RESEARCH BRIEF

Research Request:

Risks Associated With Pilots Flying Dissimilar Aircraft

Research Response:

Mixed Fleet Flying Between Two Commercial Aircraft Types: An Empirical Evaluation of the Role of Negative Transfer

By: Beth Lyall & Christopher Wickens

We examined the potential vulnerabilities of pilots flying a mixed fleet of two different aircraft types. A "worst case" scenario was evaluated in which a pilot, flying one type exclusively, would need to fly the different type, after 6 months without any recurrency training on the latter. These circumstances invite negative transfer of habits in the "old" aircraft, to performance in the "new" aircraft".

Mixed fleet flying (MFF) is defined as the operation of two or more variants or types of airplanes by the same pool of pilots. The training program for these pilots is usually as one full program that teaches the pilots both airplanes and their similarities and differences. Under an FAA approved mixed-fleet flying program requirements are given to the airline for the maximum amount of time that a pilot can go without flying one of the types or variants. This currency period is typically 3 months, which means that under a "worst case scenario" a MFF trained pilot may fly one aircraft for just under three months, and then, unexpectedly, be called upon to fly the other aircraft the next day. To qualify for approval of such program, it is required that careful scrutiny be given to the possibility of negative transfer between the two aircraft (Holding, 1987; Lyall, 1990). Such negative transfer is experienced in every day life, as, for example, we switch from one keyboard to another, where critical function keys are located in different places. Classic analysis of transfer (Holding, 1987) reveals that the "red flag" inviting negative transfer results when the similar displays and circumstances between the "old" and "new" system, and also similar, but not identical actions, whereby the latter have very different consequences in the old from the new systems (Braune, 1989; Wickens & Hollands, 2000).

Selective evidence for negative transfer (i.e., in some skills and procedures) would signal the need for specific steps to be taken prior to adopting a safe MFF regime, including selective training on those vulnerable procedures, efforts to harmonize the procedures, or possibly selective redesign.

DISCUSSION

The current data suggest that mixed-fleet flying is quite feasible with these two types of aircraft, not surprising, given the common manufacturer, and the great number of similarities in design and procedures. While a few examples of negative transfer were revealed (and more, after the longer delay period), these were small in number, given the large number that were actually sampled, (and given that this sample itself was drawn selectively, on the basis of the differences analysis, from a much larger sample that could have been assessed). Thus, assessing under what we might consider a "worst case" scenario, in which the pilot would have little time to practice the new aircraft, and evaluating those unusual circumstances (e.g., missed approaches, engine outs), where our analyses revealed negative transfer most likely to occur, we still found only a small proportion of instances in which the prior frequent piloting of the "old" aircraft produced a performance decrement. We should note too that had conventional statistical conventions been employed, many of these differences would have been hidden.

Our general assessment of the feasibility of MFF for these aircraft types does not negate the importance of considering those differences that were observed, and our conclusions spawn a tailored set of recommendations regarding how each of these can be mitigated. For example, it was observed that the engine failure during takeoff procedures differed between these two aircraft categories. This difference led, in turn, to a difference in the missed approach procedure for both normal and engine-out situations. By simply harmonizing these procedures, it is believed that most of the variability found during the maneuvers portion of the study would be eliminated. Similarly, by harmonizing the limitations (i.e., static takeoff in icing conditions, crosswind limitations, and autopilot disengagement altitude) it is believed that additional sources of variability (read: pilot confusion) would be eliminated.

Case Study—Asiana Flight 214

Pilot Training is Scruitinized

By: Andy Pasztor & Jon Ostrower, The Wall Street Journal

Lee Kang-guk, who was the captain of Flight 214 as it descended toward San Francisco International Airport in a dangerously slow and low approach, was about halfway through the final stage of his training in the wide-body jet, under the supervision of a veteran Boeing 777 pilot. Though a trainee on the 777, Mr. Lee is a veteran aviator who had logged nearly 10,000 total hours in the air on other aircraft, and previously also served as a simulator trainer himself.

But for roughly the past decade before moving over to the 777, Mr. Lee flew only smaller, single-aisle Airbus A320s, which, among other things, differ vastly in the automated systems used to maintain speed and engine thrust. Now investigators from the National Transportation Safety Board are delving into the extent of the ground and simulator instruction Mr. Lee received prior to making that transition, according to people familiar with the probe, and whether that training might be a factor in how he reacted to the predicament that confronted the crew of Flight 214 before the crash.

While flying aircraft of all sizes involves common core skills, Boeing and Airbus cockpits differ radically in key areas, including functioning of the auto-throttles, which adjust a plane's engines and speed and which have become a major focus of the investigation. Safety experts and jetliner instructor pilots say that is one of the reasons shifting between Airbus and Boeing jets is initially challenging.

"The quality of such transition training is extremely important," said James Higgins, an aviation professor at the University of North Dakota who has also taught courses to prospective Asiana Airlines pilots in Korea. Without adequate time and practice, he said, "a pilot may mistakenly think that the new aircraft is going to behave exactly like the previous model."

But as world-wide air traffic increases—and many pilots at fast-growing airlines have more opportunities to jump from one airplane type to another—questions are mounting about what constitutes the best approach to transition training. The safety board is in the process of obtaining voluminous training records for all four pilots on the Asiana flight, and people familiar with the probe said investigators intend to carefully scrutinize Mr. Lee's overall training history and the specifics of his preparation to fly Boeing 777s.

Crashes over the years "provide more than a few examples of the bad things that can happen when pilots inadvertently revert to old habits," said Richard Healing, a former top Navy air-safety official and ex-member of the NTSB.

Four years ago, the captain of a Colgan Air turboprop mistakenly pulled back hard on the controls as it was about to stall—a maneuver he had been trained to do on another model under much different circumstances—causing the commuter plane to crash and kill 50 people near Buffalo, N.Y.

[The Avionics Handbook—Chapter 9– Human Factors Engineering and Flight Deck Design]

Generally, across manufacturers, there is a great deal of variation in existing flight deck systems design, training, and operation. Because pilots often operate different aircraft types, or similar aircraft with different equipage, at different points in time, another way to avoid or reduce errors is standardization of equipment, actions, and other areas.

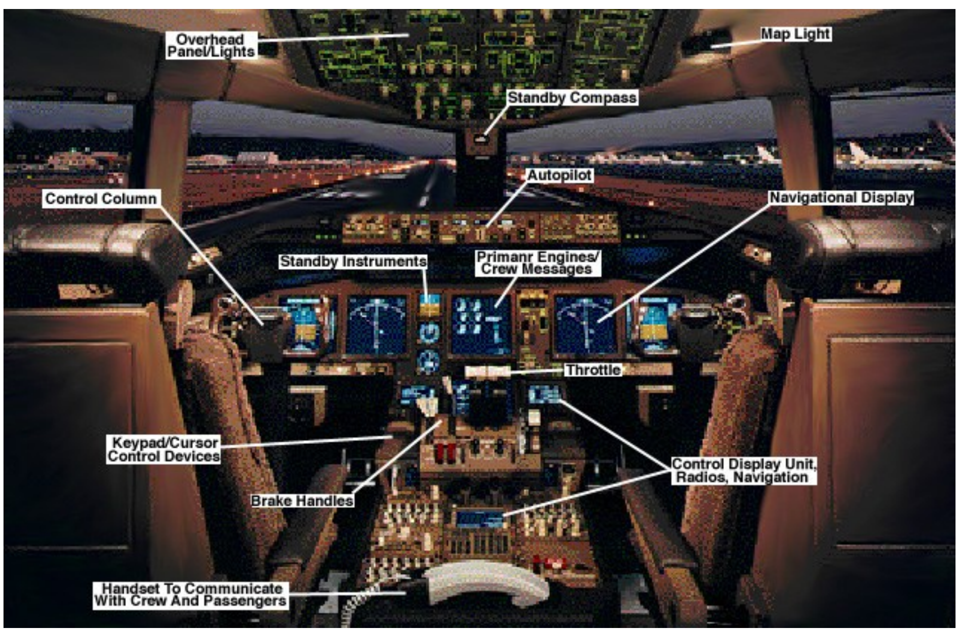
Appropriate standardization of procedures/actions, system layout, displays, color philosophy, etc. is generally desirable, because it has several potential advantages, including:

- Reducing potential for crew error/confusion due to negative transfer of learning from one aircraft to another;
- Reducing training costs, because you only need to train once; and
- Reducing equipment costs because of reduced part numbers, inventory, etc.

Human Factors in Flight

By: Frank H Hawkins

Flight Deck Design—The question of standardization of panel layout is not simply a theoretical or aesthetic one. Numerous cases have appeared in CHIRP reports of errors occurring as a result of inconsistent layout, sometimes involving inadvertent reversion to an operating practice appropriate to an aircraft flown previously.



It can be expected in most two-man crew, modern, large transport aircraft, with a high degree of system automation, that little operation difficulty will be encountered in normal, routine operation. It is in abnormal and emergency conditions that difficulties may be expected.

Training— A form of negative transfer can be a problem for pilots flying different types of aircraft, which is a relatively common practice. The policy of standardization of equipment and procedures tends to reduce the incidence of negative training transfer. From time to time incidents are reported where a pilot reverted to a pattern of behavior learned and appropriate for an earlier type of aircraft.

Cabin Environment— The location of emergency equipment throughout the cabin can have an influence on safety though where cabin staff fly different aircraft types, consistency in location between types may be more important than the location itself. The problem of inconsistency has always been a source of danger and has never been totally resolved. In the fatal DC9 accident at Cincinnati in 1983, which resulted from a fire originating in the rear toilet area, the smoke was so thick after landing that it would have been impossible to see the location of any emergency equipment. This has similarly been reported in the Paris Boeing 707 accident in 1973 and several other accidents. Certainty about the location of emergency equipment is of the utmost importance.

Approach & Landing— Pilots must learn the flare characteristics of each model of airplane they fly. The visual reference cues observed from each cockpit are different because window geometry and visibility are different. The geometric relationship between the pilot's eye and the landing gear will be different for each make and model. It is essential that the flare maneuver be initiated at the proper height—not too high and not too low.

TAILSTRIKE AND RUNWAY OVERRUN

ATSB TRANSPORT SAFETY REPORT

History of the flight

On the night of Friday 20 March 2009, 257 passengers, 14 cabin crew and 4 flight crew1F1 boarded an Airbus A340-541, registered A6-ERG, for a scheduled passenger flight from Melbourne, Victoria, to Dubai, United Arab Emirates (UAE). The flight, operating as Emirates flight EK407, was scheduled to depart Melbourne at 2225 Australian Eastern Daylight-saving Time2F2 and had a planned flight time of 14 hours and 8 minutes.

The pre-departure preparation included the use of an electronic flight bag (EFB) laptop computer to calculate the performance parameters for the takeoff from runway 16 (see section 2.3.7 Obtaining take-off performance data from the EFB). The EFB calculation required the input of a range of data: wind speed and direction; outside air temperature; altimeter setting; take-off weight; flap configuration; air conditioning status; anti-ice selection; runway surface condition; and aircraft centre of gravity.

A base take-off weight figure (361.9 tonnes) was taken from data in the aircraft's flight management and guidance system (FMGS)3F3. An additional tonne was added to that figure to allow for any minor last-minute changes in weight, making a total figure of 362.9 tonnes. When entering that take-off weight into the EFB, however, the first officer inadvertently entered 262.9 tonnes instead of 362.9 tonnes and did not notice that error.

Based on the weight and other input information, the EFB calculated take-off performance parameters (including reference speeds and engine power settings) for entry into the aircraft's flight systems. The incorrect weight and the associated performance parameters were then transcribed onto the master flight plan4F4 for later reference. At about this time, the captain and first officer discussed an aspect of the standard instrument departure that appeared to cause some confusion between the flight crew.

The EFB was handed to the captain to check the performance figures before he entered them into the aircraft systems. While the captain was checking the figures entered into the laptop, the first officer was confirming the departure clearance with air traffic control.

The captain handed the EFB back to the first officer, who stowed the EFB before they both completed the loadsheet confirmation procedure. During that procedure, the first officer correctly read the weight from the FMGS as 361.9 tonnes but, when reading from the flight plan, stated 326.9 tonnes before immediately 'correcting' himself to read 362.9 tonnes (the amended figure that included a 1 tonne allowance for last minute changes). Among the other checks in the loadsheet confirmation procedure, the first officer read out the green dot speed5F5 of 265 kts from the FMGS. The captain accepted that speed and the procedure was completed.

At 2231:53, when the aircraft had reached the calculated rotation speed, 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 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 captain selected take-off / go-around (TO/GA) thrust on the thrust levers. The engines responded immediately, and the aircraft accelerated as it passed off the end of the runway, along the stopway6F6 and across the grassed clearway7F7. The aircraft became airborne 3 seconds after the selection of TO/GA but, before gaining altitude, it struck a runway 34 lead-in sequence strobe light and several antennae, which disabled the airport's instrument landing system for runway 16.

Significant safety issue

The available Cross Crew Qualification and Mixed Fleet Flying guidance did not address how flight crew might form an expectation, or conduct a 'reasonableness' check of the speed/weight relationship for their aircraft during takeoff.

Background

The problem experienced by the flight crew in determining the 'reasonableness' of the take-off performance figures that were calculated by the electronic flight bag is not unique to this accident. Previous investigations into similar data entry error and tail-strike occurrences have highlighted the inability of flight crew to conduct a 'rule of thumb' or reasonableness check of their take-off speeds.

Furthermore, an unintended consequence of mixed fleet flying appears to be a reduction in a flight crew's ability to build a model in long-term memory to facilitate recognition of 'orders of magnitude' or 'rules of thumb' in respect of take-off performance data. That is, the effect of mixed fleet flying appears to exacerbate the difficulty already being experienced by crews in discerning the appropriateness of their aircraft's performance.

Indeed, because performance figures that are quite reasonable for one variant may not be reasonable for another variant, affected flight crew would need to build a model for each aircraft variant experienced. Currently, there is no specific guidance to assist flight crew to form those mental models in respect of the weight and corresponding take-off performance parameters for a particular aircraft variant.