Checklists, Monitoring, and Multitasking in Cockpit Operations

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Forgetting to Perform Procedural Tasks

- 20 August 2008: MD-82 on takeoff from Madrid
  - Flaps not in takeoff position
  - Takeoff configuration warning did not sound
- Similar accidents occurred in U.S. in August 1988 (B727), August 1987 (MD-82)
  - Flaps not set and warning system failed
- 27 major airline accidents in U.S. between 1987 and 2001 attributed primarily to crew error
  - In 5 the crew forgot to perform a flight-critical task
  - Did not catch with the associated checklist

The Multitasking Myth: Handling Complexity in Real-World Operations

Loukia D. Loukopoulos, Key Dismukes, & Immanuel Barshi

- Chapter 1: Introduction
- Chapter 2: What is multitasking and how it is accomplished?
- Chapter 3: The Ideal: flight operations as depicted in flight operations manuals
- Chapter 4: The Real: flight operations add complexity and variability
- Chapter 5: Analysis of concurrent task demands and crew Responses
- Chapter 6:The research applied
- Glossary
- Index
- Appendices: A. Methods, B. Human Agents, C. Perturbations, D. Errors
- References

Compared Cockpit Cognitive Demands with FOMs and Training

- Ideal (FOM): Tasks are linear/sequential, predictable, and controllable
- Real (Jumpseat): Interruptions, concurrent tasks, tasks out of sequence, unanticipated new tasks
- Perturbations create multitasking demands
  - People overestimate ability to multitask
  - Common error: forgetting/failing to perform task element
  - Factor in many accidents
- Cognitive analysis of multitasking & prospective memory situations

Chapter Six: The Research Applied

- Reviewing and Revising Procedures
  - Setting flaps for takeoff
  - The original pre-takeoff procedure
  - The new pre-takeoff procedure
- Aviation and beyond
  - Improving the effectiveness of checklists and crew monitoring
  - Strategic management of concurrent task demands
  - Training and personal techniques
- Summary of recommendations
  - For organizations
  - For individuals
- Concluding thoughts

Checklist and Monitoring Study

- Update on progress since last year’s FAA research review
- These two crucial defenses failed in many accidents — Why?
- Method: Jumpseat observations and cognitive analysis of task demands
- First step: Identify types of error and surrounding circumstances

Data Collection Recently Completed

- 60 flights observed at three airlines
  - Large U.S. airline and large international airline with world-wide flights and a regional airline
- Aircraft:
  - B737 (29)
  - A320 (11)
  - EMB (10)
  - B757 (7)
  - B767 (2)
  - B777 (1)
- Pilot flying: Captain, 63%; First officer, 37%
- Pilot making the error: Flying pilot, 50%; Monitoring pilot, 50%

Preliminary Results

- Errors defined as deviations from published SOP, regulations or good operating practice
- 899 errors observed in 60 flights
  - Observations consist of narrative descriptions of error and context
- Narratives entered in database
  - Exploring ways to categorize and analyze data

Phase of Flight at Time of Error

Pretaxi:	171	(19 percent)
Taxi-out:	78	(9 percent)
Takeoff/Initial Climb:	24	(3 percent)
Cruise Climb:	205	(23 percent)
Cruise:	74	(8 percent)
Descent:	210	(23 percent)
Approach (Vectors or Final):	89	(10 percent)
Landing:	2	(0 percent)
Taxi-in:	28	(3 percent)
Shutdown/Parking:	18	(2 percent)

Errors Per Flight

Monitoring:	6.8 ± 3.9	(range: 1-19)
Checklist:	3.2 ± 2.9	(range: 0-14)
Primary procedure:	5.0 ± 4.8	(range: 0-21)

Checklist Error Types

Item omitted or performed incompletely	50
Flow/Check performed as Read/Do	46
Responded to challenge without looking	36
Poor timing of checklist initiation	32
Checklist performed from memory	17
Checklist not called for	13
Total	194

Item(s) Omitted from Checklist

(50 instances)

- Common outcome, but several clusters of diverse situations
- Cluster: Checklist item deferred and later forgotten
  - Example: Early call for Approach checklist; last two items deferred
- Cluster: Checklist interrupted by external agent/event
  - Example: Departure Briefing interrupted. Last item never completed
- Dodhia & Dismukes: Interruptions Create Prospective Memory Tasks (*Appl. Cog. Psychol*, 2008)
  - Individuals fail to encode explicit intention to resume interrupted task
  - Absence of cues to prompt remembering to resume
- Cluster: Items overlooked without interruption or deferral
  - Normal cues absent? Attention diverted? Source memory confusion?

Performing Flow-then-check Procedure as Read-Do

(46 instances)

- Problematic:
  - Not all flow items are on checklist
  - Defeats purpose of redundant check
- Why?
  - Inherently tedious to laboriously check habitual task just performed?
  - Reversion to old Read-Do procedure after company changed SOP?

Responding to Checklist Challenge without Visually Inspecting Items

(36 instances)

- Example: Captain responded “ON” to APU Bleed challenge, but bleed was actually off
  - Conceivably a case of looking without seeing
- Example: First officer did not look up from checklist card to verify items on overhead panel
- Why?
  - Perhaps relying on memory of having just set an item
  - Undermines independent verification

Checklist Performed Entirely from Memory

(17 instances)

- Example:
  - Captain performed Approach checklist without pulling out card
  - Captain performed After Takeoff checklist late without pulling out card
  - First officer pulled out card but ran Before Start Checklist without looking at it
- Why?
  - Using card is slow and awkward compared to fluent execution from memory
  - Response to time pressure?
  - Do checkpilots notice and correct this error?

Poor Timing of Checklist Initiation

(32 instances)

- Example: First officer, pilot flying, called for In-Range Checklist at 10,000 feet instead of 18,000 feet
  - Prospective memory error

- Example: Captain called for Taxi Checklist when aircraft was approaching runway intersection, causing first officer to go head down

Checklist Not Called For

(13 instances)

- Example: First officer omitted “Flaps up, After Takeoff checklist” call
  - PM failure while attention occupied with other tasks
- Example: First officer omitted Approach checklist on final approach
- Example: Approaching departure runway, captain did not call for Before Take checklist. First officer self-initiated and captain did not act surprised.
  - A norm for some crews?

Monitoring Error Types

Callout Omitted or late	214
Verification omitted	123
Failure to monitor aircraft at level-out	64
Pilot head-down at critical juncture	5
total	406

Callout Omitted or Late

(214 instances)

- Most frequent: Omission of “1000 feet to go” call
  - Prospective memory issue: Must switch attention between monitoring altimeter and other tasks. Lack of cues to prompt timely switch
- Most serious: Omission of callouts required during unstabilized approaches
  - Example: Monitoring pilot did not call out “Unstable” when approach remained unstable below 500 feet
  - Flying pilot can be too focused on trying stabilize flight path to evaluate whether possible to land safely
  - Similar to SouthWest 1455 at Burbank and American 1420 at Little Rock

Verification Omitted

(123 instances)

- Example: Neither pilot reset altimeter climbing through FL180
- Example: Captain verified flap position by looking at and touching flap handle without looking at flap position indicator during Landing checklist

Failure to Monitor Aircraft

(64 instances)

- Example: Captain began cruise cockpit panel scan early and did not monitor level-off by automation
  - Poor workload management
  - Automation complacency?
- Crew occupied with weather avoidance did not notice fuel configuration EICAS message

Pilot Head Down at Crucial Juncture

(5 instances)

- Example: Captain called for second engine start shortly before crossing a runway, First officer went head down
- Example: First Officer started reviewing final weight data and inputting MCDU while aircraft moving through crowded ramp area
- Problematic workload management
  - Interferes with monitoring
  - Can lead to snowballing problems as crew get behind aircraft

How Often Were Errors Caught and by Whom?

Error trapped (18%); error not trapped (82%)

When trapped, trapped by:

Captain	(39%)
First officer	(40%)
ATC	(11%)
Flight attendant	(1%)
Aircraft warning system	(1%)
Jumpseat observer	(7%)

Crewmember trapping error:

Pilot making error	(21%)
Other pilot	(89%)

What are the Major Themes?

- Still analyzing data—impressions only
- 899 errors seem a lot
  - But thousands of opportunities of error on every flight
- Wide range in error rates/flight
  - Some due to flight conditions and observer familiarity with aircraft
  - Still substantial variation among crews—standardization issue?
- Unrealistic to expect 100% reliability among human operators
  - Especially when switching attention among multiple tasks

Major Themes
(continued)

- Monitoring and checklist callouts are especially likely to be dropped during high workload
  - Lose the error-trapping protection when it is most needed
- Subtle reason why error-trapping functions are the first to go
  - Primary procedural errors (e.g., setting flaps) give feedback (e.g., takeoff abort)
  - Monitoring & callout errors rarely lead to bad consequences (though safety compromised)
  - Without feedback loop, errors increase, though pilots may be unaware of it

Major Themes
(continued)

- Many errors were inadvertent errors of omission
  - Prospective memory research: human brain not well equipped to remember to perform tasks that are interrupted, deferred, or performed out of normal sequence.
  - The *Multitasking Myth* provides a cognitive account of this vulnerability and gives detailed countermeasures
- Some errors of omission were not inadvertent
  - Performing checklists from memory, etc.
  - Correct procedure goes against the grain for fluent performance of habitual tasks
  - Pilots “streamline”, perform tasks quickly and fluently but lose the protection provided by the procedure

“Streamlining” of Checklists

- Does training adequately explain to pilots their vulnerability to streamlining and its danger?
- How rigorous is checking of checklist deviations?
  - Deviations are subtle and fleeting. Checkpilots focus on big picture
  - Without feedback loops, procedures will be streamlined to be fast and to minimize mental workload
- Do companies write stringent, perhaps idealistic procedures but tacitly condone streamlining?
  - If procedures are unrealistic, should be rewritten

Ways to Improve Checklist Use and Monitoring

(from *The Multitasking Myth*)

- Beyond engineering considerations, procedures must reflect realities of operating conditions and human information processing
- Loukia's study found SOPs often idealistic, failing to capture dynamic & complex nature of real-world conditions and task demands
  - Conflicts arise among procedural demands, operational demands, and human cognitive capabilities
- Recommend companies periodically analyze SOPs for conflicts and hidden traps
  - Start with incident reports
  - Create team of experienced pilots
  - Consult with human factors experts

One Company's Overhaul of Normal Procedures

- Taxi checklist produced conflict between:
  - Procedural demand: preparing aircraft for departure and
  - Operational demands: controlling movement of aircraft—following taxi route—maintaining awareness of airport layout, aircraft position, position of other aircraft—communication
- Shifting attention among multiple tasks was a major factor in rejected takeoffs and runway incursions
- In-flight procedures, e.g.:
  - Schedule flows & checklists to avoid conflict with transitions between ATC during climb-out and descent
- Performing tasks out of normal sequence often leads to forgetting task elements
  - Deferring flaps for movement on contaminated taxiways not necessary for all aircraft types

Ways to Improve Checklist Use and Monitoring

(continued)

- Training:
  - Don’t stop with telling pilots what to do
  - Explain what errors occur and why
  - Use real-world scenarios, e.g., snowballing workload in unstabilized approaches
  - Why quality of checklist execution erodes unwittingly
  - Need for slow, deliberate execution that goes against the grain
- Expand workload management portion of CRM
  - Traditionally focuses on distribution of tasks and handling overload
  - Add ways pilots can avoid amplifying workload problems with better timing of task initiation
  - Explicitly address time pressures and dangers of rushing

Ways to Improve Checklist Use and Monitoring

(continued)

- Insure company policies & practices do not implicitly reward rushing and risky decision-making
- Company guidance for monitoring is much too vague
  - Specify what to monitor and when
  - Specify and emphasize wording and timing of callouts
- You get what you check and what you reward
  - Include how checklists are run and monitoring performed in line and sim checks
  - Reward correct use, not streamlining

More Information

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