

Leonardo Electronics

Sizing and localization of depots in order to perform a cost-effective logistic support for a set of systems located on Italian territory

Turin

14/05/2024



Electronics



Helicopters



Aircraft



Cyber & Security



Space



Unmanned Systems



Aerostructures

SUMMARY

- Scope
- Problem Description
- OPUS Suite Modeling
- OPUS Results
- Simlox Results
- CATLOC results
- Conclusions and improvements



Scope

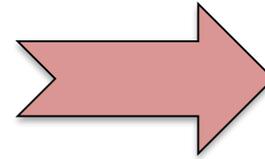


Scope

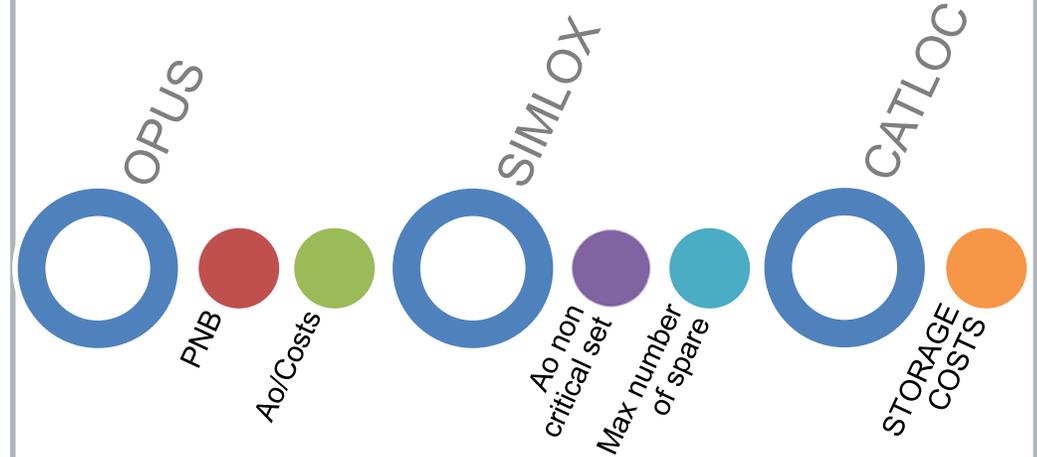
INPUT

REQUIREMENTS

- System Operation Availability (Ao) $\geq 98\%$
- Annual Operating Rate (AOR) - 100%
(≈ 8760 operating hours per year)
- System Maintenance Policy
 - During the Mission - for Critical components parts, only
 - At the End of Mission - for Not Critical components parts
- Not Critical Parts Availability (Ao_{SysNC}) $\geq 45\%$
- Max 250 spare parts units for each depot
- Site Storage Cost - Max € 2.500 (dummy)
- Number of Operating Site - 9
- Probability of No Backorder (PNB) $\geq 90\%$



OUTPUT

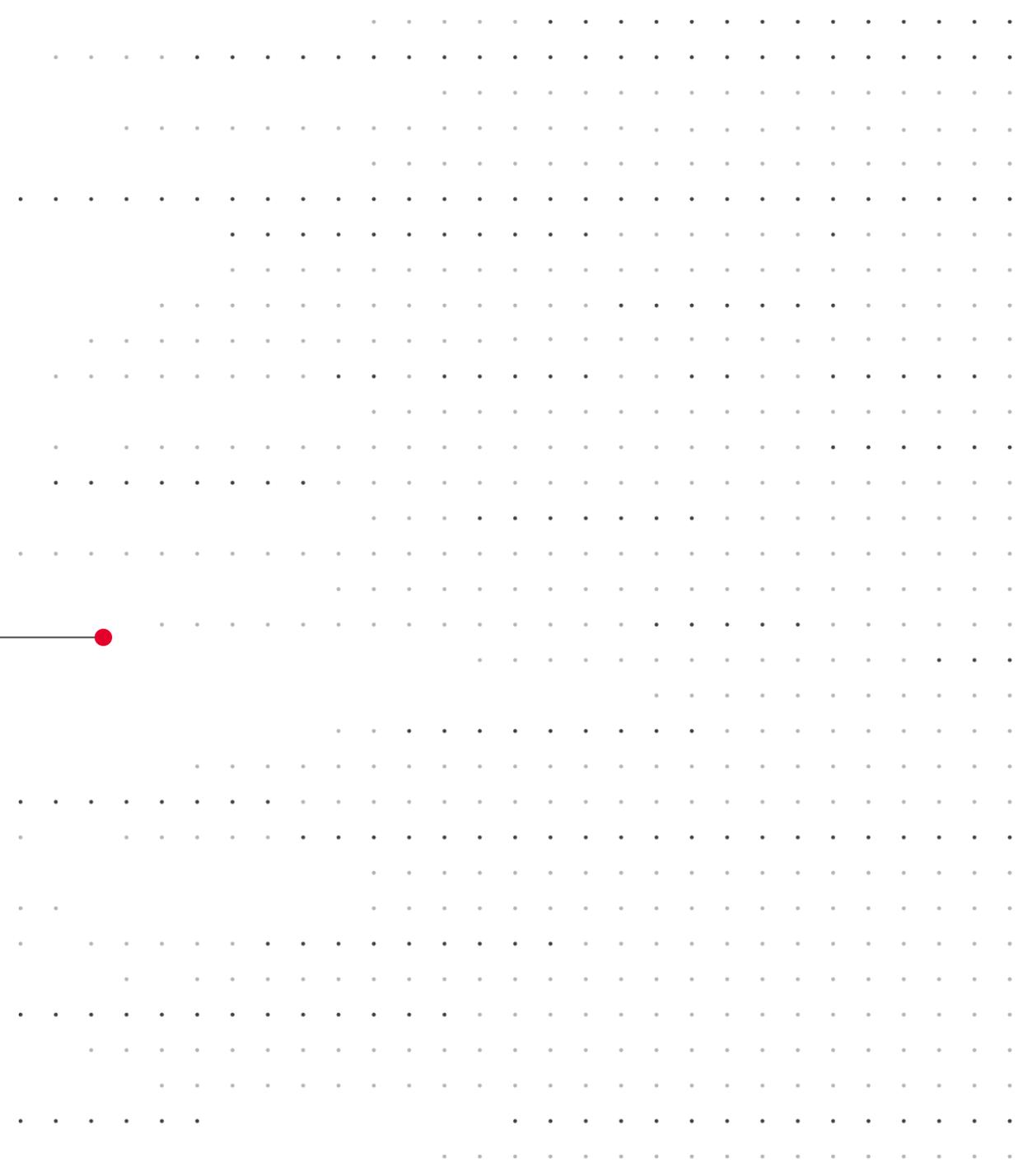


SUPPORT SYSTEM OPTIMIZATION

- Number of Stock Site
- Transfert time
- Lateral Support



Problem Description



Problem Description

Operational Scenario

- Primary System Component Parts : 166

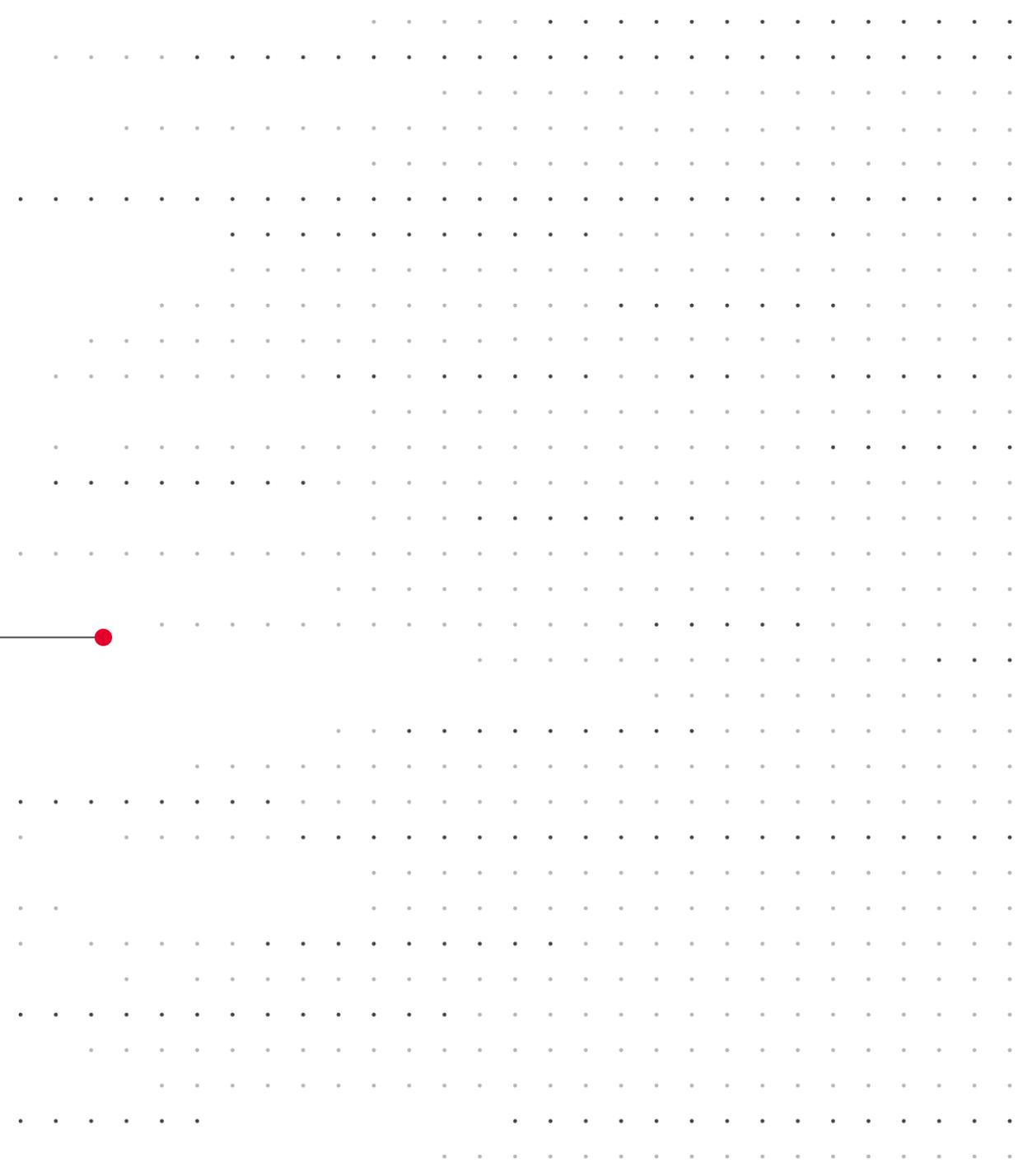
ITEMS	Critical	Not Critical
Reparable	66	73
Not Reparable	27	0



- Preventive Maintenance scheduled time (for 1 ITEM) 5years; Duration: 720h
- Reorder LEAD time: 1Year
- $1.560h < TAT < 13.200h$
- Mission Time: 30 days
- Number of mission per Year: 12

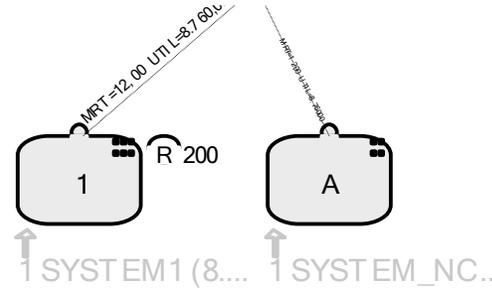
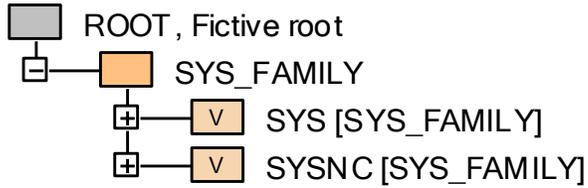


OPUS Suite Modeling



OPUS Suite Modeling

System modeling



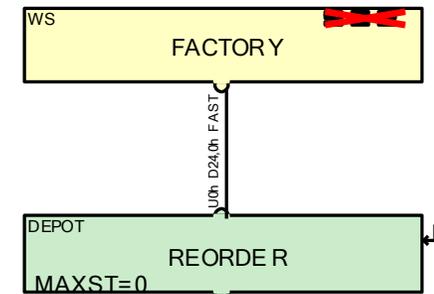
Item IDENTIFIER	UNIT	Criticality	Probability for System Effectiveness Impact (PSEI)
SYS	1	Critical	1
SYSNC	A	non-critical	0.0001

- **SYS: Set of system critical items**
- **SYSNC: Set of system NOT critical items**
- **The System is modeled as a set of two virtual units (1 and A), by means of PSEI parameter:**
 - Unit 1 refers to system critical item set. In case of occurred failures, the operating restore tasks are admitted During Mission
 - Unit A refers to system NOT critical item set. In case of occurred failures, the operating restore tasks are admitted at the End of Mission, only

Support modeling

STATION/UNIT	STORAGE COST PER UNIT	STORAGE COST PER VALUE
ALL	1	0,000001

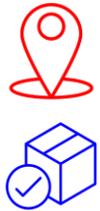
- **Lateral Support for sites**
- **Lateral Shipment time depends on the number of sites**



- **One Station dedicated for Reorders (no stock)**
- **Factory for rectifying maintenance**

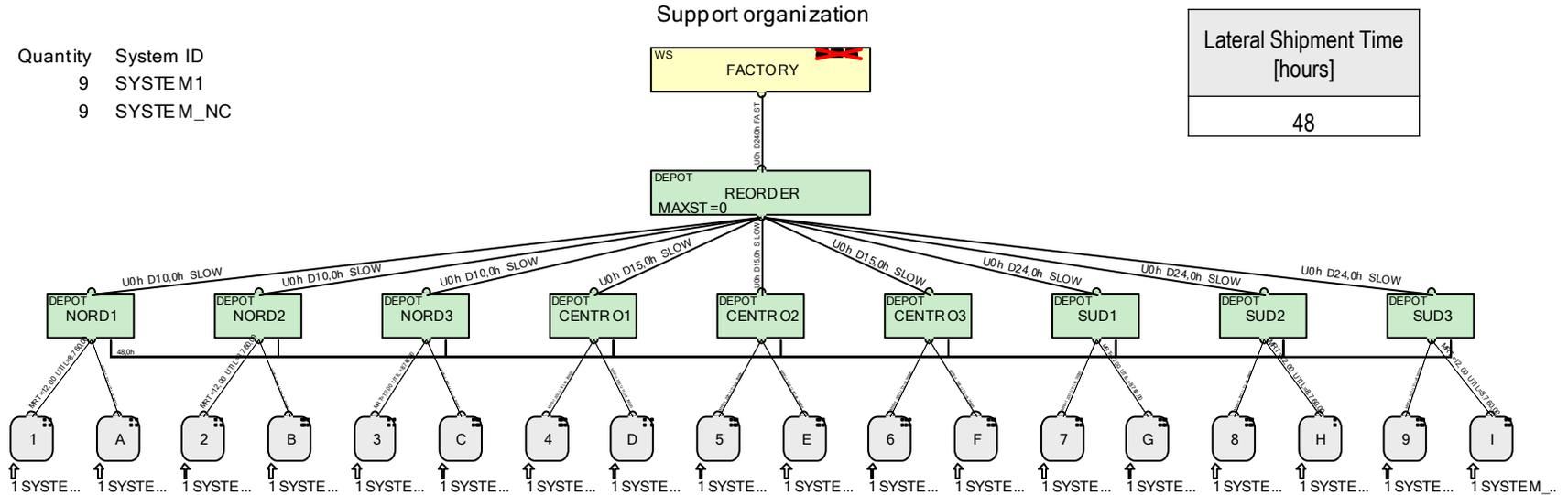


OPUS Suite Modeling Case 1: N° 9 Stock Site → N° 9 Operation Systems



System Location

Stock Site Location



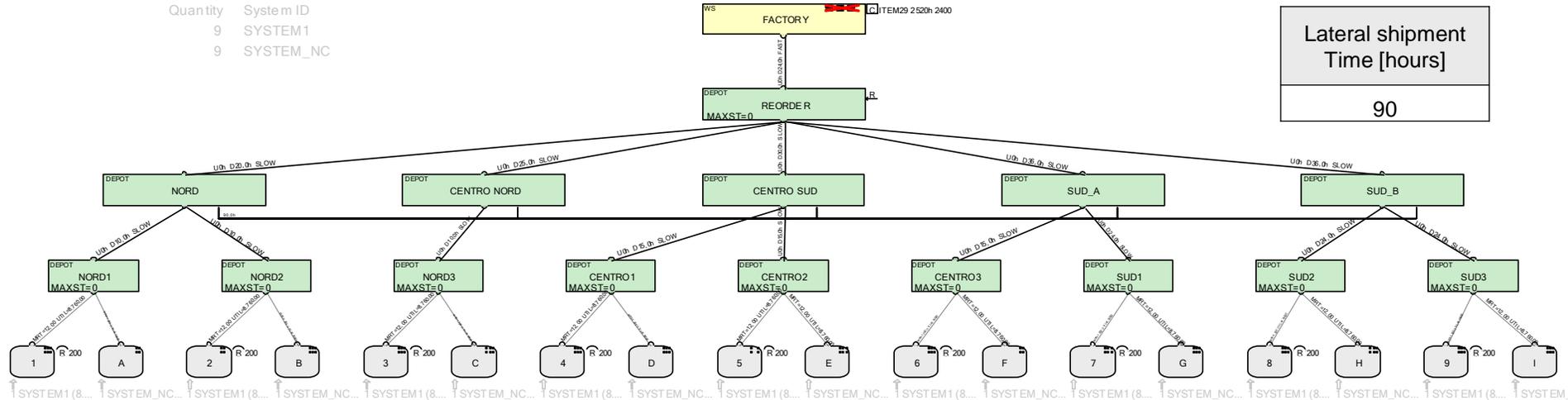
STATION	Mother STATION	Time From mother station	Time to mother station	Cost from mother station	Cost to mother station	Ordering Policy
NORD1	REORDER	10	0	5	5	SLOW
NORD2	REORDER	10	0	5	5	SLOW
NORD3	REORDER	10	0	5	5	SLOW
CENTRO1	REORDER	15	0	7,5	7,5	SLOW
CENTRO2	REORDER	15	0	7,5	7,5	SLOW
CENTRO3	REORDER	15	0	7,5	7,5	SLOW
SUD1	REORDER	24	0	12	12	SLOW
SUD2	REORDER	24	0	12	12	SLOW
SUD3	REORDER	24	0	12	12	SLOW
REORDER	FACTORY	24	0			



OPUS Suite Modeling Case 2: N° 5 Stock Site → N° 9 Operation Systems



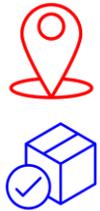
Support strategy for ITEM 29



STATION	Mother STATION	Time From mother station	Time to mother station	Cost from mother station	Cost to mother station	Ordering Policy
NORD1	NORD	15	0	10	10	SLOW
NORD2	NORD	15	0	10	10	SLOW
NORD3	CENTRO NORD	15	0	10	10	SLOW
CENTRO1	CENTRO SUD	20	0	12,5	7,5	SLOW
CENTRO2	CENTRO SUD	20	0	12,5	7,5	SLOW
CENTRO3	SUD_A	20	0	12,5	7,5	SLOW
SUD1	SUD_A	29	0	17	17	SLOW
SUD2	SUD_B	29	0	17	17	SLOW
SUD3	SUD_B	29	0	17	17	SLOW
NORD	REORDER	20	0	10	10	SLOW
REORDER	FACTORY	24	0			
CENTRO NORD	REORDER	25	0	12,5	12,5	SLOW
CENTRO SUD	REORDER	30	0	15	15	SLOW
SUD_A	REORDER	36	0	18	18	SLOW
SUD_B	REORDER	36	0	18	18	SLOW



OPUS Suite Modeling Case 3: N° 3 Stock Site → N° 9 Operation Systems

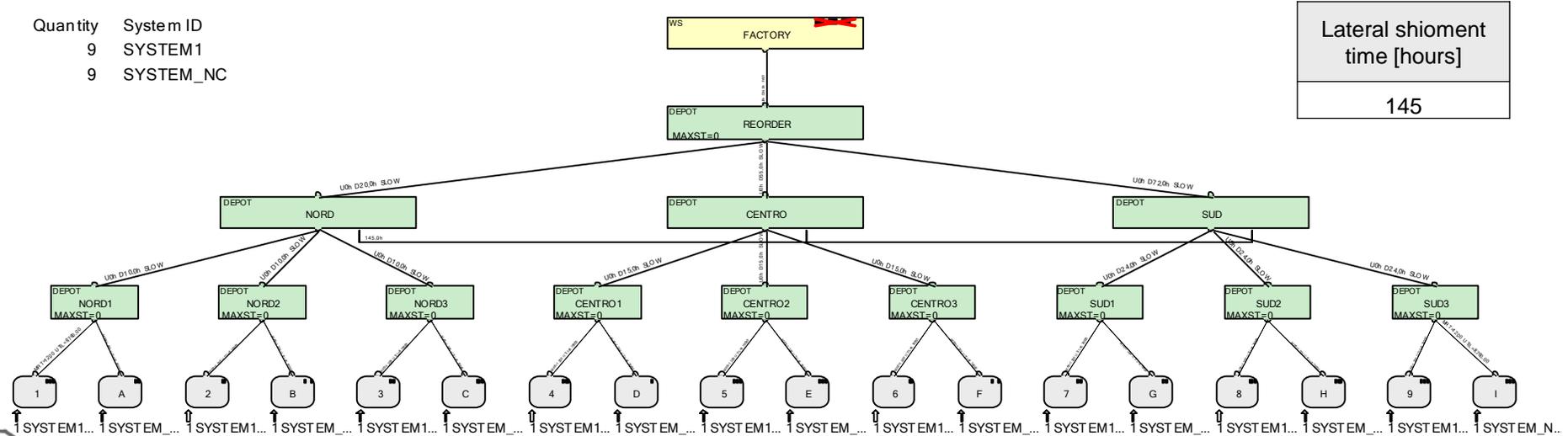


System Location

Stock Site Location

Quantity System ID
 9 SYSTEM1
 9 SYSTEM_NC

Support organization

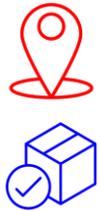


Lateral shioment
 time [hours]
 145

STATION	Mother STATION	Time From mother station	Time to mother station	Cost from mother station	Cost to mother station	Ordering Policy
NORD1	NORD	20	0	15	15	SLOW
NORD2	NORD	20	0	15	15	SLOW
NORD3	CENTRO NORD	20	0	15	15	SLOW
CENTRO1	CENTRO SUD	25	0	17,5	17,5	SLOW
CENTRO2	CENTRO SUD	25	0	17,5	17,5	SLOW
CENTRO3	SUD_A	25	0	17,5	17,5	SLOW
SUD1	SUD_A	34	0	22	22	SLOW
SUD2	SUD_B	34	0	22	22	SLOW
SUD3	SUD_B	34	0	22	22	SLOW
NORD	REORDER	20	0	10	10	SLOW
CENTRO	REORDER	55	0	27,5	27,5	SLOW
SUD	REORDER	72	0	36	36	SLOW
REORDER	FACTORY	24	0			



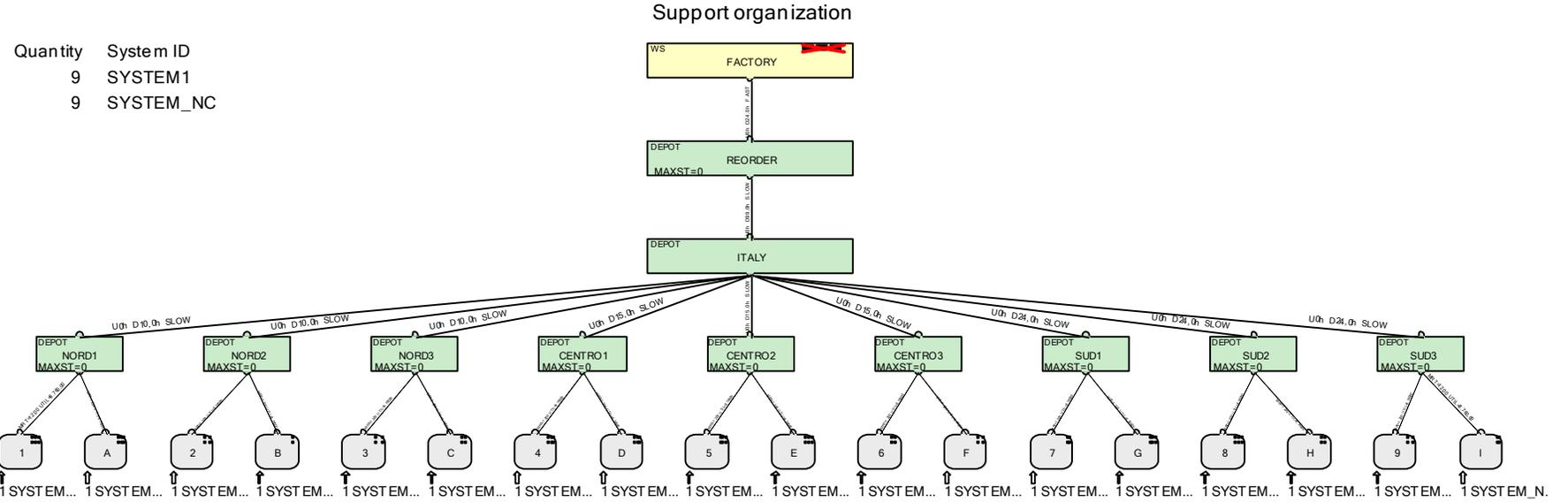
OPUS Suite Modeling Case 4: N° 1 Stock Site → N° 9 Operation Systems



System Location



Stock Site Location



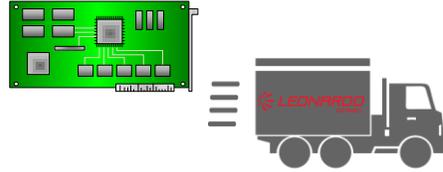
STATION	Mother STATION	Time From mother station	Time to mother station	Cost from mother station	Cost to mother station	Ordering Policy
NORD1	ITALY	25	0	20	20	SLOW
NORD2	ITALY	25	0	20	20	SLOW
NORD3	ITALY	25	0	20	20	SLOW
CENTRO1	ITALY	30	0	22,5	22,5	SLOW
CENTRO2	ITALY	30	0	22,5	22,5	SLOW
CENTRO3	ITALY	30	0	22,5	22,5	SLOW
SUD1	ITALY	39	0	27	27	SLOW
SUD2	ITALY	39	0	27	27	SLOW
SUD3	ITALY	39	0	27	27	SLOW
ITALY	REORDER	99	0	49,5	49,5	SLOW
REORDER	FACTORY	24	0			



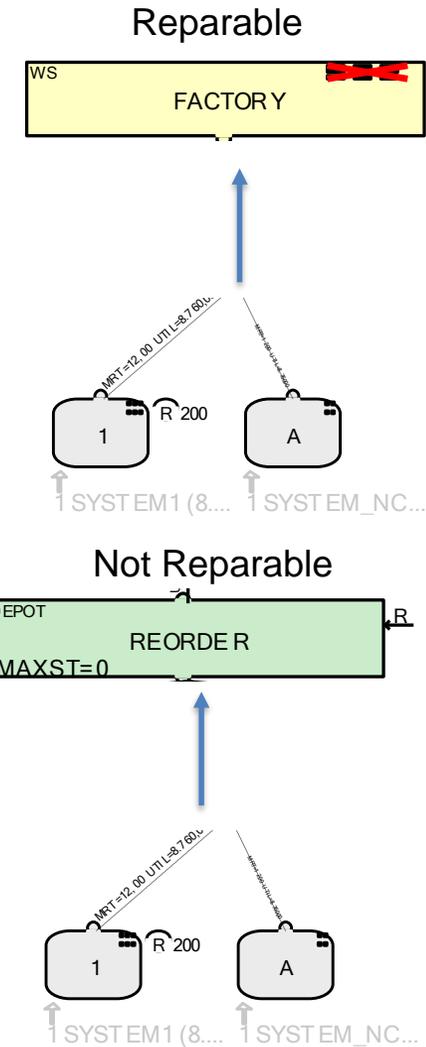
OPUS Suite Modeling:



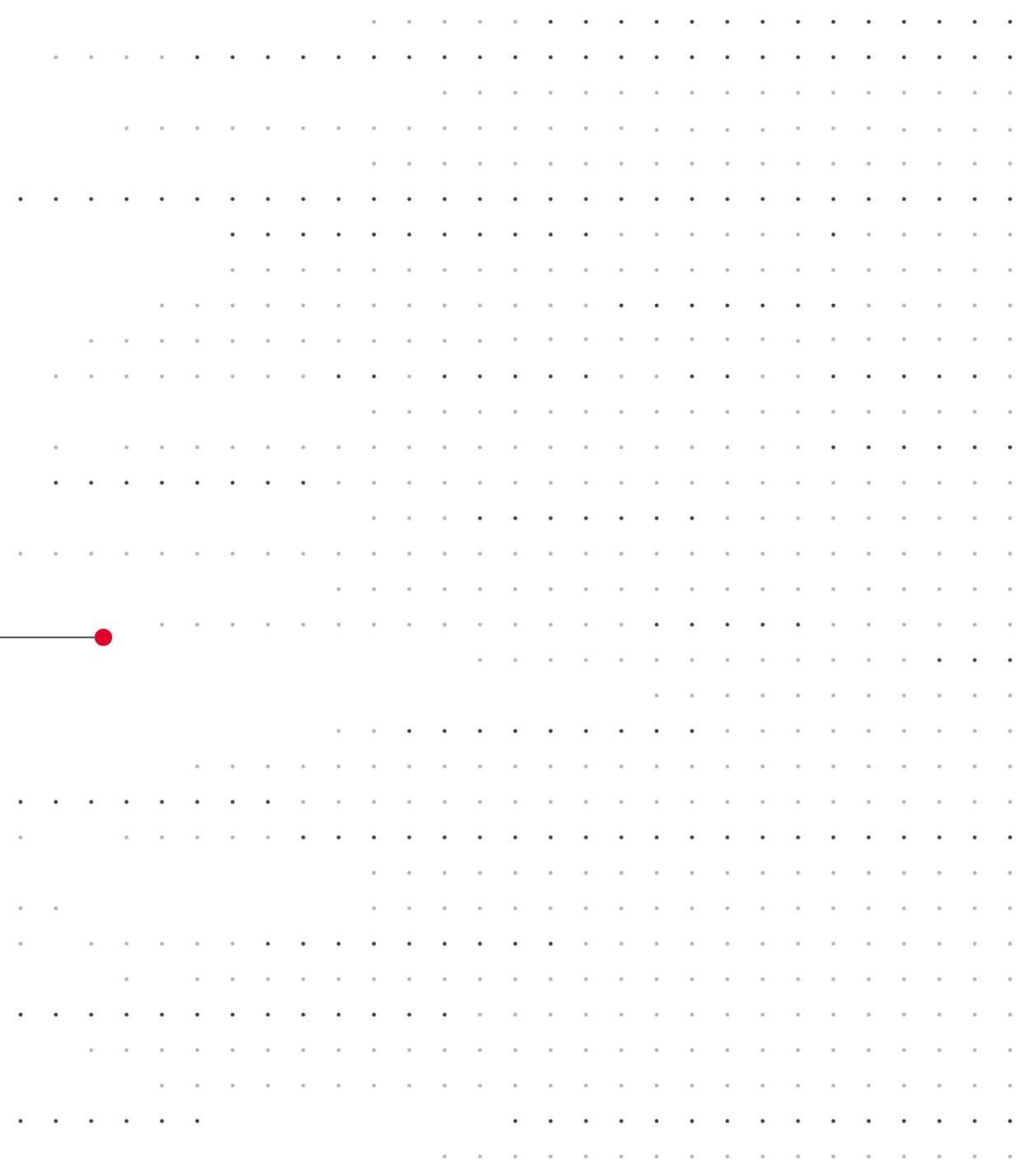
 System Location



ID Case	Number of site	ITEM Type [hours]	Mean Transfert time [h]
1	9	Reparable	41
2	5	Reparable	75
3	3	Reparable	99
4	1	Reparable	154
1	9	Not reparable	17
2	5	Not reparable	51
3	3	Not reparable	75
4	1	Not reparable	130



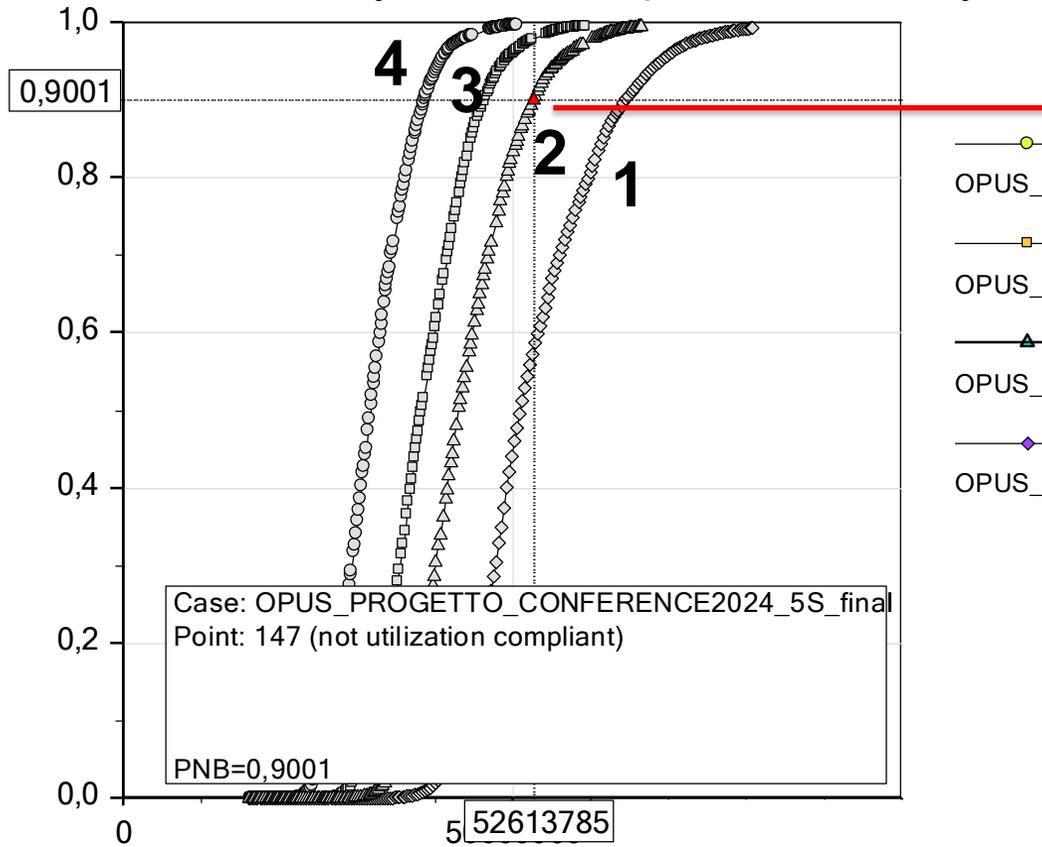
OPUS Results



OPUS Results:

C/E-Curve Diagram

Number of Systems Not Operational Ready



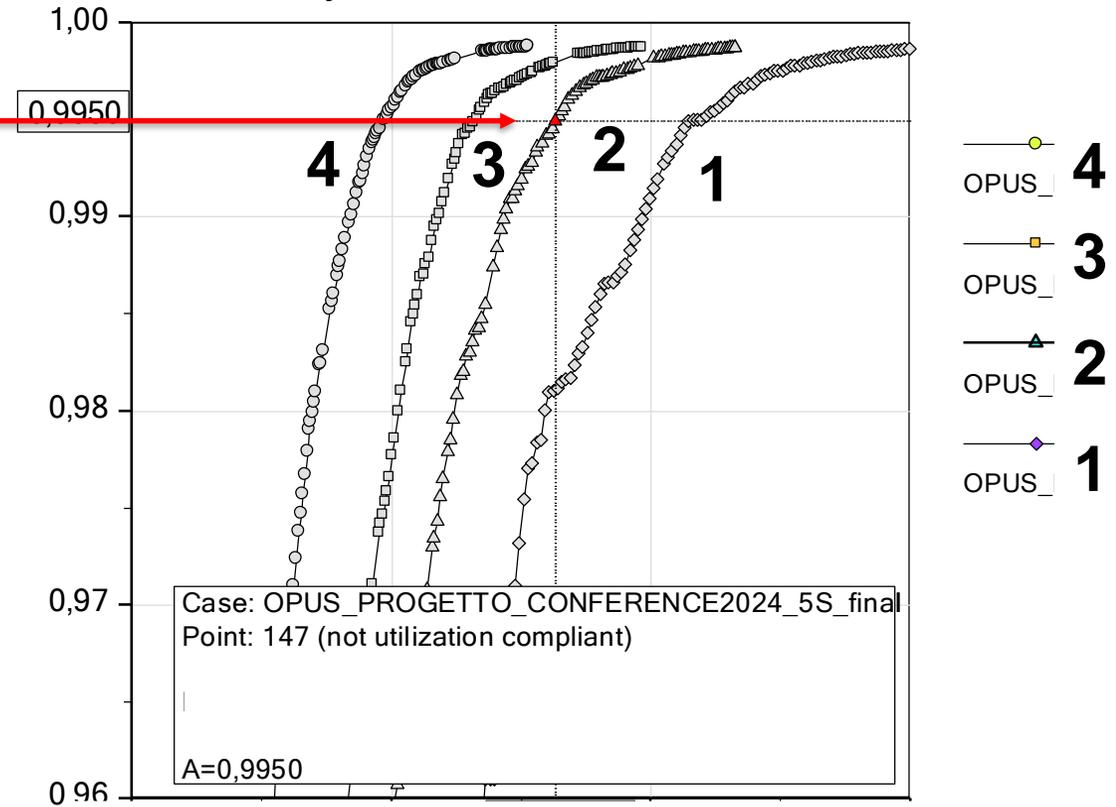
Life Support Cost

REQUIREMENT

- Probability of No Backorder (PNB) $\geq 90\%$

C/E-Curve Diagram

Availability



Life Support Cost

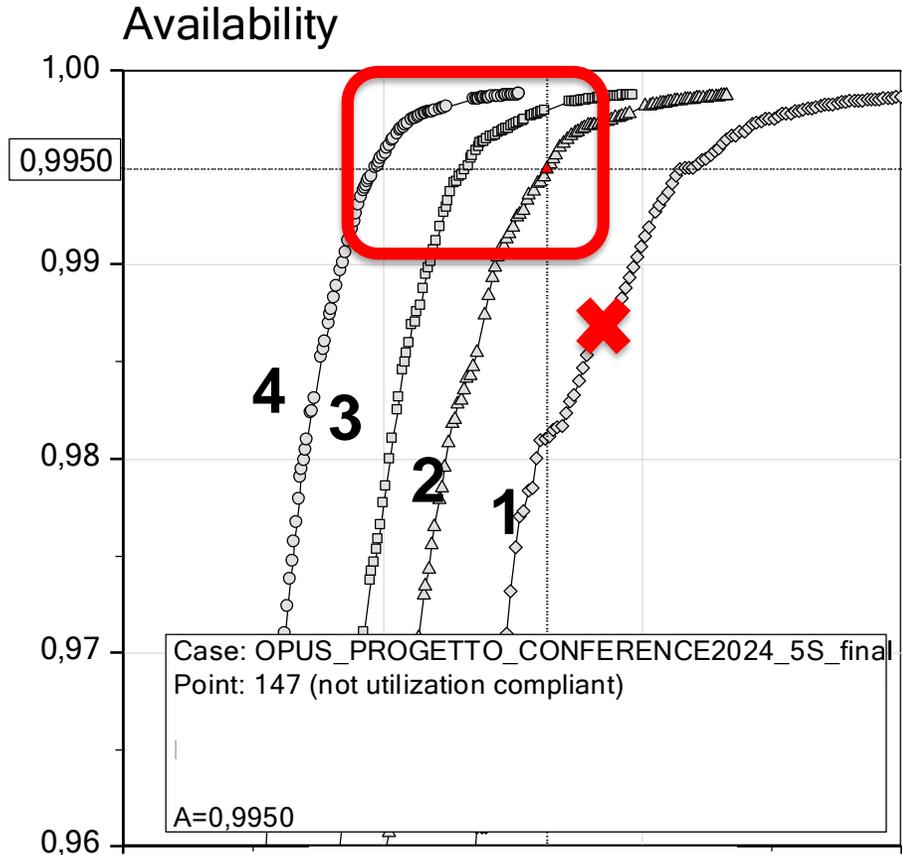
REQUIREMENT

- System Operation Availability (A_o) $\geq 98\%$

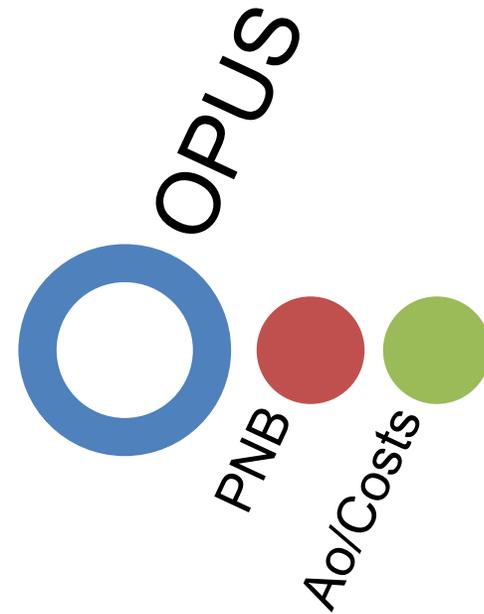


OPUS Results:

C/E-Curve Diagram



What best practice for cost-effectiveness curve choice



- Case 1 (9 stock sites) **discarded.**



OPUS Results:

ID Case	Station	Nr Item (Initial Stock)
1	CENTRO1	133
1	CENTRO2	133
1	CENTRO3	133
1	NORD1	133
1	NORD2	133
1	NORD3	133
1	SUD1	134
1	SUD2	133
1	SUD3	133
2	CENTRO NORD	127
2	CENTRO SUD	226
2	NORD	225
2	SUD_A	228
2	SUD_B	228
3	CENTRO	269
3	NORD	266
3	SUD	269
4	ITALY	449

REQUIREMENT

- System Operation Availability (Ao) - 98%
- Site Stock Volume - Max 250 spare parts units

REQUIREMENT Compliance

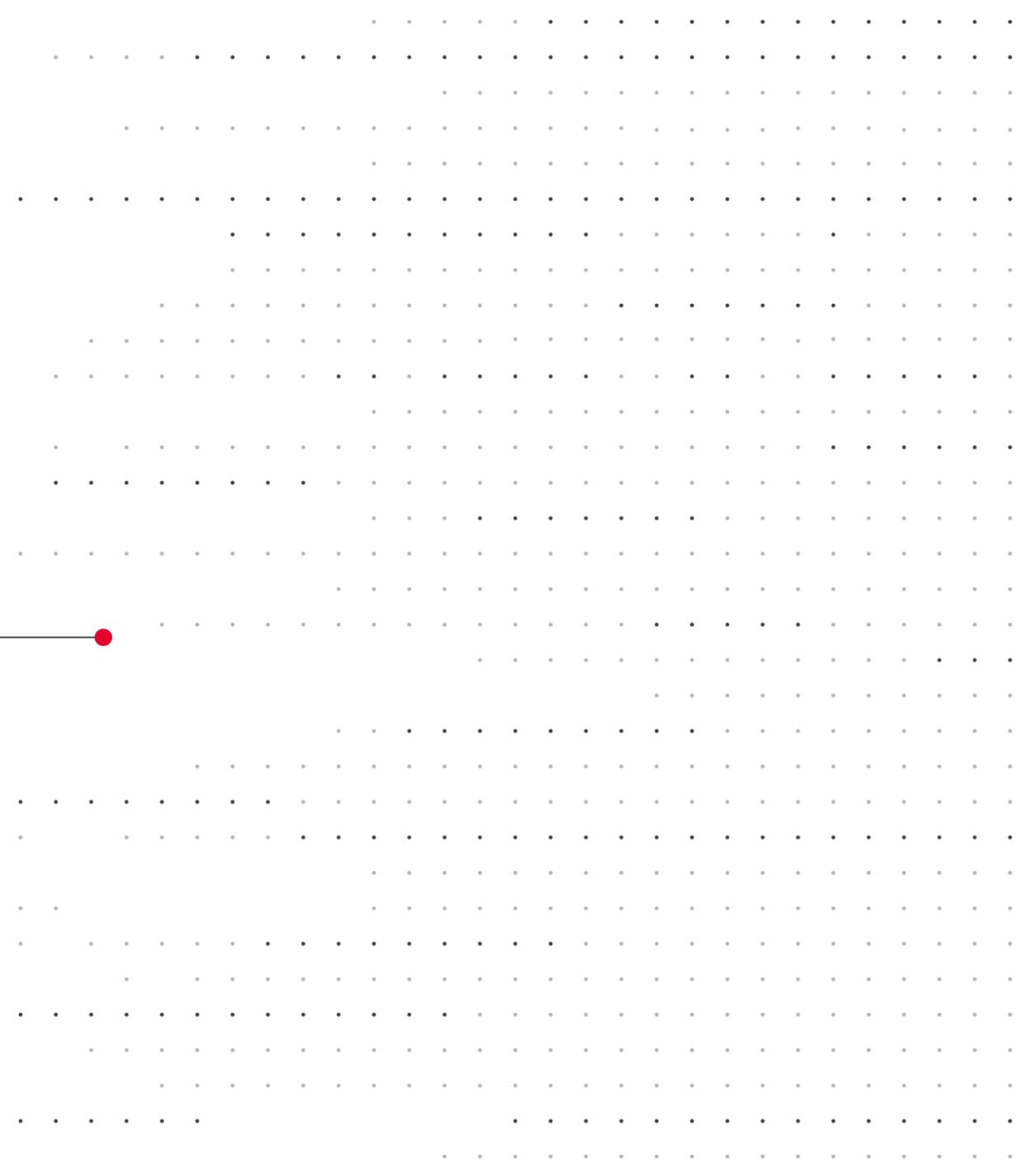
- Case 1 is **discarded**, for acquisition spare parts costs
- Case 3 & Case 4 are **discarded**, for volumes

Simlox
Analisis



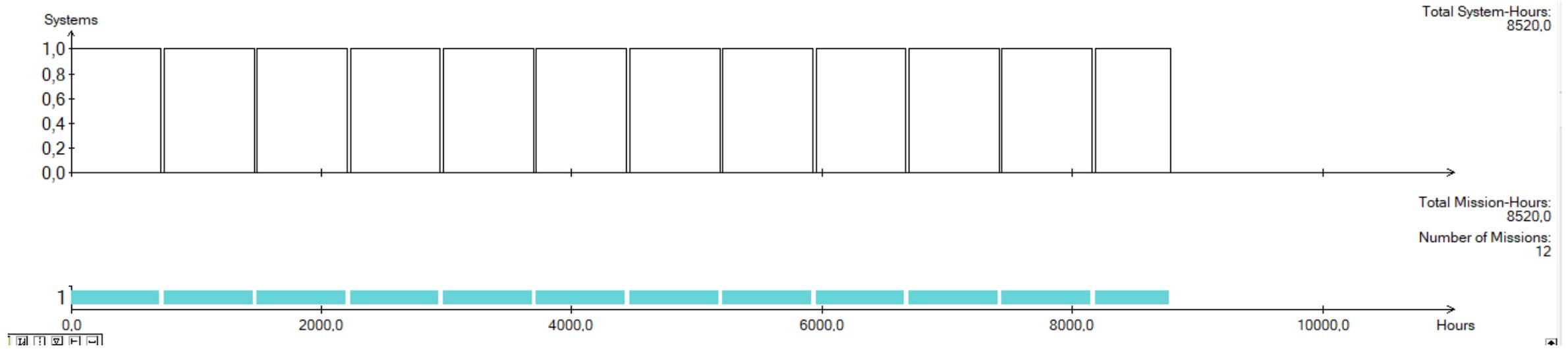
According to OPUS results, case 2 best fits requirement → It needs a Simlox Analysis for more assessment

Simlox Modeling



Simlox Modeling

Operation profile



Number of replication	500
Simulation Period (Years)	20

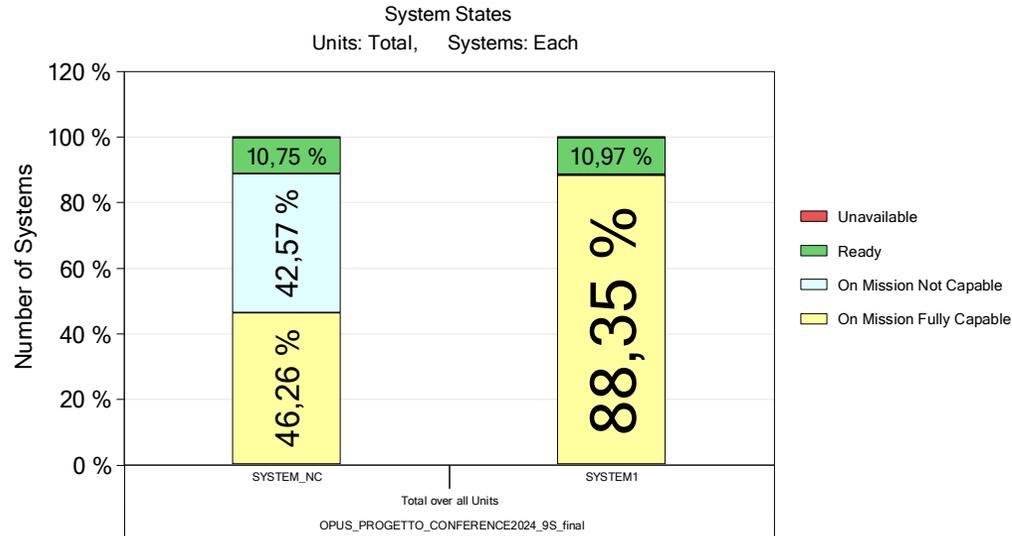


Simlox Results

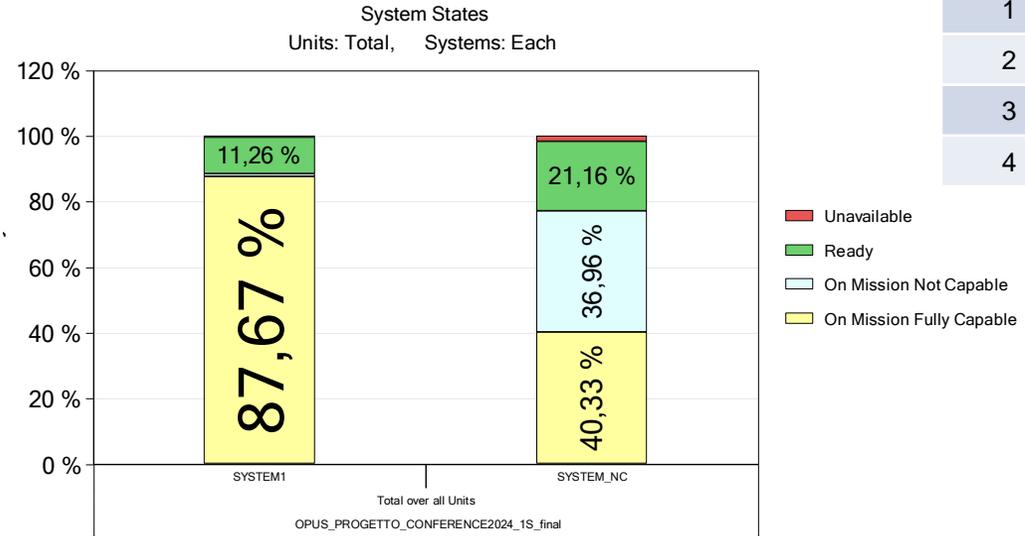


Simlox Results

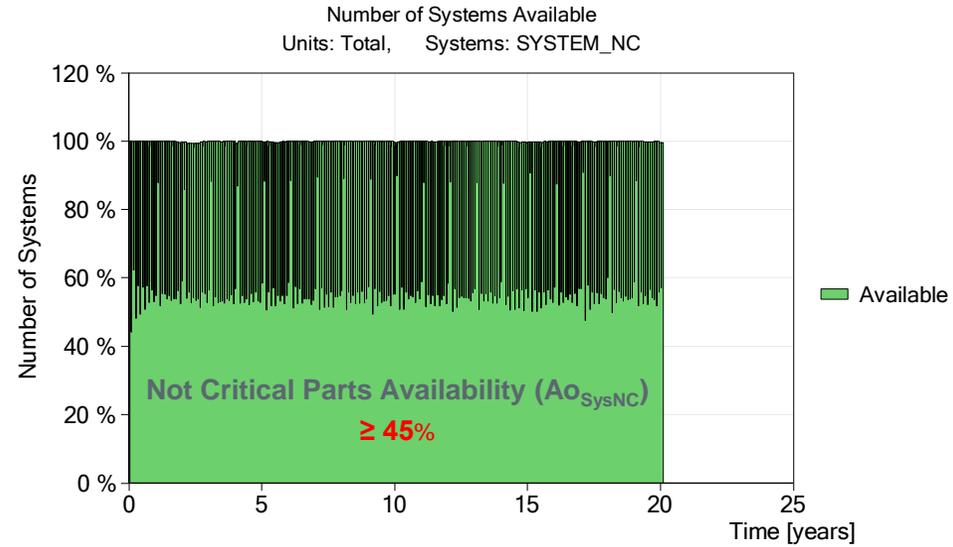
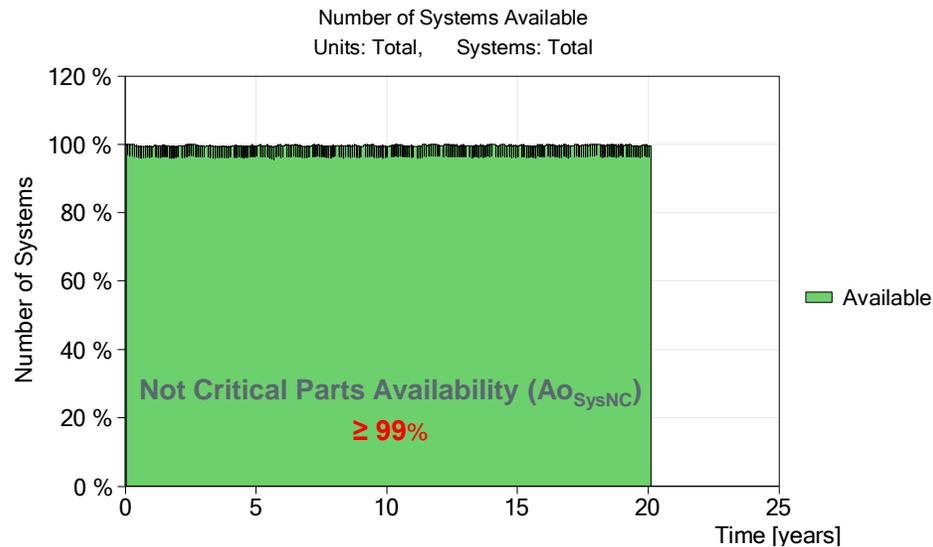
Case 1 Nr.9 stock sites



Case 4 Nr.1 stock site

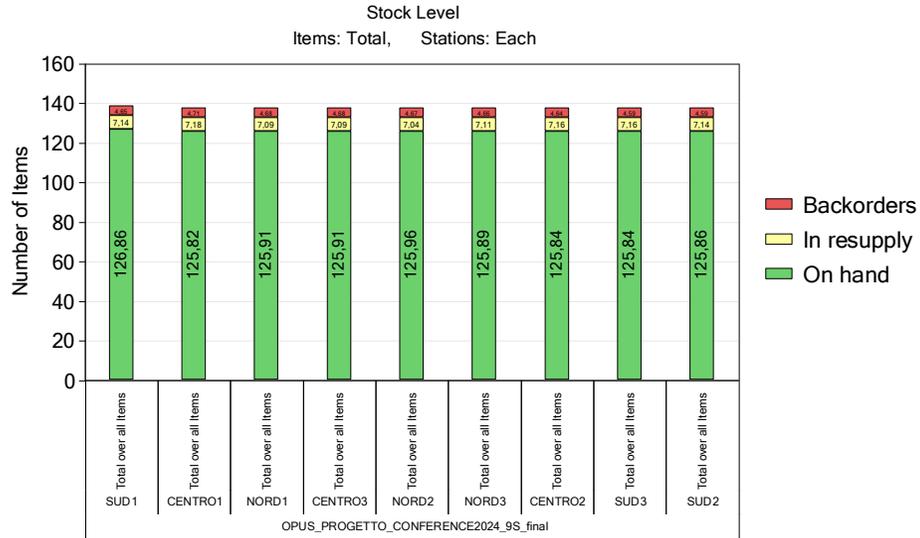


ID Case	Nr. of stock sites	Not Critical Parts Availability (Ao_{SysNC})
1	9	99%
2	5	50%
3	3	48%
4	1	45%

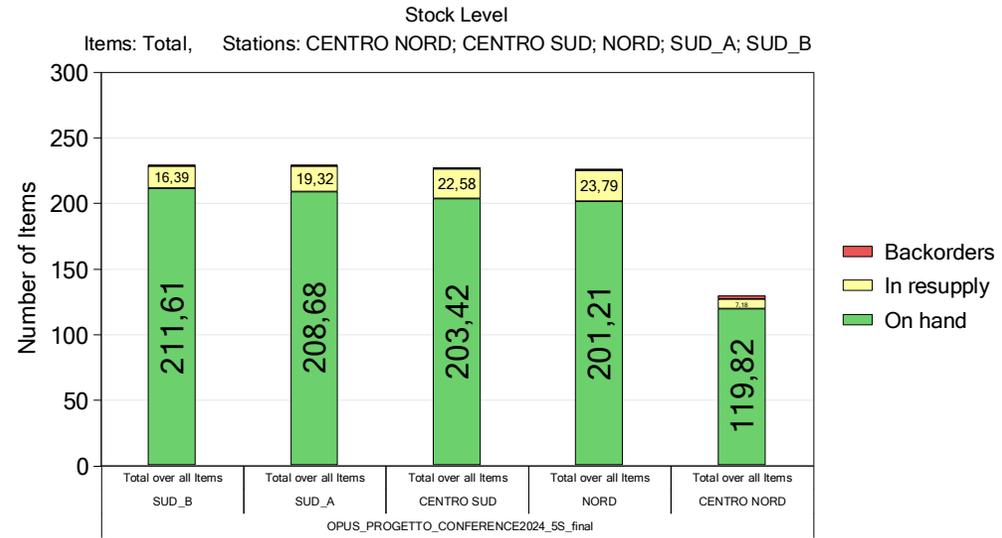


Simlox Results

Case 1 - Nr.9 stock sites

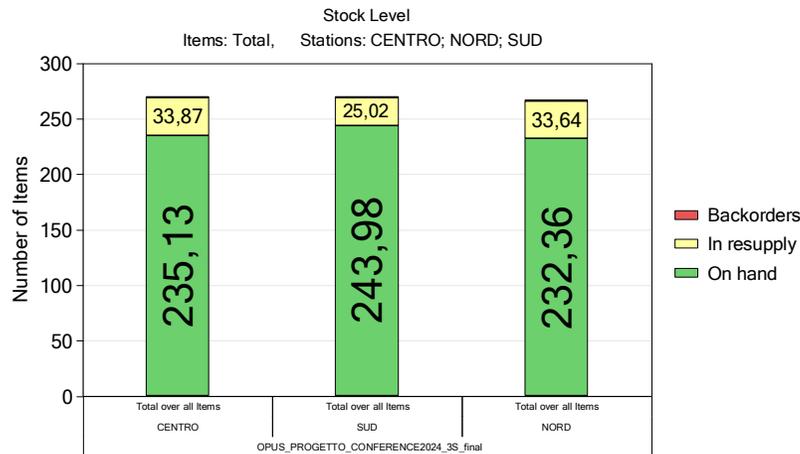


Case 2 - Nr.5 stock site

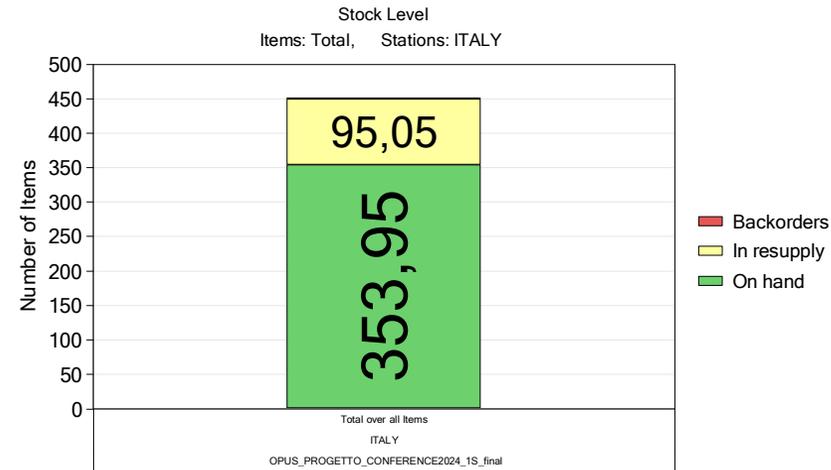


ID Case	MEAN Stock Volume	Station Worst Case
1	127	SUD
2	212	SUD_B
3	243	SUD
4	354	ITALY

Case 3 - Nr.3 stock sites



Case 4 - Nr.1 stock site



Simlox Results

ID Case	Nr. of stock sites	Not Critical Parts Availability (Ao_{SysNC})
1	9	99%
2	5	50%
3	3	48%
4	1	45%

ID Case	MEAN Stock Volume	Station Worst Case
1	127	SUD
2	212	SUD_B
3	243	SUD
4	354	ITALY

REQUIREMENT

- **Not Critical Parts Availability (Ao_{SysNC}) – 45%**
- Site Stock Volume - Max 250 spare parts units

REQUIREMENT Compliance

- Case 3 is **NOT discarded**
- Case 4 is **discarded**



According to SIMLOX results, Case 3 best fits requirements → It needs a Catloc Analysis for more assessment

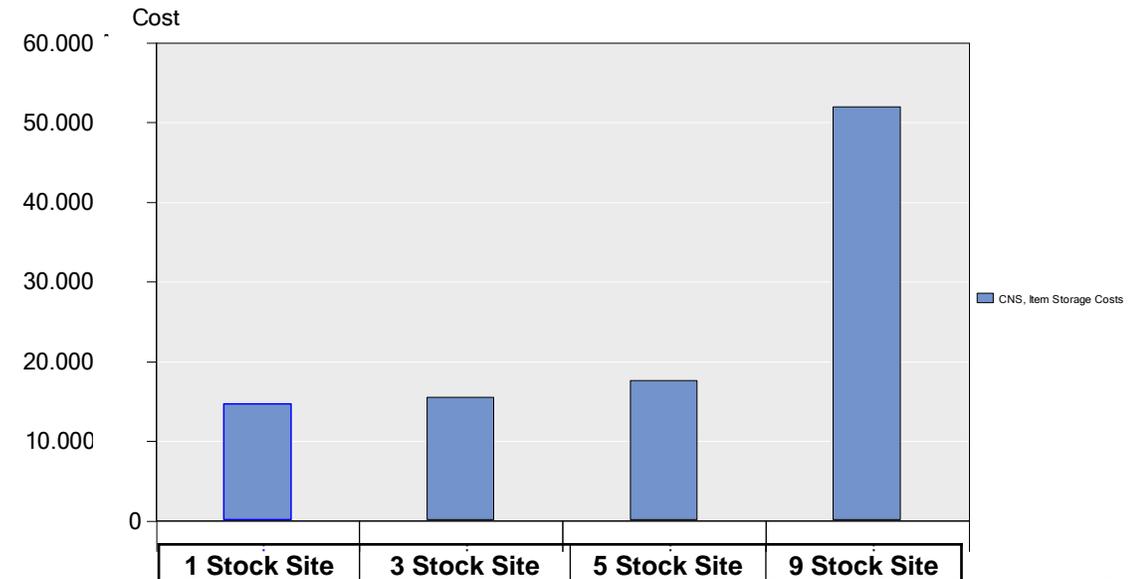
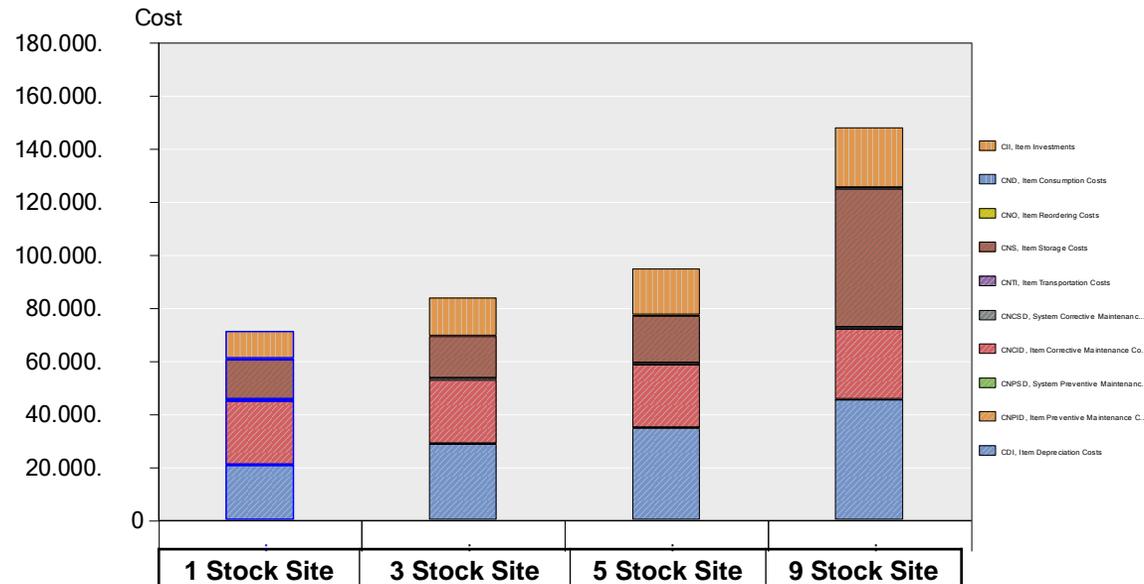


Catloc Results



Catloc Results

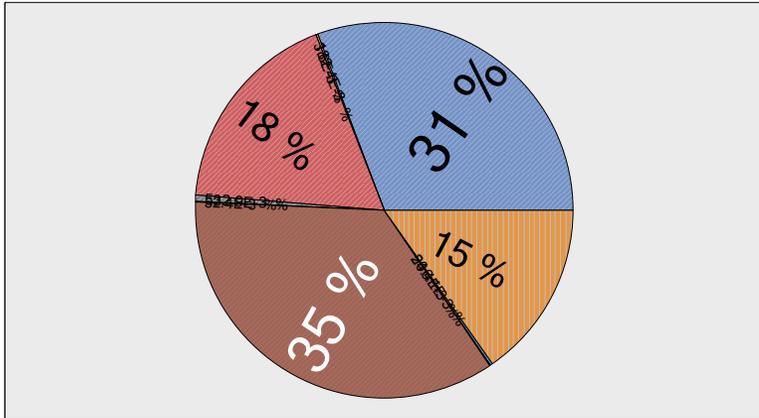
	1 Stock Site	3 Stock Site	5 Stock Site	9 Stock Site
20 Years	Case4	Case3	Case2	Case1
CII, Item Investments	10.400,00 €	14.300,00 €	17.300,00 €	22.600,00 €
CND, Item Consumption Costs	300,00 €	300,00 €	300,00 €	300,00 €
CNO, Item Reordering Costs	100,00 €	100,00 €	100,00 €	100,00 €
CNS, Item Storage Costs	14.800,00 €	15.500,00 €	17.700,00 €	52.000,00 €
CNTI, Item Transportation Costs	100,00 €	100,00 €	100,00 €	100,00 €
CNCSD, System Corrective Maintenance Costs Direct	800,00 €	800,00 €	800,00 €	800,00 €
CNCID, Item Corrective Maintenance Costs Direct	23.800,00 €	23.800,00 €	23.600,00 €	26.400,00 €
CNPSD, System Preventive Maintenance Costs Direct	- €	- €	- €	- €
CNPID, Item Preventive Maintenance Costs Direct	300,00 €	300,00 €	300,00 €	300,00 €
CDI, Item Depreciation Costs	20.900,00 €	28.800,00 €	34.700,00 €	45.400,00 €



Catloc Results

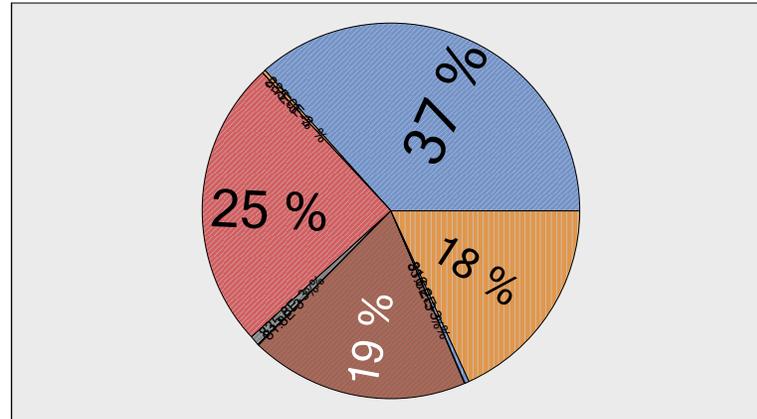
Case 1 Nr.9 stock sites

Case: OPUS_PROGETTO_CONFERENCE2024_9S_final



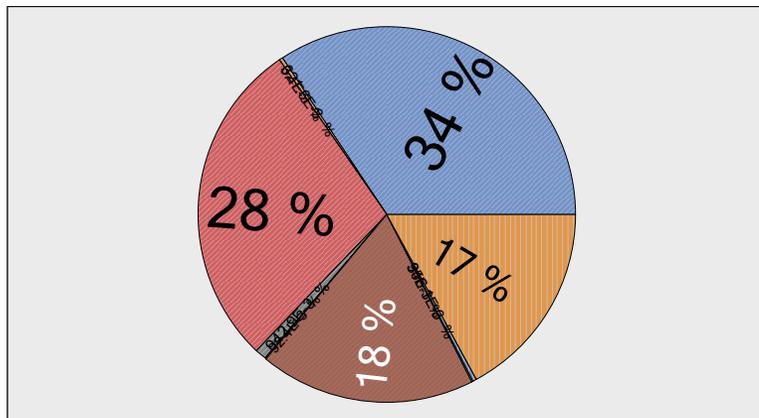
Case 2 Nr.5 stock site

Case: OPUS_PROGETTO_CONFERENCE2024_5S_final



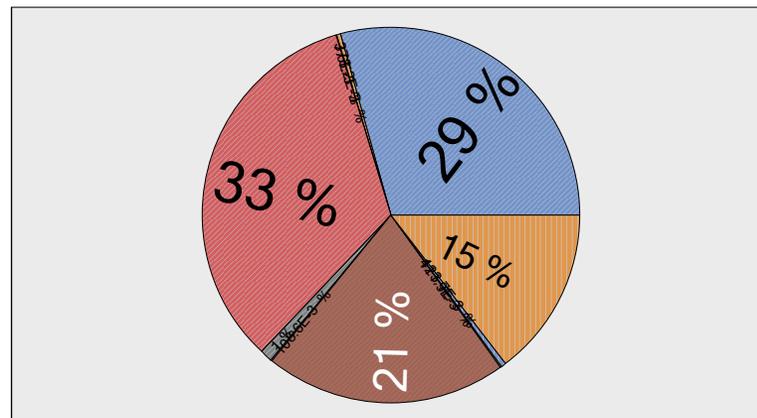
Case 3 Nr.3 stock sites

Case: OPUS_PROGETTO_CONFERENCE2024_3S_final



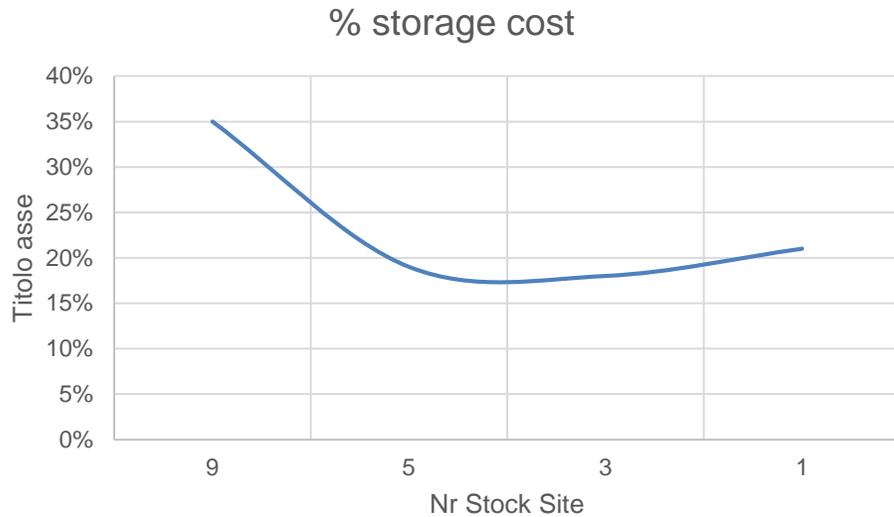
Case 4 Nr.1 stock site

Case: OPUS_PROGETTO_CONFERENCE2024_1S_final



- CII, Item Investments
- CND, Item Consumption Costs
- CNO, Item Reordering Costs
- CNS, Item Storage Costs
- CNTI, Item Transportation Costs
- CNCSD, System Corrective Maintenanc...
- CNCID, Item Corrective Maintenance Co..
- CNPSD, System Preventive Maintena...
- CNPID, Item Preventive Maintenance C...
- CDI, Item Depreciation Costs

Catloc Results



REQUIREMENT

- **Site Storage Cost - Max € 2.500 (dummy)**

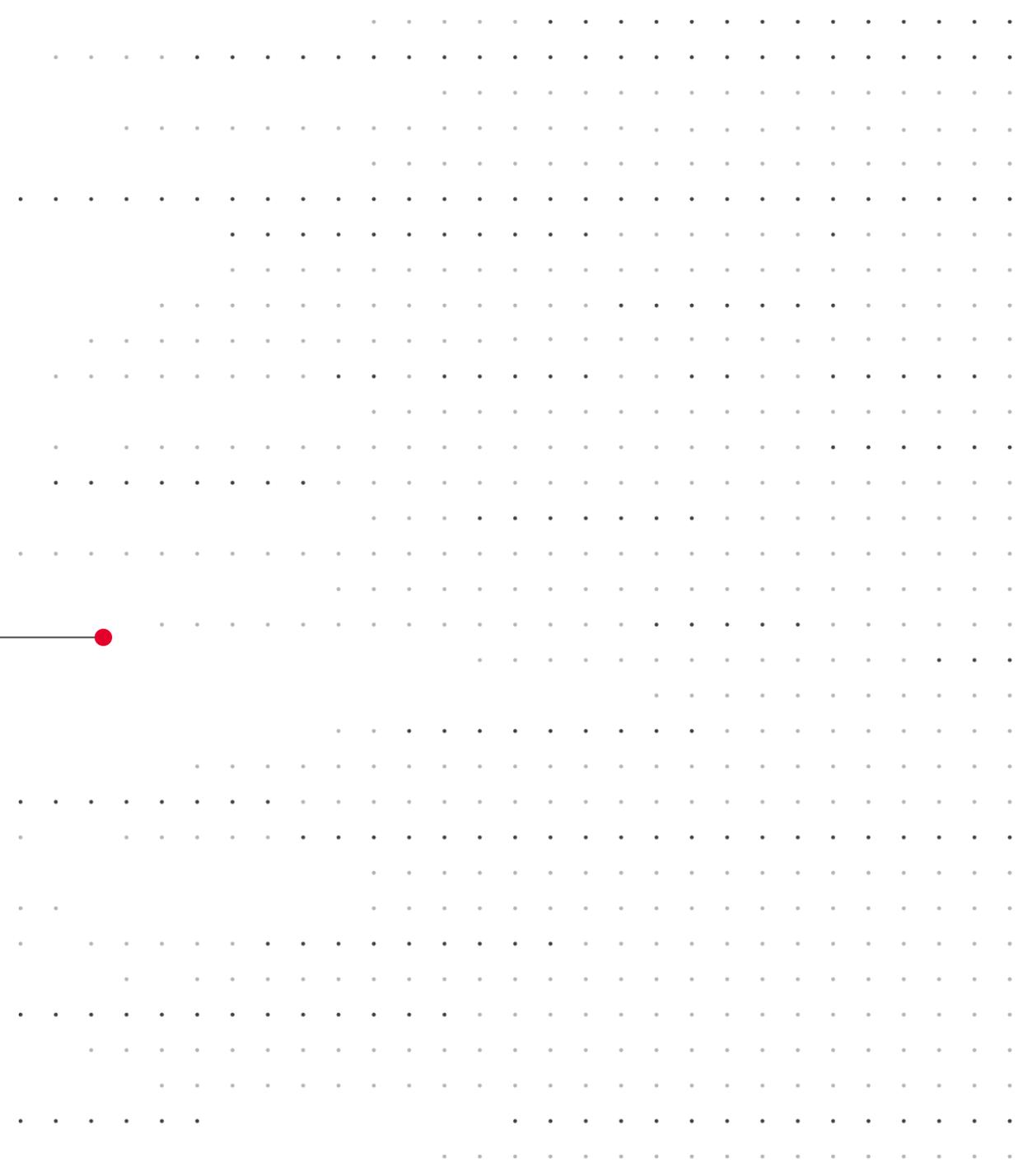
REQUIREMENT Compliance

- Case 2 is **NOT discarded**
- Case 3, Case 4 are **discarded**, for Storage Cost exceeding
- Case 1 is **discarded**, see OPUS results

STATION	STORAGE COST			
	Case4 - 1 Stock Site	Case3 - 3 Stock Site	Case2 - 5 Stock Site	Case1 - 9 Stock Site
UNIT 1	800,00 €	900,00 €	900,00 €	1.500,00 €
UNIT 2	800,00 €	900,00 €	900,00 €	1.500,00 €
UNIT 3	800,00 €	900,00 €	1.400,00 €	1.500,00 €
UNIT 4	800,00 €	900,00 €	900,00 €	1.500,00 €
UNIT 5	800,00 €	900,00 €	900,00 €	1.500,00 €
UNIT 6	800,00 €	900,00 €	900,00 €	1.500,00 €
UNIT 7	800,00 €	900,00 €	900,00 €	1.500,00 €
UNIT 8	800,00 €	900,00 €	900,00 €	1.500,00 €
UNIT 9	800,00 €	900,00 €	900,00 €	1.500,00 €
NORD1	- €	- €	- €	1.300,00 €
NORD2	- €	- €	- €	1.300,00 €
NORD3	- €	- €	- €	1.300,00 €
CENTRO1	- €	- €	- €	1.300,00 €
CENTRO2	- €	- €	- €	1.300,00 €
CENTRO3	- €	- €	- €	1.300,00 €
SUD1	- €	- €	- €	1.400,00 €
SUD2	- €	- €	- €	1.300,00 €
SUD3	- €	- €	- €	1.300,00 €
SUD_A	- €	- €	2.300,00 €	- €
SUD_B	- €	- €	2.300,00 €	- €
CENTRO NORD	- €	- €	1.300,00 €	- €
CENTRO SUD	- €	- €	2.300,00 €	- €
NORD	- €	2.700,00 €	2.300,00 €	- €
CENTRO	- €	2.700,00 €	- €	- €
SUD	- €	2.700,00 €	- €	- €
ITALY	4.500,00 €	- €	- €	- €

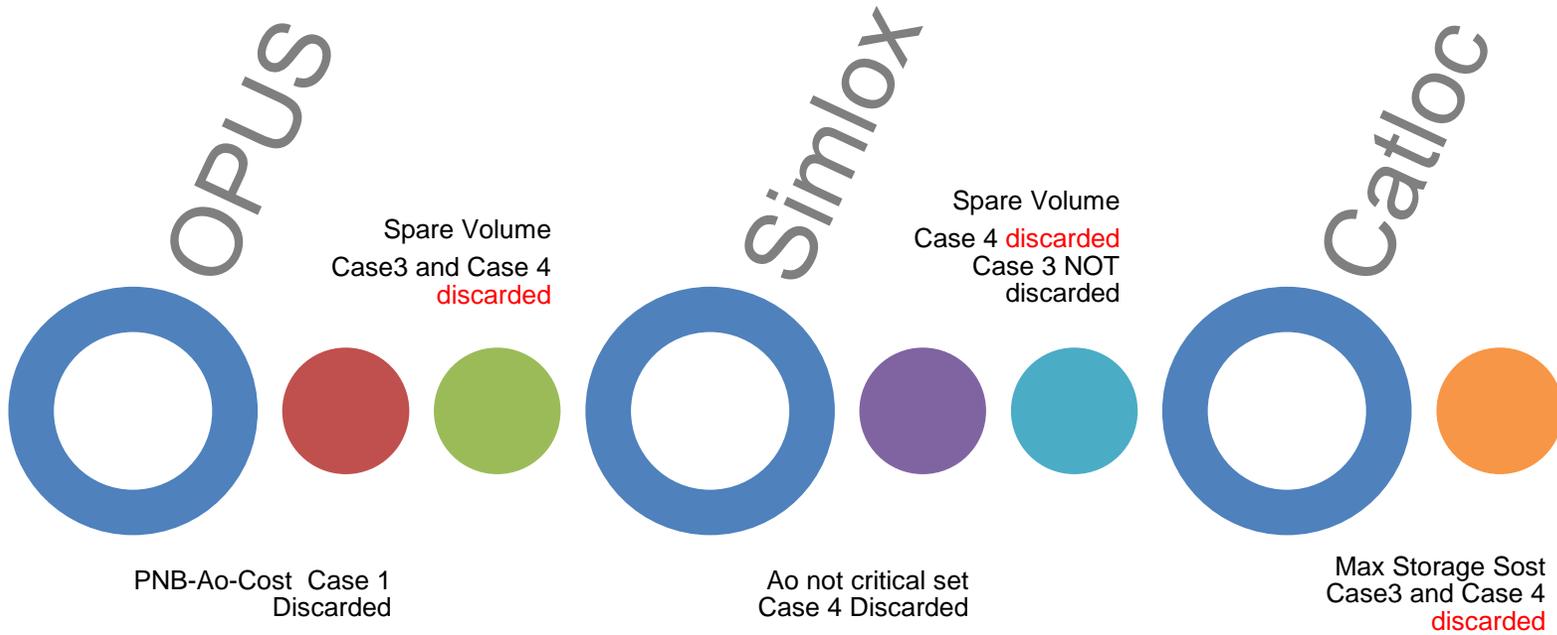


Conclusion and Improvements



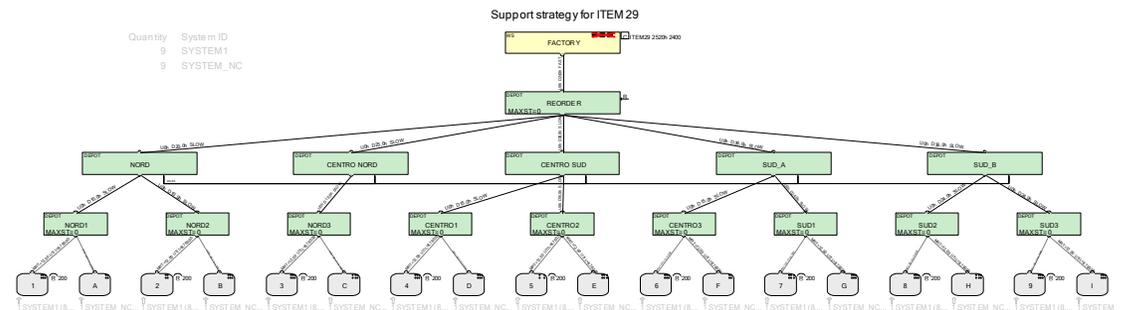
Conclusion and Improvements

Optimized Logistic Organization Structure



	OPUS		SIMLOX		CATLOC	SOLUTION
	PNB	Ao/Cost	Max num.Spare	Ao_not crit	Max site storage cost	
	>90%	>98%	250	>45%	2.500 €	
CASE 1	✓	✗	✓	✓	✓	✗
CASE 2	✓	✓	✓	✓	✓	✓
CASE 3	✓	✓	✗	✓	✗	✗
CASE 4	✓	✓	✗	✗	✗	✗

Solution: Case 2 – Nr5 Stock Site



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THANK YOU
FOR YOUR ATTENTION

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