From Ideal to Real in the Cockpit

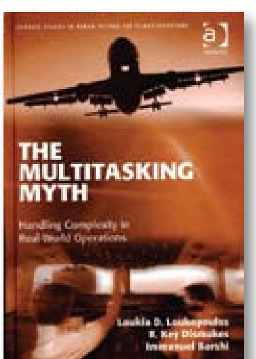
Even the best procedures need to be supplemented by pilot strategies to avoid the perils of interruptions, distractions and the unanticipated.

BOOKS

Beyond the FOM

The Multitasking Myth: Handling Complexity in Real-World Operations

Loukopoulos, Loukia D.; Dismukes, R. Key; Barshi, Immanuel. Farnham, Surrey, England and Burlington, Vermont, U.S.: Ashgate, 2009. 202 pp. Figures, appendixes, references, index.



As far back as Plato, philosophers have debated the ideal versus the real. According to the authors, it is a serious human factors issue today for airline pilots and aviation safety professionals.

As the book's title suggests, one of the most important factors separating the ideal from the real in aviation involves the demands of multitasking — simultaneously doing several things, often while keeping in mind several considerations. Proverbially, we can all walk and chew gum, but in aviation, the tasks are far more complicated and the penalties for failure potentially severe.

What kind of failure? "Performing several tasks concurrently and forgetting to do one of the essential tasks," is one way the authors describe it.

In flying for an airline, they say, the ideal is more or less what is described in the aircraft operating manual and the operator's flight operations manual (FOM). "To perform their jobs in accordance with their employers' operating and safety standards, pilots are required to follow the standardized operating procedures closely, so training is heavily based on FOMs, and rote memorization of the procedures therein," they say. "FOMs implicitly portray cockpit work as having three central characteristics. It is linear, predictable and under the moment-to-moment control of the cockpit crew."

While the procedures in the FOM normally are technically correct and ordered in a logical sequence, actually accomplishing them can require complicated responses. For example, some items "require the pilot to have pre-determined the appropriate response before accomplishing the procedure (e.g., the single procedural items for the fuel system before flight involve checking that two engine valve [lights] and two spar valve lights are illuminated; two filter bypass, one cross-feed valve, and six low pressure lights are extinguished; the cross-feed selector switch is closed; three fuel quantity gauges indicate the expected fuel quantity; and six fuel pumps switches are in the 'ON' or 'OFF' position depending on the quantity in each corresponding set of fuel tanks)."

Or the item may involve "complex, time-consuming, attention-demanding activities (e.g., the single procedural step of 'programming' the FMC [flight management computer] involves entering data — numbers and letters — derived from communication with air traffic control as well as from various pieces of paperwork into nine different 'screens' or electronic pages using the FMC keyboard and may also require consulting performance charts in a binder or on a separate, hand-held computer)."

While all these actions could be considered "linear, predictable and under the moment-to-moment control of the flight crew," they involve both action and cognition in an intense interrelationship.

And that is only the *ideal* in an airline pilot's world. In the next chapter, the authors consider how the real, as experienced in line operations, adds still more complexity and variability. "Our discussion of this real world is based on an ethnographic study in which we observed a substantial number of scheduled, passenger-carrying flights from the cockpit jumpseat at two airlines," they say. Reports by pilots to the U.S. National Aeronautics and Space Administration's Aviation Safety Reporting System were also studied.

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The researchers focused on "perturbations," or additional factors that "forced the crew to alter the sequence of execution of tasks described in the FOM, disrupted the flow of work or increased the complexity of work." They cite, as one example, "the frequently occurring situation in which the first officer attempted to contact the ground controller to obtain the required departure clearance but found the frequency occupied and had to monitor the radio for an opportunity to break in and make the request. We observed one instance in which the captain asked the first officer to request departure clearance while the first officer was still entering data into the FMC. The first officer chose to continue entering data while simultaneously monitoring the radio for an opportunity to make the request."

The basic problem in perturbations is not extra workload. The researchers observed that the added effort was "easily managed by experienced crews." But they say, "In this book, we develop a new perspective, going beyond traditional concepts of workload, to argue that these commonplace perturbations have a larger and more subtle significance than the simple volume of work." They may involve interleaving — "repeatedly suspending one or more tasks momentarily, engaging in another task to perform a few steps, then suspending the new task and re-engaging the previous tasks (or engaging a third task) to perform a few more steps of it until all tasks are completed."

Perturbations require pilots to "manage multiple tasks concurrently, interleaving performance of some tasks, deferring or suspending other tasks, responding to unexpected delays and unpredictable demands imposed by external agents, and keeping track of the status of all tasks. The cognitive demands imposed by managing concurrent tasks in this fashion play a central role in pilots' vulnerability to error, especially errors of inadvertent omission."

In the chapter on "Analysis of Current Task Demands and Crew Responses," the nature of perturbations is further explored. They are classified in four "prototypical situations":

- "Interruptions and distractions;
- "Tasks that cannot be executed in the normal, practiced sequence of procedures;
- "Unanticipated new tasks that arise; and,
- "Multiple tasks that must be interleaved."

The authors say, "Pilots typically respond to the concurrent task demands arising from the various operational perturbations we have described in one of two fundamental ways, either by *deferring* one or more tasks, or by *interleaving* multiple tasks. In some situations, pilots may be able to perform multiple tasks more or less simultaneously, but these situations only occur when the tasks are highly practiced together in a consistent fashion, which means that these situations are not really perturbations. Pilots may also … reduce task demands by changing how tasks are performed, either by lowering criteria for quality, accuracy or completeness of performance, or by deliberately omitting one or more tasks altogether."

In a final chapter about applications of their research, the authors offer some possibilities for ameliorating the demands on pilots caused by multitasking. They suggest that both organizations and pilots themselves must recognize and counteract the potential for errors.

For organizations, "it is crucial to thoroughly analyze reported and observed problems in routine operations, and to go beyond their surface manifestations to identify and understand the true nature of the problems encountered with existing procedures prior to designing and implementing new procedures," the authors say. "Likewise, it is critical to perform a careful analysis of the procedures, the training and the actual operations to identify underlying assumptions, and to characterize the discrepancies between the ideal and the real operating environment."

But while procedures should be devised with great care, it is futile to try to make them perfect: "Routine operations are highly dynamic and unpredictable, even if within predictable bounds. Thus, it is not possible to have a procedure for a given task that would work under all conditions, in all situations and for all operators. It is not even desirable to attempt to cover all of the known exceptions, because it would require unmanageably large FOMs. Given that some situations may fall outside the scope or language of the available procedures, operators [pilots] must be trained to recognize that these situations will increase the likelihood of error. … Training should help operators to recognize, accept and appreciate their own vulnerabilities, and to develop effective and safe personal strategies."

The authors advise individuals, "Recognizing the ways in which the prototypical situations manifest themselves in your own work environment can help you develop techniques to prevent them. For instance, recognizing the risks associated with interruptions can lead you to be very careful when you have to interrupt somebody else, and to adopt a strategic approach to letting yourself be interrupted. Such an approach will help you decide when to attend to an interruption after explicitly encoding your place in the interrupted task, or when to hold off the interruption until the current task gets to a good stopping point. Similarly, recognizing the need to respond to several different demands at once, you can call on a co-worker for help, or offer your help when you see somebody else in that situation."

They also recommend associating deferred tasks with retrieval cues in the environment. "It is important to identify the time or circumstances when the deferred intention should be performed and to identify or create specific cues that will be present at the appropriate time," the authors say. "In other words, determine and set your work environment equivalents of sticky notes, making use, when appropriate, of any alerting devices (alarm clocks, timers) that are available to you. You can also practice periodic, deliberate searches for incomplete tasks and for deferred intentions. … Deliberate searches are particularly useful in the transition points between distinct phases of an operation and following interruptions."

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WEB SITES

Hot Topic

Federal Aviation Administration Fire Safety, www.fire.tc.faa.gov/index.stm

The U.S. Federal Aviation Administration (FAA) William J. Hughes Technical Center Fire Safety Branch has aggregated a large amount of information — papers, presentations, videos, reports, regulatory and guidance documents, and other materials. Much of the Web site contents come from the Technical Center and the Cabin Safety Research Technical Group (CSRTG). All documents are free online, in full text, and may be printed and downloaded. Videos are also free and may be viewed online or downloaded.

The Technical Center's working groups — Materials Fire Test and International Aircraft Systems Fire Protection — have posted minutes and presentations from meetings held

from 2006 to 2009. Web pages for these groups contain links to research papers, reports, videos, FAA regulatory and guidance documents, and other materials related to their respective areas of focus and address topics such as extinguishers, insulation, fuel tank protection and flame propagation.

The CSRTG says, "In the past, various aviation authorities of the world were conducting research in transport category airplane cabin safety sometimes cooperatively, but mostly individually, without the benefit of a coordinating 'tool.'" In the early 1990s, civil aviation authorities from Europe, Japan, North America and the United Kingdom formed the CSRTG "to 'bring together' their respective cabin safety research efforts." Members from Australia, Russia, South America and elsewhere have since been added. "The goal of the CSRTG is to enhance the effectiveness and timeliness of cabin safety research," the group says. Additional information about the group is available from its Web page. Some of the materials appearing at the FAA Fire Safety Web site are from the CSRTG, such as the proceedings of the Fifth Triennial International Fire and Cabin Safety Research Conference held in 2007 and proceedings from the 1998, 2001 and 2004 conferences. Many of the CSRTG member organizations co-sponsor and participate in the conferences.

Two videos are featured: the final version of "Cabin Crew Fire Fighting Training" and "Laptop Battery Fires."

"Cabin Crew Fire Fighting Training" (color, audio, 21 minutes) was produced for flight and cabin crewmembers by the FAA in cooperation with CSRTG members. The video discusses the dangers of in-flight fires, especially hidden fires, and shows cabin crew searching for, detecting and extinguishing smoke and fire in ceiling and sidewall panels, galley and lavatory compartments, overhead bins, and other areas while demonstrating the proper use of various types of extinguishers and personal breathing equipment as covered in 2004 in Advisory Circular 120-80, "In-Flight Fires."

The video emphasizes a team approach in dealing with a cabin or flight deck fire, with scenarios illustrating effective communication and involvement of cabin crew, flight deck crew and passengers. "Serious fires must be brought under control within minutes," says the FAA. The overall message, "aggressive and immediate action is the key to fighting fires and saving lives," is repeated throughout the video.

Included in the video are Technical Center footage of flammability tests of aircraft materials, such as insulation and hydraulic fluids; tests of aerosol cans and overheated batteries in passenger electronic equipment; and a chemical or flammable liquid spill being extinguished in an aircraft cabin.

"Laptop Battery Fires" (color, audio, 11 minutes) was produced by the FAA. The video opens with actual footage of a laptop computer fire in an airport departure lounge. The video discusses hazards posed by batteries in laptops and illustrates effective and ineffective options for extinguishing a laptop computer fire in an aircraft cabin. "The objective is to extinguish the fire and cool the battery pack [lithium-ion cells] preventing additional cells from reaching thermal runaway [350° F, 177° C]," says the video narration.

The FAA says the Technical Center "conducts long-range research to develop a totally fire resistant passenger aircraft cabin with the goal of eliminating cabin fire as a cause of fatality." The Fire Research and Reports portions of the Web site describe the center's work and identify targeted research areas: interior panel construction, thermoplastics for molded parts, rubber for seat cushions and fibers for carpets and textiles. There is also a database of more than 700 research papers and reports on these and other aspects of fire safety research.

— Rick Darby and Patricia Setze