

First lessons learned from adopting MBSE in early phases of complex satellite systems

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1. ELCANO overview
2. MBSE process for ELCANO Phase 0
3. Automatic Document Generation

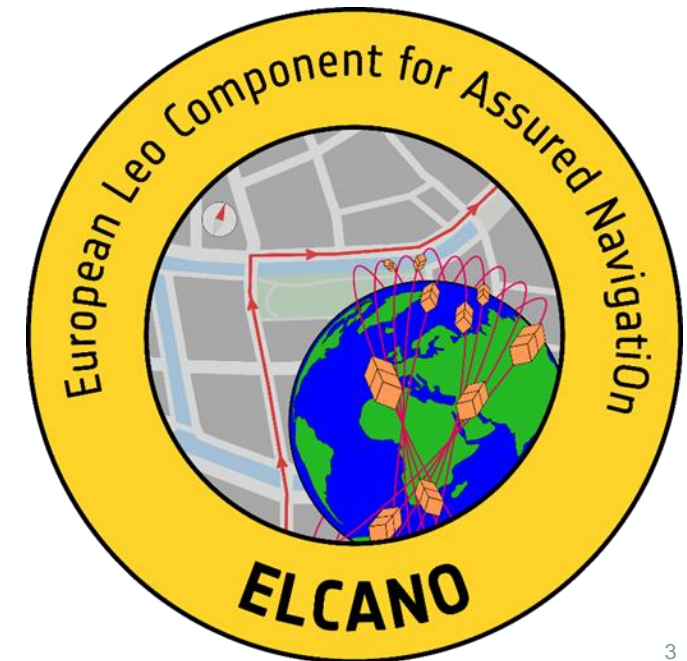
PNT services provided by GNSS in **MEO** have become essential for many different commercial, industrial, scientific and safety-critical applications.

GNSS in MEO (GPS, Galileo, ...) represents the backbone of PNT today. However, its service provision is subject to:

- **Limitations in coverage** (multipath errors, outages in urban canyons, limited reach indoor).
- Other **vulnerabilities** (natural or man-made interference, spoofing).

A constellation in LEO may offer:

- Faster dynamics
- Lower signal path loss
- Lower latency
- Frequency diversity
- Small/low- cost satellites
- Global coverage
- Measurement diversity



- ~~High Costs~~
- ~~Long development times~~

New Space approach: Lower costs & Fast-dynamics developments

- **Interoperable** with existing systems
- Increased **autonomy** of a potential constellation with **hundreds of satellites**
- **Scale down size, power and cost** of payload while maintaining quality of service

MBSE methodology used

The fact that tool, language and methodology is incorporated in a single MBSE software program facilitated our final choice of ARCADIA as the most suitable methodology.



ELCANO Phase 0

Needs Understanding

Operational Analysis

What the users of the system need to accomplish

System Analysis

What the system has to accomplish for the users

Solution Architectural Design

Logical architecture

How the system will work to fulfil the expectations

Physical architecture

How the system will be developed and built



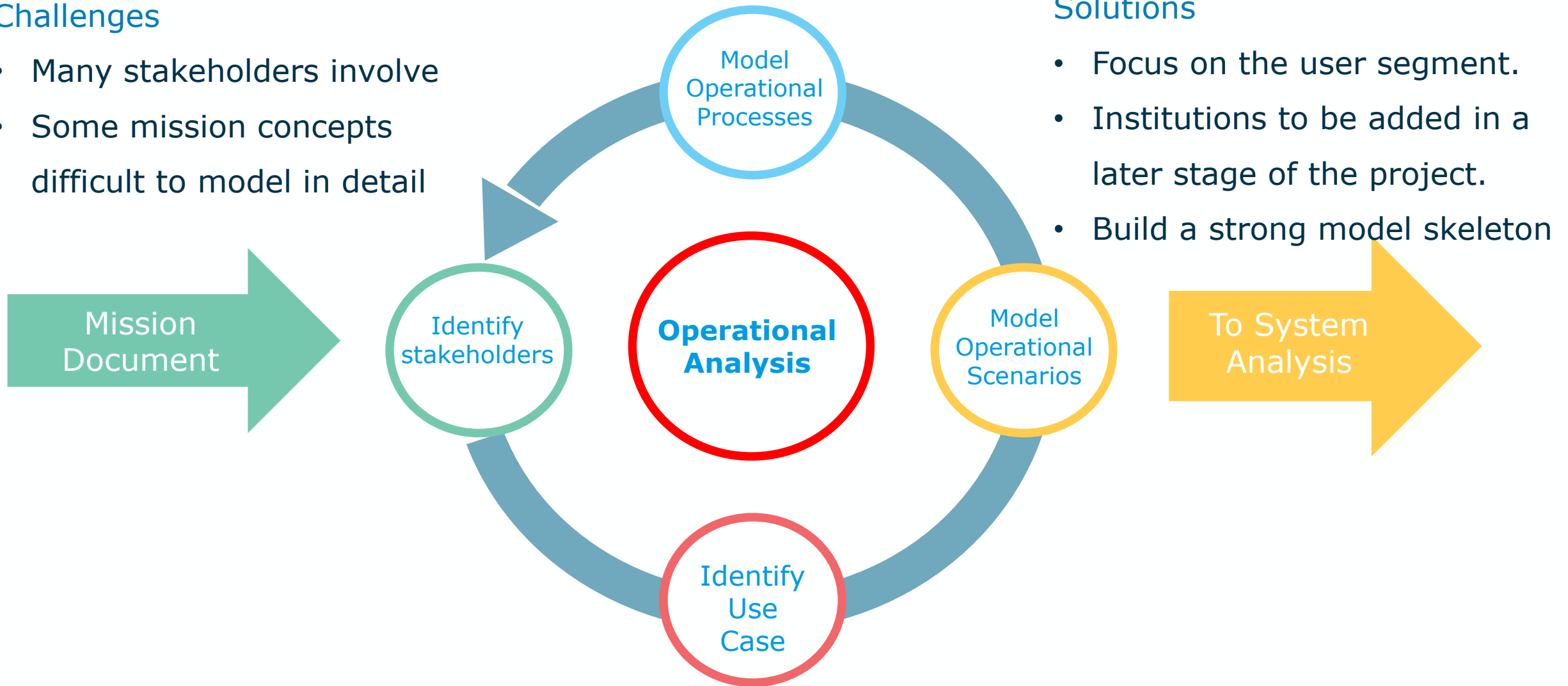
E-10 series

Specification/ Problem Space (black box)

MBSE process. Operational Analysis

Challenges

- Many stakeholders involve
- Some mission concepts difficult to model in detail



Solutions

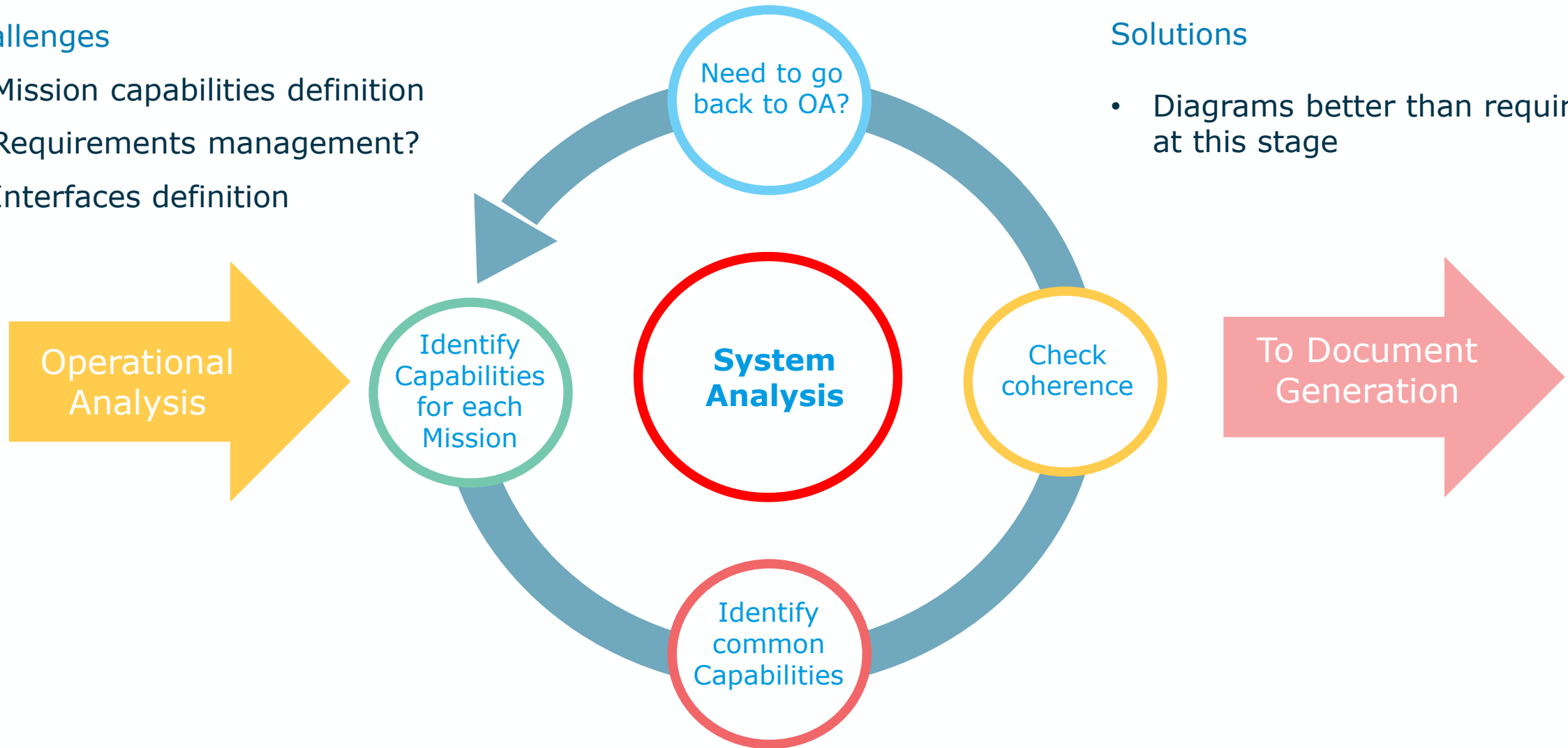
- Focus on the user segment.
- Institutions to be added in a later stage of the project.
- Build a strong model skeleton

Challenges

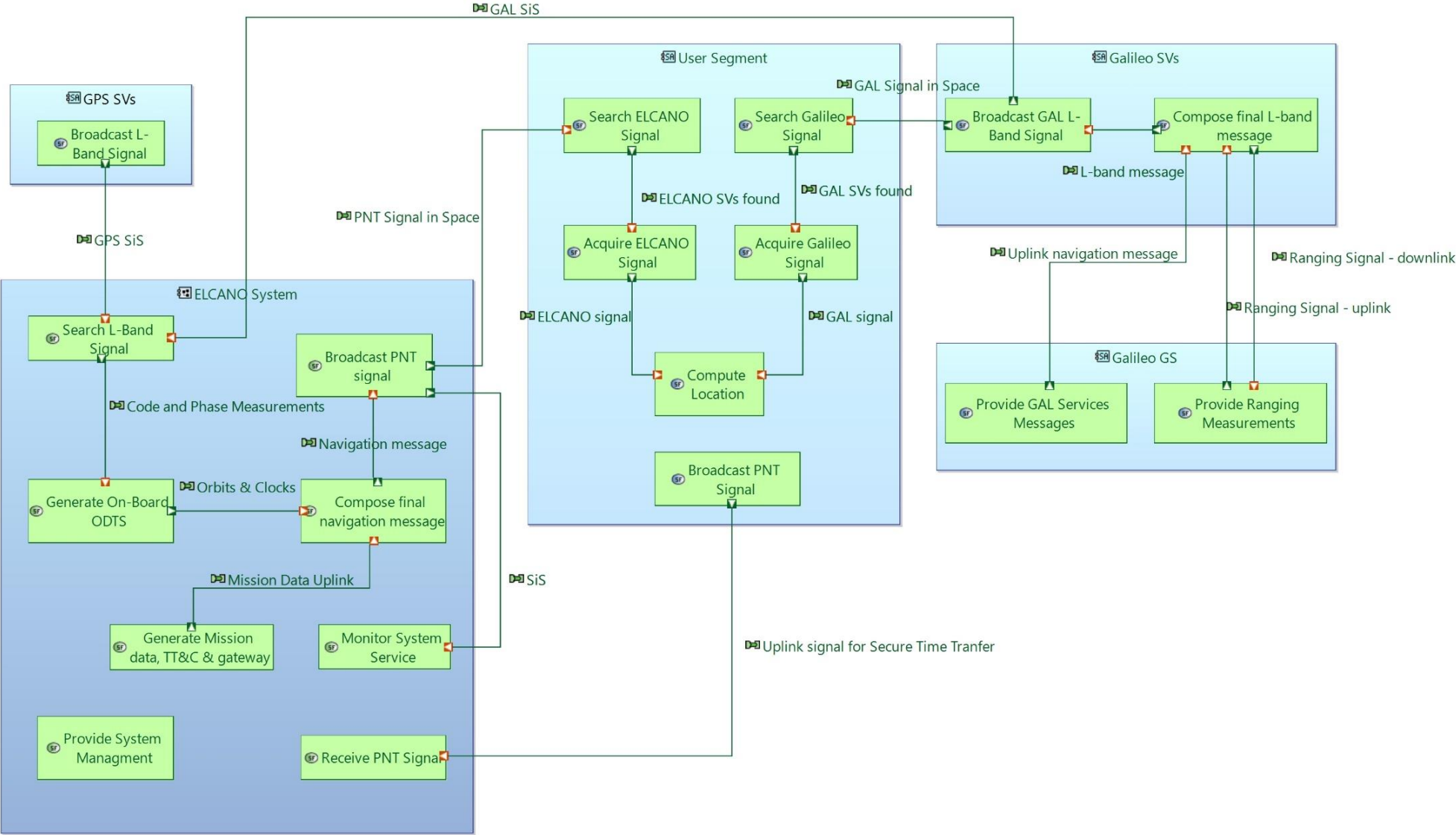
- Mission capabilities definition
- Requirements management?
- Interfaces definition

Solutions

- Diagrams better than requirements at this stage



System Architecture in broadcast PNT from LEO



What is M2Doc?

- An open-source add-on by Obeo that is used directly in Capella.
- M2Doc takes Word templates written in a language built on top of AQL as inputs to generate documents automatically directly from the model.
- It enables **flexible and custom document generation**.



Why do we needed M2Doc?

For complex systems: thousands of documents need to be created and maintained throughout the system life cycle.

Their production, and maintenance require significant effort from all parties.

Manually (Copy/Paste info from the model)	With M2Doc
Long process every time you need to update the document	Time investment is made once (when the template is written)
Prone to error	Validation every time it generates a document
Difficult to verify consistency and completeness of the document.	A change in the model is reflected in the document
Every one in the SE team can do it	You need someone in the SE team that can code templates

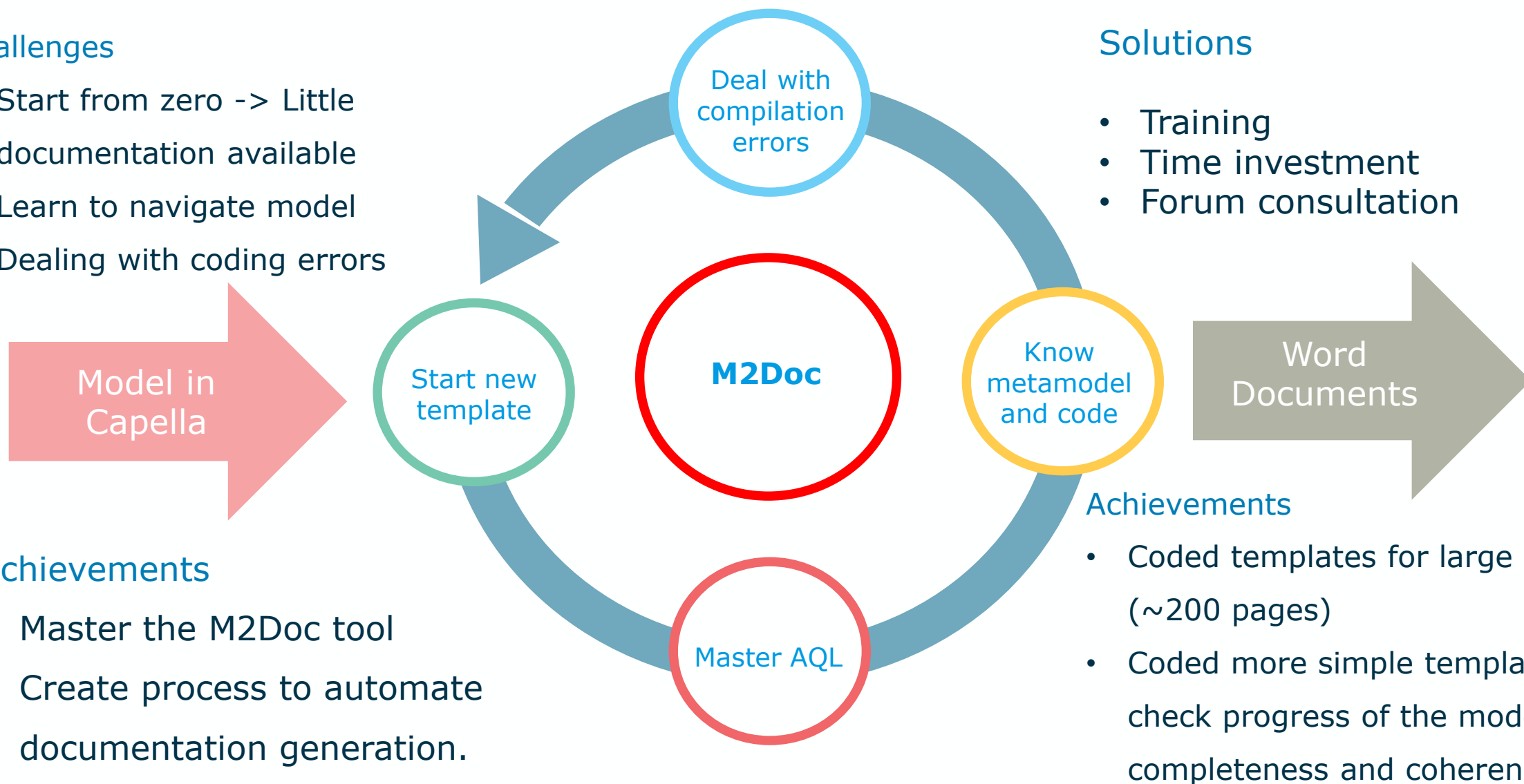
Document Generation process

Challenges

- Start from zero -> Little documentation available
- Learn to navigate model
- Dealing with coding errors

Solutions

- Training
- Time investment
- Forum consultation



Achievements

- Master the M2Doc tool
- Create process to automate documentation generation.

Achievements

- Coded templates for large documents (~200 pages)
- Coded more simple templates to check progress of the model: its completeness and coherence.

2.1 Operational Analysis

Total Operational Activities
Operational Activities realized in System Functions
Operational Activities with description

2 Model Status

2.1 Operational Analysis

Total Operational Activities	10
Operational Activities realized in System Functions	7 / 10
Operational Activities with description	0 / 10
Operational Activities with a Status associated	4/10
Operational Interactions	48
Exchange Items in OA	0

This type document allows to do a quick check of the status of the model: completeness, justification and coherence.

- From my experience, I would recommend to use M2Doc for complex systems which have to undergo major reviews/milestones.

Thank you for your attention. Any question?

