Needs and Applicability of Modeling in Concurrent Space System Design

7. Workshop „Digitale Entwurfsmethoden“

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ISD; Uni Stuttgart

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Content

DLR Institute of Space Systems - Intro
Space System Engineering
Concurrent Engineering

Model use & applicability @CEF
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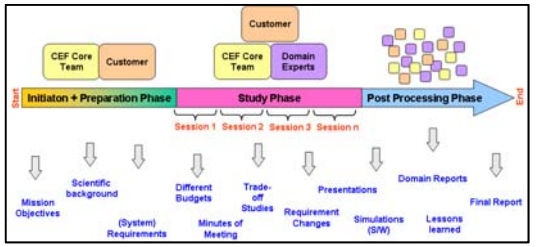
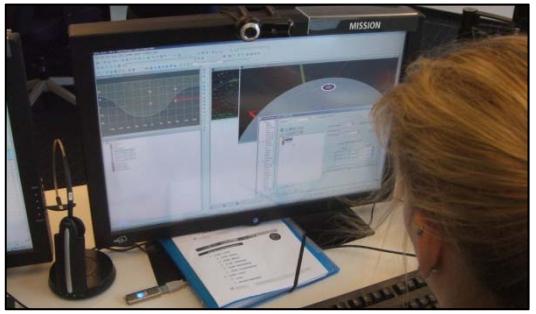
Conclusions

Discussion



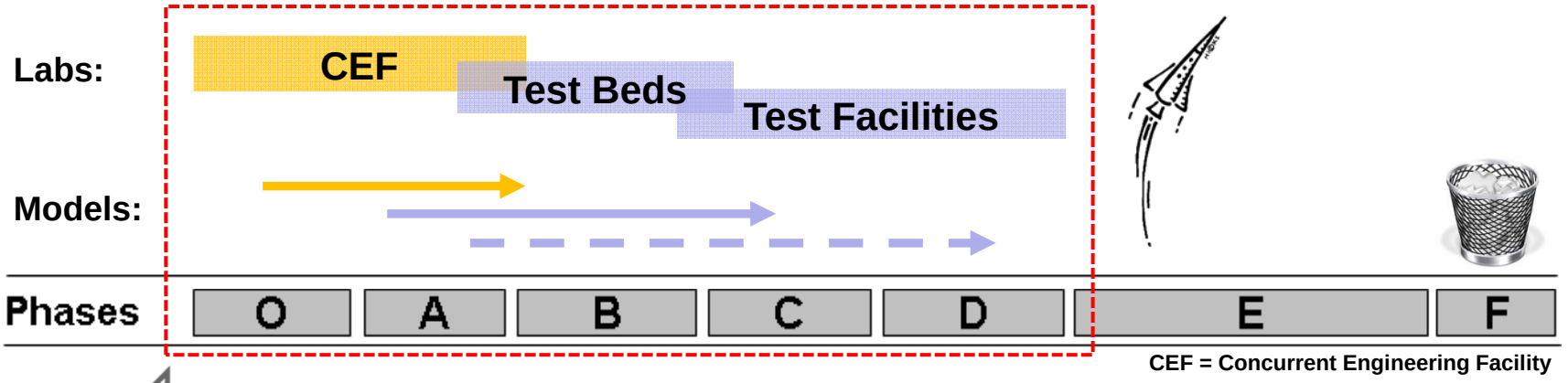


CEF = Concurrent Engineering Facility

DLR Institute of Space Systems (in brief)

- System Analysis / Systems Technology / Space Projects
  - from: Phase 0/A (Mission Need / Feasibility)
  - to: Phase D (Production & Qualification)

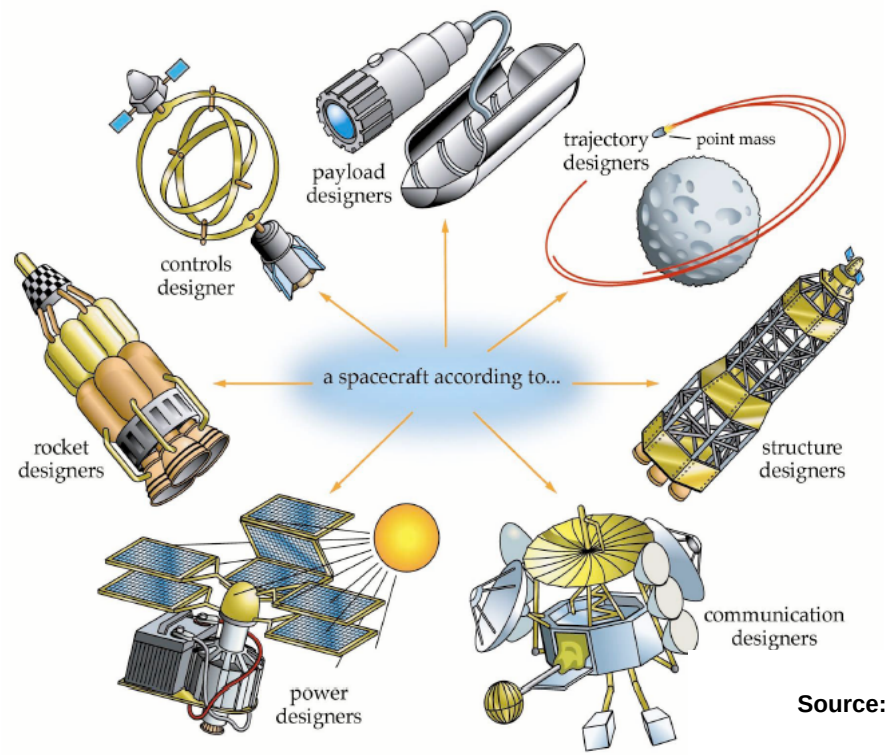
- What do we do and have?



CEF = Concurrent Engineering Facility

Space Systems Engineering

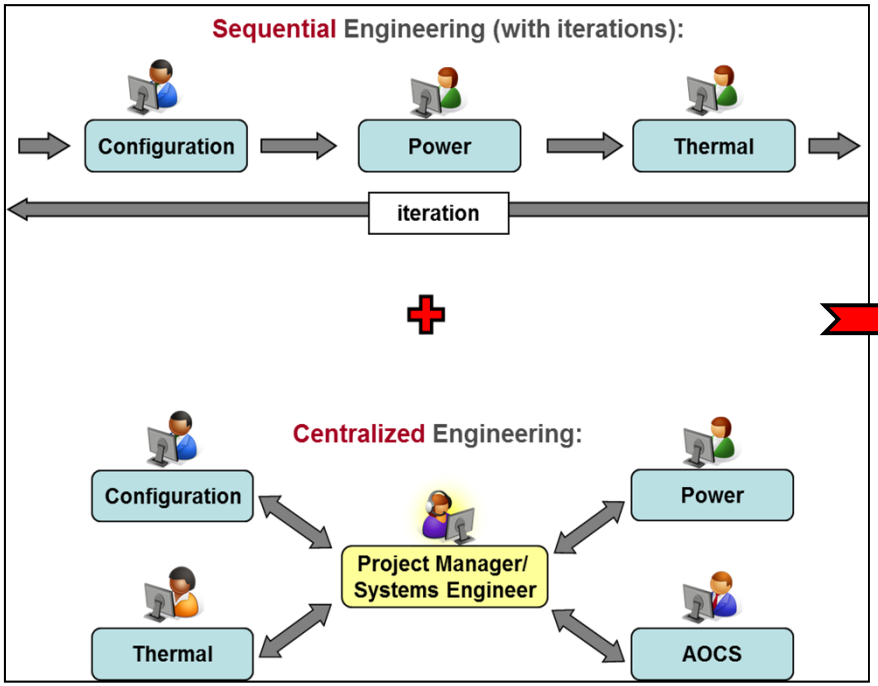
- Decomposes Systems/Problems
  - Reduces complexity
  - Balances subsystems
  - …
- Includes:
  - Requirements engineering
  - Interface definitions
  - Work breakdown
- Can be supported by:
  - Concurrent Engineering

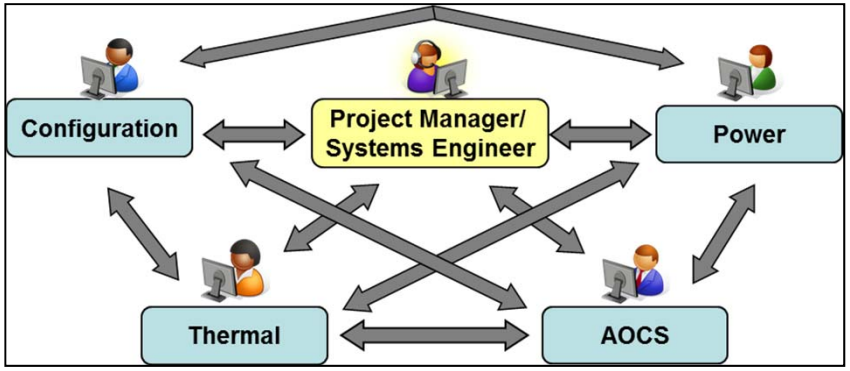


Source:

Robinson, 2008

The Concurrent Engineering (CE) Process…

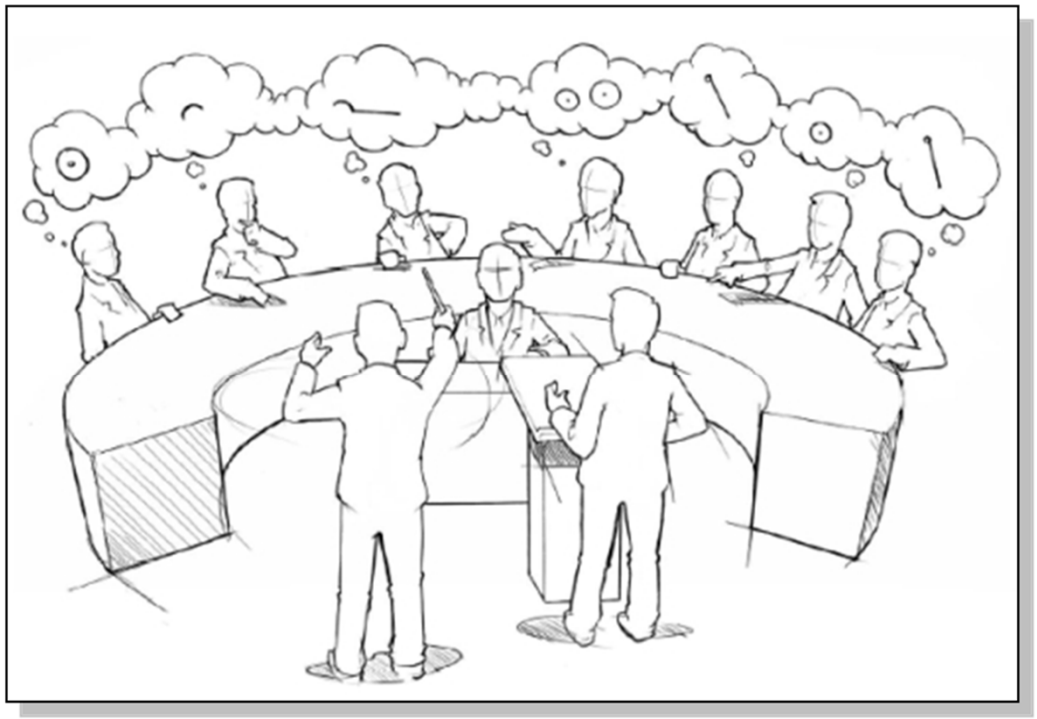




Source: ESA

DLR

… during **Plenary Sessions:**

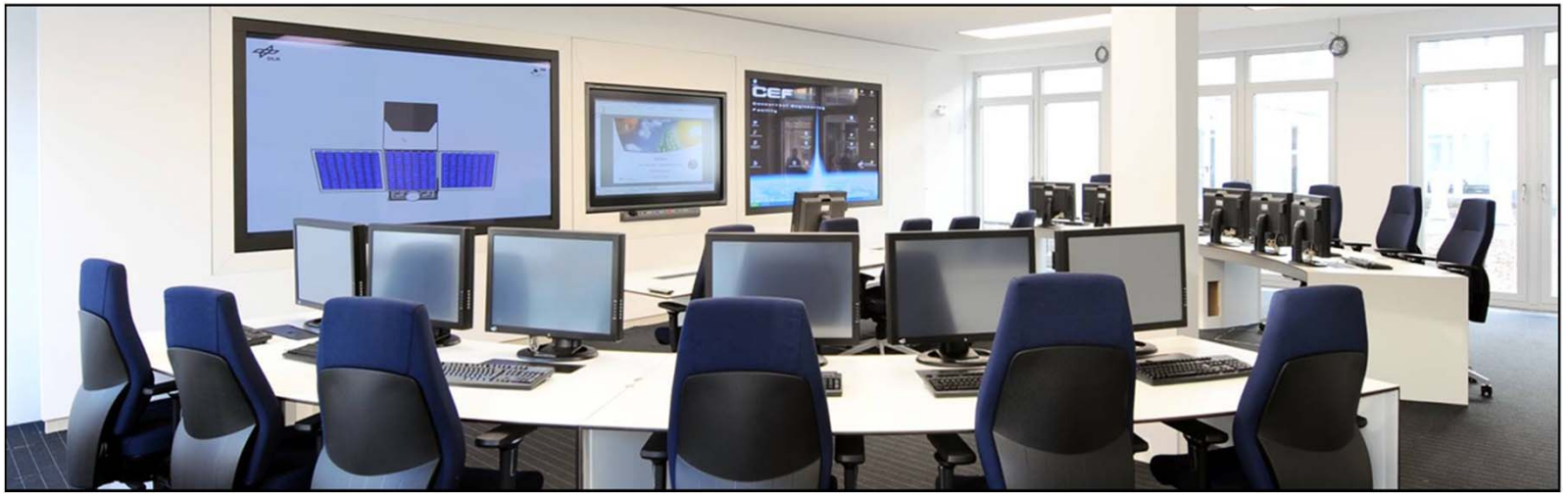


Source: JAQAR Concurrent Design Services (J-CDS)

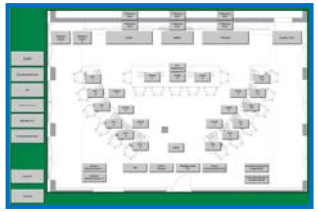
- Joint discussions
- Presentations
- Customer's Feedback
- "Domain round"
- System trades
- System decisions

… during „off-line“ Work:

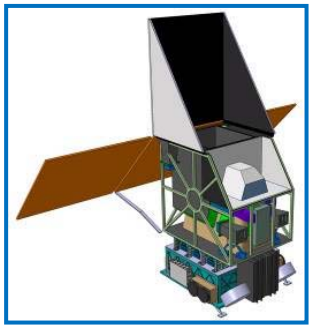
Subsystem trades	Model updates	Design negotiation
Expert tool use		Part accommodation



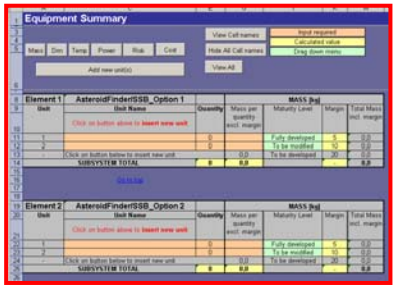
Main Elements of Concurrent Engineering

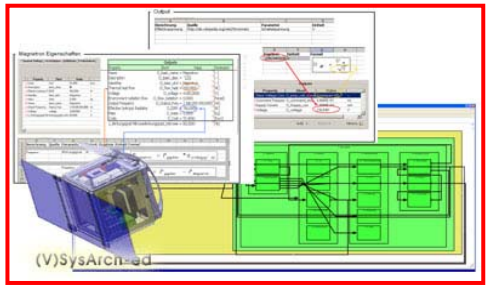


- Infrastructure → Laboratory → *here:* CEF
- Team → Domain Experts; Customer
- Process → Scheduling & Communication

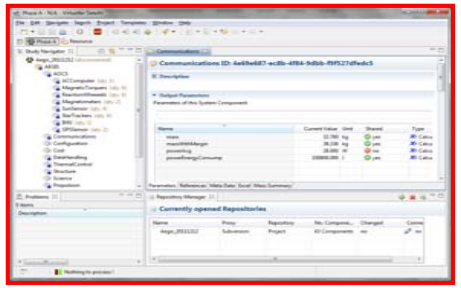


- Tools → Multimedia & domain-specific
- Model → Data-/Design Model

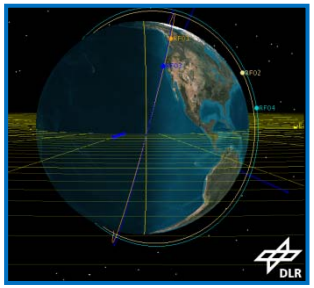




Source: TU Munich



Source: DLR SC-RV



Model Types and Applicability

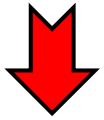
- What is a model for me/us?
  - Abstract representation of environmental and/or technical conditions
    - with clear input/output parameters,
    - which are statically/dynamically linked, processed & displayed,
  - and can possibly be re-used

- Main interesting types for us:
  - Data-/Design Models (external development)
  - Simulation/Calculation Models (internal development)

- Complexity and Size of the System matters:
  - Small sats (e.g. CubeSats) → System-simulation favoured
  - Bigger sats (e.g. >1t class) → rather domain-specific models

What is typically used in the CEF?

- Design / Data „Models“
  - IDM (by ESA)
  - Virtual Satellite (by DLR)
  - (v)Sys-ed (by TUM)
  - CDP (by JAQAR)
  - OCDT (by ESA)



  - Simultaneous use;
  - Common platforms

- Simulation / Calculation Models
  - Solar Array sizing (.xls),
  - Tank sizing (.xls),
  - Delta-V / Propellant models,
  - SMAD calculation sheets,
  - Torque Models (.xls / .mdl),
  - Cost Models (.xls), …
  - Individual models by experts
    - incl. special S/W-tools…
  - **S/W:** Catia / Satellite Toolkit

IDM = Integrated Design Model ; CDP = Concurrent Design Platform; OCDT = Open Concurrent Design Tool; SMAD = Space Mission Analysis & Design

Major Considerations for *Design* Models (Needs!)

- Capture engineering team expertise → and share it!
- Simultaneous access → latest values
- Integrate & link to system requirements
- Unique parameters
- Clear role management → who is allowed to do what?
- Handling: easy to use…
  - graphical elements / visualization → common understanding
  - rapid analyses / quick access

- Keep in mind that:
  - everybody uses his/her personal laptop →
  - with own analyses tools/models (&versions)

Some General Modeling Key Questions

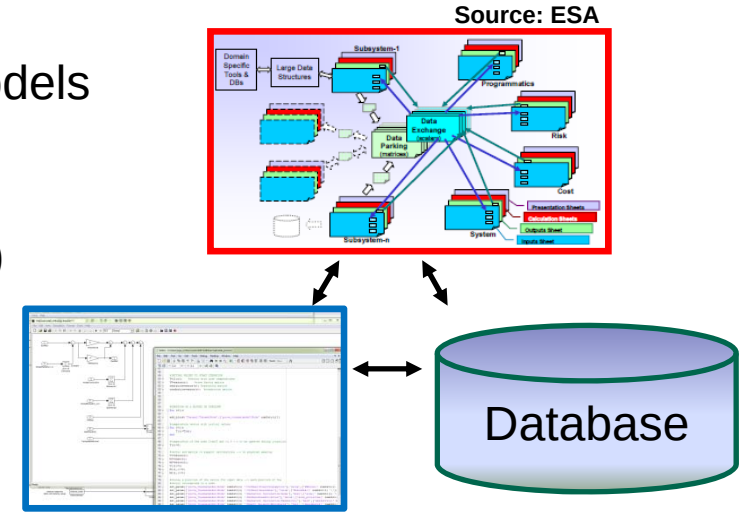
- What shall the model do?
  - What task(s) / functions?
  - Level of detail?
- Who will use it?
  - (Sub)system engineer?
  - Design team,
    - independent / in sequence,
    - or even at the same time?
- Shall the model be re-used?
- Shall the model be upgraded?
- What are the interfaces?
  - In-/outputs?
  - Need for internal features?
  - Link to other tools/models?
  - Databases accessable?
- What do I gain with the model?
  - Time?
  - Optimized design?
- How do I deal with „unknowns“
- Who builds and maintains it?

Our Vision (model-related)

- To provide domain-specific simulation models
  - e.g. on Matlab/Simulink-level,
    - independently &
    - integrated on system level (tbd..)

- To allow exchange between:
  - data/design model &
  - simulation models

Source: ESA



- To have model(s) connected to databases (& technical data sheets)
- To integrate models & tools into a knowledge management system

Our Work (of CEF core team)

- Conducting CE studies & operating the facility!

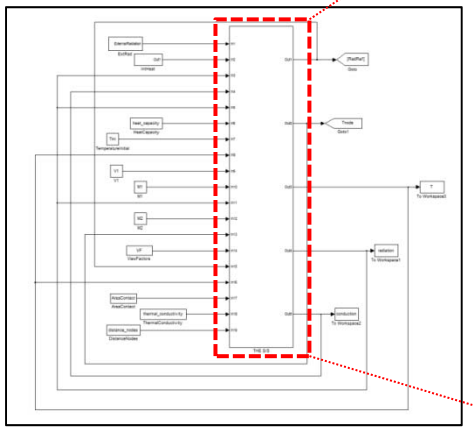
- Furthermore:
  - Identify (general) needs of the domain experts
  - Improve the design process itself
  - Elaborate on the infrastructure incl. S/W & H/W
  - …

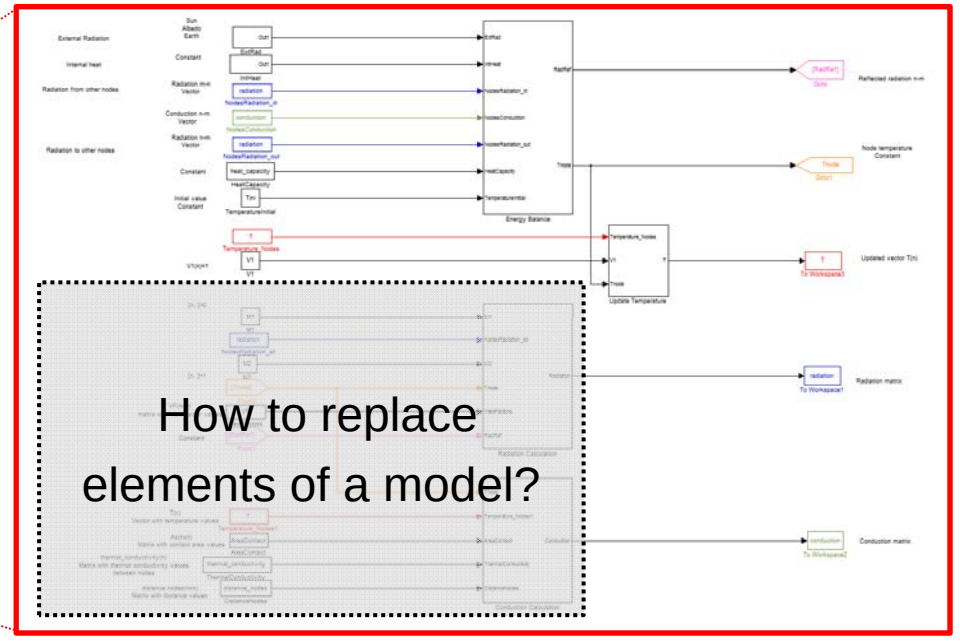
→ Model-related
  - Develop databases and link the CEF to existing ones
  - Derive requirements for common ***data/design*** model
  - Prepare and/or collect re-usable ***simulation*** models for the domains

3 Our Attempt (I) – (for System „Simulation“)

- Current Focus on: POWER; THERMAL; PROPULSION; AOCS
  - Modularity?
  - Task; Part; Domain

e.g. Thermal Model

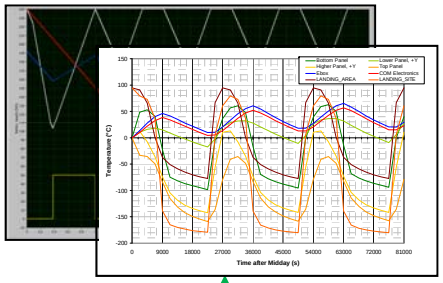




2 Our Attempt (II)

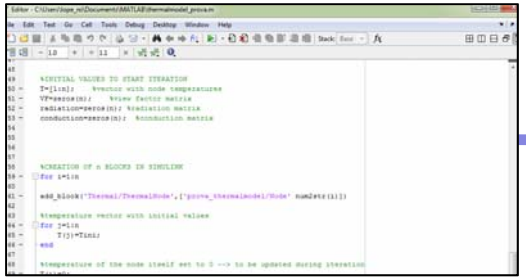
Simulation Model Architecture planned in DLR CEF

Diagrams

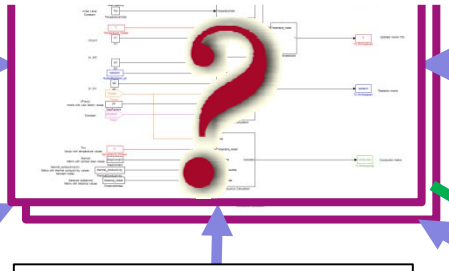


Configuration

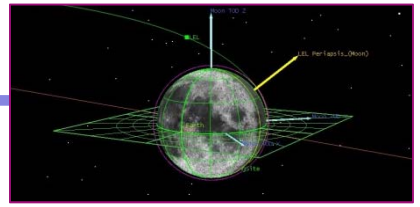
Input functions and files



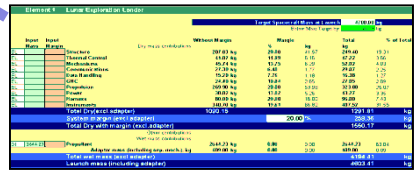
Design-/ Simulation Model



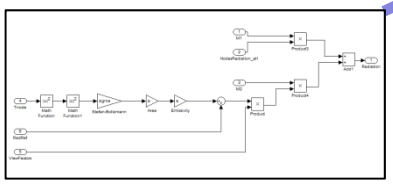
Environment

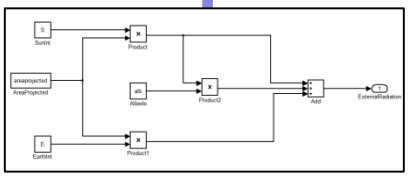


Data / Budgets



Part simulations





1 Conclusions & Current Lessons Learnt

- Modeling (of Space Systems) increases design confidence
- Models force engineers to deal with clear in-/output parameters

- Concurrent Engineering focus is still set on the team:
  - No „perfect“ S/W or Model found yet for design & simulation
  - Central data/design model → „Virtual Satellite“
    - Simultaneous access highly important
  - „Simulation“ in Phase 0/A, Excel, Matlab seem sufficient → but later?!

- Do not do what others can do better! → Interfaces to commercial tools
- Close(st) interaction amonst design team & model developer required
  - (if not united in one single person…)

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Questions?

Source: University of Erfurt

Thank you very much for your attention!

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