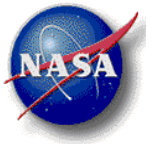
The Story of Multitasking

Immanuel Barshi

Multitasking is endemic in modern life and work: drivers talk on cell phones, office workers type while answering phone calls, students do homework while text messaging…but, nurses also prepare injections while responding to doctor's calls, and air traffic controllers direct aircraft in one sector while handling aircraft additional traffic in another. Whether in daily life or at work, we are constantly bombarded with multiple, concurrent interruptions and demands and we have all somehow come to believe in the myth that we can, and in fact are expected to, easily address them all—without any repercussions. Accumulating However, accumulating scientific evidence is now suggesting that multitasking increases the probability of human error. This talk presents a set of NASA studies that characterize concurrent demands in one work domain, routine airline cockpit operations, in order to illustrate the ways operational task demands together with the natural proclivity to manage them all concurrently make human performance in this and in any work domain vulnerable to potentially serious errors and to accidents.

Human Systems
integration division



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PGME Simulation Education and Research Symposium 2018

Postgraduate Medical Education

University of Calgary

October 4th, 2018

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A deadly omission (among other things)

- 20 August 2008: MD-82 on takeoff from Madrid
  - Flaps not set for takeoff

A deadly omission (among other things)

- 20 August 2008: MD-82 on takeoff from Madrid
  - Flaps not set for takeoff

- NASA ASRS: since 2000, pilots have reported their failure to properly set the flaps for takeoff over 60 times!

Hanging by a thread…

- ASRS #658970, night of May 2005, DCA
- DCA, VMC
- Crew of B737-800 reporting:
- ".. As we started the taxi, I called for the taxi checklist, but became confused about the route and queried the first officer to help me clear up the discrepancy. We discussed the route and continued the taxi... We were cleared for takeoff from runway 1, but the flight attendant call chime wasn't working. I had called for the Before Takeoff checklist, but this was interrupted by the communications glitch. .. On takeoff, rotation and liftoff were sluggish. At 100-150 ft as I continued to rotate, we got the stick shaker. The first officer noticed the **no flap condition** and placed the flaps to 5. (No takeoff warning horn. Discovered popped circuit breaker back at the gate)…"

Inadvertent (deadly) Procedural Omissions

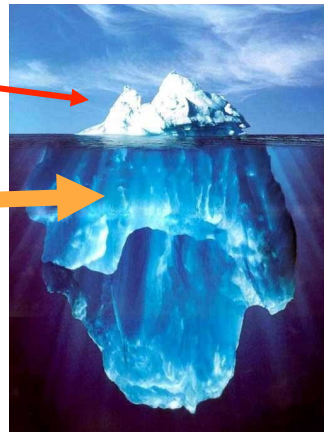
Dismukes (2006) looked at 27 major aviation accidents in U.S. (1987-2001) in which crew error was cited as causal or contributing factor

Typical examples include

- **Detroit (1987): DC-9 crashed shortly after take-off**
  - NTSB: Flaps/slats not set to take-off position
- **Dallas (1988): B-727 crashed shortly after take-off**
  - NTSB: Flaps/slats not set to take-off position
- **LaGuardia (1994): MD-82 ran off runway end after a high-speed rejected take-off**
  - NTSB: pitot heat not turned on - anomalous airspeed indications
- **Houston (1996): DC-9 landed gear-up**
  - NTSB: Hydraulic pump not set to high position
- **Little Rock (1999): MD-80 ran off runway end after landing**
  - NTSB: ground spoilers and autobrakes not armed before landing

Were these accidents unique?

- **No**, they are just the tip of the iceberg



ASRS reports tell us about:

- Rejected take-off – forgot flaps
- Runway incursion – forgot to monitor
- Broken tow-bar – forgot to clear pushback crew
- Taxiing into a ditch – forgot to brief
- Engine flame-out – forgot to stop fuel transfer
- Departing with inadequate fuel – forgot to check on preflight
- Leaving APU running during takeoff – forgot checklist item
- Took off without PDC – forgot to request
- Deviated from speed or altitude restriction – forgot to enter on MCP
- Flying wrong departure route – forgot to follow new instructions

=> Compromises to safety

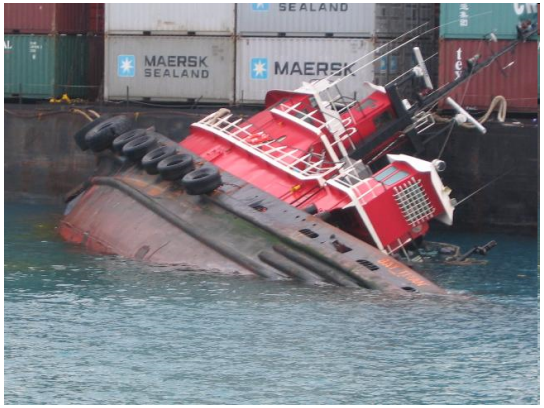
=> Unnecessary costs and delays

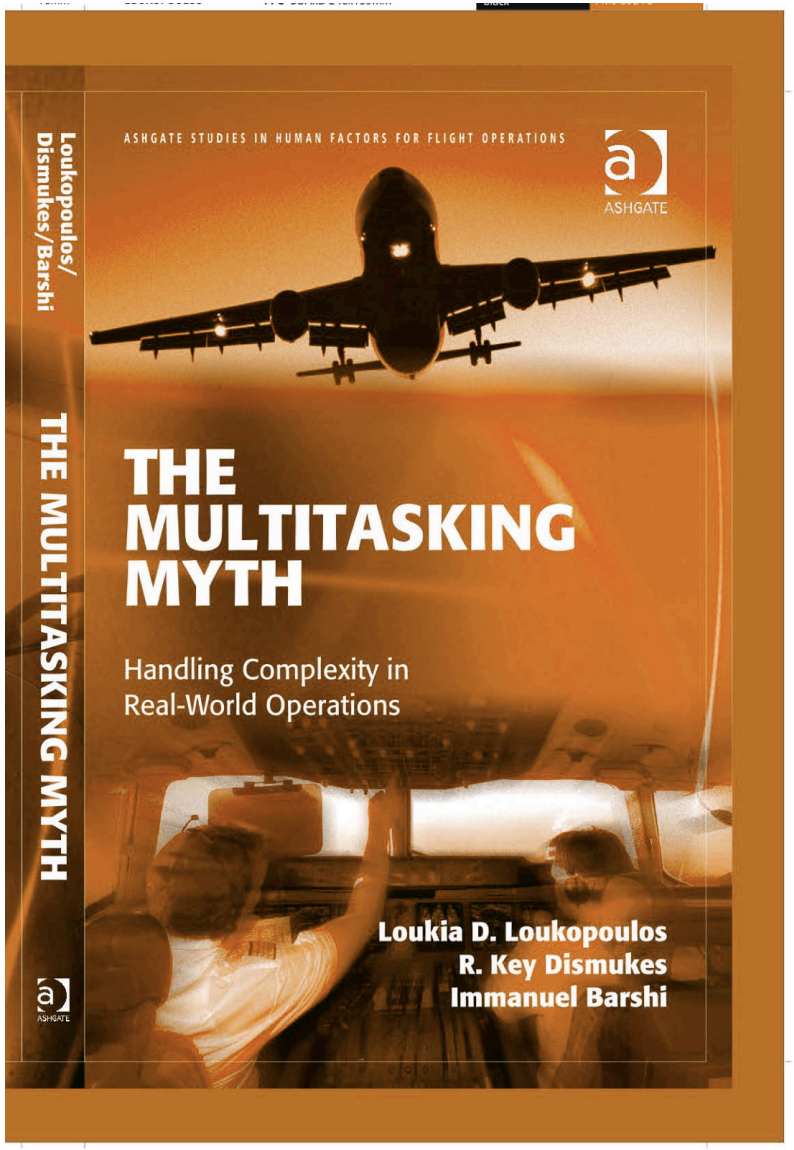
Are pilots alone?

Is Aviation alone?

No.

We see the same problems in all high-risk industries.

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Dismukes/Barshi
THE MULTITASKING MYTH
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ASHGATE STUDIES IN HUMAN FACTORS FOR FLIGHT OPERATIONS
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THE
MULTITASKING
MYTH
Handling Complexity in
Real-World Operations
Loukia D. Loukopoulos
R. Key Dismukes
Immanuel Barshi

Data Sources

Personal flying experience

Many different jumpseat observations

- Airline Training
- Analysis of FOMs, SOPs, & Checklists
- Analysis of accident and incident reports

- Extensive interaction with participating carriers and others.

Data Sources

Structured Jumpseat Observations and crew interviews

- Two major US carriers
- Routine, revenue flights, B737
- 1-2 hour legs; 3-day trips
- All phases of flight
- All over the country (domestic ops)


FOM

BEFORE START

FLIGHT DECK PREPARATION . . . . . COMPLETED
LIGHT TEST . . . . . CHECKED
OXYGEN & INTERPHONE . . . . . CHECKED
YAW DAMPER . . . . . ON
INSTRUMENT TRANSFER SWITCHES . . . . . NORMAL
FUEL . . . . . _____ KGS & PUMPS ON
GALLEY POWER . . . . . ON
EMERGENCY EXIT LIGHTS . . . . . ARMED
PASSENGER SIGNS . . . . . SET
WINDOW HEAT . . . . . ON
HYDRAULICS . . . . . NORMAL
AIR COND & PRESS . . . . . _____ PACK(S), BLEEDS ON, SET
AUTOPILOTS . . . . . DISENGAGED
INSTRUMENTS . . . . . X-CHECKED
ANTISKID . . . . . ON
AUTO BRAKE . . . . . RTO
SPEED BRAKE . . . . . DOWN DETENT
PARKING BRAKE . . . . . SET
STABILIZER TRIM CUTOUT SWITCHES . . . . . NORMAL
WHEEL WELL FIRE WARNING . . . . . CHECKED
RADIOS, RADAR & TRANSPONDER . . . . . SET
RUDDER & AILERON TRIM . . . . . FREE & ZERO
PAPERS . . . . . ABOARD
FMC/CDU . . . . . SET
N1 & IAS BUGS . . . . . SET

Taxi to the runway

CAPTAIN

“Flaps 5, taxi clearance”

MONITOR
Ground

MONITOR
Ground, Company

FIRST OFFICER

Set flaps, verify in position

Obtain clearance

TAXI CLEARANCE

CAPTAIN

"Flaps 5, taxi clearance"

MONITOR
Ground

MONITOR
Ground, Company

FIRST OFFICER

Set flaps, verify in position

Obtain clearance

TAXI CLEARANCE

Start taxiing

A
…
then
…
B
…
then
…
C
…
etc

BEFORE TAKE (down Item to check
Recall (check)
xxx xxxx (xxxxx)
Flaps (_, green light)
xxxxxxx (xx)
Cabin door (lo...)
xxx xxxxx (xx ... xxxx)
Takeoff briefing (review)

BEFORE TAKEOFF PROCEDURE (down to the line) Item to check (action required)
xxx xxxx (xxxxx)
Flight controls (check)
Flaps (_, green light)
xxxxxxx (xx)

MONITOR
CA taxiing

Ask for checklist

Pilot calls when ready

Pilot is ready

BEFORE TAKEOFF CHECKLIST (down to the line)	
Challenge	**Response**
xx xxxxx xx	xx xxxxx
Flight controls	Checked
xx	xxxxxx xx xx
Flaps	Set _, green light
Takeoff Briefing	Completed
xxx	xx

Begin checklist

Checklist complete

BEFORE TAKEOFF PROCEDURE (below the line) Item ... check (action required)
ENGINE START ... witches (CONT)
LANDING lights and STROBE light switches (as desired)
xxx xxxxx (xx xxxxxx)

BEFORE TAKEOFF PROCEDURE (below the line) Item to check (action required)
xxx xxxxx (xx xxxxxx)
FMC position update (as de...red)
Transponder (On)

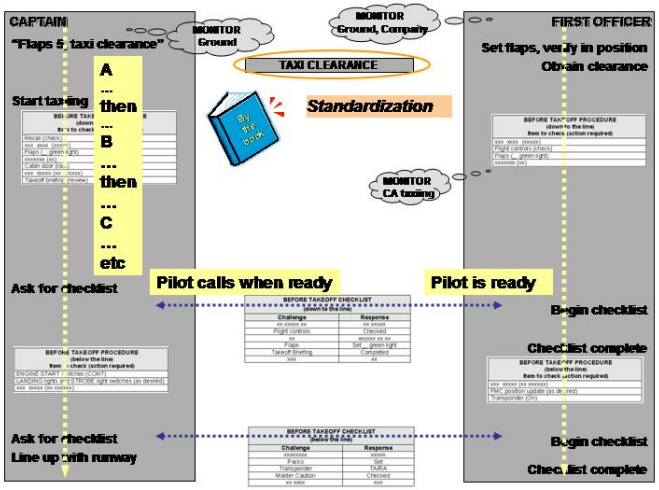
Ask for checklist

Line up with runway

BEFORE TAKEOFF CHECKLIST (below the line)	
Challenge	**Response**
xxxxxxxx	xxxxx
Packs	Set
Transponder	TA/RA
Master Caution	Checked
xx xxxx	xxx

Begin checklist

Checklist complete



In THEORY…

Activities are:

- **Linear**: task B always follows task A, in a fixed sequence
- **Controllable**: tasks initiated by each pilot, independently, at their choice
- **Predictable**: information available when needed, communications possible when necessary

Taxi.. in reality

CAPTAIN

"Flaps 5, taxi clearance"

Ice/Snow
Defer takeoff flaps
Set flaps before takeoff

Unfamiliar with airport/taxi route
Verify with FO

+ Verify ramp area clear

Start taxiing

+ Form mental picture of taxi route

BEFORE TAKEOFF PROCEDURE
(down to the line)
Item to check (action required)

Recall (check)
xxx xxxx (xxxxx)
Flaps (_, green light)
xxxxxxx (xx)
Cabin door (lock)
xxx xxxxx (xx xxxxxx)
Takeoff briefing (review)

+ MONITOR airport traffic

Ice/Snow
De-icing checklist

Systems configuration? (APU, Packs)

+ APU off-loaded 2 min before shutting down

Delay
Shut down one engine?
Restart it before takeoff
Repeat checklist

FO busy
Defer checklist
Remember to ask again when FO availa

Ask for checklist

+ Identify/remember turns
+ Follow hold-short instructions
+ Identify/Remember aircraft to follow

Change in takeoff runway
Accept new runway?
Consult charts
Brief new runway

BEFORE TAKEOFF PROCEDURE
(below the line)
Item to check (action required)

ENGINE START switches (CONT)
LANDING lights and STROBE light switches (as desired)
xxx xxxxx (xx xxxxxx)

Malfunction
Return to gate

Ask for checklist

Line up with runway

+ Landing lights
+ Shoulder harnesses
+ Radar?
+ Verify runway clear

TAKEOFF CLEARANCE

BEFORE TAKEOFF CHECKLIST
(below the line)

Challenge	Response
xxxxxxxx	xxxxx
Packs	Set
Transponder	
Master Ca	
xx xxxx	xxx

Rush/repeat checklist

TAKEOFF

FIRST OFFICER

Busy frequency
Defer communication
Contact Ground when possible

Unfamiliar taxi instructions
Consult charts

+ Acknowledge clearance
+ Form mental picture of taxi route
+ Confirm CA's understanding of route

+ MONITOR taxi progress per instructions

+ "Clear" ramp area

BEFORE TAKEOFF PROCEDURE
(down to the line)
Item to check (action required)

xxx xxxx (xxxxx)
Flight controls (check)
Flaps (_, green light)
xxxxxxx (xx)

+ "Clear" turns

MONITOR CA taxiing

New/ Additional taxi instructions
Acknowledge instructions
Form new mental picture

Just-in or new load data
Calculate & reset Performance data
Check accuracy
Continue to monitor CA

FMC: program/verify
Inform Company (new #s, delays)
Have CA cross check #s

Begin checklist

BEFORE TAKEOFF CHECKLIST
(down to the line)

Challenge	Response
xx xxxxx xx	
Flight controls	
xxxxxx x	
Set _, gr	
C	

Interruption
Resume checklist

+ Switch to Tower frequency

+ MONITOR Tower frequency

Checklist complete

BEFORE TAKEOFF PROCEDURE
(below the line)
Item to check (action required)

xxx xxxxx (xx xxxxxx)
FMC position update (as desired)
Transponder (On)

+ Acknowledge clearance
+ Confirm CA's understanding

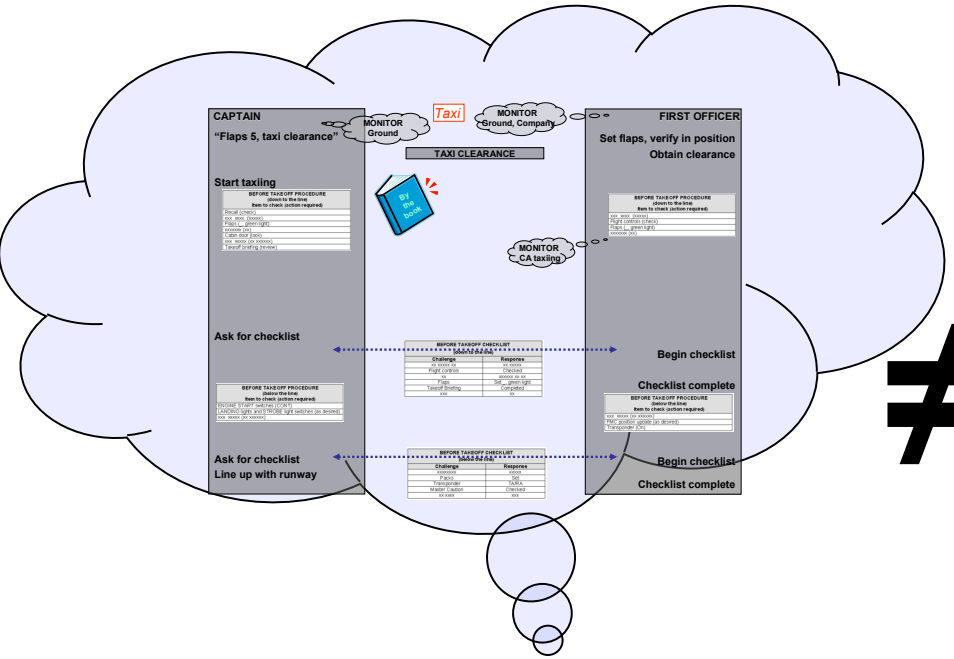
+ FMC update
+ Strobes
+ "Clear" runway

Begin checklist

Checklist complete

+ Take control of aircraft while finishing checklist

Theory is different from Practice



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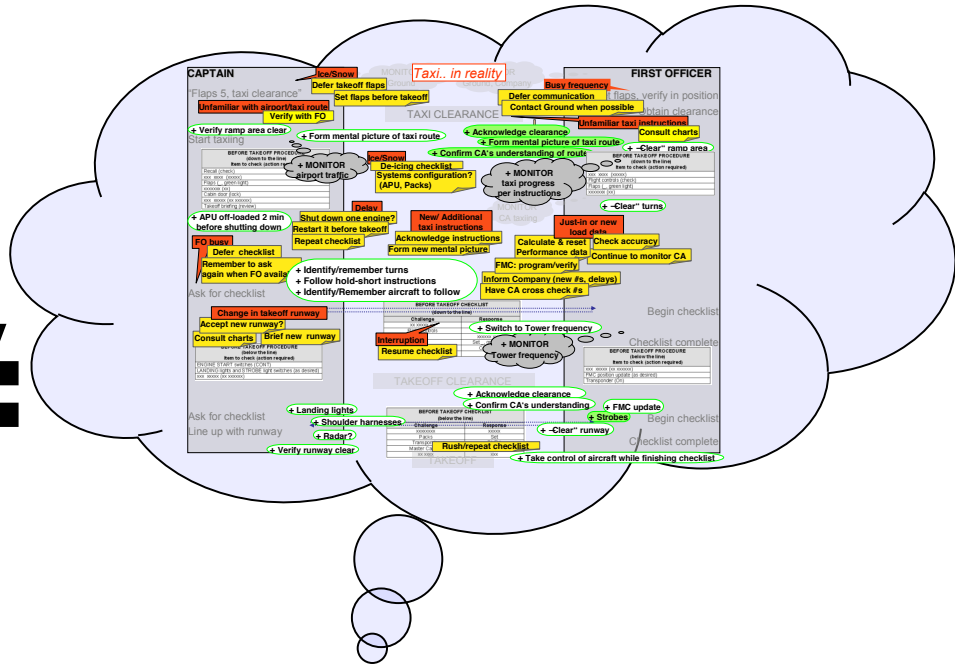


OK, so What?

- Pilots (and others) become accustomed to concurrent task demands, interruptions, distractions and disruptions.

and the truth is …

- Pilots (and others) routinely manage multiple, competing, concurrent task demands just fine…

Taxi Errors

CAPTAIN

Request taxi clearance

Ask for checklist

Line up wit

FIRST OFFICER

Obtain clearance

OUND CONTROLLER

Ask for checklist

in checklist

klist complete

in checklist

Checklist complete

OMITTED CALL FOR FLAPS - RUSHED TO CLEAR RAMP/GATE AREA FOR ARRIVING AIRCRAFT - ABORTED TAKE

STARTED TAXI WITHOUT CLEARANCE - TROUBLE-SHOOTING PROBLEM WITH ENGINE START - NEARLY HIT GROUND HANDLER

STARTED TAXI WITHOUT CLEARANCE — RUSHED BY OTHER AIRCRAFT WAITING TO PULL INTO GATE; RADIO CONGESTION; MARSHALLER' S HEADSET

CA TAXIS WITHOUT HAVING FULLY UNDERSTOOD INSTRUCTIONS - BUSY LOOKING AT OTHER AIRCRAFT ON TAXIWAY AND RAMP — WARNING ISSUED BY GROUND CONTROLLER

STARTED TAXI WITHOUT CLEARANCE - CREW DISCUSSING TAXI INSTRUCTIONS - STRUCK P

INCORRECT TRIM SETTING - CHECKLIST INTERRUPTED AFTER ITEM HAD BEEN READ BUT NOT VERIFIED — ABORTED TAKEOFF

OMITTED FLAPS - CREW DISCUSSING PROBLEM WITH APU, DELAYED FLAPS DUE TO SNOW - ABORTED TA

FAILED TO START ENGINE #-2 - DISTRACTED WHILE DISCUSSING SPECIAL OPERATIONS FOR DESTINATION; OMITTED CHECKLISTS - D

NEGLECTED TO SET FLAPS - PREOCCUPIED WITH NEW DEPARTURE CLEARANCE AND PACKS-OFF OPERATION - AB

FO FAILED TO MONITOR CA - BUSY CHECKING AND CORRECTING CALCULATIONS OF LOAD DATA - AIRCRAFT TAXIED PAST HOLD SHORT LINE

FO FAILED TO MONITOR CA — BUSY WITH FLOW; NIGHT TAXI — TAXIED IN WRONG DIRECTION

FLAPS INCORRECTLY SET, MISSED NOTICING DURING CHECKLIST CREW BUSY WITH FUEL PROBLEM, RUNWAY CHANGES, PROGRAMMING FMC - ABORTED TAKEOFF

OMITTED CHECKING INTO BLEED AIR INDICATOR LIGHT-BUSY WITH DELAYED ENGINE START AND CHECKLISTS —

CREW RUSHED TO PERFORM DELAYED ENGINE START - FLEW WITH POTENTIAL EQUIPMENT

CONFUSE OWN POSITION ON TAXIWAY DIAGRAM - NEW TERMINAL, STUDYING NOTAMS, RUNWAY CHANGE — TAXIED INTO

FO FAILED TO MONITOR CA - BUSY REPROGRAMMING FMC FOR RUNWAY CHANGE - TAXIED PAST INTENDED TAXIWAY

FAIL TO CONFIRM FLAP POSITION - EVALUATING HEAVY RAIN SHOWERS; RUSHED TO ACCEPT TAKEOFF CLEARANCE - ABOR

FO FAILED TO MONITOR CA - BUSY WITH PRE-TAKEOFF PREPARATIONS - AIRCRAFT CROSSED HOLD SHORT LINE

OMITTED CHECKLIST - BUSY WITH DELAYED ENGINE START AND CHECKLISTS; RUSHED TO ACCEPT TAKEOFF CLEARANCE - FLAPS NOT SET, ABORTED TAKEOFF

OMITTED FLAPS - CHECKLIST INTERRUPTED BY THRUST REVERSER LIGHT; CREW BUSY TROUBLESHOOTING -

MISUNDERSTOOD TOWER INSTRUCTION - NEW FO ON IOE, CA COACHING FO - TAXIED ONTO RUNWAY WITHOUT CLEARANCE

FLAPS INCORRECTLY SET - LATE PAPERWORK AND RUNWAY CHANGE; PROGRAMMING FMC;SHORT TAXI; RUSHED TO ACCEPT TAKEOFF CLEARANCE - ABORTED

OMIT CHECKLIST - RUNNING LATE, CHECKLIST INTERRUPTED BY TOWER, UNEXPECTED CLEARANCE FOR TAKEOFF - ABORTED TAKEOFF

OMITTED FLAPS-CHECKLIST INTERRUPTED BY TOWER; CREW RUSHED TO ACCEPT TAKEOFF CLEARANCE-ABORTED TAKEOFF

The reality of cockpit operations

Constant presence of **Perturbations** that:

- **Interrupt ongoing activity**
- **Force tasks to be performed outside their normal** (habitual) **sequence**
- **Give rise to new, unanticipated tasks**

Implications:

- **Attention diverted, even if for split second**
- **Actions and tasks suspended**
- **Actions and tasks deferred**
- **Actions and tasks interleaved**
- **Deferred tasks must be remembered later**
- **…There is no PAUSE button!**

A word about prospective memory…

Vulnerable to Omissions when…

- **Interrupted** *(4 Prototypical Situations)*
  - e.g., interrupted while conducting a checklist – forget to return to line item at which interrupted
- **Must perform tasks outside normal** (habitual) **sequence**
  - e.g., defer setting flaps until reaching runway for takeoff because of slush on taxiway – forget to extend flaps before takeoff
- **Must perform new, unanticipated tasks** (in lieu of habitual actions)
  - e.g., fly different heading than normal upon departure – forget to comply with new instruction and fly usual heading instead
- **Must interleave multiple tasks**
  - e.g., re-program FMC during taxi – forget to monitor aircraft

The hidden complexity of cockpit operations

- Complexity is not just a matter of workload
- Situations appear diverse but share underlying features that involve:

  Multitasking: multiple tasks, concurrently

- Pilots (all humans) **cannot multitask well**

  yet they typically do it:
  - without a second thought
  - without an appreciation of their true (in)ability
  - with an incomplete understanding of the risks they are taking when doing so

The Multitasking Myth

- We typically overestimate our ability to **multitask**
- In reality, our ability to multitask is a function of:
  - the degree to which tasks are practiced together
  - the degree to which each individual task requires conscious effort and attention
  - the cues available to prompt recall of intended actions
- Multitasking situations substantially increase our vulnerability to errors
  - Common error: forgetting/failing to perform a procedural step
  - Common error: inattention (being distracted)

And the truth about multitasking…

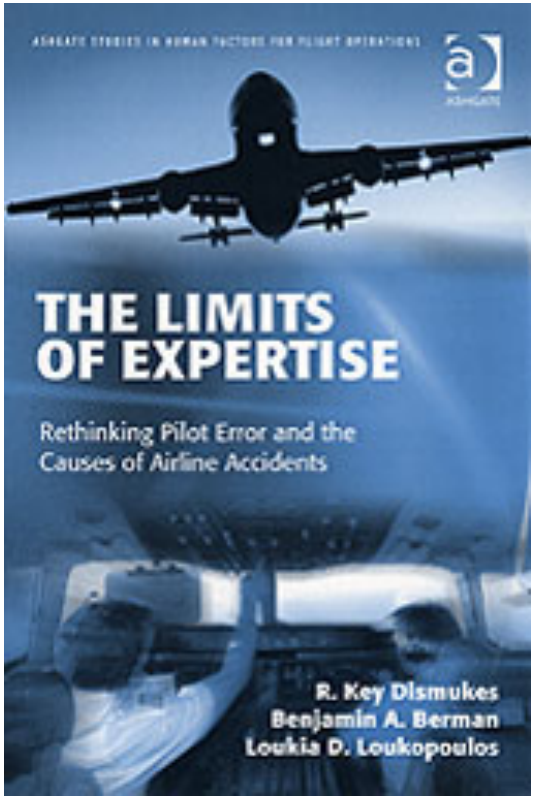
JKK 5022 Madrid
Omission: flaps for takeoff

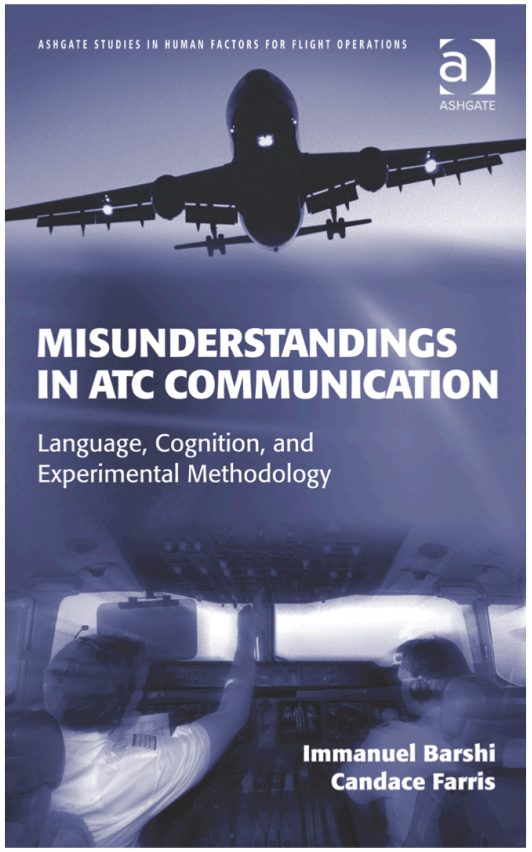
Crew experienced **perturbations**:

- An interruption (break in predictability)
- The need to re-arrange/repeat tasks
  (break in linearity)
- The need to make up for lost time
  (break in controllability)
- "Fast-forwarded" based on an expectation, and environmental cues (did not hit "Pause" button)

THANK YOU for your attention

Additional Information:





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