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Cockpit Interruptions and Distractions:
Effective Management Requires A Careful Balancing Act.

Managing several tasks concurrently is an everyday part of cockpit operations. For the most part, crews handle concurrent task demands efficiently, yet crew preoccupation with one task to the detriment of performing other tasks is one of the more common forms of error in the cockpit. Most pilots are familiar with the December 1972 L1011 crash that occurred when the crew became preoccupied with a landing gear light malfunction and failed to notice that someone had inadvertently bumped off the autopilot. More recently a DC-9 landed gear-up in Houston when the crew, preoccupied with an unstabilized approach, failed to recognize that the gear was not down because they had not switched the hydraulic pumps to high.

We have recently started a research project to study why crews are vulnerable to these sorts of errors. As part of that project we reviewed NTSB reports of accidents attributed to crew error; we concluded that nearly half of these accidents involved lapses of attention associated with interruptions, distractions, or preoccupation with one task to the exclusion of another task. We have also analyzed 107 ASRS reports involving competing tasks; we present here some of our conclusions from those ASRS reports. These 107 reports involved 21 different types of routine tasks crews neglected at a critical moment while attending to another task. Sixty-nine percent of the neglected tasks involved either failure to monitor the current status or position of the aircraft or failure to monitor the actions of the pilot flying or taxiing.

Thirty-four different types of competing activities distracted or preoccupied the pilots. Ninety percent of these competing activities fell into one of four broad categories: communication (e.g., discussion among crew or radio communication), heads-down work (e.g., programming the FMS or reviewing approach plates), responding to abnormals, or searching for VMC traffic. We will discuss examples of each of these four categories and suggest things crews can do to reduce their vulnerability to these and similar situations. Our suggestions are not perfect fixes, but we think they will be useful and hope that research will ultimately provide more powerful solutions.

Example 1: *Copilot was a new hire and new in type; first line flight out of training IOE. Copilot was hand-flying the aircraft on CIVET arrival to LAX. I was talking to him about the arrival and overloaded him. As we approached 12,000 feet (our next assigned altitude) he did not level off even under direction from me. We descended 400 feet low before he could recover. I did not realize that the speed brakes were extended, which contributed to the slow altitude recovery. (ASRS #360761)*

In this example, the captain was attempting to help the new first officer, but the combination of flying the airplane and listening to the captain was too much for the new pilot. Tellingly, the act of talking distracted the captain himself from adequately monitoring the status of the aircraft.

Thirty-one[1] of these incidents we studied involved altitude busts or failure to make a crossing restriction. In 17 of these 31 incidents (and 68 of the total 107 incidents) the crews reported being distracted by some form of communication, most commonly discussion between the pilots or with a flight attendant. Most, though not all, of these

[1] The relative frequencies of different types of neglected activity reported probably do not reflect the relative frequencies actually occurring in line operations. Pilots are more likely to report incidents observable to ATC, for example, altitude deviations, than to report incidents not observable outside the cockpit, for example, omitting a checklist item.

discussions were pertinent to the flight, however in many cases the discussion could have been deferred. (We discuss below how crews can schedule activities to reduce their vulnerability to distraction).

This finding that engaging in communication can cause problems may seem surprising, because communication is one of the themes emphasized in CRM programs. Research studies have shown that crews who communicate well tend to perform better overall than those who do not. But conversation has a potential downside because it demands a substantial amount of attention to interpret what the other person is saying, to generate appropriate responses, and to hold those responses in memory until it is one's own time to speak. One might assume that it is easy to suspend conversation whenever other tasks must be performed, however, the danger is that the crew may become preoccupied with the conversation and may not notice cues that should alert them to perform other tasks. It may seem surprising that in the incident cited above the verbal task of communication interfered with the visual task of altimeter monitoring; the accompanying sidebar explores the nature of interference between competing tasks. Special care is required when flight attendants enter the cockpit, because they may not recognize when the pilots are silently involved in monitoring, visual search, or problem-solving.

<u>Example 2</u>: *Snowing at YYZ. Taxiing to runway 6R for departure. Instructions were : taxi to taxiway B, to taxiway D, to runway 6R. As FO I was busy with checklists (and) new takeoff data. When I looked up, we were not on taxiway D but taxiway W. ATC said stop. (ASRS #397607)*

In a review of airline accidents attributed primarily to crew error over a 12 year period, the NTSB concluded that failure to monitor and/or challenge the pilot flying contributed to 31 of the 37 accidents. In 35 of the ASRS incidents we studied, the pilot not flying reported that preoccupation with other duties prevented monitoring the other pilot closely enough to catch in time an error being made in flying or taxiing. In 13 of these 35 incidents (and 22 of the total 107 incidents), the pilot not flying was preoccupied with some form of heads-down work, most commonly paperwork or programming the FMS.

Monitoring the pilot flying or taxiing is a particularly challenging responsibility for several reasons. Much of the time the monitoring pilot has other tasks to perform. Monitoring the other pilot is much more complex than monitoring altitude capture because the other pilot is performing a range of activities that vary in content and time course. Thus, it is sometimes difficult for the monitoring pilot to integrate other activities with monitoring because he or she cannot entirely anticipate the actions of the other pilot. Furthermore, serious errors by the pilot flying or taxiing do not happen frequently, so it is very tempting for the other pilot to let monitoring slide in periods of high workload.

Periods of heads-down activity, such as programming the FMS, are especially vulnerable because the monitoring pilot's eyes are diverted, preventing visual monitoring. Also, activities such as programming, doing paperwork, or reviewing approach plates, demand such high levels of attention that attempting to perform these tasks simultaneously with other tasks substantially increases the risk of error on one task or the other (see sidebar). Some FMC entries involving one or two keystrokes can be performed quickly and may be interleaved with other cockpit tasks. However, attempting to perform longer programming tasks, such as adding waypoints or inserting approaches, during busy segments of flight can be problematic. It is not possible to reliably monitor the pilot flying or the aircraft status during longer programming tasks, and it is difficult to suspend the programming in midstream without losing one's place in the programming.

<u>Example 3</u>: *PRADO 5 Departure. Cleared to climb (and) received TCASII TA (which) upgraded to an RA, monitor vertical speed. While searching for the traffic we*

went past the NIKKL intersection ...for the turn to the TRM transition. We had discussed the departure before takeoff; special procedures, combined with many step climb altitudes in a short/time/distance, made this a more demanding departure than most. Next time on difficult departures I will use autopilot sooner...will try to be more vigilant in dense traffic areas. (ASRS #403598)

In 16 incidents crews failed to turn as directed by ATC or the SID or STAR they were following. The crews reported various activities competing for their attention; in three cases the competing activity was searching for traffic called out by ATC or TCAS. Altogether, crews reported searching for traffic as a competing activity in 11 of the 107 incidents. Searching for traffic takes the pilot's eyes away from monitoring aircraft position and status; it also demands a substantial amount of mental attention. If the conflict is close the urgency may further narrow the focus of attention, a normal biologically hardwired response.

One of the insidious traps of interruptions is that their effects sometimes linger on after the interruption has ceased. For example, descending through 4500 feet, a crew might be instructed to report passing through 3000 feet, then respond to and quickly resolve a traffic alert, but then forget the instruction to report by the time they reach 3000 feet. In this example, searching for traffic preempted the reporting instruction from the crew's conscious awareness. The instruction presumably was still stored in memory in an inactive form, and if reminded the crew probably would have recognized that they had been given the instruction; however, lacking such a reminder and preoccupied with other activities, they did not remember as they passed through 3000 feet.

Example 4: *Large areas of thunderstorms; we had to deviate considerably. Several (equipment malfunctions) in short period...then cabin pressure started climbing slowly in cruise (FL290). Troubleshooting...to no avail. Requested immediate descent. Descending through FL180, both crew members forgot to reset altimeters, putting us 300 feet low at FL130. To prevent this from occurring again during any abnormal, I will: 1) delegate tasks; have one person focus on flying the airplane while the other troubleshoorts and state clearly who will do what, 2) strictly adhere to company procedures. (ASRS #404306)*

In 13 incidents crews failed to reset their altimeters when passing through transition altitude (18,000 feet in the United States and Canada). It is especially easy to forget to reset the altimeters if this action is not linked in pilots' minds to other actions through procedures (e.g., descent checklist) or habit. (Some pilots make resetting altimeters part of a cluster of action items they routinely perform together, e.g., making a passenger anouncement and turning on the seat belt sign). In principle, the problem is similar to that of monitoring for altitude level-off, except more vulnerable. With altitude level-off in air carrier operations the crew is normally aided by altitude alerting devices and by the formal procedure of making a thousand foot call, confirmed by both pilots, before reaching the assigned altitude.

ABNORMALS = DISTRACTIONS

Two of the crews that forgot to reset their altimeters reported being preoccupied with an abnormal. Altogether, abnormals were a factor in 19 of the 107 incidents. Ironically, it seems that one of the biggest hazards of abnormals is becoming distracted from other cockpit duties. Abnormals easily preempt crews' attention for several reasons. Recognizing the cockpit warning indicators, identifying the nature of the problem, and choosing the correct procedure require considerable attention. Crews have much less opportunity to practice abnormal procedures than normal procedures, so choosing and running the appropriate checklists is more effortful and requires more mental resources than normal checklists require. Also, in situations perceived to be urgent or threatening, normal human response is to narrow the focus of attention, which unfortunately tends to diminish mental flexibility and the ability to analyze and resolve non-routine situations.

Ways to Reduce Vulnerability

We suggest several lines of defense against crew errors such as those described above. These defenses are not perfect, but in combination they should, in our opinion, reduce crews' vulnerability. The first two defenses are already taught at many airline companies; the other four are more speculative.

1) Explicitly assign Pilot Flying and Pilot Not Flying responsibilities, especially in abnormal situations.

The Pilot Flying should be dedicated to monitoring and controlling the aircraft. The Pilot Flying must firmly fix in mind that he or she must concentrate on the primary responsibility of flying the airplane. This approach of course does not prevent each pilot from having to perform concurrent tasks at times, but it does insure that someone is flying the airplane and it guards against both pilots getting pulled into trying to solve problems.

2) Schedule/reschedule activities to minimize conflicts, especially during critical junctions.

When approaching or crossing an active runway, both pilots should suspend all activities, such as FMS programming and company radio calls, not related to taxiing until the aircraft has either stopped short of the runway or safely crossed it. Crews can reduce their workload during descent by performing some tasks while still at cruise, e.g.: obtaining ATIS, briefing the anticipated instrument approach, and inserting the approach into the FMS (for aircraft so equipped). Also, it may be useful for companies to review their operating practices for optimal placement of procedural items. For example, could some items on the Before Takeoff Checklist be moved to the Before Start Checklist, since the latter is performed during a period that usually has lower workload?

3) When two tasks must be performed concurrently, set up a scan and avoid letting attention linger too long on either task.

In some situations pilots must perform two tasks concurrently, for example, searching for traffic while flying the airplane. With practice, pilots can develop the habit of not letting their attention linger long on one task but rather switch attention back and forth every few seconds between the search and checking back in the cockpit. This is somewhat analogous to an instrument scan, and like an instrument scan it requires discipline and practice, for our natural tendency is to fixate on one task until it is complete. Be aware that some tasks, such as building an approach in the FMS, do not lend themselves to time-sharing with other tasks without substantial chance of error.

4) Treat interruptions as red flags.

Knowing that we are all vulnerable to preoccupation with interrupting tasks can help reduce that vulnerability. Many pilots, when interrupted while running a checklist, place a thumb on the last item performed to remind them that the checklist was suspended; it may be possible to use similar techniques for other interrupted cockpit tasks. One of us (RS) has developed a personal technique, using the mnemonic "Interruptions Always Distract" for a three-step process: (1) Identify the interruption when it occurs, (2) Ask, "What was I doing before I was interrupted", immediately after the interruption, (3) Decide what action to take to get back on track.

5) Recognize that heads-down tasks greatly reduce one's ability to monitor the other pilot and the status of the aircraft.

If possible, reschedule heads-down tasks to low workload periods. Announce that you are going heads-down. In some situations it may be useful to go to a lower level of automation to avoid having one crew member heads-down too long. For example, if ATC requests a speed change when cockpit workload is high, the crew may set the speed in the mode control panel instead of the FMS. An FMS entry might be made later, when workload permits. Also, some airlines have a policy that FMS entries should be commanded by the Pilot Flying and implemented by the Pilot Not Flying. This approach minimizes the amount of attention the Pilot Flying must divert from monitoring the aircraft.

6) Recognize that conversation is a powerful distracter.
Unless a conversation is extremely urgent, it should be suspended momentarily as the aircraft approaches a transition, such as altitude level-off or a SID turn. In high workload situations, utterances should be kept brief and to the point. Even in low workload situations crew should pause discussion frequently to scan the status of the aircraft and their situation; this requires considerable diligence because it goes against the natural grain of dialogue, which normally is fluid and continuous until the issue under discussion is resolved.

SIDEBAR

Is it surprising that an activity as routine as conversation sometimes interferes with monitoring or controlling the aircraft? Cognitive research indicates that people are able to perform two tasks concurrently only in very limited circumstances, even if they are skillful in performing each task separately.

Humans have two cognitive systems with which they perform tasks; one involves conscious control, the other is an automatic system that operates largely outside of conscious control. The conscious system is slow and effortful, and it basically performs one operation at a time, in sequence. Learning a new task typically requires conscious processing, which is why learning to drive a car or fly an airplane at first seems overwhelming: the multiple demands of the task exceed conscious capacity. Automated cognitive processes develop as we acquire skill; these processes are specific to each task, they operate rapidly and fluidly, and they require little effort or attention.

Many real-world tasks require a mixture of automatic and conscious processing. A skillful driver in a familiar car on a familiar road can perform largely on automatic, leaving enough conscious capacity to carry on a conversation. However, if the automatic system is allowed to operate without any conscious supervision, it is vulnerable to certain types of error, especially a type of error called habit capture. For example, if we intend to take a different route home from work, we are prone to miss our turn-off and continue our habitual route if we do not consciously supervise our driving. Also, if we encounter a section of road that is difficult to navigate, we find that we cannot continue the conversation without risking making errors in the driving, the conversation, or both. This is because the automatic processes are not adequate to handle the unpredictable aspects of the driving task.

Conscious control is required in four situations: i) when the task is novel, ii) when the task is perceived to be critical, difficult, or dangerous, iii) when an automatic process must be overriden to prevent habit capture, or iv) to chose among competing activities. The mixture of automatic and conscious processing required varies among tasks, and the mixture may vary with the moment to moment demands of a given task. Conversation, for example, generally requires a substantial amount of conscious processing because it involves novelty; we do not know what the other person is going to say and we have to formulate unique responses appropriate to the discussion. In contrast, an experienced pilot can manually fly a familiar aircraft in a largely automatic fashion. However, certain subtasks embedded in the act of flying manually require conscious attention. For example, leveling off at an assigned altitude requires consciously monitoring the altimeter to read the numbers and to match the current altitude with the assigned altitude the pilot is holding in memory.

The framework outlined above allows some general conclusions about the circumstances under which two tasks may be performed concurrently. A task requiring a high degree of conscious processing, FMS programming, for example, cannot be performed concurrently with other tasks without risking error. Two tasks that are largely automated can be performed together reliably if they are regularly practiced in conjunction, for example, flying the aircraft manually and intercepting the localizer. We are less certain how well individuals can combine two tasks, each of which involves a mixture of conscious and automatic processing, for example, searching for traffic while monitoring for altitude capture. We suspect that pilots can learn to integrate two tasks of this sort and achieve reliable performance, but only if they regularly practice the two tasks in conjunction. This, however, is speculation, and requires experimental research.