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# Leveraging cost engineering processes & iterative cost estimation methods with an ecosystem of internally designed cost engineering tools

## Space Cost Engineering Conference 2024, Toulouse

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**3<sup>RD</sup> & 4<sup>TH</sup> OF OCTOBER, 2024**

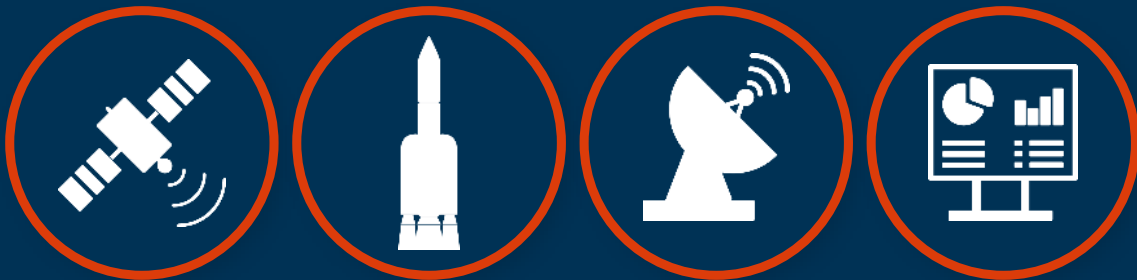
- I. What is OHB System?
- II. The Role of Cost Engineering in Space Projects
- III. The Role of a Unified Cost Management System
- IV. OHB - Baseline Cost Tool (BCT)
- V. OHB – Cost Risk Tool (CRT)
- VI. Lessons learned from ongoing projects
- VII. Achieving Synergy: Tools & Iterative Design Methodologies

# I. WHAT IS OH B SYSTEM ?

OH B SE AND OH B SYSTEM AG- AGILE.RELIABLE.INDEPENDENT.

## OH B SE ...

- Germany's first listed space company
- Family-run, medium-sized group
- Has developed from small beginnings into an internationally operating company
- Recognised player in the European aerospace industry with stakes in all major space programmes
- Space from A to Z



## OH B System AG ...

- Core company of the OH B Group
- Leading European space technology company
- 40+ years of experience
- Can rely on strong alliances with international partners and suppliers
- Acts as a large systems integrator for complex satellite programmes





# I. WHAT IS OHB SYSTEM?

RANGE OF SERVICES OF OHB SYSTEM: APPLICATIONS AND PROJECTS

**OHB**

Telecommunication

Science & Exploration

Navigation

Environmental  
Monitoring

Reconnaissance

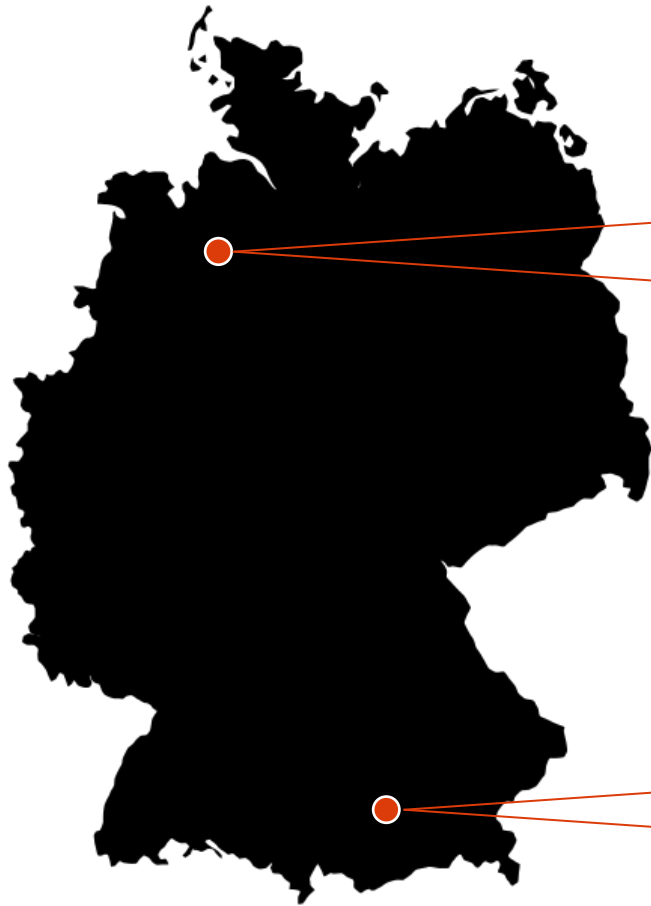
Weather Forecasting

- Satellites and payloads for all types of missions:
  - Earth observation
  - Reconnaissance
  - Navigation
  - Telecommunications
  - Science and exploration
- Projects ranging from development of small payloads to extensive space infrastructure



# I. WHAT IS OHB SYSTEM ?

OHB SYSTEM AG | LOCATIONS : BREMEN AND OBERPFAFFENHOFEN



Bremen



Oberpfaffenhofen





# I. WHAT IS OHB SYSTEM ?

OHB SYSTEM AG | BREMEN



- Group and company HQ
- Competence centre , “Large Systems“
- Approx. 1000 employees
- Integration facilities with clean rooms up to ISO 7 standard



# I. WHAT IS OHB SYSTEM ?

OHB SYSTEM AG | OBERPFAFFENHOFEN



- Competence centre „Optics & Payloads“
- Approx. 450 employees
- Integration facilities with clean rooms up to ISO 5 standard

## II. THE ROLE OF COST ENGINEERING IN SPACE PROJECTS

### A SYNERGISTIC APPROACH

- I. A comprehensive single source of truth framework for OHB System to evaluate & track space project costs during all development stages.
- II. Educating OHB System workforce and grow experts in cost estimation
- III. An ecosystem of cost engineering tools enabling:
  - Cost analyses & comparison with historic data
  - Reporting
  - Iterative design-to-cost & design-to-value trade-offs
  - Cost-Risk analyses and mitigation
  - Accurate price validation
  - Informs strategic decisions, such as **BID/NO BID**.
- IV. By integrating these insights, cost engineering empowers organizations to make informed, data-driven decisions that enhance project success and profitability.



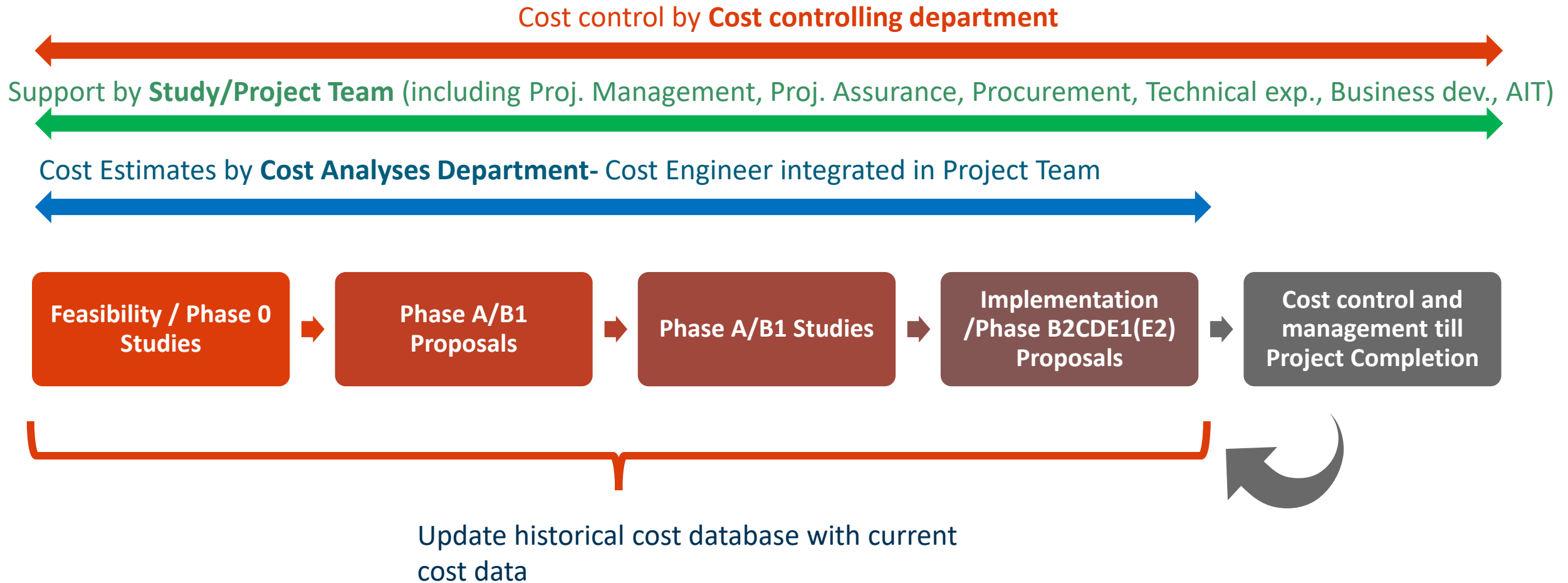
I want to build one of these satellites, How much will it cost?  
Can I afford to build this in the customer's budget? Should we bid for this project?





### III. THE ROLE OF A UNIFIED COST MANAGEMENT SYSTEM

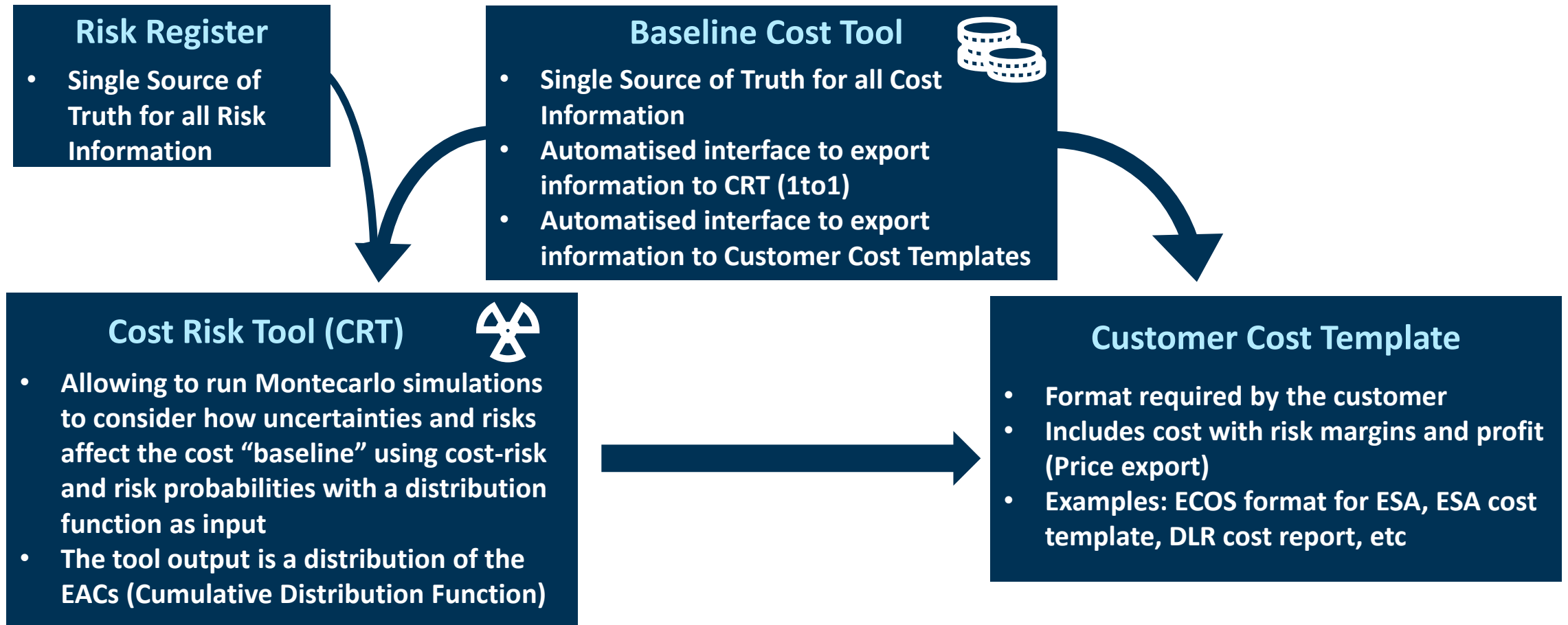
COST ESTIMATION APPROACH AT OHB SYSTEM AG



### III. THE ROLE OF A UNIFIED COST MANAGEMENT SYSTEM

#### COST ESTIMATION APPROACH AT OHB SYSTEM AG IN STUDY PHASES

The cost tools ecosystem currently focuses on cost engineering for prototypes & NRCs, but also for RCs, e.g. if several flight models are needed.

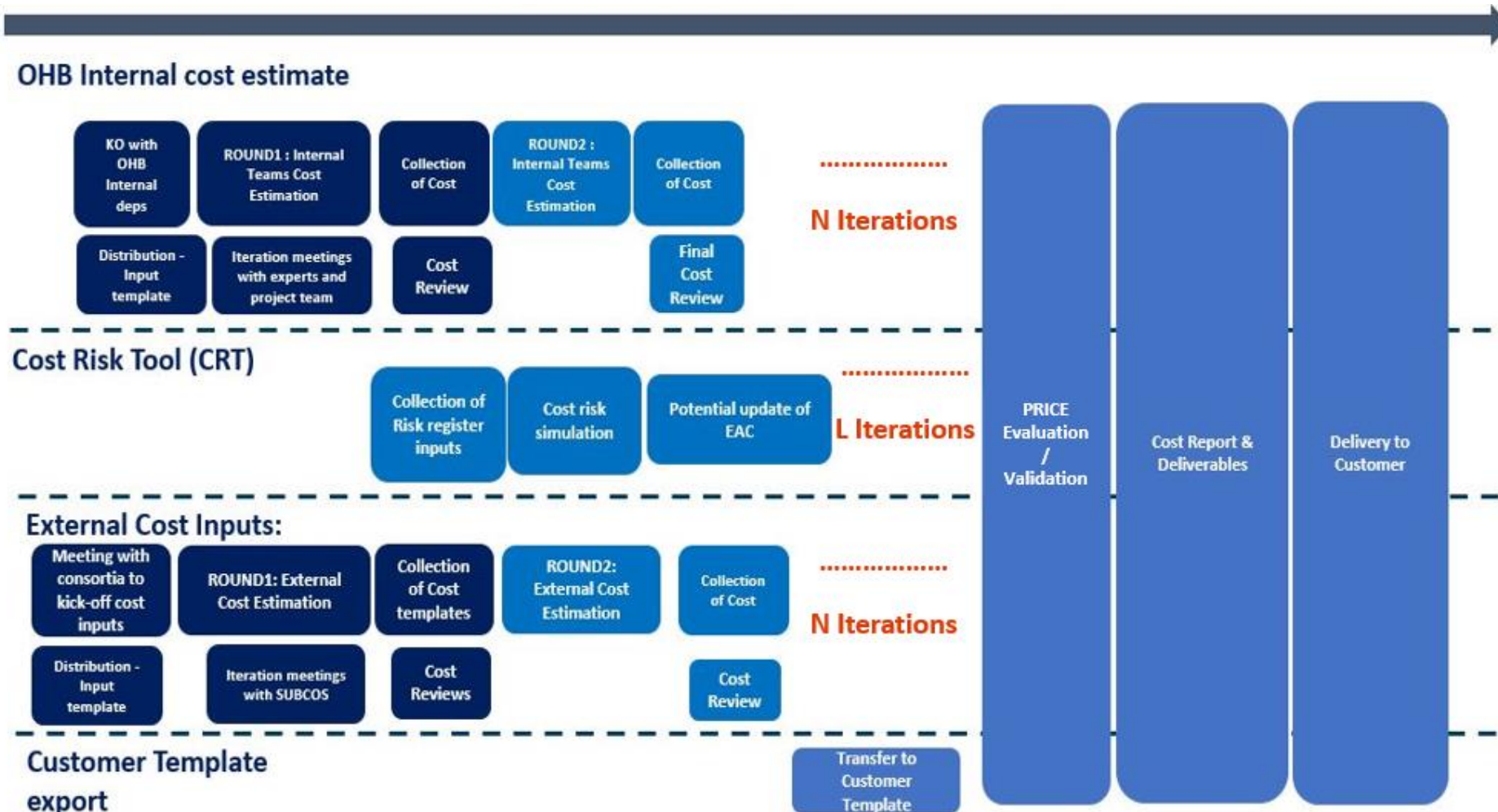




## II. THE ROLE OF COST ENGINEERING IN SPACE PROJECTS

### ITERATIVE DESIGN-TO-COST APPROACH AT OHB SYSTEM AG

#### Design-to-cost iterations done in a study phase



RFI/RFPs are also done in parallel

# III. THE ROLE OF A UNIFIED COST MANAGEMENT SYSTEM

## BENEFITS OF A UNIFIED COST MANAGEMENT SYSTEM



### Accuracy

Enhanced cost accuracy and design-to-cost for early trade-offs



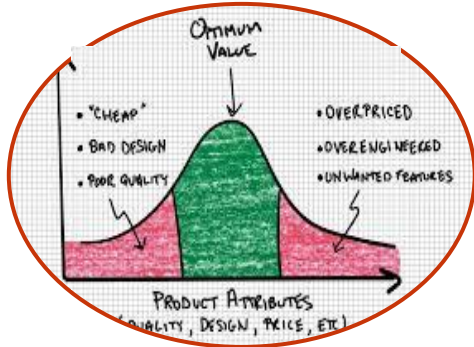
### Communication

Improved communication across teams.



### Reliability & Confidence

Reduction in discrepancies and errors.  
EAC and uncertainties



### Value/ Cost ratio

Identification of cost drivers, Design-to-value to optimize cost by less effort on low value elements



### Knowledge transfer

Maintain cost engineering know how within the company



### Homogenous flow

Uniform cost structure maintained across all project phases



# IV. OHB - BASELINE COST TOOL (BCT)

## INTRODUCTION



The OHB Baseline Cost Tool is a Microsoft excel based cost tool

- Based on a standard Cost Breakdown Structure adapted to every project
- Single Source of Truth for all cost estimate activities during study phases
- Currently utilizes Power Pivot and Power Queries. Power BI will be incorporated for reporting

#	Phase ID	Phase	Product Tree Node (ID)	Product Tree Node (name)	Product Tree Level	Function (ID)	Function (Name)	Function Level	Partner (ID)	Partner (Name)	Country
1	B2	Galactic - Phase B2	01.1.01.01.00.00	Structure SS	4	04.00.00	Procurement	1	22	Invent	Germany
2	B2	Galactic - Phase B2	01.1.01.02.00.00	Thermal Control SS	4	04.00.00	Procurement	1	1	OHB System	Germany
3	B2	Galactic - Phase B2	01.1.01.03.00.00	Propulsion SS	4	03.00.00	Engineering	1	1	OHB System	Germany
4	B2	Galactic - Phase B2	01.1.01.03.01.00	Propellant Tank	5	04.00.00	Procurement	1	1	OHB System	Germany
5	B2	Galactic - Phase B2	01.1.01.03.02.00	20N Thruster	5	04.00.00	Procurement	1	44	Nammo	United Kingdom
6	B2	Galactic - Phase B2	01.1.01.03.03.00	Ball Latch Valve	5	04.00.00	Procurement	1	1	OHB System	Germany
7	B2	Galactic - Phase B2	01.1.01.03.04.00	Pressure Transducer	5	04.00.00	Procurement	1	1	OHB System	Germany
8	B2	Galactic - Phase B2	01.1.01.03.05.00	Fill and Drain Valve	5	04.00.00	Procurement	1	1	OHB System	Germany
9	B2	Galactic - Phase B2	01.1.01.03.06.00	Propellant Filter	5	04.00.00	Procurement	1	1	OHB System	Germany

WP (ID)	WP (Name)	Work Package (ID - Name)	Responsible - Role	Responsible - Name
GLC - B2-01.1.01.01.00.00-04.00.0022	Galactic - Phase B2-01.1.01.01.00.00-Structure SS-Procurement-Invent	Galactic - WP GLC - B2-01.1.01.01.00.00-04.00.0022-Galactic - Phase B2-01.1.01.01.00.00-Structure SS-Procurement-Invent		
GLC - B2-01.1.01.02.00.00-04.00.001	Galactic - Phase B2-01.1.01.02.00.00-Thermal Control SS-Procurement-OHB System	Galactic - WP GLC - B2-01.1.01.02.00.00-04.00.001-Galactic - Phase B2-01.1.01.02.00.00-Thermal Control SS-Procurement-OHB System		
GLC - B2-01.1.01.03.00.00-03.00.001	Galactic - Phase B2-01.1.01.03.00.00-Propulsion SS-Engineering-OHB System	Galactic - WP GLC - B2-01.1.01.03.00.00-03.00.001-Galactic - Phase B2-01.1.01.03.00.00-Propulsion SS-Engineering-OHB System		
GLC - B2-01.1.01.03.01.00-04.00.001	Galactic - Phase B2-01.1.01.03.01.00-Propellant Tank-Procurement-OHB System	Galactic - WP GLC - B2-01.1.01.03.01.00-04.00.001-Galactic - Phase B2-01.1.01.03.01.00-Propellant Tank-Procurement-OHB System		
GLC - B2-01.1.01.03.02.00-04.00.0044	Galactic - Phase B2-01.1.01.03.02.00-20N Thruster-Procurement-Nammo	Galactic - WP GLC - B2-01.1.01.03.02.00-04.00.0044-Galactic - Phase B2-01.1.01.03.02.00-20N Thruster-Procurement-Nammo		
GLC - B2-01.1.01.03.03.00-04.00.001	Galactic - Phase B2-01.1.01.03.03.00-Ball Latch Valve-Procurement-OHB System	Galactic - WP GLC - B2-01.1.01.03.03.00-04.00.001-Galactic - Phase B2-01.1.01.03.03.00-Ball Latch Valve-Procurement-OHB System		
GLC - B2-01.1.01.03.04.00-04.00.001	Galactic - Phase B2-01.1.01.03.04.00-Pressure Transducer-Procurement-OHB System	Galactic - WP GLC - B2-01.1.01.03.04.00-04.00.001-Galactic - Phase B2-01.1.01.03.04.00-Pressure Transducer-Procurement-OHB System		
GLC - B2-01.1.01.03.05.00-04.00.001	Galactic - Phase B2-01.1.01.03.05.00-Fill and Drain Valve-Procurement-OHB System	Galactic - WP GLC - B2-01.1.01.03.05.00-04.00.001-Galactic - Phase B2-01.1.01.03.05.00-Fill and Drain Valve-Procurement-OHB System		
GLC - B2-01.1.01.03.06.00-04.00.001	Galactic - Phase B2-01.1.01.03.06.00-Propellant Filter-Procurement-OHB System	Galactic - WP GLC - B2-01.1.01.03.06.00-04.00.001-Galactic - Phase B2-01.1.01.03.06.00-Propellant Filter-Procurement-OHB System		
GLC - B2-01.1.01.03.07.00-04.00.001	Galactic - Phase B2-01.1.01.03.07.00-Propellant Tubing-Procurement-OHB System	Galactic - WP GLC - B2-01.1.01.03.07.00-04.00.001-Galactic - Phase B2-01.1.01.03.07.00-Propellant Tubing-Procurement-OHB System		

# IV. OHB - BASELINE COST TOOL (BCT)

## DEFINITION OF WORK BREAKDOWN STRUCTURE(WBS) AND COST BREAKDOWN STRUCTURE(CBS)

The adopted cost estimation process is based on the following cost breakdown structure(CBS):

- Each **cost node (cost package)** of the CBS is identified via 4 categories:

1. Mission Name- MNameID

2. Phase / Phase ID

3. Product Tree Element/ PTID

4. Function / FuncID

5. Subcontractor / supplier - SUBID

Example of cost item (Compact ID and Extended ID):

Mission Name – WP MNameID – PTID – FuncID SUBID – Mission Name Phase – Product  
Tree Node Mission Name – Product Tree Element - Function– Subcontractor / supplier

For example:

**Galactic - WP GLC-B2-1-2AAB2- Galactic Phase B2 - 1 Galactic Spacecraft - Contract administration – OHB System**

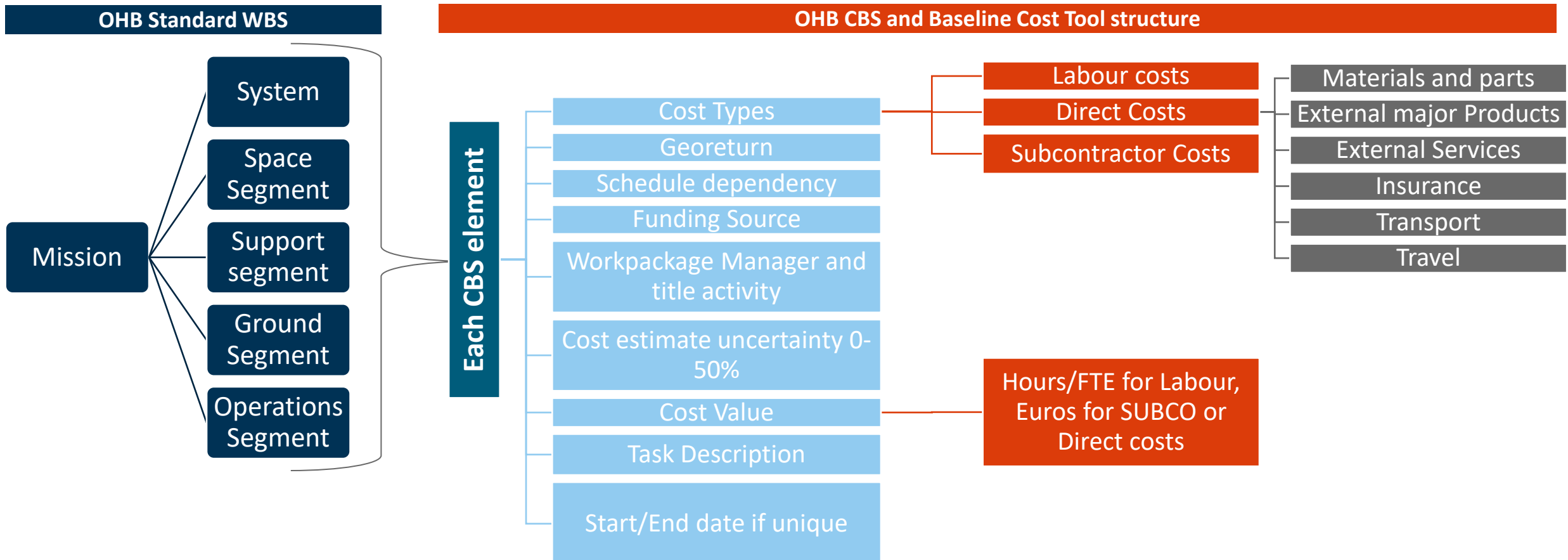


# IV. OHB - BASELINE COST TOOL (BCT)

## OHB SYSTEM AG STANDARD COST BREAKDOWN STRUCTURE

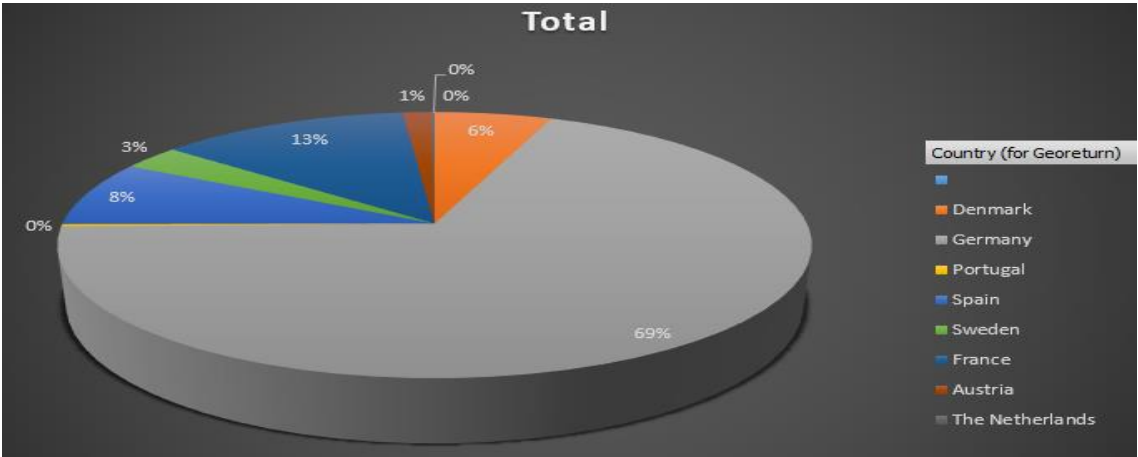


Each cost package contains one or several **cost lines**; each cost line is defined by a cost type, a value, a georeturn allocation and an uncertainty (and if Recurring/Non Recurring)

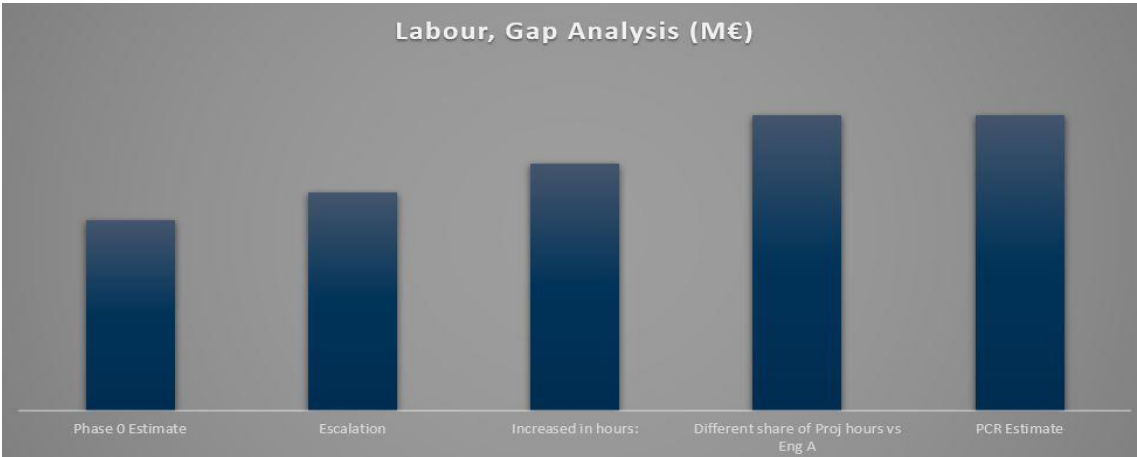


# IV. OHB - BASELINE COST TOOL (BCT)

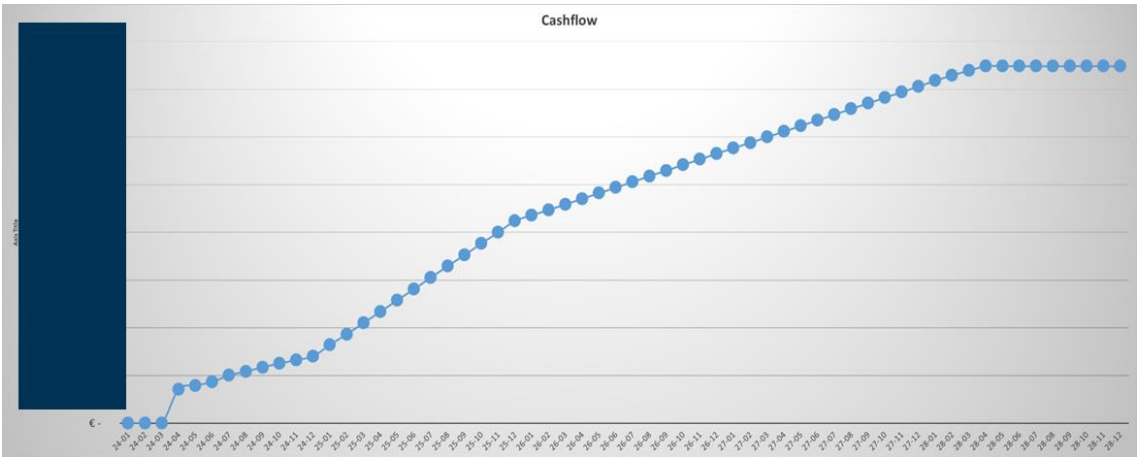
A FEW EXAMPLES OF THE BCT FUNCTIONALITIES



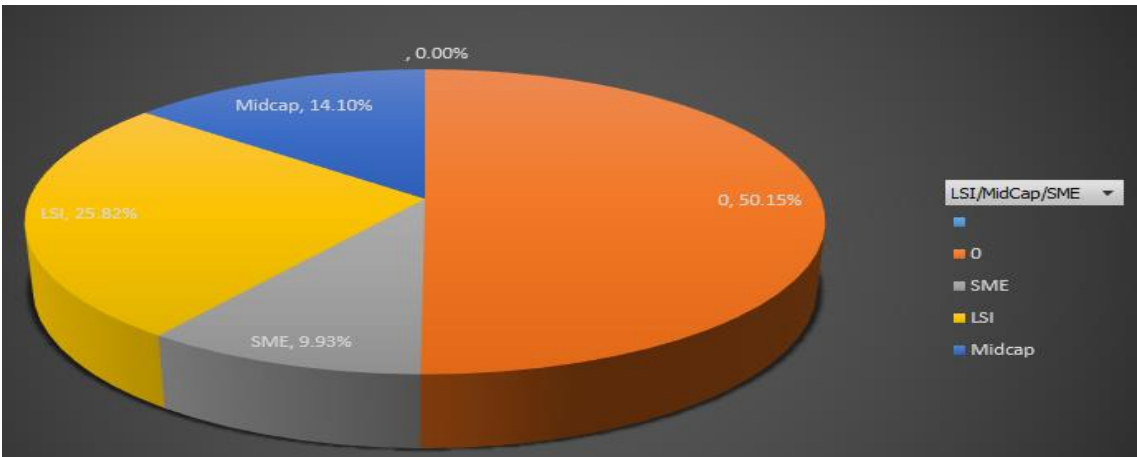
Geo-return analysis



Gap analysis



Cashflow Assessment



SME/LSI/Midcap analysis for companies



# IV. OHB - BASELINE COST TOOL (BCT)



FUNCTIONALITIES WITH POWER PIVOT AND PIVOT TABLES

PT

Sum of Internal Aggregated Cost (including all OH and escalation) [Euro] - Labour

Sum of Internal Aggregated Cost (including all OH and escalation) [Euro] - Direct Costs

Sum of Internal Aggregated Cost (including all OH and escalation) [Euro] - Subco

Sum of Internal Aggregated Cost (including all OH and escalation) [Euro]

+

01 - Space Segment

01.0 - Space Segment

01.0.00 - Space Segment

01.0.00.00 - Space Segment

01.1 - Satellite

01.1.01 - Platform

01.1.01.01 - Structure SS

01.1.01.02 - Thermal Control SS

01.1.01.03 - Propulsion SS

01.1.01.04 - Electrical Power SS

01.1.01.05 - Data Handling SS

01.1.01.06 - TTC&R S/S

01.1.01.07 - Data Downlink & Antenna S

01.1.01.08 - Attitude & Orbit Control S/S

01.1.01.09 - Software S/S

01.1.01.10 - Mechanism SS

01.1.01.11 - Payload Data Handling SS

01.1.01.12 - Harness SS

01.2 - Space Segment GSE

01.2.03 - Satellite GSE

01.2.03.00 - Satellite GSE

00 - Mission

00.0 - Mission

00.0.00 - Mission

00.0.00.00 - Mission

Grand Total

Sum of Internal - Labour [hour]

PT

Engineering A BRE Engineering A OPF Engineering B BRE Engineering C BRE Project BRE Grand Total

01 - Space Segment

03 - Engineering

01.1.01 - Platform

01.0.00 - Space Segment

04 - Procurement

01.1.01 - Platform

05 - AIT

01.0.00 - Space Segment

01.2.03 - Satellite GSE

06 - Launch Campaign

01.0.00 - Space Segment

08 - LEOP

01.0.00 - Space Segment

10 - Support Functions

01.0.00 - Space Segment

00 - Mission

01 - Project Management

00.0.00 - Mission

02 - Product Assurance

00.0.00 - Mission

Grand Total

Function

AIT

AIT Coordination

Avionics SE

Database

Electrical/Electroni...

EM AIT

Engineering

...

Labour, Direct, and Subcontractor Cost/Hours analyses

# IV. OHB - BASELINE COST TOOL (BCT)

EXAMPLES OF AUTOMATED REPORT EXPORTS FROM BCT



## ESA Cost report template

Phase A/B1 Study				
Contractor				
Maxim				
Document Number				
		Issue	Rev	Date
		0	0	0
Industrial Price ROM Estimate				
Economic Condition	2020	Other currency used (if 11-)		exchange rate
Currency	€			currency code
Cost Breakdown				
	Phase B2	Phase C/D	Phase E1	Total
Space Segment	0	0	0	0
Spacecraft / System	0	0	0	0
Project Office	0	0	0	0
Management	0	0	0	0
Product Assurance	0	0	0	0
Engineering	0	0	0	0
ATP	0	0	0	0
GSE	0	0	0	0
Service Module / Platform	0	0	0	0
Project Office	0	0	0	0
Management	0	0	0	0
Product Assurance	0	0	0	0
Engineering	0	0	0	0
ATP	0	0	0	0
GSE	0	0	0	0
Facilities	0	0	0	0
Hardware & Software	0	0	0	0
BOS	0	0	0	0
equipment 1	0	0	0	0
equipment 2	0	0	0	0
Data Handling	0	0	0	0
equipment 1	0	0	0	0
equipment 2	0	0	0	0
Onboard Software	0	0	0	0
Communication	0	0	0	0
equipment 1	0	0	0	0
equipment 2	0	0	0	0
Electrical Power	0	0	0	0
equipment 1	0	0	0	0
equipment 2	0	0	0	0
Hemant	0	0	0	0
Structure	0	0	0	0
equipment 1	0	0	0	0
equipment 2	0	0	0	0
Thermal Control	0	0	0	0
Propulsion	0	0	0	0
equipment 1	0	0	0	0
equipment 2	0	0	0	0
Mechanisms	0	0	0	0
equipment 1	0	0	0	0
equipment 2	0	0	0	0
Instrument	0	0	0	0
Project Office	0	0	0	0
Management	0	0	0	0
Product Assurance	0	0	0	0
Engineering	0	0	0	0
ATP	0	0	0	0
GSE	0	0	0	0
Facilities	0	0	0	0
Instrument Flight W/IS/W	0	0	0	0
Element Assembly 1	0	0	0	0
equipment 1	0	0	0	0
equipment 2	0	0	0	0
Element Assembly 2	0	0	0	0
equipment 1	0	0	0	0
equipment 2	0	0	0	0
Element Assembly 3	0	0	0	0
equipment 1	0	0	0	0
equipment 2	0	0	0	0
Element Assembly 4	0	0	0	0
equipment 1	0	0	0	0
equipment 2	0	0	0	0
...	0	0	0	0
...	0	0	0	0
Risk Contingency	0	0	0	0
Technical Risk	0	0	0	0
Management Reserve	0	0	0	0
Ground Segment	0	0	0	0
Level 1 resources	0	0	0	0
FOS & equipment	0	0	0	0
FOS & equipment	0	0	0	0
Contingency	0	0	0	0

- An automated report for OHB controlling for ECOS inputs or study phases ESA cost template
- Possibility to automate export into any report format using power queries and linking cells to each cost line

# V. OHB - COST RISK TOOL (CRT)

## INTRODUCTION



### The OHB Cost-Risk Tool is a Microsoft excel based tool

1. Linked to BCT for all cost inputs which is the single source of truth in study phases.
2. Identifies and quantifies potential cost uncertainties and risks.
3. Monte-Carlo Simulation: Estimates risk cost margins to aid decision-making.
4. Helps to estimate the Management Risk Reserve for OHB based on accepted Risk probability.
5. Proactive Risk Management: Allows for informed trade-offs between cost, performance, and risk.
6. **Result:** Enables better risk mitigation and cost control.

Risk Register															
Project:		Example Mission													
Issue:		1													
M for Mission affects the all Item otherwise use the abbrev (as stated in Product Breakdown) to allocate risk to subsystems as shown in the example below															
Import Data															
ALL / B2 / C / D / E1															
ABBREV1 / ABBREV2															
Risk Identification				Risk Analysis						Risk Evaluation		Risk Treatment		Likelihood of Effectiveness of Treatment/Mitigation Actions	Cost Impact of Treatment / Mitigation Actions on Baseline Budget
Risk ID	Category	Titel	Description	Complexity	Consequence	Affected Phases	Affected Cost Items	Likelihood	Cost Impact	Schedule Impact	Response	Proposed Mitigation / Treatment Option	Justification		
R-1		Risk 1		effects multiple Items		ALL	M	Middle (20% - 30%)	Significant (10% - 20%)		Accept				
R-2		Risk 2		effects single Items		ALL	M	Very low (5% - 10%)	Major (20% - 30%)		Accept				
R-3		Risk 3		effects single Items		ALL	PO	Very low (5% - 10%)	Major (20% - 30%)		Accept				
R-4		Risk 4		effects single Items		ALL	RAMS	Very low (5% - 10%)	Catastrophic (40% - 50%)		Accept				
R-5		Risk 5		effects single Items		ALL	SCSE	Very low (5% - 10%)	Significant (10% - 20%)		Accept				
R-6		Risk 6		effects single Items		ALL	MA	Very low (5% - 10%)	Significant (10% - 20%)		Accept				
R-7		Risk 7		effects multiple Items		ALL	STR / TCS	Very low (5% - 10%)	Significant (10% - 20%)		Accept				
R-8		Risk 8		effects multiple Items		ALL	STR / MECHA	Very low (5% - 10%)	Significant (10% - 20%)		Accept				
R-9		Risk 9		effects single Items		ALL	DEV2	Very low (5% - 10%)	Significant (10% - 20%)		Accept				
R-10	Schedule	Risk Mecha	Risk Mecha	effects multiple Items		ALL	MECHA / STR	Middle (20% - 30%)	Major (20% - 30%)	Significant (10% - 20%)	Treatment / Mitigate			High (60% - 70%)	Major (20% - 30%)
R-11	Technical	Risk PROP	Risk PROP	effects single Items	Risky	ALL	PROP	High (30% - 40%)	Critical (30% - 40%)	Significant (10% - 20%)	Treatment / Mitigate			High (60% - 70%)	Significant (10% - 20%)
R-12	Technical	Risk STR 1	Risk STR 2	effects single Items	Risky	ALL	STR	Middle (20% - 30%)	Significant (10% - 20%)	Significant (10% - 20%)	Accept				
R-13	Schedule	Risk SW	Risk SW	effects single Items		ALL	SW	High (30% - 40%)	Critical (30% - 40%)	Significant (10% - 20%)	Treatment / Mitigate			Very High (70% - 80%)	Major (20% - 30%)
R-14	Technical	Risk TCS 1	Risk TCS	effects single Items	Risky	ALL	TCS	Middle (20% - 30%)	Significant (10% - 20%)	Significant (10% - 20%)	Accept				



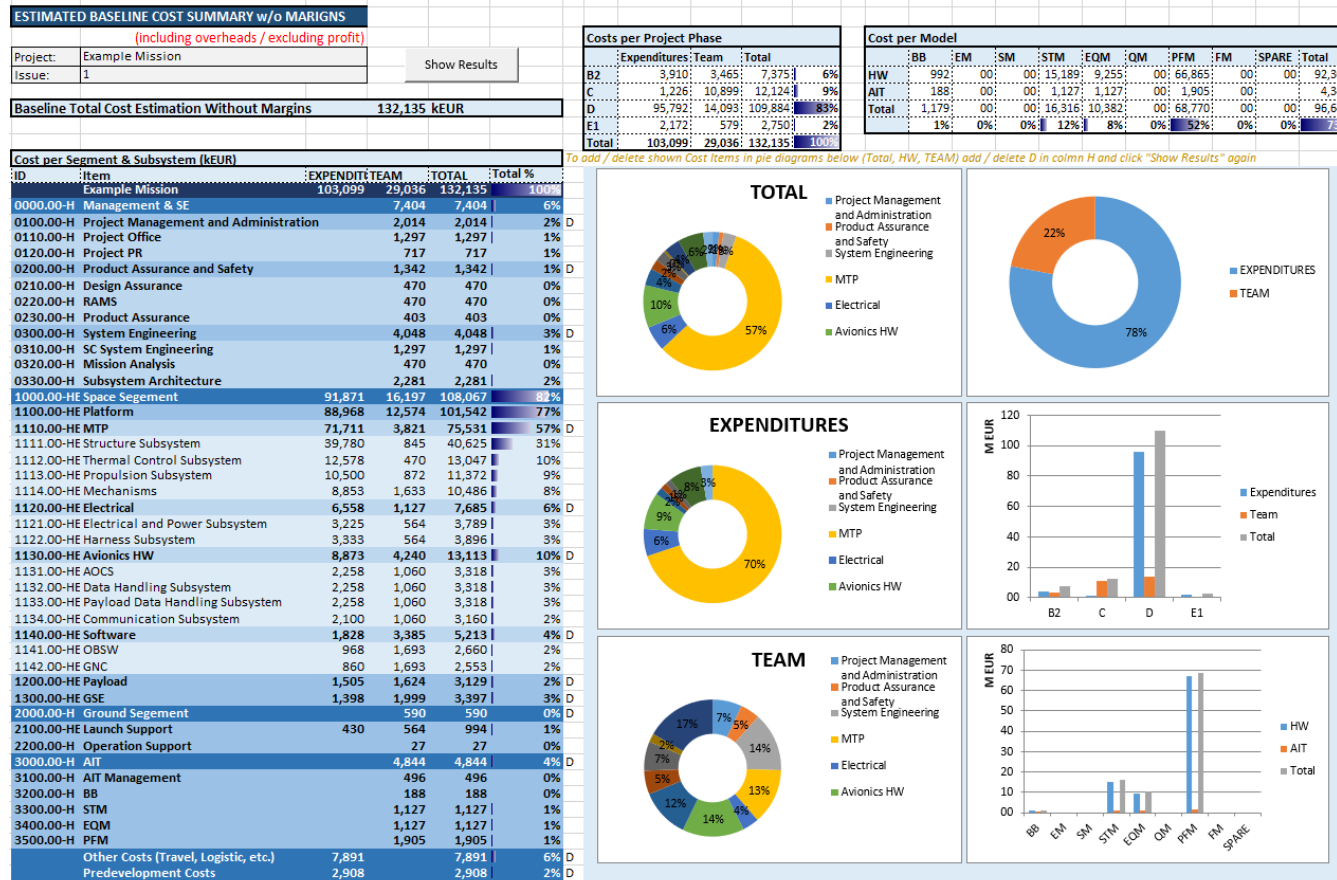
# V. OHB - COST RISK TOOL (CRT)

## INTEGRATION OF COST AND RISK MANAGEMENT TOOLS FOR ESTIMATING MANAGEMENT RISK RESERVE



### Cost-Risk Monte-Carlo simulation

### Cost Probability Distribution- Cumulative Distribution function



**Recommended Total Project Budgets & Margins [kEUR]**

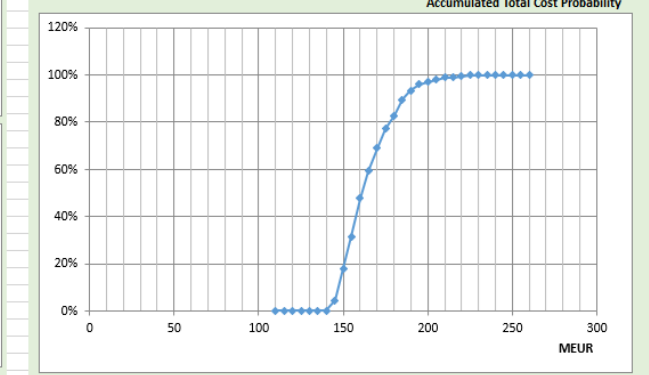
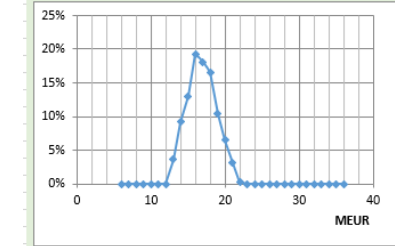
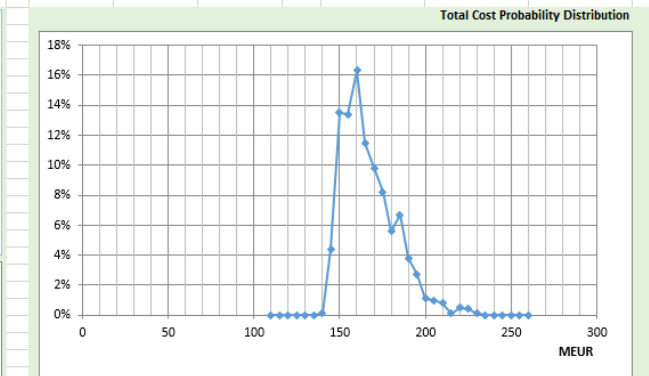
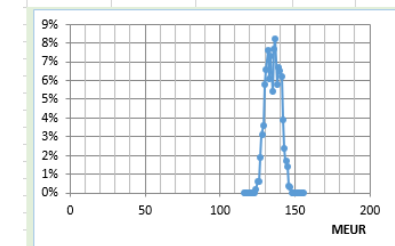
Set Scenario Coverage Level	Cost Value	Margin on EST BL
Baseline Budget	136,400	3%
Risk Mitigation Budget	16,900	13%
Risk Reserve Budget	13,000	10%
Total Budget	166,300	26%

**Simulated Total Cost Distribution**

Increment Chart	5000
Increment Table	1000
Average Cost:	164,400 kEUR
Std Deviation:	15,559

**Cost Value [kEUR] Margin on BL EST Covered Scenarios**

Cost Value [kEUR]	Margin on BL EST	Covered Scenarios
161,000	22%	50%
166,000	26%	60%
171,000	29%	70%
178,000	35%	80%
186,000	41%	90%
229,000	73%	100%



# VI. LESSONS LEARNT FROM ONGOING PROJECTS

## KEY LESSONS LEARNED

1. Importance of early adoption of a cost estimate strategy
2. Continuous refinement of tools based on feedback from all stages of different projects
3. Collaboration between teams and Transparency with Suppliers for design-to-cost
4. Leverage synergies across **all domains** (Earth observation, space exploration, transportation, science, telecommunications) and **types of customers** (Institutional and commercial)
5. In very early stages of project, iterate on assumptions about schedule, Design Development and Validation Plan, model philosophy, scope of work for the partners (ideally iterated with suppliers)
6. Always incorporating risks, inflation and maturity uncertainties for a comprehensive estimation of the global cost:
  - providing a consistent cost estimate over time
  - Enabling quantitative comparisons across the steps of the mission lifecycle

**Results:** Improved budget management, accurate cost estimations, and reduced risks.

## VII. ACHIEVING SYNERGY: TOOLS & ITERATIVE DESIGN METHODOLOGIES

### SPACE COST ENGINEERING

1. **Design-to-Value & Design-to-Cost:** Align project costs with value objectives while staying within budget.
2. **Risk Mitigation:** Proactively manage risks to reduce cost overruns.
3. **Cost Engineering & Iterative Design:** Facilitates alignment of costs with project goals, supports risk strategies, and enhances project execution.
4. **Unified Cost Management:** Critical for consistency, accuracy, and better outcomes.
5. **Complementary Tools:** CRT (Cost-Risk Tool) enhance BCT (Baseline Cost Tool) in managing uncertainties.

**Lessons Learned:** A single source of truth and iterative processes are key for continuous improvement and success in ongoing projects.



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# THANK YOU!

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