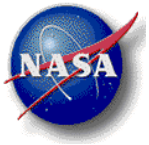
Human Systems
integration division



The Comprehensive LOFT

SWISS Flight Training

July, 2019

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20 August 2008
Madrid
Spanair 5022

16 August 1987
Detroit
Northwest Airlines 255

NASA ASRS:
Since 2000, pilots have reported their failure to properly set the flaps for takeoff well over 80 times!

Hanging by a thread…

- ASRS #658970
- 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 at the gate)…”

20 August 2008
Madrid
Spanair 5022

16 August 1987
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21 years, or rather 32, and what have we learned?

How come we keep making the same mistakes?

Question:

So what are we learning?

Or

What are we being taught?


FOM

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)

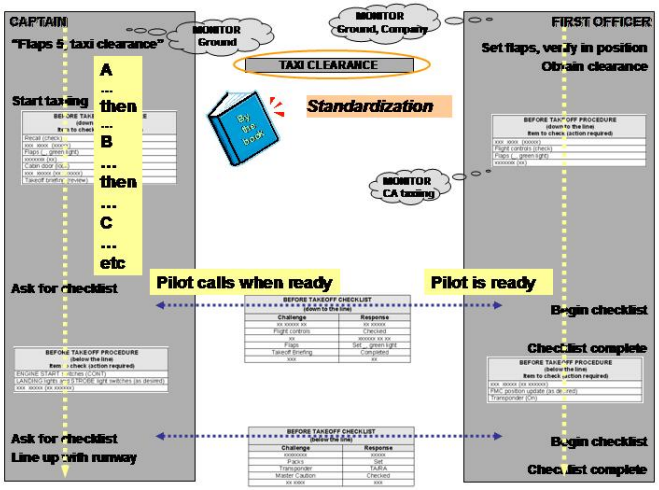
Ask for checklist

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



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

Which makes for simple teaching and easy learning!

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 re
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)

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

+ APU off-loaded 2 min before shutting down

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

FIRST OFFICER

Busy frequency
Defer communication
Contact Ground when possible

TAXI CLEARANCE

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)

MONITOR CA taxiing

+ "Clear" turns

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)

TAKEOFF CLEARANCE

+ Acknowledge clearance
+ Confirm CA's understanding

+ FMC update
+ Strobes
+ "Clear" runway

Begin checklist

BEFORE TAKEOFF CHECKLIST (below the line)	
Challenge	Response
xxxxxxxx	xxxxx
Packs	Set
Transpon	
Master Ca	
xx xxxx	xxx

Rush/repeat checklist

Checklist complete

+ Take control of aircraft while finishing checklist

TAKEOFF

Taxi Errors

CAPTAIN

Request taxi clearance

Ask for checklist

Ask for checklist

Line up wit

Loukop

- NASA

FIRST OFFICER

Obtain clearance

BEFORE TAKEOFF PROCEDURE

Recall (check)

xxxxxxx (xx)

Cabin door (lock)

xxx xxxxx (xx xxxxxx)

ROCEDURE

Transponder

Master Caution

xx xxxx

in checklist

list 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

OTHER AIRCRAFT WAITING TO PULL INTO GATE; RADIO CONGESTION; MARSHALLER' S HEADSET OUND CONTROLLER

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

NOTICING DURING CH

CREW BUSY WITH FUEL PROBLEM, RUNWAY CHANGES, PROGRAMMING FMC - ABORTED TAKEOFF

OMIT NGINE START AND CHECKLISTS — CREW RUSHED TO PERFORM DELAYED ENGINE START — FLEW WITH POTENTIAL EQUIPMENT

CONFUSE OWN POSITI TAXIED INTO

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

FAIL TO CON CLEARANCE - ABOR

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

OMITTED CHECKL CHECKLISTS; RUSHED TO ACCEPT TAKEOFF CLEARANCE - FLAPS NOT SET, ABORTED TAKEOFF

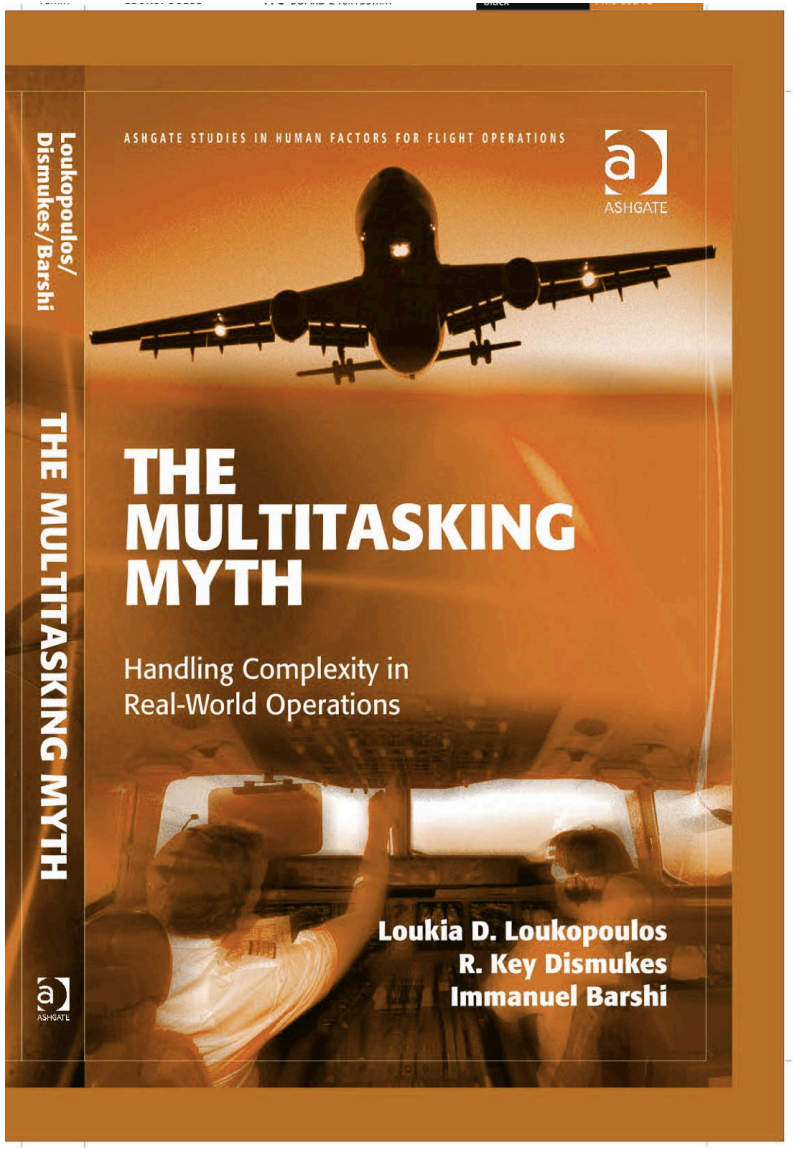
OMITTED FLAPS - CHECKLIST INTERRUPTED BY THRUST REVERSER LIGHT; CREW BUSY TROUBLESHOOTING -

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 LA…; CHECKLIST INTERRUPTED BY TOWER, UNEXPECTED CLEARANCE FOR TAKEOFF - ABORTED TAKEOFF

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


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

Two other studies

Casner, S. M., Geven, R. W., and Williams, K. T. (2013). The effectiveness of airline Pilot training for abnormal events. *Human Factors* 55(3), 477-485.
http://hfs.sagepub.com/content/55/3/477.abstract

Casner, S. M., Geven, R. W., Recker, M. P., and Schooler, J. W. (2014). The retention Of manual flying skills in the automated cockpit. *Human Factors* 56(8), 1506-1516.
http://hfs.sagepub.com/content/56/8/1506.abstract

http://www.newyorker.com/science/maria-konnikova/hazards-automation

THREE ABNORMAL EVENTS PRESENTED IN TWO WAYS

Stalls
Wind Shear Encounter at 600’ on Landing
Engine Failure on Takeoff After V_1

18 current 747-400 pilots.

EXPECTED

The Familiar Ways We See in Training

- Classic “stall series” demo
- Wind shear after suggestive ATIS
- V_1 cut on 2nd or 3rd takeoff

UNEXPECTED

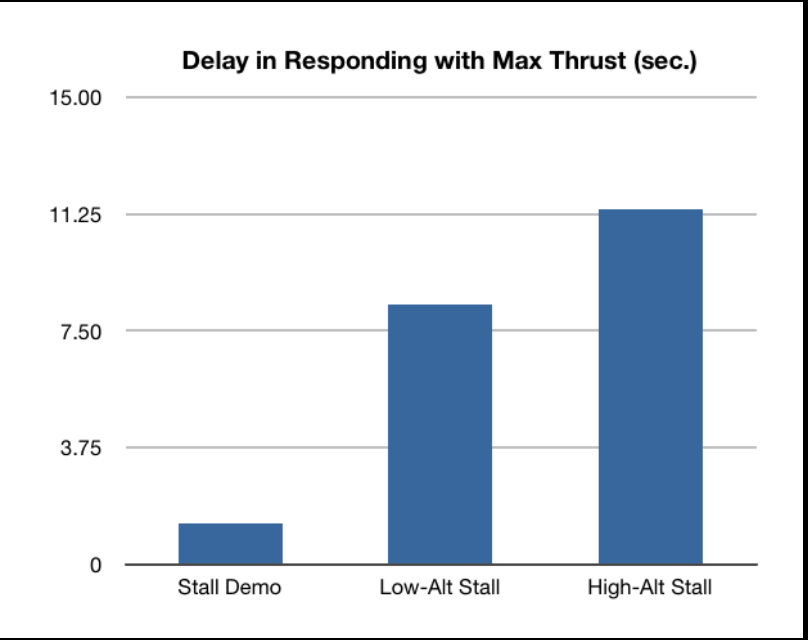
Different, Less Expected Ways

- Stall on departure at 2,500 ft
- High-altitude (FL340) stall
- Wind shear after calm winds ATIS and no “wind shear” alert
- V_1 cut on 1st takeoff of session

Compared EXPECTED and UNEXPECTED

STALLS

* THRUST RESPONSE:

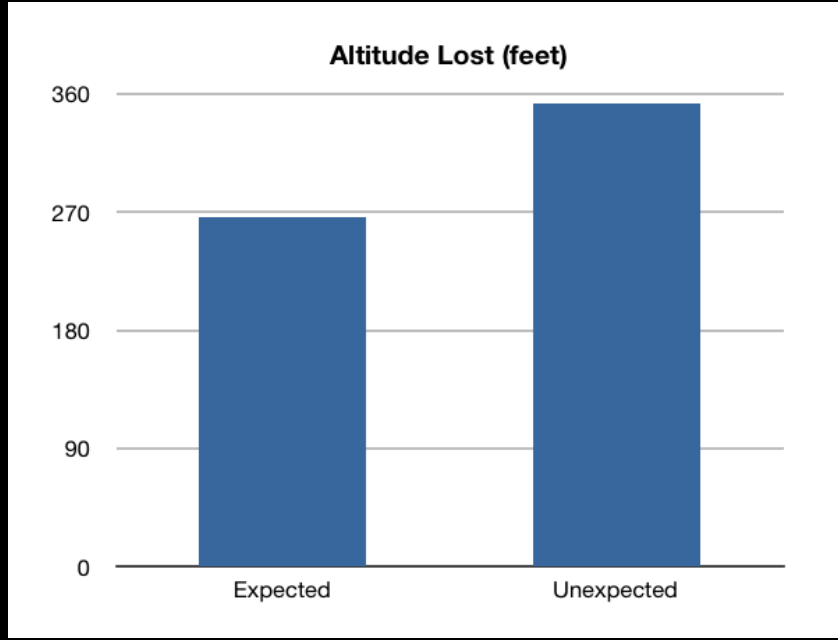


V_1 CUT

9 pilots saw failure on first takeoff.
2 aborted after V_1
9 pilots saw failure on later takeoff.
All 9 continued

WIND SHEAR ON LANDING

* ALTITUDE LOST:



* CONFIGURATION CHANGES:

EXPECTED: 2 of 18 changed config.
UNEXPECTED: 10 of 18 changed config.

WHAT WE SEE IN THE MEDIA

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Are airline pilots forgetting how to fly?

Industry is suffering from 'automation addiction,' industry insider says

The erosion of manual flying skills in highly automated aircraft

FLIGHTOPS

Diminishing Skills?

Do we really have a problem?

How bad is this really?
"Manual flying" refers to a broad collection of skills. Are we forgetting **all** of it?
Do we need to launch a comprehensive program to train everything?

B747-400 SIMULATOR STUDY:
We asked 16 current B744 pilots to fly published arrivals, approaches, and missed approaches in five different automation situations:

1. Full automation
2. No autopilot
3. No flight director
4. No FMC
5. Instrument system failures with no EICAS

PILOT PERFORMANCE: HAND FLYING & RAW DATA

TABLE 3: Pilots' Flying Performance (Instrument Scanning and Manual Control Skills) in Three Automation Conditions (N = 16)

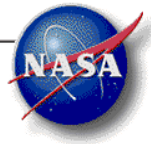
	Automation Condition		
Flight Phase	Autoflight	Manual Control	Raw Data and Manual Control
Arrival			
Off course (3 course assignments per pilot)	0% (0 of 48)	0% (0 of 48)	2% (1 of 48)
Speed > 10 kts (3 speed assignments per pilot)	8% (4 of 48) (M = 17 kts)	23% (11 of 48) (M = 15 kts)	15% (7 of 48) (M = 42 kts)
Altitude > 300′ (3 altitude assignments per pilot)	2% (1 of 48) (M = 740′)	10% (5 of 48) (M = 968′)	10% (5 of 48) (M = 732′)
Approach			
Off localizer (1 localizer assignment per pilot)		0% (0 of 16)	6% (1 of 16)
Off glide slope (1 glide slope assignment per pilot)		0% (0 of 16)	13% (2 of 16)
Speed > 10 kts (3 speed assignments per pilot)		0% (0 of 48)	6% (3 of 48) (M = 21 kts)
Altitude > 300′ (3 altitude assignments per pilot)		0% (0 of 48)	0% (0 of 48)
Missed Approach			
Off course (1 course assignment per pilot)		6% (1 of 16)	13% (2 of 16)
Speed > 10 kts (2 speed assignments per pilot)		6% (2 of 32)	38% (12 of 32)
Altitude > 300′ (1 altitude assignment per pilot)		0% (0 of 16)	6% (1 of 16) (M = 310′)

Note. Data in cells refer to percentage of tasks during which pilots committed at least one operationally significant

PILOT PERFORMANCE: DEALING WITH FAILURES

TABLE 7: Pilots' Performance During the Three Instrument System Failure Events (N = 16)

System Failure Event and Pilot Action	Proportion of Pilots
Altimeter lag	
Verbalized problem	100%
Cross-checked instruments	69%
Deviated from altitude	75%
Diagnosed problem	81%
Heading indicator skew	
Verbalized problem	94%
Cross-checked instruments	63%
Deviated from heading	38%
Diagnosed problem	56%
Unreliable airspeed	
Verbalized problem	100%
Cross-checked instruments	94%
Approached stall (# of stick shakers)	94% (M = 4.6, SD = 4.0)
Diagnosed problem	94%



Conclusions from these three studies

We seem to do a good job training crews for the training situations,
but perhaps not such a good job for the (unexpected) line situations.

Hand-eye skills that are “just like riding a bike” seem to be reasonably well-retained if initially well-learned, even when they are not practiced very often: e.g., raw data flying. But still could use some practice.

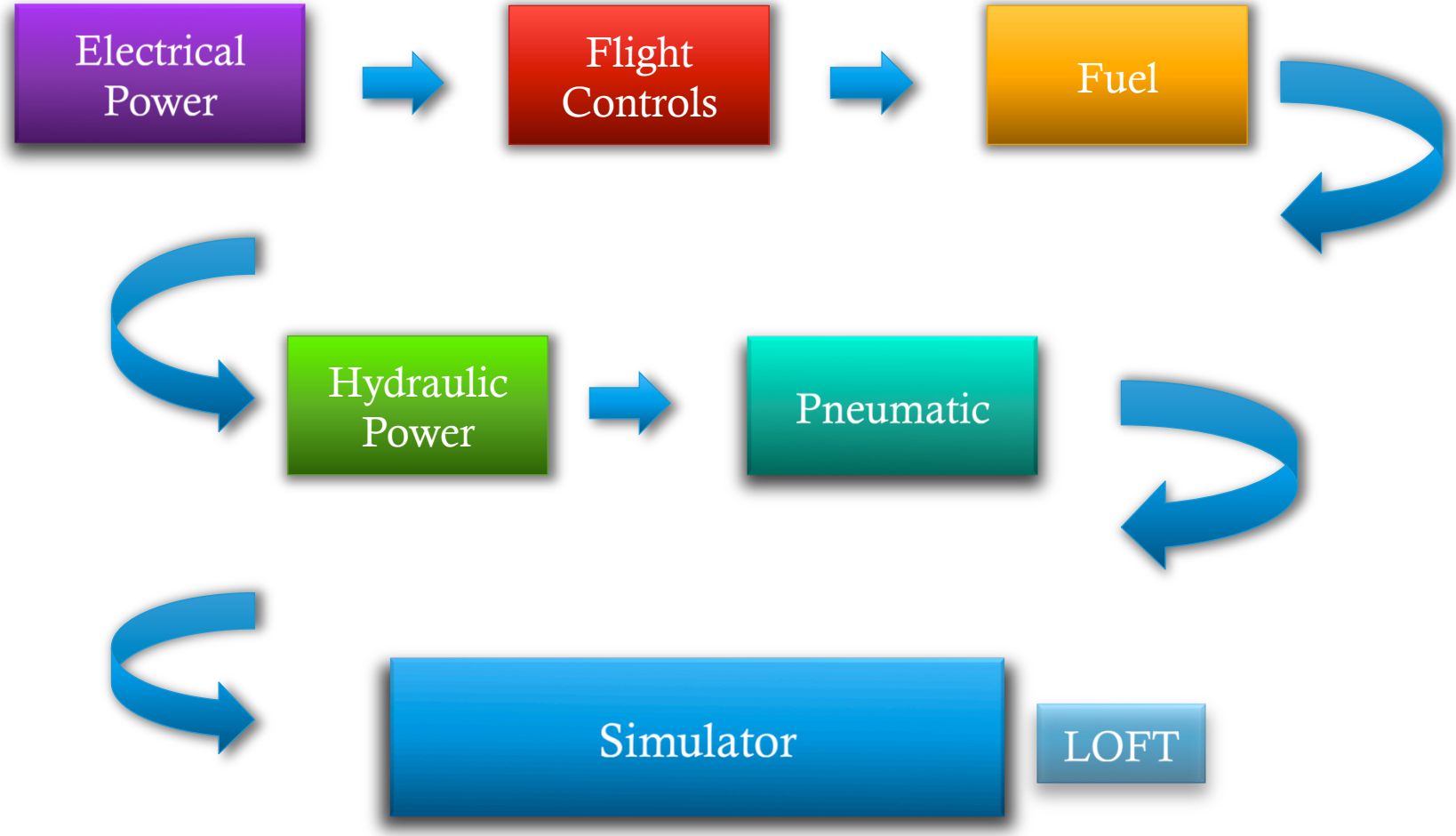
We don’t seem to have a performance problem, but a recognition problem.
When pilots recognize the situation correctly – they respond correctly.

We may not be losing “manual flying skills,”
But we seem to be losing “manual thinking skills!”

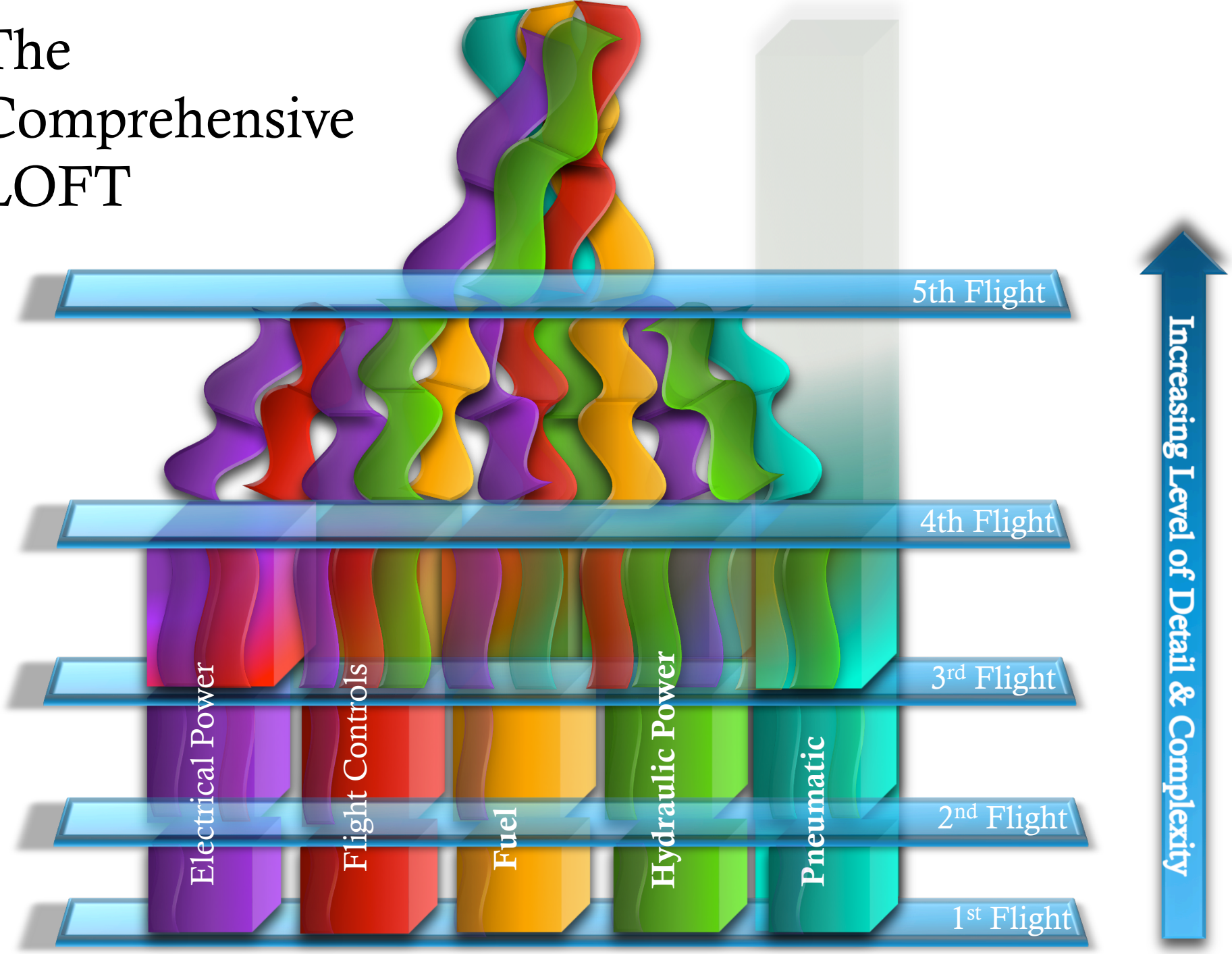
So,

maybe we are not teaching right.

Traditional Training



The Comprehensive LOFT



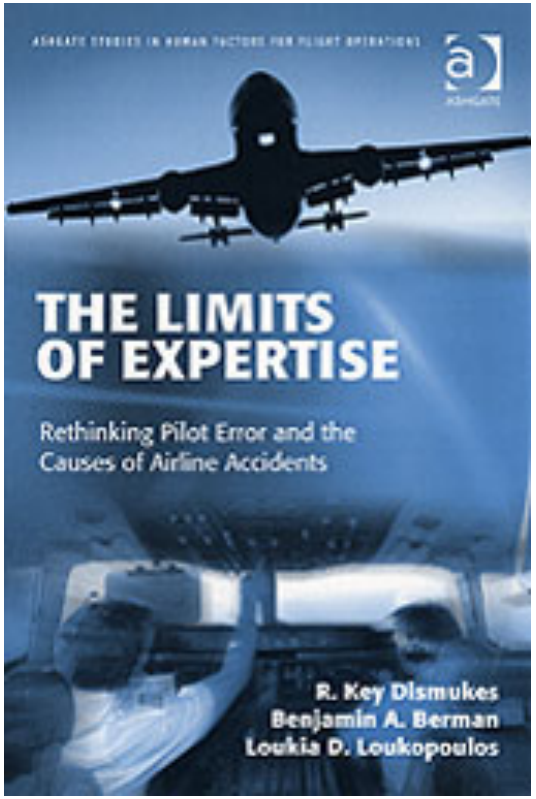
Psychological principles underlying The Comprehensive LOFT:

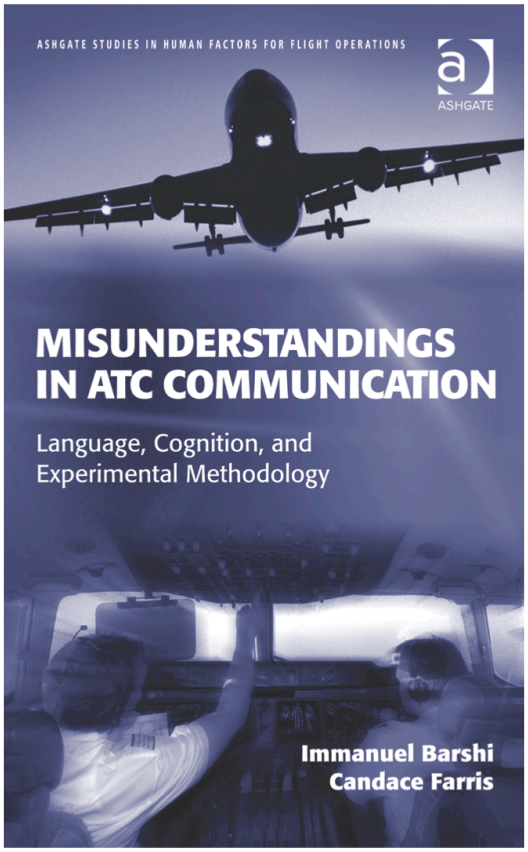
- Strategic use of knowledge and scaffolding
- Deliberate practice
- Generation effect
- Depth of processing
- Variability of practice
- Spacing
- Procedural reinstatement
- …

Barshi, I. (2015). From Healy's training principles to training specifications:
The case of the Comprehensive LOFT.
American Journal of Psychology, 128, 219-227.

THANK YOU for your attention

Additional Information:





Or contact me at: Immanuel.Barshi@nasa.gov