MBSE case study:

Fugro Pioneer Methanol Conversion

Agenda

- Introduction: case study
- Model setup in CDP4-COMET
- Results

Case Study: Fugro Pioneer Methanol Conversion

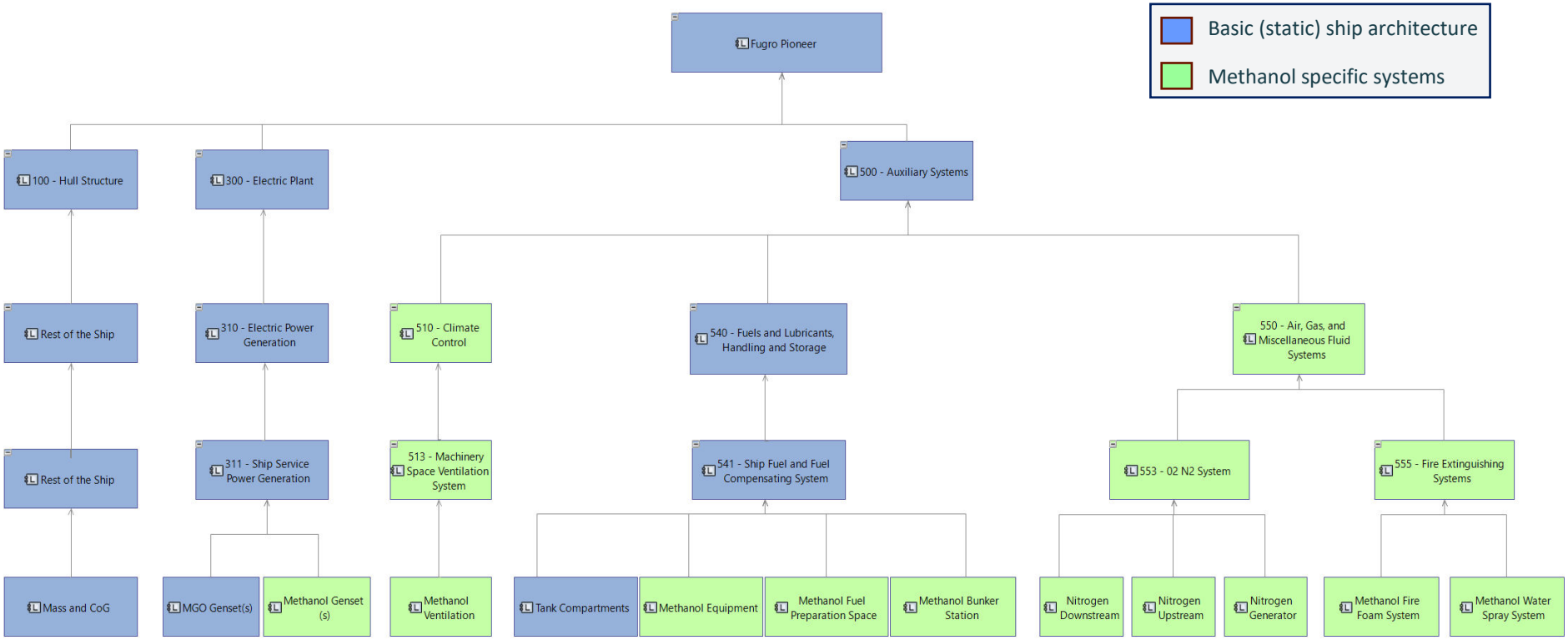
- Goal: Create a “zero-emissions” ship
- Requirements:
  - Methanol-specific systems
  - Dimensions
  - Power output
  - Stability
  - Endurance

System Requirements		
Dimensional Constraints		
☑ R09-Length	R09 - Length	The vessel shall have a length of 53.7m.
☑ R10-Breadth	R10 - Breadth	The vessel shall have a breadth of 12.5m
Endurance Requirements		
☐ R01-EnduranceMeOH	R01 - Endurance MeOH	The vessel shall have an operating endurance of at least 4 weeks (28 days) when running on methanol (MeOH).
☑ R02-EnduranceMGO	R02 - Endurance MGO	The vessel shall have an operating endurance of at least 65 days when running on Marine Gas Oil (MGO).
Fuel and Storage Systems		
▪ R11-FPS	R11 - Fuel Preparation Space	The vessel shall include one fuel preparation space (FPS)
▪ R12-BS	R12 - Bunker Space	The vessel shall include one bunker station (BS) space.
☐ R13-MeOH_storage_tanks	R13 - MeOH storage tanks	The vessel shall have a minimum of 2 methanol (MeOH) storage tanks.
▪ R14-MeOH_service_tank	R14 - MeOH service tank	The vessel shall have a minimum of 1 methanol (MeOH) service tank.
Power and Propulsion Requirements		
☐ R03-MethanolPower	R03 - Methanol Generating Power	At least 2 out of the 4 diesel gensets shall be converted to run on methanol (MeOH).
☑ R04-PowerOutput	R04 - Power Output	The vessel's power output shall be at least 4 units of 372 kW, maintaining the same performance as before the conversion.
Stability and Safety Requirements		
☑ R05-Draft	R05 - Draft	The vessel shall not exceed a maximum extreme draft of 3.1m.
☑ R06-GM	R06 - Min. GM	The vessel shall maintain a minimum GM (metacentric height) of 1.293m for stability.
☑ R07-Trim	R07 - Max. Trim	The vessel shall not exceed the maximum allowable trim og 0.131m.
☑ R08-List	R08 - Max. heeling angle	The vessel shall not exceed the maximum allowable heeling angle (list) of 0.5 degrees.

Why MBSE?

- Connecting multiple engineering tools
- Concurrent design
- Multiple design options in one model
- Automatic requirements verification
- Short design iterations

Model Architecture



Design Iteration

COMET model (3 design options)

CDP4 COMET

Requirements verification

Requirements Compliance

Spec	Group	Requirement	MeOH	MGO
System Requirements				
	Dimensional Constraints			
		R09 - Length	V	V
		R10 - Breadth	V	V
			V	
			V	V
			V	?
			V	?
			?	?
			?	?
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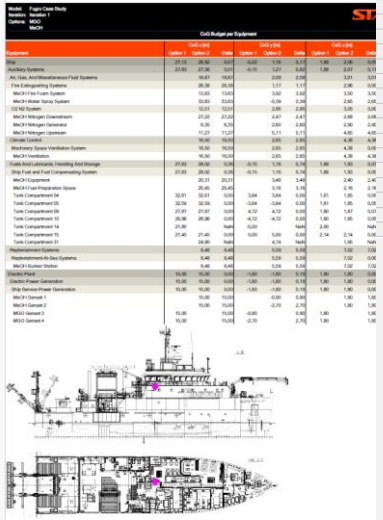
			V	V
			V	V
			V	V



Mass budget and centre of gravity computation

Tank arrangement data

Tank capacity and weight parameters

Tank arrangement calculations

	A	B	F	G	K	L
1	MeOH Option					
2		Tank Compartment	4	5	9	10
3		Volume [m3]	50,79375	50,79375	30,53946	44,10639
4		Density [t/m3]	0,792	0,792	0,792	0,792
5		Cofferdam mass penalty [kg]	1500	1500	1500	1500
6		Cofferdam volume penalty [%]	29	29	29	29
7		CoG_z	1,805	1,805	1,796	1,796
8		CoG_z_adjusted for Cffd [m]	1,850663	1,850663	1,870371	1,8486955
9		Mass [kg]	32685	32685	20249,81	28579,272
10						
11		is MeOH tank? [1=yes]	1	1	1	1
12						
13		MeOH Capacity [m3]	39,375	39,375	23,674	34,191
14		MGO Capacity [m3]	0	0	0	0
15		Ballast/Sewage Capacity [m3]	0	0	0	0
16						
17	Total MeoH Capacity [m3]	147,132		Total MeOH tanks:		5
18	Total MGO Capacity [m3]	138,867				
19						

Tank capacity + E-system specs

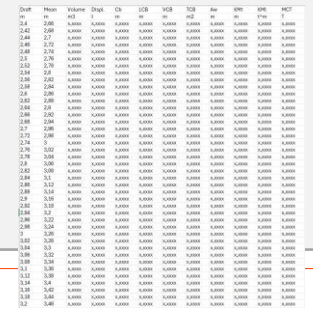
Endurance parameters

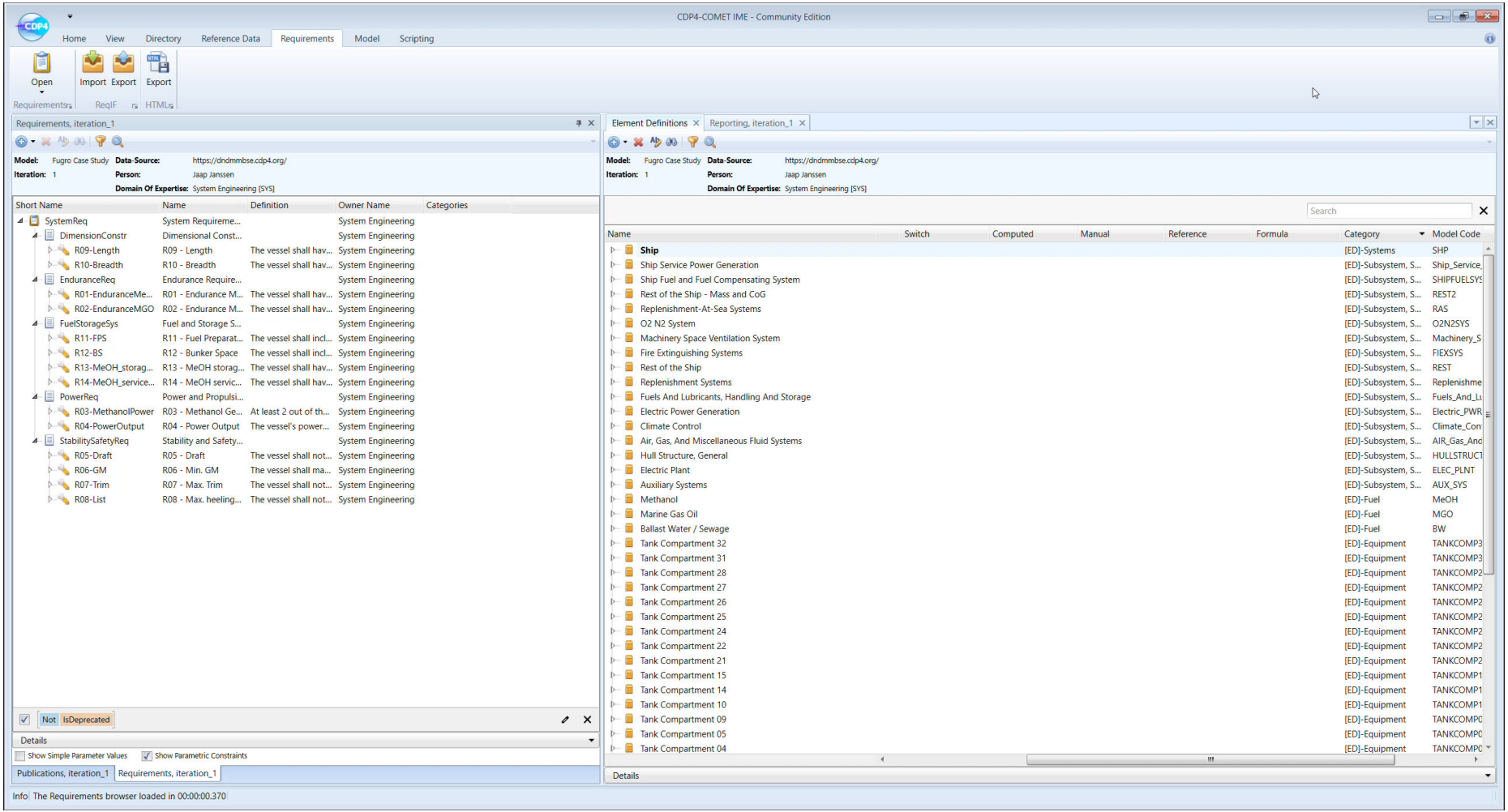
Ship endurance calculations

Centre of gravity and weight data

Stability parameters

Hydrostatics model




CDP4-COMET IME - Community Edition
Home
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Requirements, iteration_1
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Data-Source: https://dndmmbse.cdp4.org/
Iteration: 1
Person: Jaap Janssen
Domain Of Expertise: System Engineering [SYS]
Short Name
Name
Definition
Owner Name
Categories
SystemReq
System Requireme...
System Engineering
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Dimensional Const...
System Engineering
R09-Length
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System Engineering
R10-Breadth
R10 - Breadth
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R01 - Endurance M...
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System Engineering
R02-EnduranceMGO
R02 - Endurance M...
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R03 - Methanol Ge...
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System Engineering
R04-PowerOutput
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StabilitySafetyReq
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System Engineering
R05-Draft
R05 - Draft
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System Engineering
R06-GM
R06 - Min. GM
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R07-Trim
R07 - Max. Trim
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R08-List
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Publications, iteration_1
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Element Definitions
Reporting, iteration_1
Model: Fugro Case Study
Data-Source: https://dndmmbse.cdp4.org/
Iteration: 1
Person: Jaap Janssen
Domain Of Expertise: System Engineering [SYS]
Search
Name
Switch
Computed
Manual
Reference
Formula
Category
Model Code
Ship
[ED]-Systems
SHP
Ship Service Power Generation
[ED]-Subsystem, S...
Ship_Service_
Ship Fuel and Fuel Compensating System
[ED]-Subsystem, S...
SHIPFUELSYS
Rest of the Ship - Mass and CoG
[ED]-Subsystem, S...
REST2
Replenishment-At-Sea Systems
[ED]-Subsystem, S...
RAS
O2 N2 System
[ED]-Subsystem, S...
O2N2SYS
Machinery Space Ventilation System
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Machinery_S
Fire Extinguishing Systems
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FIEXSYS
Rest of the Ship
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REST
Replenishment Systems
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Replenishme
Fuels And Lubricants, Handling And Storage
[ED]-Subsystem, S...
Fuels_And_Lu
Electric Power Generation
[ED]-Subsystem, S...
Electric_PWR
Climate Control
[ED]-Subsystem, S...
Climate_Con
Air, Gas, And Miscellaneous Fluid Systems
[ED]-Subsystem, S...
AIR_Gas_And
Hull Structure, General
[ED]-Subsystem, S...
HULLSTRUCT
Electric Plant
[ED]-Subsystem, S...
ELEC_PLNT
Auxiliary Systems
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AUX_SYS
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MeOH
Marine Gas Oil
[ED]-Fuel
MGO
Ballast Water / Sewage
[ED]-Fuel
BW
Tank Compartment 32
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TANKCOMP3
Tank Compartment 31
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Tank Compartment 05
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Tank Compartment 04
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TANKCOMP0
Details
Info
The Requirements browser loaded in 00:00:00.370

Results after “first” iteration

Requirements Compliance

Spec	Group	Requirement	Full MeOH	MeOH	MGO
System Requirements					
	Dimensional Constraints				
		R09 - Length	V	V	V
		R10 - Breadth	V	V	V
	Endurance Requirements				
		R01 - Endurance MeOH	V	V	
		R02 - Endurance MGO		V	V
	Fuel and Storage Systems				
		R11 - Fuel Preparation Space	V	V	?
		R12 - Bunker Space	V	V	?
		R13 - MeOH storage tanks	V	V	
		R14 - MeOH service tank	V	V	?
	Power and Propulsion Requirements				
		R03 - Methanol Generating Powe	V	V	
		R04 - Power Output	V	V	V
	Stability and Safety Requirements				
		R05 - Draft	V	V	V
		R06 - Min. GM	V	V	V
		R07 - Max. Trim			V
		R08 - Max. heeling angle			V

Full Methanol	Conversion	Original	Parametric Constraint
53.7m	53.7m	53.7m	= 53.7m
12.5m	12.5m	12.5m	= 12.5m
56.6 days	32.7 days	0 days	>= 28 days
0 days	73.1 days	162.2 days	>= 65 days
1	1	-	= 1
1	1	-	= 1
12	5	0	>= 2
1	1	-	= 1
4	2	0	>= 2 MeoH gensets
1488 kW	1488 kW	1488 kW	>= 1488 kW
3.1 m	3.16 m	3.1 m	<= 3.1 m
1.719 m	1.713 m	1.734 m	>= 1.293 m
-0.099 m	-0.025 m	-0.011 m	<= 0.131 m
-2.482 deg	-2.124 deg	0.165 deg	-0.5 deg < x < 0.5 deg

Filter on Option:

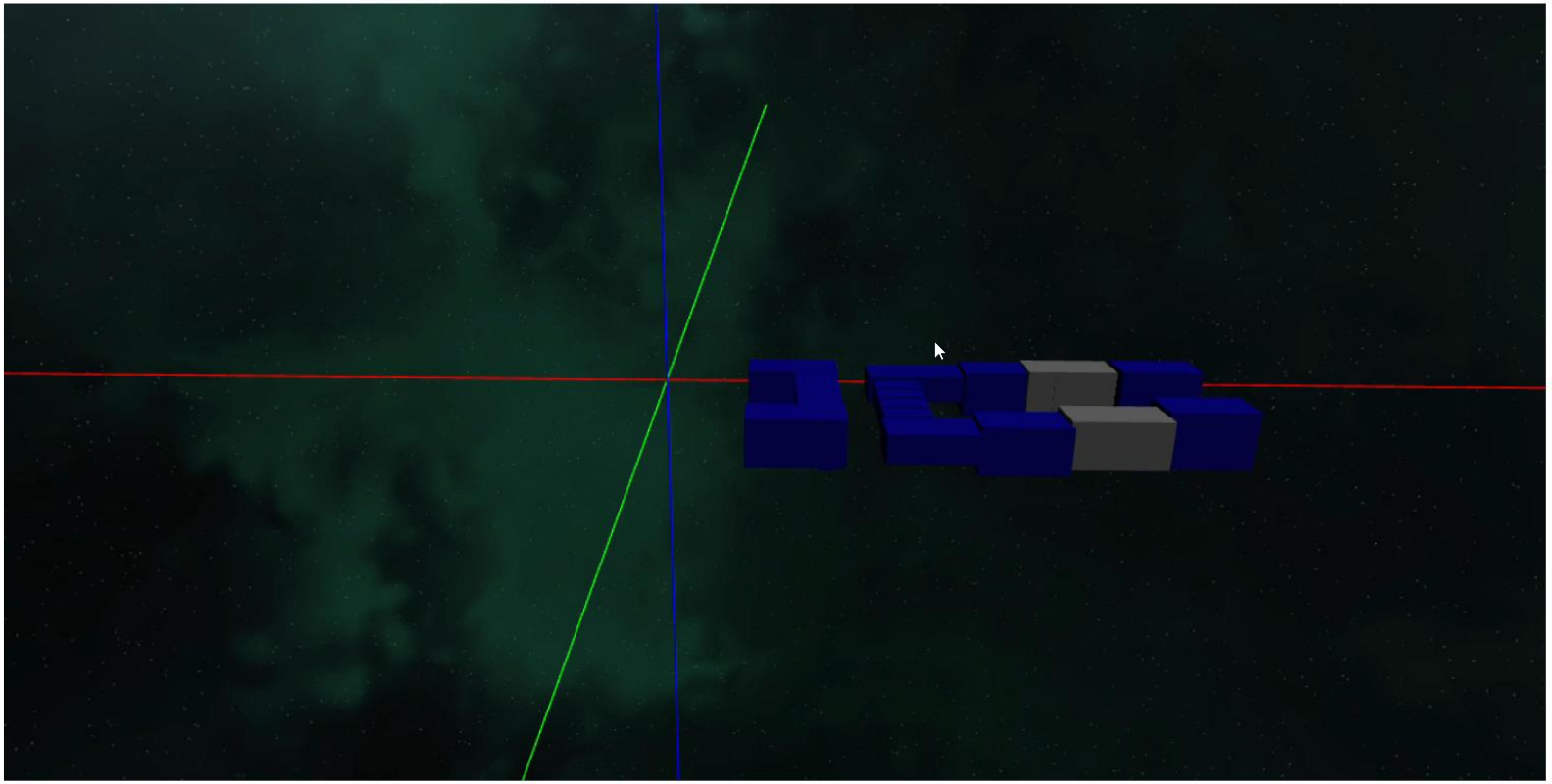
MGO

Product Tree

ShowFullTree

Search...

Ship



Meaning

- Small time investment in setting up model
- Creates insight into the impact of an architectural change on the requirements
- Allows prioritisation of engineering effort

Thank you

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