The Requirement Specification Framework (RSF)
Model Driven Systems Engineering for Energy System Operators

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**Definition: The Requirement Specification Framework (RSF)**

The Requirement Specification Framework (RSF) is an integrated and harmonized collection of support **tools** for use in energy related projects that aim to improve the **quality** and efficiency of the requirement specification management **process**.

**Tools**: Standards (IEC-IRM), Software, (Use-case) Templates, Structures, Selected Modelling Languages (UML/ArchiMate), Predefined Requirement Specifications, etc.

**Quality**: Consistency, Testability, Completeness, Understand-ability, Traceability, Impact Analysis, Sharing & Leveraging, Customization, Documentation, etc.

**Process**: Requirement Elicitation, Communication with Stakeholders, Conformance verification, Change Management, Estimation, Weighing & Scoring, Structuring, etc.
The V-model of the system development/procurement cycle

Quality Loop

Time

Concepts of Operation

Operation & Maintenance

Architecture & Requirements

Integration & Validation

Specification & Design

Module Test & Verification

Procurement & Implementation

The Requirement Specification Framework (RSF)
Contents

1. A short introduction to modelling and its benefits (9 slides)
2. The Requirement Specification Framework (RSF) (5 slides)
3. An example: the State Estimation (SE) use-case (20 slides)
A short introduction to modelling and its applications
A short introduction to modelling and its benefits (and costs)

A model: what the architect does with cardboard...

Simplification & visualization for communication purposes
Why use a model?

- To manage complexity
- To use a formal language (UML)
- Generate Documentation / Code
- Structures & methods (e.g. SysML)
- Re-use libraries of model-elements
- Ensure consistency / reproducibility
- Simplify maintenance of products
- Helps in leveraging and education
- Reduces the development effort
- To “make smarter decisions”
How to use models? Or rather: how to use a model repository?

- We already use (2D) models (whiteboard, Visio, flow-charts, napkins, etc.)
- A modelling language (UML) relies on a repository (e.g. Enterprise Architect)
- From the (Multi-D) model-database various diagrams & views can be created
- Diagrams are used for Data Entry (to create the model) and Visualization
Features that are needed to achieve the goal (manage complexity)

A model supports all of the interdependencies and relationships between different aspects (actors, processes, functions, platforms, etc.) and provides visualizations.
A model represents the real-life complexity that needs to be managed

- A model represents all of the real-life complexities that need to be managed
- Models exclude complexities that do not have to be managed (in this context)
- A model adds some (temporarily) complexity (language, methodologies, tooling)
- Software tooling is needed to effectively use models for (specification) tasks
RSF applies Black-box modelling on a (top down) functional level

- How the system is “used” by entities in its environment (hence: use-case)
- As opposed to a “White-box” model that defines the system’s “inner workings”
Requirement Realization Options

- The model defines Requirement-owners that cause (or realize) the requirements
- The realization dependencies are mainly used for traceability and impact analysis
- Other dependencies (data flows) and containments (packages) are also supported
The Advantages of Model Based (or Driven) System Engineering

- The main aim of Model Based (or Driven) System Engineering (MBSE or MDSE) and the RS-Framework is to Manage Complexity. A model (tool) is used to:
  
  - View systems and environments from multiple perspectives or viewpoints
  - Improve system understanding through visualization & validation functions
  - Perform impact analysis (discover causes & effects using model traceability)
  - Identify the consequences of changes/alternatives early in the system lifecycle
  - Improve estimation and risk-susceptibility of modifications & implementations
  - Capture and share the expert knowledge in a persistent (baselined) repository
  - Reuse existing information and lessons-learned in new projects (efficiency)
  - Experiment with systems & process migrations without any risks

- The model becomes the backbone of the systems design/procurement process
- The model provides the reference for verification along the full system lifecycle
The Requirement Specification Framework (RSF)
Some RSF Features

- Driver for RSF: Word documents are too difficult to manage and keep consistent.
- RSF creates Word documents from a model that helps management & quality:
  - Strict implementation of the Systems Engineering (ISO/IEC 15288) methodology
  - An integrated approach on a functional level (use-cases) for the system life-cycle
  - Defines the business processes, information, application functions & infrastructure
  - Common, holistic, view on the subjects for all stakeholders (multi-disciplinary)
  - Early verification & validation of requirements & specs to reduce correction efforts
  - Based on (ISO/IEC/W3C) standards and sector best practices (ENTSO, EPRI, etc.)
  - SMART, pre-defined, requirements for Interface Reference Model (IRM) use-cases
  - Supported by formal modelling languages (UML) and tooling (Enterprise Architect)
Document

Introduction
What, Where, When, Who, How, & Why
(the Zachman framework extended with:)
Which Verification
Which Environment
Which Requirements

Predefined templates

Containment
the IEC-61968-1 Interface Reference Model (IRM) chapters extended with:
SCADA functions and field devices
Processes & project implementation
Infrastructures and facilities

Test cases & scenarios

Environment Library
Enterprise (ArchiMate) model layers:
Business processes and products
Application and system functions,
Infrastructure & platform services,
Migration & motivation extensions

Use Case
Description (Block definition diagram)
Use case diagram (Use-case diagram)
Interaction analysis (Sequence diagram)
Functional description (Activity diagram)
Requirement specification (Alignment)

Actors & Roles Library
the IEC Use-case repository
Actors & Role model conforms with:
ENTSO-E, DKE, EG3, SMCG/SGCG.
(Extended with project actors & roles)

Requirement Library

Note: Predefined standard specifications for SCADA, EMS, DMS, OMS, AMI, RTU, Cabinets, etc.

Note: Document generation for conformance tables, test cases, questionnaires, checklist, scripts, etc.
The use of use-cases to subdivide the scope in function “blocks”

- Use-case template (IEEE-EPRI IntelliGrid Template - IEC-PAS 62559 standard)
- Contained in the IEC Interface Reference Model (IRM) structure
- With dependency links and associations to context elements
Requirement Specification Framework
- Example: The State Estimation Use-case
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Example: The State Estimation Use-case

- The RSF model for the State Estimation use-case:
  - Introduction (Zachman structure)
  - Context (ArchiMate 2) model
  - Requirements & Use-cases
  - Various other packages

- The Context model serves many use-cases
- The Use case repository (according to IRM)

Shown on the left are the top-level packages Of RSF in the Enterprise Architect software tool (the Project Browser)
Example: The State Estimation Use-case

The Requirements & Use Cases package
- Holds the use-cases & requirements (for UCs)
- Inside the IRM Containment structure
- The State Estimation use-case
  - Is inside the CLC Package
  - Which is inside the NO Package

The structure and containment is compliant with the IEC 61968 part 3/10 (CIM) standard.

Use-case repositories (EPRI, IEC, Europe SGCG) all use the same structure and abbreviations.
Example: State Estimation Use-case

The State Estimation use-case

- Largely in line with the EPRI repository
- A generic starting point for specific models

- The internal structure is according to the
  - IntelliGrid (now PAS/IEC-62559) template

- The package can be used to document
  - use-case specific features using the
    - documentation (notes) features of EA.

- Next page shows the coverage of the RSF
  - Use-case template with the PAS standard.
The RSF Use-case template compared to IntelliGrid (IEC-62559)

The RSF Context Model
- Actors & Roles
- Business Processes
- Application Functions
- Infrastructure Platforms
- Data & Business Objects

The IntelliGrid (IEC-62559) Template
- 1 Descriptions of Function
  - 1.5 Actor (Stakeholder) Roles
  - 1.1 Function Name
  - 1.2 Function ID
  - 1.3 Brief Description
  - 1.4 Narrative
  - 1.6 Information exchanged
  - 1.7 Activities/Services
  - 1.8 Contracts/Regulations
- 2 Step by Step Analysis of Function
  - 2.1 Steps to implement function
  - 2.2 Architectural Issues in Interactions
  - 2.3 Diagram
- 3 Auxiliary Issues
  - 3.1 References and contacts
  - 3.2 Action Item List
  - 3.3 Revision History

The RSF Use-case Template
- 1.1 Use-case description
- 1.2 Overview and scope
- 1.4 Functional description
- 1.5 Data Model & Data Flow
- 1.3 Interaction analysis
- 1.6 Requirement Specification
- 1.7 Verification and Testing
- Revisions and Remarks

Note: The sequence of Use-case sections is changed for clarity.
The RSF Use-case template uses codes as part of the use-case name to support the function ID (in section 1.2).
The RSF Template provides support for various diagrams in every section (not just a sequence diagram in 2.3).
Example: The State Estimation Use-case

- The use case is documented using the UML language and diagrams (with notes)
- The diagrams may use many elements from the context model (blue & yellow)

The State estimation application fetches data values from SCADA operations model, processes topology, estimates a new state, detects bad measurements and returns estimated states to SCADA operations model. It also makes a copy of the network state available for other network analysis applications.

This use case is an alternative and expansion of the SCADA Data Update use case. It separates the Power System State Model between three subsystems: Data Acquisition, Topology Processor and State Estimator.
Example: The State Estimation Use-case

- Predefined templates model elements, structure, requirements, and other items
- The scope diagram is used to map responsibilities (RACI) and use-case scope
Example: The State Estimation Use-case

- Sequence diagrams to document Sequence of Events (normal, exception, alt...)

The Topology Processor publishes events, if any, for the Alarm Subsystem and the History/Logging processes:
- Islands created or combined events
- Branches open or closed
- Equipment energized or de-energized

The State Estimator publishes events, if any, for the Alarm Subsystem:
- Network failed to solve
- Measurement estimated quality change (bad/good)
- Limit crossings
Example: The State Estimation Use-case

- Diagrams are used to provide unambiguous data on interfaces and messaging
- The language used matches the common vendor software engineering approach
Example: The State Estimation Use-case

- Data flow and structure analysis references CIM profiles and packages directly
- The mapping of Business Objects & CIM classes is part of the context model
Example: The State Estimation Use-case

- The requirement alignment (custom) diagram is “invisible” for documentation.
- Its purpose is for model maintenance only. It allows to define dependencies.
- The diagram below shows the requirements for a sub-use-case & aggregation.
- Many dependencies in the model exist for traceability & impact assessment.
Example: The State

Use cases feature:
- Attributes
- Constraints
- Scenarios
- Other Links
- Other Files
- & Requirements

Requirements are
- Internal (none)
- External (8)
- Visible or Invisible
Example: The State Estimation Use-case

The associations in the model allow for traceability and impact assessment

- What-if analysis
- Optimization options
- Risk susceptibility
- Transformations
- Drill-down views
- Life Cycle support
  - Design, As-is, Deployment, etc.
  - Gap analysis (from baselines)
- Glossary (references, authorities)
- Relationship Matrix / Coverage Map
Example: The State Estimation Use-case

Requirements:
- Approved
- Implemented
- Mandatory
- Proposed
- Validated

Example: The State Estimation Use-case

- Document Generation using (Predefined) Templates for any repository viewpoint
- Document management using fragments, master documents & custom layouts.
Example: The State Estimation Use-case

- State Estimation Use-case document in MS-Word: Consistent & Up-to-date!
- 6 visible diagrams (+5 invisible diagrams in the model, not included in the output)
Requirement Specification Framework
- Remainders
Origins of the RSF Framework and touch points with other services

- Energy Sector Knowledge. Systems, roles, responsibilities
- Information Modelling & Data (Quality) Management
- Management & Optimization of (core) Business Processes
- Quality Control and Assurance. Methodologies & Auditing.

E(D)MS  BPM  Tooling  QA/QC

CIM
Context sensitivity of (generic & specific) RSF Components

**Tools & Methods**
- Zachman & Archimate
- Unified Modelling Language (UML)
- Sparx Enterprise Architect (Tool)

**Context Specific**
- IntelliGrid Use Case Template
- IEC Interface Reference Model
- Requirement Verification Testing
- SCADA/EMS/DMS
- Standard Specification
- Actors & Roles Model

Increase of complexity, level of detail, and (content matter) expertise required
Balancing between business needs and standard solutions

Standard
- Functions
- Data Model
- Infrastructure

Adaptation
- of Processes
- of Requirements
- of the system (through configuration)

Custom
- Software Functions
- Information Model
- Hardware Platforms

Increase of (initial) complexity, efforts, costs & risks