



Parameter Analysis of a Concurrent Engineering Satellite Study

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Knowledge for Tomorrow



Content

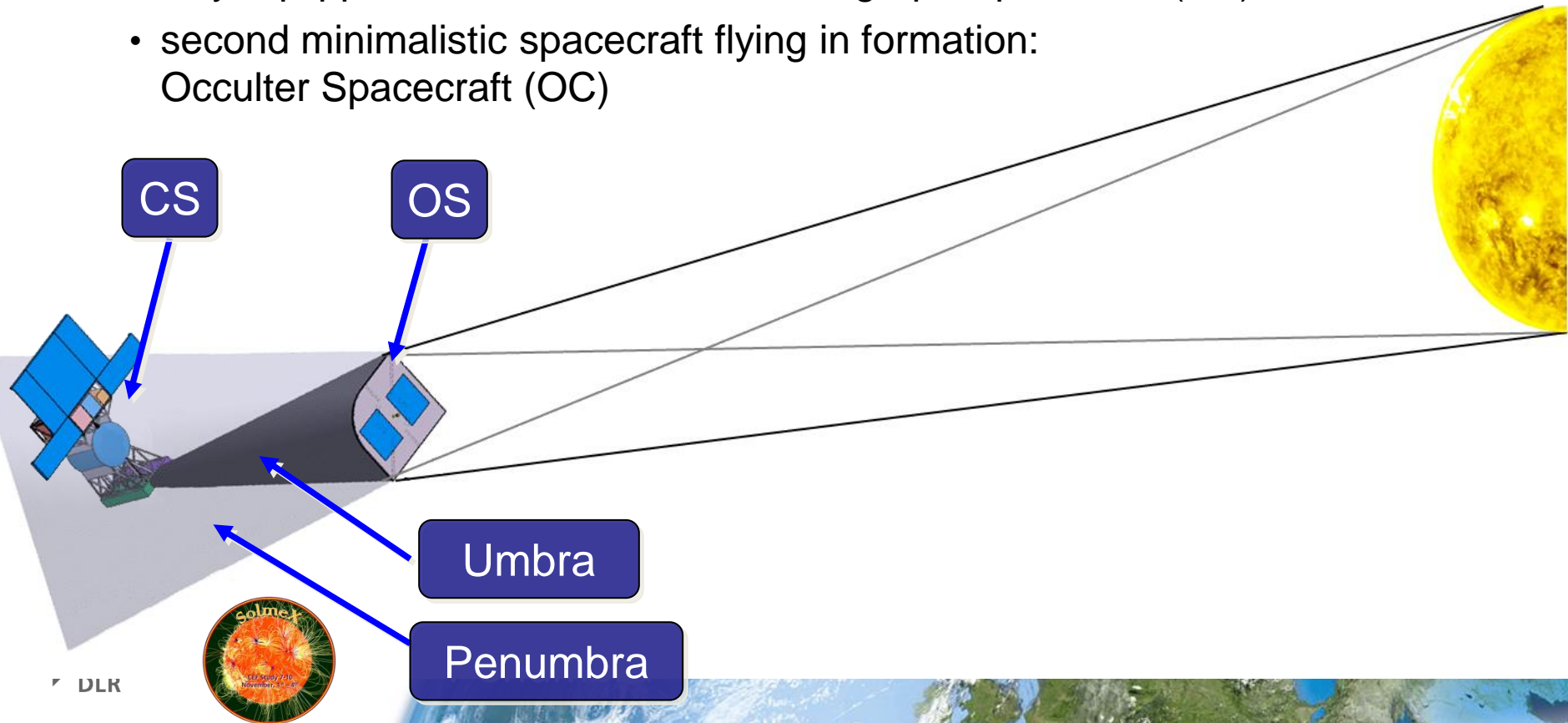
- SolmeX CE Study
 - What is SolmeX?
 - Concurrent Engineering at DLR
 - Integrated design model
- “Main Parameters”
- “Implicit Parameters”
- Parameter Graphs
 - Design Structure Matrix
 - Impacts / Relations
- Discussion
 - Meaning for MDO



SolmeX CE Study

What is SolmeX?

- Solar Magnetism Explorer proposal under lead of the Max Planck Institute for Solar System Research, answering 2010 Cosmic Vision call for M-class mission opportunity in ESA's Science Programme:
 - fully equipped science satellite: Coronagraph Spacecraft (CS)
 - second minimalistic spacecraft flying in formation: Occulter Spacecraft (OC)



SolmeX CE Study

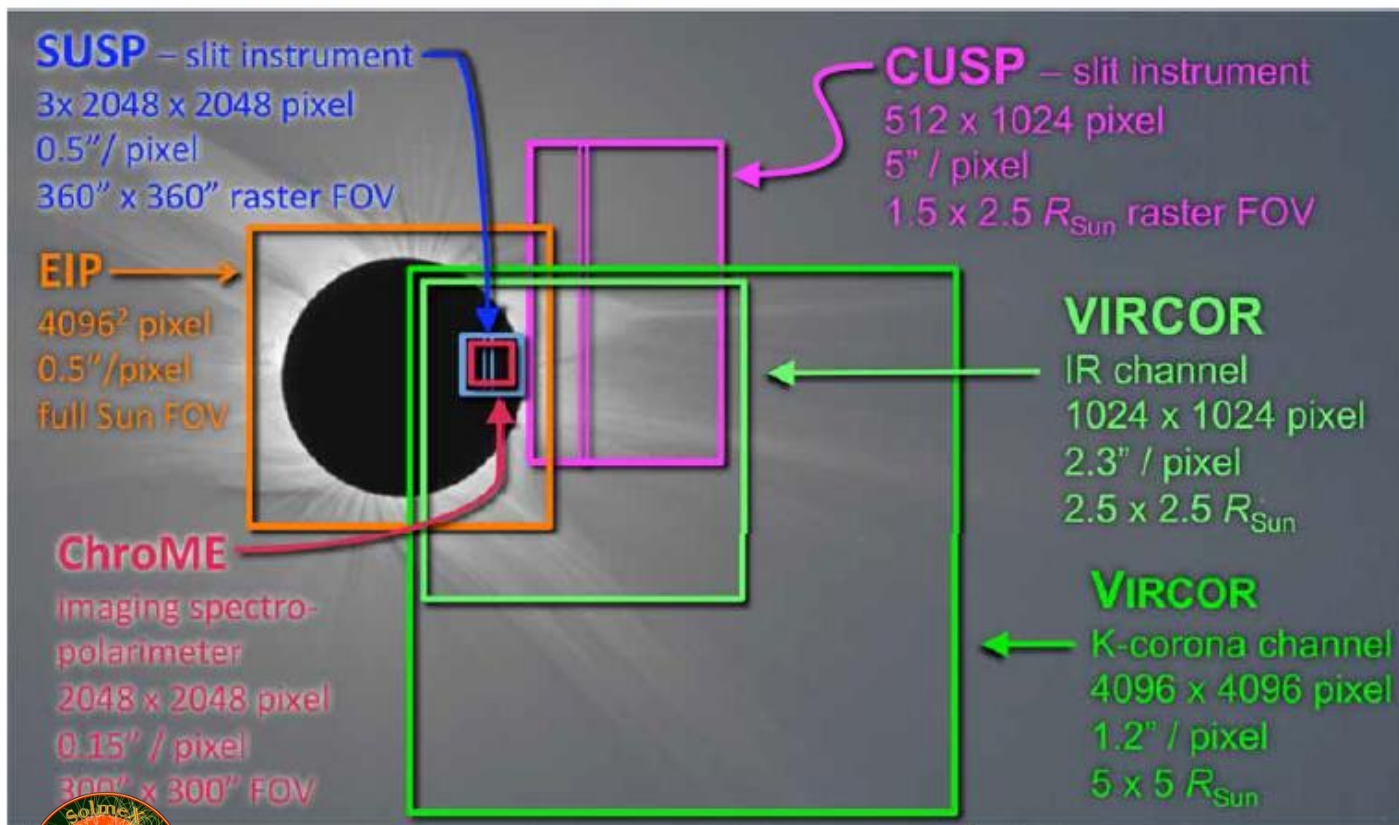
What is SolmeX: Solar Magnetism Explorer

on-disk:

- EIP (EUV imaging polarimeter)
- SUSP (Scanning UV spectro-polarimeter)
- ChroME (Chromospheric magnetic explorer)

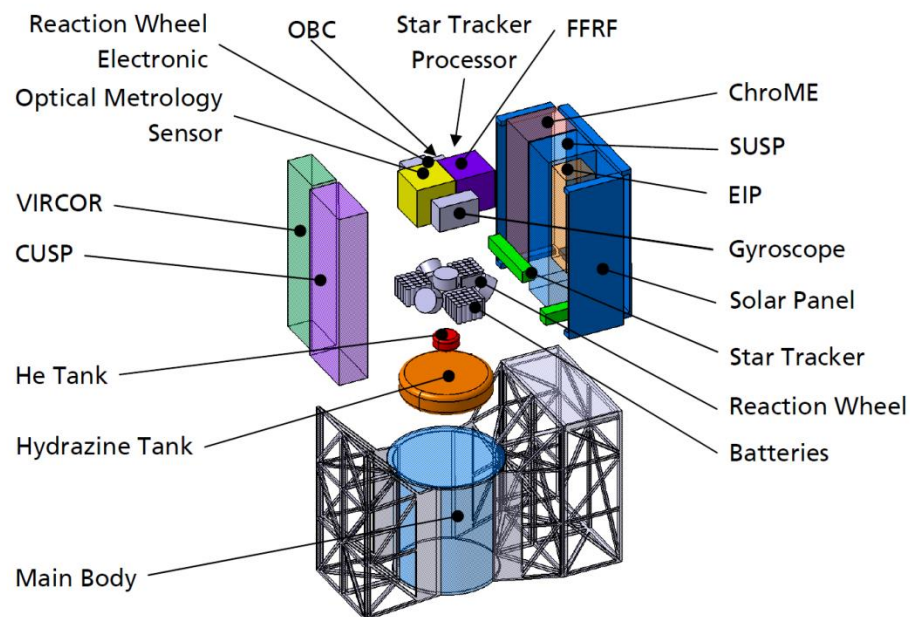
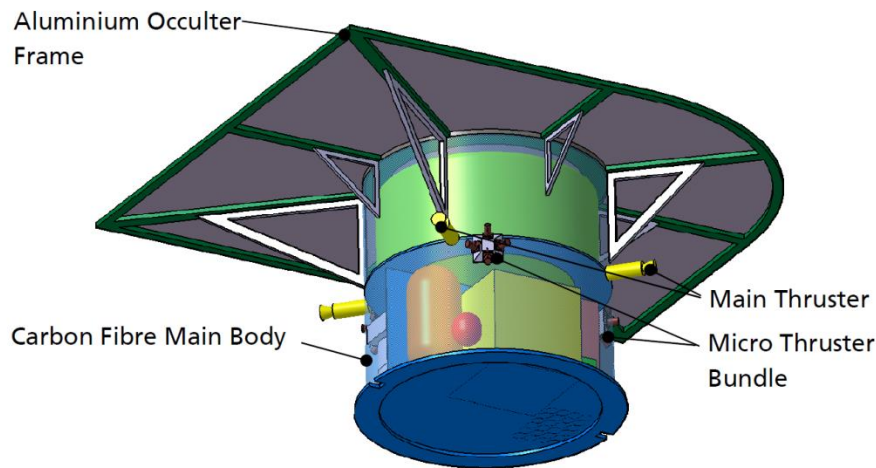
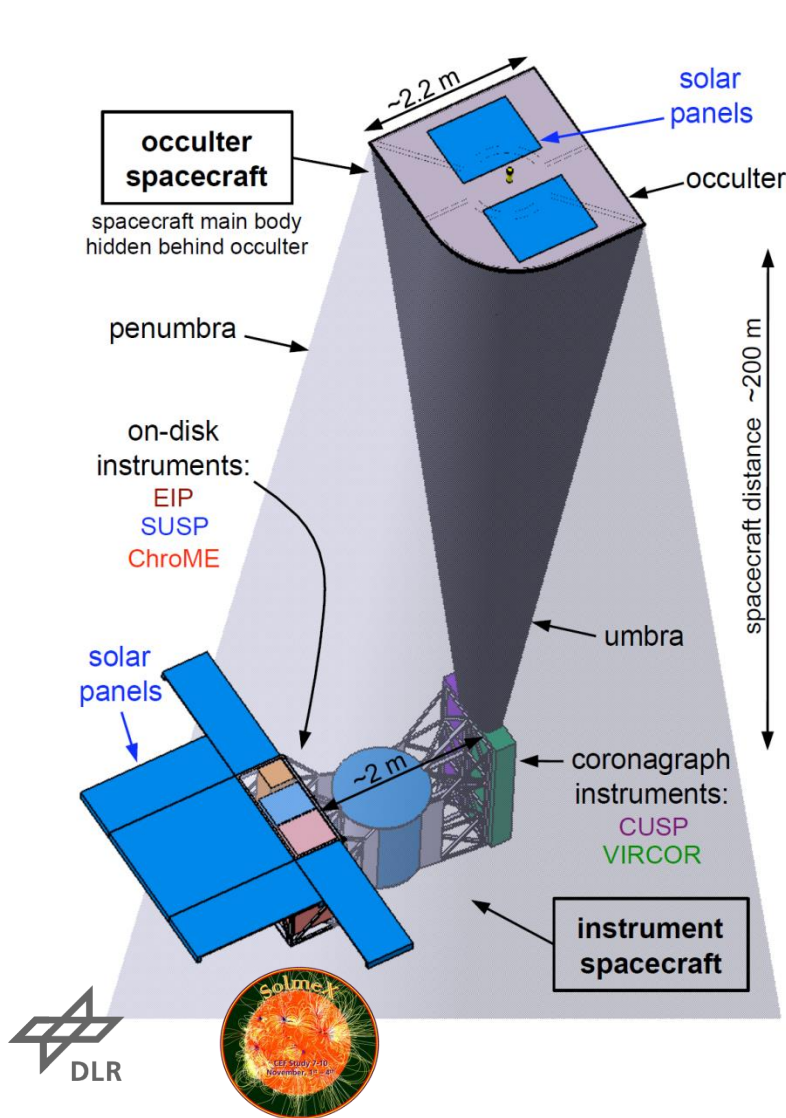
off-limb:

- CUSP (Coronal UV spectro-polarimeter)
- IRCOR (Visible light and IR coronagraph)



SolmeX CE Study

What is SolmeX: Solar Magnetism Explorer

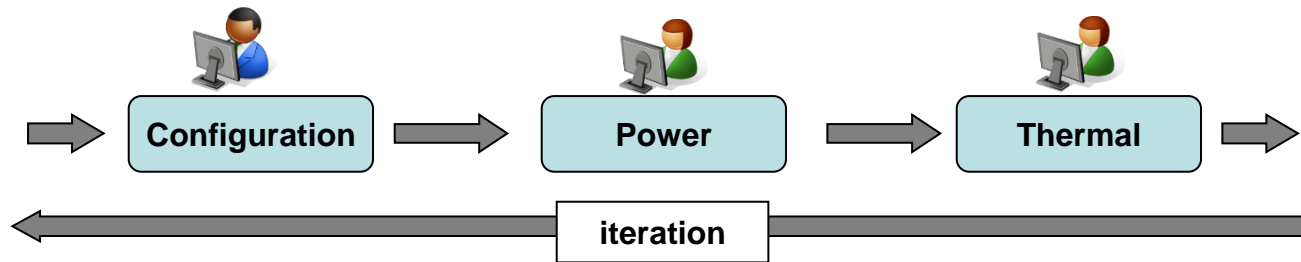


SolmeX CE Study

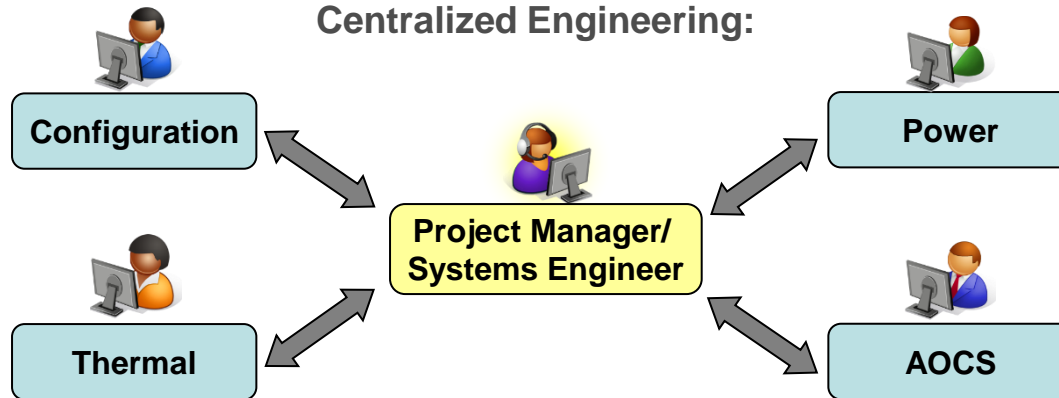
Concurrent Engineering ...is not...

- **Conventional Design / Engineering Processes**

Sequential Engineering (with iterations):



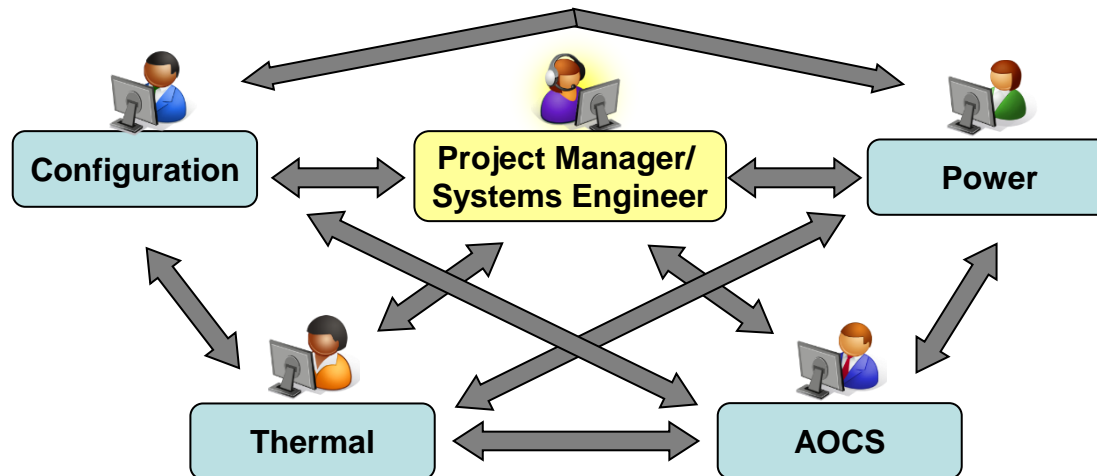
Centralized Engineering:



SolmeX CE Study

...but Concurrent Engineering is...

- **Concurrent Design / Engineering Process**

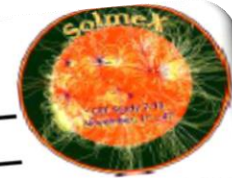


- **The five key elements:**

- Interdisciplinary expert team
- Moderated CE - process
- Integrated design model
- Facility / infrastructure
- Tools (e.g. S/W; multi-media)



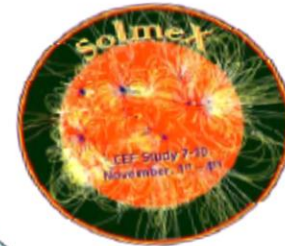
SolmeX CE Study - Schedule



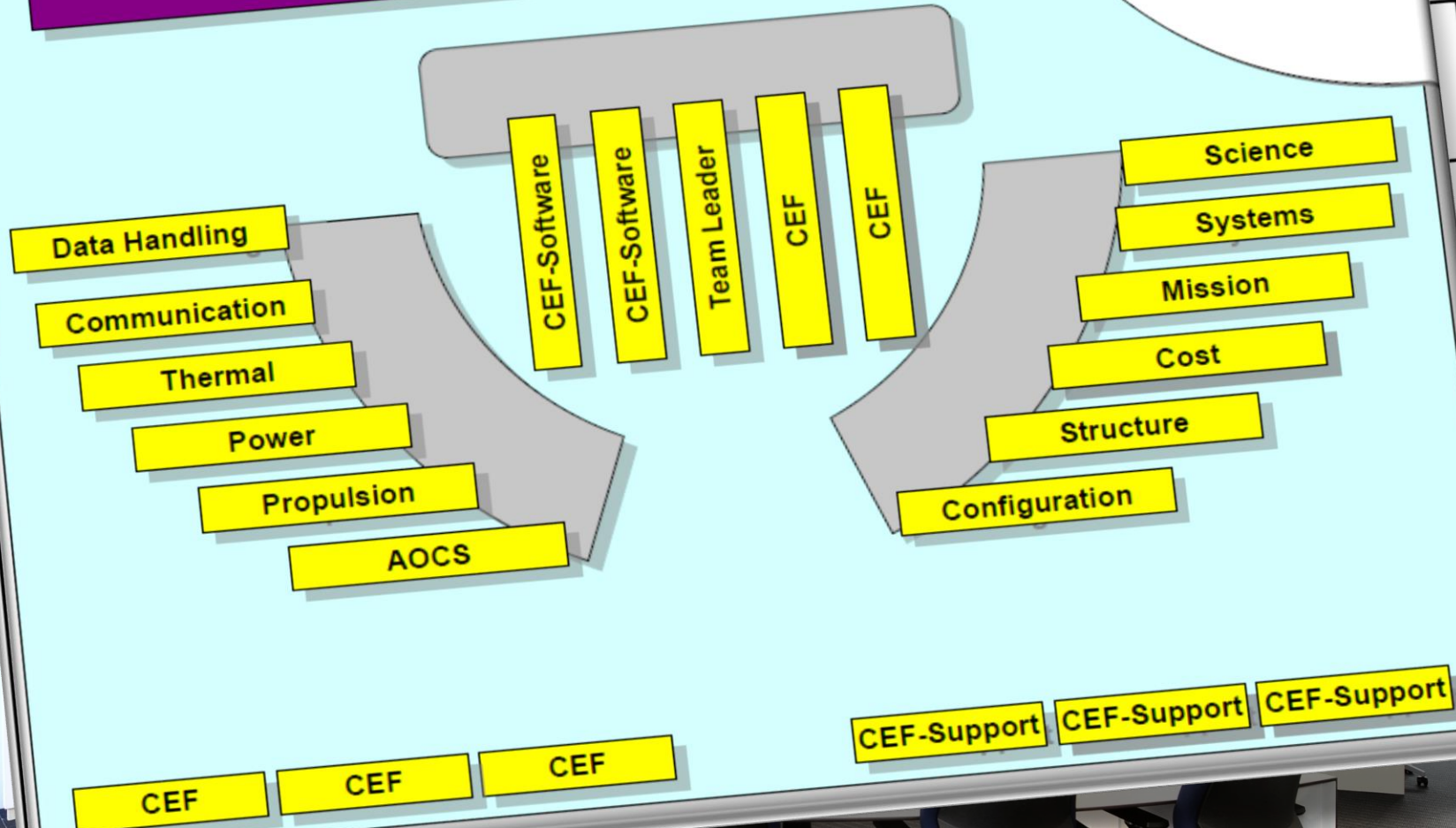
SolmeX CEF Study Schedule CW44-10

	Monday 01.11.2010	Tuesday 02.11.2010	Wednesday 03.11.2010	Thursday 04.11.2010
09:00	Arrival	Postprocessing	Session 3 (Start: 09:30)	Session 4 (Start: 09:30)
10:00				Final Presentations
11:00	Kick-off Presentations	Session 2	Session 3 (Start: 09:30)	Final Presentations
12:00				
13:00	Lunch			
14:00	Session 1	Session 2	Postprocessing / Final Presentation Preparation	Final Presentations
15:00		Postprocessing		Final Presentation Preparation
16:00				
17:00				

SolmeX CE Study - Domains



CEF Study Seating (SolmeX)



SolmeX CE Study

Subsystem Mass Budget of the CS

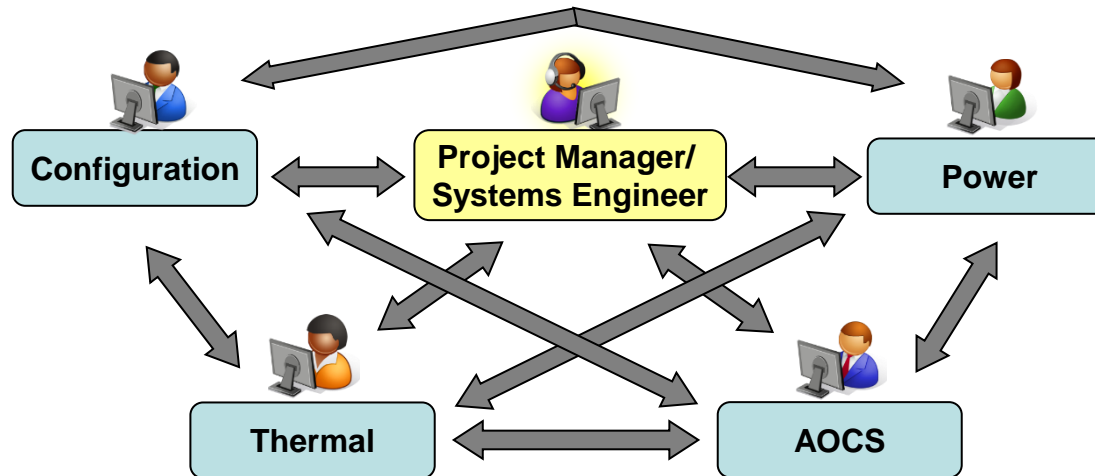
		Session #1			Session #2			Session #3		
Input Mass	Input Margin		Total kg	% of Total	Total kg	% of Total	Total kg	% of Total		
Dry mass contributions										
DI	450,00	Structure	450,00	37,71	450,00	37,37	450,00	45,12		
EL		Thermal Control	30,00	2,51	35,00	2,91	32,71	3,28		
EL		Communications	27,84	2,33	27,84	2,31	20,90	2,10		
EL		Data Handling	4,40	0,37	4,40	0,37	7,70	0,77		
EL		AOCS	33,50	2,81	61,10	5,07	71,18	7,14		
EL		Propulsion	37,13	3,11	294,36	24,45	53,69	5,38		
SST		Power	300,00	25,14	20,88	1,73	50,75	5,09		
EL		Harness	19,00	1,59	19,00	1,58	19,00	1,90		
EL		Instruments	291,48	24,43	291,48	24,21	291,48	29,22		
Total Dry(excl.adapter)			1193,34	kg	1204,05	kg	997,41	kg		
System margin (excl.adapter)			238,67	kg	240,81	kg	199,48	kg		
Total Dry with margin (excl.adapter)			1432,01	kg	1444,86	kg	1196,89	kg		
Other contributions										
Wet mass contributions										
DI	230,00	Propellant	264,00	15,57	478,00	24,86	230,00	16,12		
Adapter mass (including sep. mech.), kg			100,00	0,06	100,00	0,05	100,00	0,07		
Total wet mass (excl.adapter)			1606,01	kg	1922,86	kg	1426,89	kg		
Launch mass (including adapter)			1796,01	kg	2022,86	kg	1526,89	kg		



SolmeX CE Study

...but Concurrent Engineering is...

- **Concurrent Design / Engineering Process**



- **The five key elements:**

- Interdisciplinary expert team
- Moderated CE - process
- **Integrated design model**
- Facility / infrastructure
- Tools (e.g. S/W; multi-media)



SolmeX CE Study

Integrated Design Model

- At date of study (2010) we used ESA's CDF Integrated Design Model (IDM):
Collection of domain specific MS Excel workbooks linked via data exchange and data parking macros

EQ Summary (manual input)

Element	Unit	Unit Name	Quantity	Mass per quantity excl. margin	Maturity Level	Margin	Total Mass incl. margin
Element 1: AsteroidFinderSSB_Option 1	1		0		Fully developed	5	0.0
	2		0		To be modified	10	0.0
	SUBSYSTEM TOTAL			0	0.0	To be developed	-
Element 2: AsteroidFinderSSB_Option 2	1		0		Fully developed	5	0.0
	2		0		To be modified	10	0.0
	SUBSYSTEM TOTAL			0	0.0	To be developed	-

SWITCH (Manual/Linked)

Directly linked

DATA EXCHANGE.XIS

DATA EXCHANGE.XIS

Parameter	Unit Name	Linked Value	Manual Value	External Value
mechanisms example parameter 1	Workcell_EquipParam1	AsteroidFinderSSB		
mechanisms example parameter 2	Workcell_EquipParam2	1200000	220,000	
mechanisms example parameter 3	Workcell_EquipParam3	1000	Memory	
mechanisms example parameter 4	Workcell_EquipParam4	400000	2,000	
mechanisms example parameter 5	Workcell_EquipParam5	100000000	2,000	
mechanisms example parameter 6	Workcell_EquipParam6	50000	2000	
mechanisms example parameter 7	Workcell_EquipParam7	30000	3	

Calculation (Sheets), e.g. Power Budget

Parameter	Cell Name	Internally linked	Manual Value	Units (read comment)	switch
AOCSS Example parameter 1	AOCSS_EquipParam1	0.5000		units	switch
AOCSS Example parameter 2	AOCSS_EquipParam2	200,000		bits	switch
AOCSS Example parameter 3	AOCSS_EquipParam3	Manual_AOCSS		description	switch
AOCSS Example parameter 4	AOCSS_EquipParam4	Manual_AOCSS		description	switch
AOCSS Example parameter 5	AOCSS_EquipParam5	Manual_AOCSS		test run mode	switch
AOCSS Example parameter 6	AOCSS_EquipParam6	Manual_AOCSS		test run mode	switch
AOCSS Example parameter 7	AOCSS_EquipParam7	Manual_AOCSS		test run mode	switch
AOCSS Example parameter 8	AOCSS_EquipParam8	Manual_AOCSS		test run mode	switch

Input-Sheet

Output-Sheet

SWITCH (Manual/Linked)



“Main Parameters”

e.g. Propulsion Subsystem EQ Summary:

- Explicitly entered to the data model:

- Mass
- Dimension
- Temperature
- Power

- Summed up to systems level:

- Total Mass
- Total Power demand (dependent on mode/duty cycle)



Equipment Summary						
View Cell names		Input required				
Hide All Cell names		Calculated value				
View All		Drag down menu				
Mass	Dim	Temp	Power	Risk	Cost	
Add new unit(s)						
Element 1	SolmeX Coronagraph Spacecraft		MASS [kg]			
Unit	Unit Name	Quantity	Mass per quantity excl. margin	Maturity Level	Margin	Total Mass incl. margin
	Click on button above to insert new unit					
1	CHT 10 Thruster	12	0,2	Fully developed	5	3,0
2	N2H4 Tank	1	29,6	To be developed	20	35,6
3	Helium Tank	1	1,1	To be developed	20	1,4
4	He pressuration	1	0,5	Fully developed	5	0,5
5	Heater	1	0,1	Fully developed	5	0,1
6	Valve	1	0,1	Fully developed	5	0,1
-	Click on button below to insert new unit		0,0	To be developed	20	0,0
SUBSYSTEM TOTAL		6	34,3		18,4	40,7
Go to top						
Element 2	-		MASS [kg]			
Unit	Unit Name	Quantity	Mass per quantity excl. margin	Maturity Level	Margin	Total Mass incl. margin
	Click on button above to insert new unit					
1	Helium Tank	1	0,8	To be developed	20	0,9
2	Propellant Tank	1	12,1	To be developed	20	14,6
3	CHT 10 Thruster	6	0,2	Fully developed	5	1,5
4	Cold Gas Tank	1	113,8	To be developed	20	136,6
5	N2 Propellant	1	0,0	Fully developed	5	0,0
6	He pressuration	1	0,8	Fully developed	5	0,8
7	N2 thruster	12	0,2	Fully developed	5	2,5
8	N2H4 Heater	1	0,1	Fully developed	5	0,1
9	N2H4 Valve	1	0,1	Fully developed	5	0,1
-	Click on button below to insert new unit		0,0	To be developed	20	0,0
SUBSYSTEM TOTAL		9	131,5		19,5	157,1
Go to top						

“Implicit Parameters”

- Domain specific parameters:
 - Calculated outside the data model
 - Or via “self-made” calculation sheets

EQ Summary (manual input)

Element 1	AsteroidFinderSSB_Option 1	Quantity	Mass per quantity excl. margin	Maturity Level	Margin	Total Mass incl. margin	
1		0		Fully developed	5	0.0	
2		0		To be modified	10	0.0	
SUBSYSTEM TOTAL							0 0.0

SWITCH (Manual/Linked)

Directly linked

Calculation (Sheets), e.g. Power Budget

Unit Name	Quantity	Power	...
...

Output-Sheet

SWITCH (Manual/Linked)

DATA EXCHANGE.XIS

DATA EXCHANGE.XIS

Parameter	Standard Reference	Linked Value	Manual Value	External
mechanisms example parameter 1	Wrench_EnglParam	400000 [N]	400000	not used

Input-Sheet

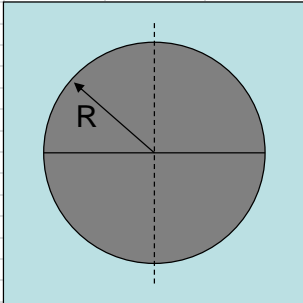
Parameter	Cell Name	Internally linked	Manual Value	Units (read comment)	Switch
DO NOT ADD ROWS ABOVE THIS ROW	...	CHECK UNITS!	CHECK UNITS!	CHECK UNITS!	



“Main vs. Implicit Parameters”

- e.g. Propulsion Subsystem:
 - Components:
 - Thruster
 - Tank → Main Parameters: Tank Mass, Dimensions, Temperature
 - Heater
 - Valve

This sheet calculates mass for a spherical COPV (composite over wrapped pressure vessel) tank.	
STA 6AI-4V Ti	
Input Values	
Volume [m ³]	0,09326235
Pressure [bar]	16,2
Safety factor for pressure [-]	2
Tensile strenght of composite [N/mm ²]	923,897477
Safety factor for tensile stress [-]	2
Wall thickness of liner [m]	0
Density of composite material [kg/m ³]	4428,784
Density of liner material [kg/m ³]	0
Factor "spars & bolts" [-]	1,2
Margin [%]	20
Output values	
R [m]	0,28132343
Max. permitted tensile stress [N/mm ²]	461,948739
Layout pressure [bar]	32,4
Composite thickness [m]	0,00098657
Composite material mass [kg]	4,34543567
Liner material mass [kg]	0
Pure tank mass [kg]	4,34543567
(without margin and spars & bolts factor)	
Total tank mass [kg]	6,25742736
(including margin and spars & bolts factor)	



$$r = \sqrt[3]{\frac{3V}{4\pi}}$$

$$t = \frac{p \cdot r}{2 \cdot \sigma} \cdot \frac{1}{10}$$

$$m_{comp} = 4 \cdot \pi \cdot r^2 \cdot t_{comp} \cdot \rho_{comp}$$

$$m_{lin} = 4 \cdot \pi \cdot r^2 \cdot t_{lin} \cdot \rho_{lin}$$

NOTES:

It is assumed that the pressure loads will be carried by the composite material alone; the liner serves only for sealing purposes.

The margin will be applied, when the spars and bolts factor has already been added.

“Main vs. Implicit Parameters”

$$m_{\text{tank}} = 4 \pi r^2 t \rho_{\text{tank}} = \frac{3}{20} \cdot \frac{p \rho_{\text{tank}}}{\rho_{\text{propellant}} \sigma} \cdot m_{\text{launch}} \left(1 - \frac{1}{e^{(\Delta v/c)}} \right)$$

$$r = \left(\frac{3 V_{\text{propellant}}}{4 \pi} \right)^{1/3}$$

$$V_{\text{propellant}} = \frac{m_{\text{propellant}}}{\rho_{\text{propellant}}}$$

$$m_{\text{propellant}} = m_{\text{launch}} \left(1 - \frac{1}{e^{(\Delta v/c)}} \right)$$

$$t = \frac{1}{10} \cdot \frac{p r}{2 \sigma}$$



“Main vs. Implicit Parameters”

$$m_{tank} = 4 \pi r^2 t \rho_{tank} = \frac{3}{20} \cdot \frac{p \rho_{tank}}{\rho_{propellant} \sigma} \cdot m_{launch} \left(1 - \frac{1}{e^{(\Delta v/c)}} \right)$$

Main Parameter
Input

Implicit
Parameters

Main Parameter
Output

Systems → Launch Mass:
 m_{launch}

tank pressure p

Propulsion → Tank Mass:
 m_{tank}

Mission Analysis
→ Δv

density of tank material ρ_{tank}

Propulsion → Tank Radius:
 r

tensile strength of tank material σ

thruster exhaust velocity c

Propulsion → Thickness
of Tank Wall: t

density of propellant $\rho_{propellant}$

→ 10 parameters for tank design + temperature parameters



Source: Bachelor Thesis
 Florian Ruhhammer *

Parameter Graphs - Collection of Study Parameters

Propulsion

Power

$$m_{evs_sp} = A \cdot t \cdot \rho \quad m_{evs_sp} = A \cdot F_{spec}$$

Thermal

$$Q_{int} + \alpha \cdot \sigma \cdot T_H^4 \cdot F_p = \sigma \cdot \epsilon \cdot T^4 \cdot F_{rad}$$

Communication

$$m_{kom} = \psi \cdot (\pi \cdot D^2 \cdot \eta \cdot 0,25) \cdot t \cdot \rho$$

$$GAIN_t = \frac{A_{eff} \cdot (4\pi)}{\lambda^2} \quad W_f = \frac{P \cdot L_l \cdot G_t \cdot L_a}{4\pi \cdot r_{trans}^2}$$

$$C = \frac{P \cdot L_l \cdot G_t \cdot L_a \cdot D_r^2 \cdot \eta}{16 \cdot r^2} \quad R_{max} = B \cdot \log_2 \left(1 + \frac{C}{N} \right)$$

$$\frac{D \cdot Margin}{F \cdot T_{max} - T_{int}} = B \cdot \log_2 \left(1 + \frac{C}{N} \right) \quad R = \frac{D \cdot Margin}{F \cdot T_{max} - T_{int}}$$

$$m_{kom} = \psi \cdot t \cdot \rho \cdot \frac{\lambda^2}{(4\pi)} \left(2^{\frac{D \cdot Margin}{B \cdot F \cdot (T_{max} - T_{int})}} - 1 \right) \cdot \frac{N \cdot (4 \cdot \pi \cdot r)^2}{\lambda^2 \cdot P \cdot L_l \cdot L_a \cdot GAIN_r}$$

$$\left(1 - \frac{1}{e^{(\Delta v/c)}} \right)$$

$$\frac{AU^2}{DoD[\%]}$$

$$\cdot F_p$$

$$\cdot E_{spec}$$

* Untersuchung des Parameterraums einer Concurrent-Engineering-Studie
 FH Aachen, DLR-Bremen, 2011



Parameter Graphs - Formulary

i	name	equation	dimension	relations / dependencies
1	coverage / contact times	$A = (P/180^\circ) \cos^{-1}(\cos \lambda_{max} / \cos \lambda)$	[s]	5,44
2	absorbitivity	$P_{\alpha\lambda} = \alpha \cdot S \cdot A_p$	[W]	4,5,6,12,30,36,37,38,44,46 57,64,68,69,71,78,83,89,102,108 113,114,115
3	antenna gain	$G_A = 4\pi\eta A_p / \lambda$		2,4,5,6,7,12,30,33,36,37 38,39,44,46,57,60,64,68,69,83 89,90,98,102,108,113,114,115,118
4	argument of perigee	ω	[°]	
	inclination	i		
			[m ³]	2,4,5,6,8,12,18,26,30,36 37,38,42,44,46,57,64,65,68,69 71,78,89,102,103,107,108,114,115
114	true anomaly	v	[°]	
115	heat flux	$\dot{Q} = \sum f(\Delta T)$	[W/s]	2,4,5,12,26,30,36,37,38,44 46,57,69,71,78,83,89,102,103,107 108,113,114
116	maintenance cycle			
117	angular velocity	$v = \dot{r}$	[m/s]	
118	efficiency	η	[%]	
119	cycle life	$\Delta t = t_{0_on} - t_{0+1_off}$	[s]	

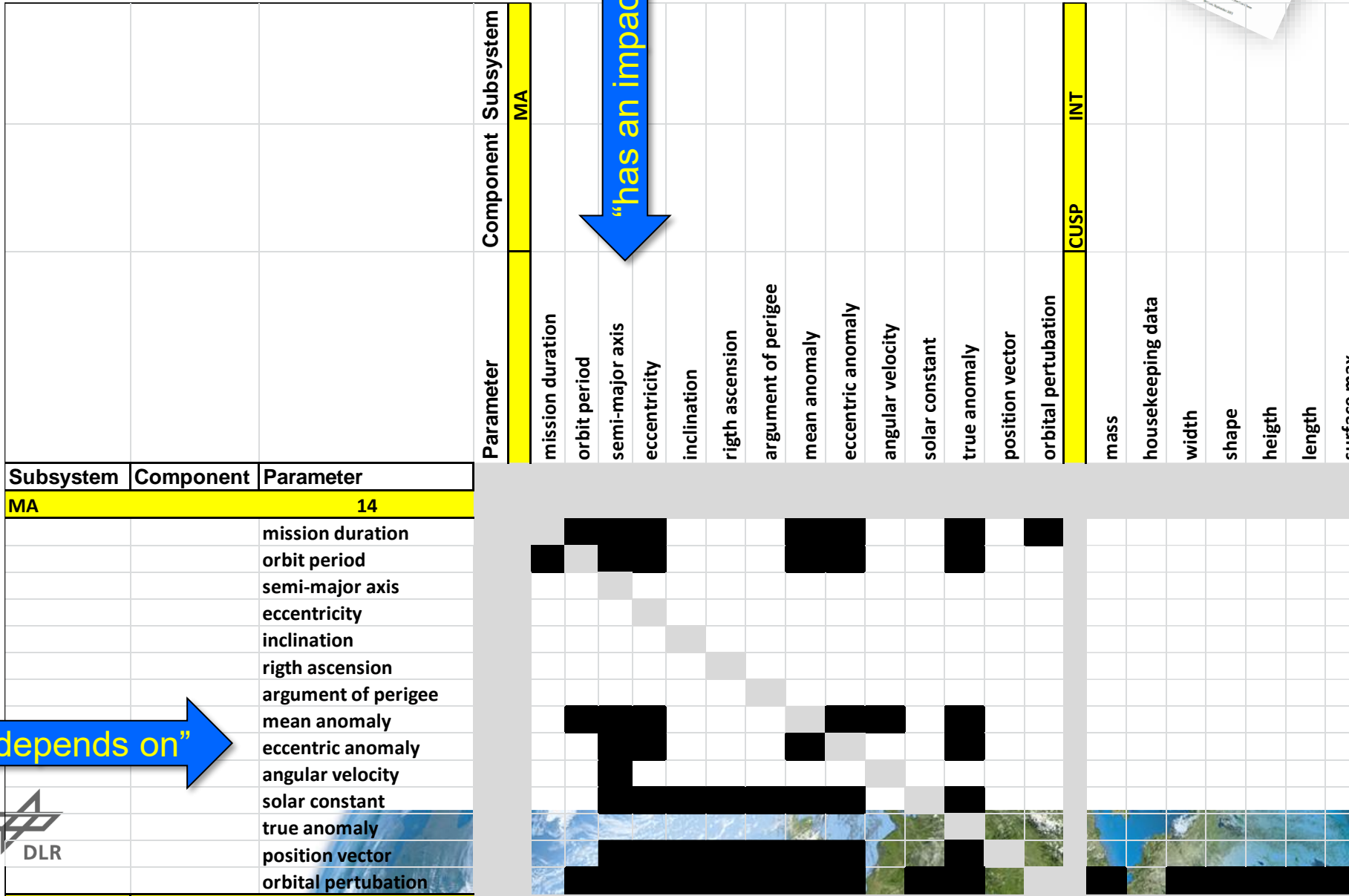
Parameter Graphs – Relations per Parameter per Component

i	Subsystem	Component	Parameter	Relations
	propulsion			
420		tank		
421			mass	16,37,58,79,100,121,126,152,179,233,256 283,301,318,339,358,381,397,412,413,414,415 416,418,422,423,424,425,426,427,428,434
422			housekeeping data	
423			width	1,2,3,4,5,6,7,8,9,11,12 413,414,418,420,423,424,425,426,427,428,429 430,431,432,433,434
424			density	1,2,3,4,8,9,11,12,412,413,414 415,416,418,420,422,424,425,426,427,428,429 430,431,432,433,434
425			shape	3,4,5,6,7,8,9,11,12,413,414 418,422,423,425,426,427,428,429,430,431,432 433,434
426			height	1,2,3,4,5,6,7,8,9,11,12 413,414,418,420,422,423,424,426,428,429,430 431,432,433,434
427			length	1,2,3,4,5,6,7,8,9,11,12 413,414,418,420,422,423,424,425,427,428,429 430,431,432,433,434
428			surface me	



Source: Bachelor Thesis
 Florian Ruhhammer
 Universität Bremen

Parameter Graphs – Design Structure Matrix (Adjacency Matrix)



“has an impact on”

“depends on”



Parameter Graphs – Design Structure Matrix (Adjacency Matrix)

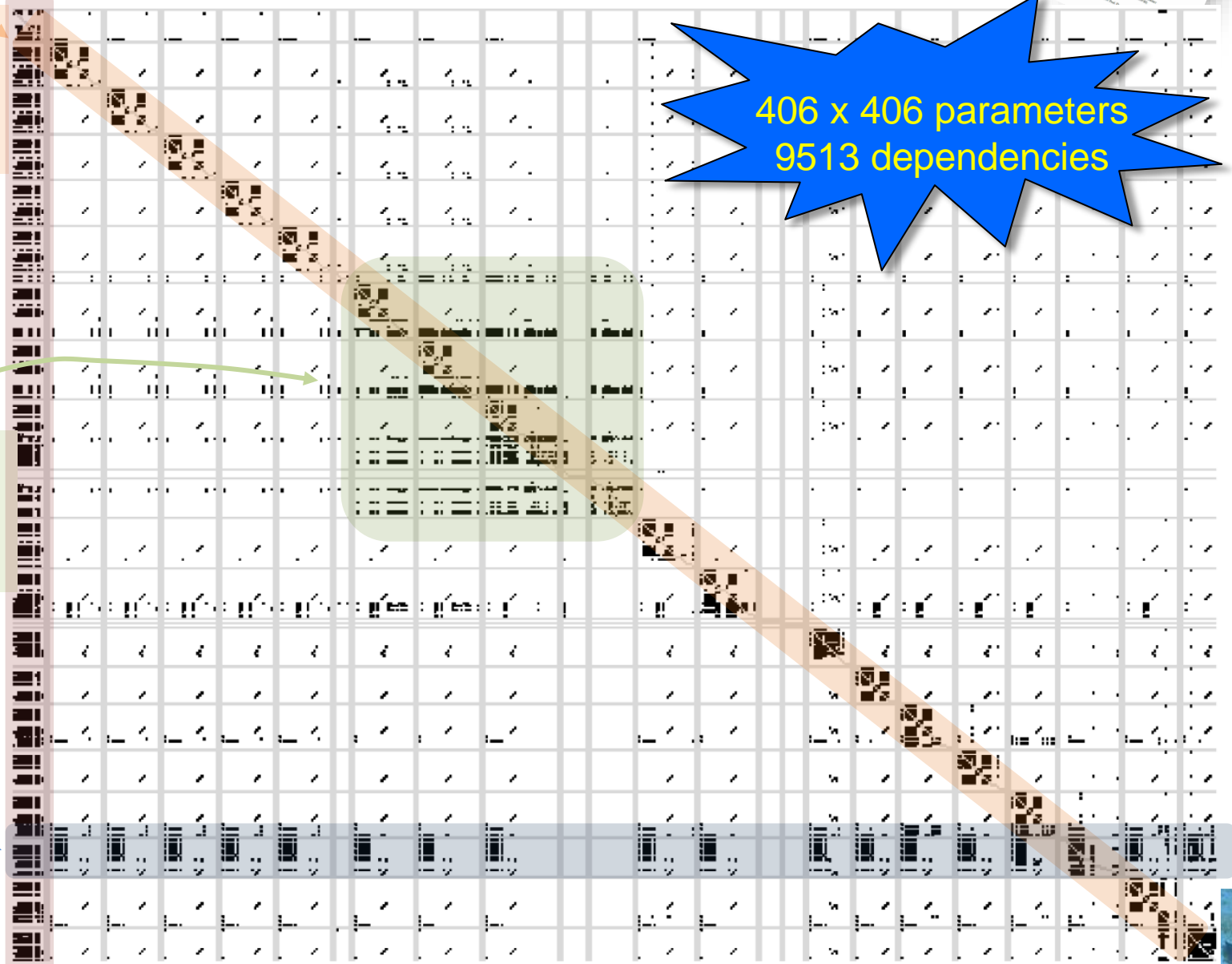
Domain-specific parameters

Mission Analysis

Data Handling & Communication

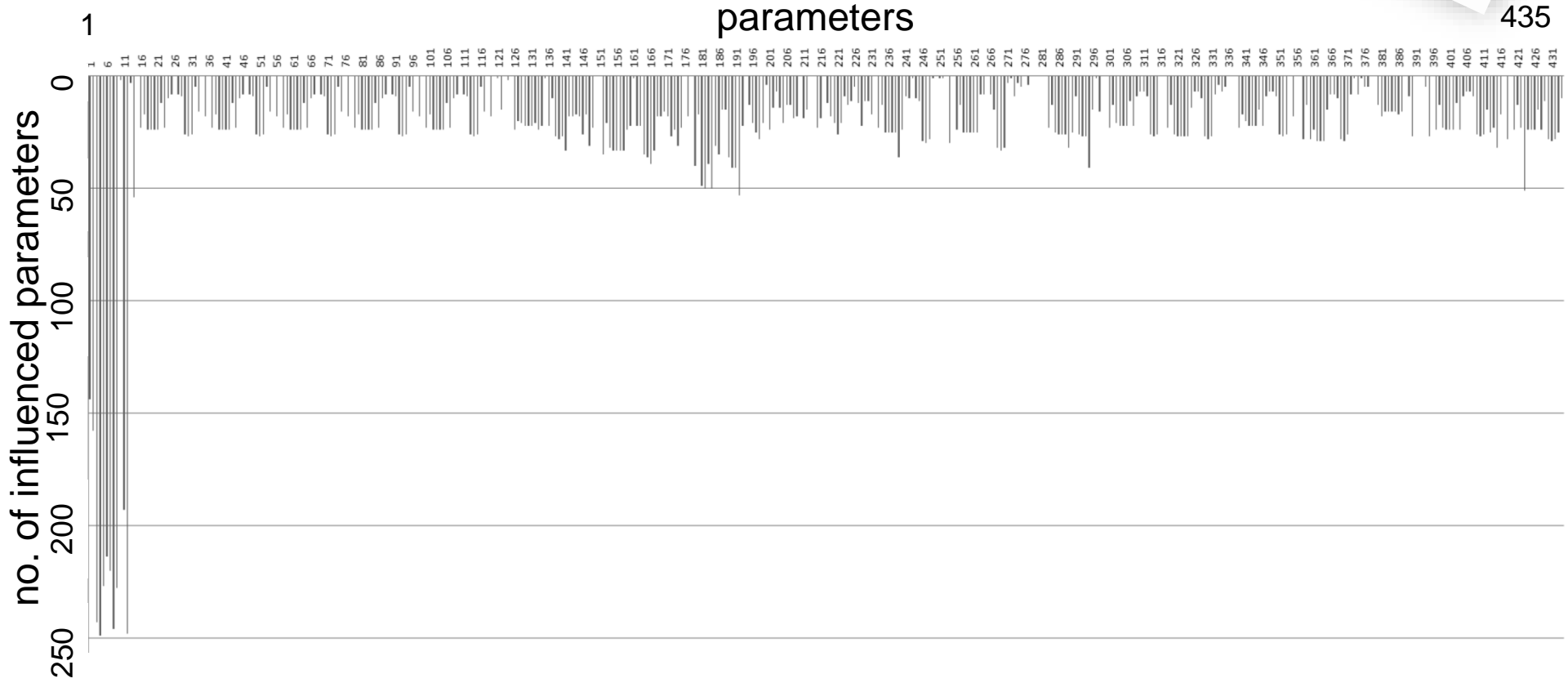
Configuration

406 x 406 parameters
9513 dependencies



Source: Bachelor Thesis
Florian Ruhhammer

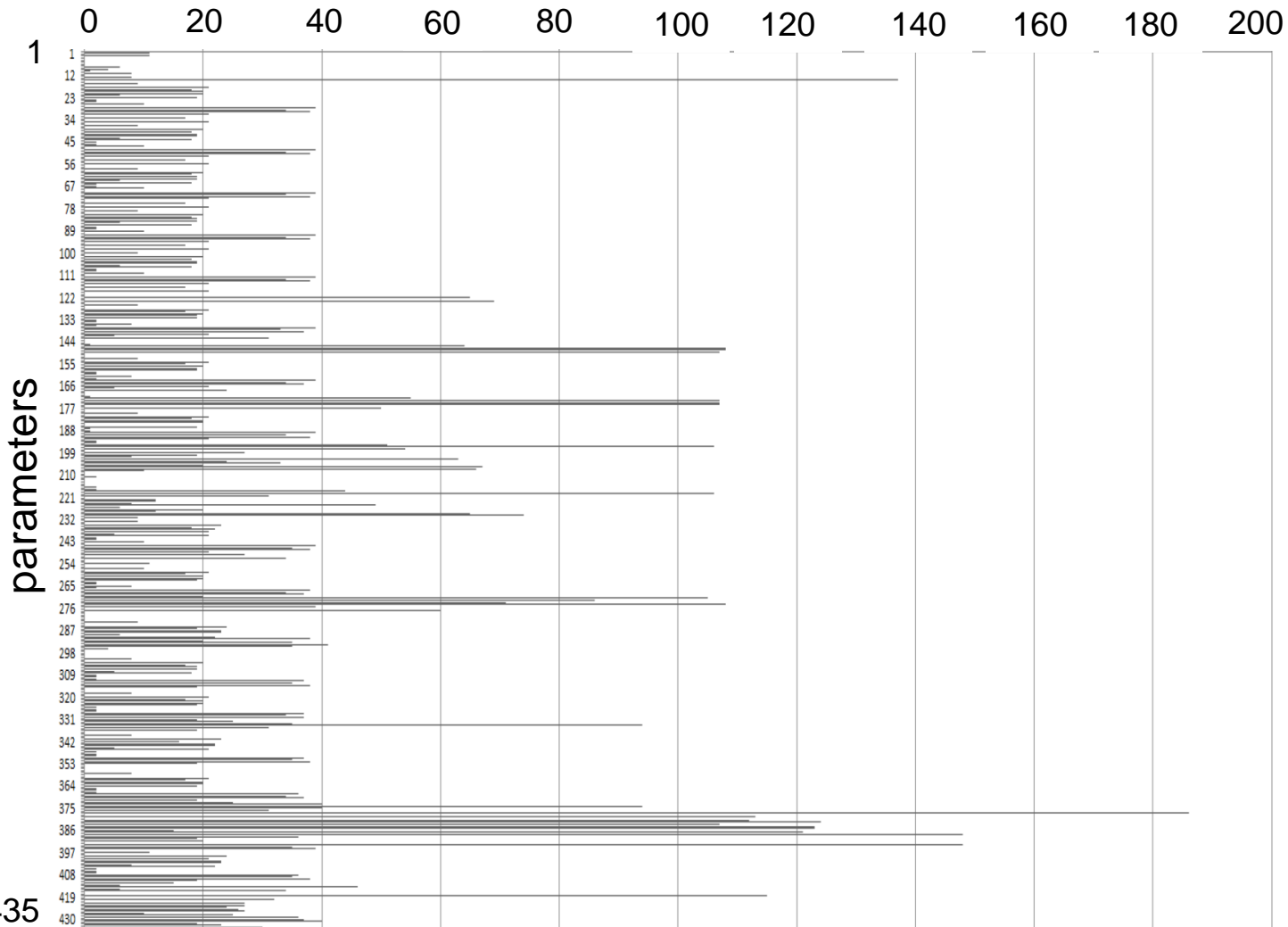
Parameter Graphs – DSM: Impacts



Source: Bachelor Thesis
Florian Ruhhammer

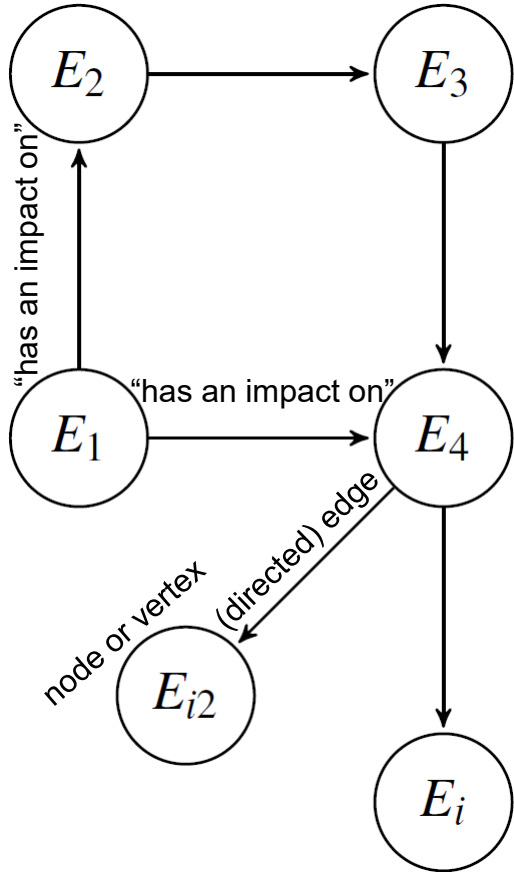
Parameter Graphs – DSM: Dependencies

no. of influencing parameters

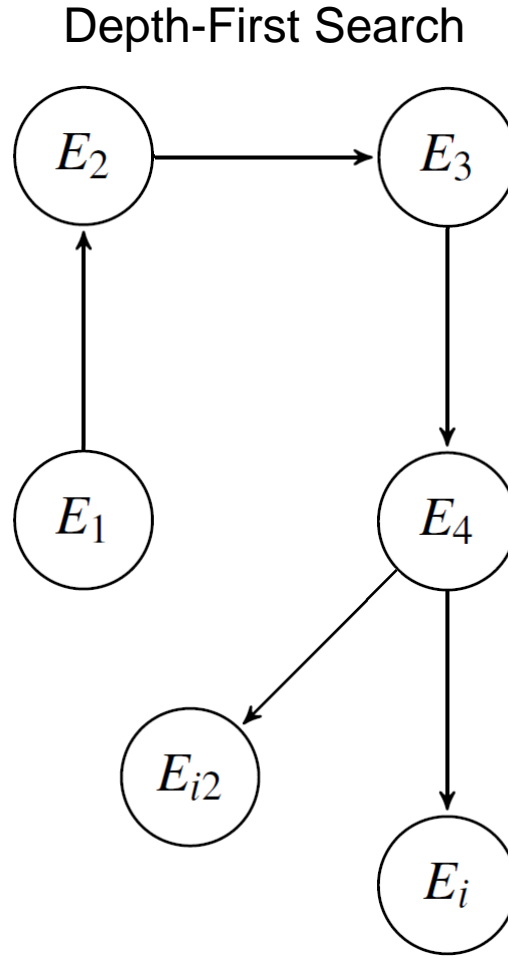


Source: Bachelor Thesis
Florian Ruhhammer

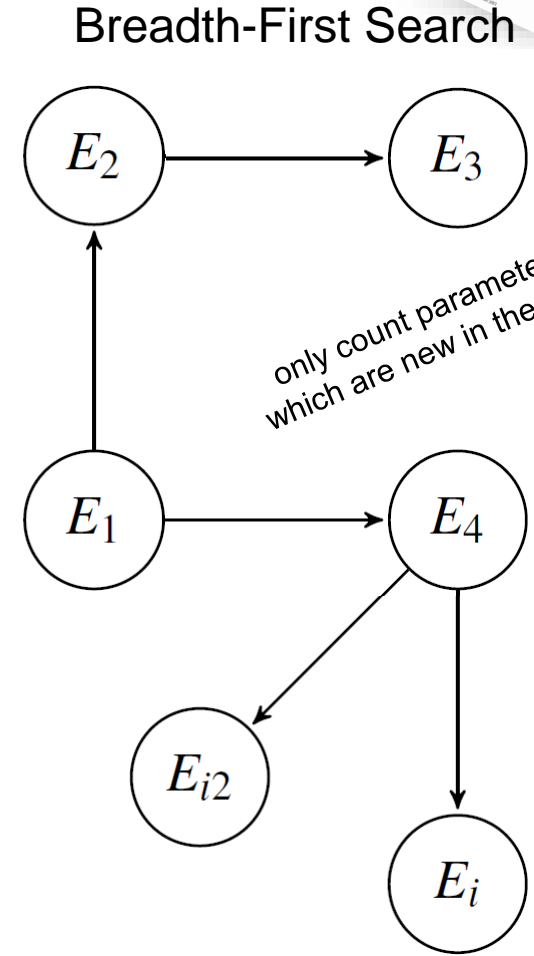
Parameter Graphs



Graph Data Structure



Depth: 4



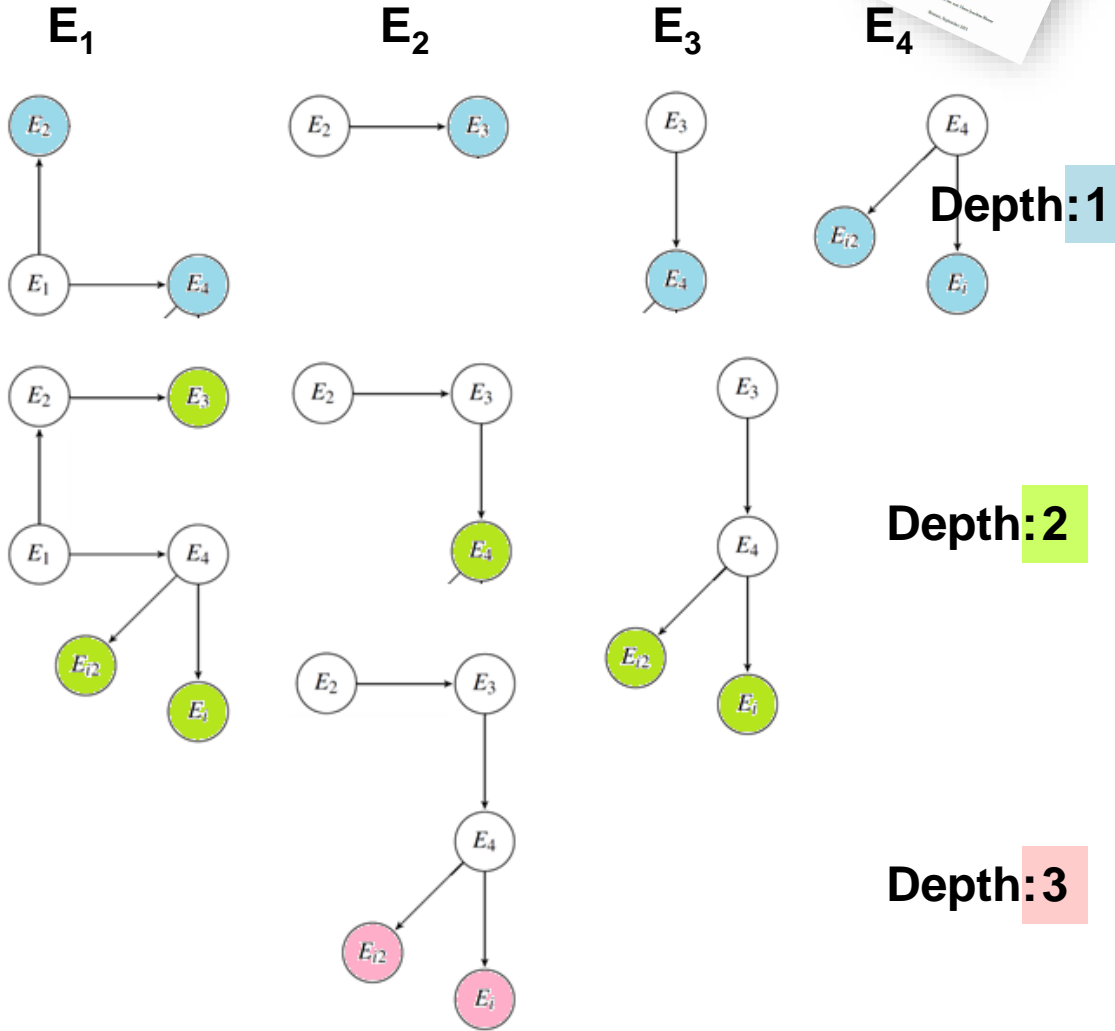
Depth: 2



Source: Bachelor Thesis
 Florian Ruhhammer
 (Breadth-First Search)

Parameter Graphs – Impacts on Parameters

Depth	Hits Total	Max	Min	Ratio to 1. depth occurrence	Occurrence
1	6	2	1	1.2	5
2	6	2	1	1.2	4
3	2	2	2	0.4	2
4	0	0	0	0	0
∅2	∅3.5	5	2	one parameter; all depths	



Parameter Graphs – Impacts on Parameters

Depth	Hits Total	Max	Min	Ratio to 1. depth occurrence	Occurrence
1	9513	249	1	25.23	377
2	29583	246	1	78.47	377
3	30691	204	2	81.41	367
4	6699	162	1	17.77	360
5	7689	137	1	20.40	349
6	9778	137	1	25.94	211
7	8334	137	9	22.11	131
8	5045	137	9	13.38	113
9	1149	137	9	3.05	73
10	292	13	7	0.77	32
11	27	9	9	0.07	3
12	0	0	0	0.00	0
Ø6.35	Ø288.59	299	2 (one parameter; all depths)		

Sum of Total Hits:
108,800

Source: Bachelor Thesis
 Florian Ruhhammer

Parameter Graphs – Parameter Impacts/Dependencies for “Launch Mass”

Sum of Total Hits:
 Impact on 296
 Dependent on 367

Depth	Impact on	Dependent on
1	28	112
2	59	111
3	183	26
4	15	40
5	11	41
6		31
7		3
8		

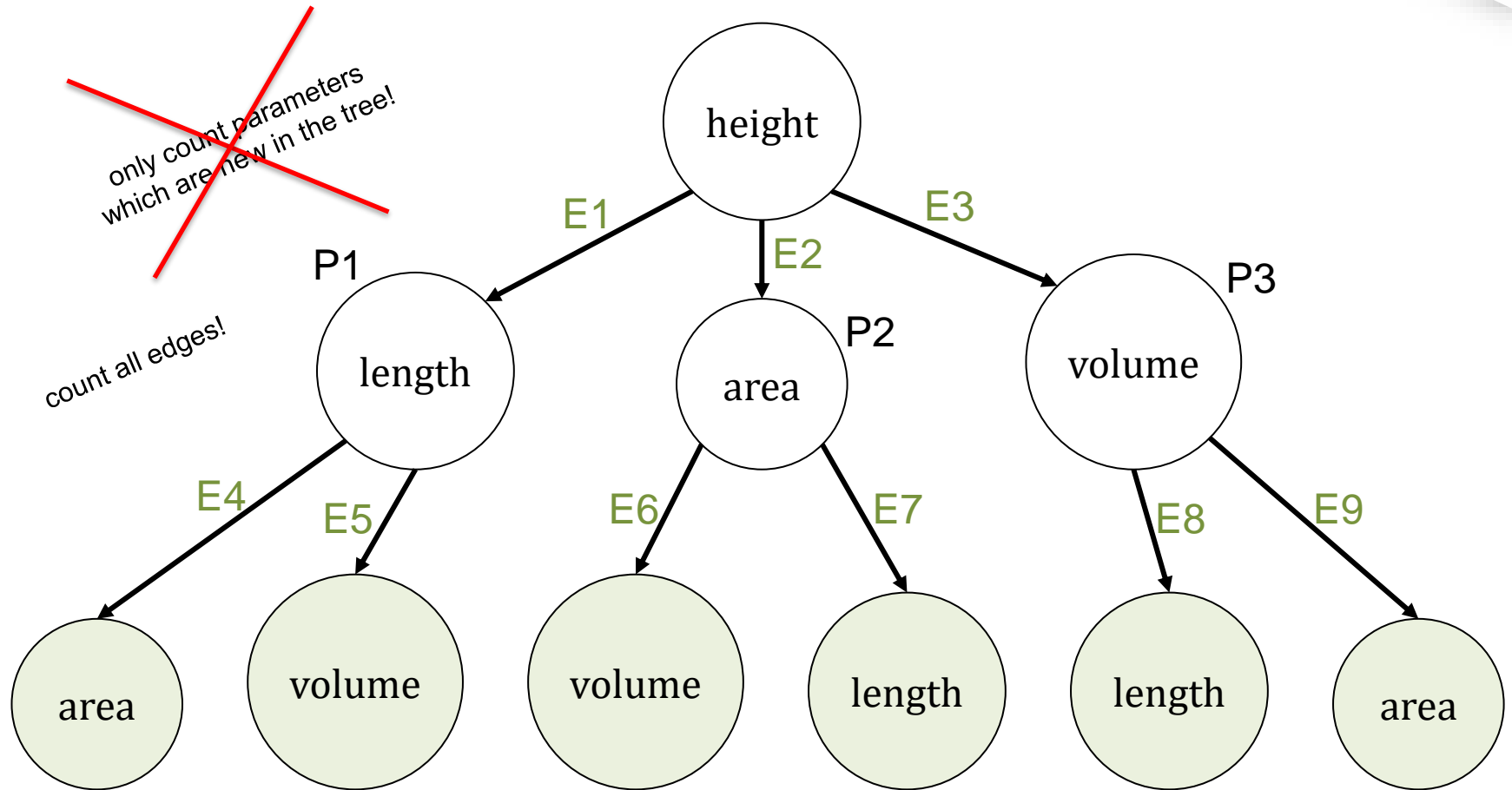
System: $m_{launch} = m_{structure} + m_{payload} + m_{propulsion} + \dots$

Subsystem: $m_{propulsion} = m_{thruster} + m_{tank} + \dots$

Component: $m_{tank} =$



Parameter Graphs – Impacts on Directed Edges



Parameter Graphs – Impacts on Directed Edges

Depth	Hits Total	Max	Min	Ratio to 1. depth occurrence	Occurrence
1	9513	249	1	25.23	377
2	188047	6088	1	498.80	377
3	634509	5831	1	1683.05	376
4	684090	5213	36	1814.56	369
5	182442	3567	24	483.93	362
6	238397	3135	24	632.35	351
7	254914	3127	24	676.16	211
8	207088	3127	228	549.31	131
9	134584	3127	450	356.99	112
10	44021	3123	445	116.77	73
11	16445	528	445	43.62	32
12	1584	528	528	4.20	3
Ø7.36	Ø6884.97	7273	3 (one parameter)		

Sum of Total Hits:
2,595,634

Source: Bachelor Thesis
 Florian Ruhhammer

Parameter Graphs – Edges Impacts/Dependencies for “Launch Mass”

Sum of Total Hits:
 Impact on 7024
 Dependent on 8569

Depth	Impact on	Dependent on
1	28	115
2	553	2752
3	1115	2975
4	4248	112
5	516	518
6	564	1089
7		959
8		49

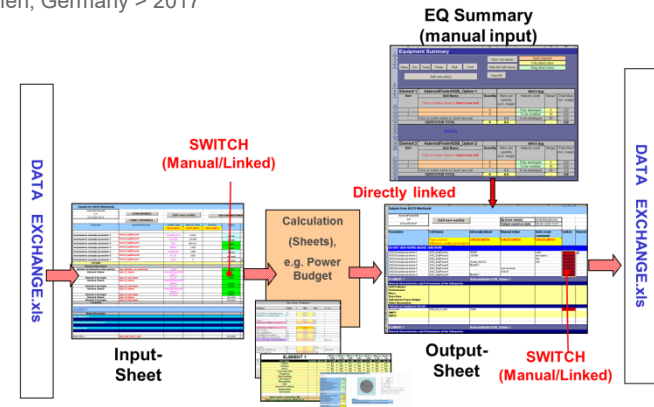
System: $m_{launch} = m_{structure} + m_{payload} + m_{propulsion} + \dots$

Subsystem: $m_{propulsion} = m_{thruster} + m_{tank} + \dots$

Component: $m_{tank} =$



Discussion – Meaning for MDO



- Assumption regarding the Data Model:

- So far: only **fixed values** for input/output parameters
- What if it would be possible to e.g. declare all dependent parameters as **variables within a specific interval** ?!
(generic / each study started from scratch)

Min. Launch Mass / Cost
 Max. Mission Lifetime
 Max. downloaded Science Data

Multidisciplinary Design Optimization task

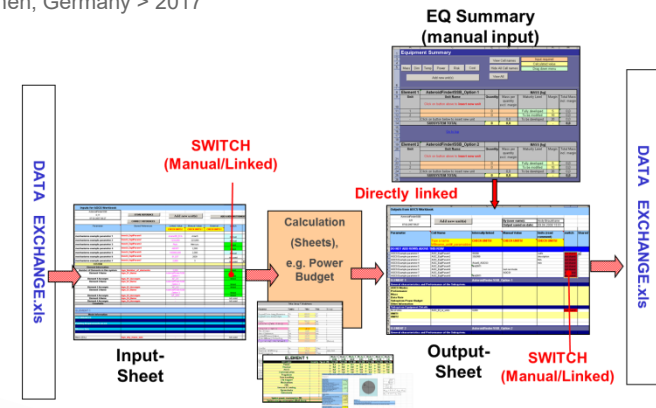
- 377 variables out of 406 parameters
- 9513 dependencies in the first depth
- 108,800 parameter relations
- 2,595,634 edges



Discussion – Meaning for MDO

- Which kind of functions?

- Linear, exponential, logarithmic, trigonometric
- Non-convex design space, discontinuous (e.g. different thruster types of fixed thrust: 3 x 10N vs. 1 x 30N)
- Not always differentiable (no Jacobi/Hesse)
- Loops between parameters



$$m_0 = (m_{\max-low} - m_{NUTZ} - m_{SUB}) \cdot (1 - \exp^{-\frac{\Delta v}{c}})$$

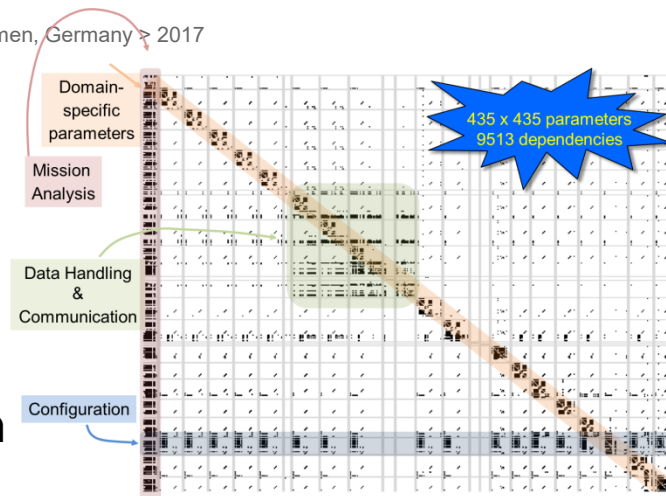
$$\frac{D \cdot \text{Margin}}{F \cdot (T_{\max} - T_{int})} = B \cdot \log_2 \left(1 + \frac{P \cdot L_l \cdot \text{GAIN}_t \cdot L_a \cdot \text{GAIN}_r \left(\frac{\lambda}{4 \cdot \pi \cdot r} \right)^2}{N} \right)$$

$$P_{el} = S_0 \cdot \left(\frac{1AU}{r} \right)^2 \cdot A \cdot \eta \cos(\varphi)$$



Discussion – Meaning for MDO

- Domain specific blocks could be used as a problem decomposition and be simplified via curve fitting techniques
- Exclude Configuration parameters since they are more dependent than having impacts on others
- Sensitivity analysis upstream the optimization in order to neglect variables which have low influence on the total system or objective function
- Interval arithmetic for knowing the feasible solution interval



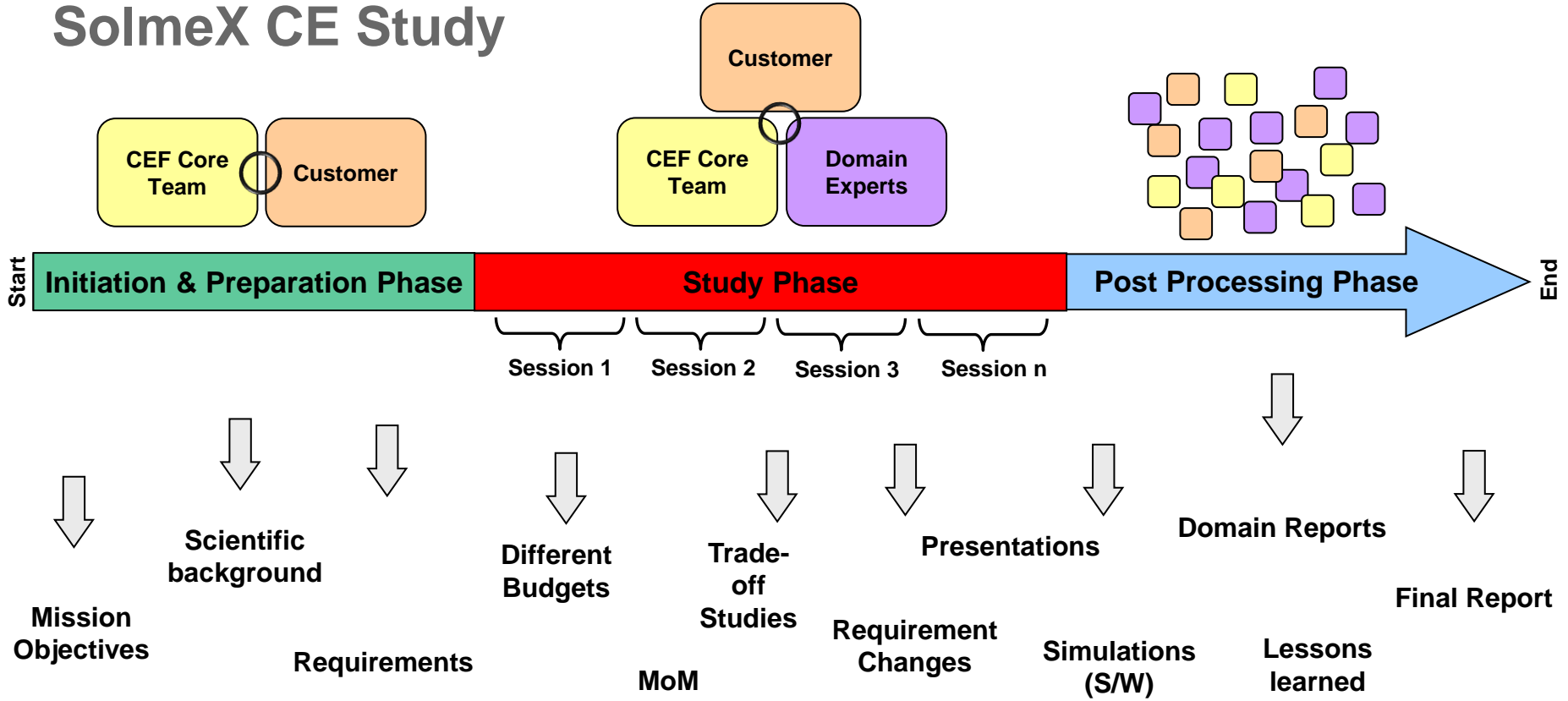
Thank you and enjoy the coffee break!



Backup Slides



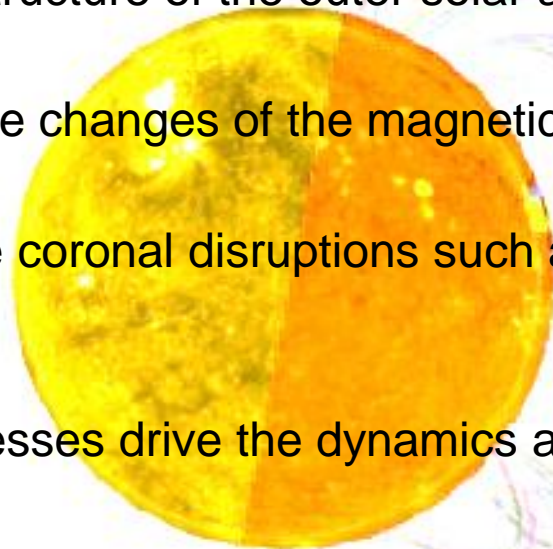
SolmeX CE Study



SolmeX CE Study

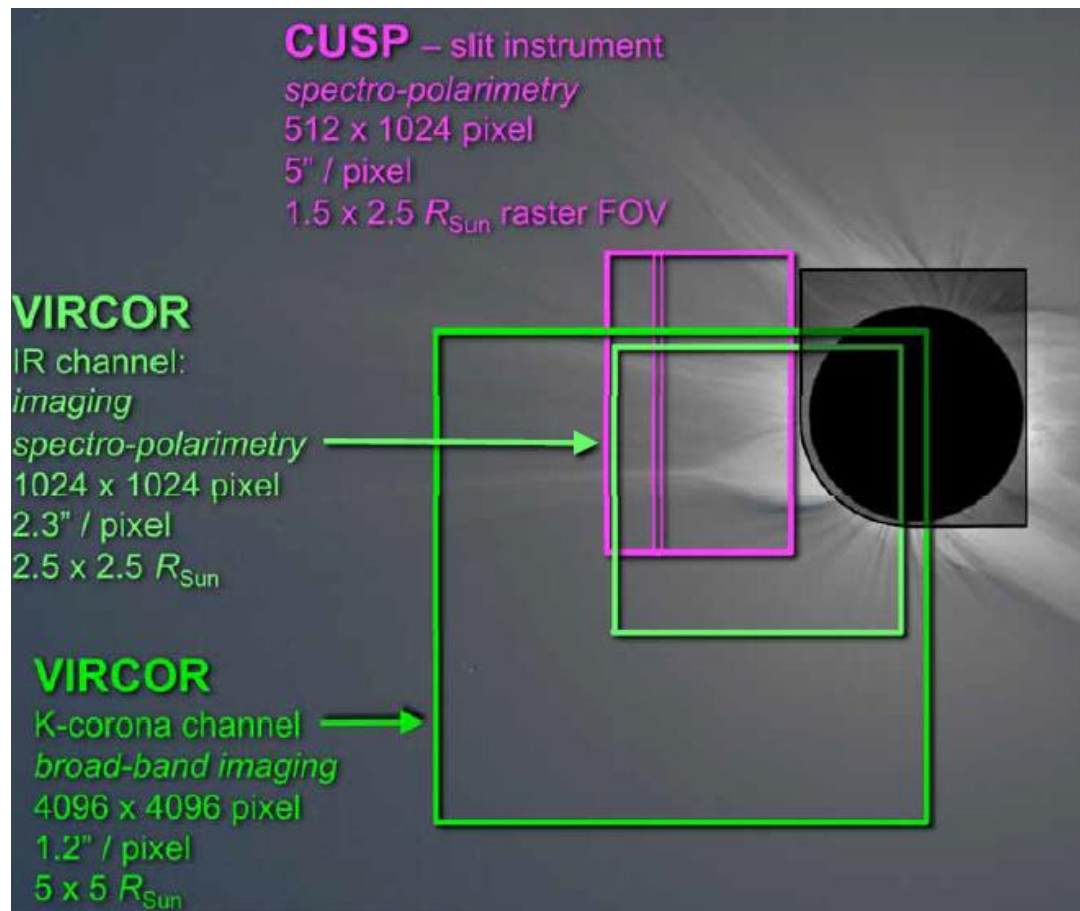
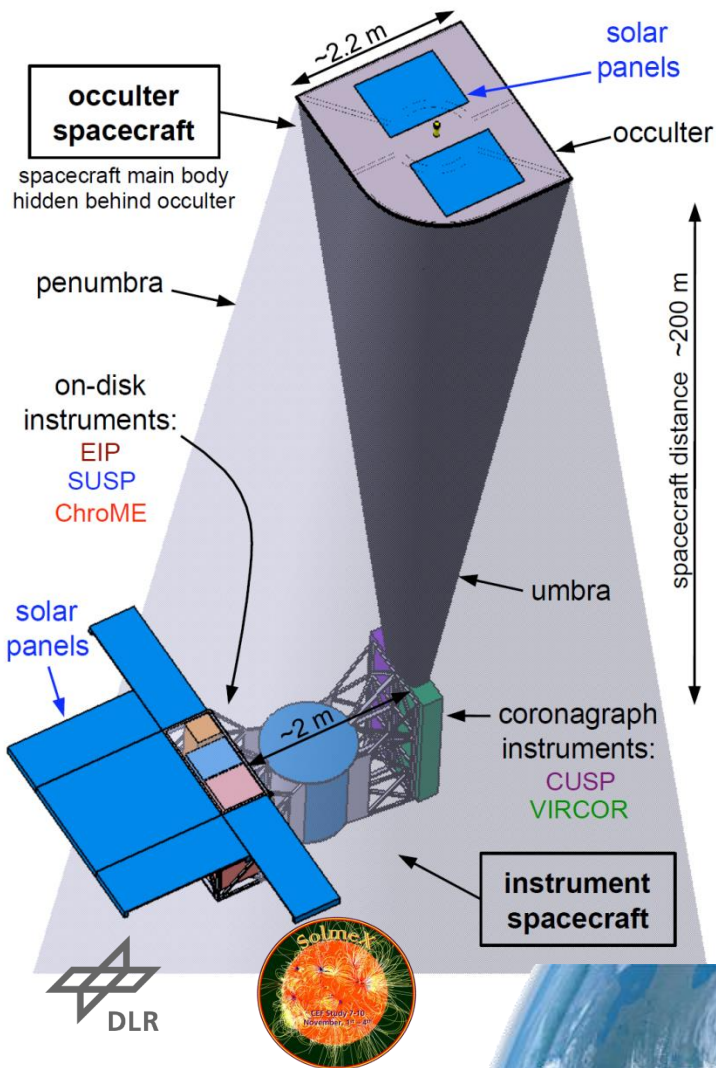
What is SolmeX? - Science Background -

- What is the magnetic structure of the outer solar atmosphere?
- What is the nature of the changes of the magnetic field over the solar cycle?
- What drives large-scale coronal disruptions such as flares and coronal mass ejections?
- How do magnetic processes drive the dynamics and heating of the outer solar atmosphere?
- How does the magnetic field couple the solar atmosphere from the photosphere to the corona?



SolmeX CE Study

What is SolmeX: Solar Magnetism Explorer



Parameter Graphs – Launch Mass

$$m_0 = (m_{max-low} - m_{NUTZ} - m_{SUB}) \cdot (1 - \exp^{-\frac{\Delta v}{c}}) \quad (3.80)$$

$$= \left\{ m_{max-low} \right. \quad (3.81)$$

$$- (m_{CHROME} + m_{CUSP} + m_{SUSP} + m_{EIP} + m_{VIRCOR})_{nutz} \quad (3.82)$$

$$- \left[(m_{cpu} + m_{massenspeicher})_{dvs} \right. \quad (3.83)$$

$$+ \left\{ \left[\psi \cdot t \cdot \rho \cdot \frac{\lambda^2}{(4\pi)} \left(2^{\frac{D \cdot Margin}{B \cdot F \cdot (T_{max} - T_{int})}} - 1 \right) \cdot \frac{N \cdot (4 \cdot \pi \cdot r)^2}{\lambda^2 \cdot P \cdot L_l \cdot L_a \cdot GAIN_B} \right]_{uplink} \right. \quad (3.84)$$

$$+ \left. \left[\psi \cdot t \cdot \rho \cdot \frac{\lambda^2}{(4\pi)} \left(2^{\frac{D \cdot Margin}{B \cdot F \cdot (T_{max} - T_{int})}} - 1 \right) \cdot \frac{N \cdot (4 \cdot \pi \cdot r)^2}{\lambda^2 \cdot P \cdot L_l \cdot L_a \cdot GAIN_B} \right]_{downlink} \right\}_{kom} \quad (3.85)$$

$$+ \left[F_{spec} \cdot \frac{(P_{evs_DVS} + P_{evs_KS} + P_{evs_EVS_Eigen} + P_{evs_TS} + P_{evs_LBS} + P_{evs_SIMK} + P_{evs_AS}) \cdot r^2}{S_0 \cdot \eta \cdot \cos \phi \cdot AU^2} \right. \quad (3.86)$$

$$\left. \cdot \frac{P_{evs_el} \cdot t \cdot 100 \cdot (-0,0272)}{3600 \cdot \eta \cdot [\ln(CL) - \ln(207800)] \cdot E_{spc}} \right]_{evs} \quad (3.87)$$

$$+ \left[F_{spez} \cdot \frac{Q_{int} + \alpha \cdot \sigma \cdot \left(\frac{P_{S,i}}{\sigma \epsilon F} + \frac{P_{A,i}}{\sigma \epsilon F} + \frac{P_{IR,i}}{\sigma \epsilon F} - \frac{\sum r_{ij}(T_j^4 - T_i^4)}{\epsilon F} \right) \cdot F_p}{\sigma \cdot \epsilon \cdot T^4} + m_{heiz} \right]_{ts} \quad (3.88)$$

$$+ (m_{dral} + m_{gyr} + m_{ste})_{lbs} \quad (3.89)$$

$$+ m_{simk} + \left. \left[m_{due} + 4 \cdot \pi \cdot \frac{3 \cdot V_{komp}}{4 \cdot \pi} \cdot \rho \cdot \frac{p}{20} \right]_{as} \right]_{sub} \quad (3.90)$$

$$\cdot (1 - \exp^{-\frac{\Delta v}{c}}) \quad (3.91)$$



Imprint

Topic: **Parameter Analysis
of a Concurrent Engineering Satellite Study**

Date: 2017-03-28

Author: Dominik Quantius

Institute: DLR Institute of Space Systems

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