OPUS_Suite for an analytical PBL contracting strategy

Criteria for In-Service Support economic evaluation and penalties definition

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PBL scope and background

- Performance Based Logistics (PBL) is an attractive solution that offers a potential to reduce ownership cost while maintaining the nominal functional capability. PBL contracting does not mean buying spare parts or services but buying performance.

- If applied correctly, and tailored to the specific scenario, PBL potential is substantial, but it is a complex task. Five factors shall be satisfied to achieve a successful PBL contract.

1. ***The supplier scope shall be clearly defined and the supplier and customer responsibilities shall be clearly identified.***

2. ***The KPIs shall be selected based on the nature and scope of the contract and shall allow the customer performance and affordability control. A small number of selected KPIs is preferred, in general too many KPIs is the result of performance uncertainties.***

3. ***KPIs target level (quantitative requirement) shall be related with the mathematical model of the KPIs.***

4. ***A clear incentive model shall be defined to adopt when performance is on, or above, the target. Disincentives (penalties) shall be also stated when performing below the target.***

5. ***Performance measurement method and intervals are also important issues.***

PBL contracting strategy: a way to deliver affordable readiness

- Effective PBL contracts contain core attributes to deliver improved reliability and availability performance at lower cost. In general attributes include:
  - *A performance work statement which defines the outcomes and value.*
  - *The minimal set of metrics that support the stated outcomes.*
  - *Incentives to deliver performance and reduce total cost.*
  - *A baseline and sufficient performance and cost insight.*
  - *An understanding of the risks associated with non-performance and the strategies to mitigate adverse outcomes.*
- PBL metrics need to include both thresholds and objectives as a part of an incentive approach. In general, thresholds represent the minimum acceptable operational values below which the utility of the system becomes questionable.

Key performance metrics, high level settings (MIL-HDBK-502A)

SeTeL since 1973

KPP

- Force Performance
- System Survivability
- System Sustainment
- System Energy

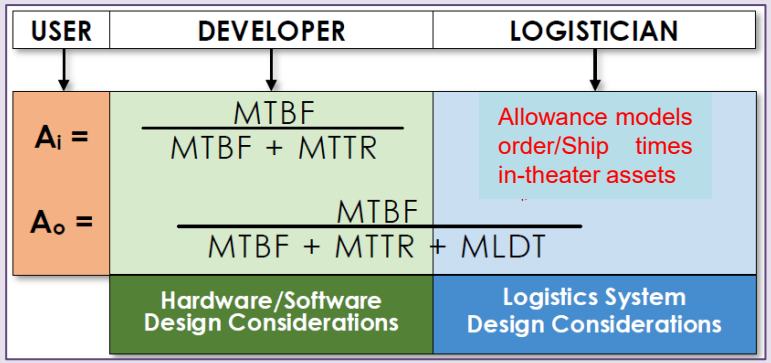
KPI

Aм is the percentage of the total inventory of a system operationally capable (ready for tasking) of performing an assigned mission at a given time, based on materiel condition.

$$A(T) = \frac{1}{T}\int_0^T A(t)\,dt = \frac{1}{T}\int_0^T \frac{f_{up}(t)}{f_{up}(t) + f_{down}(t)}\,dt$$

- Material Availability
- Operational Availability

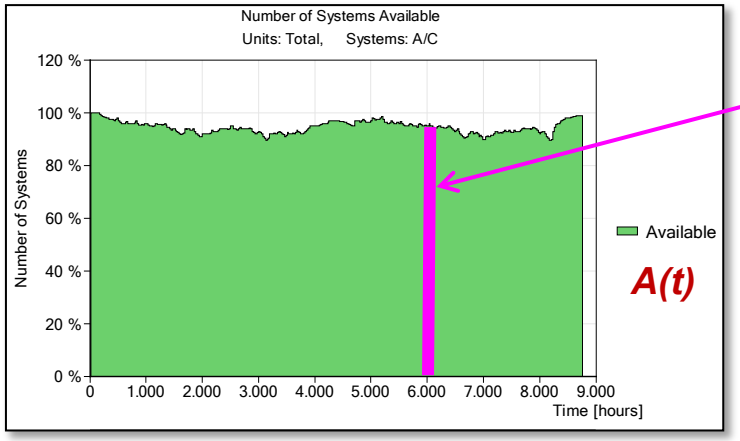
KSA



- Materiel Reliability
- Materiel Maintainability
- Operation & Support Cost

Life cycle sustainment outcomes metrics

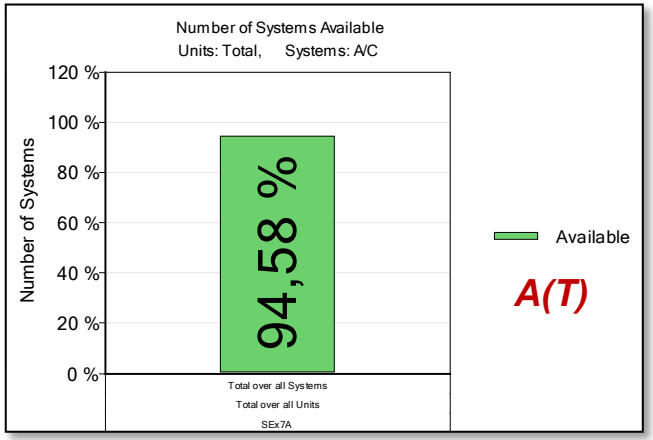
- **System Sustainment KPP**:
  - **Operational Availability KPI and/or Materiel Availability KPI are achieved by caring:**
    - Reliability KSA
    - Maintainability KSA
    - Operating and Support Cost KSA



dt = integration step

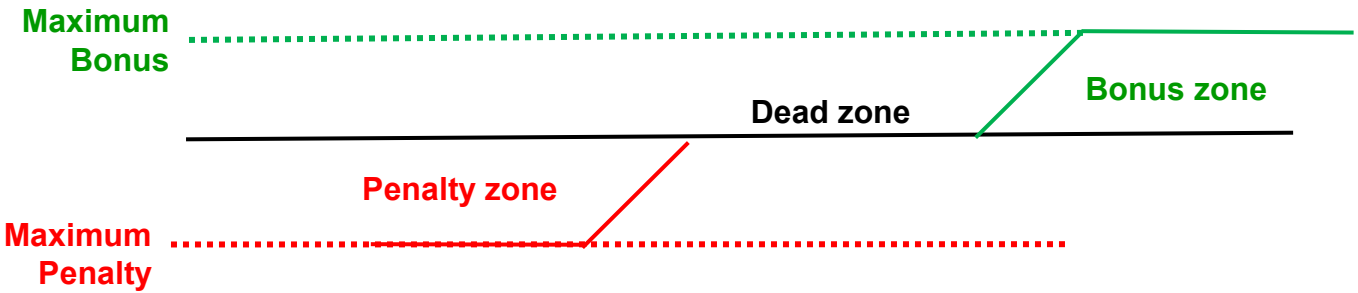
Mean Value

$$A(T) = \frac{1}{T}\int_0^T A(t)\,dt$$



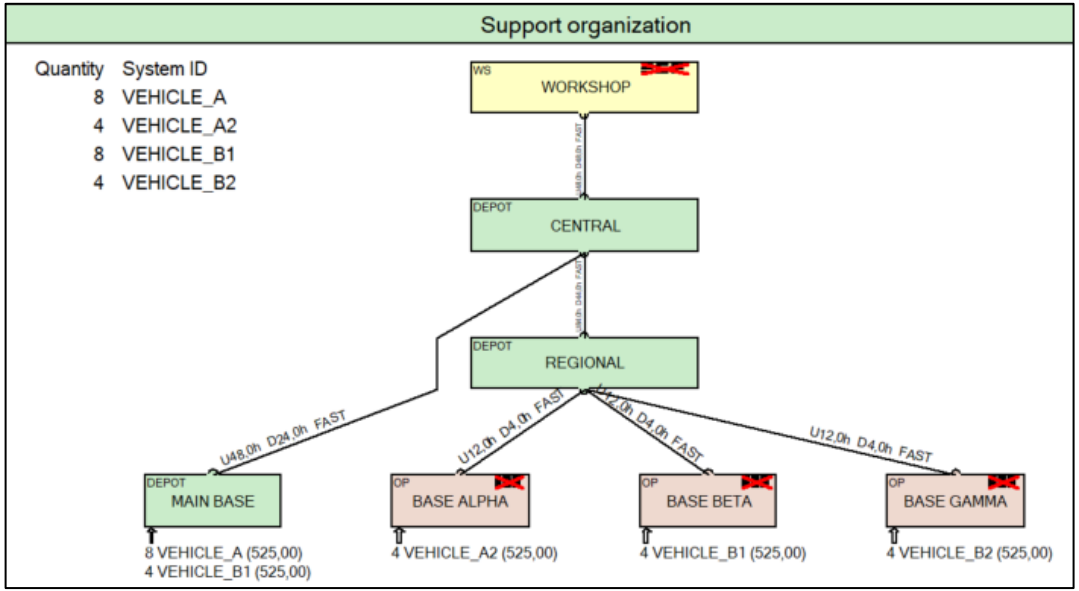
Risk and opportunity management issues

- Robust best practice PBL programme pays attention to total program risk reduction along with appropriate off-ramp exit criteria that are captured in the contract.
- PBL costs are better defined with fixed-price to estimate delivered efficiency vs costs. Higher startup profit can be accepted because contractors share risk and penalties policy is part of the contract.
- Contractor is paid as service is delivered regardless of impact on end-user who owns the performance risk.
- The end-user owns the results if they accept the product or service.
- Unless specified in the contract, end-user is responsible for mitigating obsolescence issues.
- Strategies and models specifications for operating PBL are missing, however it is necessary to create the concept for contract and costs management.



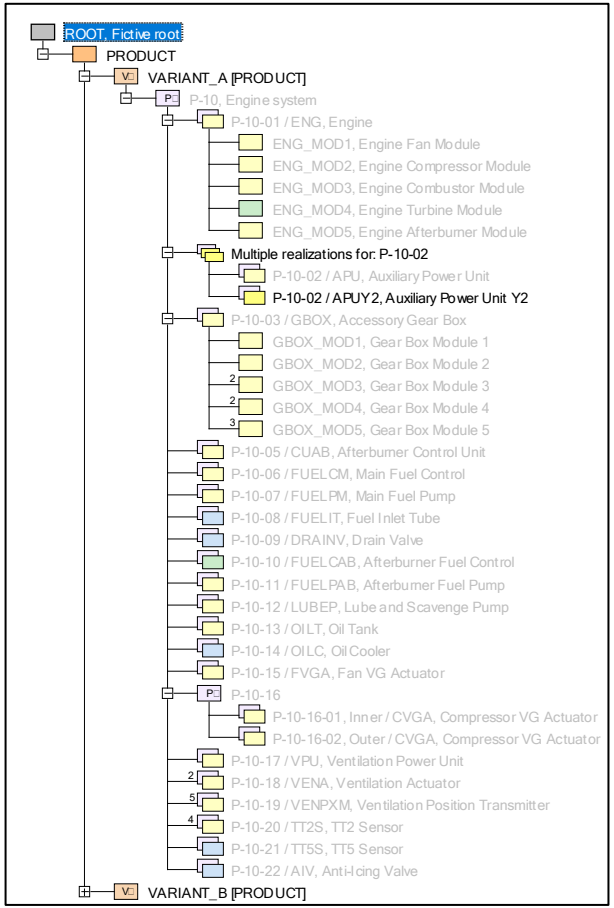
Example scenario: PBL contract about an Air Force Wing

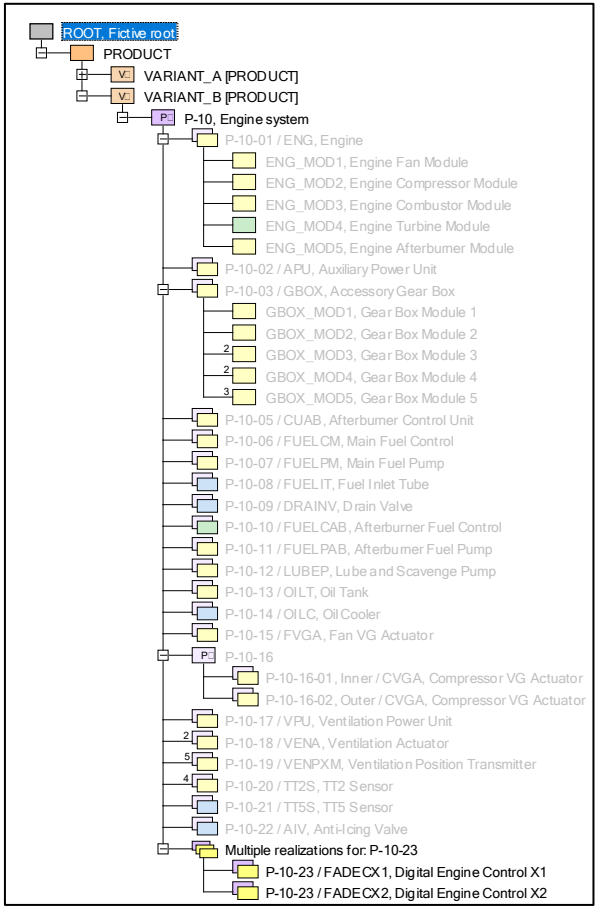
- The scenario is based on the formulation of PBL contract terms concerning the *Aircraft Engine* using *"Backorders"* (NBO) target as performance metrics to support 24 aircraft deployed on the four bases.. The PBL contract value ***"C"*** that should cover the supplier expenses is: ***C = (1+Profit_Rate)·LSC***



- The supplier responsibility is to provide both a cost efficient spares stock and a repair services solution so that the average system operational availability is: ***A ≥ 0.85.***
- Above requirement is assumed to be translated into *"Backorders"* requirement.
- The PBL contract covers a 5-year period where the average backorders are measured and monitored on a time period ***"T"*** basis to ensure that the supplier fulfils the contract commitments.

PBL object: multiple configuration *"Engine Product"*





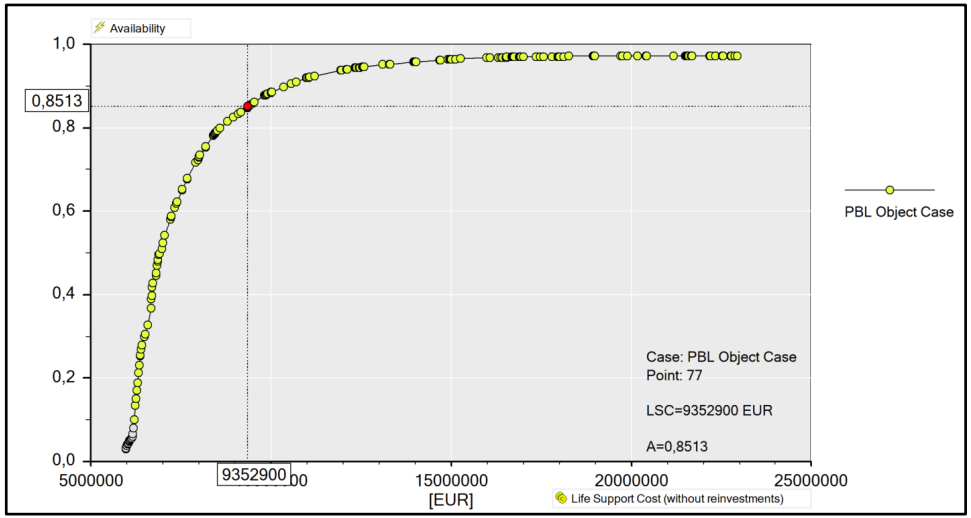
- The Engine product consists of two variants, each one with two multiple realizations to equip four A/C system models.
- The 24 systems are utilized an average of 525 hours per Year.
- *Primary Items* and *Sub-assy Modules* are repaired at the *Workshop* in 6 months. Lead time for reorders is also 6 months and performed at the *Central* site.

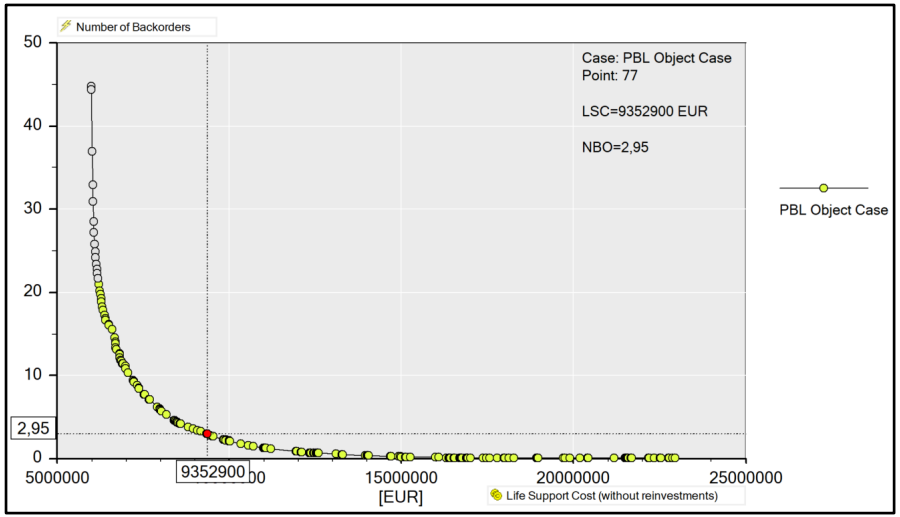
Product Supportability Data

	SID System identifier	AINHE In-herent avail-ability	MTBM Mean op time between main-tenance [Hours]	MTBF Mean op time between failure [Hours]
1	VEHICLE_A	0,9742	98,88	161,08
2	VEHICLE_A2	0,9743	100,16	164,50
3	VEHICLE_B1	0,9740	97,20	156,67
4	VEHICLE_B2	0,9741	97,68	157,90

PBL initial analysis: spares optimization and LSC prediction

- Running the model by OPUS10 and selecting the solution for **A ≥ 0,85** we get **NBO = 2,95.**
- Above results are average data over the 5-years scenario. To verify whether requirements may not be compliant in some periods along the scenario, it is useful to run SIMLOX simulation. To this scope the stock size related with *Solution Point 77* is allocated to the model.



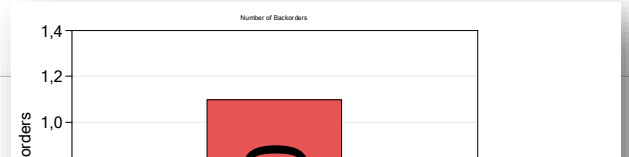


PBL initial analysis: support solution simulation and warnings

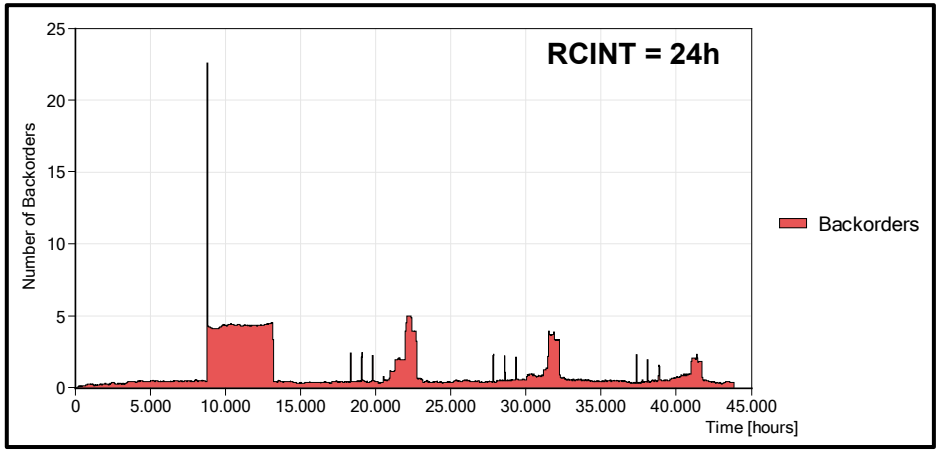
StockAllocation

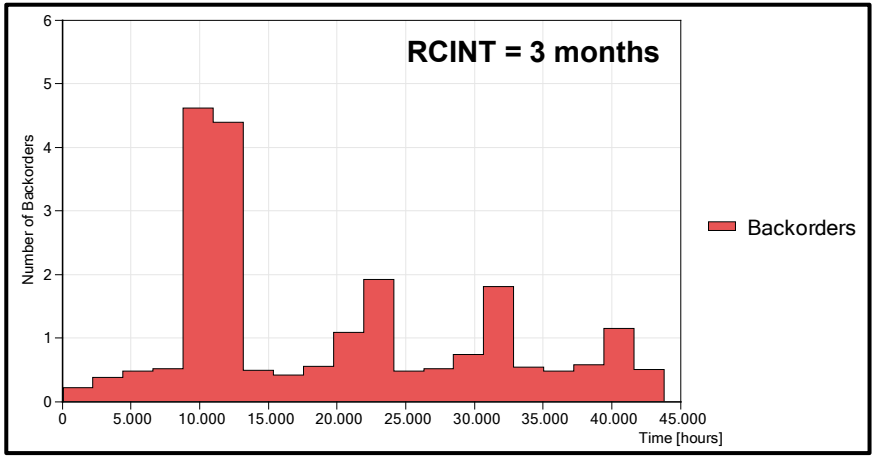
	POINT	IID	STID	STSIZ	ROSIZ	ROSIZT	AINST	ISTOH	NOTE
	Point identifier	Item identifier	Station identifier	Stock size <0>	Reorder size <1>	ROSIZ Time dependent value identifier	Additional initial stock <0>	Initial stock on hand	User note
1	77	APU	CENTRAL	3					
2	77	APUY2	REGIONAL	1					
3	77	CUAB	CENTRAL	2					
4	77	FUELCM	CENTRAL	2					
5	77	FUELPM	CENTRAL	5					
6	77	FUELPM	MAIN BASE	1					
7	77	FUELPM	REGIONAL	1					
8	77	FUELIT	CENTRAL	1					
9	77	FUELIT	MAIN BASE	1					
10	77	FUELIT	REGIONAL	1					
11	77	DRAINV	CENTRAL	19	3				
12	77	DRAINV	MAIN BASE	1					
13	77	DRAINV	REGIONAL	1					
14	77	FUELPAB	CENTRAL	3					
15	77	LUBEP	CENTRAL	2					
16	77	OILT	CENTRAL	2					
17	77	OILC	CENTRAL	7	2				
18	77	OILC	MAIN BASE	1					
19	77	OILC	REGIONAL	1					
20	77	FVGA	CENTRAL	1					
21	77	CVGA	CENTRAL	4					
22	77	VPU	MAIN BASE	1					
23	77	VPU	REGIONAL	1					
24	77	VENA	CENTRAL	2					
25	77	VENPXM	CENTRAL	4					
26	77	TT2S	CENTRAL	6					
27	77	TT2S	REGIONAL	1					
28	77	TT5S	CENTRAL	3					
29	77	AIV	CENTRAL	2					
30	77	AIV	MAIN BASE	1					

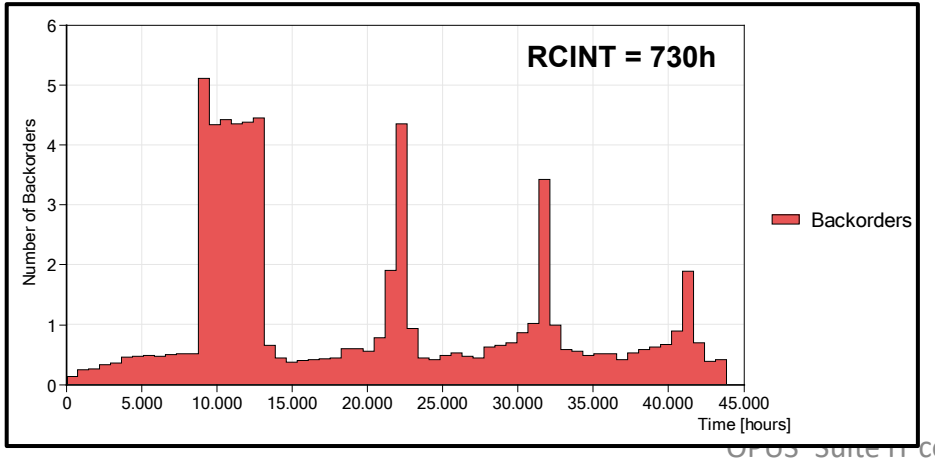
- Running SIMLOX, 100 iterations, RCINT = 24h, the following Backorders results are achieved: *average result* and *vs single items*.

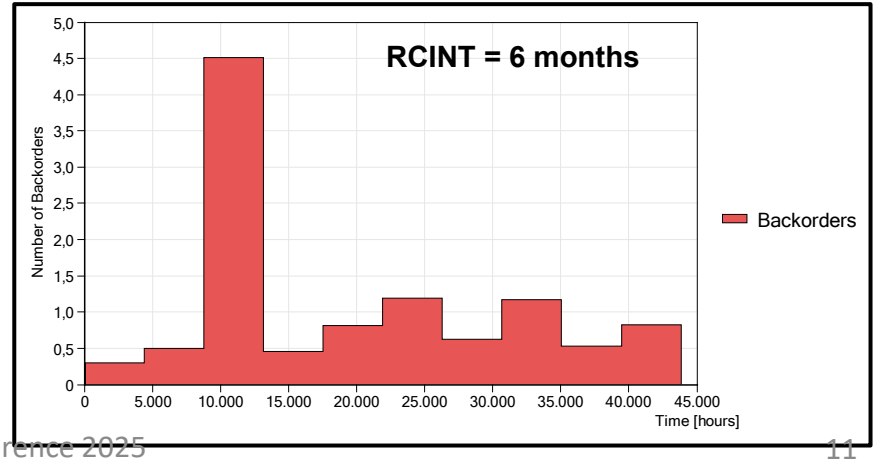


Backorders analysis for contract verification interval definition

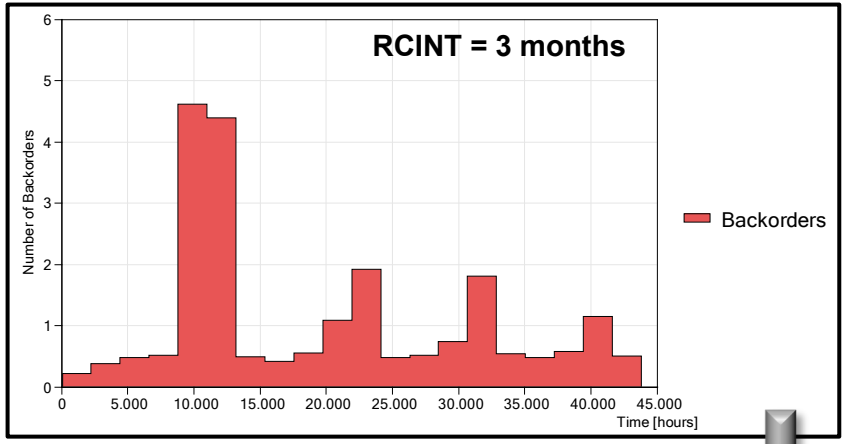


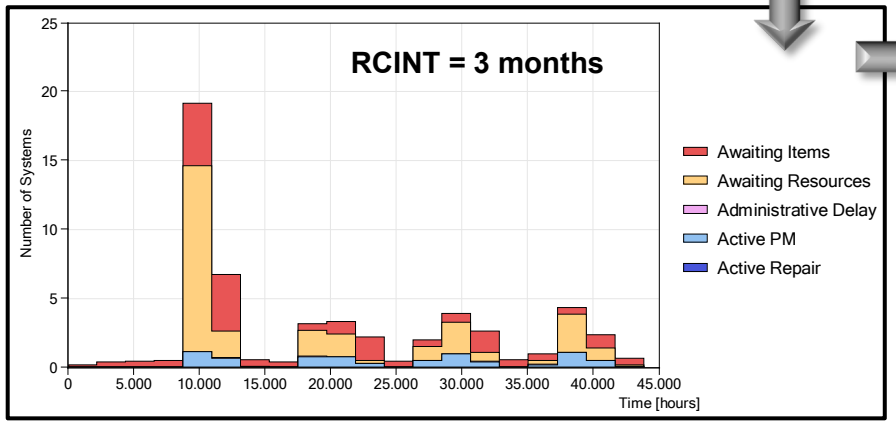




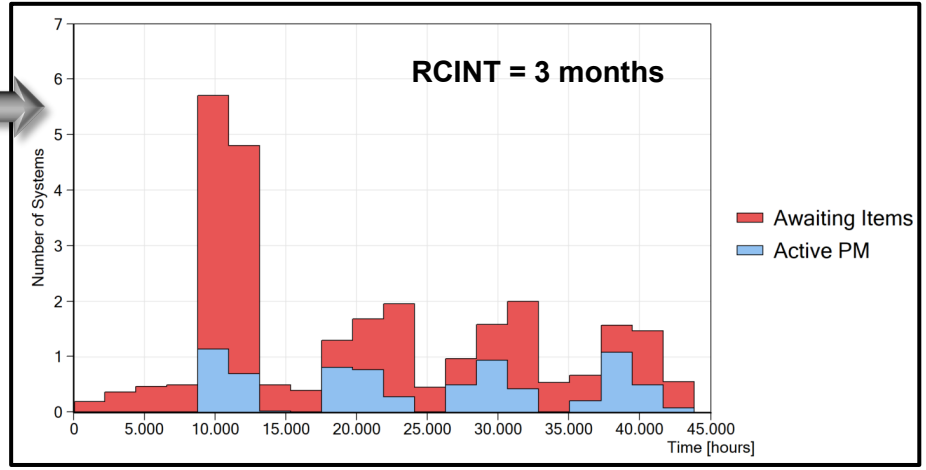


Causes of NBO fluctuations risk, quarterly accomplishment check



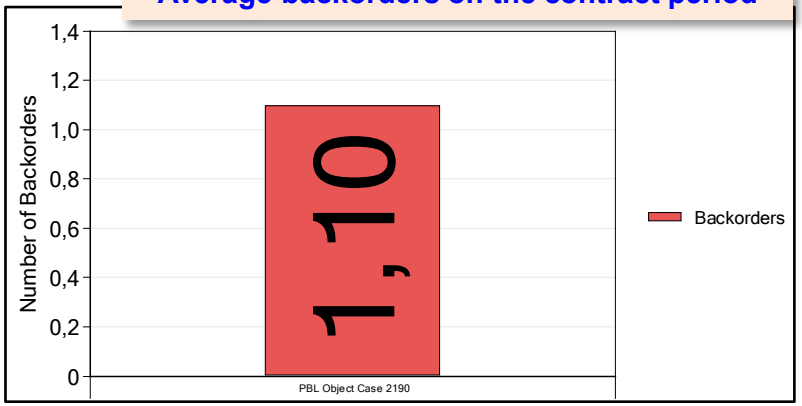


- Assuming that the contract is checked against a 3 months period for average NBO achievement, it is useful to evaluate the causes that can bring into the *"penalty"* area.
- Causes of *"unavailability"* is spot lack of resources and spare parts. The reason is due to concentration of PM schedule requiring life limited item replacement, this condition can be mitigated by appropriate ordering policy. Resources impact mitigation shall be analyzed and shift organized.

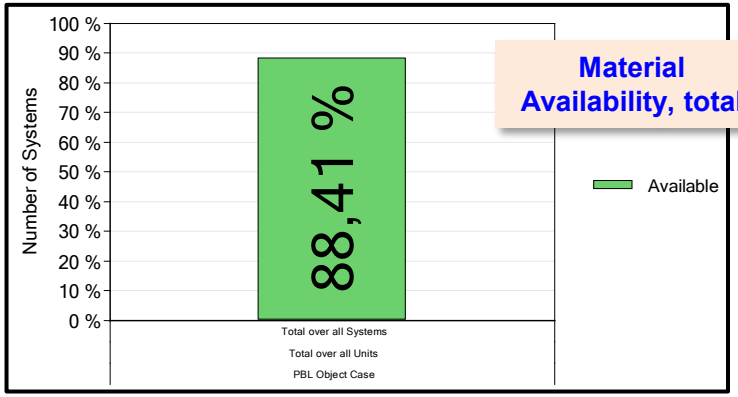


Expected KPI and reference parameters

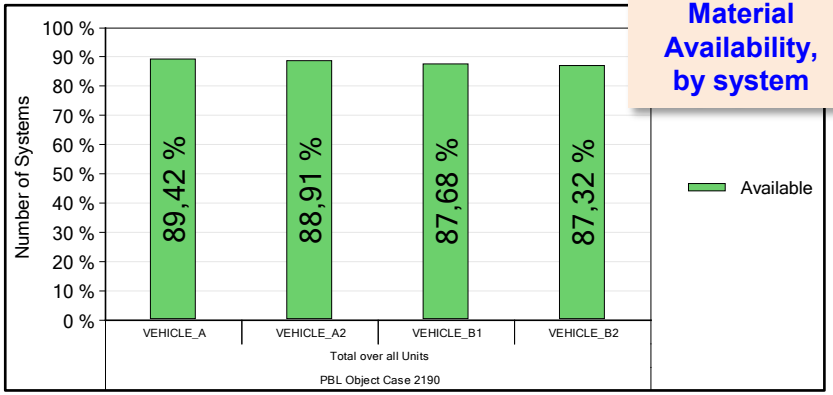
Average backorders on the contract period



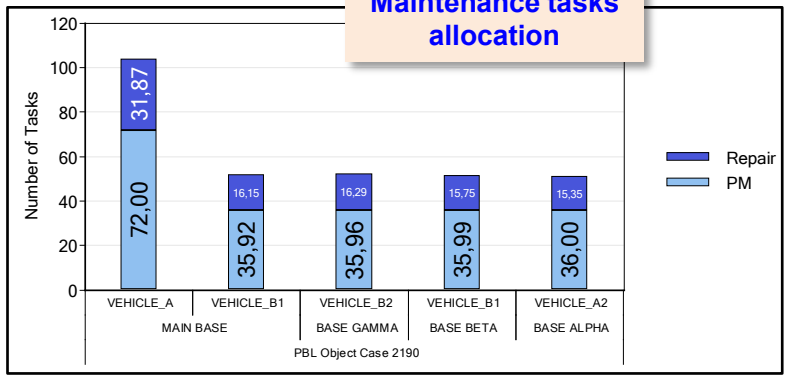
Material Availability, total



Material Availability, by system

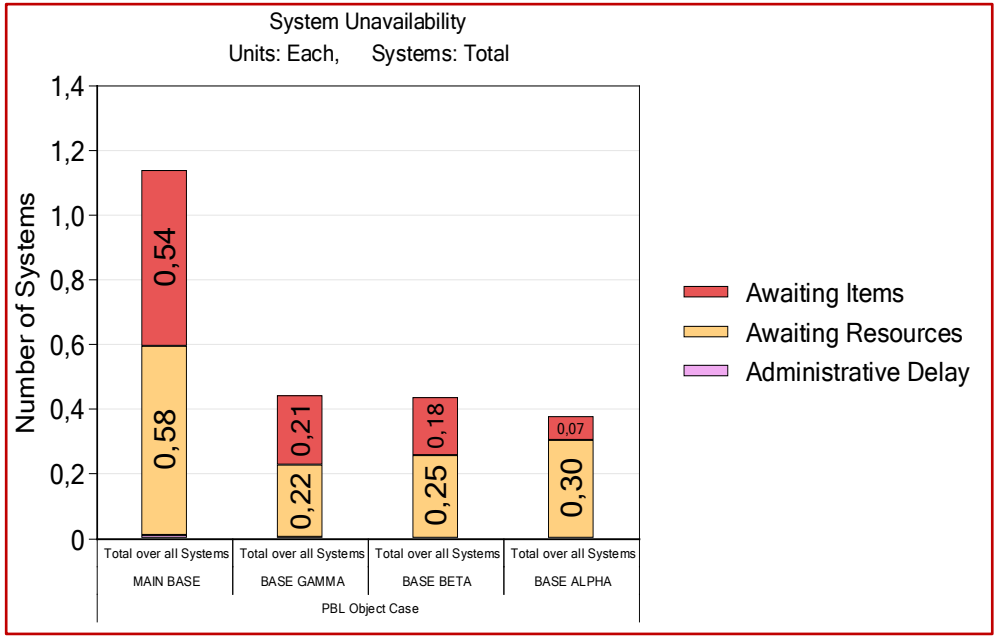


Maintenance tasks allocation

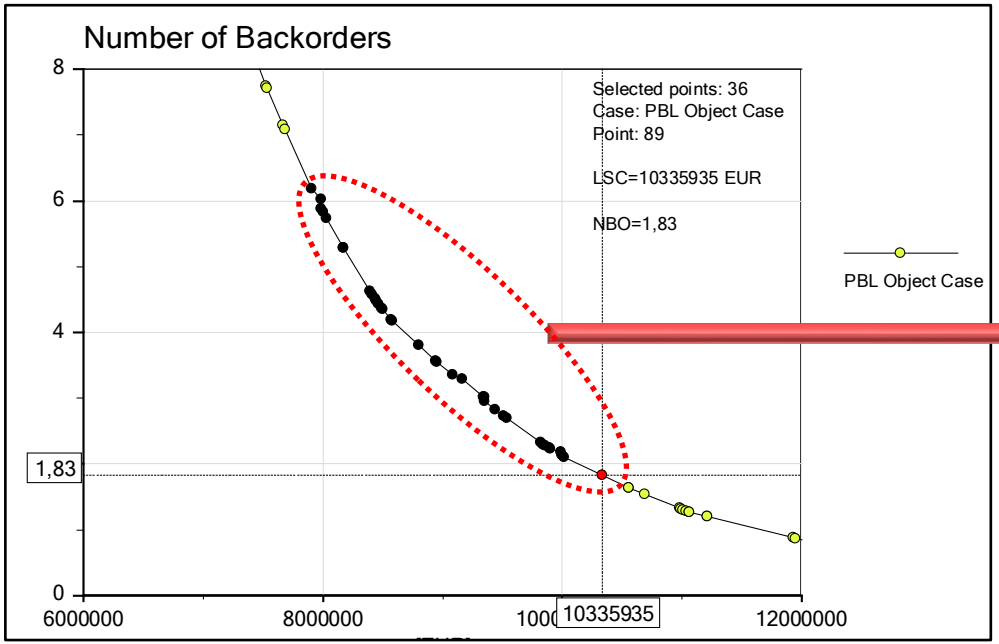


PBL activities relative risk classification

- Systems unavailability causes rate data allow to understand the possible areas of risk vs PBL requirements. This allows to setup management warnings to plan countermeasures in case of field data degradation.
- The example simulation result outlines that on the Main Base one A/C, on average, is not operable because of spares delays and/or Resources overload.
- Whether necessary SIMLOX simulation allows to identify eventual adjustments of the stock size.



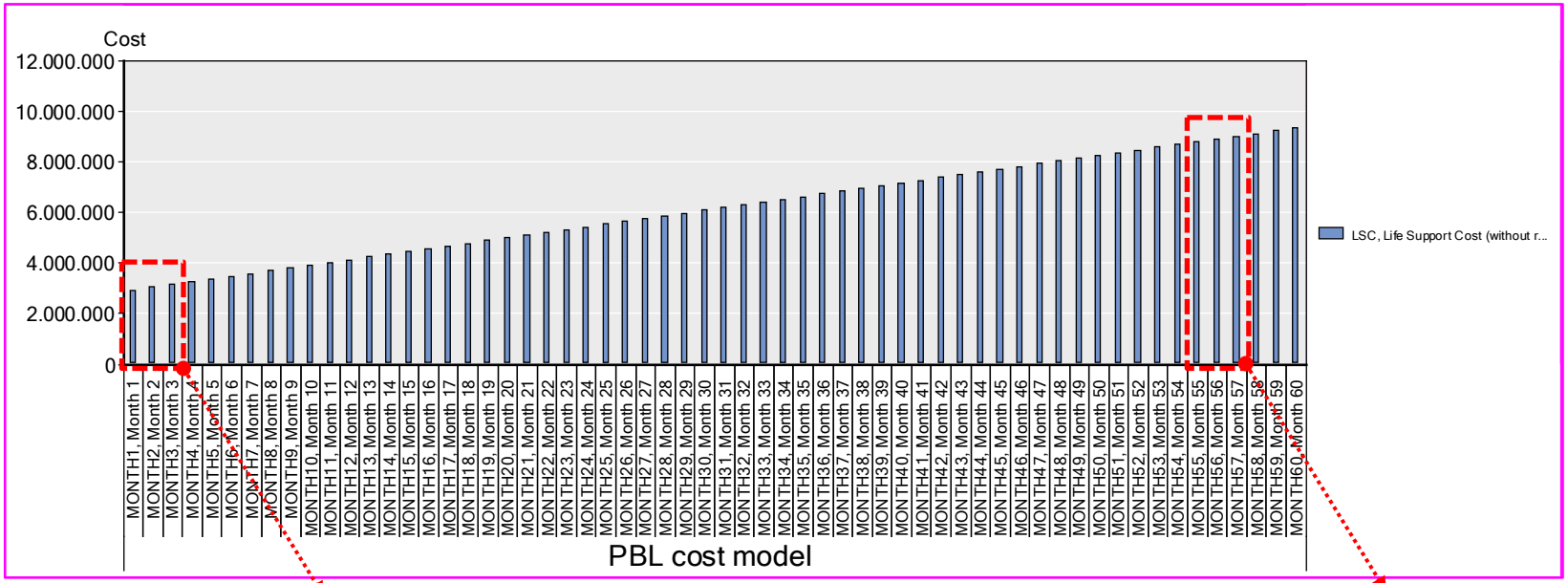
PBL reference sensitivity to Backorders



POINT Point identifier	LSC Life support cost without reinvest-ments	NBO Expected number of back-orders	PNB Proba-bility of no back-order	1 - PNB
54	7900134,03	6,1913	0,0027	
55	7981709,03	6,0320	0,0032	0,9968
56	7987444,03	5,8728	0,0037	
57	7996929,03	5,8392	0,0038	0,9958
58	8026929,03	5,7339	0,0042	
59	8170889,03	5,2814	0,0063	0,9937
60	8172457,91	5,2788	0,0063	
61	8393362,91	4,6282	0,0120	
62	8412447,71	4,5770	0,0125	0,9875
63	8436793,71	4,5111	0,0134	
64	8448698,71	4,4790	0,0138	
65	8464832,21	4,4369	0,0143	
66	8489588,21	4,3737	0,0152	
67	8500764,91	4,3456	0,0156	
68	8570097,41	4,1968	0,0182	
69	8576811,41	4,1837	0,0184	0,9816
70	8797716,41	3,8007	0,0259	
71	8941676,41	3,5613	0,0320	
72	8946228,53	3,5538	0,0322	0,9678
73	9078748,53	3,3539	0,0389	
74	9160323,53	3,2900	0,0413	
75	9339873,53	3,0244	0,0540	
76	9347165,03	3,0128	0,0546	
77	9352900,03	2,9489	0,0578	**0,9422**
78	9440210,03	2,8237	0,0651	
79	9507115,03	2,7337	0,0709	
80	9532715,03	2,7001	0,0733	
81	9820610,03	2,3274	0,1066	
82	9839610,03	2,3040	0,1091	
83	9855629,03	2,2850	0,1108	
84	9885629,03	2,2502	0,1143	
85	9896173,53	2,2381	0,1157	
86	9987373,25	2,1857	0,1220	
87	9992943,53	2,1332	0,1285	0,8685
88	10016329,99	2,1095	0,1315	
89	10335934,99	1,8259	0,1770	

- To determine <u>model sensitivity</u> against the NBO, extract MoE results produced by OPUS10. Using PNB it is possible to calculate backorders probabilities (1 – PNB). Solution point 77 satisfies the requirements, thus investigation is extended across points 54 to 89 (NBO = 6 to 2).

LSC cost distribution: initial investment and 3-months recurring costs



			PBL cost model
1	CI, Total Investments	MONTH1, Month 1	2.847.885
2	CN, Recurring Costs	MONTH1, Month 1	108.417
3	CN, Recurring Costs	MONTH2, Month 2	108.417
4	CN, Recurring Costs	MONTH3, Month 3	108.417

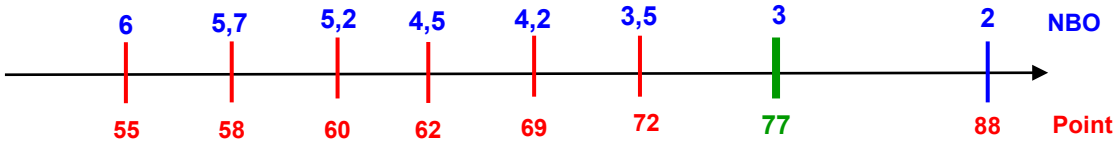
			PBL cost model
1	CN, Recurring Costs	MONTH55, Month 55	108.417
2	CN, Recurring Costs	MONTH56, Month 56	108.417
3	CN, Recurring Costs	MONTH57, Month 57	108.417

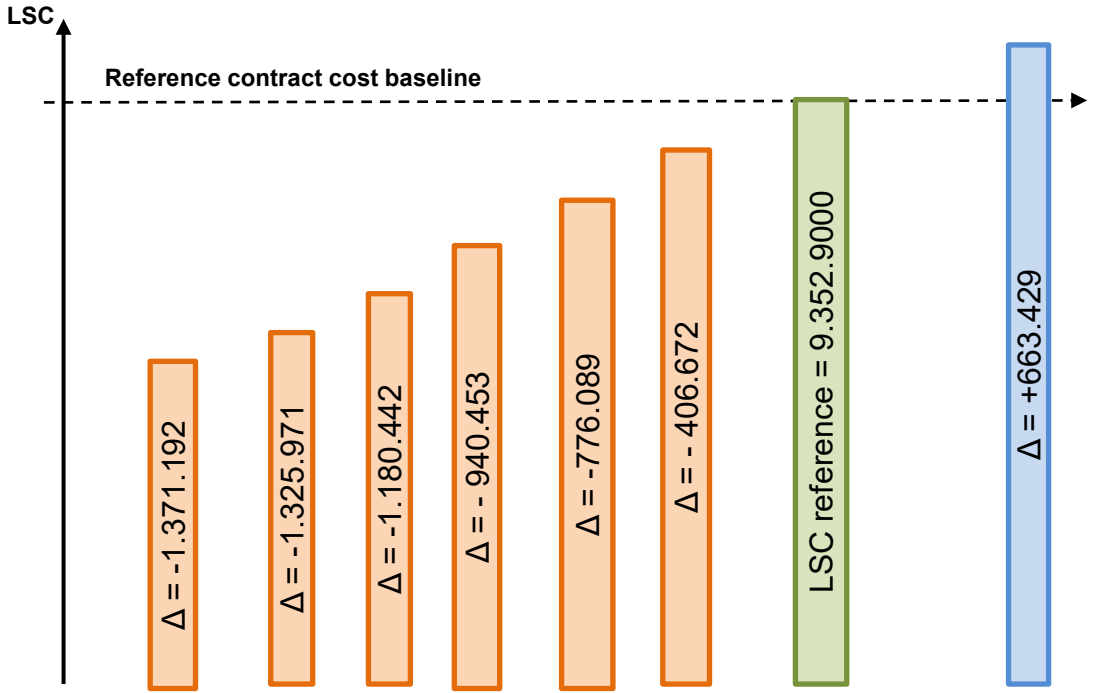
PBL Budget allocation to each site per quarter time interval

- Budget to be allocated to the involved locations is calculated by using CATLOC on 3-months basis and takes into account of both CM and PM tasks.

			PBL cost model			
			CENTRAL	MAIN BASE	WORKSHOP	REGIONAL
1	CNC, Corrective Maintenance Costs	MONTH55, Month 55	17.475	3.763	5.881	1.450
2	CNC, Corrective Maintenance Costs	MONTH56, Month 56	17.475	3.763	5.881	1.450
3	CNC, Corrective Maintenance Costs	MONTH57, Month 57	17.475	3.763	5.881	1.450
4	CNP, Preventive Maintenance Costs	MONTH55, Month 55	8.158	18.256		
5	CNP, Preventive Maintenance Costs	MONTH56, Month 56	8.158	18.256		
6	CNP, Preventive Maintenance Costs	MONTH57, Month 57	8.158	18.256		
Totals =			**76.899**	**66.057**	**17.643**	**4.350**

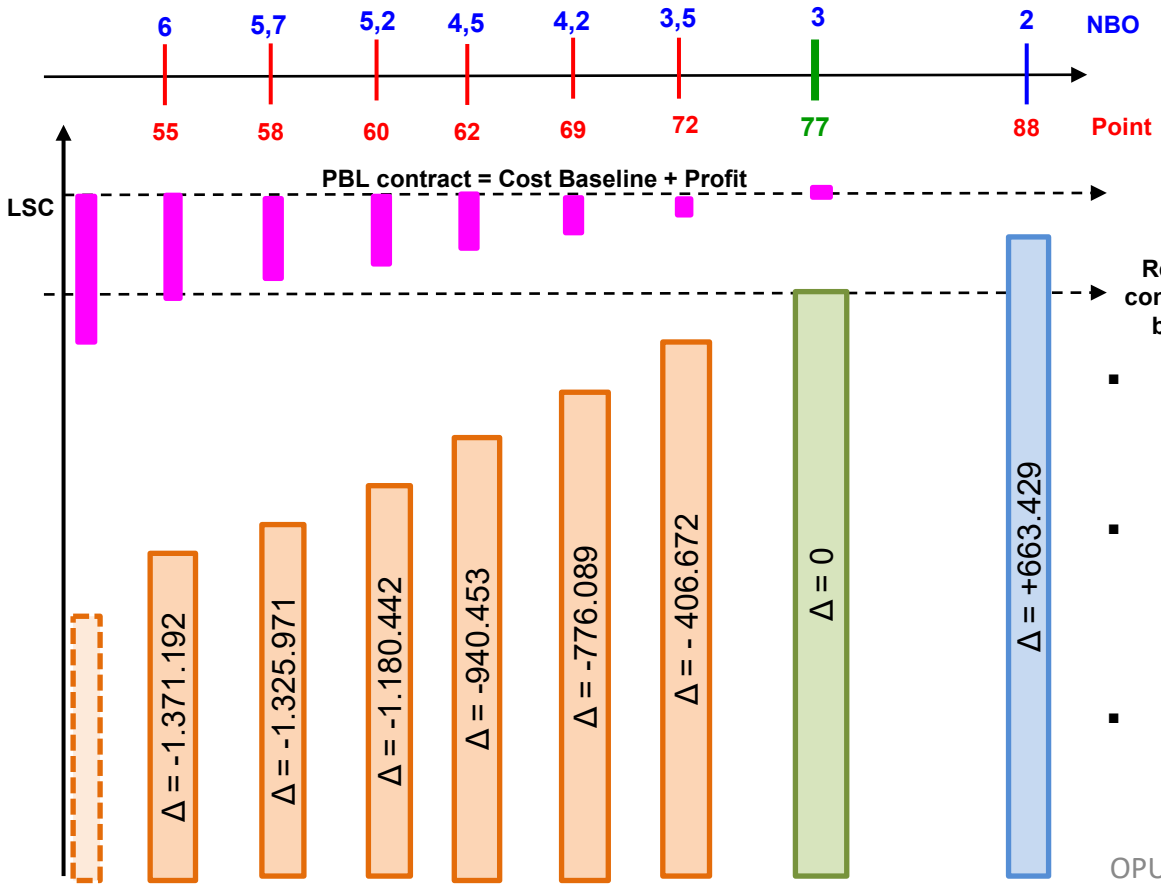
Contract cost baseline and economic reason of backorders





- Assuming solution point 77 satisfies the Operational Availability requirements, the related LSC is accepted as a reference for calculating the additional ***"Profit"*** which is assumed to be +15% of the contract activities cost.
- If the Supplier does not perform the necessary investment, OPUS10 provides the LSC is for NBO in the ranges 3 to 6. This risk, or equivalent unefficiency, shall be applied to the Supplier in terms of economic penalties.
- Strategic decision depends upon the contract. In this case assumption made is that the gap to the reference cost baseline shall be filled in with *"penalties"* from NBO = 3,5 with progressive levels until profit loss at NBO = 6.

Penalty policy definition



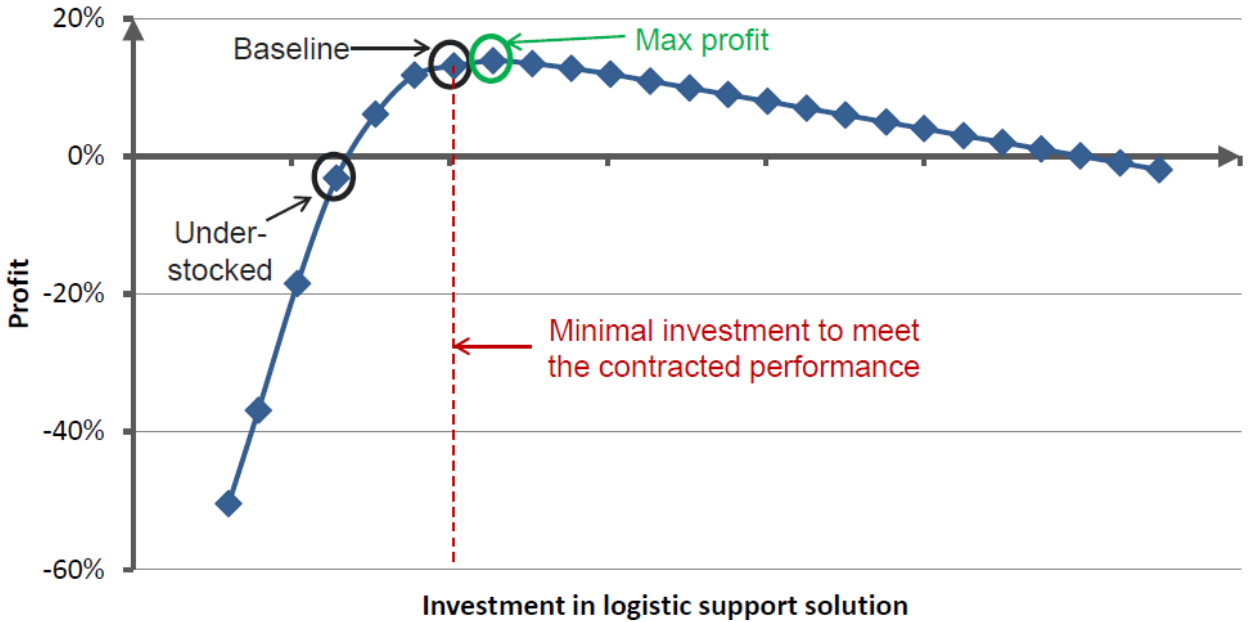
Penalty = Negative incentives

- *Penalties* are calculated to cut to zero any Profit if NBO = 6, and in case NBO > 6 the contract turns into a total loss.
- Policy escalation shall define the correct gradient also taking into account that underrated results are due to not correct spare and resources investment plus mis-organization.
- In case of confirming NBO ≤ 2 an overstocked was made and this can be compensated with an incentive.

Profit vs Investment

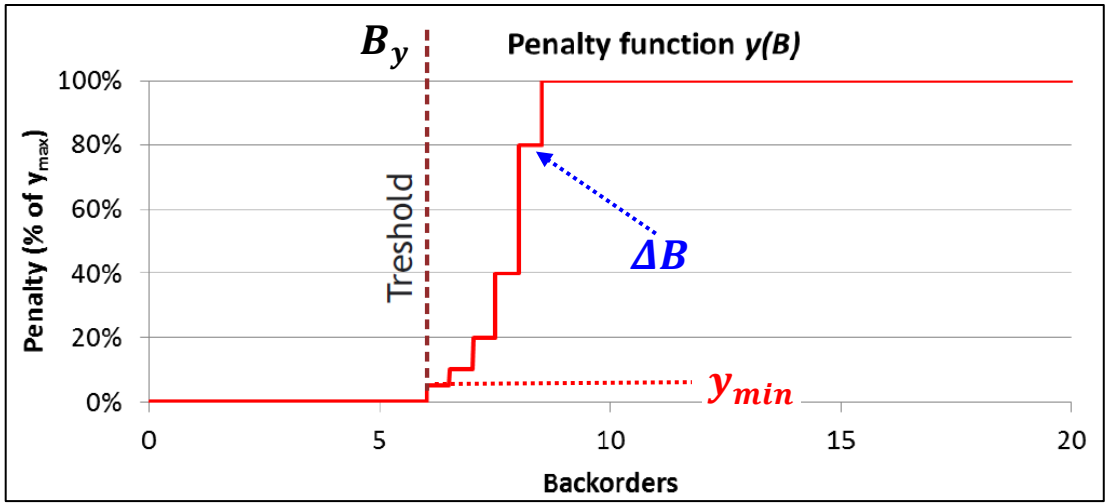
- For contract clauses definition it is important to establish *"Profit"* earned vs the LSC commitment achieved through resources investment. In case of contract NBO periodic confirmation (i.e.: NBO = 3), *baseline payments* will be made.

- *Profit vs Investment* diagram decreases so that, for instance, in case field data confirm NBO = 6, the profit is zeroed, after that level contract losses are quite evident.



- Maximum profit is achieved if NBO = 2 is confirmed with and additional *"incentive"* that depends on the system and the situation.

Penalty function, escalation example



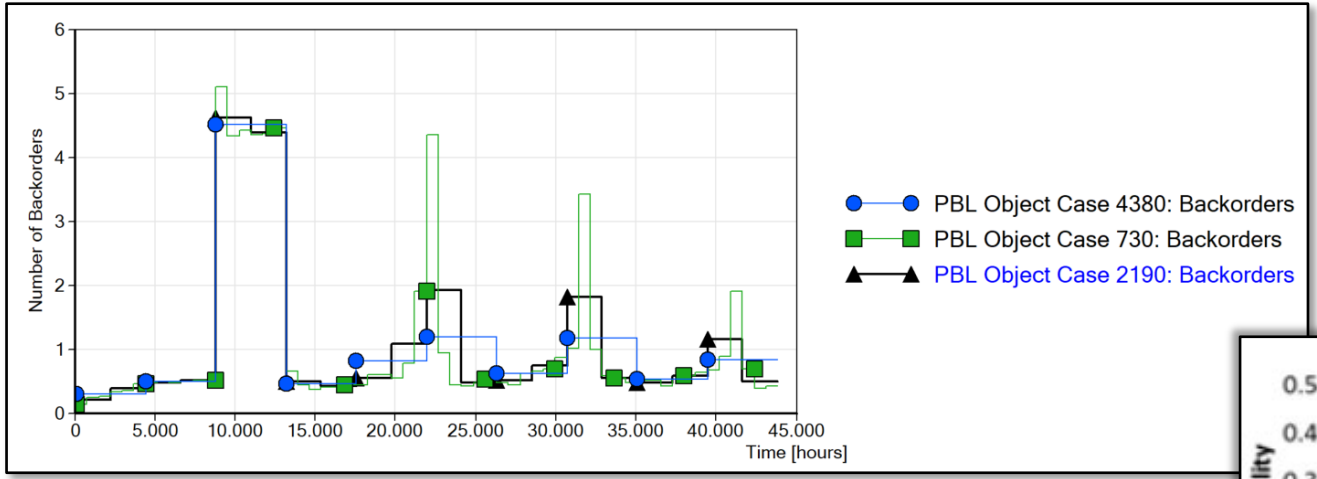
- The function $y(B)$ is recommended to be designed iteratively by evaluating it on simulation results.
- y_{max} represents the maximum penalty for a backorder measurement time period T. If the contract cover N time periods, it is possible to state that:

$$y_{max} = \beta \cdot \frac{Profit}{N}$$

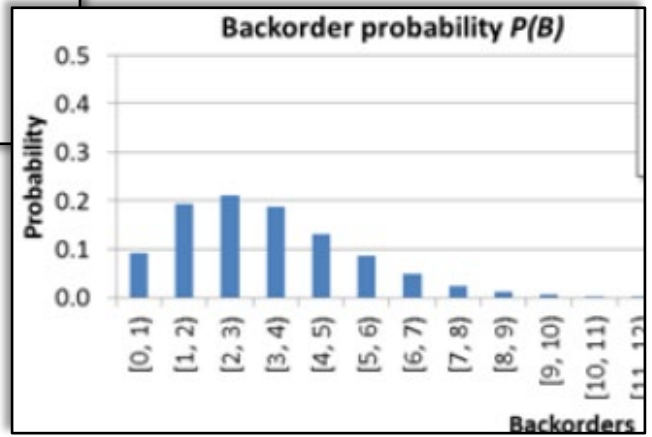
$$y(B) = \begin{cases} \min\left(y_{max},\ y_{min}(1+f_y)^{\left\lfloor \frac{B-B_y}{\Delta B} \right\rfloor}\right), & B \geq B_y \\ 0, & B < B_y. \end{cases}$$

y_{min}:	Minimum penalty per time period T
y_{max}:	Maximum penalty per time period T
f_y:	Penalty increase fraction
B_y:	Backorder penalty threshold
ΔB:	Backorder step size

Final considerations



- SIMLOX simulations indicate that the inherent *backorders variations* can be large over time. It is therefore important to define a proper RCINT when designing the penalty function $y(NBO)$.



- The backorder variation dependence upon the performance measurement time period. *RCINT* should be considered to determine the time steps for contract compliancy evaluation.
- Statistical variation of parameters modeling support sensitivity analysis.
- Useful guide is provided by plotting the Probability of Backorder (1 – PNB) vs the NBO and a “wish” is to add the Probability of Backorders in the MoE list.
- How helpful will be OPUS_EVO in this process?.....***certainly important !***

Grazie per l'Attenzione

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