



Return of experience on the implementation of the System Engineering approach in Alstom

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Table of contents

- 1. Evolution of railway operators**
- 2. Evolution of rolling stock**
- 3. Alstom Advanced System Architect Program**
- 4. System Engineering Process: a Top-Down approach**
- 5. Requirement Based & Model Based System Engineering**
- 6. SysML model**
- 7. Gained benefits:**
- 8. System engineering team feedback**
- 9. Threats**





Evolution of railway operators

Railway carbuilders shall develop a more structured design process in order to face the lack of technical background of the new railway operators

- Historically, railway traffic was operated by state owned national operators (SNCF, DB, Trenitalia, Renfe, ecc..) and they were mastering the full technical know-how to design a railway system. Carbuilder were just producing following the operators instructions...
- Today national railway operation market is formally opened (in Europe due to a CEE directive) to other operators (private or not).
- New private operators have not any historical technical background and they're fully operational oriented
- Some incumbent operators, are also changing their mind-set by becoming more operational oriented (and less technical) in order to be more competitive against the new private ones.





Evolutions of rolling stocks:

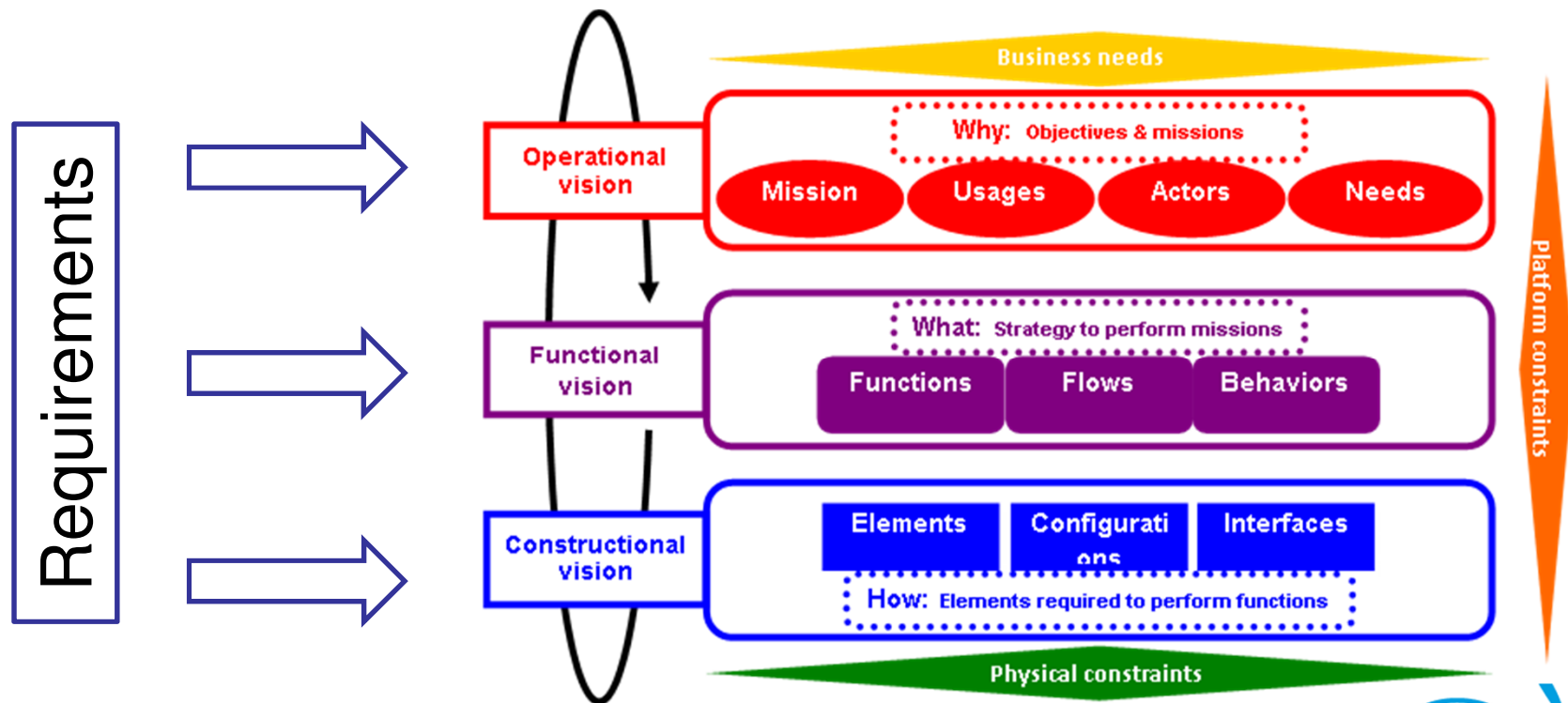
Rolling stock systems have increased the level of complexity due to additional functionalities / services to be implemented and due to the introduction of the software

- Historically, railway vehicle were fully mechanical and once electronic appeared all the « non mechanical » functions to monitor and control the system were realized with wiring logic (relays logic).
- With the introduction of the “train control and monitoring system” some “not safety relevant” function were implement with software, and here the level of complexity arisen in a way to require a more structured approach (MODAL process)
- Today the tendency is to implement (when possible) more and more functionalities (also “safety relevant” functionalities) in software and in this case, to manage such complexity, it’s necessary to introduce a more robust system approach: Alstom **Advanced System Architect Program**



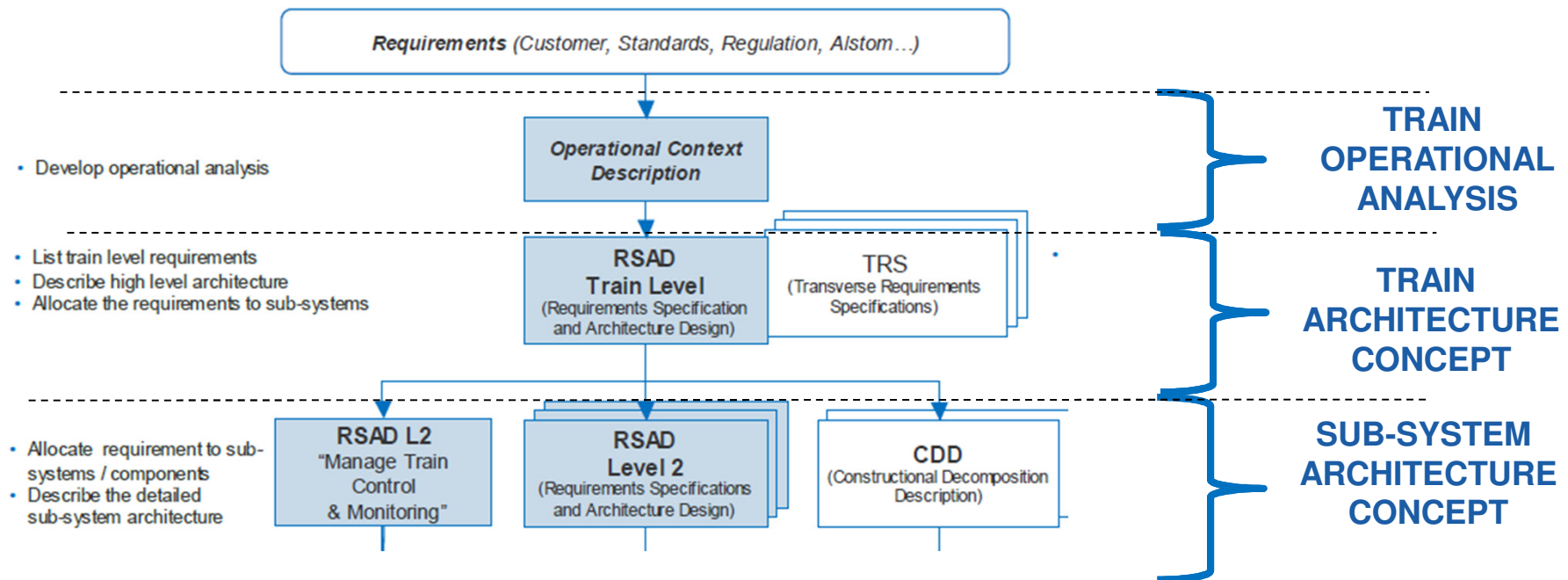
ALSTOM Advanced System Architect Program

Alstom Advance System Architect Program is the new Alstom System Engineering approach which aim to reduce the “problem” complexity



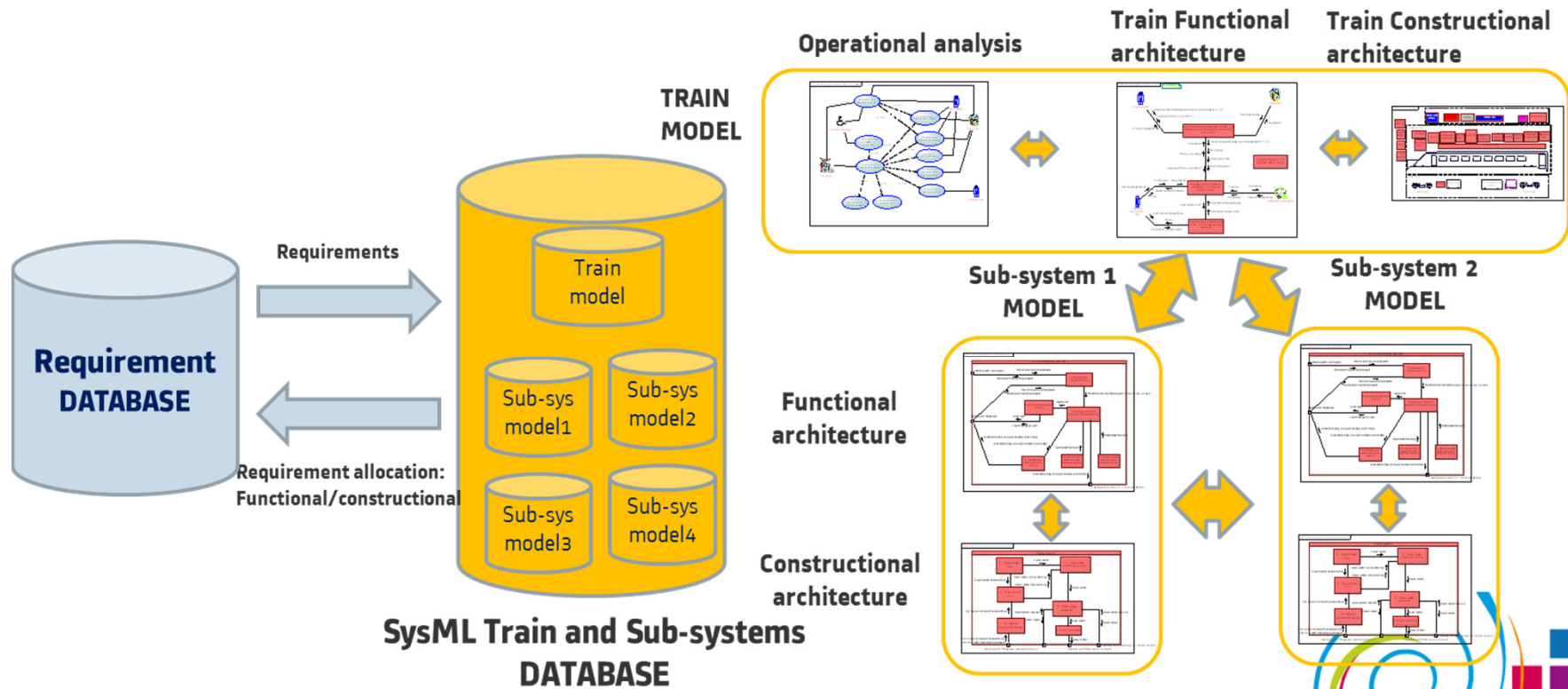
System Engineering Process: a Top-Down approach

System views are developed using a Top-Down approach starting from reqs



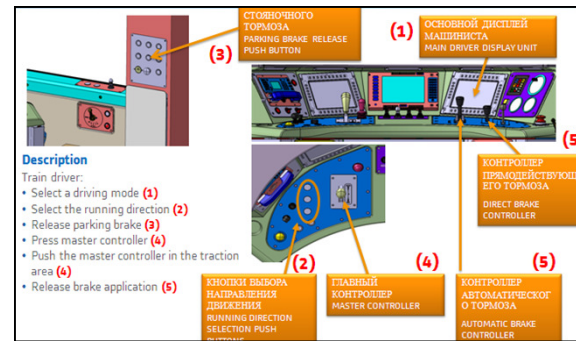
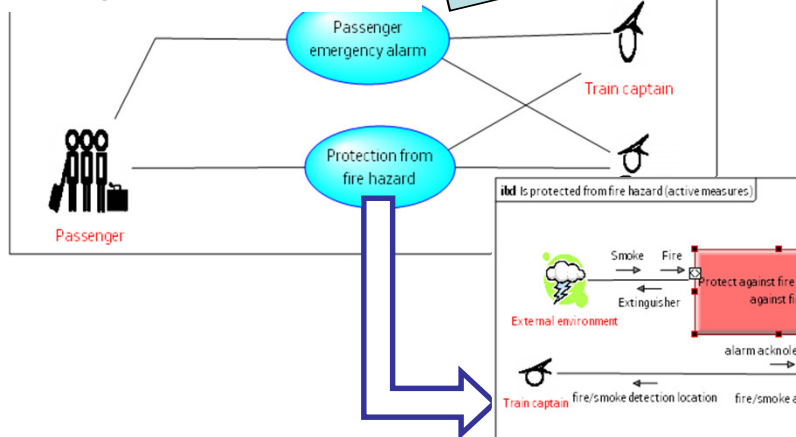
Requirement Based & Model Based System Engineering (SysML)

Requirement Based and Model Based System Engineering are applied to implement the System Engineering approach

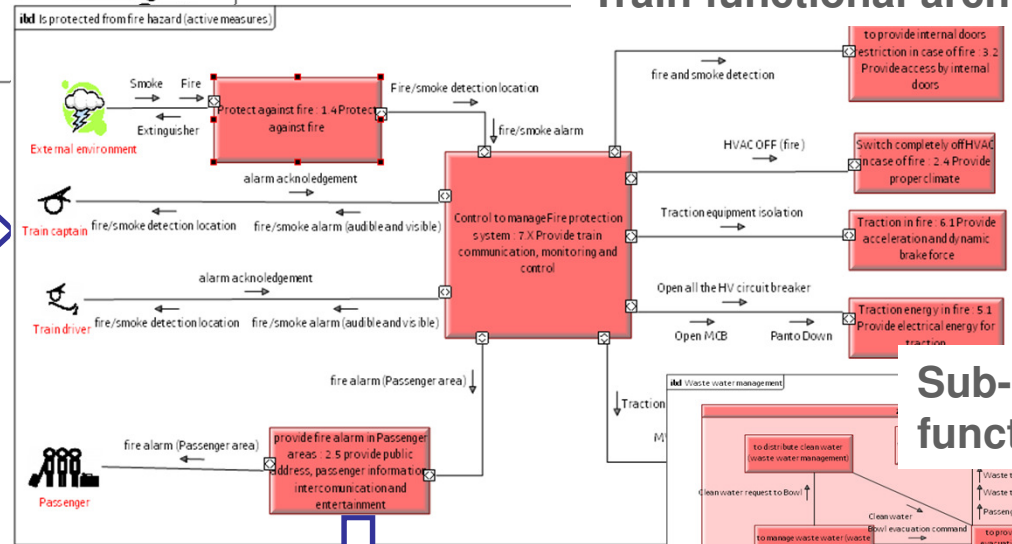


SysML model

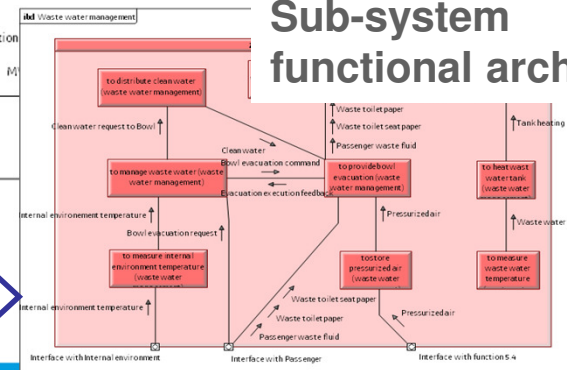
Train operational analysis



Train functional architecture



Sub-system functional architecture





Gained benefits:

- **Improved design quality:**

- ✓ Rigorous traceability between requirements, their implementation into the systems architecture, Verification and Validation
- ✓ Enhanced design coherency and consistency (interfaces) between all the different subsystems
- ✓ Rigorous management of design change and system architecture configuration

- **Increased productivity**

- ✓ Reuse of existing models to support design evolution
- ✓ Reduced errors and time during integration and V&V
- ✓ Enabled concurrent system architecture definition
- ✓ Documents generated automatically from the model





Gained benefits:

- **Reduced development risk:**

- ✓ Rigorous traceability between requirements, their implementation into the systems architecture, Verification and Validation
- ✓ Accurate system development cost estimation
- ✓ Accurate system architecture impact analysis versus requirements/need change

- **Enhanced communications**

- ✓ Shared understanding of the system analysis and architecture across tile development team and other stakeholders
- ✓ Ability to integrate views of the system from multiple perspectives

- **Enhanced knowledge transfer**

- ✓ System architecture and choices justifications are captured in a standard format that can be easily accessed





System engineering team feedback

System Engineers which have worked following ASAP principles have perceived the **ADDED VALUE** and the **GLOBAL QUALITY IMPROVEMENT** improvement of their results.

Most of System Engineers trained with ASAP easily accepted the **System Approach** and the **SysML modelling** finding it as an **HIGH ADDED VALUE** way of working where the team working is boosted:

- all the architectural choices are discussed and agreed by the System Engineering team before to formalize them in the model, having a TSE (Train System Engineer) as responsible and “animator”
- Train and subsystem architecture definitions are done in parallel ensuring the consistency and the homogeneity
- Domains experts has injected their know-how in the model supported by the system engineers





Key points for the new approach deployment:

The key points to deploy the approach is to CLEARLY COMMUNICATE and MANAGE THE CHANGE!

The following are key factors to be carefully considered in order to efficiently drive the change:

- Demonstrate the feasibility and the benefits of the new process with a real full application of the new methodology (pilot project)
- Provide a well structured training
- Provide a strong support during the deployment on site
- Management shall actively support the change of the way of working





Thanks for your attention

