GET THE FIGURES RIGHT

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From Computation to Performance

On the night of 20 March 2009 Emirates Flight EK407, an Airbus 340-541, first sustained a tailstrike and then took off by overrunning the end of the runway on departure from Melbourne Airport's 3657 metre long runway 16.

A successful lift-off requires thrust and speed. These depend on ambient conditions and critically, on the actual weight of the aircraft.

On flight EK407 the flight crew made a mistake while entering the take-off performance parameters into the electronic flight bag (EFB) and then copying these data into the Flight Management Computer.

The flight crew did not detect the incorrect data entry in subsequent checks. Before take-off, their fuelled aircraft weighed 362 tones. But they had accidentally entered a weight of only 262 tones, resulting in too little engine power. It was only late in the take-off run that the pilots realized their potentially fatal mistake and applied TO/GA power.

In climb the cabin did not pressurize as a consequence of the tailstrike having cracked the composite rear pressure bulkhead and deformed the bulkhead diaphragm support ring.

A mistake during data entry and subsequent ineffective and superficial verification by the flight crew led to the occurrence.

ERROR
Emirates Flight EK407 experienced a tail-strike take-off after a pilot's mistake when entering the take-off performance parameters.

It became obvious that the flight crew had failed, as other crew in many other occurrences, to perform reasonableness checks to determine if the parameters were appropriate for the flight. The Australian Transport Safety Bureau's accident report also highlights that the flight crew did not detect the degraded take-off performance until well into the take-off run.

Typing figures into a machine is no easy task

Pilots often err when calculating takeoff parameters. Some interesting studies have been conducted to better understand the nature of such errors and to explore ways to avoid that such errors are repeated.

In 2008 the French BEA published a report by the Laboratoire d'Anthropologie Appliquée (LAA) on the "Use of Erroneous Parameters at Takeoff". The most salient conclusions are:

❍ The variety of events shows that the problem of determining and using takeoff parameters is independent of the operating airline, of the aircraft type, of the equipment and of the method used;

❍ Half of the crews who responded to the survey of participating airlines had experienced errors in parameters or configuration at takeoff, some of which involved the weight input into the FMS;

❍ Checks on the "takeoff parameter calculation" function can be ineffective because they consist of verifying the input of the value but not the accuracy of the value itself,

In addition, the FMS itself normally does not alert pilots when weight and speed values are missing or grossly wrong.

In a survey, pilots cited their strategy to avoid significant errors: pilots first determine by empirical methods (i.e. experience) the order of magnitude of takeoff parameters for a given airplane type and then compare these remembered parameters to compare them with the actual parameters. However, since such parameters change with environmental conditions and airplane configuration/weight, pilots struggle to maintain experienced parameters in working memory for a long time and they typically do not succeed in creating an internal representation of the values. This might explain why pilots do not possess orders of magnitude of speeds and thus do not raise a doubt over values incompatible with the flight. This loss of memory is accentuated in cases where pilots do not fly very often, as is the case in many business aircraft operations.

An important factor for erroneous takeoff parameters is distraction and time pressure shortly before departure, ineffective procedures and non-compliance with procedures.

The design of automated systems can also contribute to errors. The user interface and the functionalities vary between different EFB system providers and subtle differences can make a big difference. The loss of a B747-200 freighter in 2004 in Halifax was traced to miscalculated power settings. The EFB retained data from the previous flight and this data was used erroneously to calculate the power setting for the take-off in Halifax.

Preventing errors in entering data

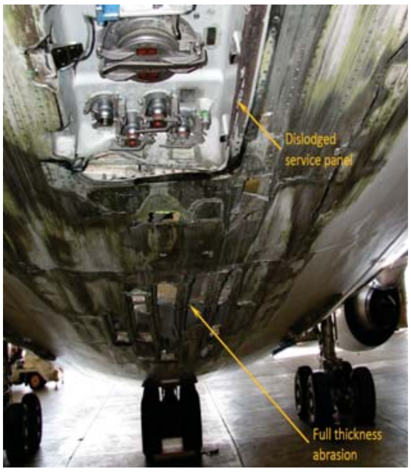
Procedures and their disciplined implementation are and remain the most powerful risk control mechanism, in particular when it comes to information flow across several persons and systems. Advisory Circular (AC) 120-76B, recently released by the US FAA, contains guidelines for the certification, airworthiness and operational use of EFBs. This document is a useful reference with regard to the development of procedures related to the use of EFBs, as it includes instructions to "avoid complex, multi-step data entry tasks during takeoff, landing and other critical phases of flight. An evaluation of EFB intended functions should include a qualitative assessment of incremental pilot workload, as well as pilot system interfaces and their safety implications."

Pressures of the Operating Environment

Distraction is the number one killer of discipline and procedural stability. Interruption, task resumption and prospective memory also contribute to errors. Prospective memory means the intention to perform an action in the future, coupled with a delay between recognizing the need for the action and the opportunity to perform it.[1]

The ATSB Accident Report clearly states: "Although SOPs are normally presented in operational documents in a sequential manner, in the operating environment, many of them can often be carried out in parallel or in a different order, depending on the flow of information into the cockpit."

In the context of utilizing electronic tools such as EFBs, pilots easily type wrong figures into the algorithm, resulting into wrong outputs, which become the input to the FMS which in turn controls the energy status of the flight. The majority of errors, slips and lapses pilots incur into, as studies have shown, involve attention problems, most often related to competing demands in high-tempo operations.[2] It also appears, as another study found, that the majority of errors occurs during pre-departure, takeoff, and descent-approach-landing.



Crews detect errors by routine checks, in particular when crews suspected a problem and go looking for it.

In the case of the EK407, the crew did not suspect a mistake and attention was low. Many commentators of the Australian report criticized it for not acknowledging fatigue as a major contributor to such errors.

Interaction with Automation

Data presented by automated systems is perceived by system users as being highly reliable and accurate. This is a dangerous assumption, since automation only presents data either entered by humans or calculated along man-made algorithms.

As computer scientists like to remind us: garbage in - garbage out. Utilizing an EFB requires pilots to be aware of transcription errors, keystroke errors, and the selection/calculation of incorrect data. This gross error check was unfortunately not successfully performed by the crew of EK407 on that night when preparing for departure. The screen figures were indeed wrong.

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[1] Dismukes, K. (2006). Concurrent task management and prospective memory: pilot error as a model for the vulnerability of experts. In Proceedings of the Human Factors and Ergonomics Society 50th Annual Meeting – 2006, 909-913.

[2] Sarter, N.B. & Alexander, H.M. (2000). Error types and related error detection mechanisms in the aviation domain: an analysis of aviation safety reporting system incident reports. The International Journal of Aviation Psychology 10(2), 189-206.

SCRATCH
Serious dents in the airframe and scratches in the runway' surface resulted from the faulty take-off.