

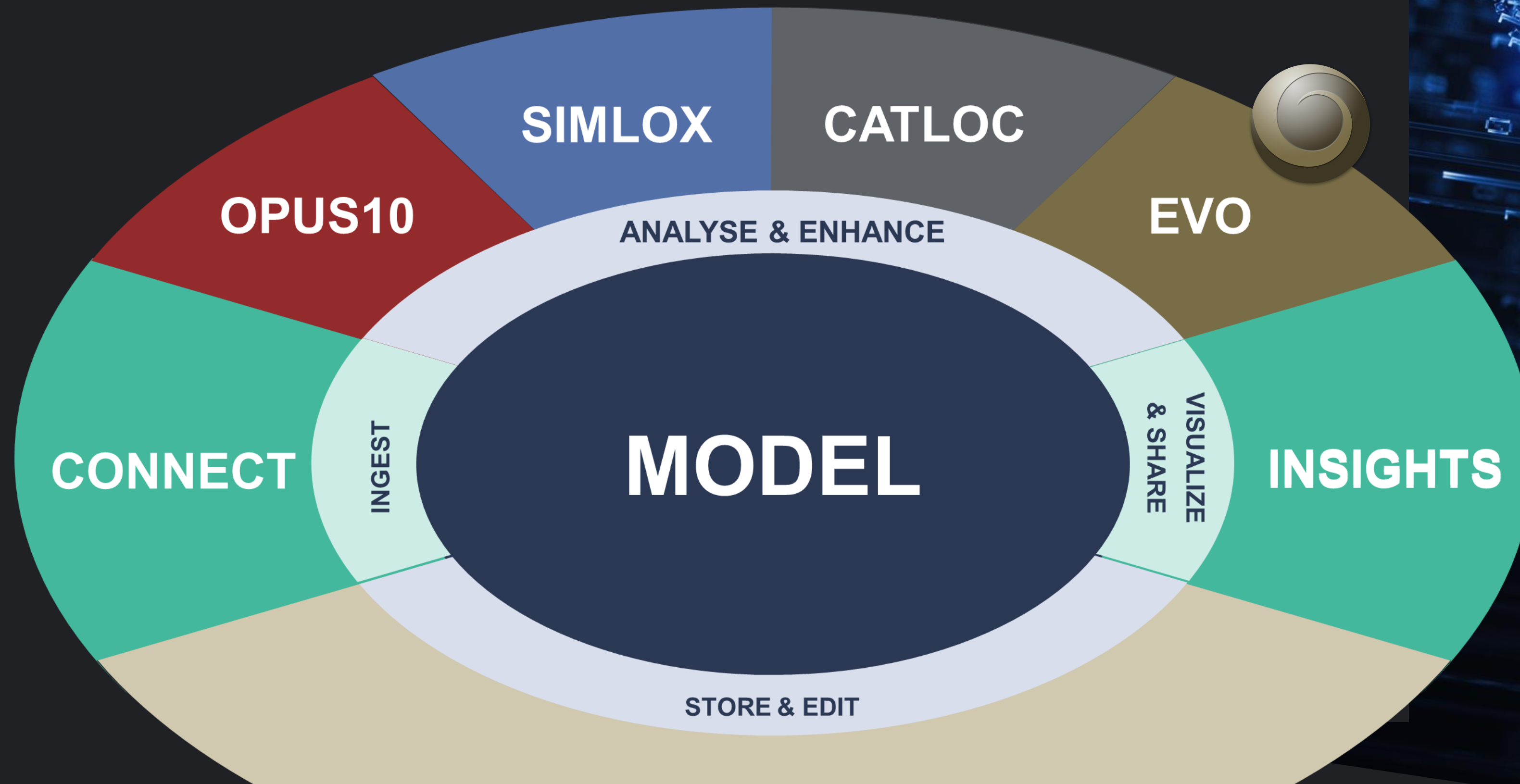
April 9, 2024

***Optimization of mission success in a dynamic scenario
with multiple constraints powered by Opus Evo***

Olle Wijk, PhD.

Opus Evo

- Unlocks new spectrum of capabilities
 - Evolutionary Algorithms + Evaluator (Simulation)
- Strong complement to the other Opus Suite software
 - Using the same Opus Suite model and data set
 - Incorporate dynamic aspects - non steady state

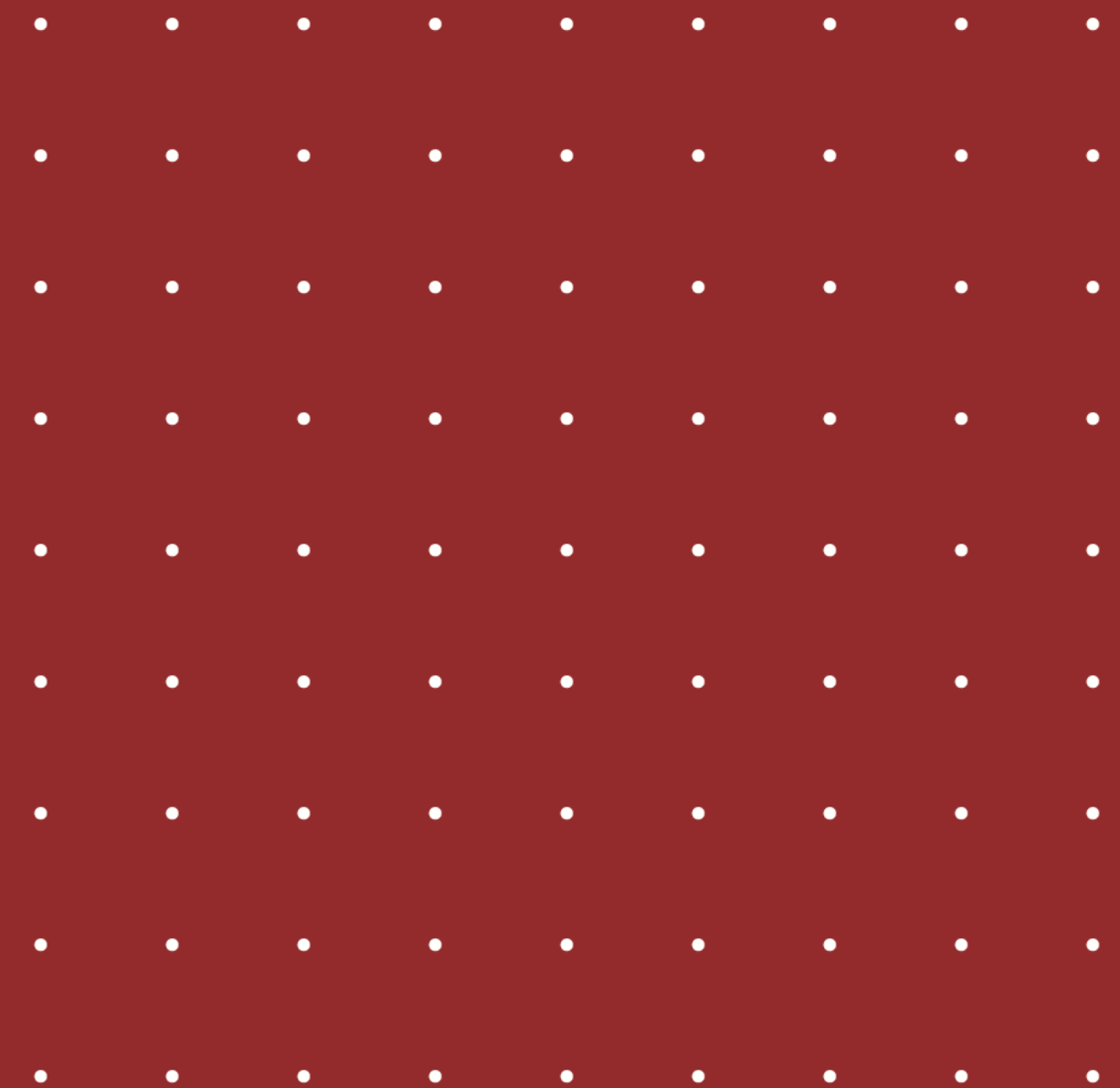


Opus Evo

- Opus Evo uses *evolutionary* search for optimum

- *The ability to scale is what matters most!*
 - Opus Evo can solve *any* problem size using horizontal scaling of computing power

Scenario



Scenario

- Three types of battle tanks (all based upon a common platform), Infantry, Command and Recovery
- 100 items
 - Failure rate (op hours, terrain km, road km, rounds)
 - Price, Weight and Volume

ChatGPT 3.5 ▾

You

Please use the following part number and description list for battle tank components to estimate the Price [USD], Volume [m3] and Weight [kg] for each part number

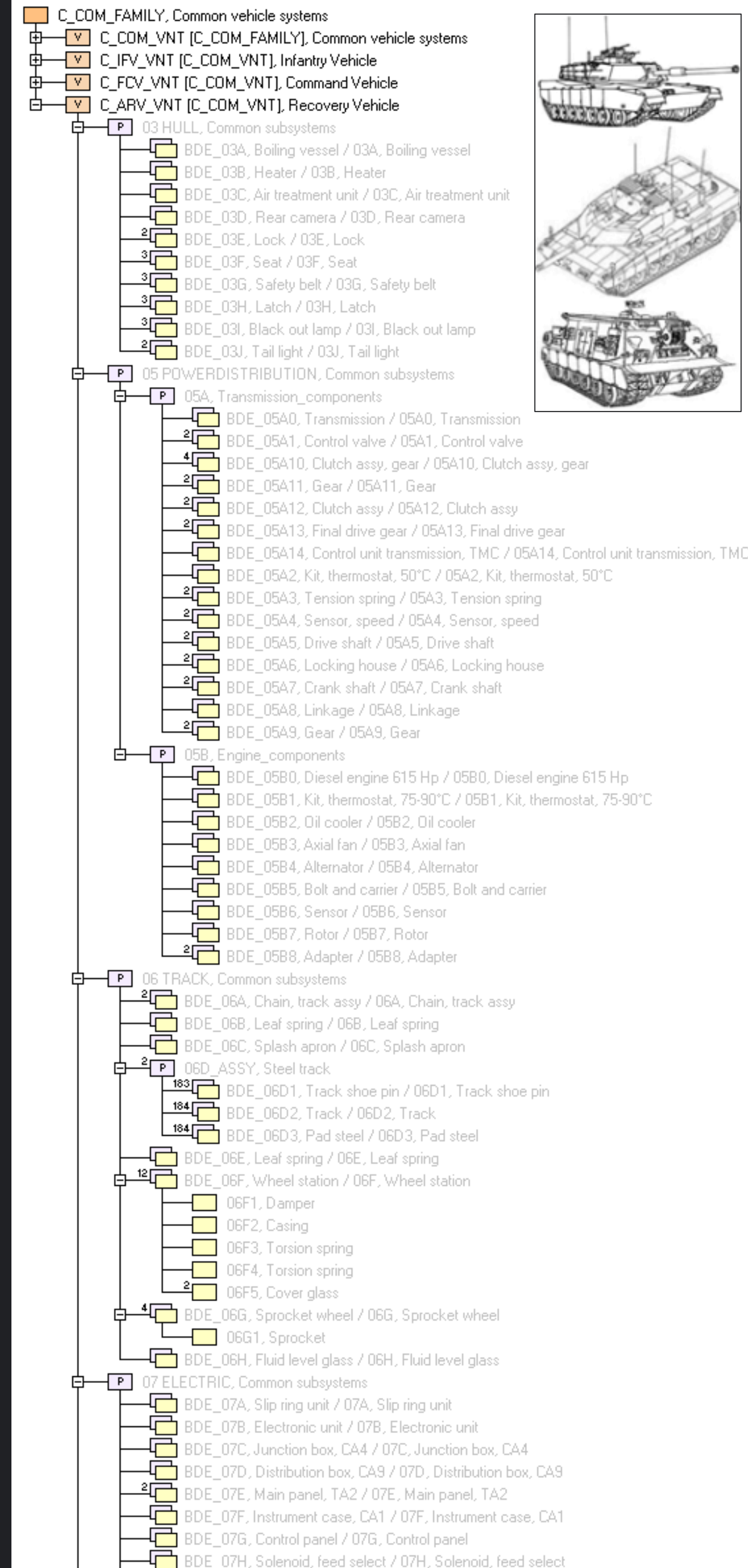
ItemId	Description
03A	Boiling vessel
03B	Heater
03C	Air treatment unit
03D	Rear camera
03E	Lock
03F	Seat
...	...

ChatGPT

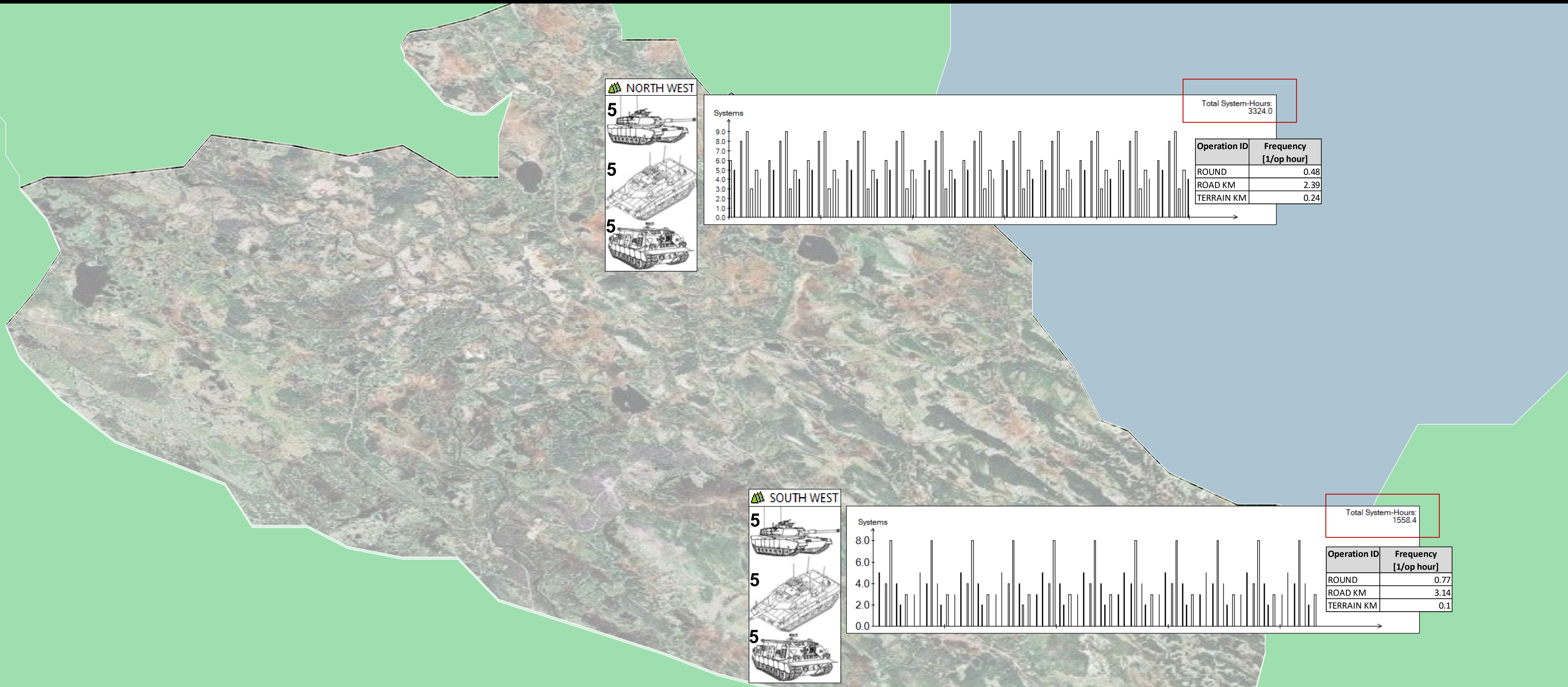
Here's the data set in tab-separated CSV format:

CSV Copy code

ItemId	Description	Price [USD]	Volume [m3]	Weight [kg]
03A	Boiling vessel	1000	0.1	50
03B	Heater	500	0.05	20
03C	Air treatment unit	3000	0.1	30
03D	Rear camera	1000	0.02	5
03E	Lock	200	0.01	2
03F	Seat	1500	0.05	15
03G	Safety belt	200	0.001	1
03H	Latch	200	0.002	2
03I	Black out lamp	200	0.001	1
03J	Tail light	200	0.001	1



Scenario

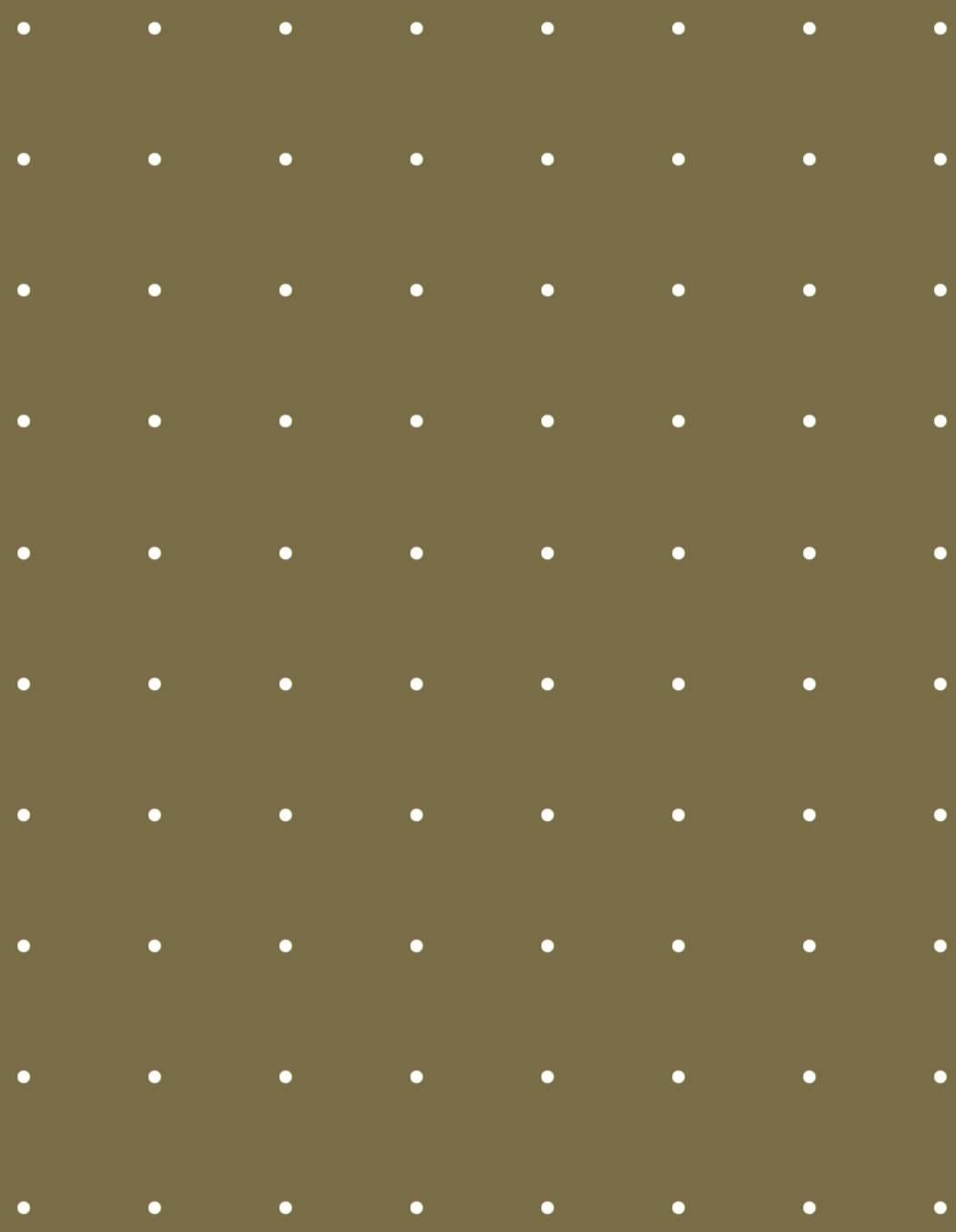


- Endurance period: 90 days
- Assignment for the Opus Suite Analytics Team:
 - A spares package that maximizes the achievement of planned operation time

Opus Suite
Conference

STOCKHOLM

DAY 1



DAY 1

Military Command Team

Please provide us with a spares package that maximizes the achievement of planned operational time. The maximum budget is 5 MUSD and the maximum weight is 20 tonnes

Opus Suite Analytics Team

Ok we will get back to you within 24 hours with the requested spares package

Setup of Opus Evo run

SIMLOX - [EvaluateMe.sxi <Model Tree View>]

File Edit View Data Tools Window Help

Product Breakdown

- ROOT, Fictive root
 - C_COM_FAMILY, Common vehicle systems
 - C_COM_VNT [C_COM_FAMILY], Common vehicle systems
 - C_IFV_VNT [C_COM_VNT], Infantry Vehicle
 - 03 HULL, Common subsystems
 - 05 POWERDISTRIBUTION, Common subsystems
 - 06 TRACK, Common subsystems
 - 07 ELECTRIC, Common subsystems
 - 08 HYDRAULIC, Common subsystems
 - BDE_COBRA, Remote Controlled Weapon Station / 14A, Remote Controlled Weapon Station
 - 10 WEAPON, Variant unique subsystem
 - BDE_10A, Sensor / 10A, Sensor
 - BDE_10B, Barrel / 10B, Barrel
 - BDE_10C, Barrel camera / 10C, Barrel camera
 - BDE_10D, Electric motor / 10D, Electric motor
 - BDE_10E, Gyro / 10E, Gyro
 - BDE_10F, Recoil mechanism / 10F, Recoil mechanism
 - 11 FIRE_CONTROL, Variant unique subsystem
 - BDE_11D, Control Handle Gunner/Commander / 11D, Control Handle Gunner/Commander
 - BDE_11F, Electronic unit, ammunition programmer / 11F, Electronic unit, ammunition programmer
 - BDE_11G, Optics Module / 11G, Optics Module
 - BDE_11I, Laser module / 11I, Laser module
 - 12 COMMAND_AND_RADIO, Variant unique subsystem
 - BDE_12A, Display, 10.4" / 12A, Display, 10.4"
 - BDE_12B, Computer / 12B, Computer
 - BDE_12C, Navigation unit / 12C, Navigation unit
 - BDE_12D, Feeder assy / 12D, Feeder assy
 - BDE_12E, Receiver / 12E, Receiver
 - C_FCV_VNT [C_COM_VNT], Command Vehicle
 - 03 HULL, Common subsystems
 - BDE_03A, Boiling vessel / 03A, Boiling vessel
 - BDE_03B, Heater / 03B, Heater
 - BDE_03C, Air treatment unit / 03C, Air treatment unit
 - BDE_03D, Rear camera / 03D, Rear camera
 - BDE_03E, Lock / 03E, Lock
 - BDE_03F, Seat / 03F, Seat
 - BDE_03G, Safety belt / 03G, Safety belt
 - BDE_03H, Latch / 03H, Latch
 - BDE_03I, Black out lamp / 03I, Black out lamp
 - BDE_03J, Tail light / 03J, Tail light
 - 05 POWERDISTRIBUTION, Common subsystems
 - 05A, Transmission_components
 - BDE_05A0, Transmission / 05A0, Transmission
 - BDE_05A1, Control valve / 05A1, Control valve
 - BDE_05A10, Clutch assy, gear / 05A10, Clutch assy, gear
 - BDE_05A11, Gear / 05A11, Gear
 - BDE_05A12, Clutch assy / 05A12, Clutch assy
 - BDE_05A13, Final drive gear / 05A13, Final drive gear
 - BDE_05A14, Control unit transmission, TMC / 05A14, Control unit transmission, TMC
 - BDE_05A2, Kit, thermostat, 50°C / 05A2, Kit, thermostat, 50°C
 - BDE_05A3, Tension spring / 05A3, Tension spring

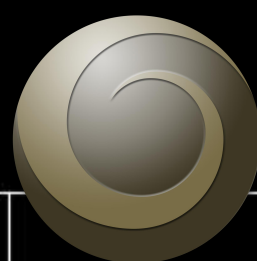
Support organization

Quantity	System ID	Support organization
10	C_ARV	DEPOT NORTH WEST
10	C_FCV	
10	C_IFV	
5	C_ARV	DEPOT SOUTH WEST
5	C_FCV	
5	C_IFV	

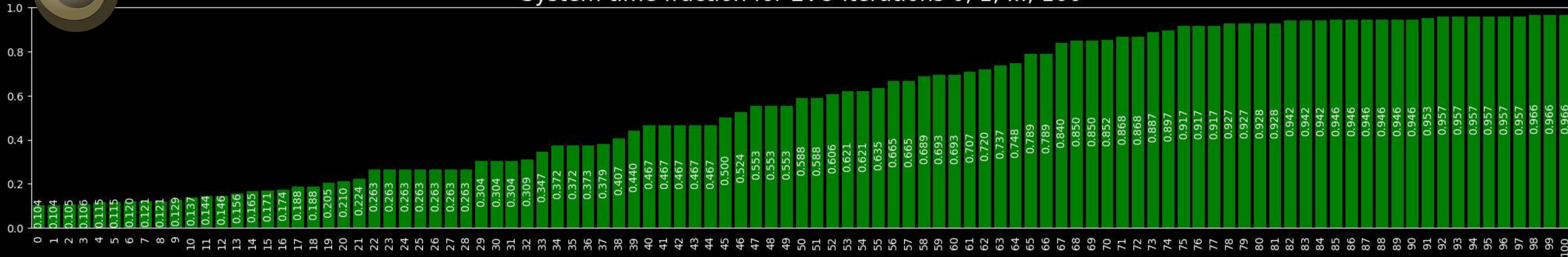
BreakdownElement			
BDEID	DESCR	ATYPE	REPL
Breakdown element identifier	Description	Aggregation type	Replaceability strategy
		<HARDWARE>	<REPLACEABLE>
1	BDE_03A		
2	BDE_03B		
3	BDE_03C		
4	BDE_03D		
5	BDE_03E		
6	BDE_03F		
7	BDE_03G		
8	BDE_03H		
9	03 HULL	POSITION	NONREPLACEABLE
10	BDE_03I		
11	BDE_03J		
12	05A	POSITION	NONREPLACEABLE



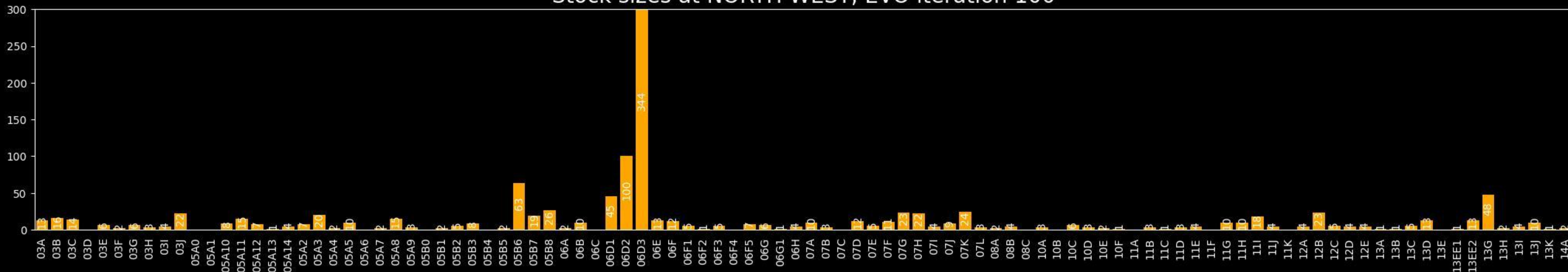
Running EVO with {Total Cost & Weight Constraints} ...



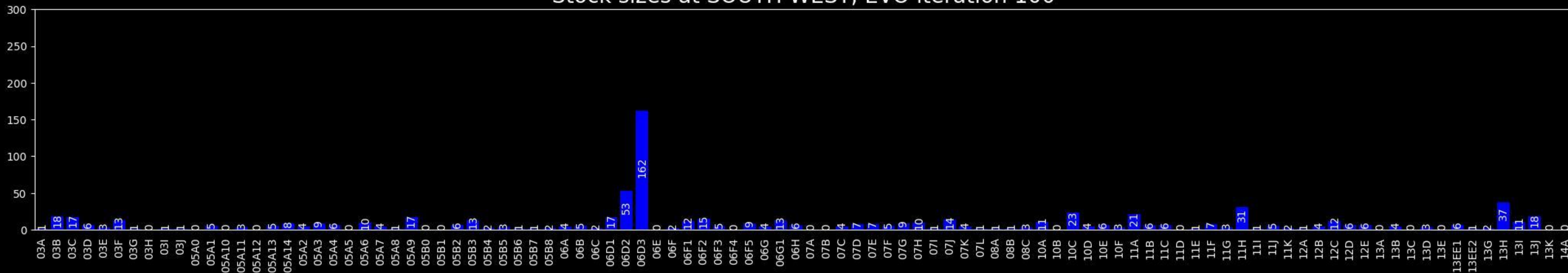
System time fraction for EVO iterations 0, 1, ..., 100



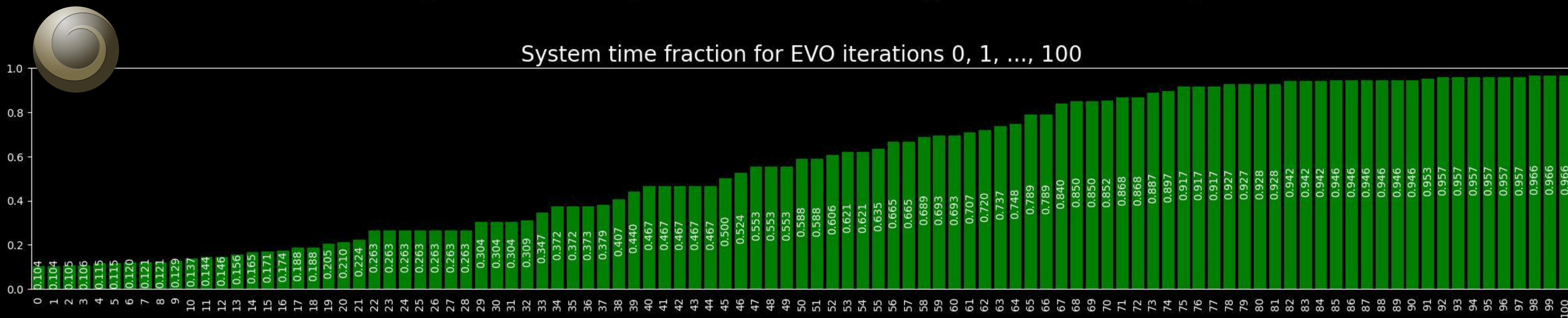
Stock sizes at NORTH WEST, EVO iteration 100



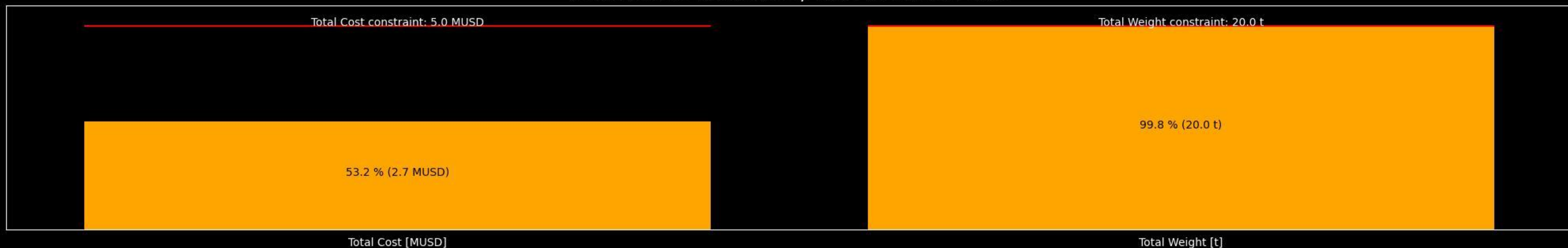
Stock sizes at SOUTH WEST, EVO iteration 100



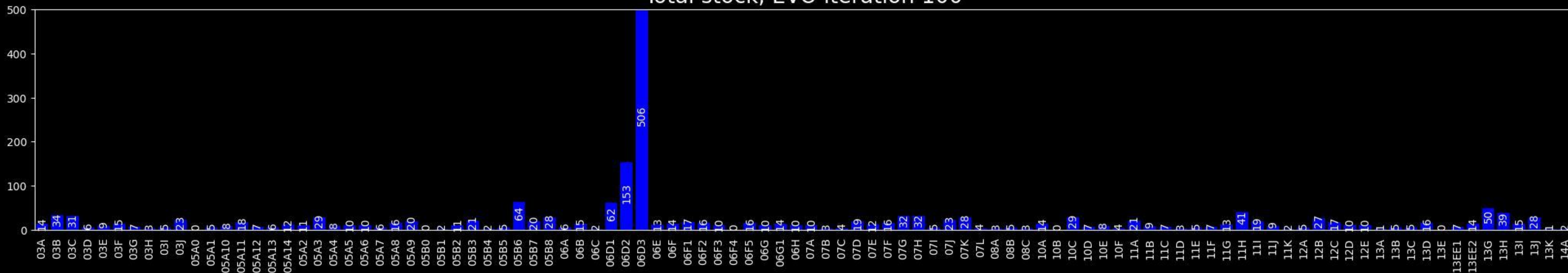
Running EVO with {Total Cost & Weight Constraints} ...



Constraint validation, EVO iteration 100



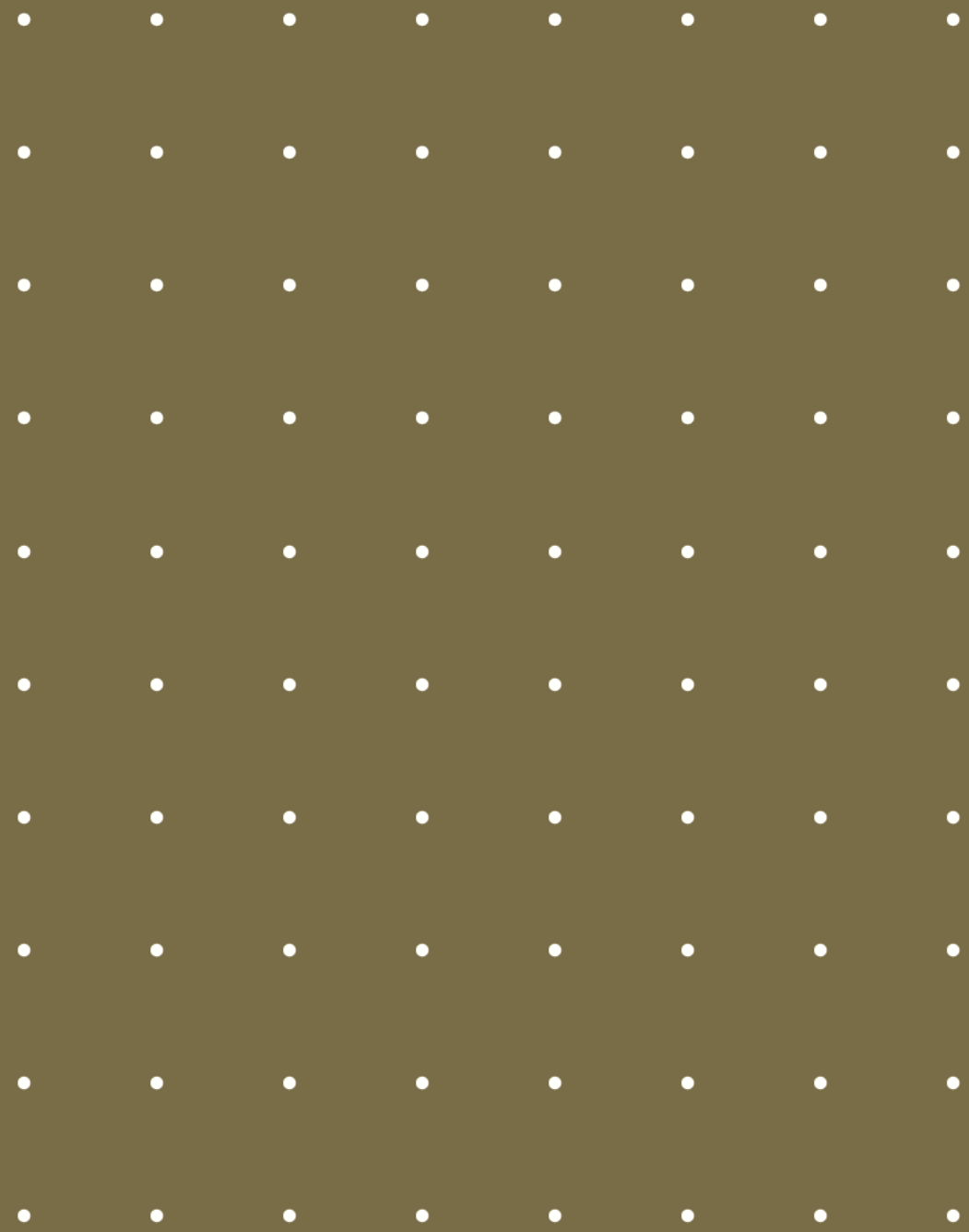
Total stock, EVO iteration 100



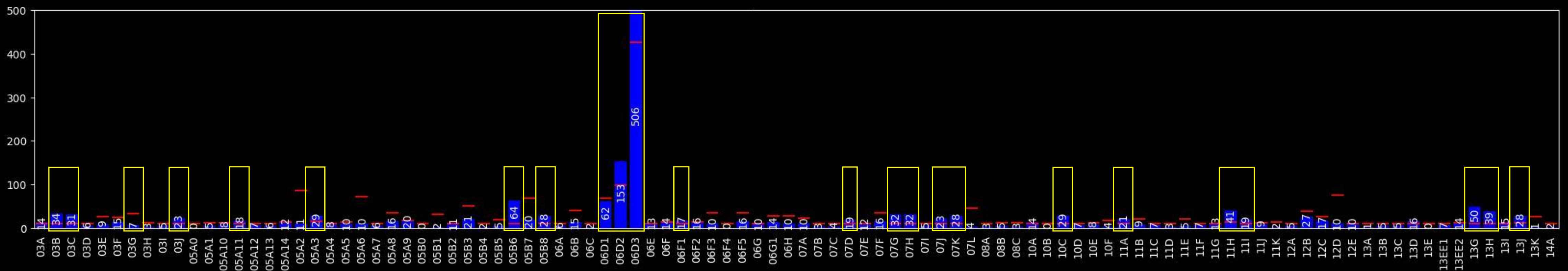
Opus Suite
Conference

STOCKHOLM

DAY 2



Available stock limits exceeded!



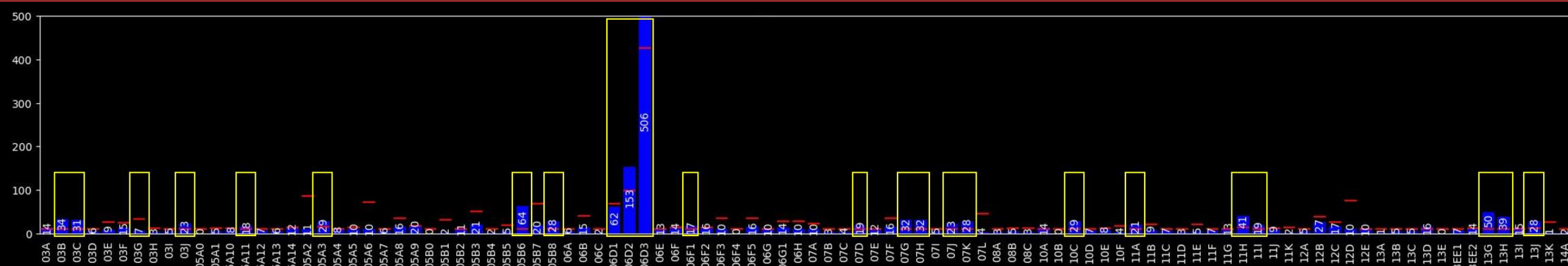
DAY 2

Military Command Team

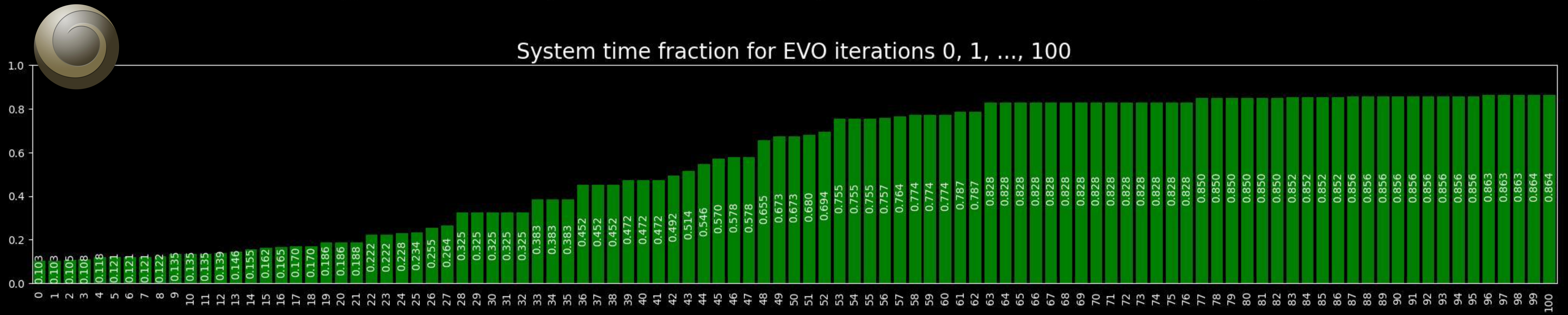
Analysts Team

Thanks for the suggested spares package, unfortunately it exceeds the existing stock for some items, can you please redo the analysis

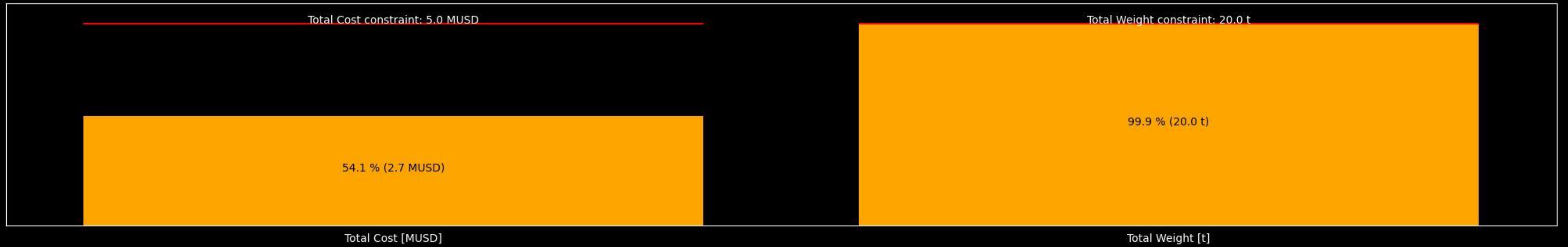
Ok sorry for that, we will get back to you soon with a revised spares package



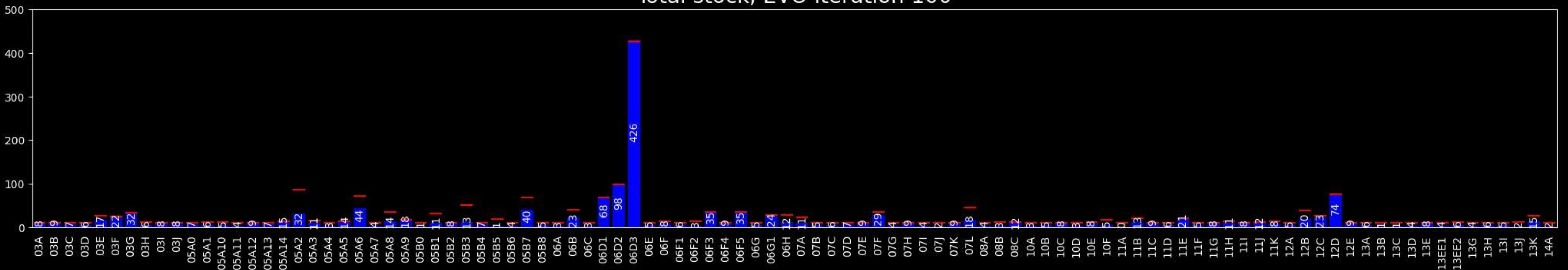
Running EVO with {Total Cost, Weight and Stock Constraints} ...



Constraint validation, EVO iteration 100



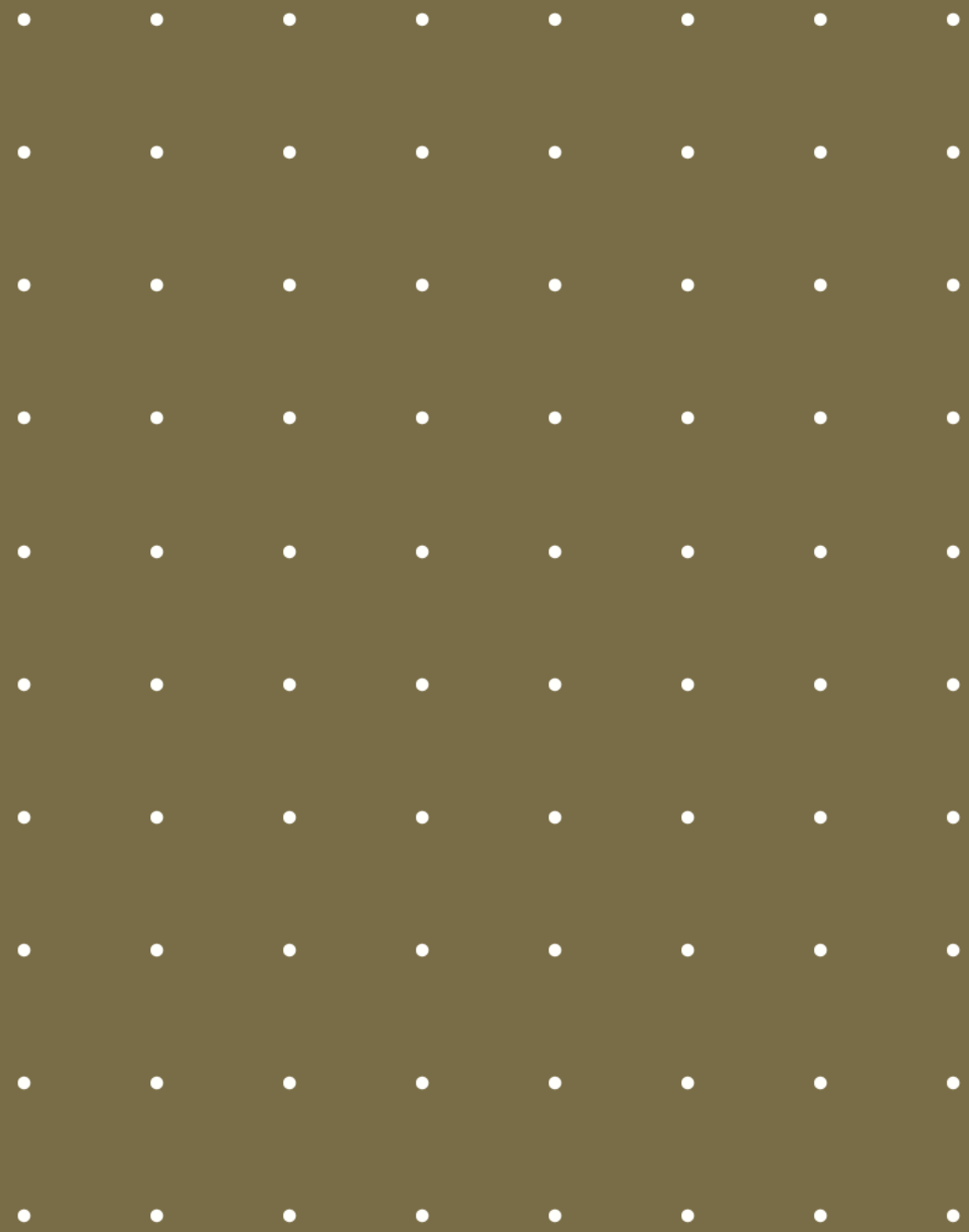
Total stock, EVO iteration 100



Opus Suite
Conference

STOCKHOLM

DAY 3



DAY 3

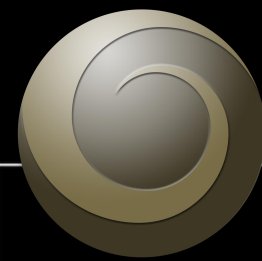
Military Command Team

Thanks for the suggested spares package, can you please update the analysis since there are also container volume constraints, 10 m³ for the NORTH WEST unit and 5 m³ for the SOUTH WEST unit

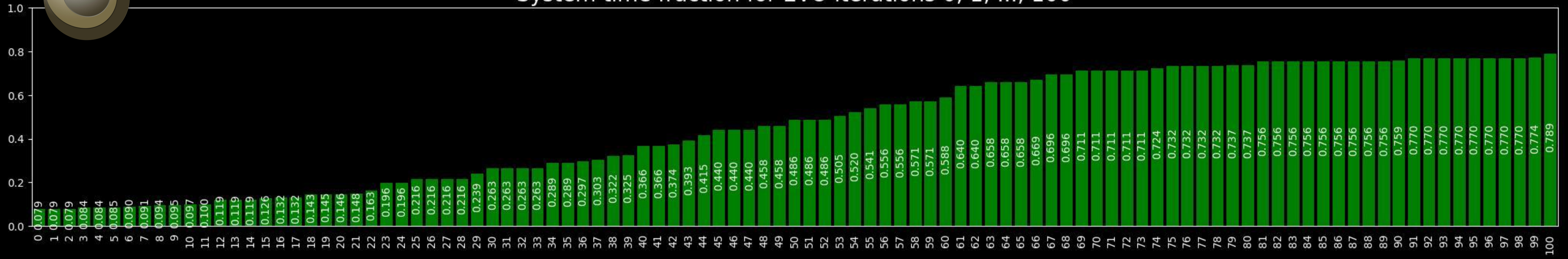
Analysts Team

Sure, we will get back to you within 24 hours with a revised spares package

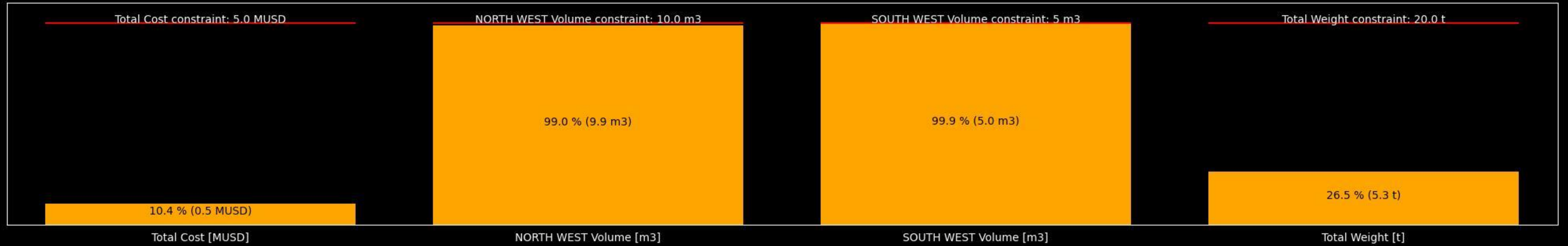
Running EVO with {Total Cost, Weight and Stock Constraints} and {Local Volume Constraints}...



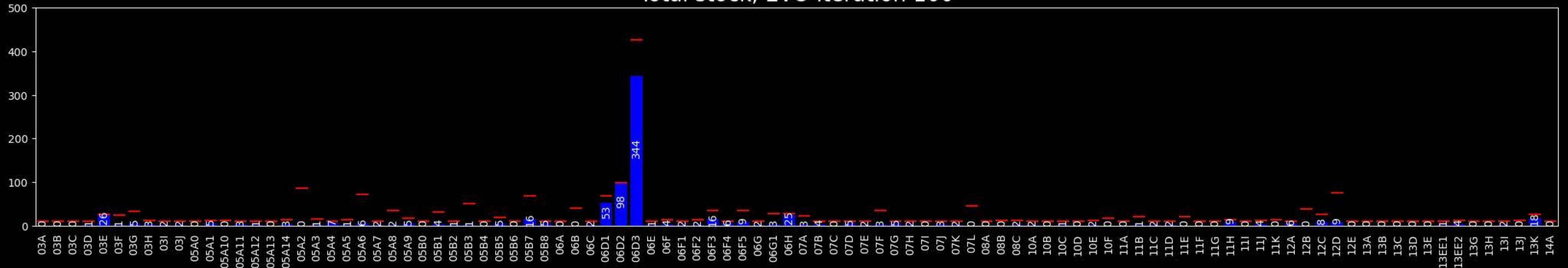
System time fraction for EVO iterations 0, 1, ..., 100



Constraint validation, EVO iteration 100



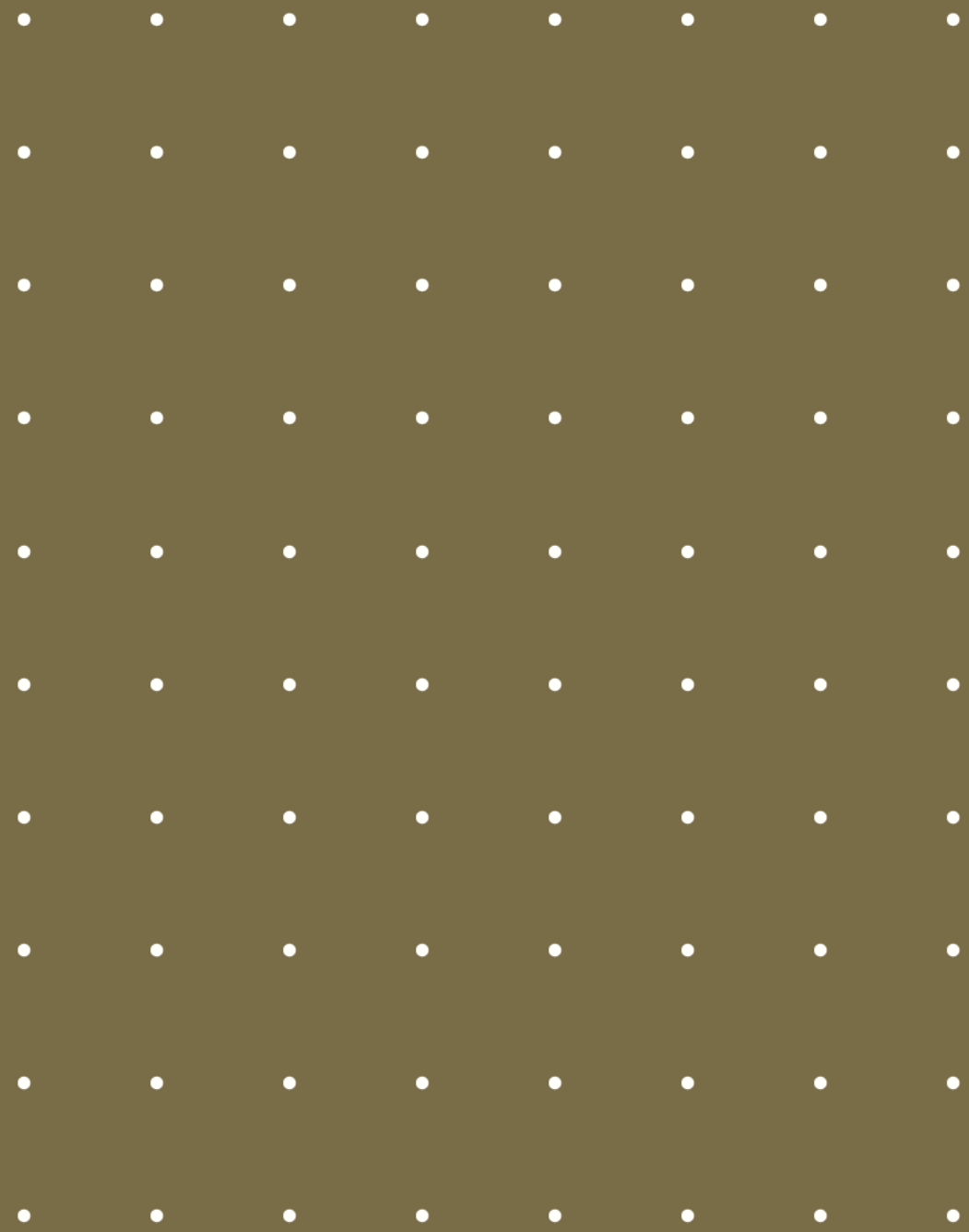
Total stock, EVO iteration 100



Opus Suite
Conference

STOCKHOLM

DAY 4



DAY 4

Military Command Team

Thanks for the suggested spares package, can you please do a complementary analysis taking into account that if there is a *shortage* of spares, the battle tanks may steal parts from one another...



Analysts Team

Sure, we will update our SIMLOX model to reflect this and then do a EVO rerun. We will get back to you as soon as we believe we have found a efficient spares package

Adjusting the SIMLOX model used by Opus Evo ...

SIMLOX - EvaluateMe_Robbing.sxi

File Edit View Data Tools Window Help

EvaluateMe_Robbing.sxi:1 <Model Tree View>

Product Breakdown

- ROOT, Fictive root
 - C_COM_FAMILY, Common vehicle systems
 - C_COM_VNT [C_COM_FAMILY], Common vehicle systems
 - 03 HULL, Common subsystems
 - BDE_03A, Boiling vessel / 03A, Boiling vessel
 - BDE_03B, Heater / 03B, Heater
 - BDE_03C, Air treatment unit / 03C, Air treatment unit
 - BDE_03D, Rear camera / 03D, Rear camera
 - BDE_03E, Lock / 03E, Lock
 - BDE_03F, Seat / 03F, Seat
 - BDE_03G, Safety belt / 03G, Safety belt
 - BDE_03H, Latch / 03H, Latch
 - BDE_03I, Black out lamp / 03I, Black out lamp
 - BDE_03J, Tail light / 03J, Tail light
 - 05 POWERDISTRIBUTION, Common subsystems
 - 05A, Transmission_components
 - BDE_05A0, Transmission / 05A0, Transmission
 - BDE_05A1, Control valve / 05A1, Control valve
 - BDE_05A10, Clutch assy, gear / 05A10, Clutch assy, gear
 - BDE_05A11, Gear / 05A11, Gear
 - BDE_05A12, Clutch assy / 05A12, Clutch assy
 - BDE_05A13, Final drive gear / 05A13, Final drive gear
 - BDE_05A14, Control unit transmission, TMC / 05A14, Control unit transmission, TMC
 - BDE_05A2, Kit, thermostat, 50°C / 05A2, Kit, thermostat, 50°C
 - BDE_05A3, Tension spring / 05A3, Tension spring
 - BDE_05A4, Sensor, speed / 05A4, Sensor, speed
 - BDE_05A5, Drive shaft / 05A5, Drive shaft
 - BDE_05A6, Locking house / 05A6, Locking house
 - BDE_05A7, Crank shaft / 05A7, Crank shaft
 - BDE_05A8, Linkage / 05A8, Linkage
 - BDE_05A9, Gear / 05A9, Gear
 - 05B, Engine_components
 - BDE_05B0, Diesel engine 615 Hp / 05B0, Diesel engine 615 Hp
 - BDE_05B1, Kit, thermostat, 75-90°C / 05B1, Kit, thermostat, 75-90°C
 - BDE_05B2, Oil cooler / 05B2, Oil cooler
 - BDE_05B3, Axial fan / 05B3, Axial fan
 - BDE_05B4, Alternator / 05B4, Alternator
 - BDE_05B5, Bolt and carrier / 05B5, Bolt and carrier
 - BDE_05B6, Sensor / 05B6, Sensor
 - BDE_05B7, Rotor / 05B7, Rotor
 - BDE_05B8, Adapter / 05B8, Adapter
 - 06 TRACK, Common subsystems
 - BDE_06A, Chain, track assy / 06A, Chain, track assy
 - BDE_06B, Leaf spring / 06B, Leaf spring
 - BDE_06C, Splash apron / 06C, Splash apron
 - 06D_ASSY, Steel track
 - BDE_06D1, Track shoe pin / 06D1, Track shoe pin
 - BDE_06D2, Track / 06D2, Track
 - BDE_06D3, Pad steel / 06D3, Pad steel
 - BDE_06E, Leaf spring / 06E, Leaf spring
 - BDE_06F, Wheel station / 06F, Wheel station

EvaluateMe_Robbing.sxi:2 <ProductBreakdown>

PVID	BDSID	BDMID	QTYPM	TID	RTID	NOTE
Product or product variant identifier	Breakdown sub identifier	Breakdown mother identifier	Quantity per mother element	Replacement task identifier	Robbing victim replacement task identifier	User note
			<1>			
1 C_COM_VNT	BDE_03A	03 HULL		REPLACE_03A	REPLACE_03A	
2 C_COM_VNT	BDE_03B	03 HULL		REPLACE_03B	REPLACE_03B	
3 C_COM_VNT	BDE_03C	03 HULL		REPLACE_03C	REPLACE_03C	
4 C_COM_VNT	BDE_03D	03 HULL		REPLACE_03D	REPLACE_03D	
5 C_COM_VNT	BDE_03E	03 HULL	2	REPLACE_03E	REPLACE_03E	
6 C_COM_VNT	BDE_03F	03 HULL	3	REPLACE_03F	REPLACE_03F	
7 C_COM_VNT	BDE_03G	03 HULL	3	REPLACE_03G	REPLACE_03G	
8 C_COM_VNT	BDE_03H	03 HULL	3	REPLACE_03H	REPLACE_03H	
9 C_COM_VNT	03 HULL					
10 C_COM_VNT	BDE_03I	03 HULL	3	REPLACE_03I	REPLACE_03I	
11 C_COM_VNT	BDE_03J	03 HULL	2	REPLACE_03J	REPLACE_03J	
12 C_COM_VNT	05A	05 POWERDISTRIBUTION				
13 C_COM_VNT	BDE_05A0	05A		REPLACE_05A0	REPLACE_05A0	
14 C_COM_VNT	BDE_05A1	05A	2	REPLACE_05A1	REPLACE_05A1	
15 C_COM_VNT	BDE_05A10	05A	4	REPLACE_05A10	REPLACE_05A10	
16 C_COM_VNT	BDE_05A11	05A	2	REPLACE_05A11	REPLACE_05A11	
17 C_COM_VNT	BDE_05A12	05A	2	REPLACE_05A12	REPLACE_05A12	
18 C_COM_VNT	BDE_05A13	05A	2	REPLACE_05A13	REPLACE_05A13	
19 C_COM_VNT	BDE_05A14	05A		REPLACE_05A14	REPLACE_05A14	
20 C_COM_VNT	BDE_05A2	05A		REPLACE_05A2	REPLACE_05A2	
21 C_COM_VNT	BDE_05A3	05A	2	REPLACE_05A3	REPLACE_05A3	
22 C_COM_VNT	BDE_05A4	05A	2	REPLACE_05A4	REPLACE_05A4	
23 C_COM_VNT	BDE_05A5	05A	2	REPLACE_05A5	REPLACE_05A5	
24 C_COM_VNT	BDE_05A6	05A	2	REPLACE_05A6	REPLACE_05A6	
25 C_COM_VNT	BDE_05A7	05A	2	REPLACE_05A7	REPLACE_05A7	
26 C_COM_VNT	BDE_05A8	05A		REPLACE_05A8	REPLACE_05A8	
27 C_COM_VNT	BDE_05A9	05A	2	REPLACE_05A9	REPLACE_05A9	
28 C_COM_VNT	05B	05 POWERDISTRIBUTION				
29 C_COM_VNT	BDE_05B0	05B		REPLACE_05B0	REPLACE_05B0	
30 C_COM_VNT	BDE_05B1	05B		REPLACE_05B1	REPLACE_05B1	
31 C_COM_VNT	BDE_05B2	05B		REPLACE_05B2	REPLACE_05B2	
32 C_COM_VNT	BDE_05B3	05B		REPLACE_05B3	REPLACE_05B3	
33 C_COM_VNT	BDE_05B4	05B		REPLACE_05B4	REPLACE_05B4	
34 C_COM_VNT	BDE_05B5	05B		REPLACE_05B5	REPLACE_05B5	
35 C_COM_VNT	BDE_05B6	05B		REPLACE_05B6	REPLACE_05B6	
36 C_COM_VNT	BDE_05B7	05B		REPLACE_05B7	REPLACE_05B7	
37 C_COM_VNT	BDE_05B8	05B	2	REPLACE_05B8	REPLACE_05B8	
38 C_COM_VNT	05 POWERDISTRIBUTION					
39 C_COM_VNT	BDE_06A	06 TRACK	2	REPLACE_06A	REPLACE_06A	
40 C_COM_VNT	BDE_06B	06 TRACK		REPLACE_06B	REPLACE_06B	
41 C_COM_VNT	BDE_06C	06 TRACK		REPLACE_06C	REPLACE_06C	
42 C_COM_VNT	BDE_06D1	06D_ASSY	183	REPLACE_06D1	REPLACE_06D1	
43 C_COM_VNT	BDE_06D2	06D_ASSY	184	REPLACE_06D2	REPLACE_06D2	

Support organization

Quantity System ID

10 C_ARV

10 C_FCV

10 C_IFV

DEPOT NORTH WEST

5 C_ARV

5 C_FCV

5 C_IFV

DEPOT SOUTH WEST

5 C_ARV

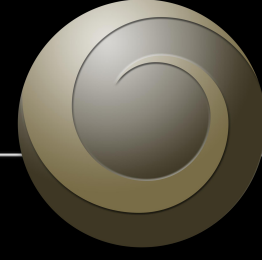
5 C_FCV

5 C_IFV

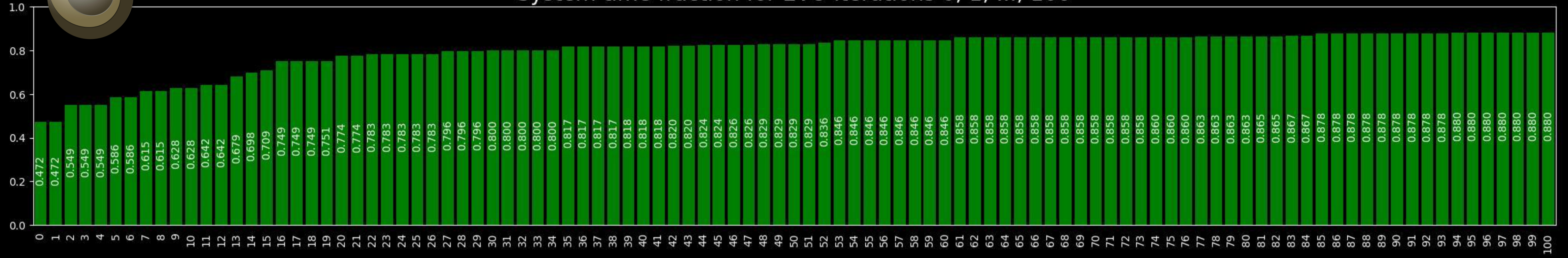
Control

NREPS	Number of replications	<1>	10
SIMPE	Simulation period	[Hours]	2190.0
RSEED	Random seed		123
APID	Allocation point identifier		
RCINT	Result collection interval	[Hours] <24.0>	2190.0
RCSTA	Result collection start time	[Hours] <0.0>	
RCEND	Result collection end time	[Hours]	
ENPM	Enable Preventive Maintenance	<Y>	
ENLAT	Enable lateral support	<Y>	
ENROB	Enable robbing	<N>	Y
ENALU	Enable alternative units	<Y>	
TCLEV	Target confidence level		
ENLOG	Enable simulation log	<N>	
RMVFR	Removal fraction of replacement time	<0.500>	
WTLIM	Waiting time tolerance for ROST	[Hours] <0.00>	
ENBOP	Enable backorder prioritisation	<N>	

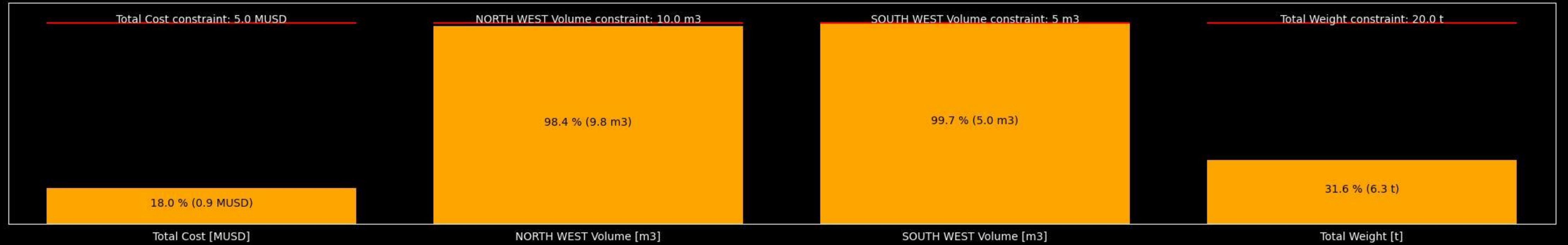
Running EVO with {Total Cost, Weight and Stock Constraints} and {Local Volume Constraints}...



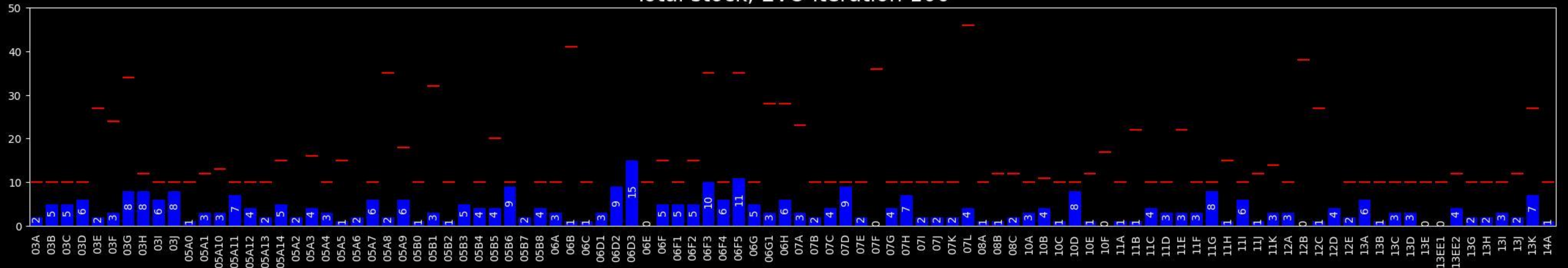
System time fraction for EVO iterations 0, 1, ..., 100



Constraint validation, EVO iteration 100



Total stock, EVO iteration 100



Ready to go ...

Military Command Team

Thank you for the spares
recommendations!

Analysts Team

You are welcome!

Conclusions

- In the presented scenario it was shown how Opus Evo can be used to find efficient spares packages satisfying a series of cost, weight and volume constraints.
 - NOTE: Opus Evo also supports cost, weight and volume constraints in the *system* and *resource* dimension
- Opus Evo is a powerful tool for solving real world problems using horizontal scaling of computer power

Thank you.

