is available at <atsb.gov.au>.