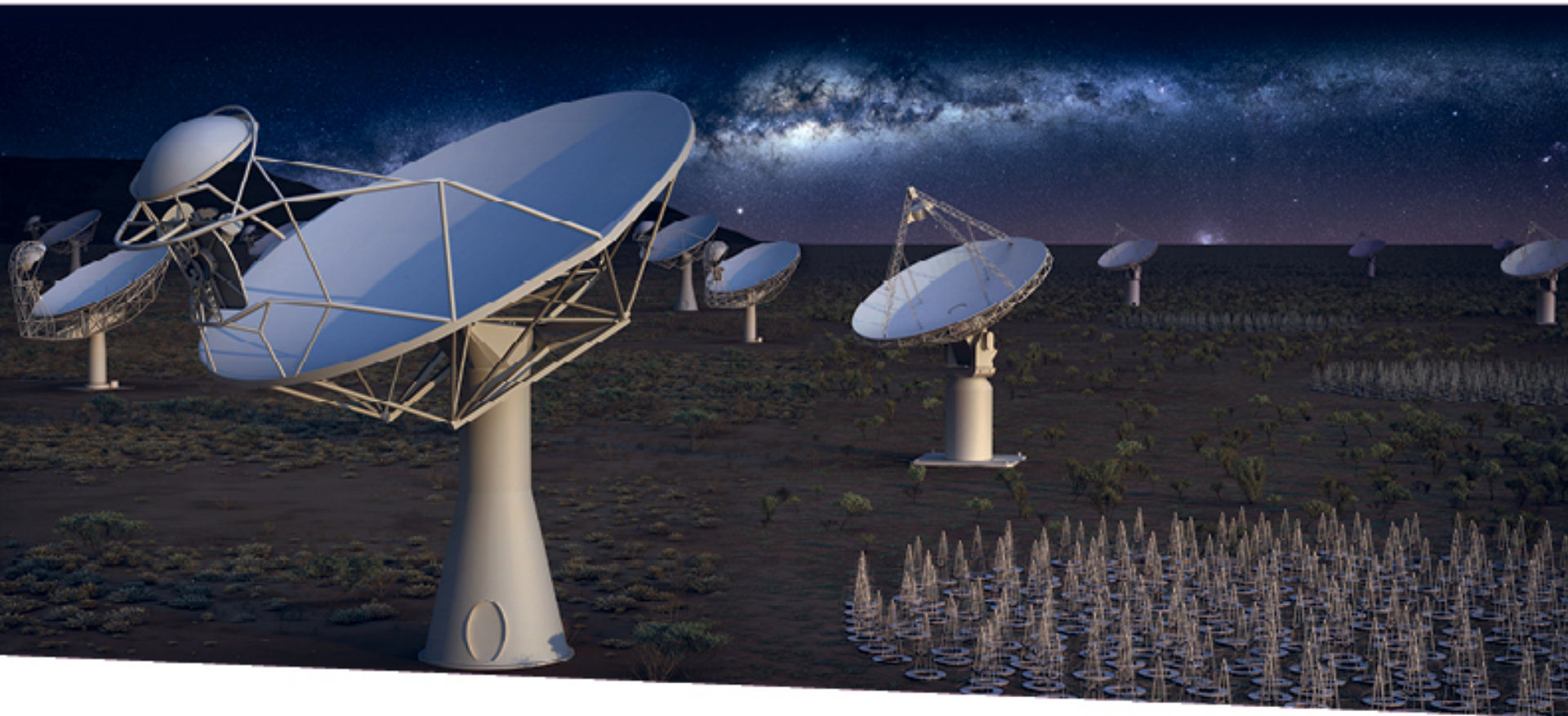# Systems Engineering Methodology

SQUARE KILOMETRE ARRAY

Exploring the Universe with the world's largest radio telescope

Hermine Schnetler
2015-11-12

Model Based Systems Engineering

Is based in three pillars:

- **Systems Engineering methodology**

- **Modelling Framework (SE2)**

- **Tool – current preferred tool = CAMEO NOMAGIC**

MBSE – Skills required

- Experience Systems Engineer
  - Systems Engineering Fundamentals
  - Domain Knowledge
- To model you need knowledge of the modelling:
  - Language
  - Tool
  - Framework
 - Method

Document-Based SE and MBSE

Project Documentation

- SKA1 Systems Requirements Specification
- SKA1 Operational Concept
- SKA1 Interface Control Document
- SKA1 LFAA Element Req Spec
- SKA1 LFAA ICD
- SKA1 LFAA System Overview
- SKA1 LFAA AIV Plan
- SKA1 LFAA Qualification Test Report
- SKA1 POC

System Engineering Tasks

- Requirements Engineering
- Architecture Design
- Assembly, Integration and Verification
- Technical Leadership

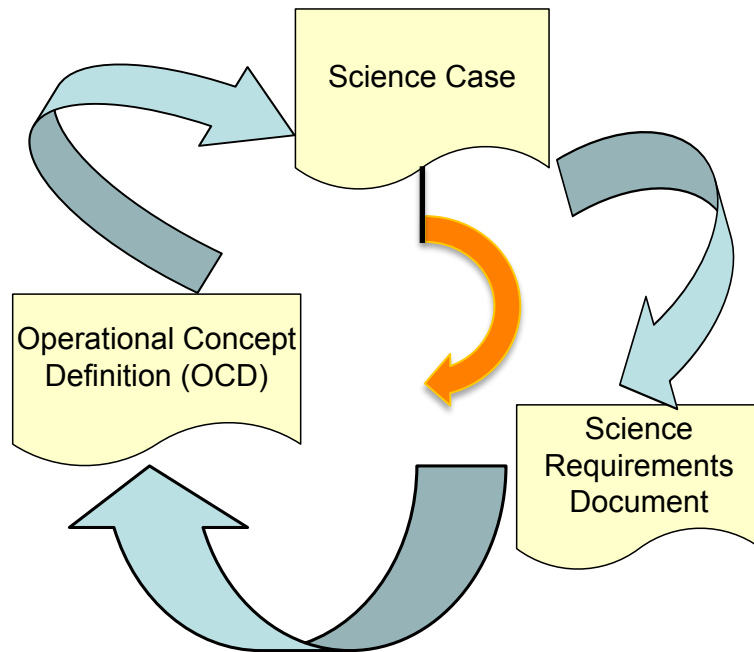## Model
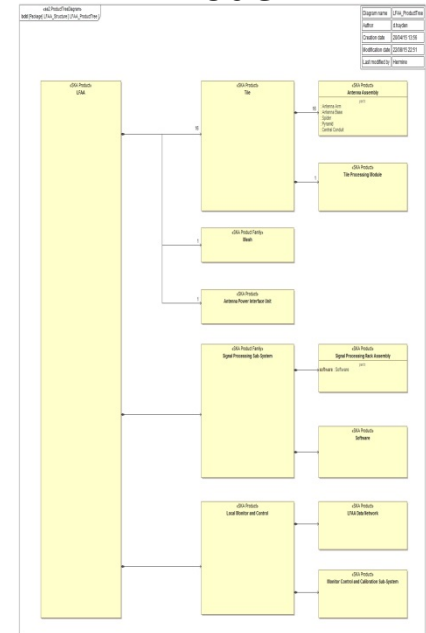
The SE process

- Evaluation of the need or problem
- Understanding your customer/client's needs
  - Ensure you understand all the directives and constraints
  - Operating Environment
  - Operational use
- Functional analysis
- Bounding of the problem (system)
- Realisation of solution (implementing the functions)
  - Structural (mainly hardware realisation of functions)
  - Partitioning of system in building blocks
  - Behavioural definition and design (primarily software realisation)
- System level architectural design
- Analysis, capturing and management of requirements
- Performance analysis

IBM Software Thought Leadership White Paper, December 2011, "Model-based systems engineering: Revolution or evolution?", Barclay Brown, IBM Rational

Context

Usage

Realisation

Execution
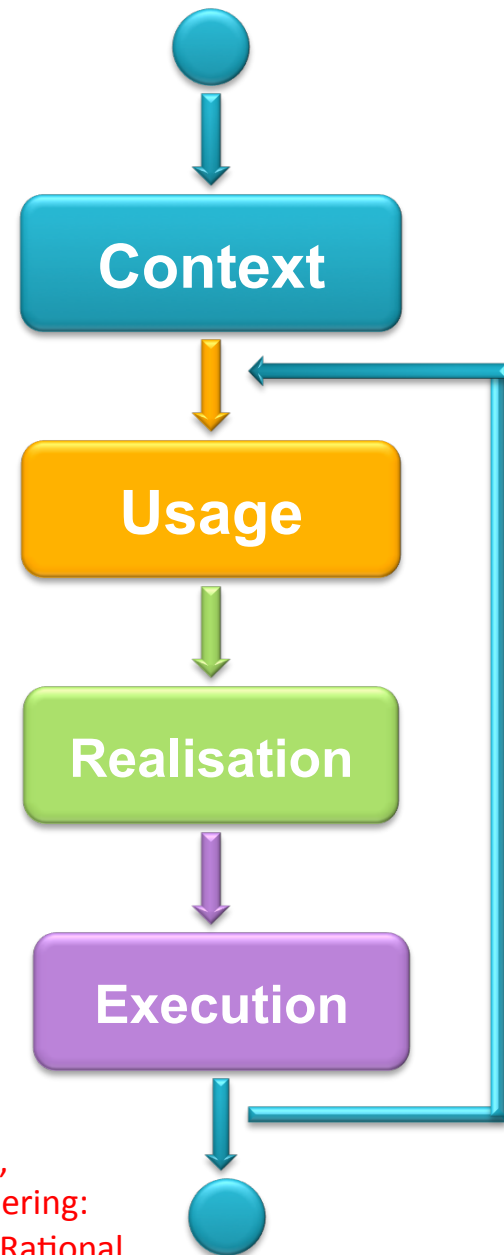
Stakeholders Requirements

Capture User Requirements

Science Case

Science Requirements Document
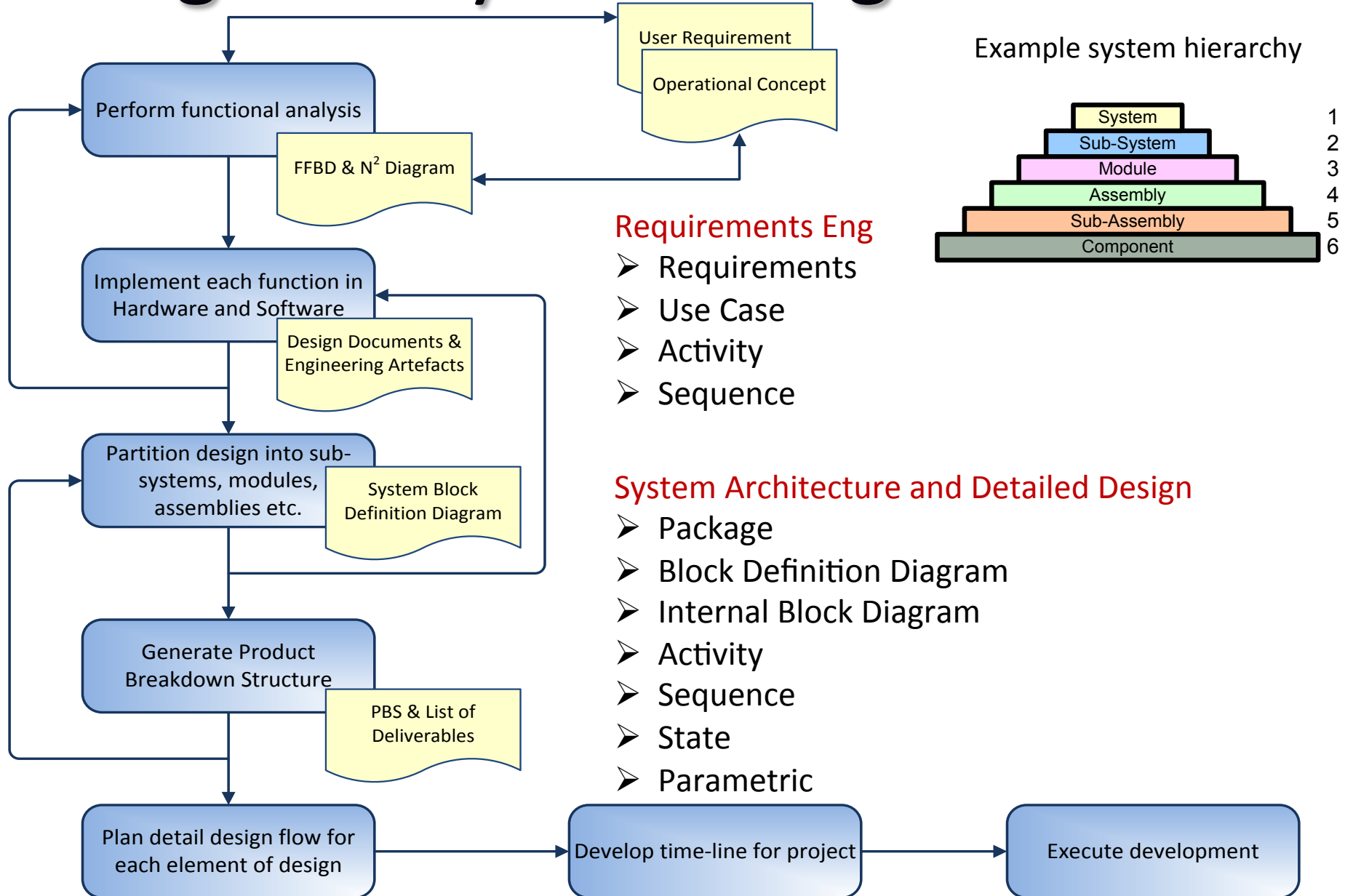
Operational Concept Definition (OCD)

Process always starts with the science case!

Iterative and incremental during the concept and preliminary design but should be finalised and frozen as part of the Preliminary Design Review (PDR)

Integrated System Design Process

Perform functional analysis

User Requirement

Operational Concept

FFBD & N^2 Diagram

Implement each function in Hardware and Software

Design Documents & Engineering Artefacts

Partition design into sub-systems, modules, assemblies etc.

System Block Definition Diagram

Generate Product Breakdown Structure

PBS & List of Deliverables

Plan detail design flow for each element of design

Develop time-line for project

Execute development

Example system hierarchy

System	1
Sub-System	2
Module	3
Assembly	4
Sub-Assembly	5
Component	6

Requirements Eng

➢ Requirements
➢ Use Case
➢ Activity
➢ Sequence

System Architecture and Detailed Design

➢ Package
➢ Block Definition Diagram
➢ Internal Block Diagram
➢ Activity
➢ Sequence
➢ State
➢ Parametric

Document

I will just do the functional analysis, structural design & PBS in Visio

Deriving Requirements

System Requirements Specification

Specification is a by-product
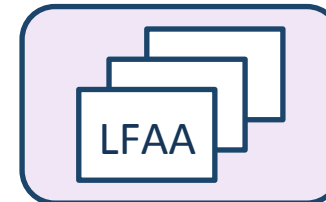
Manual Traceability

XLS

Model Centric
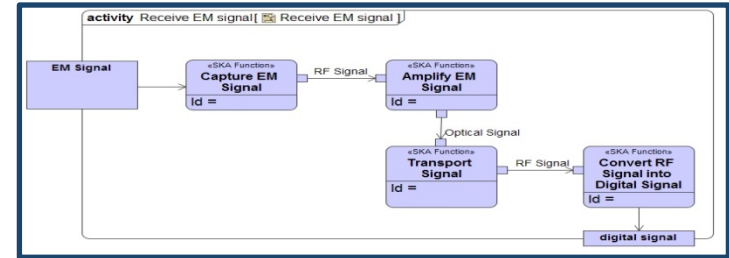
Functional Model
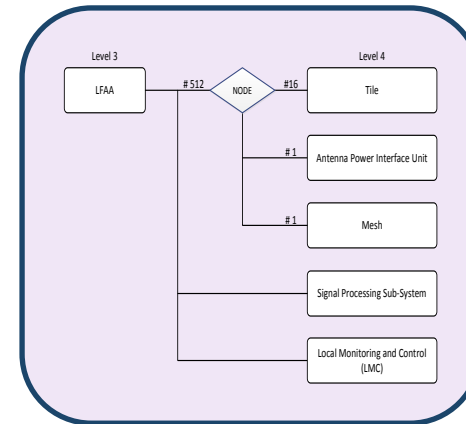
Architectural Model

Test View

LFAA

Decision Database
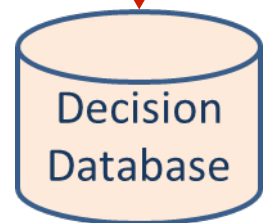
Performance Allocation and Performance Estimation Process

Instrument Requirements

Science Requirements

Telescope Interface Requirements

Generate System Development Specification

Design System Architecture

Prepare performance budgets for each top level characteristic

De-scope

Once each sub-system has been designed, for each sub-system perform a sensitivity analysis

System performance = comply to budget?

No the nth time

Yes

Re-design non-conformance parts of design

No

Overall Instrument performance = comply to requirements?

Yes

Update budget allocation with actual predicted performance numbers

Run end-to-end simulations to assess the overall instrument performance model with system design characteristics

No

Run end-to-end Instrument simulation model and finalise System Specifications

System Development Specifictions

END OF PROCESS

Performance allocation forms part of the "so called" requirements flow down process.
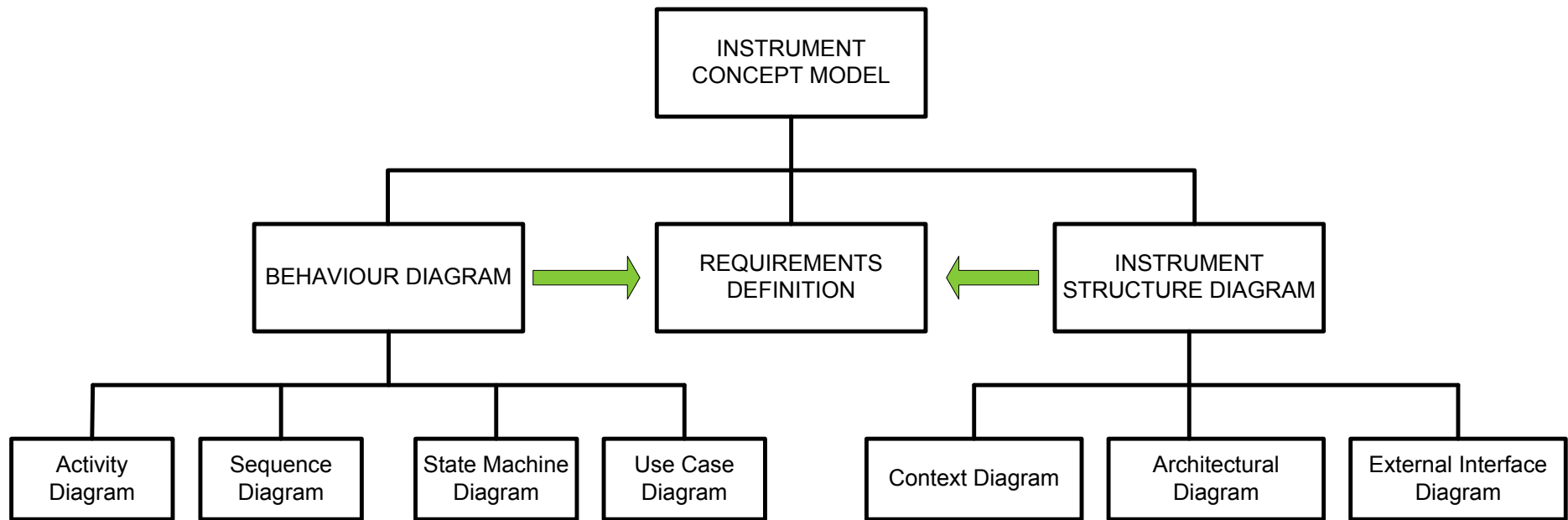
Verification

Performance estimation is the process used to predict whether the proposed solution will comply with the user requirements.
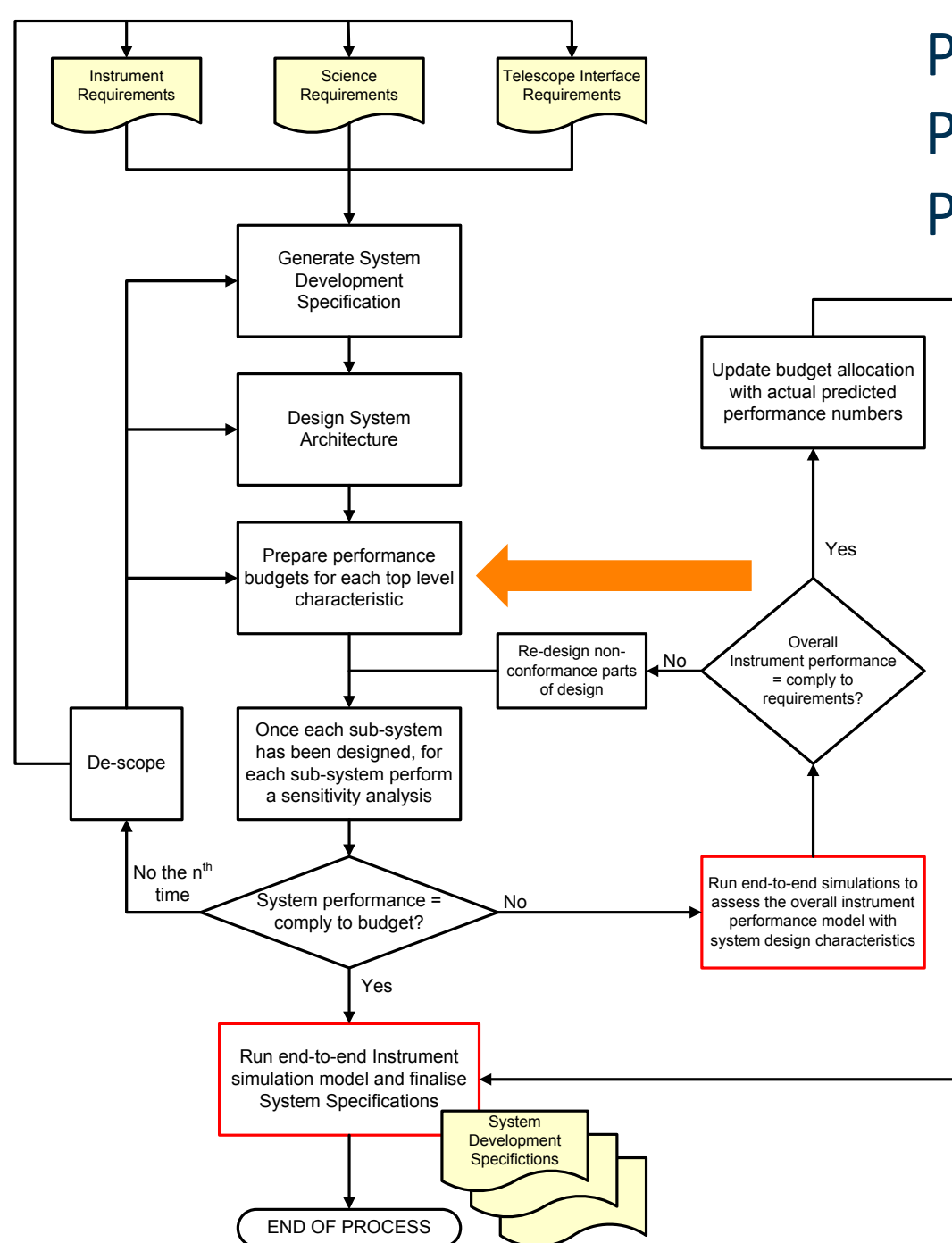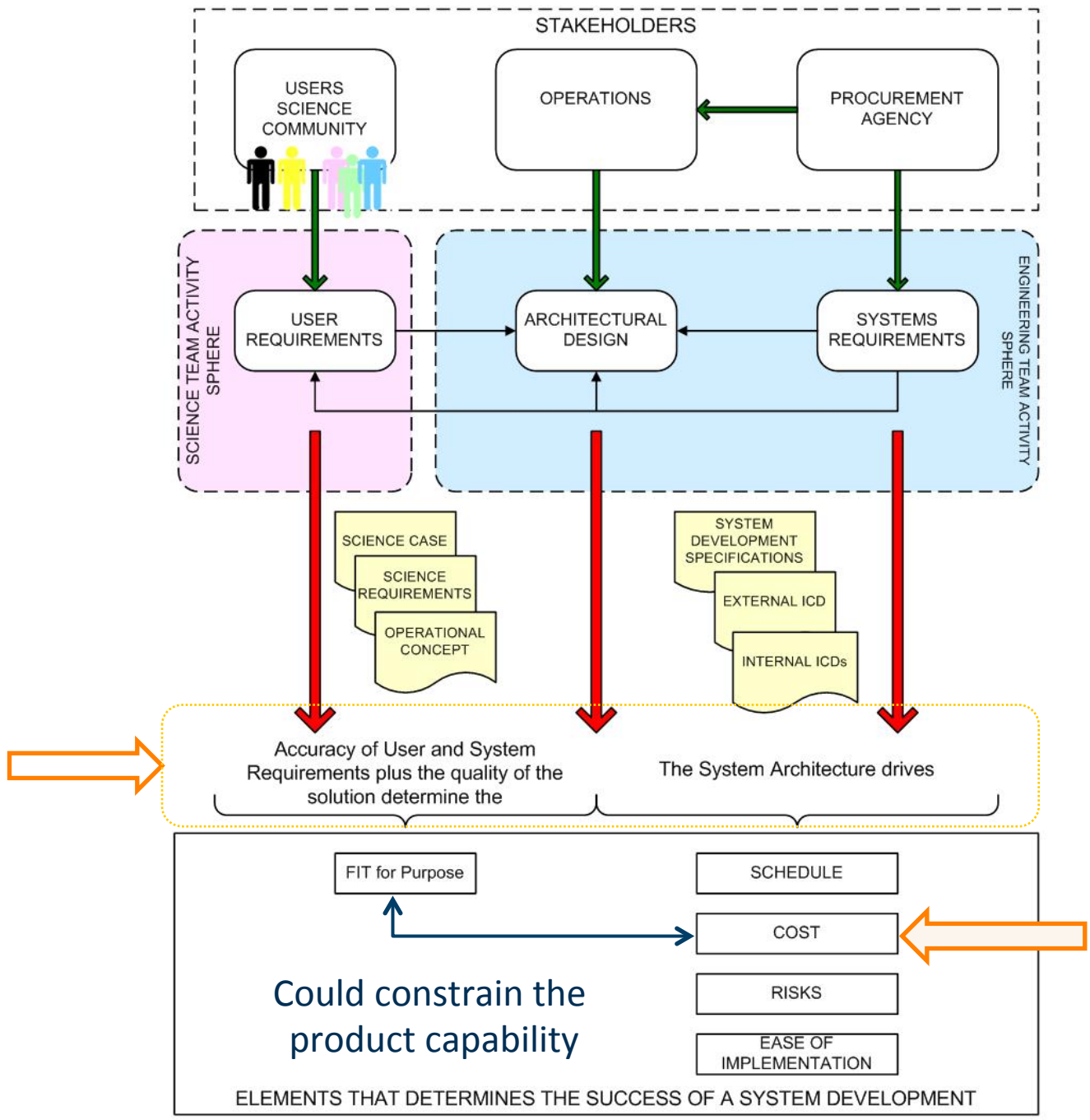
System Perspectives

Two Perspectives required to specify a system:
1. Describe the system by the functions it performs.
2. Physical architecture with interacting elements that will interact with one another and the environment to achieve the "mission"

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                        ┌─────────────────────┐
                        │     INSTRUMENT      │
                        │   CONCEPT MODEL     │
                        └─────────────────────┘
```

| BEHAVIOUR DIAGRAM | → | REQUIREMENTS DEFINITION | ← | INSTRUMENT STRUCTURE DIAGRAM |

| Activity Diagram | Sequence Diagram | State Machine Diagram | Use Case Diagram | Context Diagram | Architectural Diagram | External Interface Diagram |

Questions?