IT'S HUMAN NATURE!

By Loukia D. Loukopoulos

"As we pushed back, I noticed a lengthy line of aircraft waiting for takeoff at our anticipated runway, which was just a short distance behind us. I made a decision to just taxi the short distance on one engine (engine #2). This break in our normal flow was distractive enough that I didn't call for flaps. Ground Control then assigned us a different, distant runway with more complicated than normal instructions. … Still anticipating a wait at the end, I continued taxiing on one engine. During the taxi, we continually evaluated the heavy rain showers we would encounter on our departure… We stopped at the end of the parallel and Ground sent us to Tower. Tower told us to pull up (#1 in line). We started the second engine and with rollback, I started moving immediately to #1 (in line), fearing delay might make ATC change their mind about us being next. Again, the break in flow resulted in not calling for takeoff flaps. We continued scanning the weather as we moved ahead and turned, running the checklist. The combination of doing these things resulted in passing through the flaps item on the checklist without confirming their position. We were cleared for departure and as I pushed the throttle up we got 2 chirps from the takeoff warning horn."

(the crew aborted the takeoff after the warning sytem alerted them to the fact that the flaps had not been set for takeoff as required).

Aviation Safety Reporting System – incident report # 519061
(edited narrative)

Why would a highly experienced airline captain forget to ask the first officer to set flaps to takeoff position, a simple but crucial command he must have routinely communicated thousands of times previously, as required by standard operating procedures? And why would an experienced first officer not notice that the captain did not call for him to execute this crucial step he must have performed on every previous flight? Is this an extraordinary, rare case of bad coincidences? Or is there something more to it?

Studies of ASRS[1] incident reports similar to this one (e.g., Dismukes, Young, and Sumwalt, 1998; Loukopoulos, Dismukes, & Barshi, 2001, 2003), and data from safety audits (e.g., Helmreich, Klinect, & Wilhelm, 2001) point to the sobering fact that errors are an inevitable aspect of routine, passenger-carrying flights. Fortunately most of these errors are either inconsequential or are detected before harm is done, although crew error is still widely cited as the most common

[1] The Aviation Safety Reporting System is a large database of reports voluntarily submitted by aviation personnel who have experienced or observed a compromise in safety (the database can be accessed at https://www.nasdac.faa.gov/).

"cause" of aircraft accidents. Before you assume these errors to be manifestations of pilot "carelessness," "complacency," or "inattention," however, consider that a growing body of scientific research indicates that many errors of skilled experts are … well, human nature! The source of these errors? The context within which pilots operate and the multiple, concurrent, challenging, and unpredictable demands placed on human cognitive processes. Our research on cognition in the cockpit shows that such demands are an under-recognized threat that renders even the most expert, well-trained, conscientious pilots vulnerable to errors of forgetting to perform familiar and habitual tasks. If we want to truly understand the source of a seemingly careless omission, such as forgetting to set the flaps for takeoff, one must look deeply at basic human cognitive skills and their interaction with the challenges of the routine operating environment.

To this end I will analyze the incident in the ASRS report above in terms of the cognitive demands of the crew's multiple, unfolding tasks. But first here is some background readers who are not pilots will need:

In an ideal, perfect world, air carrier flight operations manuals instruct crews to accomplish a series of actions comprising a large number of procedural steps in a well-defined sequence during the taxi operation. Here I assume a 2-pilot crew, a 2-engine aircraft and a flaps 5 takeoff, and for brevity only present a high level description of actions:
After both engines have been started at the ramp area, the captain calls "flaps 5, taxi clearance." In response, the first officer positions the flap lever, visually confirms the flap gauge indicating 5, and contacts the ground controller to request taxi clearance (permission to taxi and exact routing instructions). When the clearance has been granted, the captain releases the brakes and steers the aircraft (with the flaps set to 5) along the instructed taxi route. The first officer monitors the aircraft movement on the taxiways, performs procedures to prepare the aircraft for takeoff and executes the Taxi checklist. One of the items on this checklist requires the crew to check that the flaps are in the takeoff position (in this case, 5 degrees). During the taxi phase, the pilots remain in radio communication with the Ground controller. As they approach the runway, they switch radio frequencies and expect permission for takeoff from the Tower controller. As soon as this latter clearance has been issued, the crew conducts a short Pretakeoff checklist and takes position on the runway. The captain pushes the throttles forward and the aircraft proceeds to take off.

Our analysis of this incident appears in plain face text after bold face text from the ASRS report:

"As we pushed back, I noticed a lengthy line of aircraft waiting for takeoff at our anticipated runway, which was just a short distance behind us.
A captain typically listens to the Ground controller issue instructions to other aircraft to stay informed about the conditions at the airport at the time of pushback. The act of seeking and integrating information in order to maintain situational awareness, however, increases the amount of workload and diverts some of the captain's attention away from the main, ongoing task (monitor the pushback, start the engines). ***I made a decision to just taxi the short distance on one engine (engine #2).*** Taxiing on two engines is the default, well-practiced, habitual procedure, however some air carriers allow captains to taxi on one engine when concerned about fuel conservation. Taxiing on one engine requires deferring starting the second engine later during taxi (i.e., out of the normal sequence), and also requires that the Taxi checklist be deferred until the

second engine has been started (again, out of the normal sequence). Deferring an activity requires having to remember to do it later. Pilots sometimes create cues to remind them to perform a deferred action at the appropriate time. When this action is important and highly habitual, however, they often do not attempt to create cues because they assume it would be impossible to forget. What they fail to recognize is that, under normal circumstances, they remember to perform habitual actions because those actions are by definition imbedded in a sequence of other actions they have practiced many times in the same order. In the normal situation they do not have to think about what to do next: performing one step of the sequence automatically retrieves the next step out of memory. But when a habitual action is deferred out of its normal sequence, the previous step no longer helps trigger retrieval of the next step in the sequence from memory. ***This break in our normal flow was distractive enough that I didn't call for flaps.*** The deliberate rearrangement of activities (i.e., start the second engine later than usual) disrupts the chain of events and actions that normally prompt the captain to remember to call for flaps. Also at this point the captain appears to be already thinking ahead, mentally noting the upcoming, long queue of aircraft and planning a single engine taxi to save fuel. Although thinking ahead is highly desirable, it competes for his attention, making it less likely that he will notice that he has not automatically called for flaps at the usual point. Having two crewmembers that back each other up is an important safeguard against pilot error, so why does the first officer not notice that the captain has not called for flaps? Again we suspect automaticity (executing highly practiced skills with a minimum of conscious supervision), which is highly reliable when actions are performed in normal sequence but much less reliable when they are performed out of sequence or when normal cues are absent. Very likely the first officer has come to unconsciously rely on the captain to call for flaps to automatically trigger this habitual action. Lacking this habitual trigger, the first officer does not retrieve this action from memory and does not recognize that he has not performed the action. And perhaps the first officer's attention is also diverted by the single engine taxi procedure.

Ground Control then assigned us a different, distant runway with more complicated than normal instructions… Changes in taxi routing are not uncommon at a busy airport and in changing weather. When they do occur, however, they require substantial attention from the crew to work out the unplanned taxi route while in motion, often by referring to charts if the route is complicated. **Still anticipating a wait at the end, I continued taxiing on one engine.** The controller's unexpected instruction diverts yet more of the two pilots' attention away from the ongoing task The captain, still thinking ahead of the long queue of aircraft ahead and focusing on the repercussions on fuel consumption, considers the implications of the new instructions only with respect to his prior decision to taxi on one engine. This effectively draws his attention even further from the normal flow of activities and thus reduces his opportunity to mentally review his actions and perhaps to realize that he has forgotten to call for the flaps.

During the taxi, we continually evaluated the heavy rain showers we would encounter on our departure. We stopped at the end of the parallel and Ground sent us to Tower. Tower told us to pull up (#1 in line). We started the second engine and with rollback, I started moving immediately to #1, fearing delay might make ATC change their mind about us being next. Again, the break in flow resulted in not calling for takeoff flaps. Crews are always looking out for factors that may affect the flight. In this instance, keeping track of evolving weather conditions is yet one more factor that requires the crew's attention. Both pilots must interleave thinking about weather implications with other, ongoing activities. The crew's workload is further compounded when the Tower controller asks for the aircraft to be pulled up to the runway. The deferred action of starting the second engine is suddenly brought to the foreground, as it must be performed immediately- -the aircraft cannot be brought to the runway until both engines are running and ready. The crew starts the second engine, aware of the fact that any delay from their part can easily translate into a much longer delay if they lose their place in the queue. Juggling the almost opposing priorities of taking the time to carefully execute the critical activity of starting a jet engine and rushing to retain position in line is challenging. In general, managing multiple, concurrent, cognitively complex task demands is challenging and limits the amount of attention devoted to any single task. More insidiously, when attention is switched back and forth among several tasks, one task may drop out of awareness altogether. As a result, neither pilot is prompted to think to check for an action (setting the flaps) that they normally would have accomplished much earlier and would not normally check at this later stage of the operation.

We continued scanning the weather as we moved ahead and turned, running the checklist. The combination of doing these things resulted in passing through the flaps item on the checklist without confirming their position. Starting the second engine, because of its normal association with running the Taxi checklist, acts as a trigger reminding the crew of this second deferred activity, and they promptly perform the Taxi checklist. Their attention, however, is already taxed by the multiple, concurrent activities and the element of time-pressure. When visual verification of the flaps position is called for by the Taxi checklist, neither pilot notices that the flaps remain retracted. Expectation may play a role here: because the flaps have normally been set considerably earlier, the crew probably think they are set and are less likely to notice the discrepancy if they do not take time to perform the check in a deliberate fashion that requires mental effort. Checklists are a major safeguard, but because items being checked are almost always in the desired state, pilots' responses to the checklist items tend to become automatic (e.g., First Officer: "Flaps"? Captain: Flaps 5") and may become de-coupled from the action of visually verifying status of items checked. Note that this automatization and de-coupling of the response happens without pilots awareness, and effort is required to maintain the proper habit of checking status of items in a controlled manner at a deliberate pace.

We were cleared for departure and as I pushed the throttle up we got 2 chirps from the takeoff warning horn." When the Captain pushes the throttles forward to begin the takeoff roll, the warning system indicates the inappropriate flaps setting and prevents an impending disaster.

We recognize that our account is speculative and that in the interest of brevity we have only just sketched out the complex cognitive processes involved. However we believe that analyzing these seemingly simple, preventable, errors in light of the complexities of the real operating environment and the cognitive skills and vulnerabilities of human operators helps open up a new perspective on pilot error. The cognitive complexities at play in the cockpit situation (e.g., deferring actions, maintaining and remembering intentions, managing concurrent task demands, interrupting and rescheduling activities) are issues we are actively researching. Using this forum we hope to stimulate discussion and interaction between the operational community and the scientific community; from this interaction may grow deeper insight and perhaps ways to improve safety.

<u>Pilots</u>: what similar situations have you encountered? Do you have personal techniques to reduce your vulnerability to errors of omission? How effective and practical to use do you find them?
<u>Scientists</u>: Does this characterization of cognitive underpinnings of errors of omission make sense to you? Can you suggest other aspects that should be considered?
<u>Others</u>: Have you observed similar phenomena in other areas of human performance?

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