System Engineering (at ESO)

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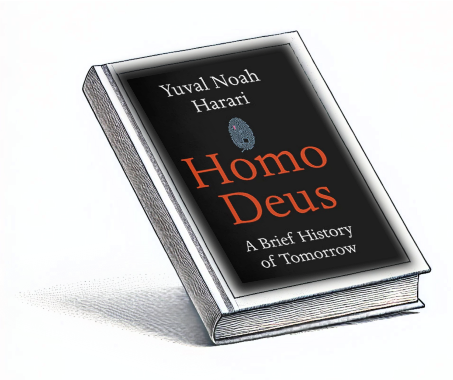
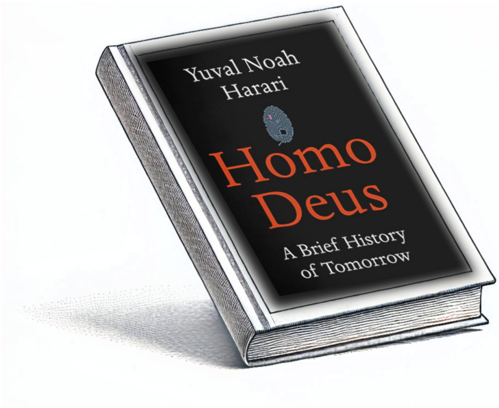
1. System Engineering in General
2. System Engineering at ESO

System Engineering in General

Overcoming the Limit



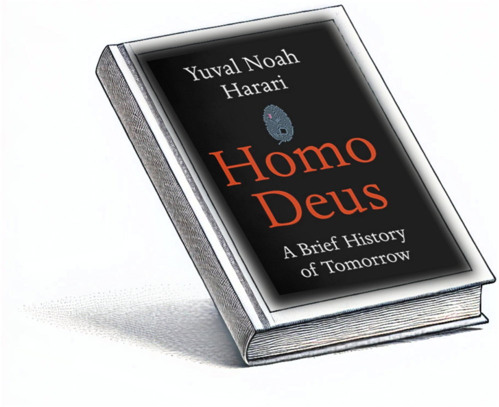
Overcoming the Limit



Distinguishing feature enabling Homo Sapiens to dominate all other animals?

⇒ Only species capable of co-operating flexibly in large numbers.

Overcoming the Limit



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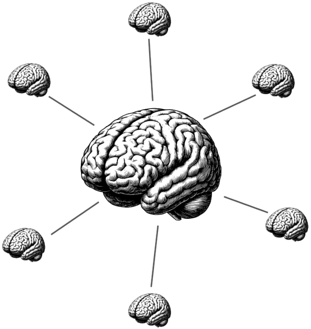
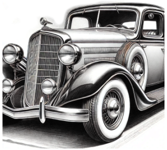
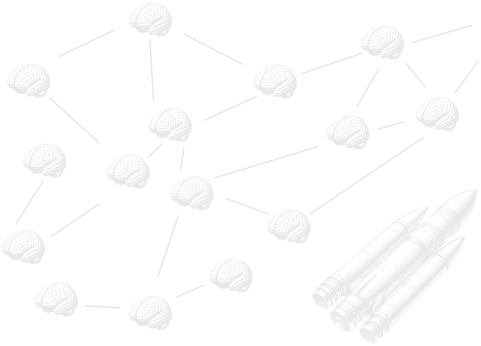
Overcoming Complexity

Chief Engineer / ”Craftsman” Approach





System Engineering Approach



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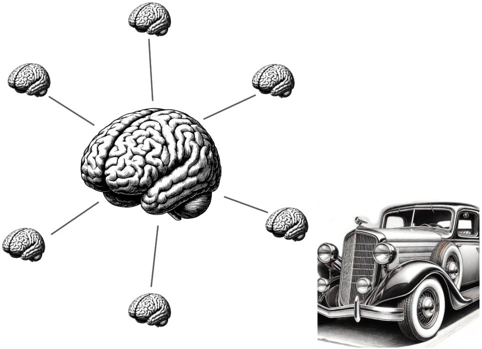

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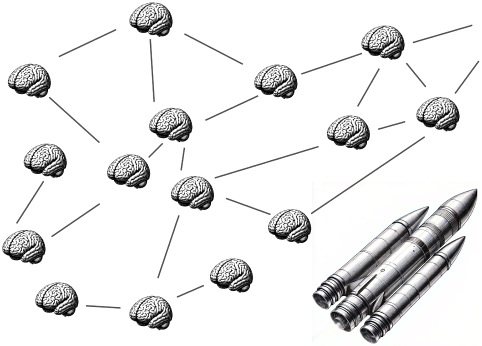
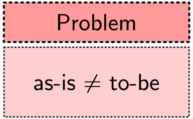


Systems Engineering Concept Haberfellner/Daenzer ETH

Problem

Systems Engineering Concept Haberfellner/Daenzer ETH



Problem

as-is ≠ to-be

Systems Engineering Concept Haberfellner/Daenzer ETH

Problem

as-is $\neq$ to-be

Solution

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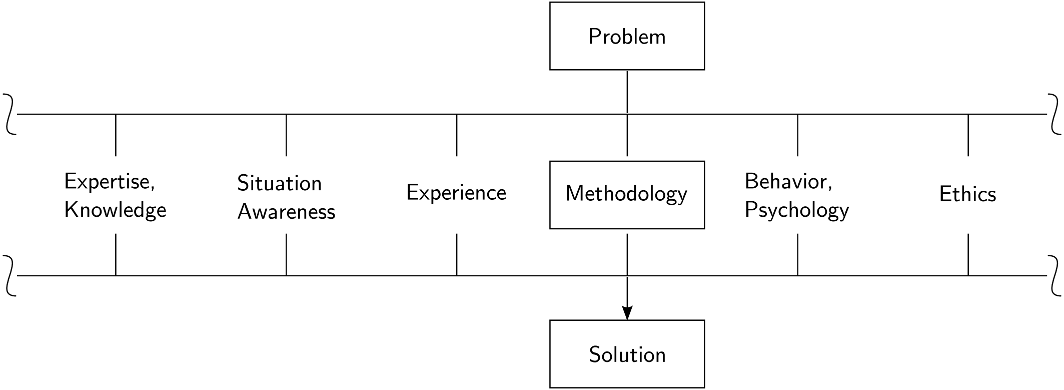


Problem

Expertise, Knowledge

Situation Awareness

Experience

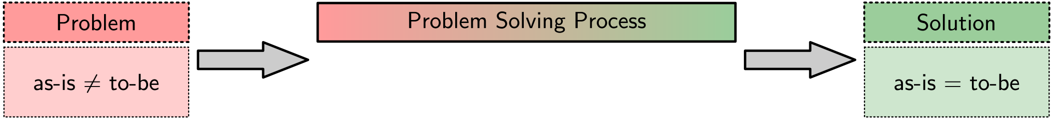
Methodology

Behavior, Psychology

Ethics

Solution

Systems Engineering Concept Haberfellner/Daenzer ETH



Problem

as-is ≠ to-be

Problem Solving Process

Solution

as-is = to-be

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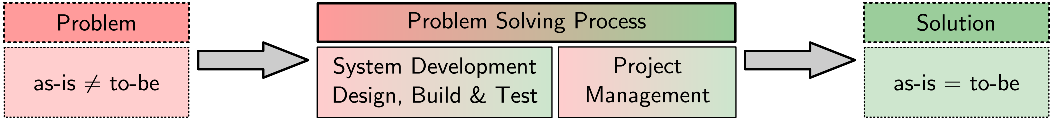

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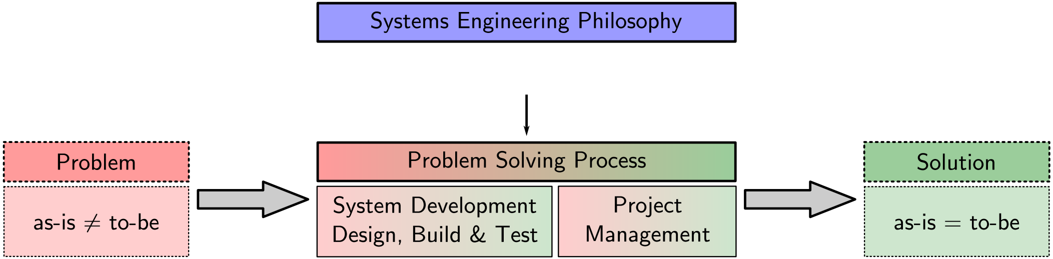

Systems Engineering Philosophy

Problem

as-is ≠ to-be

Problem Solving Process

System Development Design, Build & Test

Project Management

Solution

as-is = to-be

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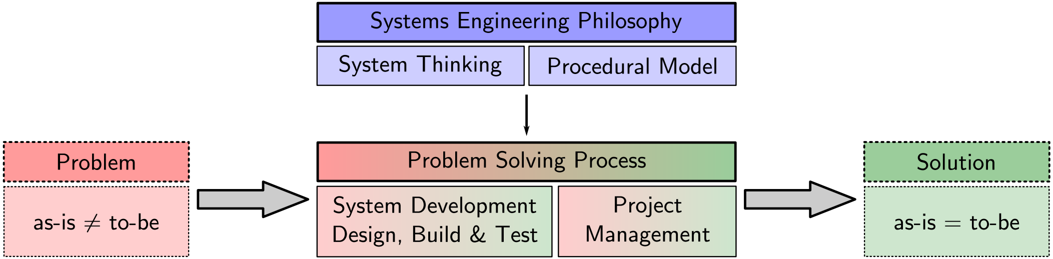

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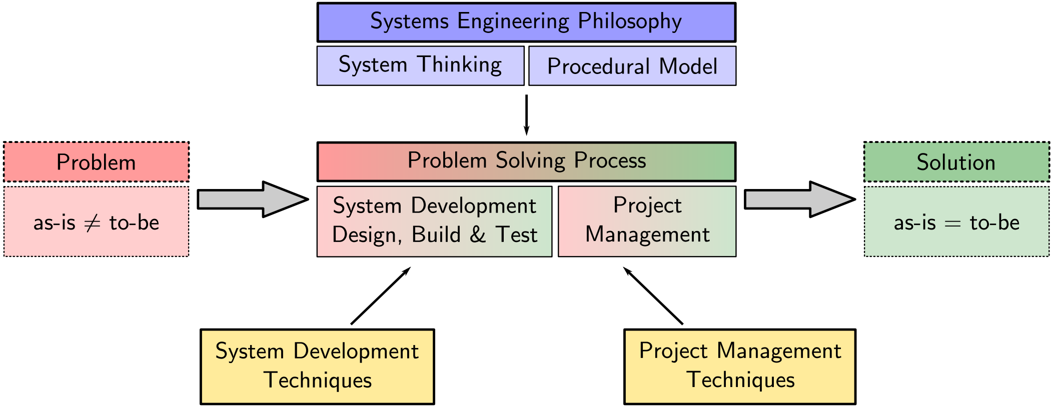

Systems Engineering Philosophy

System Thinking

Procedural Model

Problem

as-is $\neq$ to-be

Problem Solving Process

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System Development Techniques

Project Management Techniques

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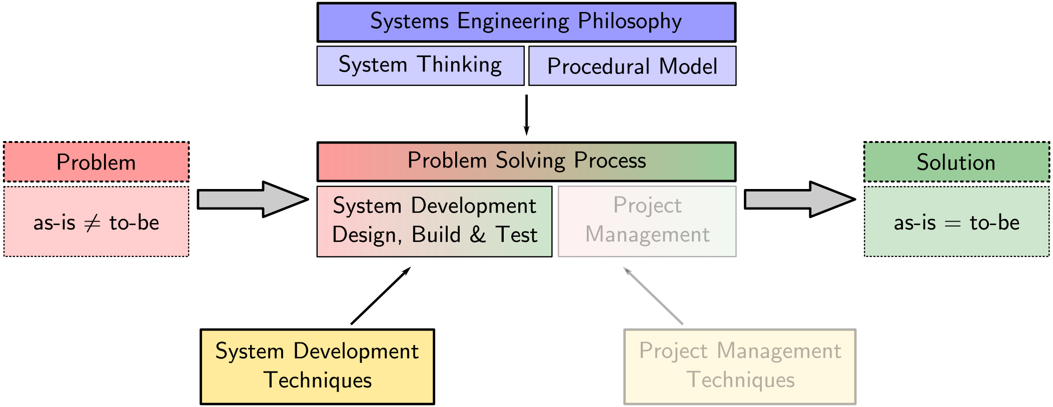
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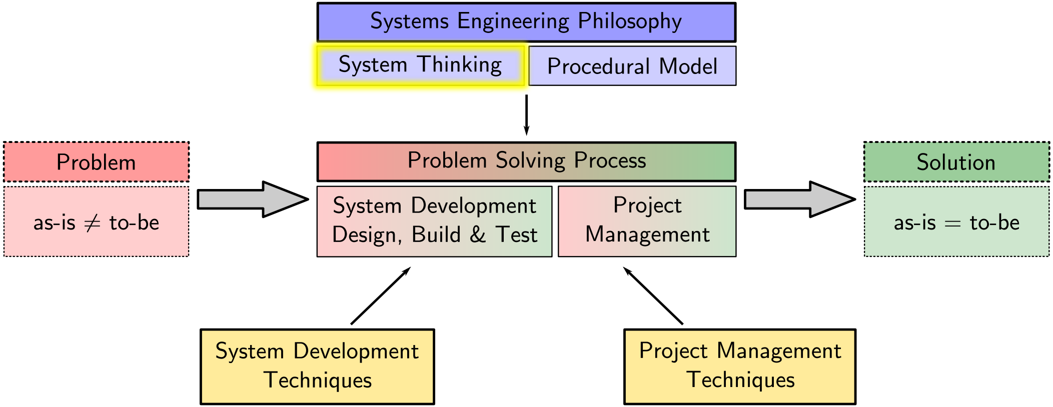
Project Management Techniques

Systems Engineering Philosophy Systems Thinking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Systems Thinking

A holistic approach to decompose a given entity (system) into structural and functional parts according to their mutual interdependencies and environmental interactions.

Function

- What a system does
- Generates behavior
- Source of benefits
- Needs structure/ elements of form

Structure/Form

- What a system is
- Is dis-/assembled
- Source of costs
- Enables the function

$$\text{Value} = \frac{\text{Benefits}}{\text{Costs}}$$

⇒ related to Emergence

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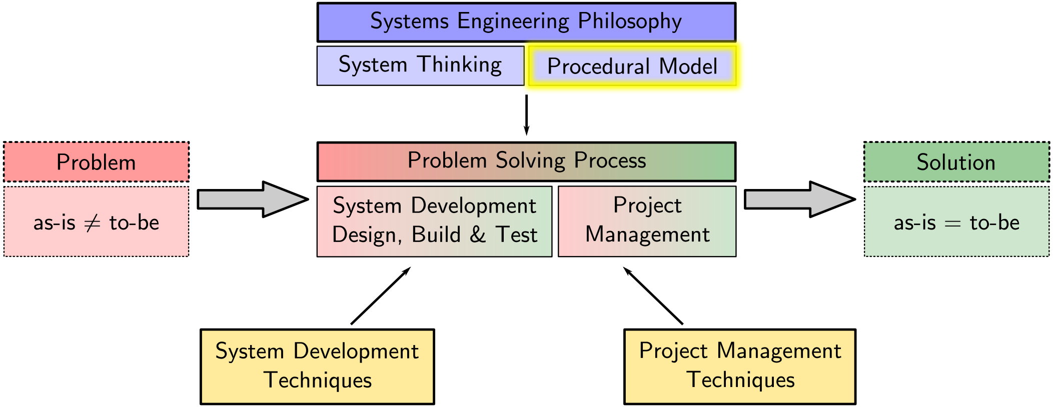
Systems Engineering Philosophy Procedural Model



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Systems Engineering Philosophy   Procedural Model

⇒ Macro (high-level) logic on how to structure the problem solving process

- Plan-driven Models
  - Waterfall
  - Phase Models (A, B, C, D / CD, PD, FD, Build)
  - Spiral
  - etc.
- Agile Models (not well established in SE, rather SW projects)

  → **Note:** Agile $\langle$ Systems Engineering $\rangle \neq \langle$ Agile Systems $\rangle$ Engineering

⇒ Typically adapted and tailored to the specifics of the project.

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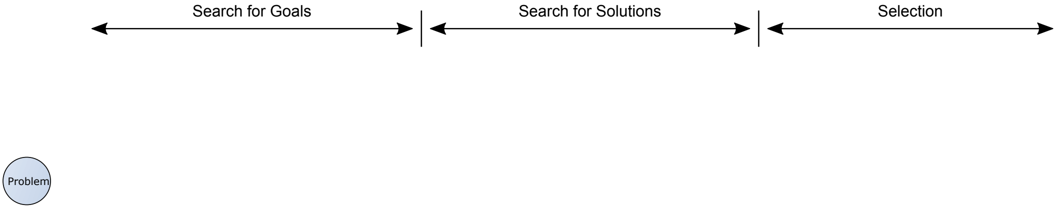
Fundamental Problem Solving Logic

⇒ Micro (low-level) logic repeatedly applied within stages of the Procedural Model

Fundamental Problem Solving Logic



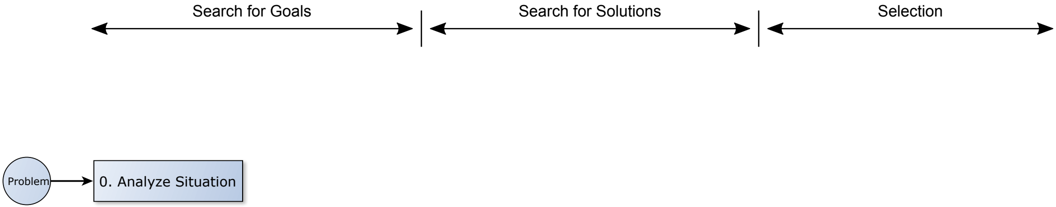
Search for Goals

Search for Solutions

Selection

Problem

Fundamental Problem Solving Logic



Search for Goals

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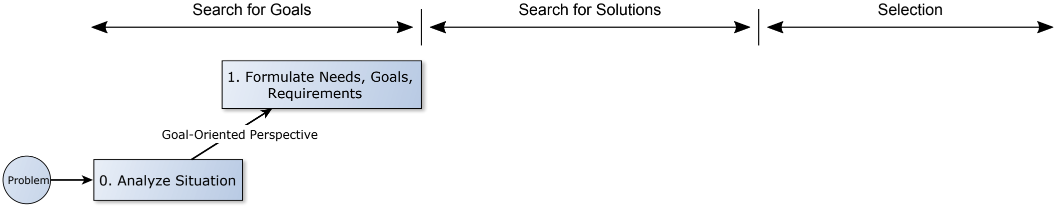
0. Analyze Situation

Fundamental Problem Solving Logic



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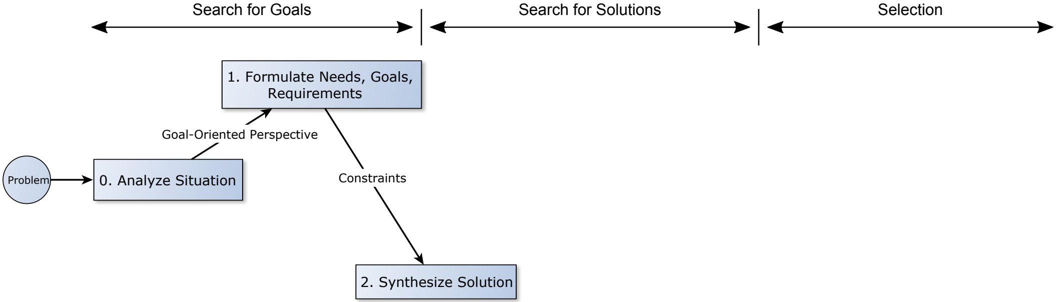

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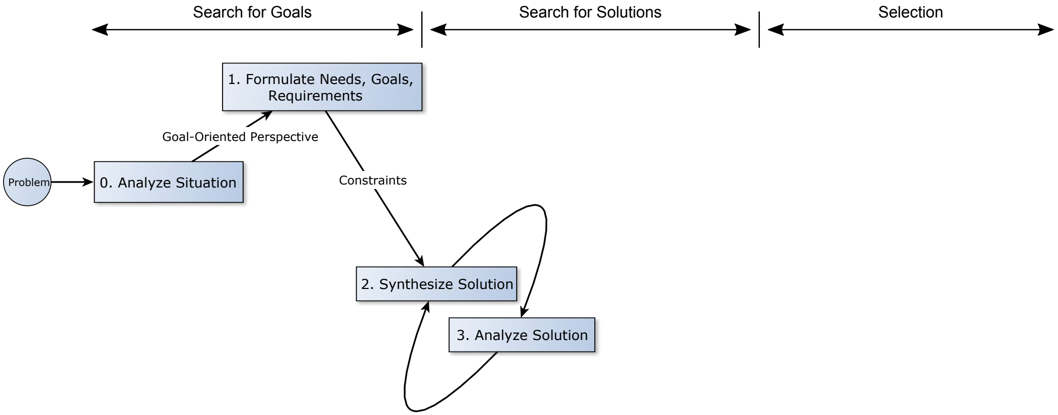

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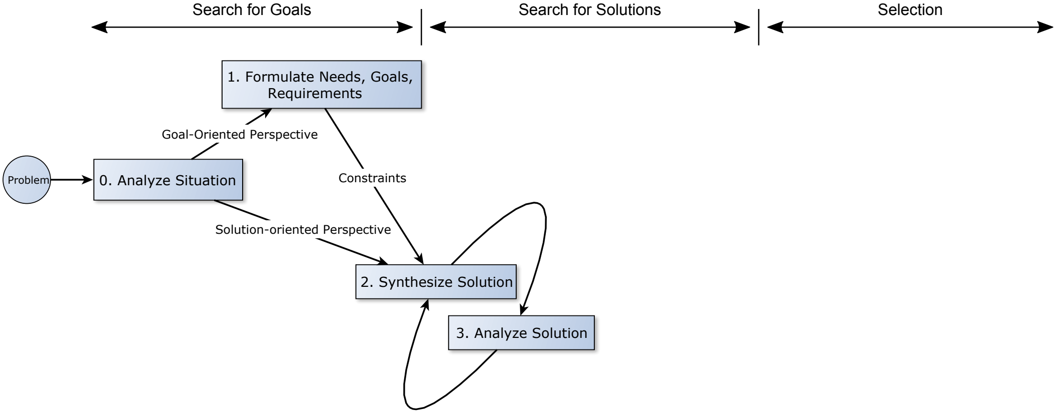

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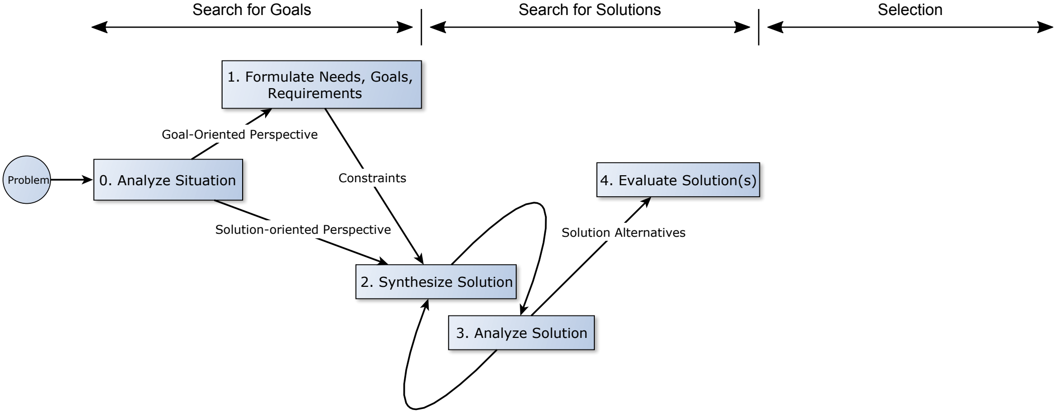

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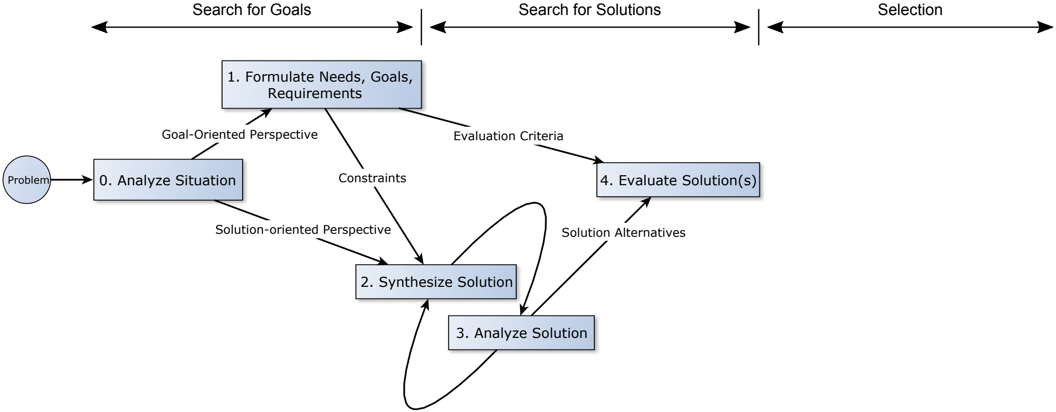

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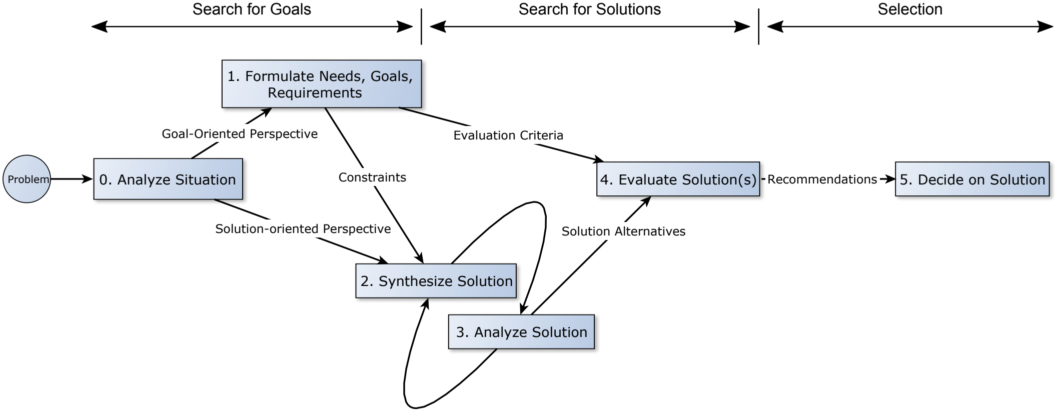
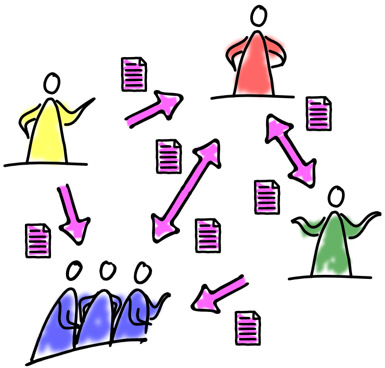
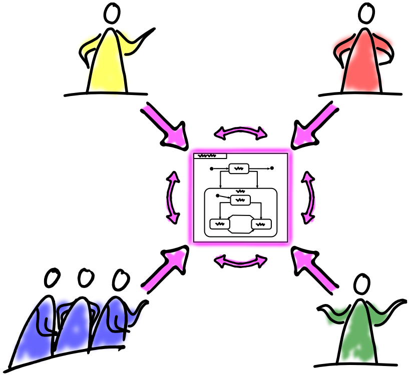


System Engineering at ESO

Document-Centric vs Model Based Systems Engineering





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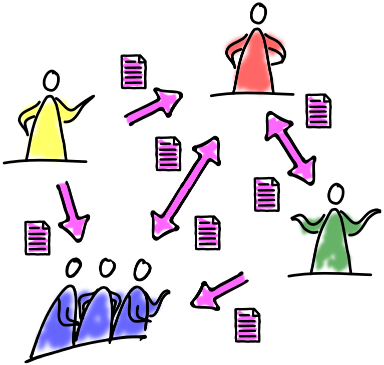

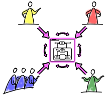

Procedural Model

Project Phases at ESO → Europe

Pre-Phase A

- First studies of science cases

→ Phase A proposal

Phase A
Feasibility Study

- Consolidate science cases

→ TLR, TRS

→ System Architecture

Phase B
Concept Design

- Finalize Architecture

→ Subsystem TRS

→ Perf. Budgets

Phase C
Final Design

- Detailed Design
- Verification activities

→ Lower level qualification testing and manufacturing

Phase D
System Build

- System AIT

→ Preliminary Acceptance Europe

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Procedural Model

Project Phases at ESO → Chile

Phase A
Feasibility Study

- Consolidate science cases

→ TLR, TRS

→ System Architecture

Phase B
Concept Design

- Finalize Architecture

→ Subsystem TRS

→ Perf. Budgets

Phase C
Final Design

- Detailed Design
- Verification activities

→ Qualification, testing

Phase D
System Build

- System AIT

→ Preliminary Acceptance Europe

Commissioning

- On-site Assembly, Integration
- On-sky verification

→ Science validation

Procedural Model

Project Phases at ESO → Chile

Phase A
Feasibility Study

- Consolidate science cases
- → TLR, TRS
- → System Architecture

Phase B
Concept Design

- Finalize Architecture
- → Subsystem TRS
- → Perf. Budgets

Phase C
Final Design

- Detailed Design
- Verification activities
- → Qualification, testing

Phase D
System Build

- System AIT
- → Preliminary Acceptance Europe

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Procedural Model

Project Phases at ESO → Chile

Phase B Concept Design

- Finalize Architecture

→ Subsystem TRS

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Phase C Final Design

- Detailed Design
- Verification activities

→ Qualification, testing

Phase D System Build

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Phase E Operation

→ Provisional acceptance Chile

Procedural Model

Project Phases at ESO → Chile

Phase B
Concept Design

- Finalize Architecture

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→ Qualification, testing

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- System AIT

→ Preliminary Acceptance Europe

Commissioning

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Phase E
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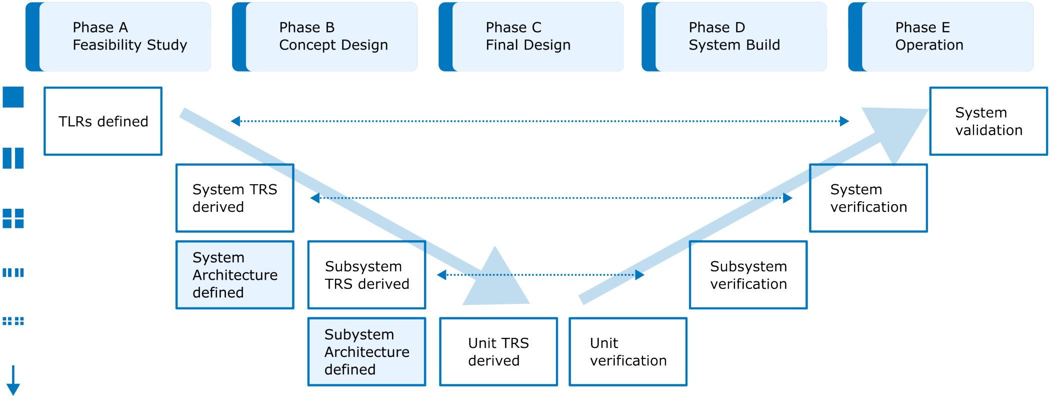
V Model



Phase A
Feasibility Study

Phase B
Concept Design

Phase C
Final Design

Phase D
System Build

Phase E
Operation

TLRs defined

System TRS derived

System Architecture defined

Subsystem TRS derived

Subystem Architecture defined

Unit TRS derived

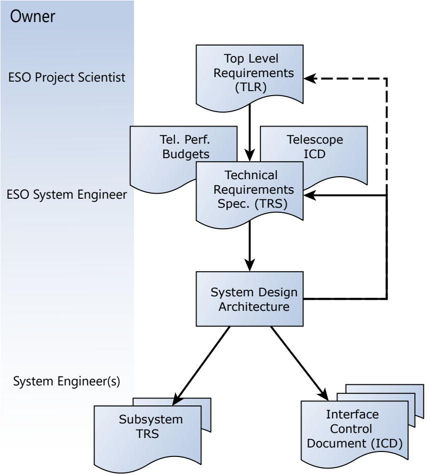
Unit verification

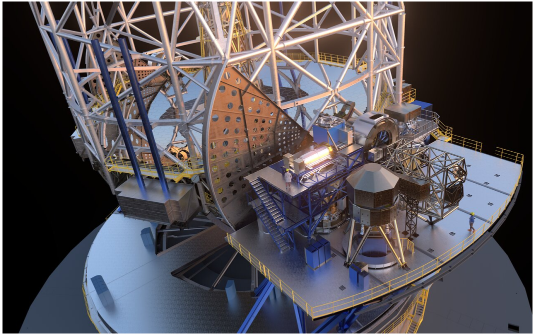
Subsystem verification

System verification

System validation

Involvement (→ Instruments)


Owner
ESO Project Scientist
ESO System Engineer
System Engineer(s)
Top Level Requirements (TLR)
Tel. Perf. Budgets
Telescope ICD
Technical Requirements Spec. (TRS)
System Design Architecture
Subsystem TRS
Interface Control Document (ICD)



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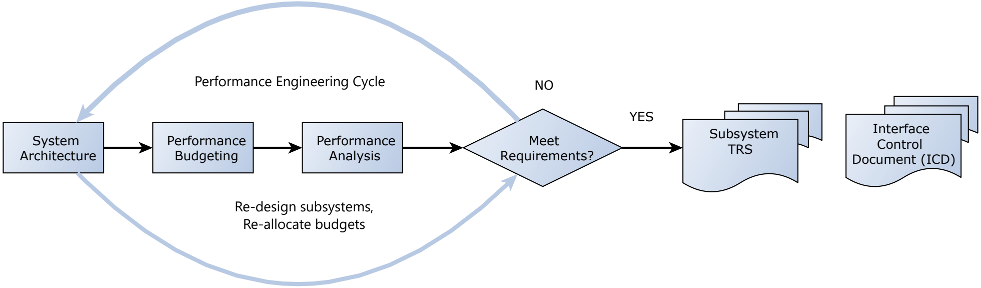
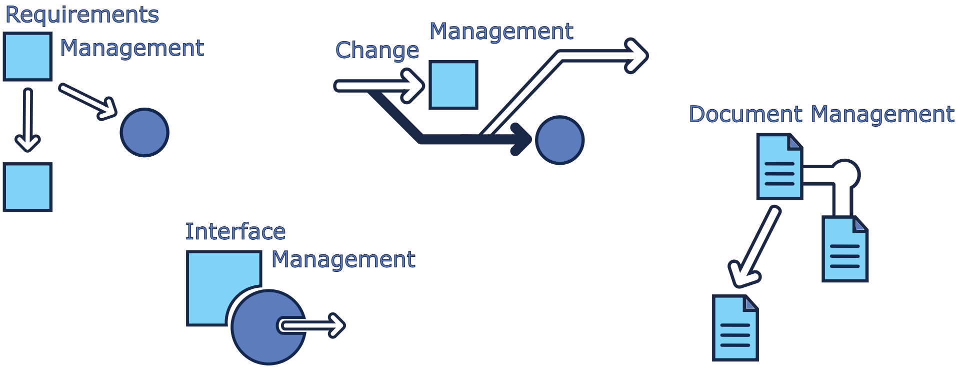


Key Processes



Requirements Management

Change Management

Document Management

Interface Management