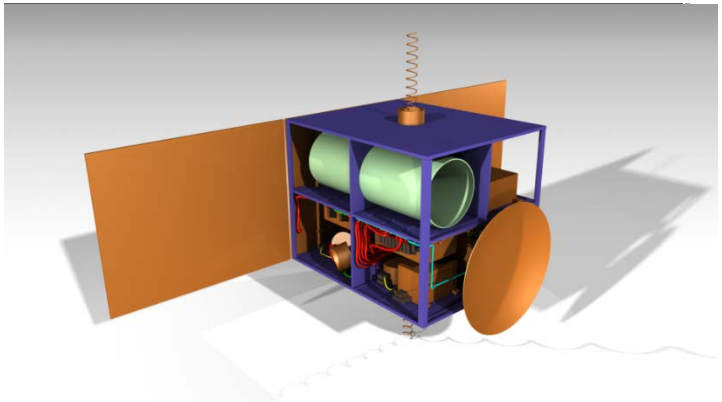
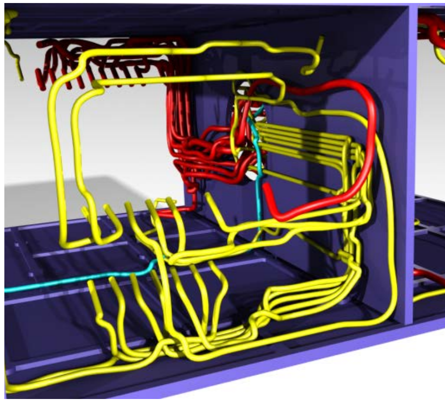
Johannes Groß
Similarity Mechanics Group
Head: PD Dr. Stephan Rudolph

Institute for Statics und Dynamics
of Aerospace Structures
University of Stuttgart





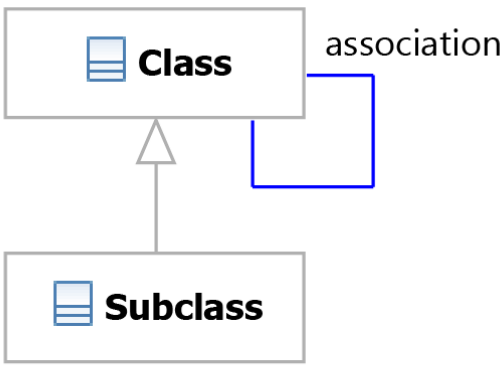
Thinking Model Based Systems Engineering Further

SECESA 2012, Lissabon, Portugal

Model-Based Systems Engineering

Model Based

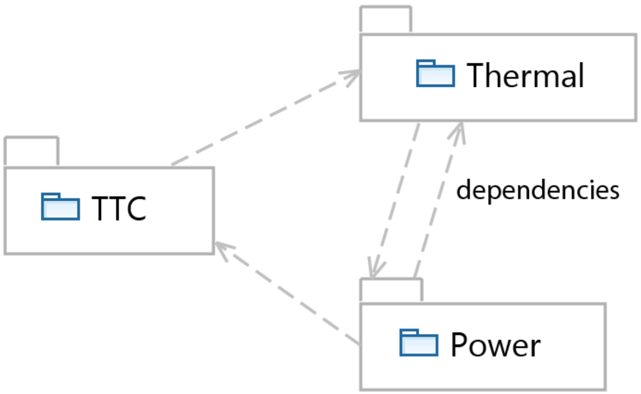
Mechanisms



- Formalization of information
- Object oriented concepts

Systems Engineering

Characteristics



- Increasing performance of Systems
- Increasing role of dependencies

We can formalize the description of a satellite system but the model will be large.

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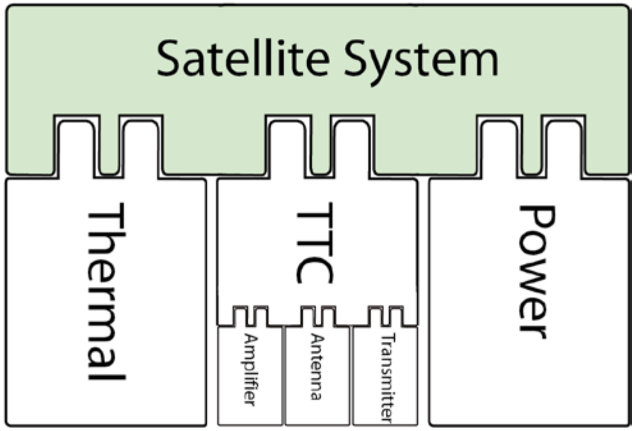
Divide et Impera (Divide and Conquer)

Plug-in Mechanism



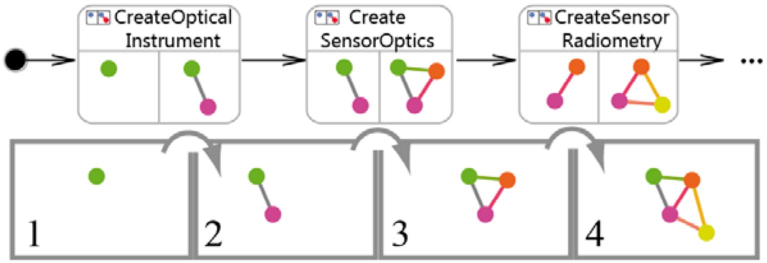
- Exchangeable Subsytems
- Generically resolve dependencies

Knowledge Base

a) Parametric Rules

$$mass = \frac{\pi}{6} \cdot \sqrt{\left(1 + 4 \cdot diameter^2\right)^3} \cdot strength \cdot density$$

a) Topologic Rules



- Straightforward expression of engineering knowledge
- Declarative expression of knowledge

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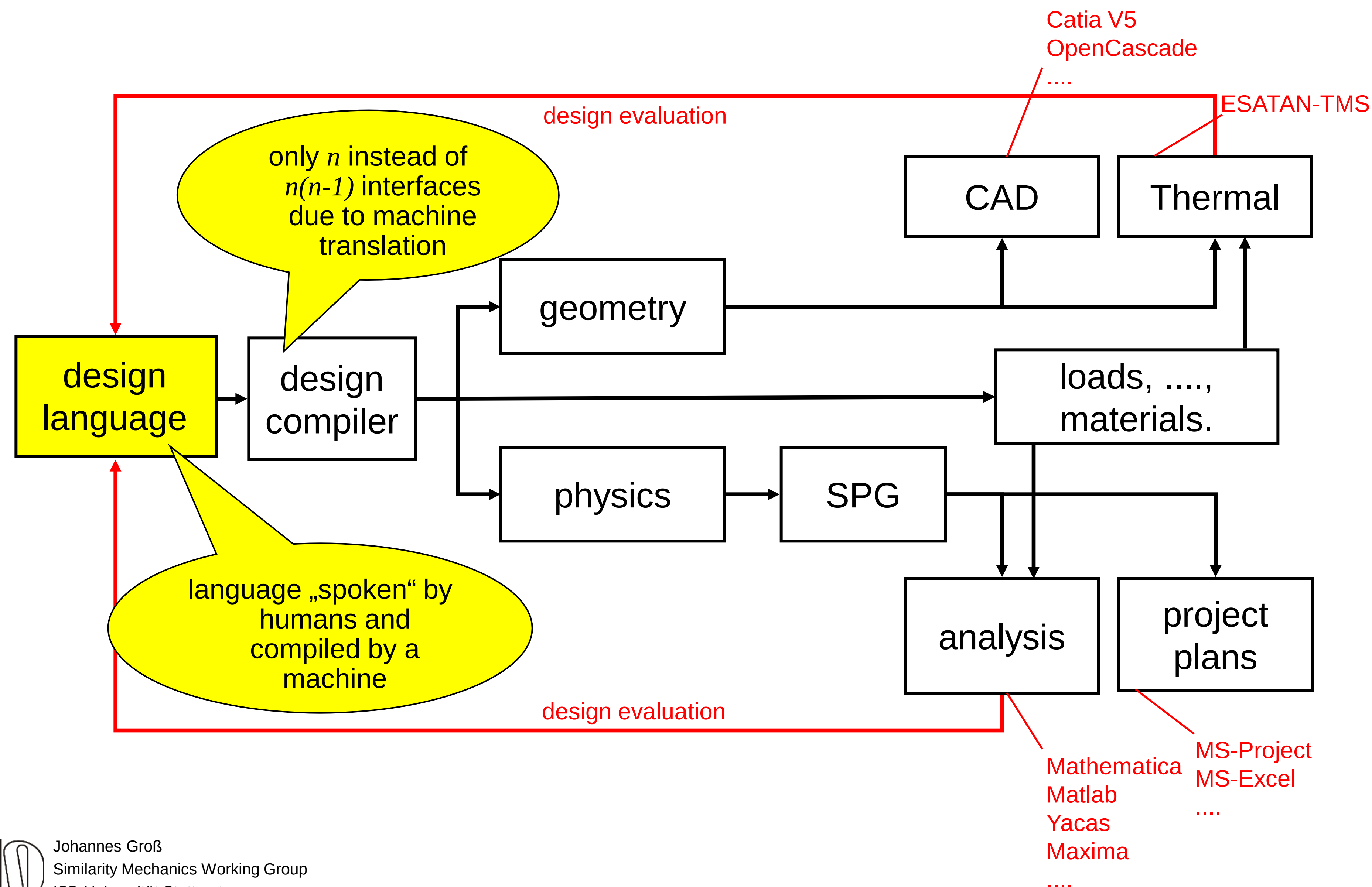
Design Language Information Hierarchy



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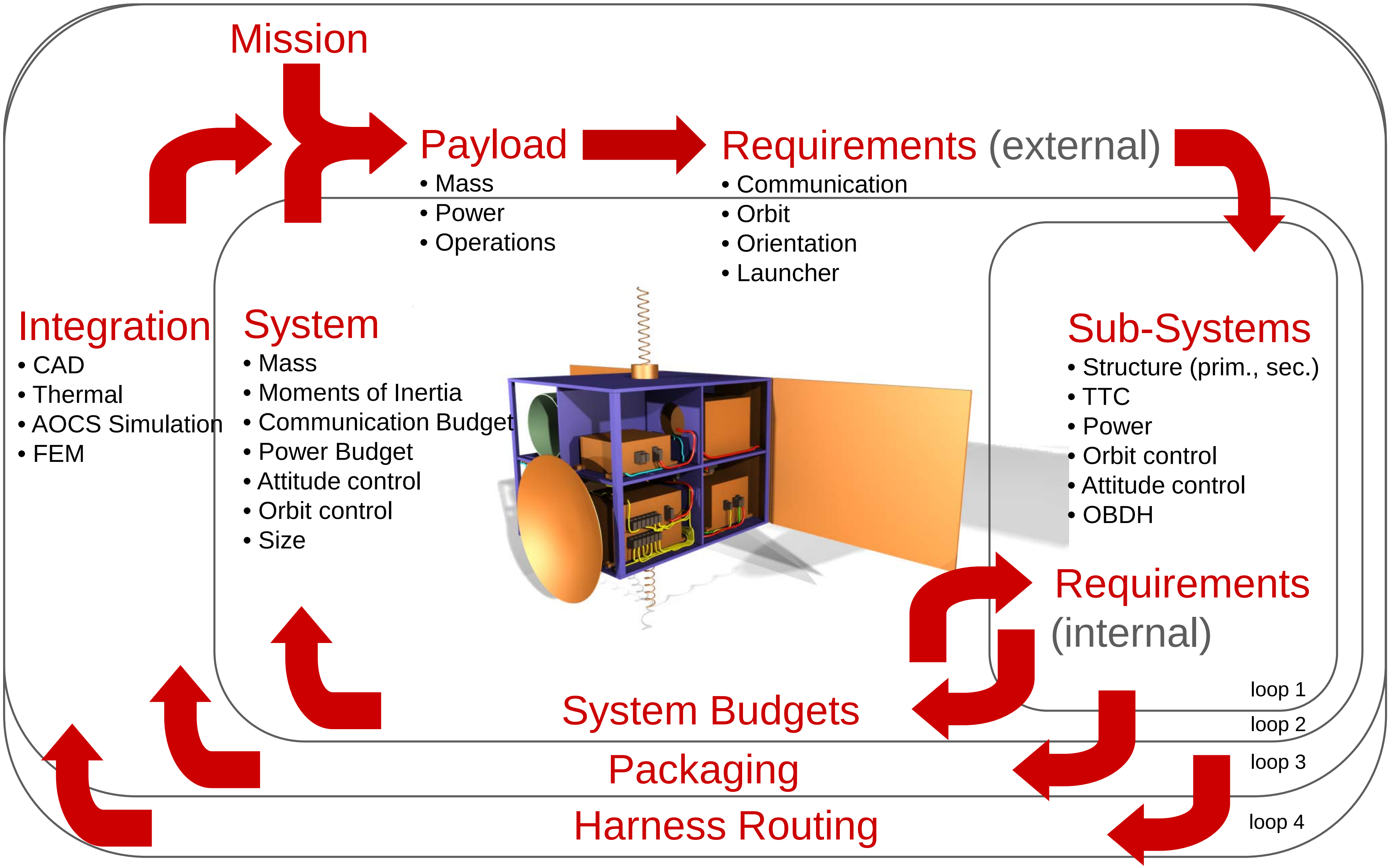
Design Process Satellite



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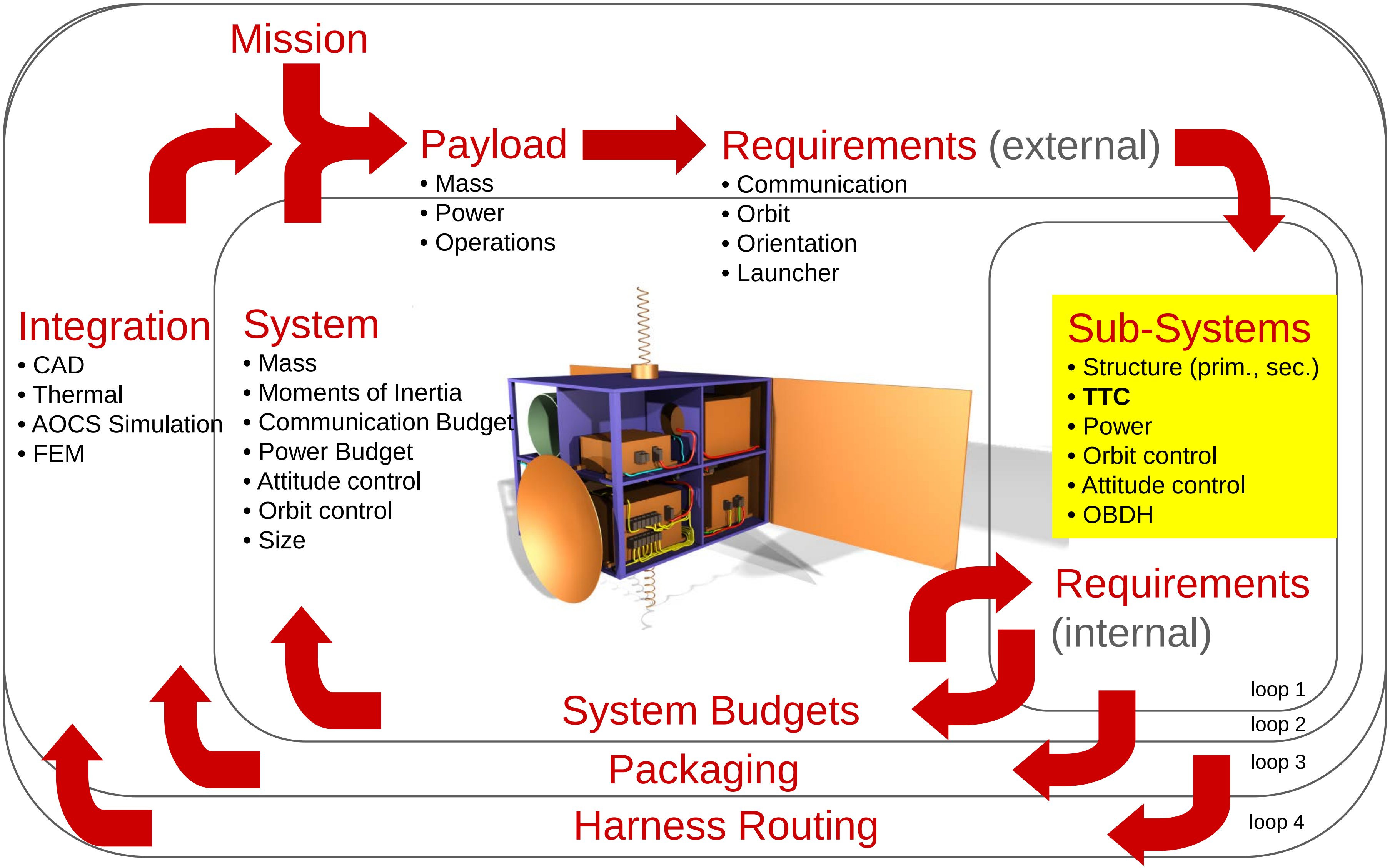
Source: „Satellite design by design grammars“
Schaefer, Rudolph, Aerospace Science and Technology
Volume 9, Issue 1, January 2005, Pages 81-91

Design Process Satellite



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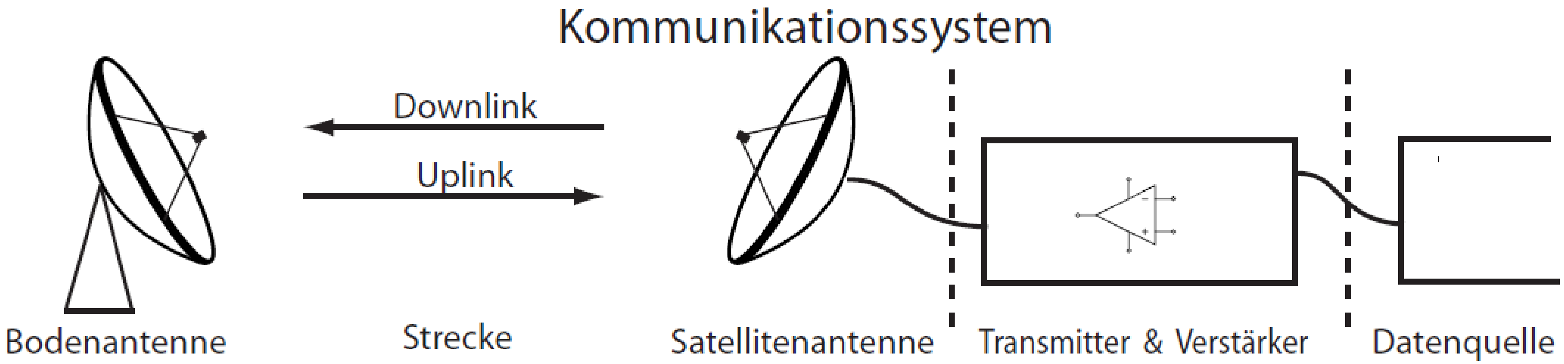
Design TTC System



$$\frac{E_b}{N_0} = \frac{powerAmplifier \cdot gainAntenna \cdot gainGroundAntenna}{boltzmann \cdot noiseTemperature \cdot downLinkRate \cdot lossLine \cdot lossSpace}$$

Requirements to the satellites antenna:

- gain
- wavelength (lossSpace)
- mass

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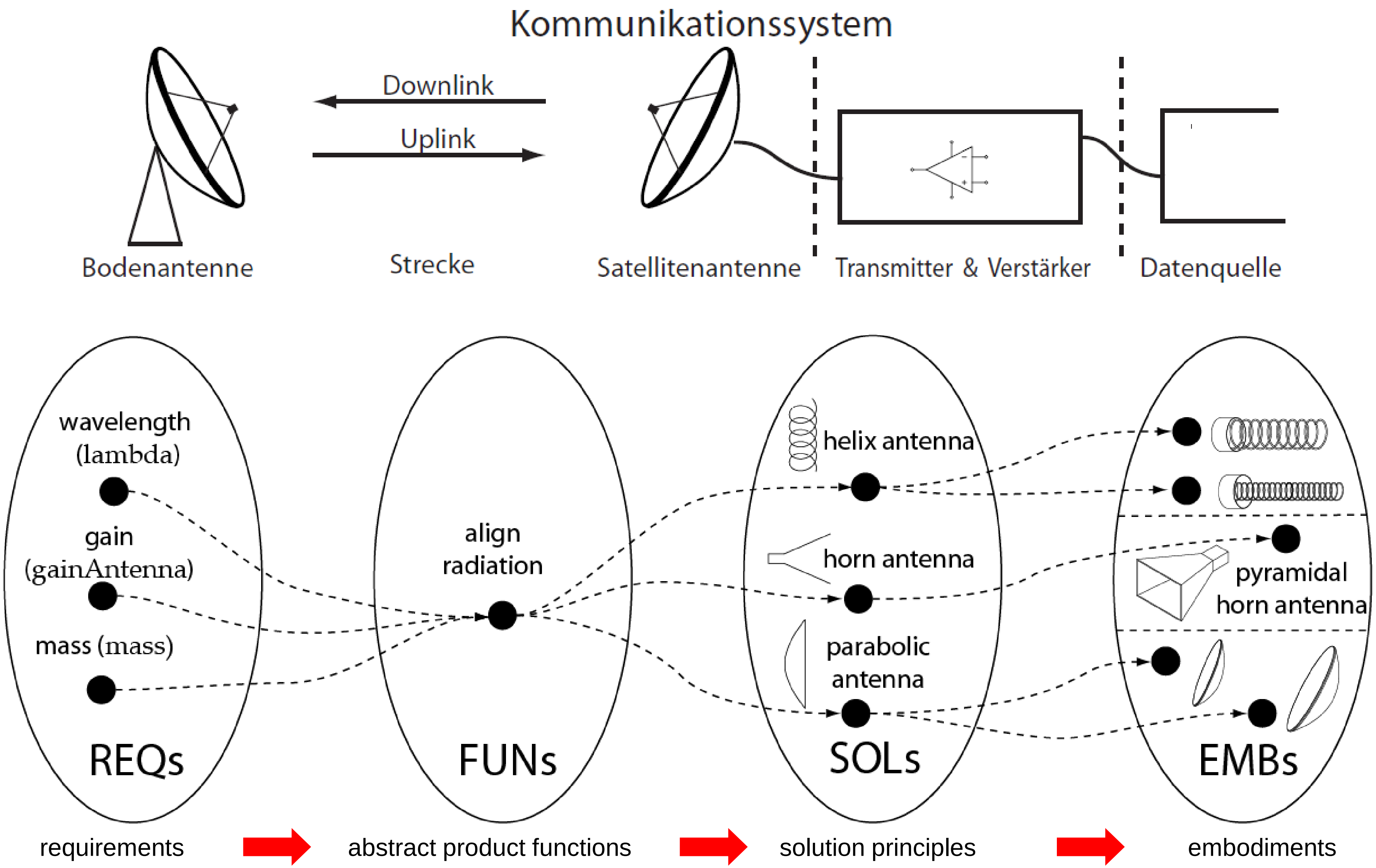
Selection Antenna



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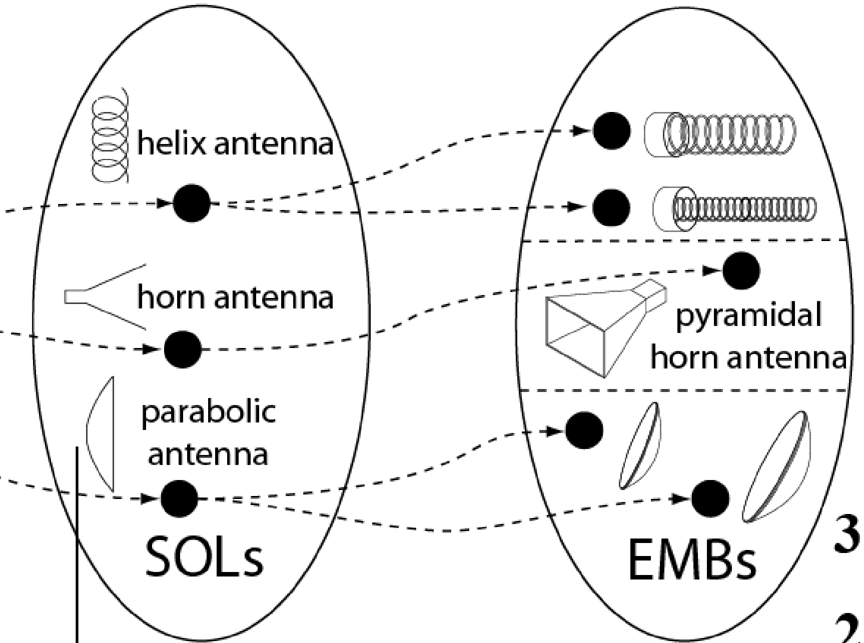
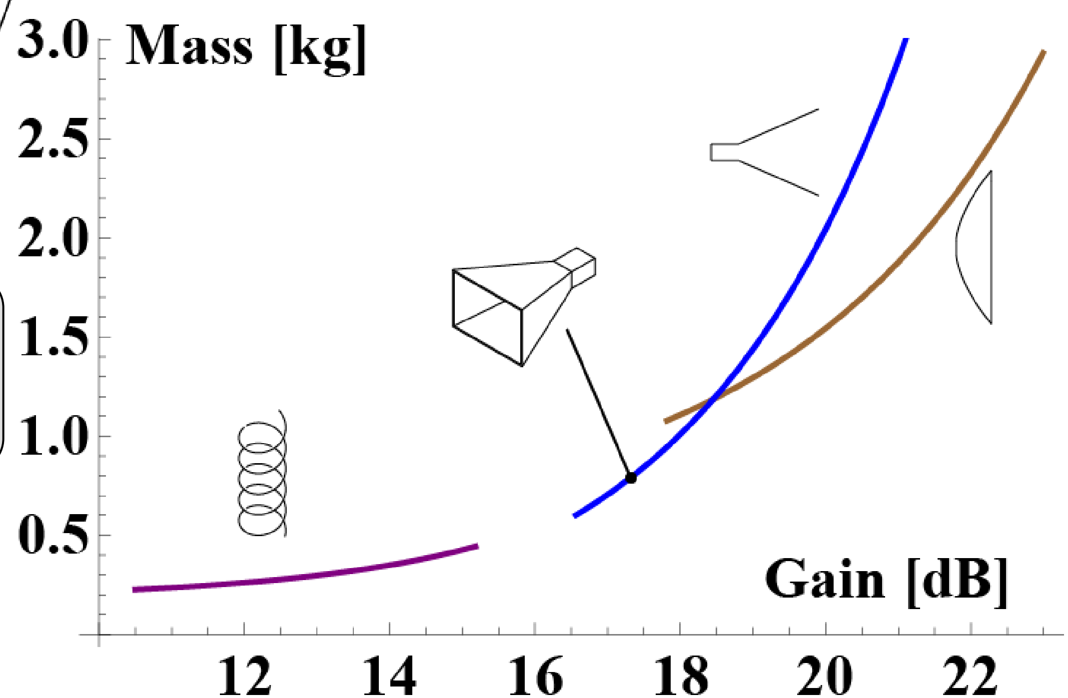
Choice Solution Principle and Embodiment

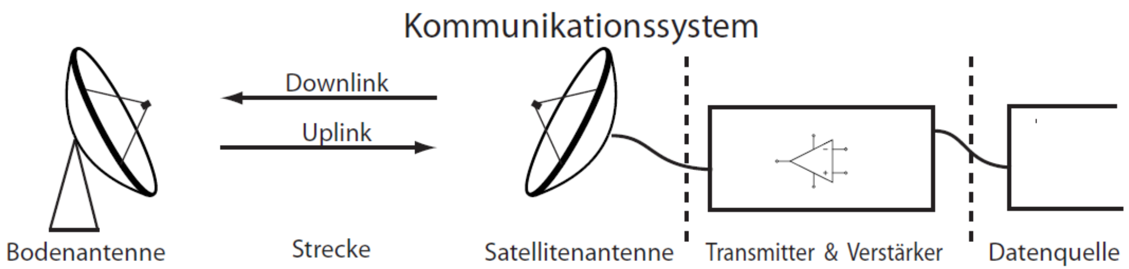


$$gainAntenna = \pi^2 \cdot \frac{diameter^2}{\lambda^2}$$

$$mass = \frac{\pi}{6} \cdot \sqrt{\left(1 + 4 \cdot diameter^2\right)^3} \cdot strength \cdot density$$



Performance TTC System

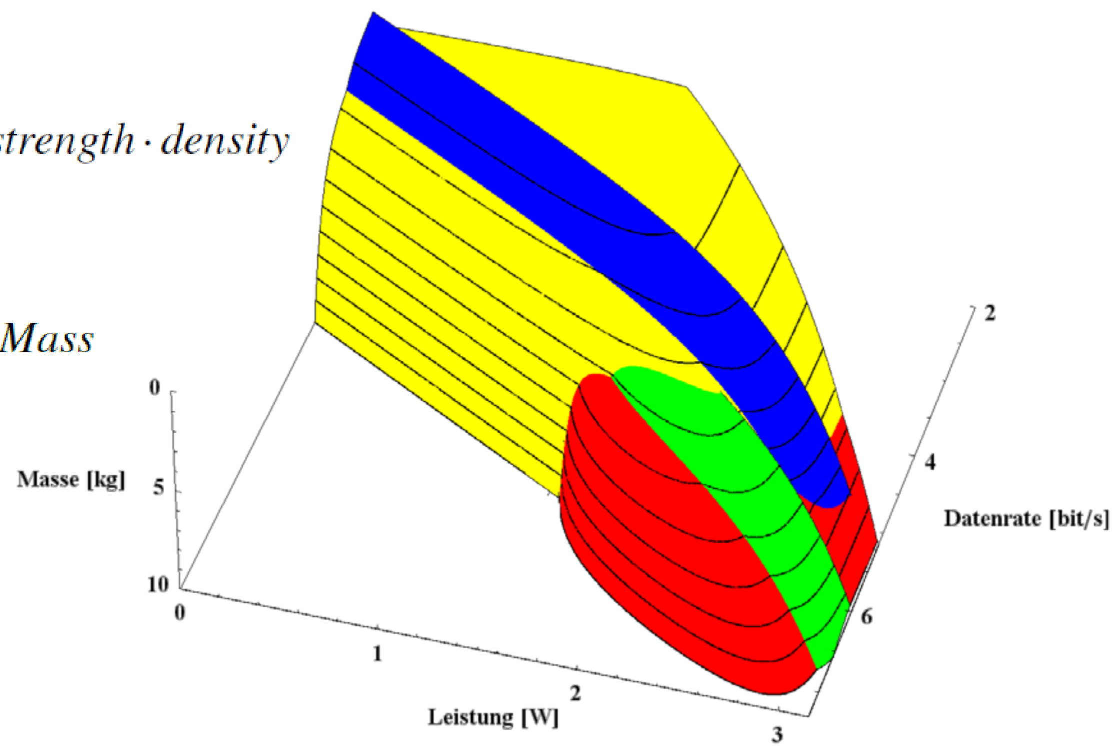


$$\frac{E_b}{N_0} = \frac{powerAmplifier \cdot gainAntenna \cdot gainGroundAntenna}{boltzmann \cdot noiseTemperature \cdot downLinkRate \cdot lossLine \cdot lossSpace}$$

$$gainAntenna = \pi^2 \cdot \frac{diameter^2}{\lambda^2}$$

$$mass = \frac{\pi}{6} \cdot \sqrt{\left(1 + 4 \cdot diameter^2\right)^3} \cdot strength \cdot density$$

$$\begin{aligned} mass &= power \cdot massFactor + baseMass \\ power &= \frac{powerAmplifier}{efficiency} \end{aligned}$$



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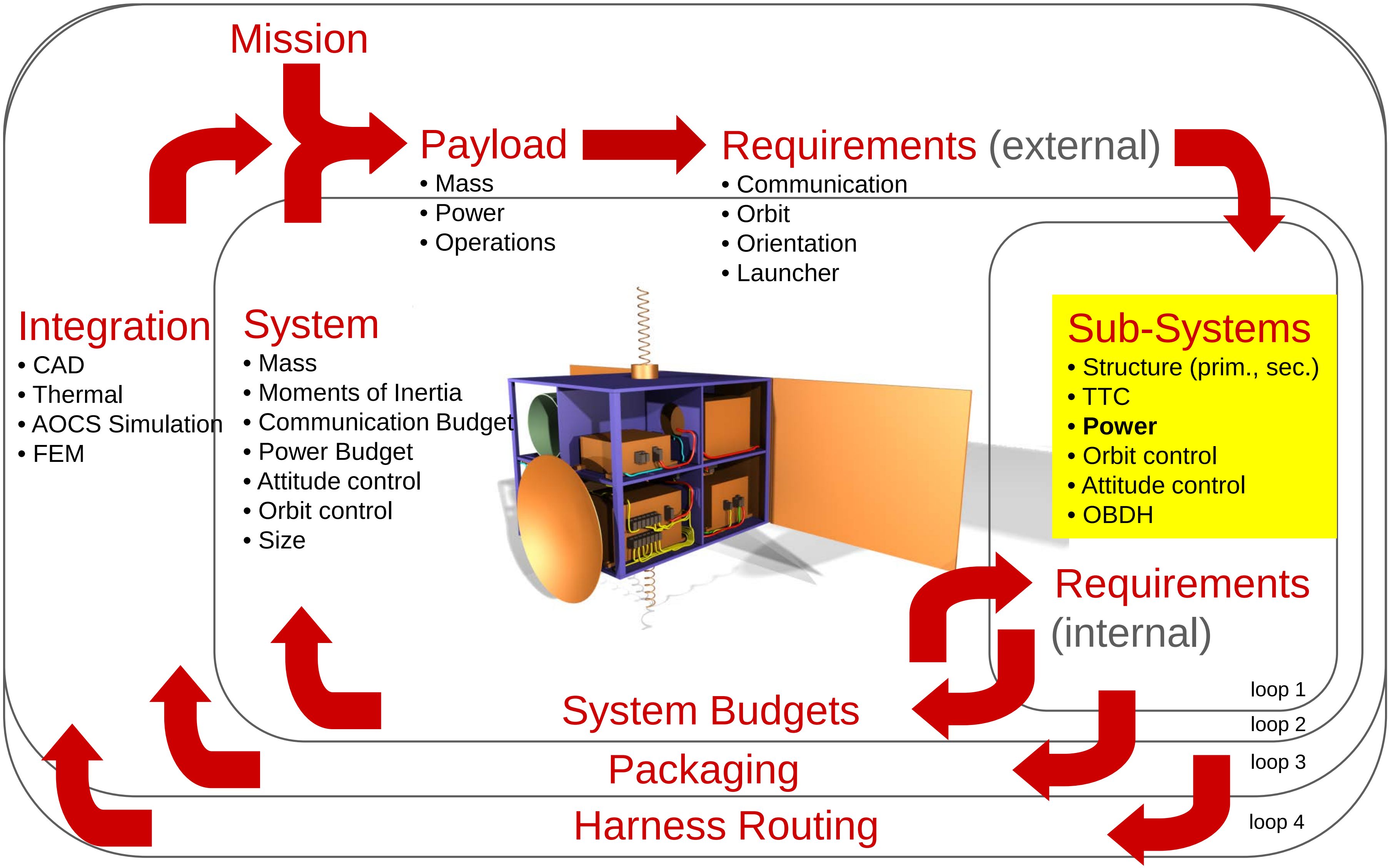
Design Process Satellite



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Schaefer, Rudolph, Aerospace Science and Technology
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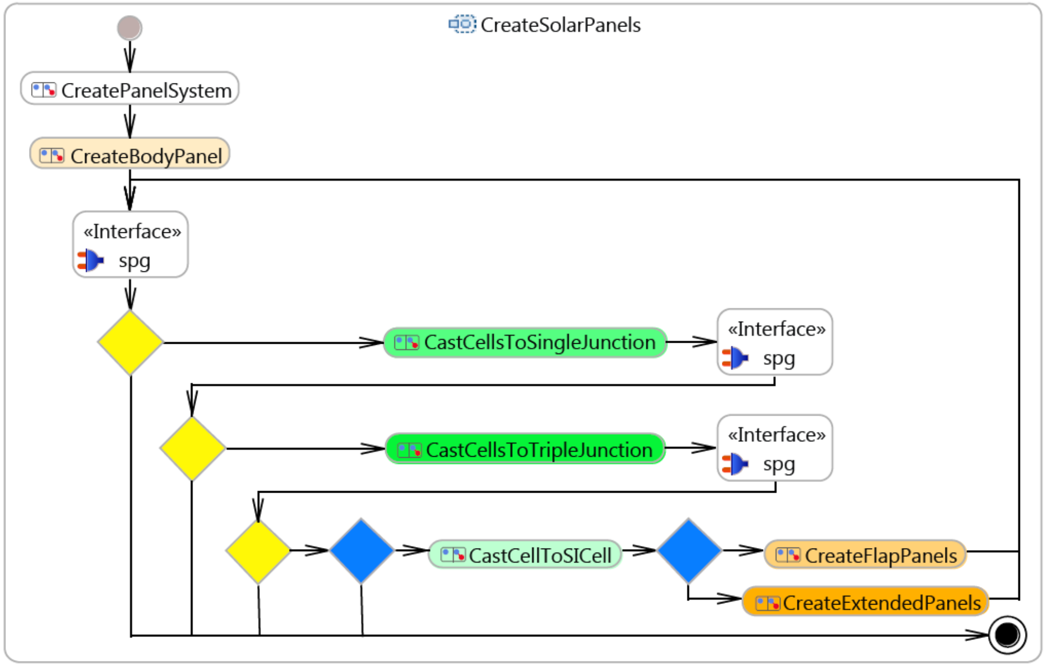
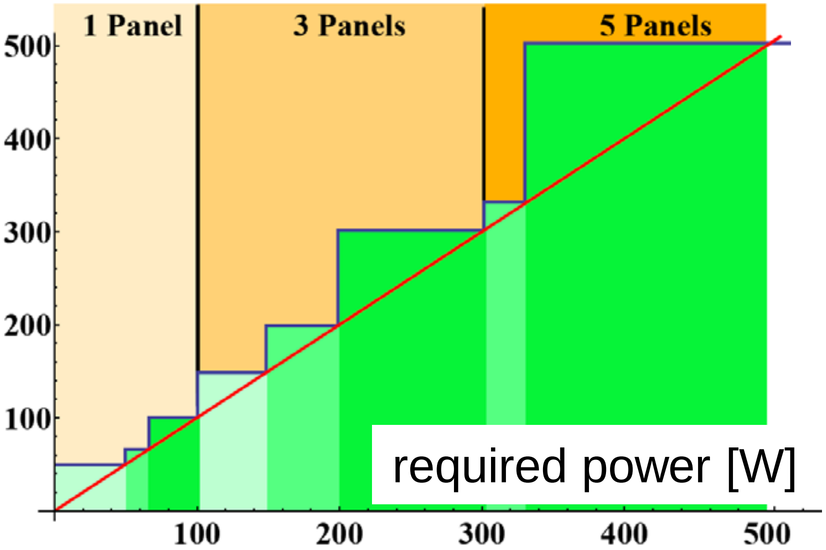
Create Solar Panels



design rules:

- cells with low efficiency are cheaper than cells with high efficiency
- more efficient cells are cheaper than more panels

delivered power [W]



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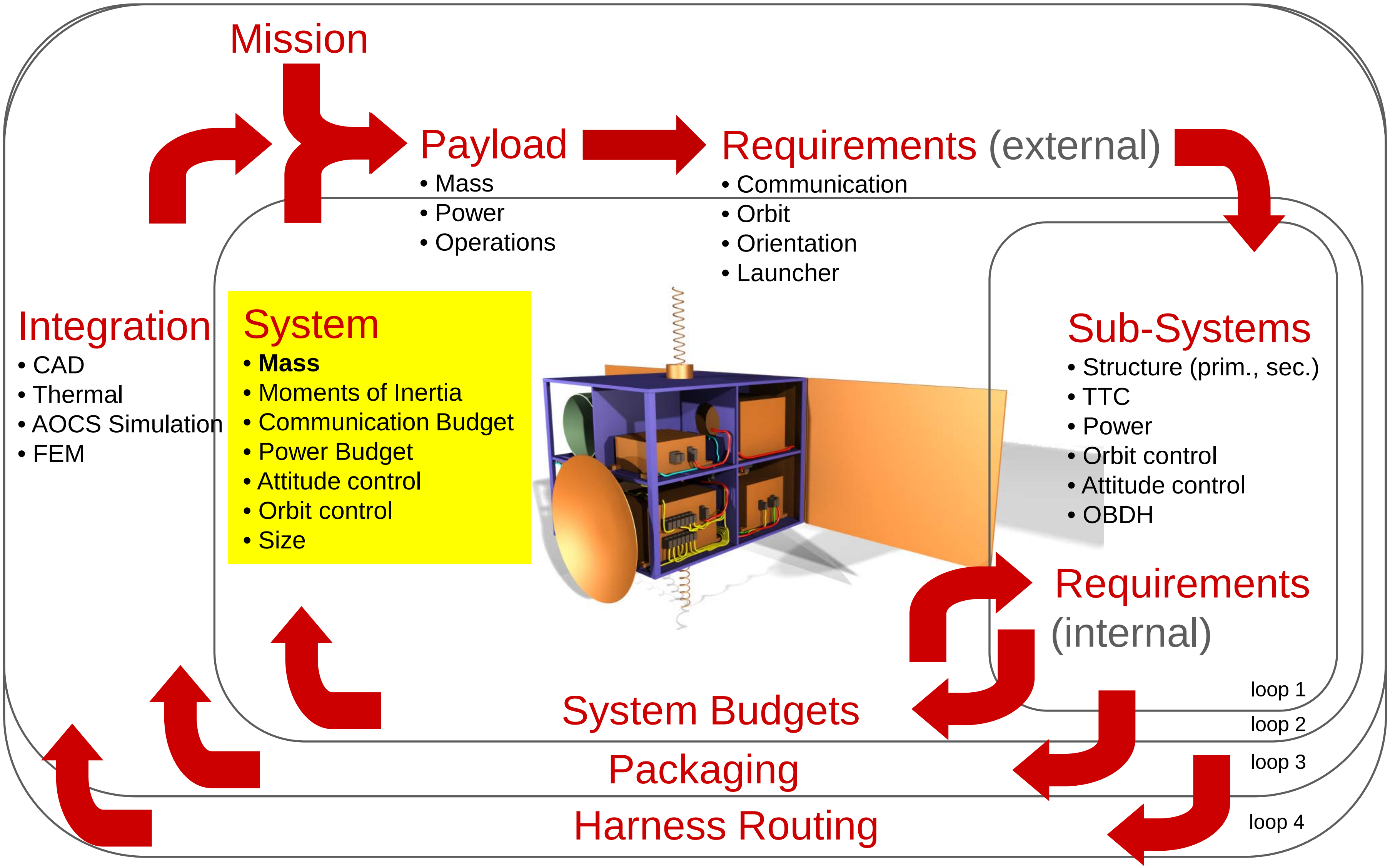
Design Process Satellite



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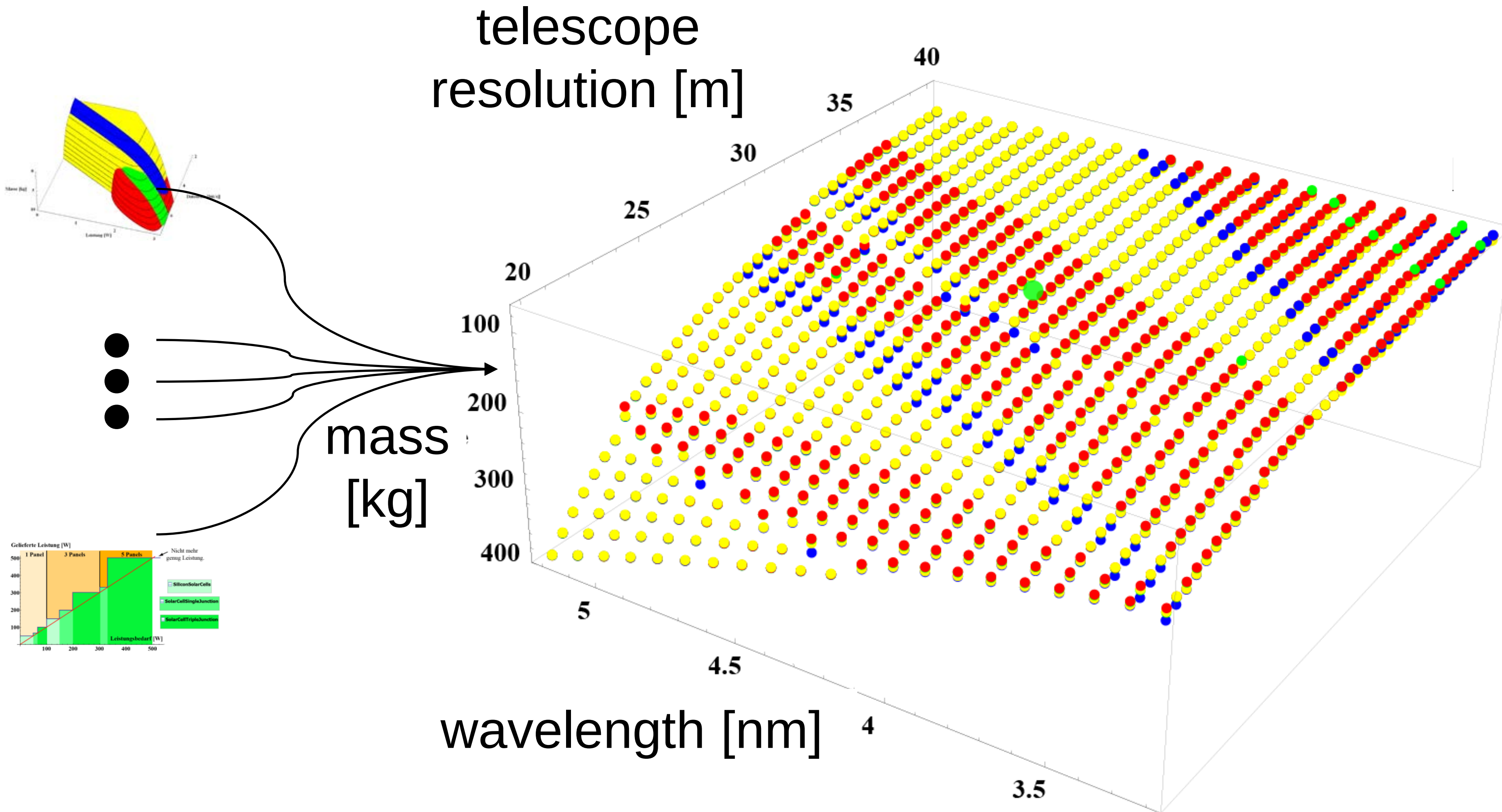
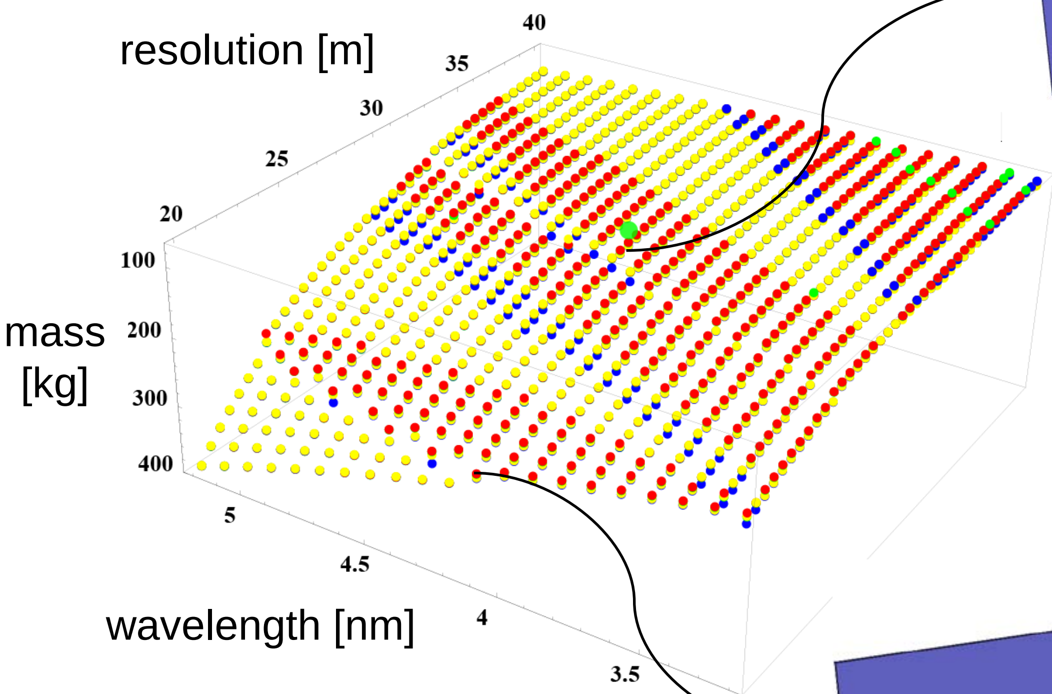
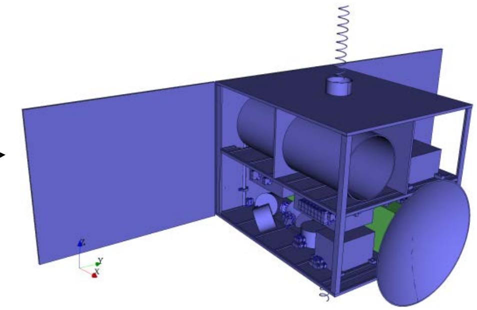
System Integration

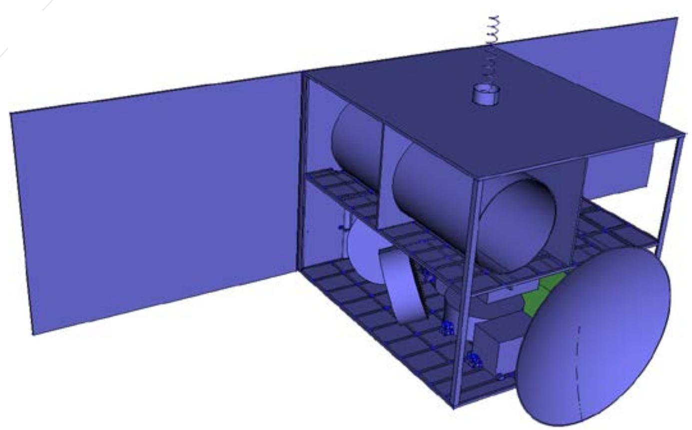


Analytical Evaluation



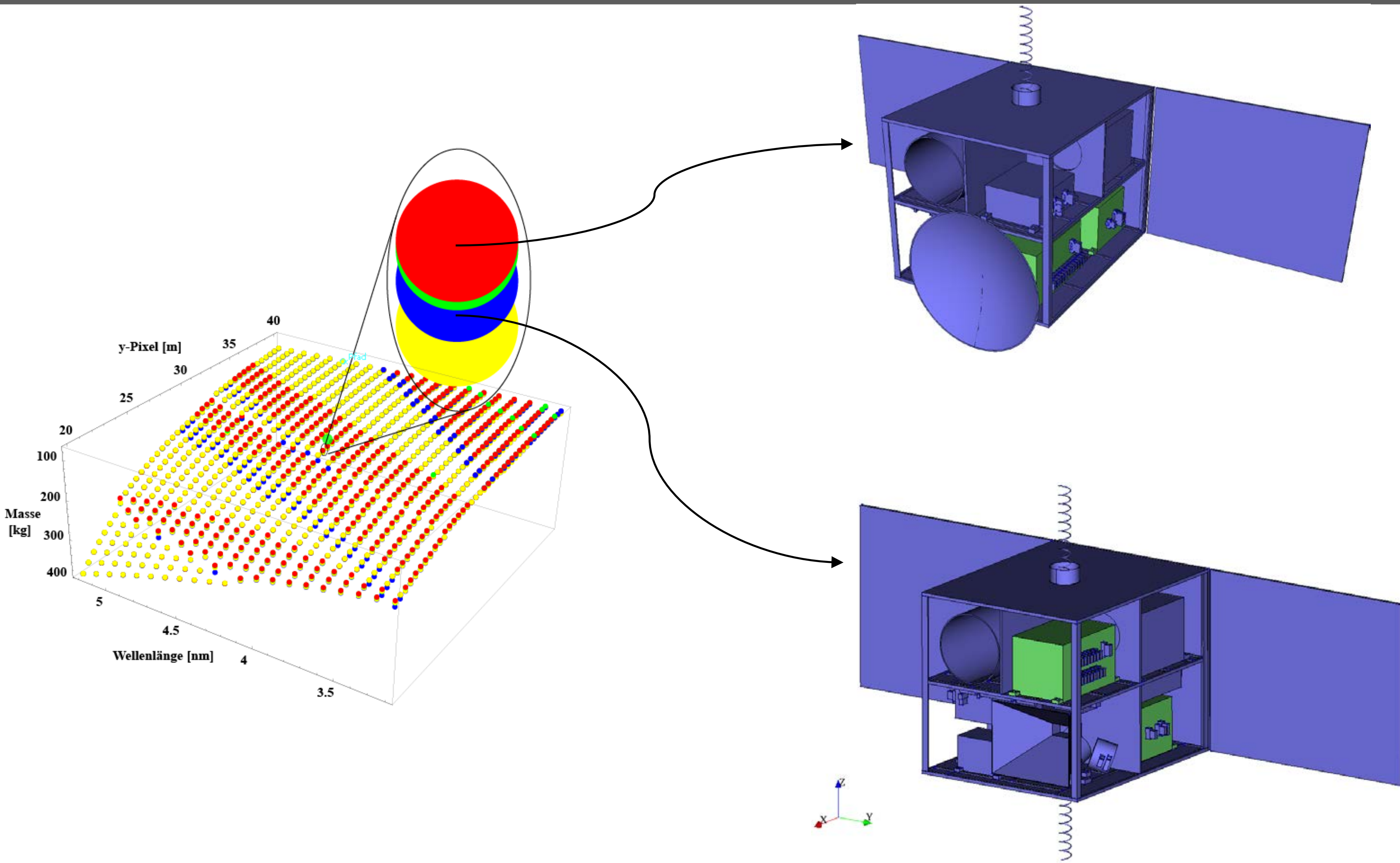


- Mass = 134 kg
- Size:
  - length = 420mm
  - width = 400mm
  - height = 390mm



- Mass = 308 kg
- Size:
  - length = 600mm
  - width = 560mm
  - height = 510mm

TTC Design Decisions



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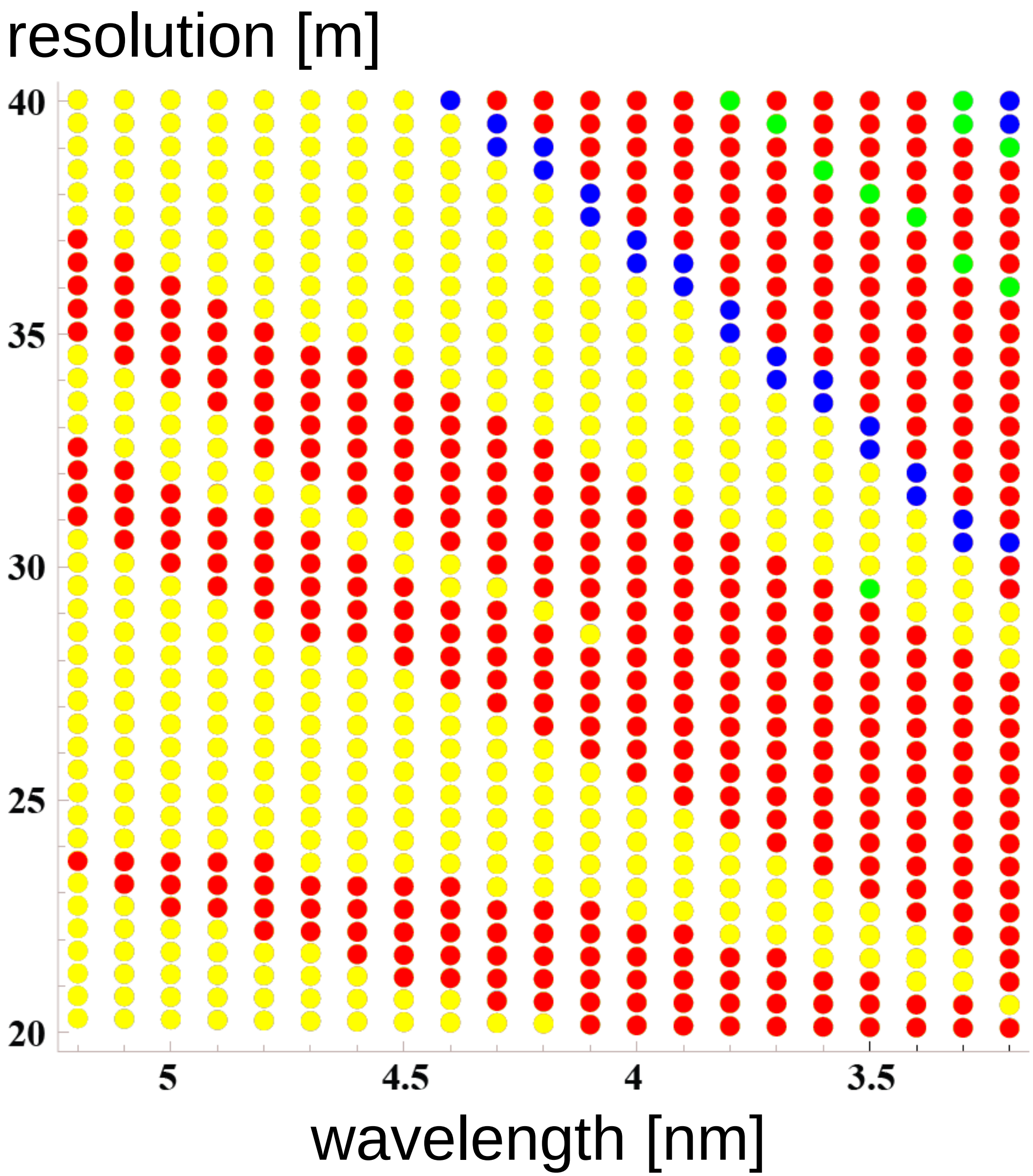
Design Space Regions



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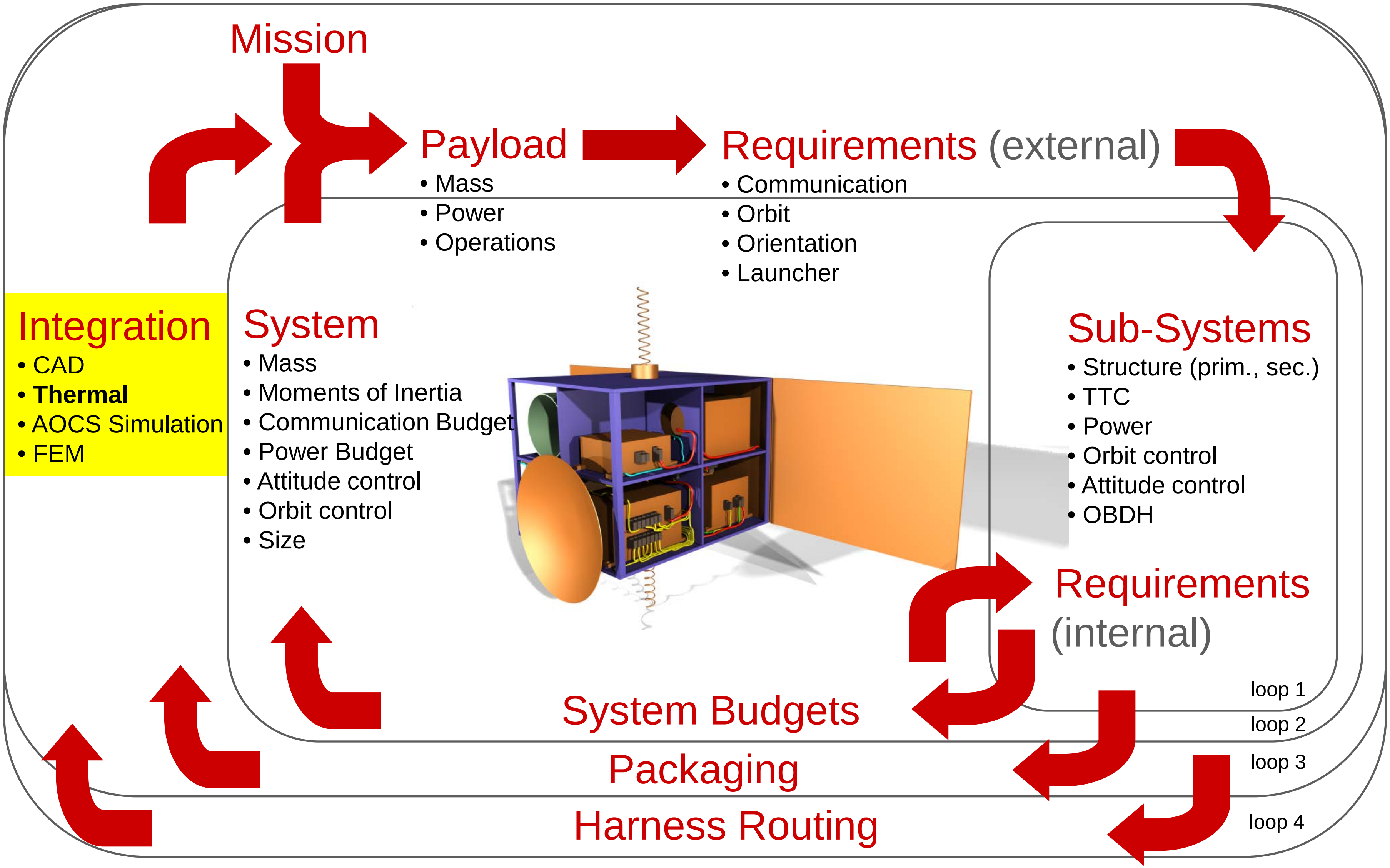
Design Process Satellite



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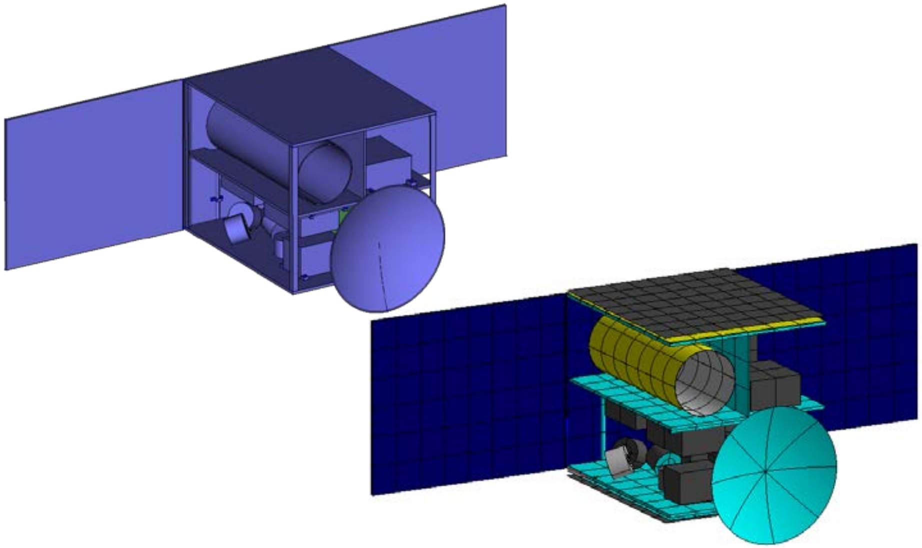
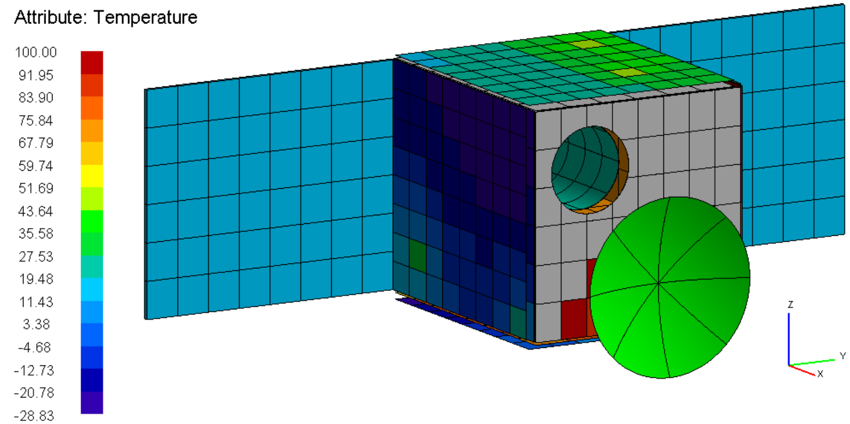
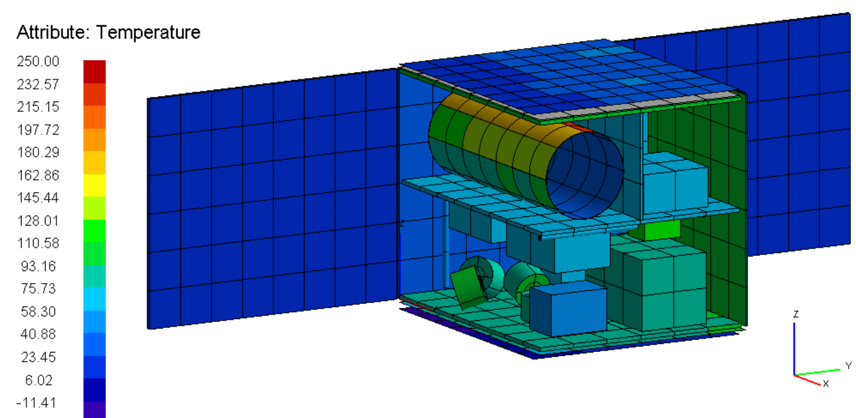
Thermal Design






```
# ---------------------------------------------------------------------------
# SOLAR_POWER calculation
#
# Q_SOLAR is combined with ETA_SOLAR (ca. 27%) the power which can
# be provided by the solar array.
# ---------------------------------------------------------------------------
      SUBROUTINE SOLAR_POWER LANG = MORTRAN # Calculate Power of SolarArray
C SOLAR POWER
        Q_SOLAR = 0.0
C SOLAR PANEL 1
        Q_SOLAR = Q_SOLAR + QS3154
        Q_SOLAR = Q_SOLAR + QS3155
        Q_SOLAR = Q_SOLAR + QS3156
        Q_SOLAR = Q_SOLAR + QS3157
        ...
        ...
        ...
        Q_SOLAR = Q_SOLAR + QS22212
        Q_SOLAR = Q_SOLAR + QS22213
        Q_SOLAR = Q_SOLAR + QS22214
        Q_SOLAR = Q_SOLAR + QS22215
C Power by solar cells
        POWER_SOLAR = Q_SOLAR * ETA_SOLAR
      RETURN
      END
C
```



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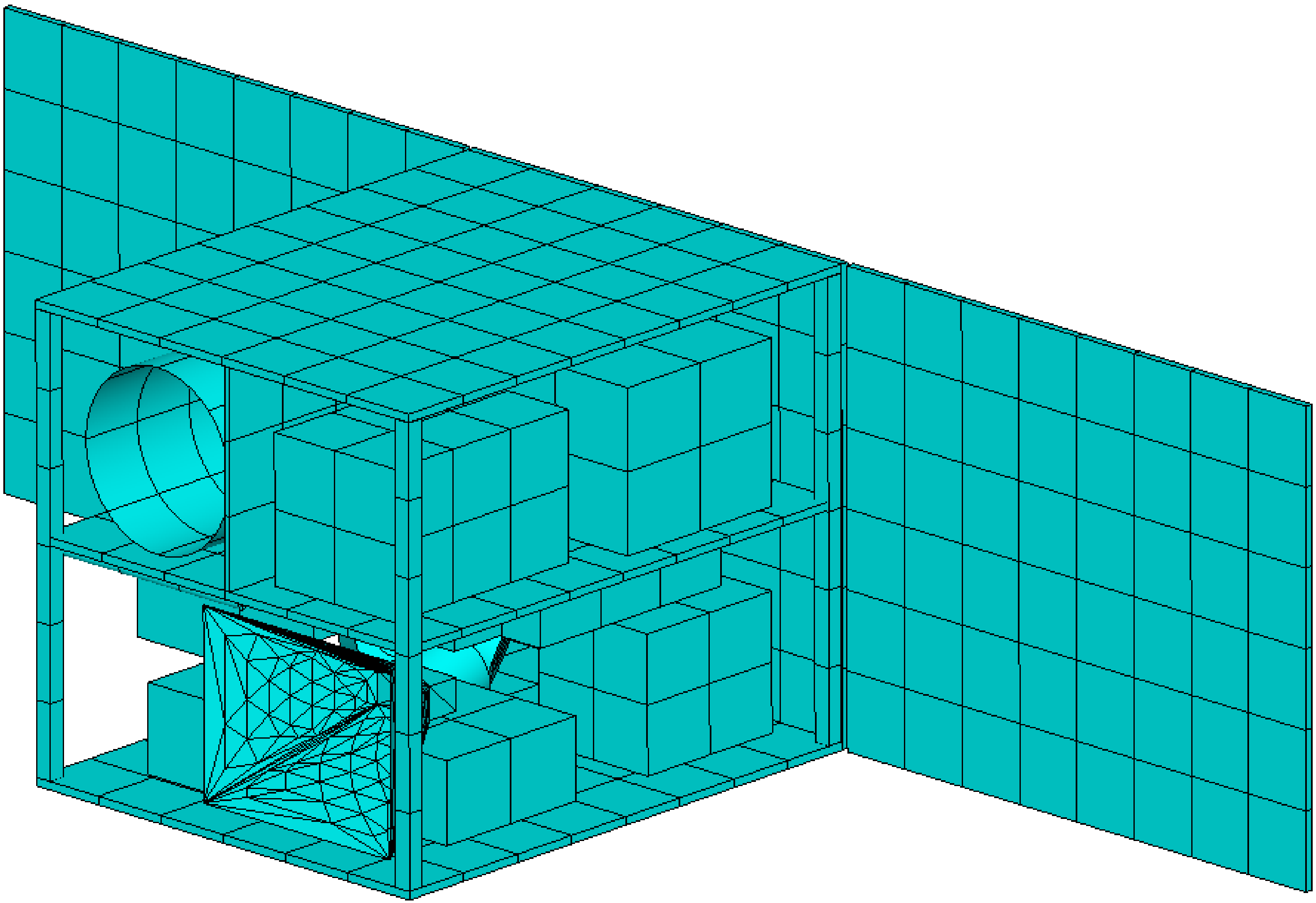
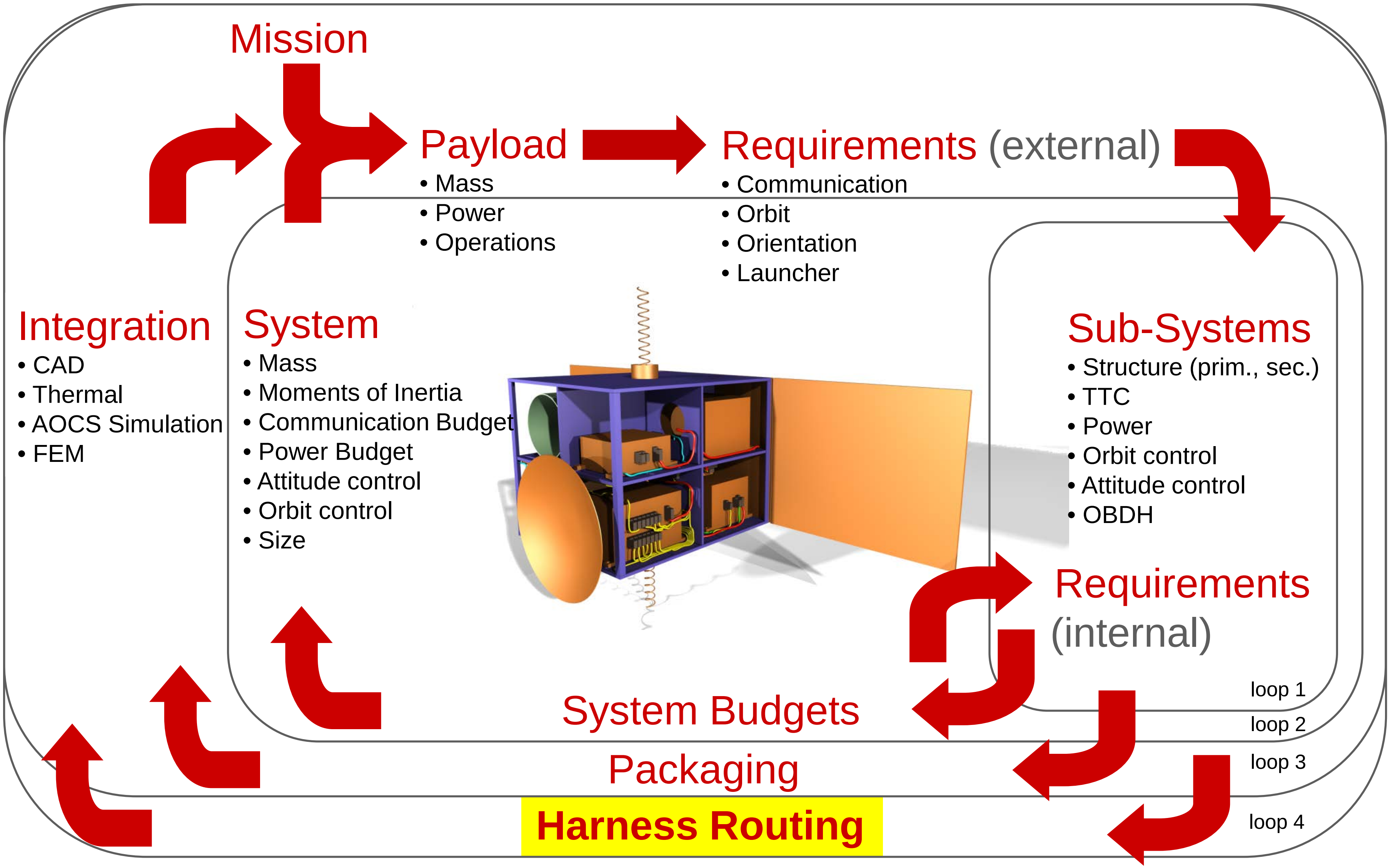
Thermal Design



Design Process Satellite



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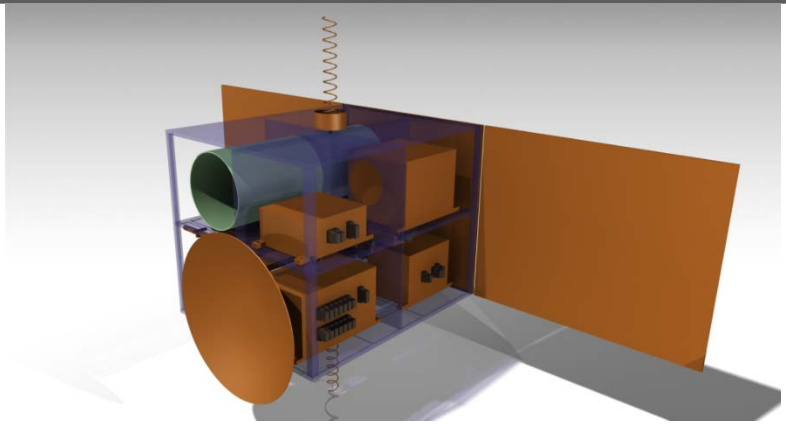
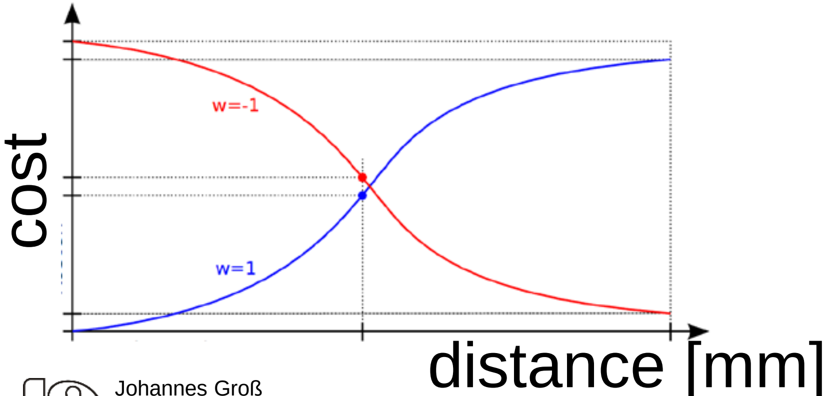
Harness Routing



Different Routing Rules:
1. Attraction of cables
2. Attraction to wall
3. Strong attraction to wall



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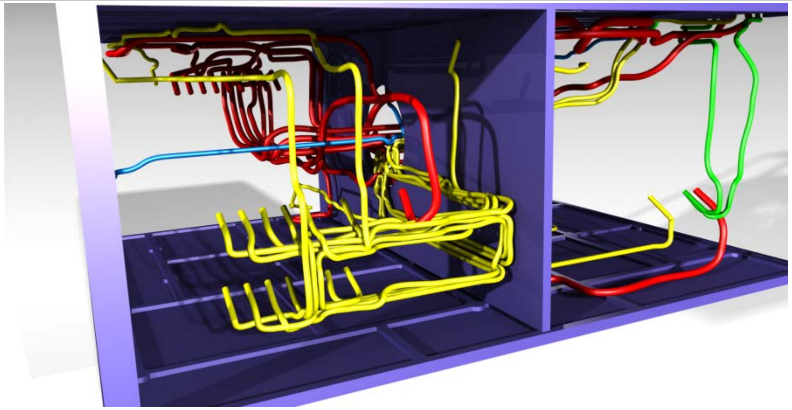

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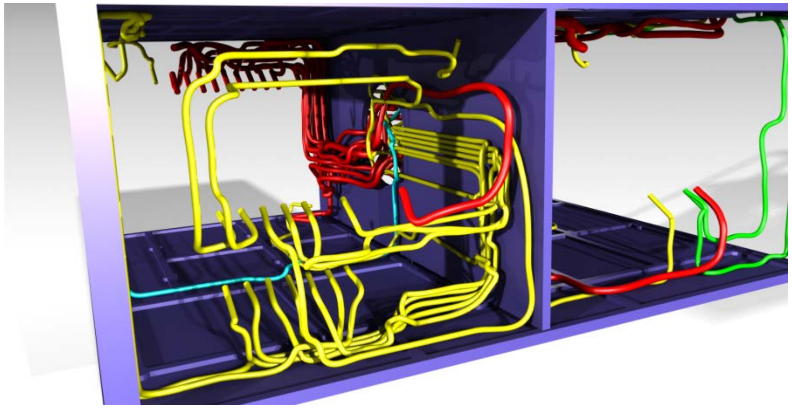

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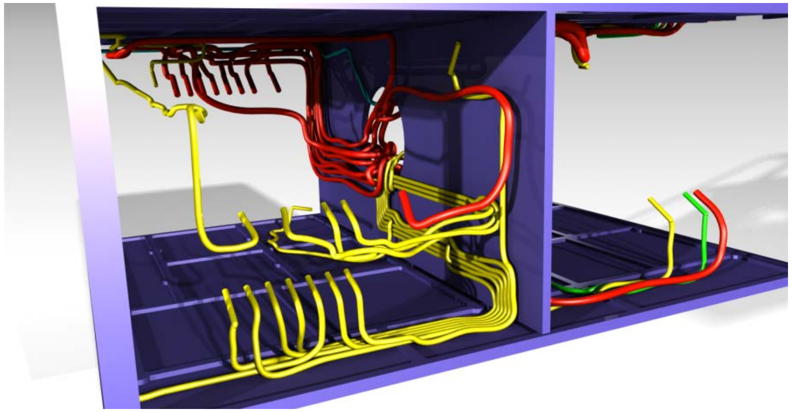

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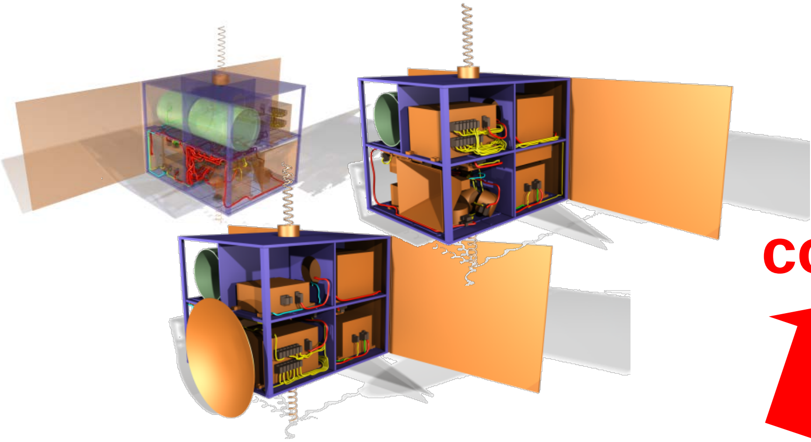
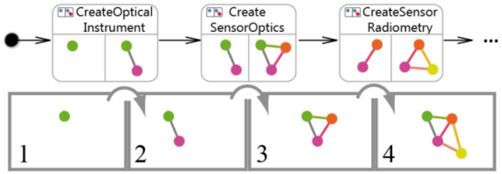
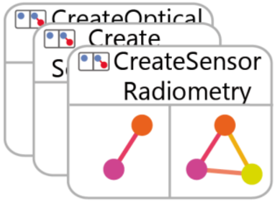
Thinking MBSE Further



competence

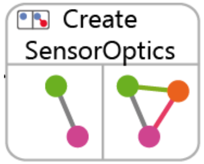
pragmatics
capability of model synthesis and analysis
with arbitrary boundary conditions

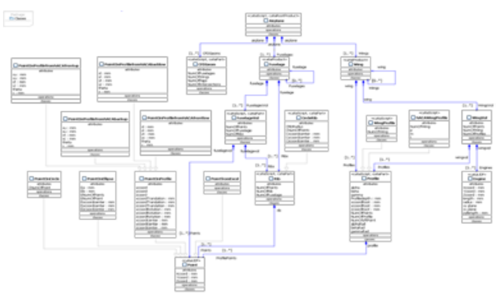




knowledge

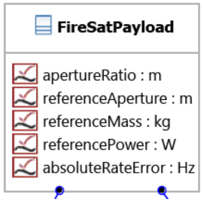
semantics
patterns, couplings





information

syntax
information representation,
formats, interfaces



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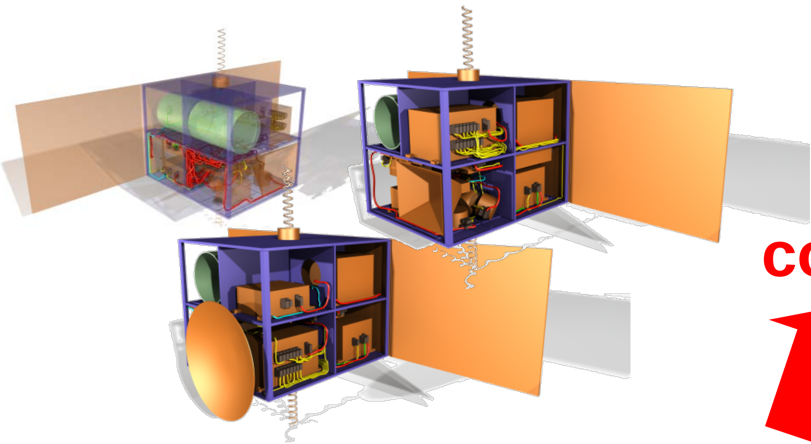
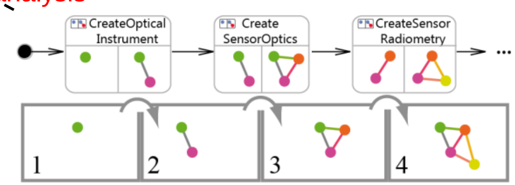
Thinking MBSE Further

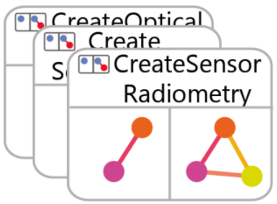


thank you!

competence

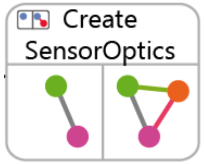
pragmatics
capability of model synthesis and analysis
with arbitrary boundary conditions

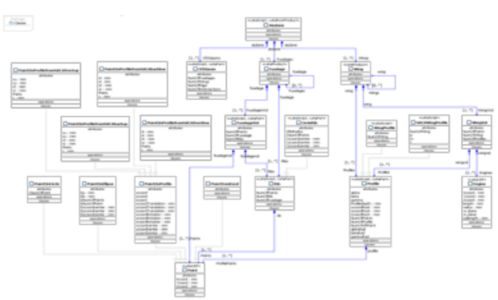




knowledge

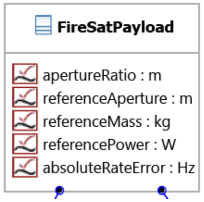
semantics
patterns, couplings





information

syntax
information representation,
formats, interfaces



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