B737 Non-normal Checklists: A Comparison Study

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A Little Background Information

- What are aviation emergency and abnormal checklists?
UNABLE TO RAISE GEAR LEVER

NOSE STEERING WHEEL .................... OPERATE (C)

If steering wheel does NOT turn and centering indices are aligned:
Indicates a malfunction of the anti-retraction mechanism.

If desired, retract landing gear:

GEAR HANDLE RELEASE BUTTON ............... PUSH (PNF)
GEAR LEVER ...................................... UP (PNF)

If steering wheel turns:
DO NOT RETRACT THE GEAR

Indicates ground shift mechanism is still in the ground mode.

No auto-pressurization, and takeoff warning horn will sound when flaps/slats are retracted.

The ground control relay electrical circuits can be placed in the flight mode by pulling the Ground Control Relay circuit breakers (H20 and J20).

Do not exceed VLE (300 kts/M.70).

Approach and landing:
If landing gear was not retracted prior to landing, ground spoilers must be operated manually.

AIRPLANE .................................... DEPRESSURIZE (PNF)
ANTI-SKID SWITCH (before 30 kts) ............... OFF (PNF)
GROUND CONTROL RELAY C/Bs (if pulled)
(H20 and J20) ........................................... RESET (C or FO)
A Little Background Information

- What are aviation emergency and abnormal checklists?
- Why is their design and content important?

THERE IS NO PERFECT CHECKLIST.
A Little Background Information

- What are aviation emergency and abnormal checklists?
- Why is their design and content important?
- Who develops them?
A Little Background Information

- What are aviation emergency and abnormal checklists?
- Why is their design and content important?
- Who develops them?
- Introduction to some terms:
  - Emergency
  - Abnormal
  - Non-Normal
  - Quick Reference Handbook (QRH) – dynamic documents, so the data we are presenting are not current
Project Overview

- **Purpose of the Study: Comparison**
  - Part I – Design and Content related to Design (e.g., physical lengths)
  - Part II – Technical Content of Selected Checklists

- **Why Choose to Compare B737 Checklists/QRHs?**

- **Participants:**
  - All Domestic US Air Carriers who fly the B737 ($N = 11$):
    - Classic (-200, -300, -400, -500) and/or
    - Next Generation (NG: -600, -700, -800, -900) Models
  - Aircraft Manufacturer: Boeing Commercial Airplanes
  - Total of Number of QRHs to code: 25
Findings - Overview

- Partially finished with Part I coding:
  - 5 B737 Classic: 4 Air Carrier QRHs, 1 Manufacturer QRH
  - 6 B737 Next Generation: 4 Air Carrier QRHs, 2 Manufacturer QRHs (Boeing NG and Boeing NG-Revised)
  - No single air carrier is represented in both the Classic and NG coding results presented here: 8 air carriers, one manufacturer

- Will be reporting results in two areas:
  - Memory (Recall) Items
  - Jumping among checklists and to other resources (e.g., tables)
Background Information: Memory (Recall) Items

- Memory Items – “actions” that must be performed so quickly in response to a situation that there is no time for reference to a printed checklist

- Differences in Terminology: Memory, Recall, Immediate Action
  - Confusion in Terminology
    - Boeing has a step in normal checklists: “Recall……..Checked”
    - Some air carriers have immediate action items AND memory items
Background Information: Memory (Recall) Items

- Why code memory items?
- Errors made in their completion
- What makes them easy or difficult to remember?
  - “It Depends…”
    - Environmental Cues (most important factor)
    - Number
    - Complexity of Items / Checklist
    - Aspects of the Situation: time available, threat, distractions, etc.
Before engine start lever raised to IDLE:

ENGINE START SWITCH ........................................... OFF

After engine start lever raised to IDLE:

Before starter cutout:

ENGINE START LEVER ....................................... CUTOFF
Continue to motor the engine for 60 seconds.
[Clears fuel and cools engine components.]

ENGINE START SWITCH ........................................... OFF

After starter cutout:

ENGINE START LEVER ....................................... CUTOFF

After N2 decreases to below 20%:

ENGINE START SWITCH ....................................... GRD
Motor the engine for 60 seconds.
[Clears fuel and cools engine components.]

ENGINE START SWITCH ........................................... OFF
Background Information: Memory (Recall) Items

- Why code memory items?

- Errors made in their completion

- What makes them easy or difficult to remember?
  - “It Depends…”
    - Environmental Cues (most important factor)
    - Number
    - Complexity of Items / Checklist
    - Aspects of the Situation: time available, threat, distractions, etc.

- Trend in the industry
  - reducing number of items to be performed from memory
  - reducing the number of checklists with memory items
Findings: Memory (Recall) Items
(Classic and Next Generation Separated)

Approach to coding:

– Used documentation to help us determine if item/information was to be memorized

– Evacuation checklists with memory items split between Captain and First Officer ($n = 4$):
  - Only counted those items for the person who had the most to memorize
Finding: Memory (Recall) Items
(Classic and Next Generation Separated)

Approach to coding, continued:

- Coded overall numbers of items and types of items:

  - **Action Items:** Thrust Levers…………………………………………………………Close
    Do not attempt to maintain altitude until control is recovered.

  - **Conditionals:** If cabin altitude is uncontrollable:

  - **Notes (informational, how an action is to be performed, etc.):**
    Attitude and thrust information is provided in the Performance-Inflight section.

  - **Other (e.g., Delaying Items):** After N2 decreases to below 20%:
Findings: Memory (Recall) Items
(Classic and Next Generation Separated)

Numbers of Memory Items by Air Carrier or Manufacturer QRH

<table>
<thead>
<tr>
<th>Air Carrier/Manuf.</th>
<th>N of CL with MI</th>
<th>Total N of MI</th>
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<tbody>
<tr>
<td>A Classic</td>
<td>23</td>
<td>120</td>
<td>93</td>
<td>21</td>
<td>3</td>
<td>3</td>
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<tr>
<td>B Classic</td>
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<td>15</td>
<td>13</td>
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<tr>
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<tr>
<td>Boeing NG – Rev.</td>
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### Findings: Memory (Recall) Items
*Classic and Next Generation Separated*

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</tbody>
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Findings: Memory (Recall) Items
(Classic and Next Generation Separated)

Checklists with the Most Memory Items

<table>
<thead>
<tr>
<th>n of QRHs</th>
<th>Checklist Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Aborted Engine Start</td>
</tr>
<tr>
<td>1</td>
<td>Engine Fire, Severe Damage, or Separation</td>
</tr>
<tr>
<td>1</td>
<td>Runaway Stabilizer *</td>
</tr>
<tr>
<td>5</td>
<td>Uncommanded Rudder, Yaw, Roll</td>
</tr>
</tbody>
</table>

* Tie with Aborted Engine Start
## Findings: Memory (Recall) Items
(Classic and Next Generation Separated)

### Number of Memory Items in Selected Checklists

<table>
<thead>
<tr>
<th>Checklist Title</th>
<th>Classic</th>
<th>Next Generation</th>
<th>Number of Items in Each Checklist</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aborted Engine Start</td>
<td>13</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>Eng. Fire, Svr Dmg, Sep</td>
<td>8</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>Loss Thrust Both Eng.</td>
<td>-</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Rapid Depressurization</td>
<td>11</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>Emergency Descent</td>
<td>9</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>Runaway Stabilizer</td>
<td>7</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Uncommand. Rudder</td>
<td>8</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Uncommand. Yaw / Roll</td>
<td>9</td>
<td>7</td>
<td>7</td>
</tr>
</tbody>
</table>
Background Information: Jumping (Progression) (Classic and Next Generation Combined)

- “Progression” – movement within and among checklists and other resources to complete the necessary procedures

- “Jumping” – movement among checklists and other resources only

- We coded jumping:
  - to other non-normal checklists within the QRH
  - to normal checklists
    - Integration of normal checklists within non-normal checklists
  - to performance charts and tables (within QRH and in other resources)
  - to other resources (e.g., MEL, FOM)
Findings: Jumping (Progression)  
(Classic and Next Generation Combined)

Jumps to other Non-Normal Checklists

- Across the 11 QRHs coded: average of 25 checklists called for at least one jump to another non-normal checklist (range: 20-35)

- Information given to aid finding subsequent checklists:

<table>
<thead>
<tr>
<th>Aid</th>
<th>Number of QRHs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of checklist</td>
<td>11</td>
</tr>
<tr>
<td>Page number</td>
<td>5</td>
</tr>
<tr>
<td>Section number</td>
<td>1</td>
</tr>
<tr>
<td>Tab number</td>
<td>1</td>
</tr>
<tr>
<td>Nothing other than title</td>
<td>5</td>
</tr>
</tbody>
</table>
Findings: Jumping (Progression)
(Classic and Next Generation Combined)

Jumps to Normal Checklists

– Across the 11 QRHs coded: median of 4 checklists called for user to go to and complete at least one normal checklist (range: 1-18)

– 9 QRHs had checklists that required the user to return and complete non-normal checklist items after having completed a normal checklist
Findings: Jumping (Progression)
(Classic and Next Generation Combined)

Jumps to Normal Checklists, continued

Integrating Normal Checklists into Non-Normal Checklists:

- Was done when normal checklist procedures needed to be modified for the condition
  - normal checklist partially presented: 2 QRHs
  - normal checklist completely presented: 11 QRHs

Types of situations where normal checklists were integrated with non-normal checklists:

- some engine problems (e.g., Engine Failure and Shutdown)
- some hydraulics problems (e.g., Manual Reversion)
- some problems with flight controls (e.g., Jammed Stabilizer)
- gear lever / gear problems (e.g., Gear Lever Will Not Move Up after TO)
- Ditching
Findings: Jumping (Progression)
(Classic and Next Generation Combined)

Jumps to Performance Tables or Charts

- Across the 11 QRHs coded: **median of 5** checklists called for at least one jump to a performance table or chart (range: 0-15)
  - 8 QRHs had checklists that required jumps to tables or charts located within the QRH
  - 6 QRHs had checklists that required jumps to tables or charts located outside the QRH (i.e., in other resources)

- Information given to aid finding table or chart:

<table>
<thead>
<tr>
<th>Aid</th>
<th>Number of QRHs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of table or chart</td>
<td>11</td>
</tr>
<tr>
<td>Page number</td>
<td>2</td>
</tr>
<tr>
<td>Section number</td>
<td>7</td>
</tr>
</tbody>
</table>
Findings: Jumping (Progression)
(Classic and Next Generation Combined)

Jumps to Other Resources

- 4 QRHs included at least one checklist that required a jump to the MEL (1, 1, 5, 42)

- 6 QRHs included at least one checklist that required a jump to the FOM (range = 1 to 13)
Findings: Jumping (Progression)
(Classic and Next Generation Combined)

Multiple Jumps Involving Non-normal Checklists

Jumps to Two Different Non-Normal Checklists from an Originating Checklist: $n = 9$ QRHs

Jumps to Three Different Non-Normal Checklists from an Originating Checklist: $n = 0$ QRHs
Findings: Jumping (Progression)  
(Classic and Next Generation Combined)

Multiple Jumps Involving Non-normal Checklists

One of the most complicated jumping chains we found: \( n = 10 \) QRHs

A \( \rightarrow \) B \( \rightarrow \) C \( \leftarrow \) D  
\( \text{or} \)

B \( \rightarrow \) A

A – Loss of Thrust on Both Engines  
B – Inflight Engine Start  
C – Engine Failure Shutdown  
D – One Engine Inoperative Landing
Emergency and Abnormal Situations Project

Barbara Burian, Ph.D.
bburian@ mail.arc.nasa.gov

http://human-factors.arc.nasa.gov/eas