

# Improving the Boeing Quick Reference Handbook

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**Aviation System Safety  
Boeing Commercial Airplanes  
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# *A Simple Scenario*

EICAS Messages:

**L AC BUS OFF**  
**R AC BUS OFF**

Lights:

**BUS**  
**OFF**

**BUS**  
**OFF**

Crew opens the QRH

Crew selects a checklist

Is it the correct one?

Will it solve the problem?

How do they know?

---

**AC BUS OFF**

Condition: An AC BUS OFF light illuminated indicates the AC bus is unpowered.

**GENERATOR CONTROL SWITCH . . . . . OFF, THEN ON**  
Attempt only one reset.

**APU SELECTOR**  
(If APU available) . . . . . START, RELEASE TO ON  
[Provides an additional source of electrical power.]

**After APU running:**

**LEFT BUS TIE SWITCH . . . . . OFF, THEN AUTO**  
Attempt only one reset.

**RIGHT BUS TIE SWITCH . . . . . OFF, THEN AUTO**  
Attempt only one reset.

If both AC BUS OFF lights were illuminated and AC power is restored:

**FMC ROUTE . . . . . ACTIVATE**  
**FMC PERFORMANCE DATA . . . . . ENTER**

If an IRS ALIGN light is illuminated:

**IRS MODE SELECTOR**  
(Affected IRS(s) only) . . . . . ATT

**HEADING . . . . . ENTER**  
Enter heading on IRS control panel or FMC POS INIT page.

Continued on next page

# Checklist verification

## AC BUS OFF

Condition: An AC BUS OFF light illuminated indicates the AC bus is unpowered.

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Attempt only one reset.

APU SELECTOR  
(If APU available) ..... START, RELEASE TO ON  
[Provides an additional source of electrical power.]

After APU running:

LEFT BUS TIE SWITCH ..... OFF, THEN AUTO  
Attempt only one reset.

RIGHT BUS TIE SWITCH ..... OFF, THEN AUTO  
Attempt only one reset.

If both AC BUS OFF lights were illuminated and AC power is restored:

FMC ROUTE .....ACTIVATE  
FMC PERFORMANCE DATA ..... ENTER

If an IRS ALIGN light is illuminated:

IRS MODE SELECTOR  
(Affected IRS(s) only) ..... ATT

HEADING ..... ENTER  
Enter heading on IRS control panel or FMC POS  
INIT page.

Continued on next page

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Attempt only one reset.

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(If APU available) . . . . . START, RELEASE TO ON  
[Provides an additional source of electrical power.]

After APU running:

LEFT BUS TIE SWITCH . . . . . OFF, THEN AUTO  
Attempt only one reset.

RIGHT BUS TIE SWITCH . . . . . OFF, THEN AUTO  
Attempt only one reset.

If both AC BUS OFF lights were illuminated and AC power is restored:

FMC ROUTE . . . . . ACTIVATE

FMC PERFORMANCE DATA . . . . . ENTER

If an IRS ALIGN light is illuminated:

IRS MODE SELECTOR  
(Affected IRS(s) only) . . . . . ATT

HEADING . . . . . ENTER  
Enter heading on IRS control panel or FMC POS  
INIT page.

Continued on next page

Attempt to restore power  
by following these steps

**AC BUS OFF**

Condition: An AC BUS OFF light illuminated indicates the AC bus is unpowered.

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Attempt only one reset.

APU SELECTOR  
(If APU available) . . . . . START, RELEASE TO ON  
[Provides an additional source of electrical power.]

After APU running:

LEFT BUS TIE SWITCH . . . . . OFF, THEN AUTO  
Attempt only one reset.

RIGHT BUS TIE SWITCH . . . . . OFF, THEN AUTO  
Attempt only one reset.

If both AC BUS OFF lights were illuminated and AC power is restored:

FMC ROUTE . . . . . ACTIVATE  
FMC PERFORMANCE DATA . . . . . ENTER

If an IRS ALIGN light is illuminated:

IRS MODE SELECTOR  
(Affected IRS(s) only) . . . . . ATT

HEADING . . . . . ENTER  
Enter heading on IRS control panel or FMC POS  
INIT page.

Continued on next page

Power was not restored

Condition 1 →

Are there more?

It says “continued” →

*3 more possible conditions*

Continued from previous page

Condition 2 →

If the left AC BUS OFF light remains illuminated:

Flight in icing conditions may result in some erroneous flight instrument indications.

All autopilots inoperative.

Left and center flight directors inoperative.

Flap indicator inoperative.

Plan to land at the nearest suitable airport.

Condition 3 →

If the right AC BUS OFF light remains illuminated:

Flight in icing conditions may result in some erroneous flight instrument indications.

Right autopilot/flight director inoperative.

Plan to land at the nearest suitable airport.

Condition 4 →

If both AC BUS OFF lights remain illuminated:

**CAUTION:** Flight beyond 30 minutes will result in complete loss of electrical power and the inability to extend gear and flaps.

If electronic engine control ALTN lights illuminated:

THRUST LEVERS . . . . . RETARD TO MID POSITION

LEFT ELECTRONIC ENGINE

CONTROL SWITCH . . . . .ALTN

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If the left AC BUS OFF light remains illuminated:

Flight in icing conditions may result in some erroneous flight instrument indications.

All autopilots inoperative.

Left and center flight directors inoperative.

Flap indicator inoperative.

Plan to land at the nearest suitable airport.

If the right AC BUS OFF light remains illuminated:

Flight in icing conditions may result in some erroneous flight instrument indications.

Right autopilot/flight director inoperative.

Plan to land at the nearest suitable airport.

If both AC BUS OFF lights remain illuminated:

**CAUTION:** Flight beyond 30 minutes will result in complete loss of electrical power and the inability to extend gear and flaps.

If electronic engine control ALTN lights illuminated:

THRUST LEVERS . . . . . RETARD TO MID POSITION

LEFT ELECTRONIC ENGINE

CONTROL SWITCH . . . . .ALTN

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- Read the caution statement →
- Second-level condition →
- Second-level actions →
- that continue... →





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If electronic engine control ALTN lights illuminated: (continued)

Continued...

Second-level actions →

**RIGHT ELECTRONIC ENGINE CONTROL SWITCH . . . . .ALTN**

**Do not accomplish the following checklists:  
ELECTRONIC ENGINE CONTROL  
ENGINE EEC MODE**

First-level actions →

**EQUIPMENT COOLING SELECTOR . . . . . OVRD**  
[Increases cooling airflow.]

- Master caution inoperative.
- Auto speedbrake inoperative.
- Antiskid for outboard wheels inoperative.
- Avoid icing conditions.  
[Wing and engine anti-ice inoperative]
- Flap indicator inoperative.
- Thrust reversers inoperative.
- Plan to land at the nearest suitable airport.

Review consequences for condition 4, but 2 & 3 also apply...

**Accomplish the following checklist:  
CABIN AUTOMATIC INOPERATIVE**

**APU GENERATOR OFF**

Condition: The APU generator OFF light illuminated indicates the APU generator control breaker is open due to a fault with the APU running.

**APU GENERATOR CONTROL SWITCH . . . . . OFF, THEN ON**  
Attempt only one reset.

Continued from previous page

If the left AC BUS OFF light remains illuminated:

Flight in icing conditions may result in some erroneous flight instrument indications.

All autopilots inoperative.

Left and center flight directors inoperative.

Flap indicator inoperative.

Plan to land at the nearest suitable airport.

If the right AC BUS OFF light remains illuminated:

Flight in icing conditions may result in some erroneous flight instrument indications.

Right autopilot/flight director inoperative.

Plan to land at the nearest suitable airport.

If both AC BUS OFF lights remain illuminated:

**CAUTION:** Flight beyond 30 minutes will result in complete loss of electrical power and the inability to extend gear and flaps.

If electronic engine control ALTN lights illuminated:

**THRUST LEVERS . . . . . RETARD TO MID POSITION**

**LEFT ELECTRONIC ENGINE  
CONTROL SWITCH . . . . . ALTN**

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If electronic engine control ALTN lights illuminated: (continued)

**RIGHT ELECTRONIC ENGINE  
CONTROL SWITCH . . . . . ALTN**

Do not accomplish the following checklists:  
**ELECTRONIC ENGINE CONTROL  
ENGINE EEC MODE**

**EQUIPMENT COOLING SELECTOR . . . . . OVRD**  
[Increases cooling airflow.]

Master caution inoperative.

Auto speedbrake inoperative.

Antiskid for outboard wheels inoperative.

Avoid icing conditions.

[Wing and engine anti-ice inoperative]

Flap indicator inoperative.

Thrust reversers inoperative.

Plan to land at the nearest suitable airport.

Accomplish the following checklist:  
**CABIN AUTOMATIC INOPERATIVE**

**APU GENERATOR OFF**

Condition: The APU generator OFF light illuminated indicates the APU generator control breaker is open due to a fault with the APU running.

**APU GENERATOR CONTROL SWITCH . . . . . OFF, THEN ON**  
Attempt only one reset.



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If electronic engine control ALTN lights illuminated: (continued)

**RIGHT ELECTRONIC ENGINE  
CONTROL SWITCH . . . . .ALTN**

**Do not accomplish the following checklists:  
ELECTRONIC ENGINE CONTROL  
ENGINE EEC MODE**

**EQUIPMENT COOLING SELECTOR . . . . . OVRD**  
[Increases cooling airflow.]

**Master caution inoperative.**

**Auto speedbrake inoperative.**

**Antiskid for outboard wheels inoperative.**

**Avoid icing conditions.**  
[Wing and engine anti-ice inoperative]

**Flap indicator inoperative.**

**Thrust reversers inoperative.**

**Plan to land at the nearest suitable airport.**

{ **Accomplish the following checklist:  
CABIN AUTOMATIC INOPERATIVE**

**APU GENERATOR OFF**

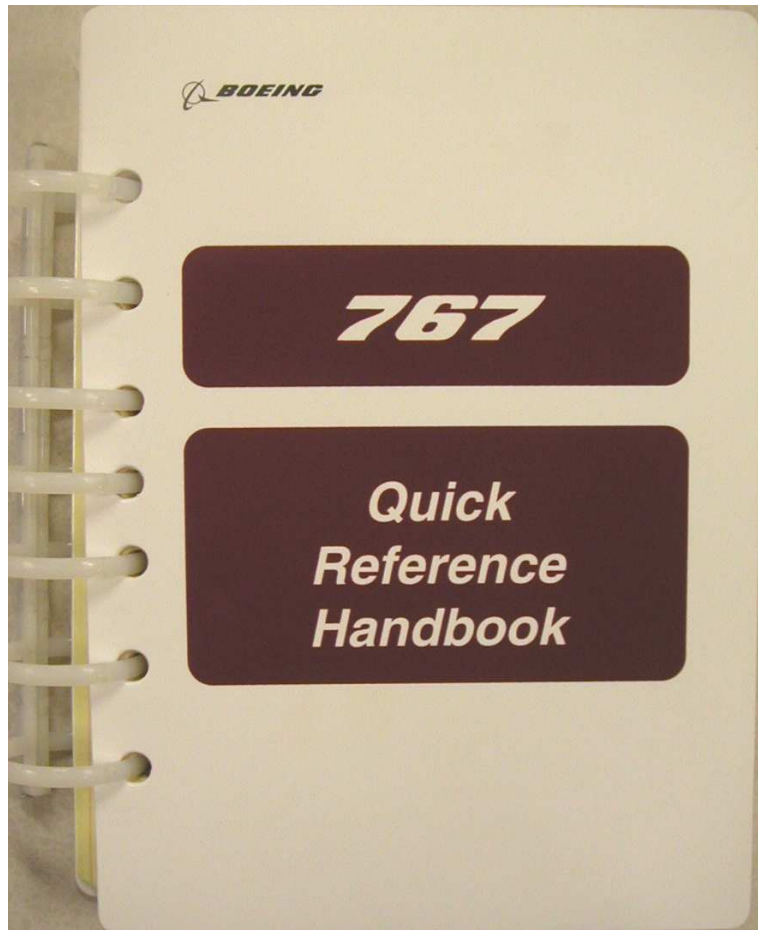
**Condition: The APU generator OFF light illuminated indicates the  
APU generator control breaker is open due to a fault  
with the APU running.**

**APU GENERATOR CONTROL SWITCH . . . . . OFF, THEN ON**  
**Attempt only one reset.**

Instruction to go complete  
a different checklist

Checklist is complete

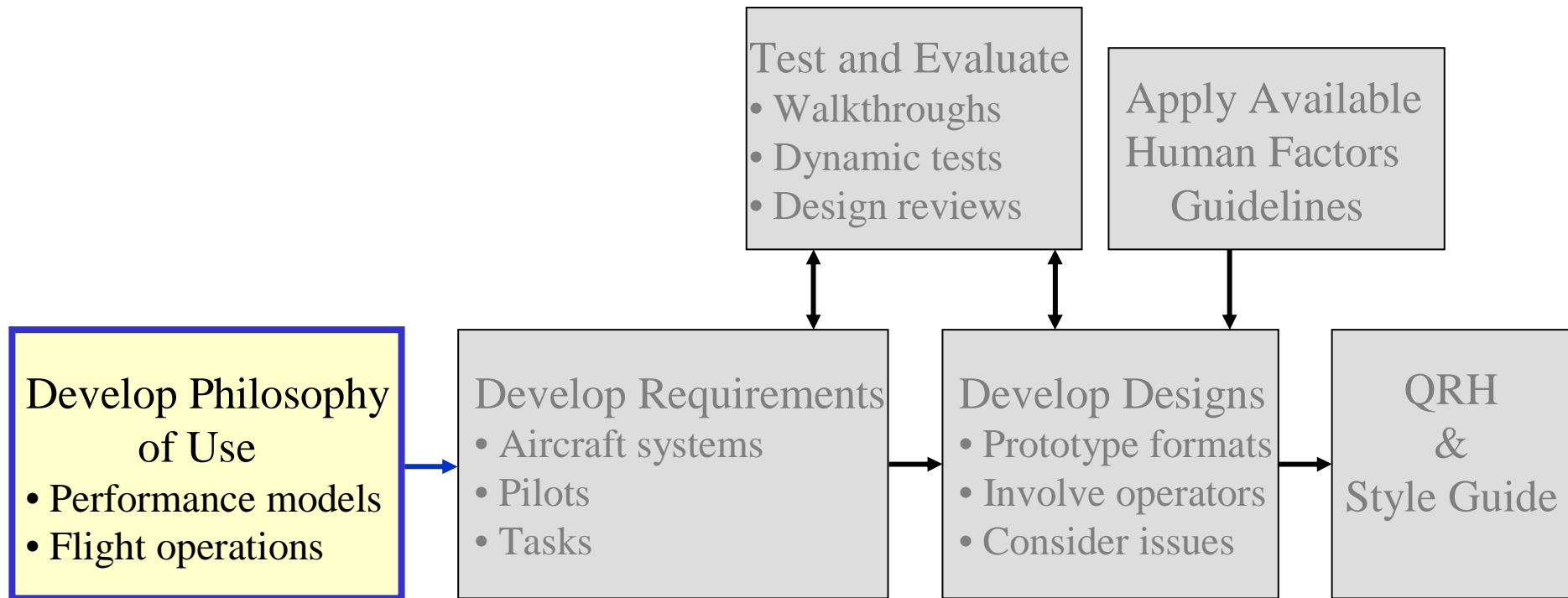
# *Primary Research Objective*



Identify all the relevant guidance, information, and data needed to support the flight crew in the conduct of non-normal tasks in a presentation that is simple and readily understood.



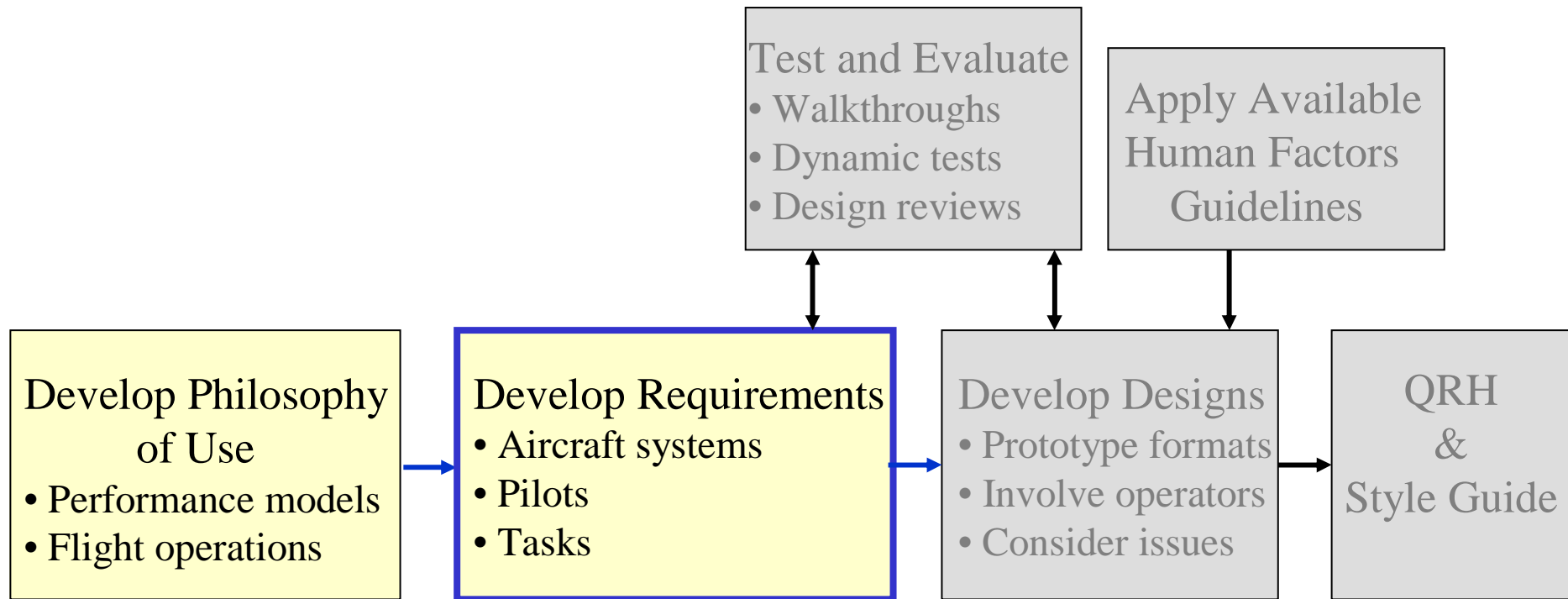
# Human-Centered Approach



## Develop a Philosophy of Use:

- A vision of how the crew will interact with the QRH
- Is based on:
  - Assumptions about flight crew competencies and conduct
  - Models of human performance

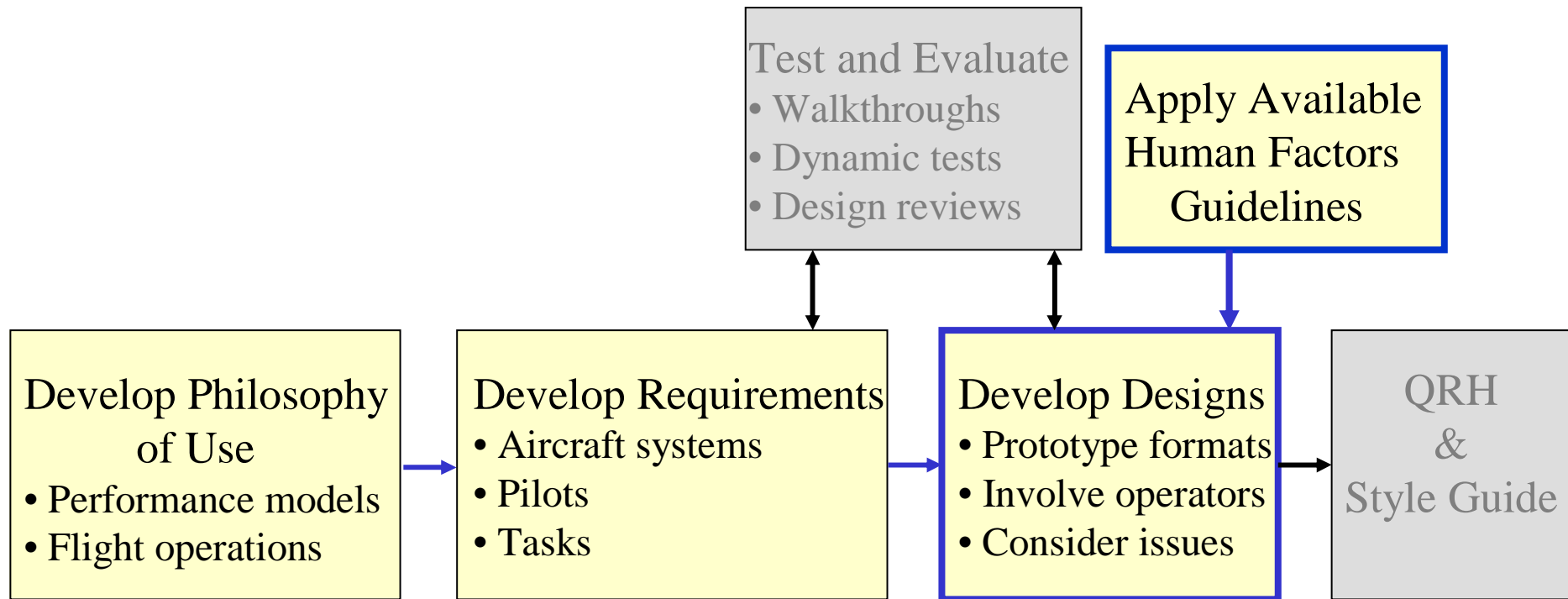
# Human-Centered Approach



## Develop QRH Requirements:

- Based on user needs, flight deck design, and the operational tasks users perform
- Requirements lead to checklist features and functions that are needed to better support human performance.

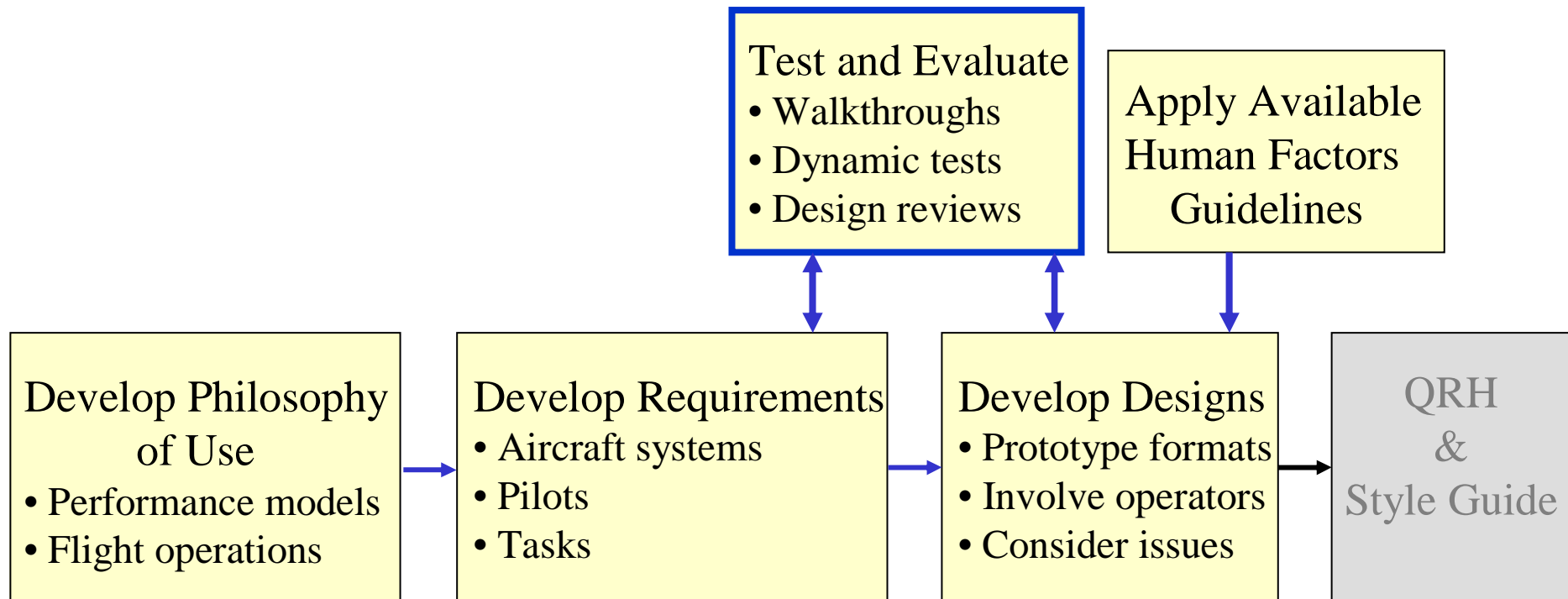
# *Human-Centered Approach*



## **Develop QRH and Checklist Designs:**

- Apply available human factors engineering guidelines to QRH design elements.
- Use data gathered on QRH issues to suggest design concepts.

# Human-Centered Approach

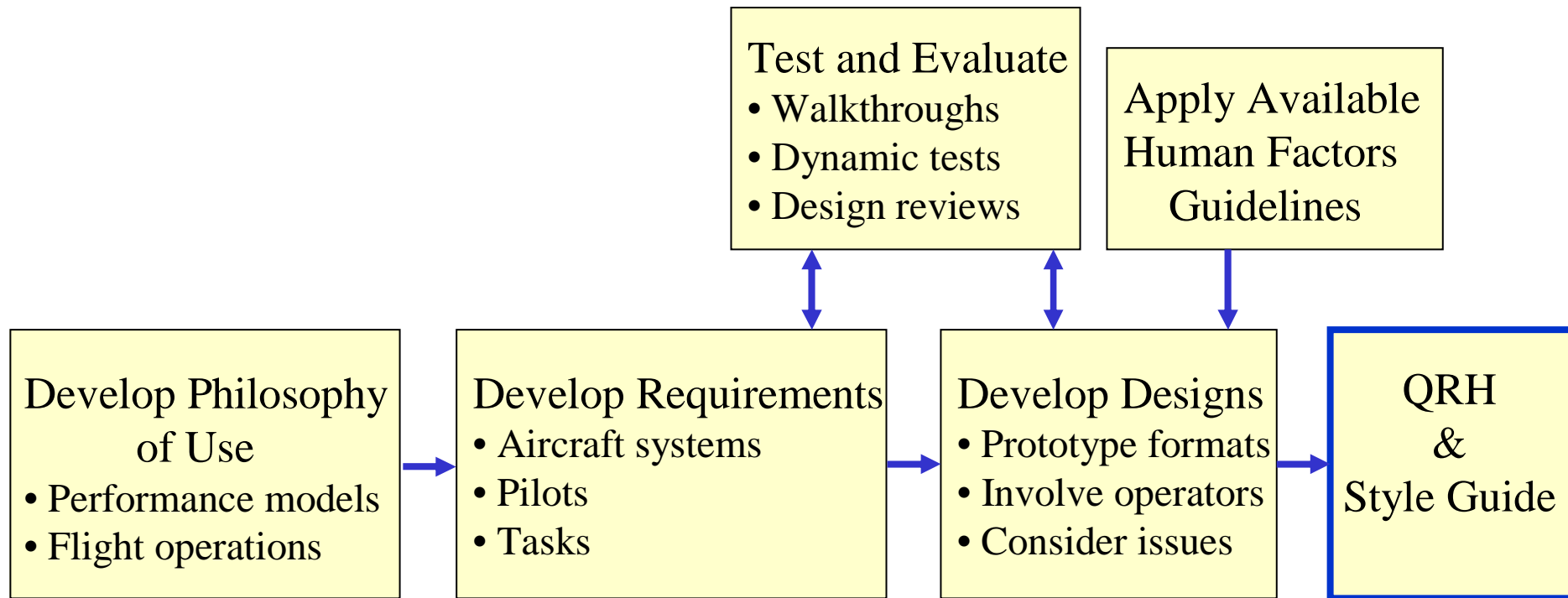


## Test and Evaluation:

- Obtain user feedback candidate concepts so the best design options can be identified.
- Tests and evaluations ensure the QRH is well designed, easy to use, and meets human performance requirements.



# *Human-Centered Approach*



## **Final Products:**

- Final QRH
- A style guide is developed that provides guidance for implementing the selected design.
- The guide can be used by QRH developers to improve and standardize their designs.

# *Expected Context of Use*



# *Design Should Reflect Use*

- Flight crews
  - Trained pilots
  - Variation in crew skill and experience
  - English proficiency varies
  - Dynamic, stressful conditions
- Flight operations
  - Compatible with other flight deck interfaces
  - Ground operations and flight operations
  - Timing of operational tasks
  - Operational policies and practices
  - Regulatory constraints



# *Data Collection*

- Structured interviews with 15 operators across Asia, Europe, North America
- Surveyed of 300 Boeing operators worldwide
  - 111 surveys returned, 37% response rate
- Analyzed content and presentation of current Boeing QRH to identify and validate issues



# *Convergence on Human Performance Issues*

- Difficulty finding the correct checklist
- Doing the wrong checklist
- Difficulty resolving decision steps with complex logical relationships, such as "if" statements
- Difficulty interpreting qualitative terms, such as "as required"
- Performing and remembering recall steps
- Skipping checklist steps
- Performing unnecessary checklist steps
- Loosing place
- Difficulty finding supporting information needed to complete a task
- Difficulty using supporting information
- Failure to remember that a NC has changed following use of a NNC
- Difficulty in physically handling and manipulating the QRH
- Knowing when to stop



# *Issues Focus Design Effort*

- Role of the QRH and its philosophy of use
- Organization of the QRH
- Checklist selection and verification
- Checklist steps (immediate action and reference)
- Warning and caution format
- Technical data format and placement
- Supporting information and rationale
- Operational consequences (airplane and mission)
- Navigation and place-keeping aids
- Document size, binder, paper, etc.



## *Proposed Role of the QRH*

- Guide the crew in efficient and safe management of non-normal conditions.
- Support standardized crew performance across Boeing airplanes.
- Provide a single-source reference document for guiding non-normal tasks.
- Support the range of flight crew competencies and skills world-wide.

# *Design Objectives*

- Design to support QRH roles
- Minimize error and provide design features to detect errors where they occur
- Minimize imposition of secondary task workload
- Reflect human-centered design principles





# *A Related Design Effort*

## *Cross-Model Standardization*

Standardize procedures and checklists across airplane models as much as technical differences will allow

## *Objectives:*

Provide logical scan flows that are easy to learn and perform

Possibly reduce training through common procedures

Enable mixed-fleet flying approvals



# *Overall Benefits*

- Improve safety through error and workload reduction during non-normal situations
- Improve operator understanding of Boeing-issued checklists and information
- Reduce customer changes needed to create an airline QRH
- Possibly reduce documentation maintenance costs
- Possibly reduce training costs through standardized format and content



**Thank You**