

Needs and Applicability of Modeling in Concurrent Space System Design

7. Workshop „Digitale Entwurfsmethoden“

28./29.06.2012

ISD; Uni Stuttgart

Andy Braukhane (DLR Bremen)



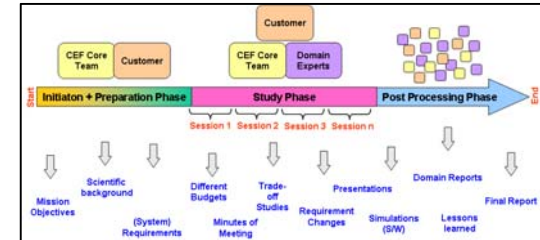
Knowledge for Tomorrow

Content

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

- Model use & applicability @CEF
- Key questions & considerations
- Modeling activities & plans @CEF
- Conclusions

- Discussion



CEF = Concurrent Engineering Facility

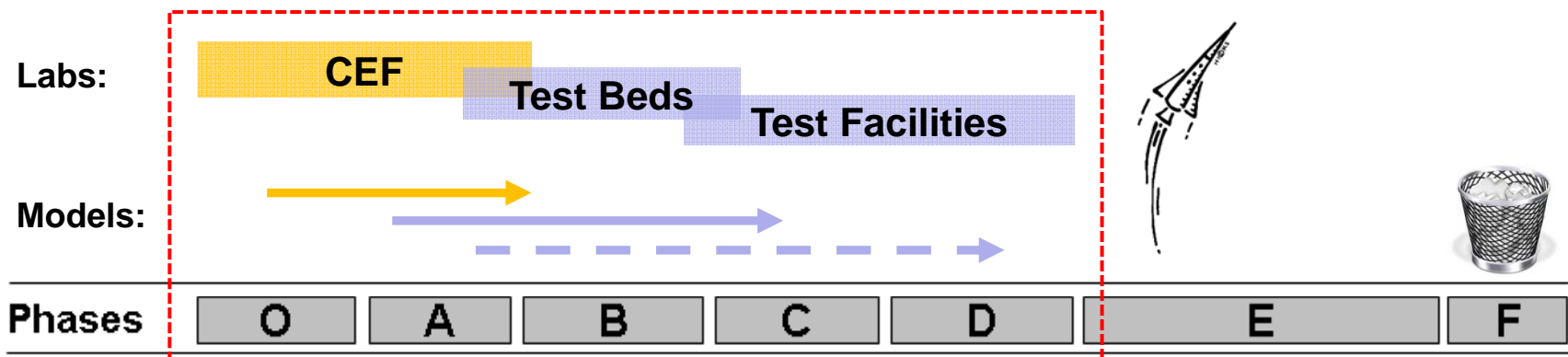


DLR Institute of Space Systems (in brief)

- System Analysis / Systems Technology / Space Projects

- from: Phase 0/A (Mission Need / Feasibility)
- to: Phase D (Production & Qualification)

- What do we do and have?

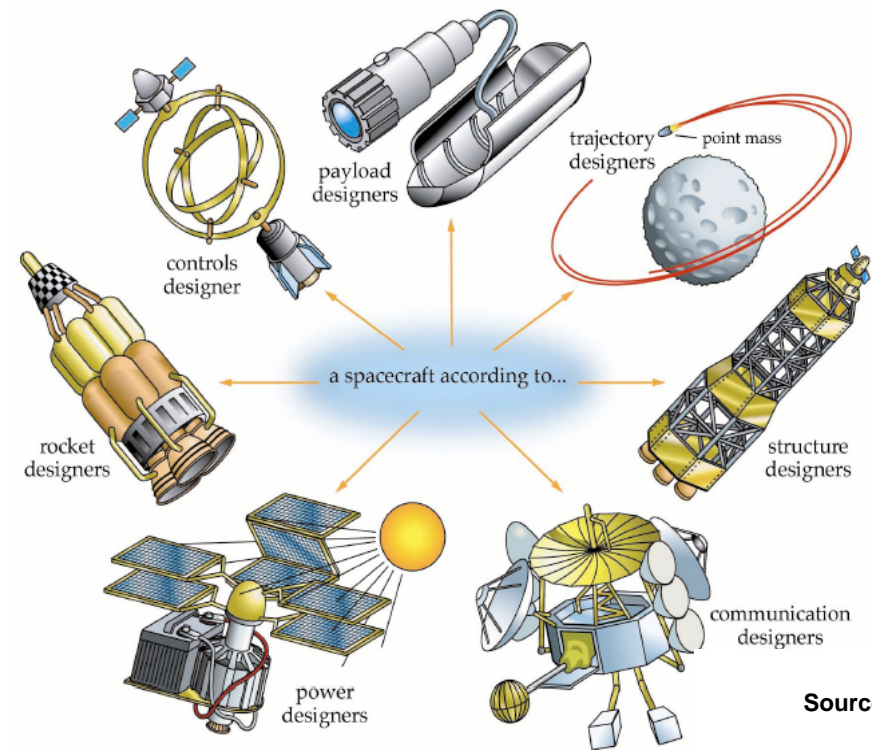


CEF = Concurrent Engineering Facility



Space Systems Engineering

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



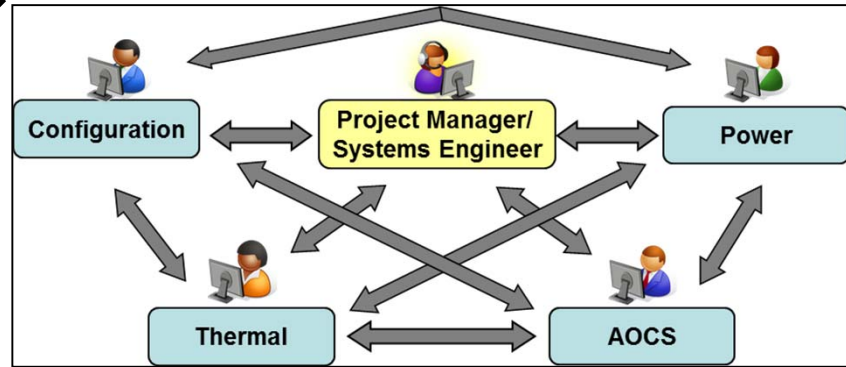
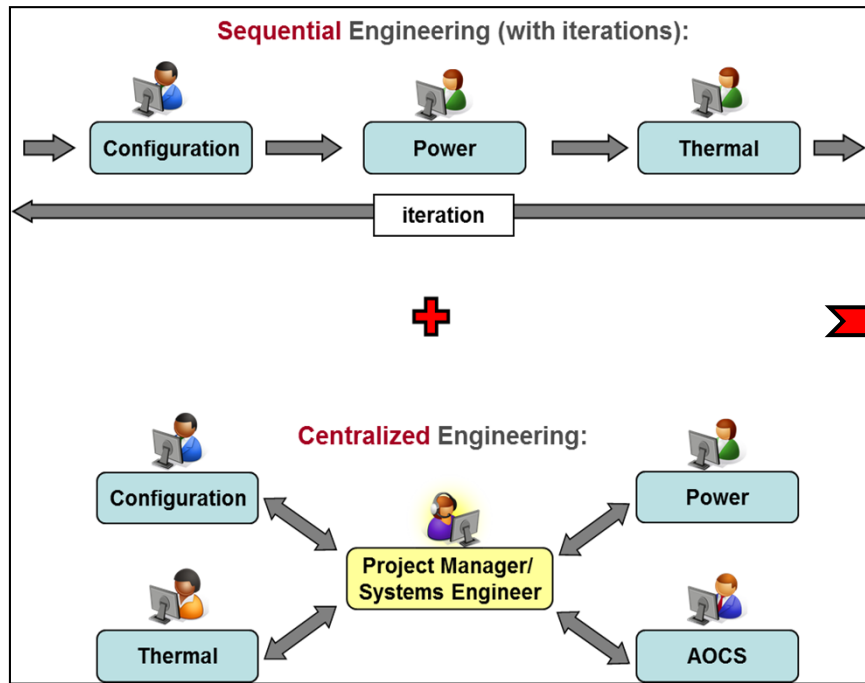
Source:

Robinson, 2008



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The Concurrent Engineering (CE) Process...

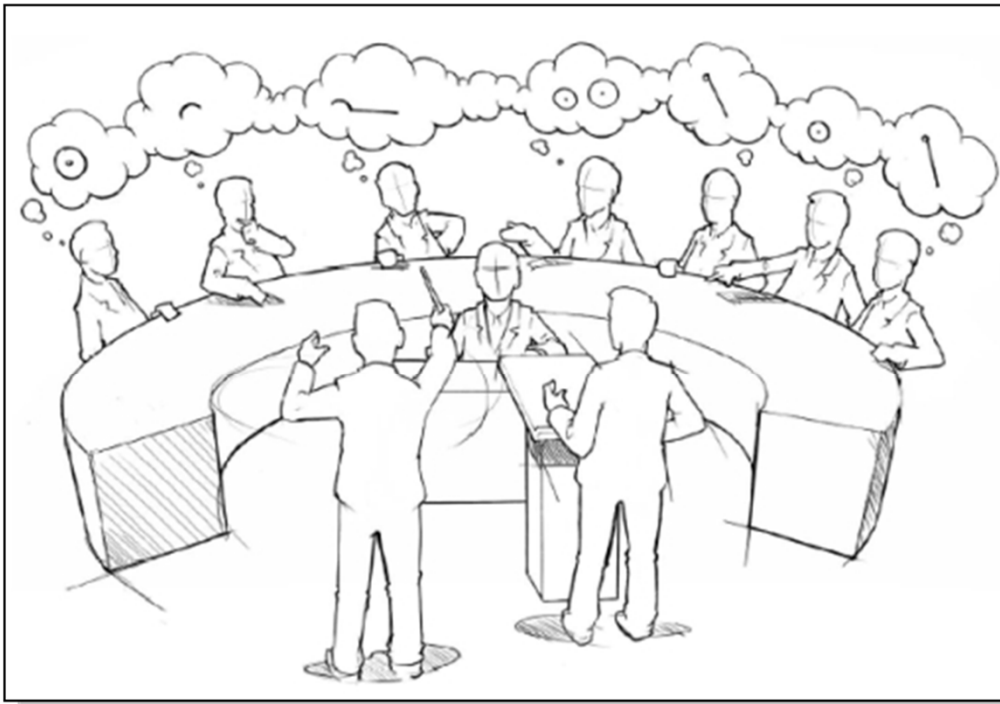


Source: ESA



12

... during **Plenary Sessions:**



Source: JAQAR Concurrent Design Services (J-CDS)

Joint discussions

Presentations

Customer's
Feedback

“Domain round”

System trades

System decisions



DLR



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... during „off-line“ Work:

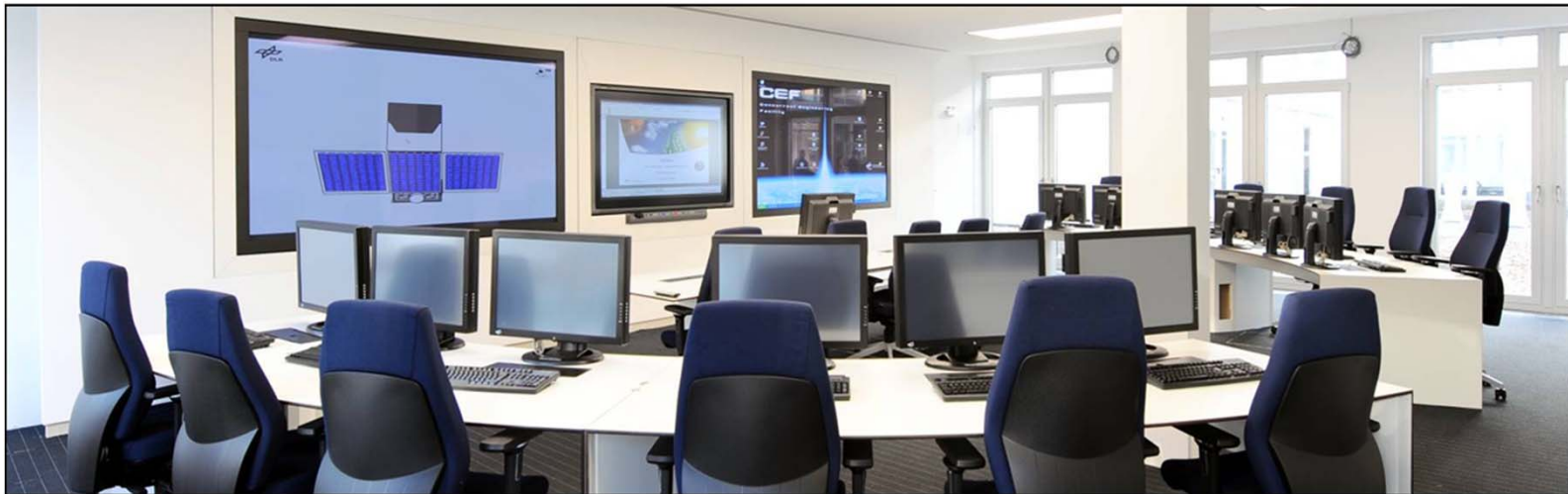
Subsystem trades

Model updates

Design negotiation

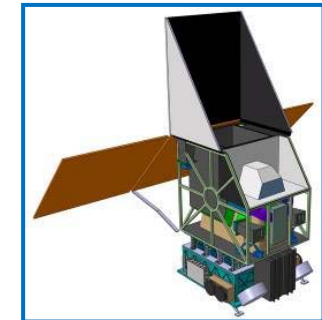
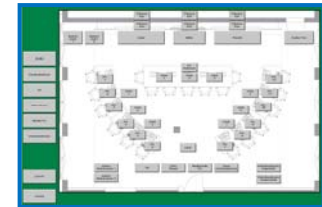
Expert tool use

Part accommodation

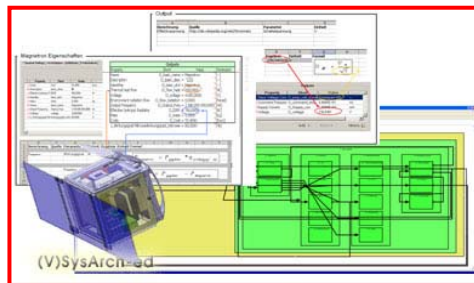


Main Elements of Concurrent Engineering

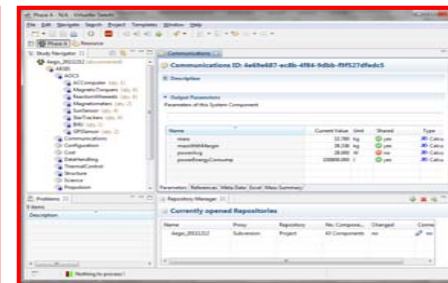
- Infrastructure → Laboratory → *here: CEF*
- Team → Domain Experts; Customer
- Process → Scheduling & Communication
- Tools → Multimedia & domain-specific
- Model → Data-/Design Model



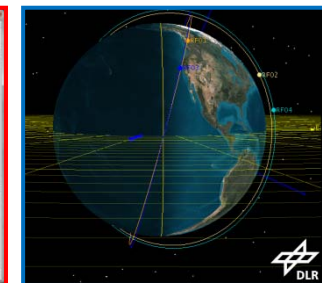
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Source: TU Munich



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)
- OCDDT (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

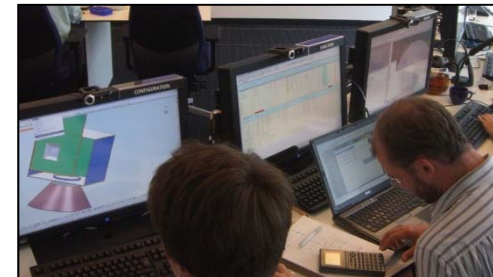
IDM = Integrated Design Model ; CDP = Concurrent Design Platform; OCDDT = Open Concurrent Design Tool; SMAD = Space Mission Analysis & Design



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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... → common understanding
 - graphical elements / visualization
 - 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

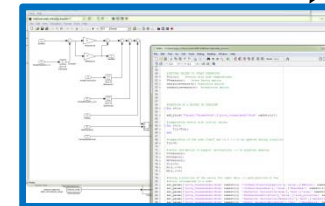
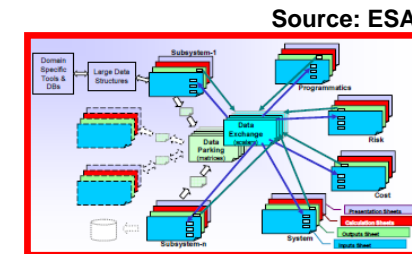
- What shall the model do?
 - What task(s) / functions?
 - Level of detail?
- Who will use it?
 - (Sub)system engineer?
 - Design team,
 - independent / in sequence,
 - or even at the same time?
- Shall the model be re-used?
- Shall the model be upgraded?
- What are the interfaces?
 - In-/outputs?
 -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



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



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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

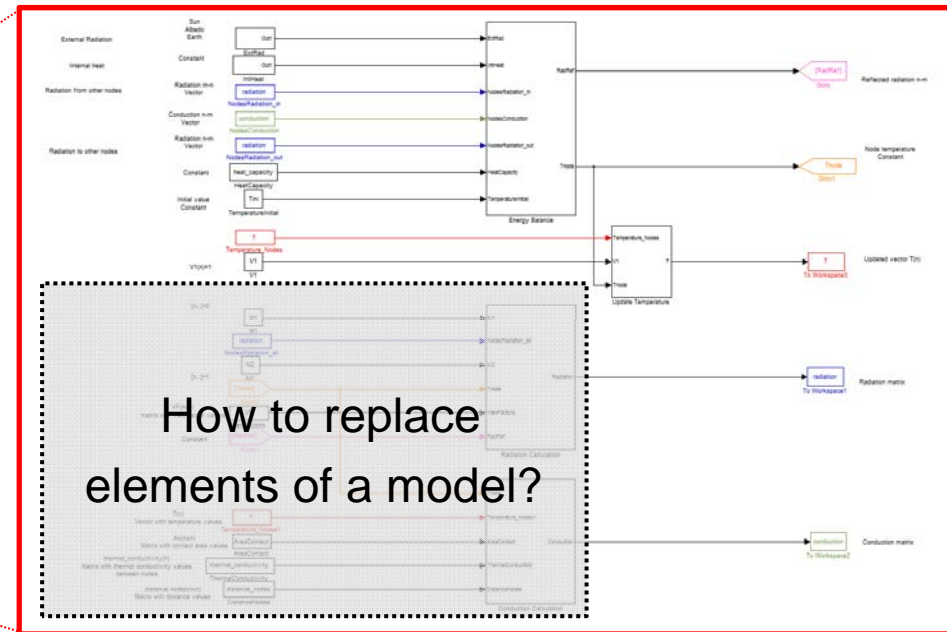
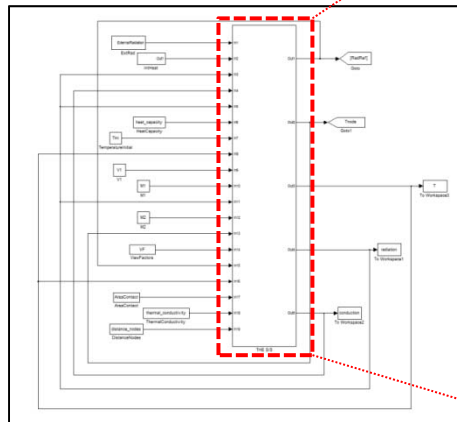


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Our Attempt (I) – (for System „Simulation“)

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

e.g. Thermal Model



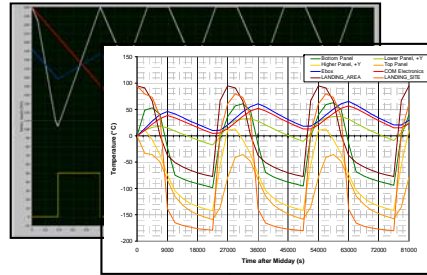
Our Attempt (II)

Simulation Model Architecture planned in DLR CEF

Diagrams

Configuration

Input functions and files

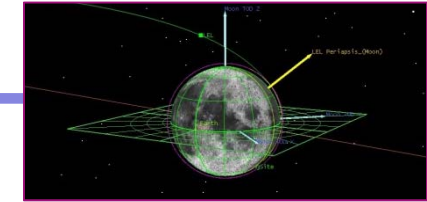


Design-/ Simulation Model

Environment

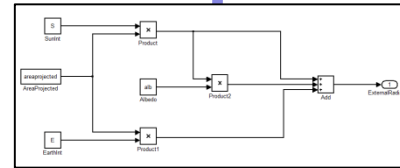
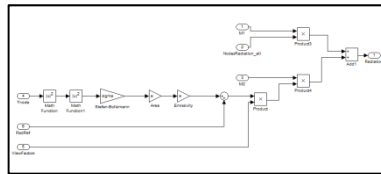
```

Editor: C:\Programme\mat\Document\MATLAB\thermalmodel\process...
File Edit Tool Cell Tools Debug Desktop Window Help
...
44
45
46 VERTICAL VALUES TO START ITERATION
47 T=[1;1]; % INITIAL WITH MODE TEMPERATURE
48 TPARAMETER(1) = VERTICAL VALUES MATRIX
49 RADIATIONPARAMETER(1) = RADIATION MATRIX
50 CONDUCTIONPARAMETER(1) = CONDUCTION MATRIX
51
52
53
54
55
56
57 VERTICALIZATION OF A BLOCKS TO SIMULATION
58 for k=1:1
59     add_block('Thermal/ThermalNode',[sprintf('ThermalNode%d',k)]);
60     %Temperature profile with vertical values
61     for i=1:1
62         T(i)=T(i);
63     end
64 end
65
66 %TEMPERATURE OF THE ROOM STAYS NEG TO 0 -> TO BE UPDATED DURING ITERATION
    
```



Data / Budgets

Part simulations



Estimate 1 - Lunar Exploration Launch					
Block	Name	Target Allocation (Mass) [kg]			%
		Target	Actual	% of Target	
TOTAL	Launch	20000	20000	100.0	100.0
1	Structure	10000	9950	99.50	99.50
2	Powerplant	10000	9950	99.50	99.50
3	Communication	10000	9950	99.50	99.50
4	Thermal Control	10000	9950	99.50	99.50
5	Command and Data	10000	9950	99.50	99.50
6	Propulsion	10000	9950	99.50	99.50
7	Life Support	10000	9950	99.50	99.50
8	Navigation	10000	9950	99.50	99.50
9	Thermal	10000	9950	99.50	99.50
10	Thermal	10000	9950	99.50	99.50
11	Thermal	10000	9950	99.50	99.50
12	Thermal	10000	9950	99.50	99.50
13	Thermal	10000	9950	99.50	99.50
14	Thermal	10000	9950	99.50	99.50
15	Thermal	10000	9950	99.50	99.50
16	Thermal	10000	9950	99.50	99.50
17	Thermal	10000	9950	99.50	99.50
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19	Thermal	10000	9950	99.50	99.50
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46	Thermal	10000	9950	99.50	99.50
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48	Thermal	10000	9950	99.50	99.50
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78	Thermal	10000	9950	99.50	99.50
79	Thermal	10000	9950	99.50	99.50
80	Thermal	10000	9950	99.50	99.50
81	Thermal	10000	9950	99.50	99.50
82	Thermal	10000	9950	99.50	99.50
83	Thermal	10000	9950	99.50	99.50
84	Thermal	10000	9950	99.50	99.50
85	Thermal	10000	9950	99.50	99.50
86	Thermal	10000	9950	99.50	99.50
87	Thermal	10000	9950	99.50	99.50
88	Thermal	10000	9950	99.50	99.50
89	Thermal	10000	9950	99.50	99.50
90	Thermal	10000	9950	99.50	99.50
91	Thermal	10000	9950	99.50	99.50
92	Thermal	10000	9950	99.50	99.50
93	Thermal	10000	9950	99.50	99.50
94	Thermal	10000	9950	99.50	99.50
95	Thermal	10000	9950	99.50	99.50
96	Thermal	10000	9950	99.50	99.50
97	Thermal	10000	9950	99.50	99.50
98	Thermal	10000	9950	99.50	99.50
99	Thermal	10000	9950	99.50	99.50
100	Thermal	10000	9950	99.50	99.50





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 amongst **design team & model developer** required
 - (if not united in one single person...)





Questions?



Source: University of Erfurt

Thank you very much for your attention!

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