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SUSTAINABLE AEROSPACE INNOVATION IN A GLOBALISED WORLD
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Instituto Tecnológico de Aeronáutica

A Requirements Engineering-based Approach for Defining a System Modification Process during Aircraft Operation

Washington Carvalho Tricote Resende, M.Eng.
Luís Gonzaga Trabasso, Ph.D.
Marina Mendonça Natalino Zenun, Sc.D.

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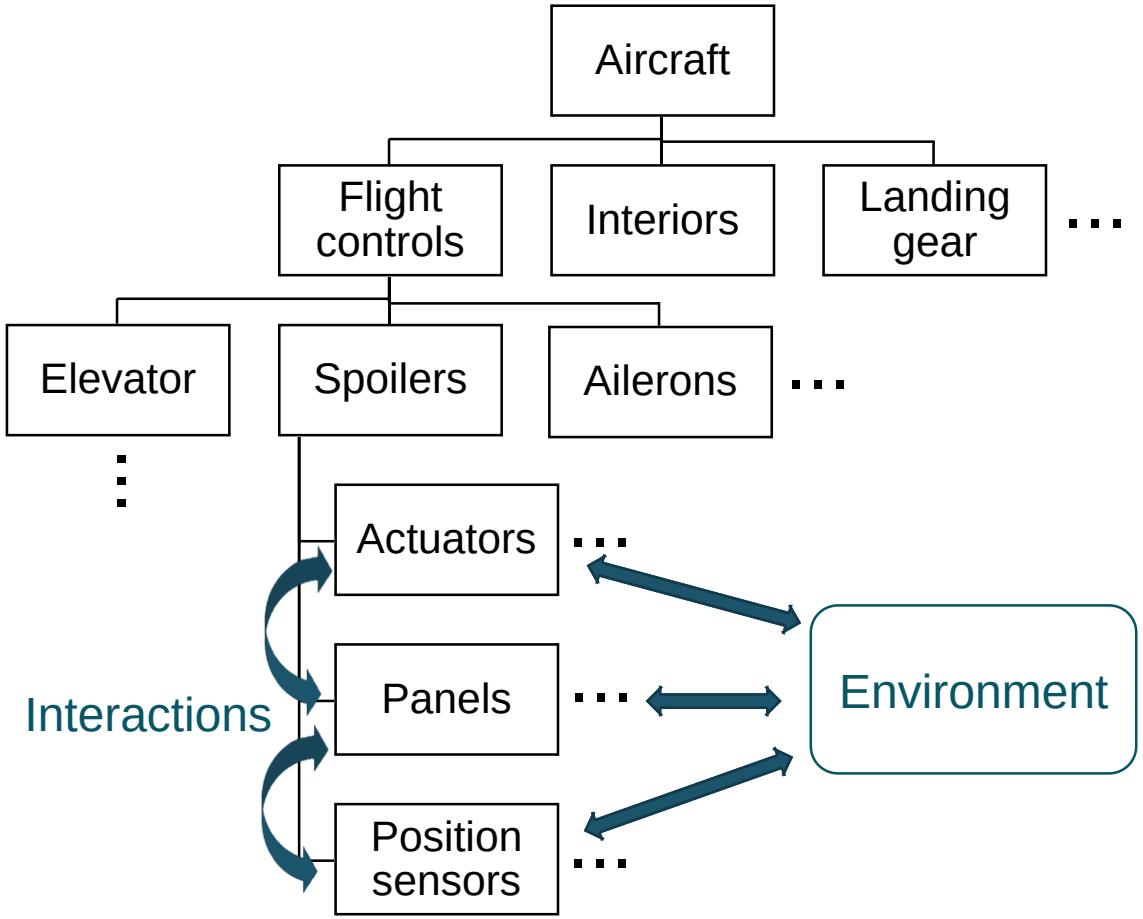
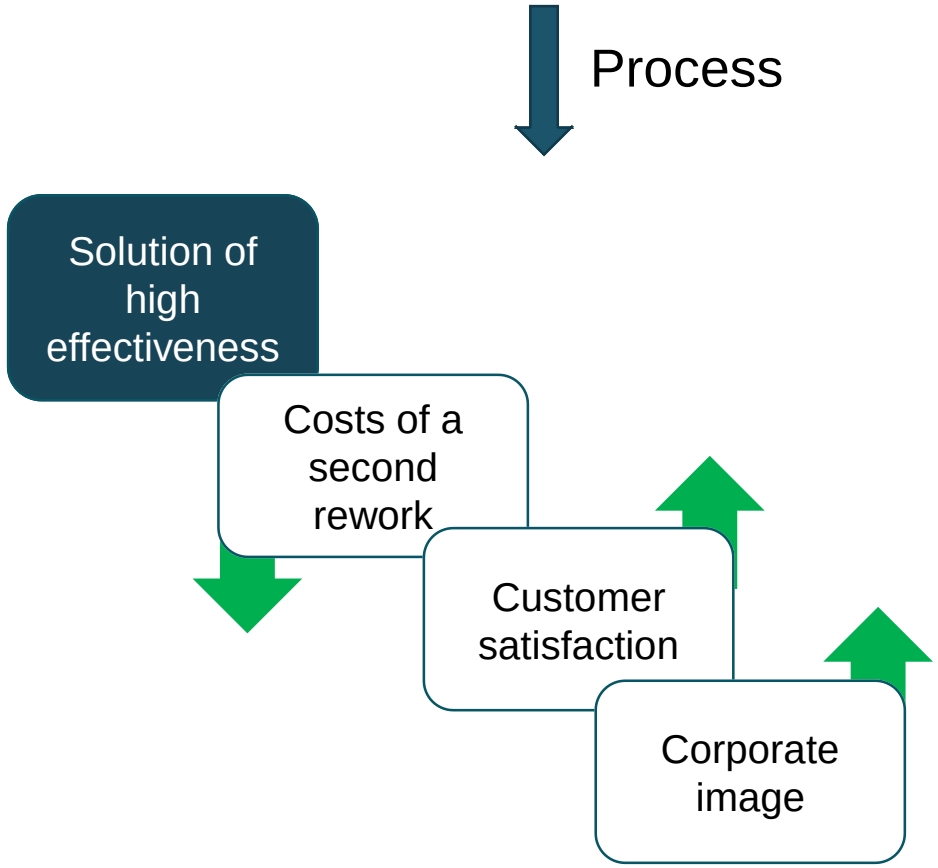
Aircraft: a high complex system

Hierarchy within the system and emergent effects:



System modification during aircraft operation:

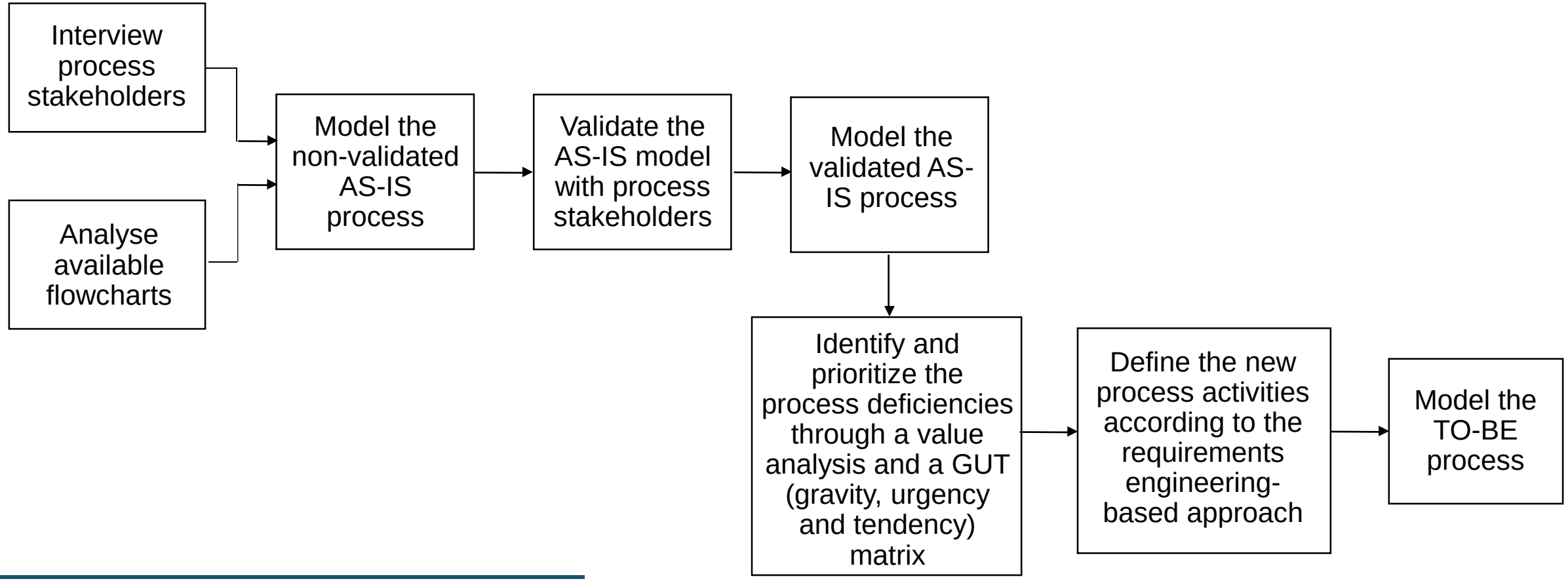


Case study

- ✓ Interior systems:
  - measuring customer perception is a challange;
  - stakeholder concerns are often qualitative;
  - measuring the effectiveness of the solution is difficult and time consuming;
  - the standardization of the process is difficult and the process can become dependent on the expertise of its stakeholders.
- ✓ Process under analysis: modification process of interior systems.
- ✓ System under analysis: folding table of executive aircraft – mechanism and finishing material.

Case study

- ✓ Methodoly used to model the AS-IS and TO-BE processes:
  - integration between process modelling and requirements engineering.

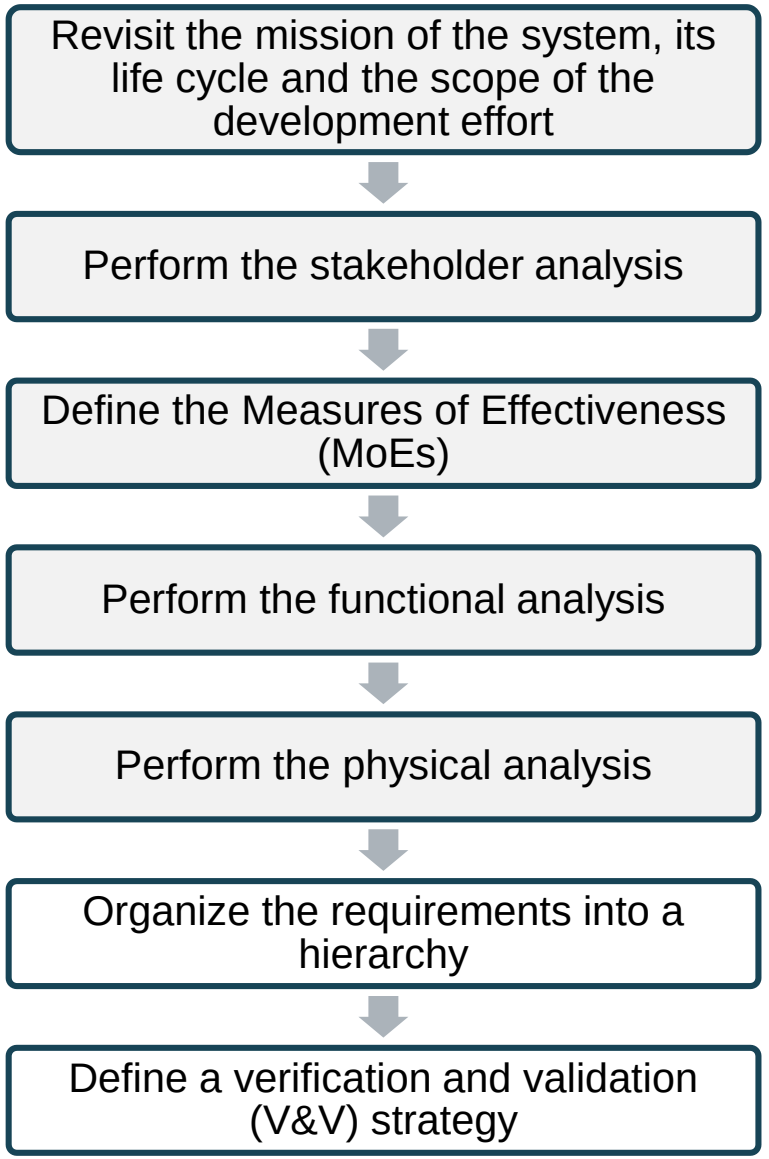


System modification process

Tailored from the Total View Framework and the framework for a Sufficient Set of Requirements (SCoRe) to fit the modification of a system at an advanced life cycle stage.

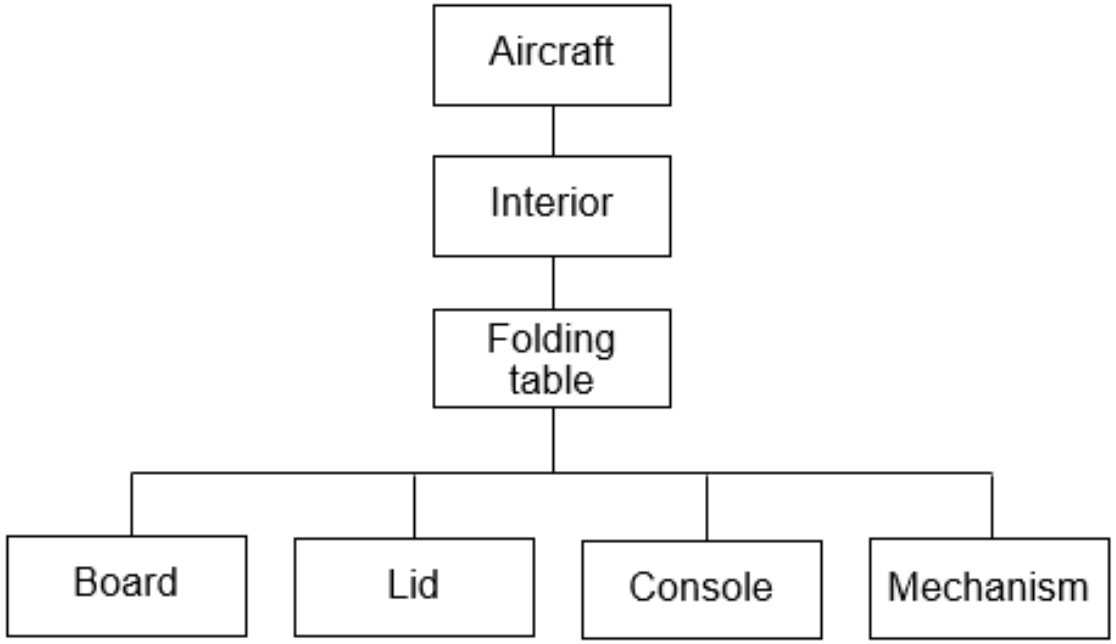
Each step may be adapted according to the:

- ✓ complexity of the system;
- ✓ stakeholders' background;
- ✓ company's standards.



System modification process

Hierarchy:



- ✓ Mission: *to provide comfort, practicality, entertainment and safety to passengers from start to finish of the trip.*

Revisit the mission of the system, its life cycle and the scope of the development effort

↓

Perform the stakeholder analysis

↓

Define the Measures of Effectiveness (MoEs)

↓

Perform the functional analysis

↓

Perform the physical analysis

↓

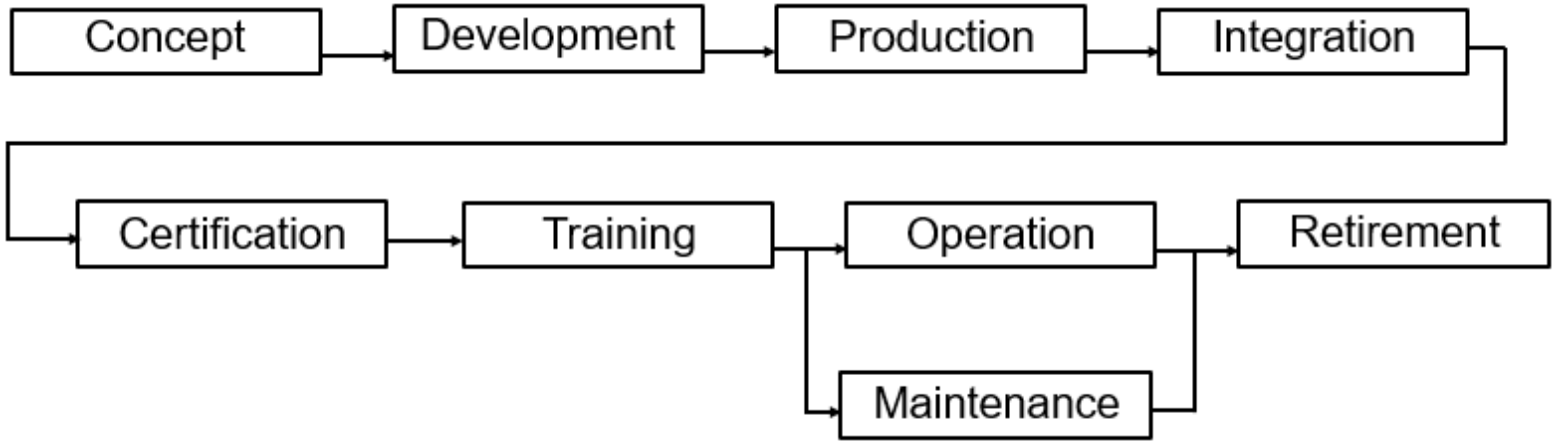
Organize the requirements into a hierarchy

↓

Define a verification and validation (V&V) strategy

System modification process

- ✓ Life cycle:



- ✓ Development organizations: aircraft manufacturer and interior supplier.

Broad scope of the development effort

Revisit the mission of the system, its life cycle and the scope of the development effort

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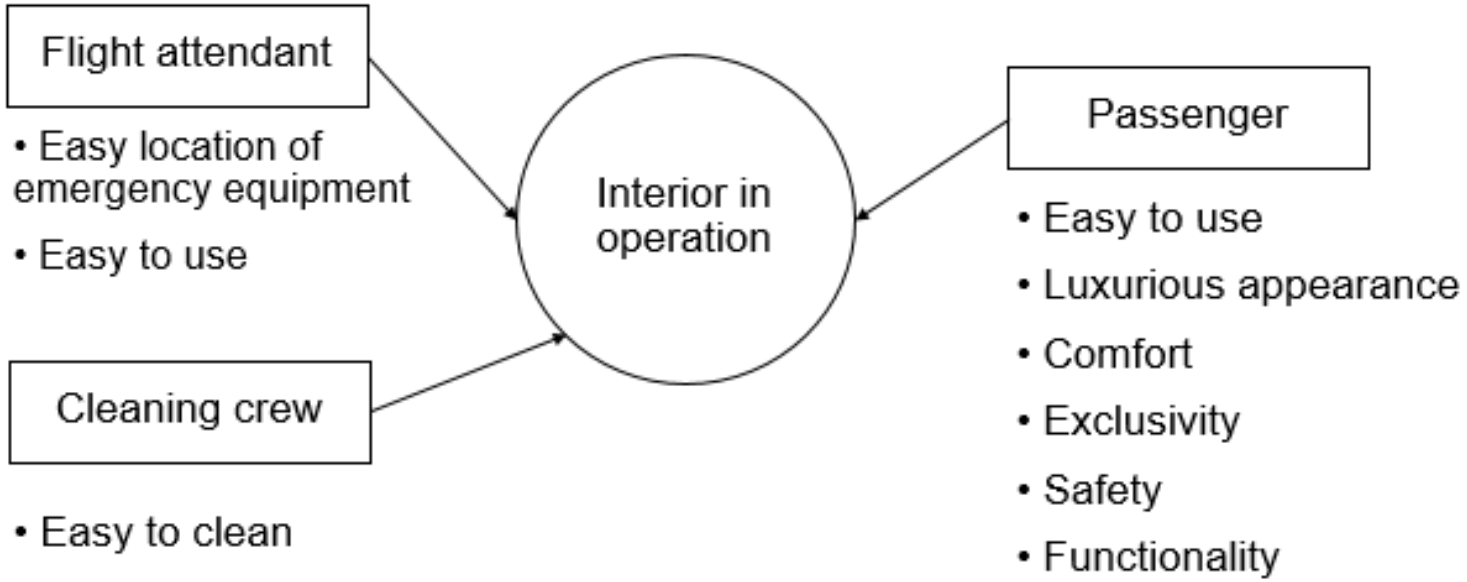
Stakeholders and their concerns:



Stakeholder requirements:

- ✓ The passenger shall be able to use all aircraft interior features on all flights *(type of requirement: capability)*.
- ✓ **The passenger shall be able to feel satisfied with the appearance of the aircraft interior *(type of requirement: capability)*.**

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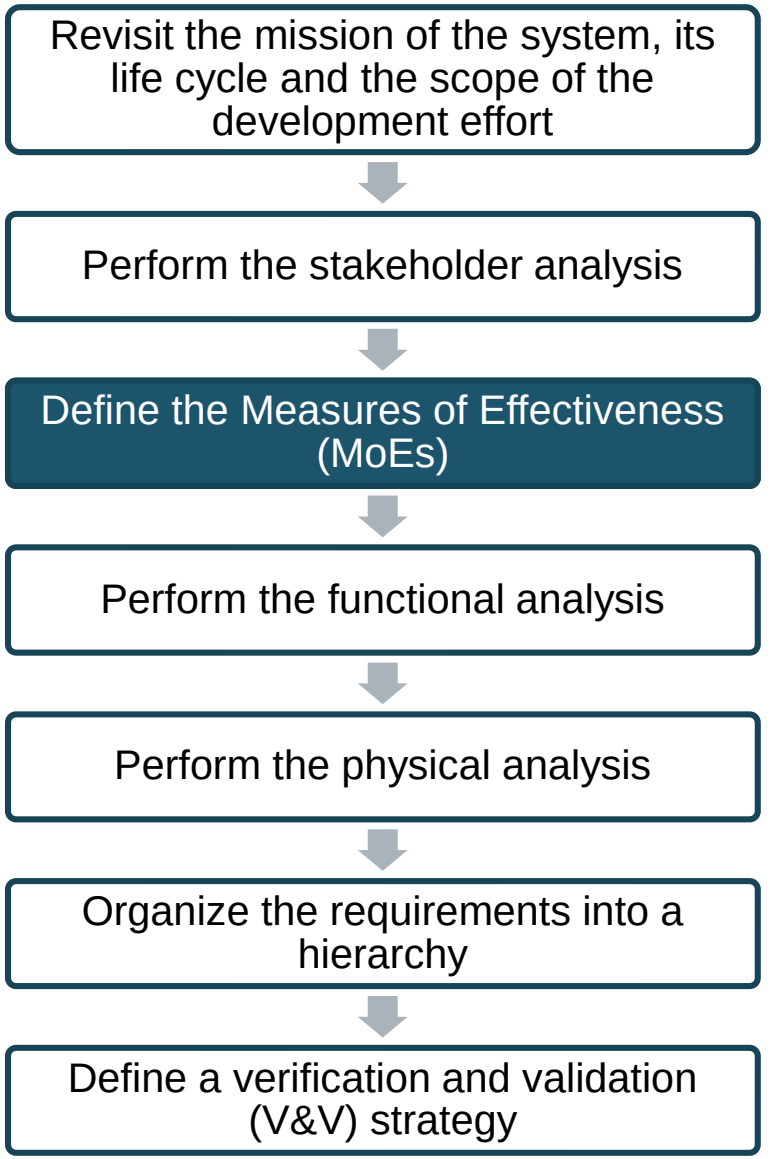
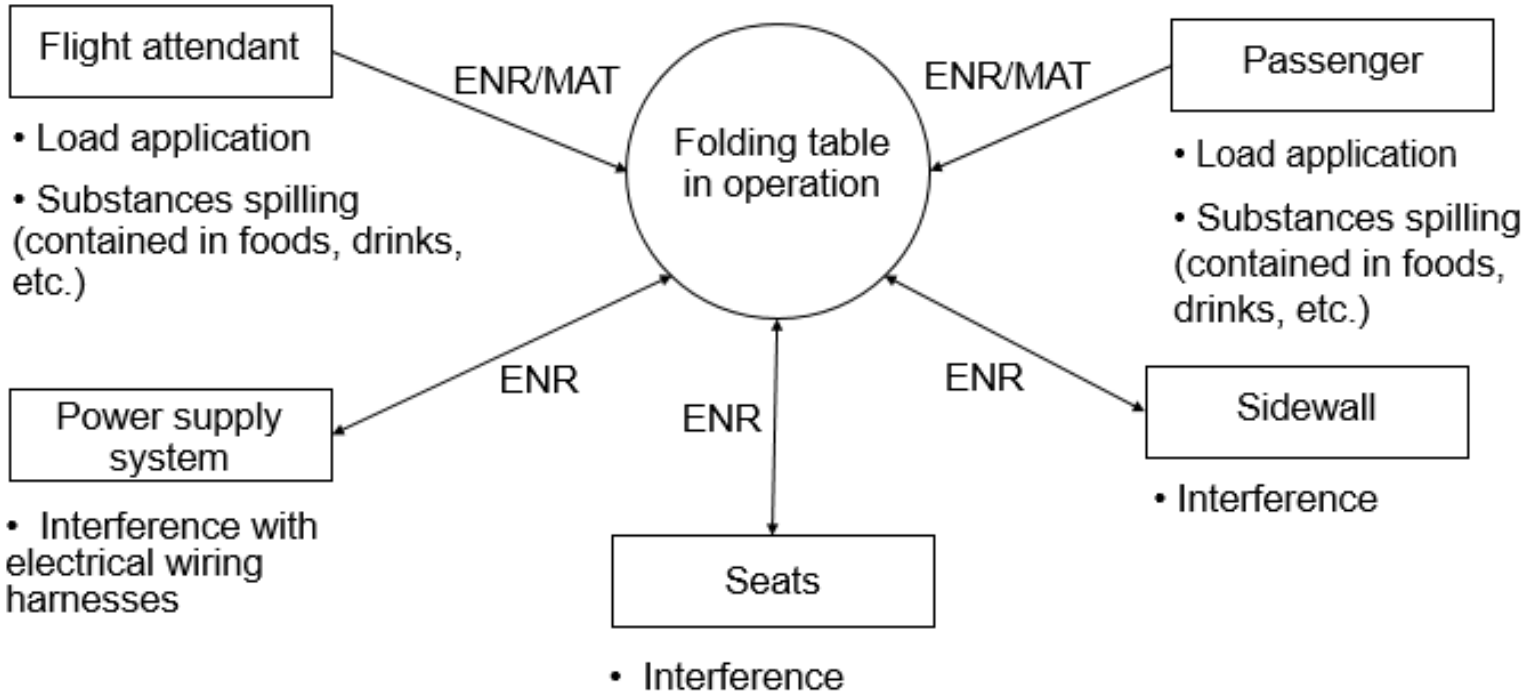
MoEs for the folding table:

MoE	Criterion
Resistance to scratching	**No permanent scratches on the finishing material after X cycles, under normal conditions of use**
Resistance to pressure marks	No permanent dimples in the finishing material after X cycles, under normal conditions of use
Stain resistance	No permanent stains on the finishing material after X cycles under normal conditions of use
Abrasion resistance	No noise indicating abrasion of the components of the mechanism after X cycles, under normal conditions of use



System modification process

Functional context diagram:



In which:

- ENR: energy
- MAT: material

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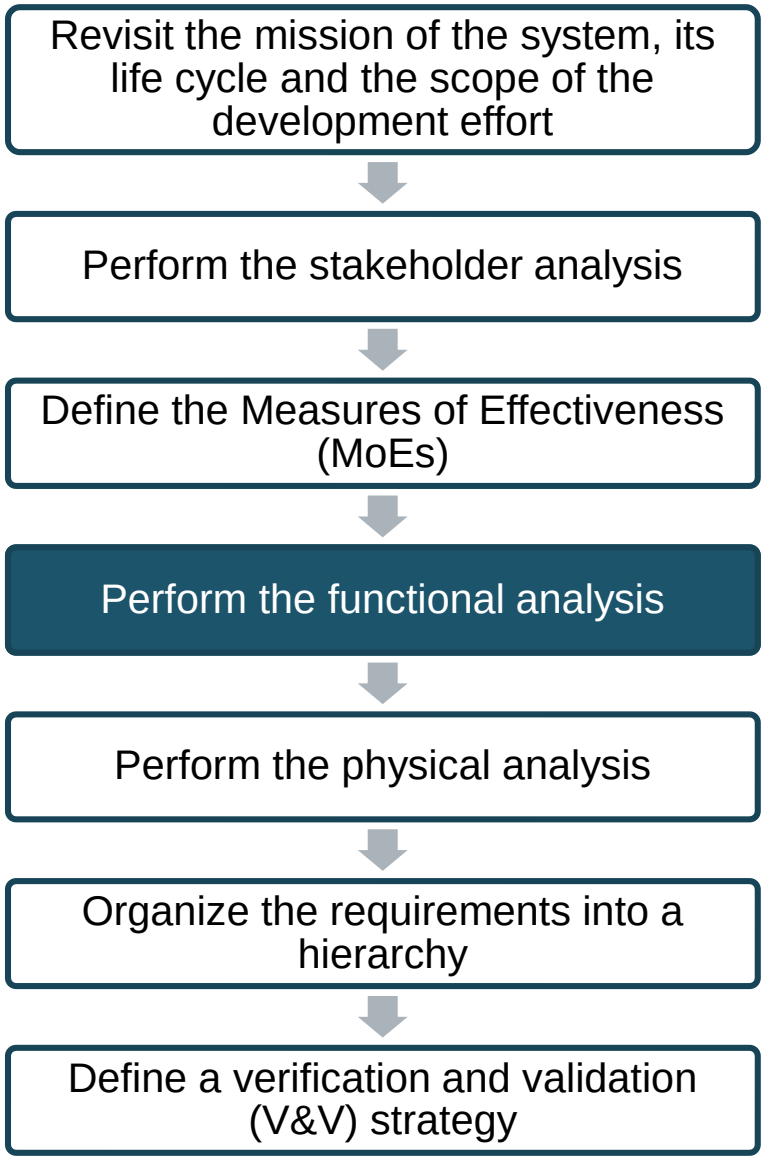
System modification process

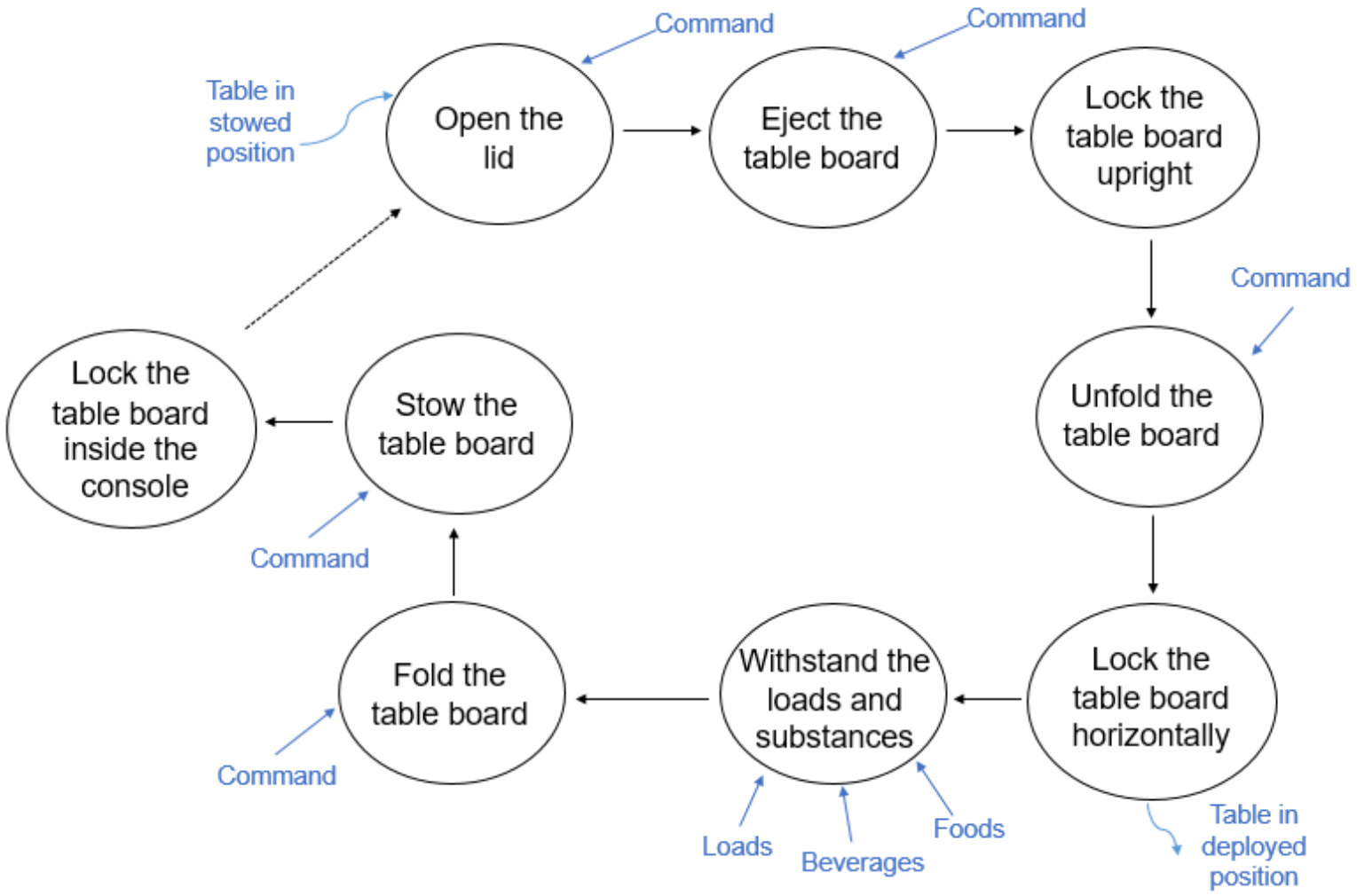
Event list to identify system functions:

System stimulus	System response
1. User press the lid	1. The system opens the lid
2. User press the table board	**2. The system partially lifts the table board**
3. User pull up the table board	**3. The system locks the table board when it is completely released**
4. User moves the table board down	4. The system locks the table board horizontally
5. User unfolds the table board	5. The system locks the outer part of the table board horizontally
6. User makes use of the table	6. The system withstands user-imposed loads
7. User folds the outer part of the table board	7. The system retracts the outer part over the inner part of the table board
8. User raises the table board to the upright position	8. The system opens the lid
9. User stows the table board	9. The system locks the table board inside the console
10. User closes the lid	10. The system is not in use



System modification process

Functional structure diagram:



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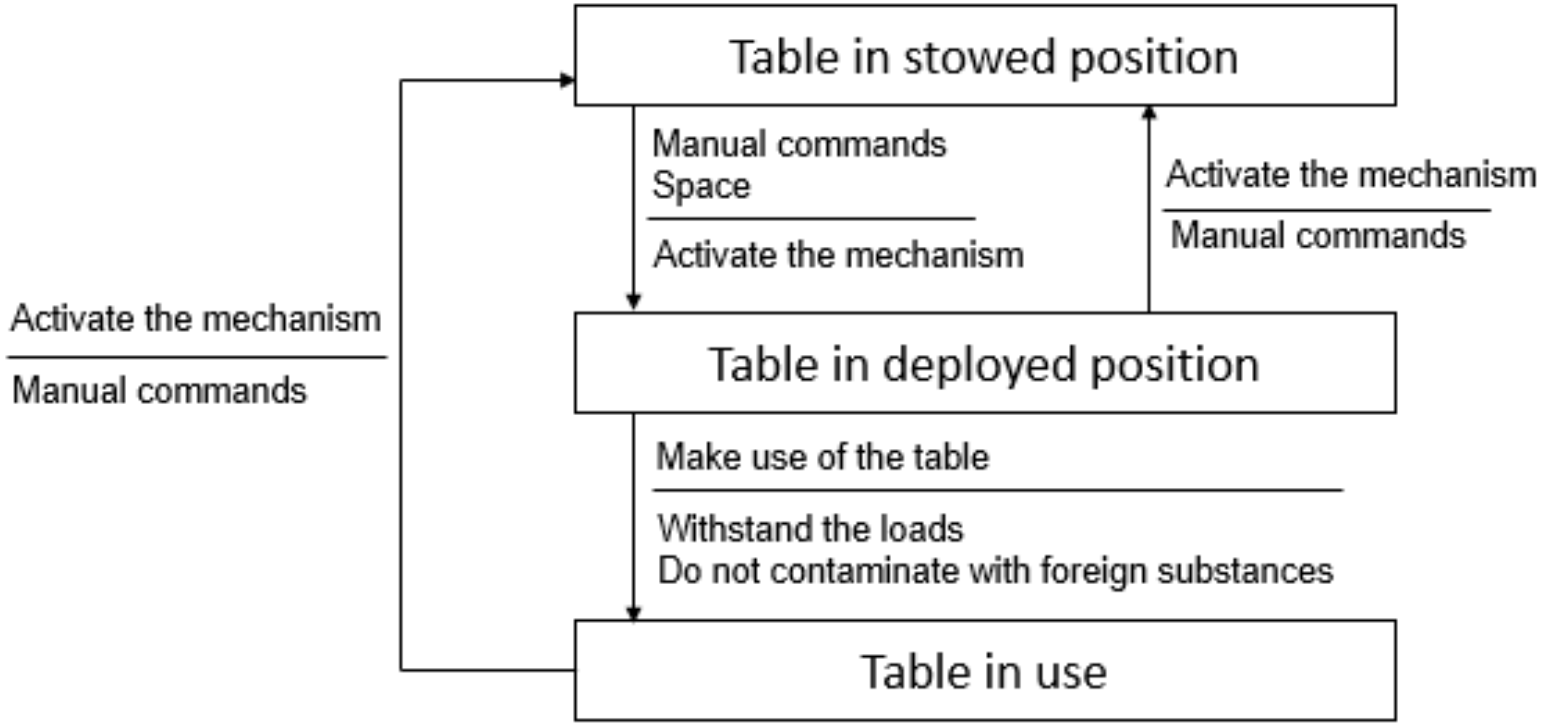
State transition diagram:



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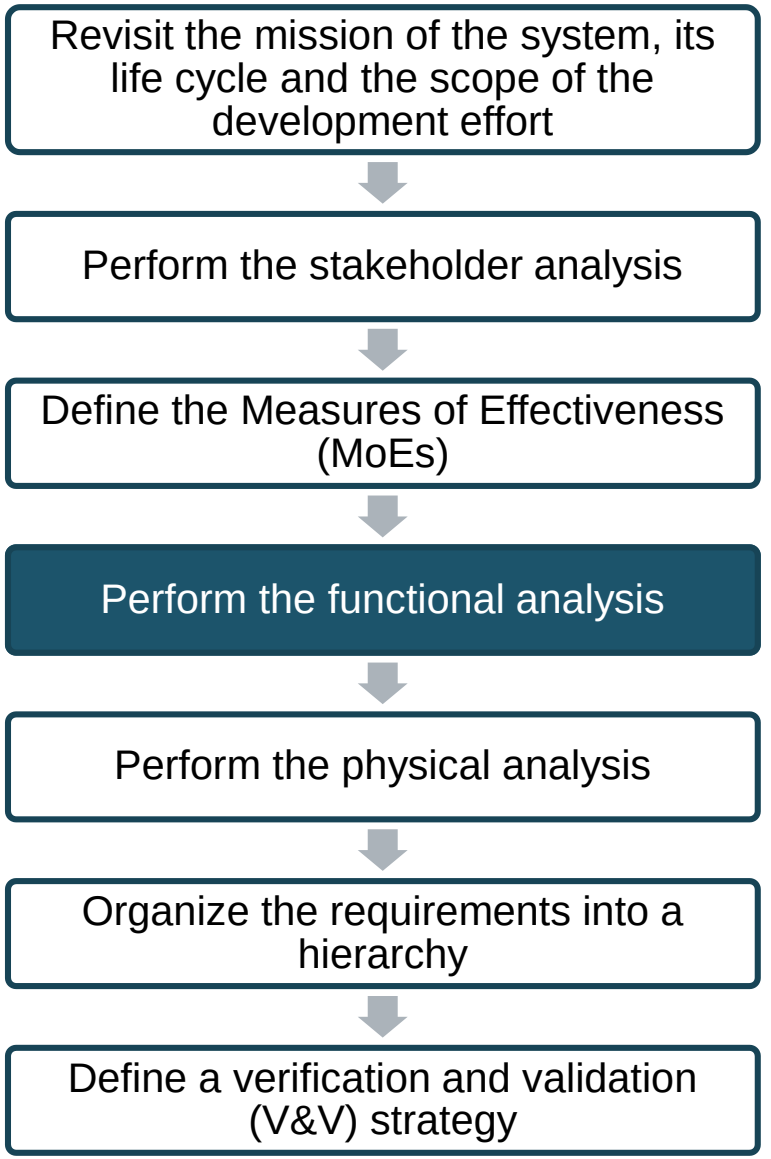
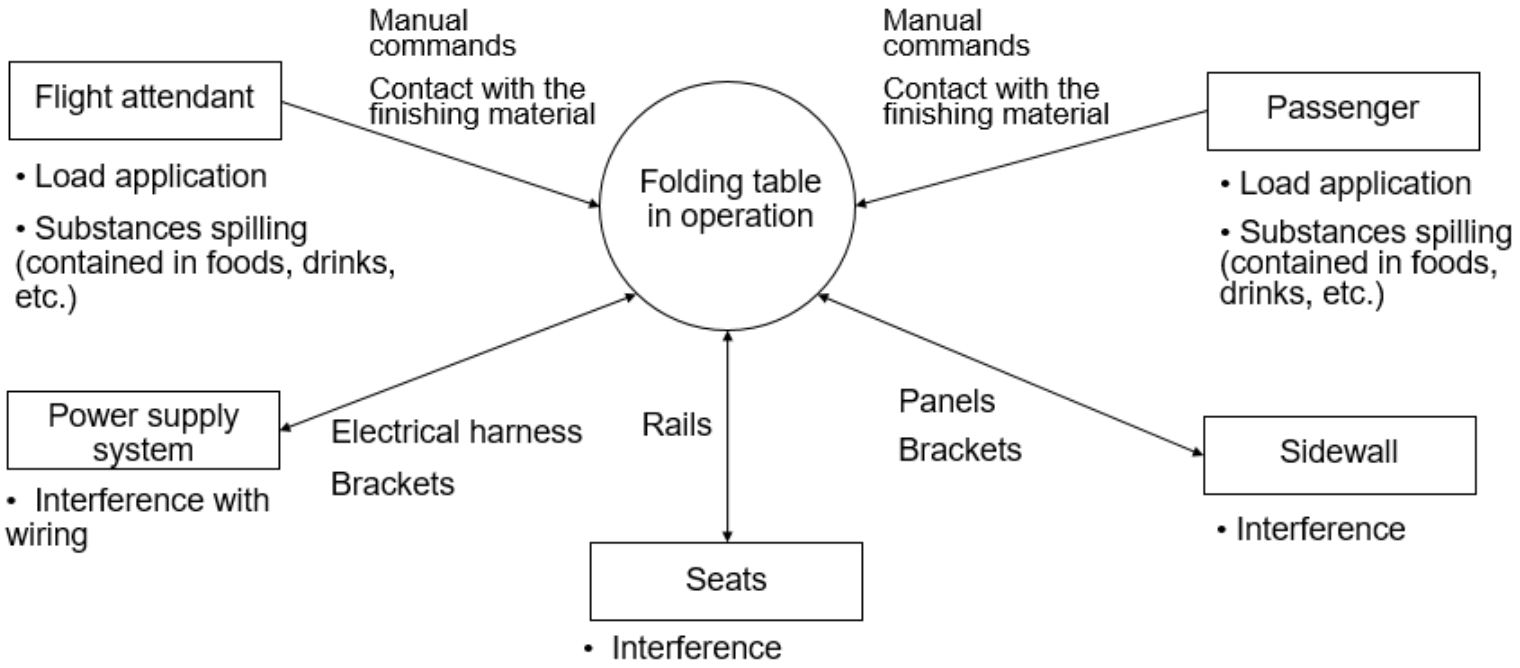
System requirements:

- ✓ While under normal conditions of use, the aircraft interior shall operate for X cycles without damage to the finishing material *(type of requirement: functional)*.
- ✓ While under normal conditions of use, the aircraft interior shall operate for X cycles without damaging its functionality *(type of requirement: functional)*.
- ✓ While being stowed by the user, the table shall not have its movement blocked by contact between any parts *(type of requirement: interface/constraint)*.
- ✓ **When the table board reaches a position of (X ± Y)º, the lid shall be in vertical position (90º) *(type of requirement: interface)*.**
- ✓ While the table is stowed, the table shall not have contact between parts with finishing material *(type of requirement: constraint)*.
- ✓ **While the table is stowed, the outer part of the table board shall not have contact with the inner part of the table board *(type of requirement: interface/constraint)*.**
- ✓ The table shall not have contact between its metal parts and finishing material *(type of requirement: interface/constraint)*.
- ✓ While the table is stowed, the table board shall not have contact with the mechanism *(type of requirement: interface/constraint)*.



System modification process

Acrhitecture context diagram:



System requirements:

- ✓ **The table shall absorb the impacts coming from contact with the sidewall panel *(type of requirement: interface)*.**
- ✓ The table shall not have abrasion damage after X cycles (type of requirement*: constraint)*.

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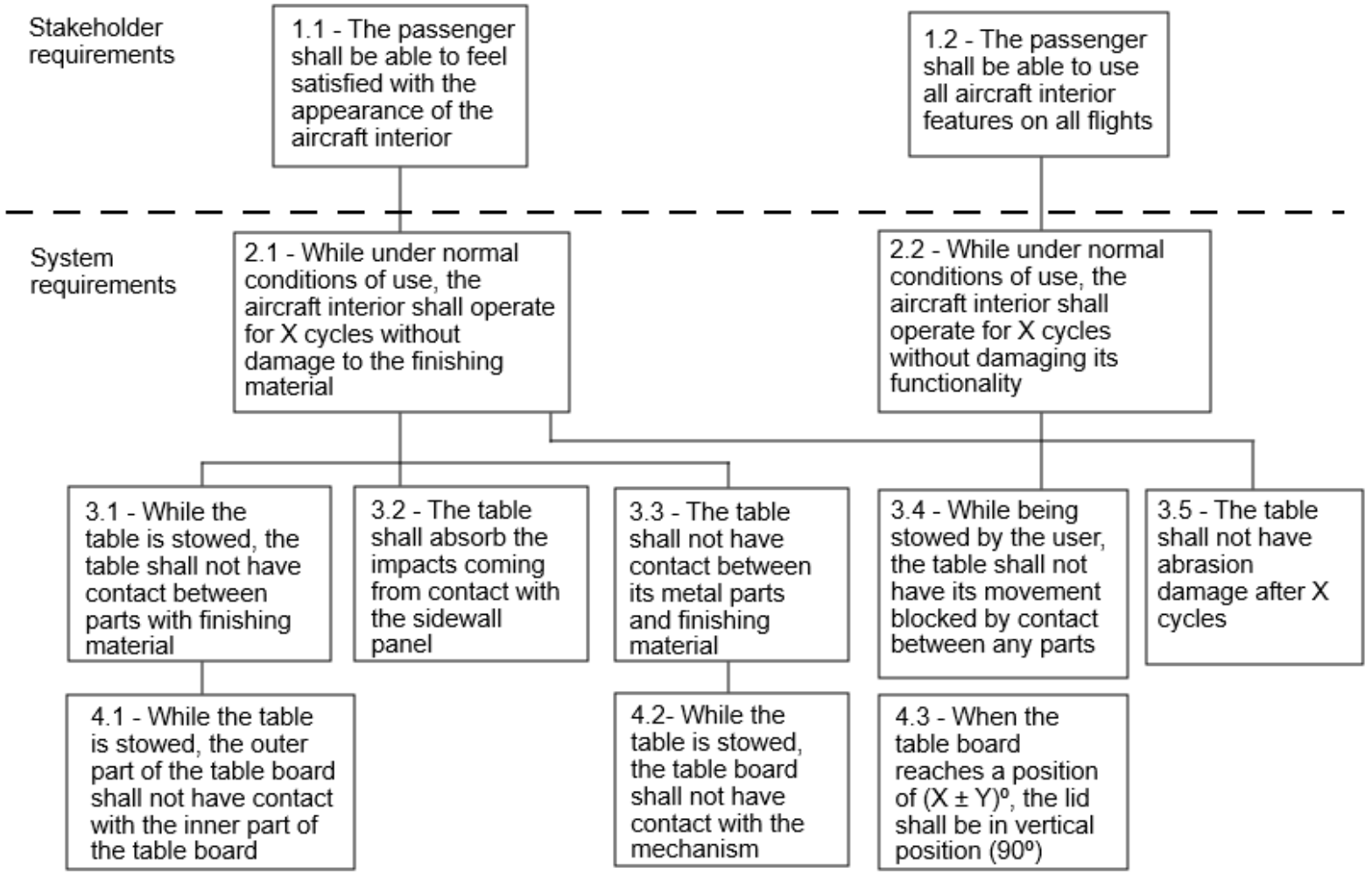
Requirements hierarchy:



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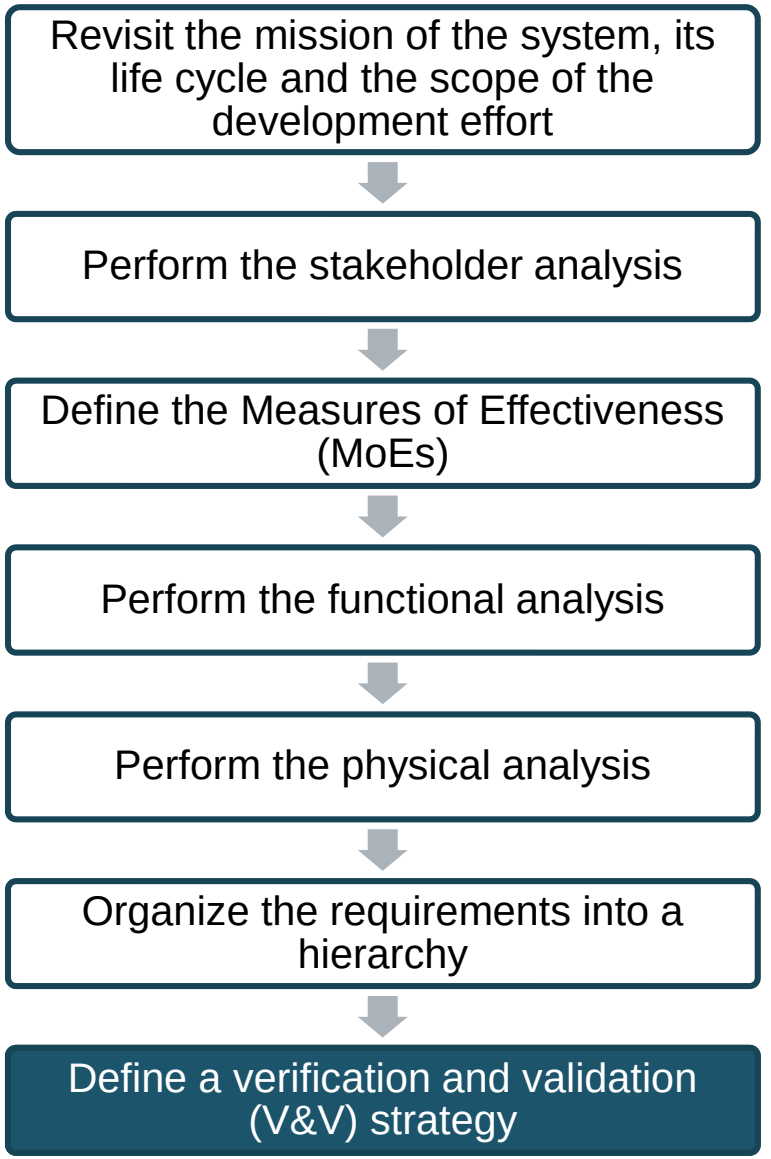
System modification process

- ✓ Requirements verification:
  - characteristics of a good requirement;
  - boilerplates.
- ✓ Requirements validation:
  - traceability.
- ✓ System verification:
  - from the lowest to the highest level of the hierarchy;
  - methods: analyses, tests, simulations, traceability, etc.
- ✓ System validation:
  - effectiveness (MoEs);
  - traceability.



System modification process

- ✓ Case study outcome: potential reduction of 60% of the problems reported during the system operation. It is believed that this figure would be even greater if the process were actually implemented.

- ✓ This work contributes to the industry by presenting a system modification process that avoids additional costs.

- ✓ This work contributes to the literature by tailoring the use of requirements engineering at an advanced life cycle stage, showing the importance of defining new requirements to modify an aircraft subsystem during operation.

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Washington Carvalho Tricote Resende, M.Eng.

washingtontricote@gmail.com

Luís Gonzaga Trabasso, Ph.D.

gonzaga@ita.br

Marina Mendonça Natalino Zenun, Sc.D.

marina.natalino@hotmail.com

Instituto Tecnológico de Aeronáutica

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