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)

➢ 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?

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➢ Introduction to some terms:

    - Emergency

    - Abnormal

    - Non-Normal

    - Quick Reference Handbook (QRH) – dynamic documents, so the data we are presenting are not current

Approximately 6 ½ inches
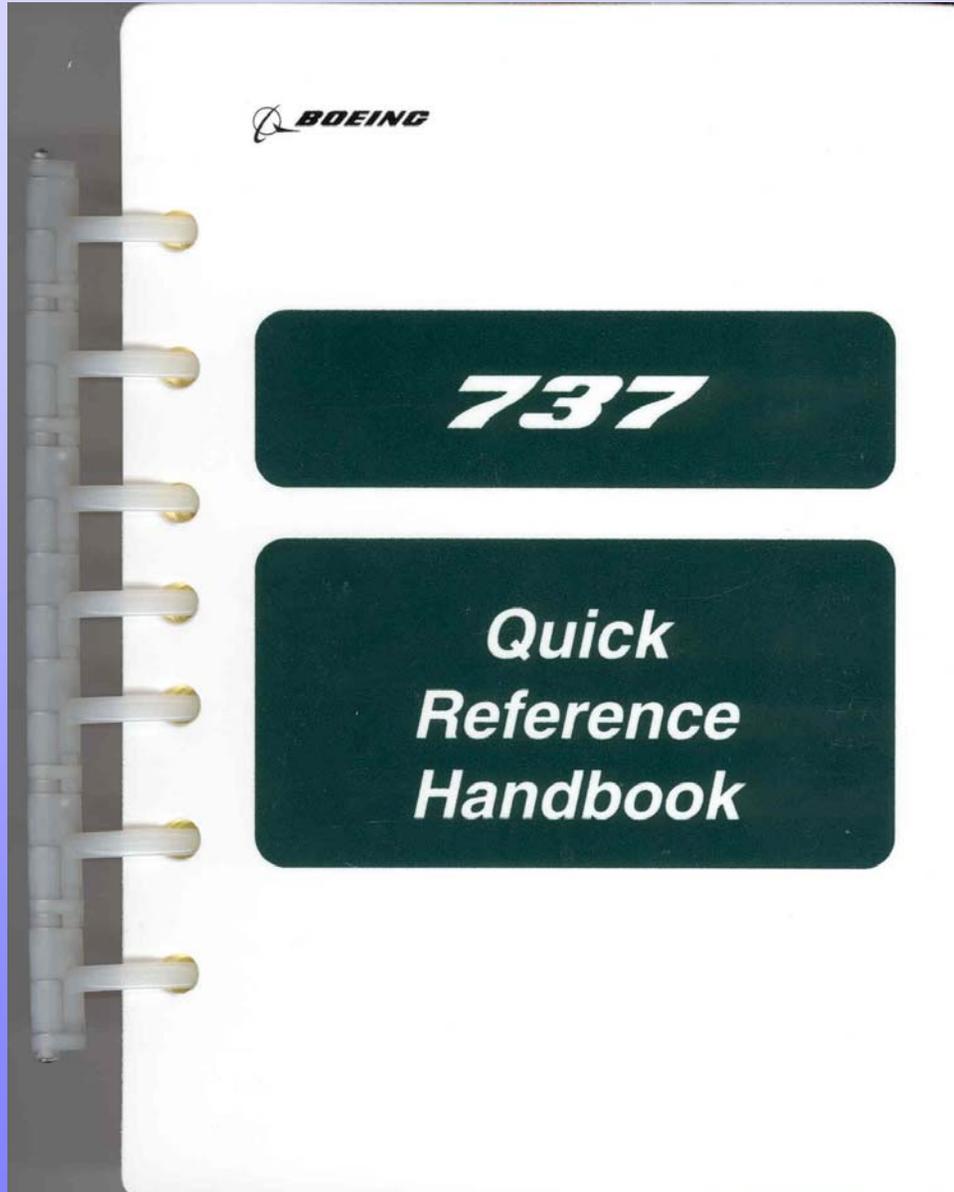
Approximately 9 inches

BOEING

737

Quick Reference Handbook

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

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➢ 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

Findings: 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

Air Carrier/Manuf.	*N* of CL with MI	Total *N* of MI	Action Item MI	Conditional MI	Note MI	Other MI
A Classic	23	120	93	21	3	3
B Classic	4	15	13	1	0	1
C Classic	16	112	73	16	21	2
D Classic	5	17	15	2	0	0
Boeing Classic	16	113	73	16	22	2
E NG	9	20	17	3	0	0
F NG	3	11	10	1	0	0
G NG	12	45	37	5	2	1
H NG	10	44	35	5	2	2
Boeing NG	18	129	83	19	24	3
Boeing NG – Rev.	13	77	52	10	14	1

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(Classic and Next Generation Separated)

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Findings: Memory (Recall) Items
(Classic and Next Generation Separated)

Checklists with the Most Memory Items

n of QRHs	Checklist Title
5	Aborted Engine Start
1	Engine Fire, Severe Damage, or Separation
1	Runaway Stabilizer *
5	Uncommanded Rudder, Yaw, Roll

* Tie with Aborted Engine Start

Findings: Memory (Recall) Items
(Classic and Next Generation Separated)

Number of Memory Items in Selected Checklists

Checklist Title	Number of Items in Each Checklist										
	Classic					Next Generation					
	A	B	C	D	Boe.	E	F	G	H	Boe.	Boe.-R
Aborted Engine Start	13	0	15	2	15	4	0	7	5	15	1
Eng. Fire, Svr Dmg, Sep	8	0	13	0	13	0	0	2	0	13	13
Loss Thrust Both Eng.	-	4	4	0	4	0	0	4	6	4	4
Rapid Depressurization	11	3	12	2	12	2	2	2	4	11	12
Emergency Descent	9	3	12	2	12	0	0	0	0	12	12
Runaway Stabilizer	7	0	8	2	8	4	0	0	6	8	8
Uncommand. Rudder	8	7	7	9	7	1	7	8	7	7	7
Uncommand. Yaw / Roll	9	7	7	9	7	1	7	8	7	7	7

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)

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:

Aid	Number of QRHs
Name of checklist	11
Page number	5
Section number	1
Tab number	1
Nothing other than title	5

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

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

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 <u>within</u> the QRH

   – **6** QRHs had checklists that required jumps to tables or charts located <u>outside</u> the QRH (i.e., in other resources)

– Information given to aid finding table or chart:

Aid	Number of QRHs
Name of table or chart	11
Page number	2
Section number	7

Jumps to Other Resources

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

- **6** QRHs included at least one checklist that required a jump to the <u>FOM</u> (range = 1 to 13)

Multiple Jumps Involving Non-normal Checklists

Jumps to <u>Two</u> Different Non-Normal Checklists from an Originating Checklist: **n = 9** QRHs

B

A

C
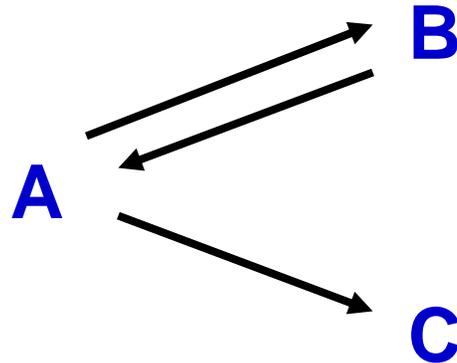
Jumps to <u>Three</u> Different Non-Normal Checklists from an Originating Checklist: **n = 0** QRHs

Multiple Jumps Involving Non-normal Checklists

One of the most complicated jumping chains we found: *n* **= 10** QRHs

A ⟶ **B** ⟶ **C** ⟨ **D**   or   **B** ⟶ **A**
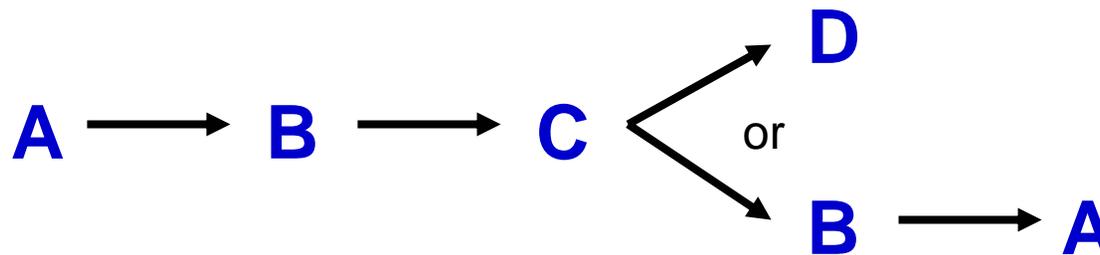
A – Loss of Thrust on Both Engines

B – Inflight Engine Start

C – Engine Failure Shutdown

D – One Engine Inoperative Landing

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