Why do people make mistakes?

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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 70 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


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 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 crashed into approach lights at departure end of runway
  - NTSB: Ground spoilers not armed before landing (combination with other errors)
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.
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)
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 CUTOFF 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
<table>
<thead>
<tr>
<th>CAPTAIN</th>
<th>MONITOR Ground</th>
<th>MONITOR Ground, Company</th>
<th>TAXI CLEARANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Flaps 5, taxi clearance”</td>
<td>“By the book”</td>
<td>“Set flaps, verify in position”</td>
<td>“Obtain clearance”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taxi to the runway</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**MONITOR**

<table>
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<tr>
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<td>Company</td>
</tr>
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</table>

**CAPTAIN**

| “Flaps 5, taxi clearance” |

**FIRST OFFICER**

| Set flaps, verify in position |
| Obtain clearance |

**TAXI CLEARANCE**
**CAPTAIN**

- "Flaps 5, taxi clearance"
- Start taxying
- Ask for checklist
- Line up with runway
- Ask for checklist

**MONITOR**

- Ground
- Company

**FIRST OFFICER**

- Set flaps, verify in position
- Obtain clearance
- Begin checklist
- Checklist complete
- Begin checklist
- Checklist complete

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### Checklist

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>xx xxxx</td>
<td>xx xxxx</td>
</tr>
<tr>
<td>Flight controls</td>
<td>Checked</td>
</tr>
<tr>
<td>xx</td>
<td>xx xxxx</td>
</tr>
<tr>
<td>Flaps</td>
<td>Set (green light)</td>
</tr>
<tr>
<td>Takeoff briefing</td>
<td>Completed</td>
</tr>
</tbody>
</table>

### Before Takeoff Procedure

- ENGINE START
- Lights and strobe light switches (as desired)
- xx xxxx (xx xxxx)

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**CAPTAIN**

- Pilot calls when ready

**FIRST OFFICER**

- Pilot is ready

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**BEFORE TAKEOFF CHECKLIST**

- Challenge
- Response

---

**BEFORE TAKEOFF PROCEDURE**

- Item to check (action required)
  - xx xxxx (xx xxxx)
  - Flight controls
  - Takeoff briefing

---

**BEFORE TAKEOFF CHECKLIST**

- Challenge
- Response

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**BEFORE TAKEOFF PROCEDURE**

- Item to check (action required)
  - xx xxxx (xx xxxx)
  - Flight controls
  - Takeoff briefing
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
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...
Obtain clearance

Start checklist

Checklist complete

Begin checklist

Checklist complete

TAKEOFF CLEARANCE

Request taxi clearance

Start taxiing

Ask for checklist

Failed to start engine #2 - distracted while discussing special operations for destination; omitted checklists - delay takeoff

Confuse own position on taxiway diagram - new terminal; studying NOTAMs; runway change – taxied into ditch

Neglected to set flaps - preoccupied with new departure clearance and packs-off operation - aborted takeoff

Incorrect trim setting - checklist interrupted after item had been read but not verified – aborted takeoff

Started taxi without clearance – rushed by other aircraft waiting to pull into gate; radio congestion; marshaller’s headset

Omitted flaps - crew discussing problem with APU, delayed flaps due to snow - aborted takeoff

FO failed to monitor CA - busy with flow; night taxi – taxied in wrong direction

FO failed to monitor CA - busy checking and correcting calculations of load data - aircraft taxied past hold short line

Confuse own position on taxiway diagram - new terminal, studying NOTAMs, runway change – taxied into intended taxiway

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 problem

FO failed to monitor CA - busy with pre-takeoff preparations - aircraft crossed hold short line

Omitted flaps - checklist interrupted by thrust reverser light; crew busy troubleshooting – aborted takeoff

Flaps incorrectly set, missed noticing during checklist - crew busy with fuel problem, runway changes, programming FMC - aborted takeoff

Omitted call for flaps - rushed to clear ramp/gate area for arriving aircraft - aborted takeoff

Started taxi without clearance - trouble-shooting problem with engine start - nearly hit ground handler

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 pushback tug

FO failed to monitor CA - busy with delayed engine start and checklists; rushed to accept takeoff clearance - flaps not set, aborted takeoff

Misunderstood Tower instruction - new FO on IOE, CA coaching FO - taxied onto runway without clearance

Omitted flaps - checklist interrupted by Tower, unexpected clearance for takeoff - aborted takeoff

Omitted flaps - checklist interrupted by Tower; crew rushed to accept takeoff clearance - aborted takeoff
SET FLAPS, VERIFY IN POSITION

OBTAIN CLEARANCE

BEGIN CHECKLIST

CHECKLIST COMPLETE

TAKEOFF CLEARANCE

"FLAPS 5, TAXI CLEARANCE"

UNFAMILIAR WITH AIRPORT/TAXI ROUTE

VERIFY WITH FO

VERIFY RAMP AREA CLEAR

START TAXIING

MONITOR

GROUND

MONITOR

GROUND, COMPANY

MONITOR

CA TAXIING

NEW/ADDITIONAL TAXI INSTRUCTIONS

CONTINUE TO MONITOR CA

CALCULATE & RESET PERFORMANCE DATA

INFORM COMPANY (NEW #S, DELAYS)

HAVE CA CROSS CHECK #S

FMC: PROGRAM/VERIFY SYSTEMS CONFIGURATION?

(APU, PACKS)

JUST-IN OR NEW LOAD DATA

Busy frequency

Ice/Snow

FO busy

Change in takeoff sequence

Delay

Shut down one engine?

RUSH/REPEAT CHECKLIST

ACKNOWLEDGE CLEARANCE

Form mental picture of taxi route

Confirm CA’s understanding of route

APU OFF-LOADED 2 MIN BEFORE SHUTTING DOWN

Defer communication

CONTACT GROUND WHEN POSSIBLE

ASK FO FOR TAKEOFF FLAPS

DEFER TAKEOFF FLAPS

VERIFY WITH FO

Defer takeoff flaps

+ "Clear" ramp area

Consult charts

Accept new runway?

Change in takeoff runway

Line up with runway

Consult charts

Judge distance to line

Receive taxi clearance

verify in position

THIS RUNWAY CLEAR

+ “Clear” taxi turns

+ “Clear” runway

+ “Clear” turns

Switch to tower frequency

Resume checklist

Interruption

Brief new runway

CONSULT CHARTS

ACCEPT NEW RUNWAY?

Need for CONCATENATE TASK MANAGEMENT

(≠ THAN HIGH WORKLOAD)
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!**
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
OK, but WHY?

Individuals forget to act because the cognitive demands of these situations interact with the ways in which the human brain processes information.
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)
THANK YOU for your attention

Additional Information:

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