

The Hardware vs. Software on new Equipment “Design to Cost” Struggle



^{2nd}
ESA - CNES
SPACE COST
ENGINEERING
CONFERENCE

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KOSTENKLARHEIT SCHAFT GEWINN
COST CLARITY CREATES PROFIT



Introduction

Challenge

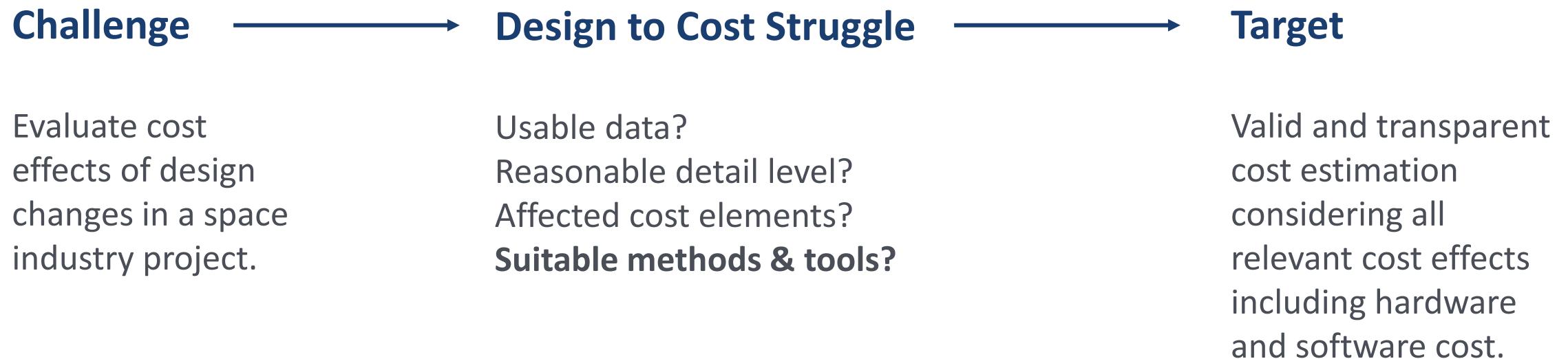
Evaluate cost effects of design changes in a space industry project.

Target

Valid and transparent cost estimation considering all relevant cost effects including hardware and software cost.



Introduction



Initial Situation – Fictional Example on Base of a historical Project

Redesign

Modification of an antenna system of a TV satellite payload module.

- new / redesigned hardware components
- different software protocols
- integration into the payload module

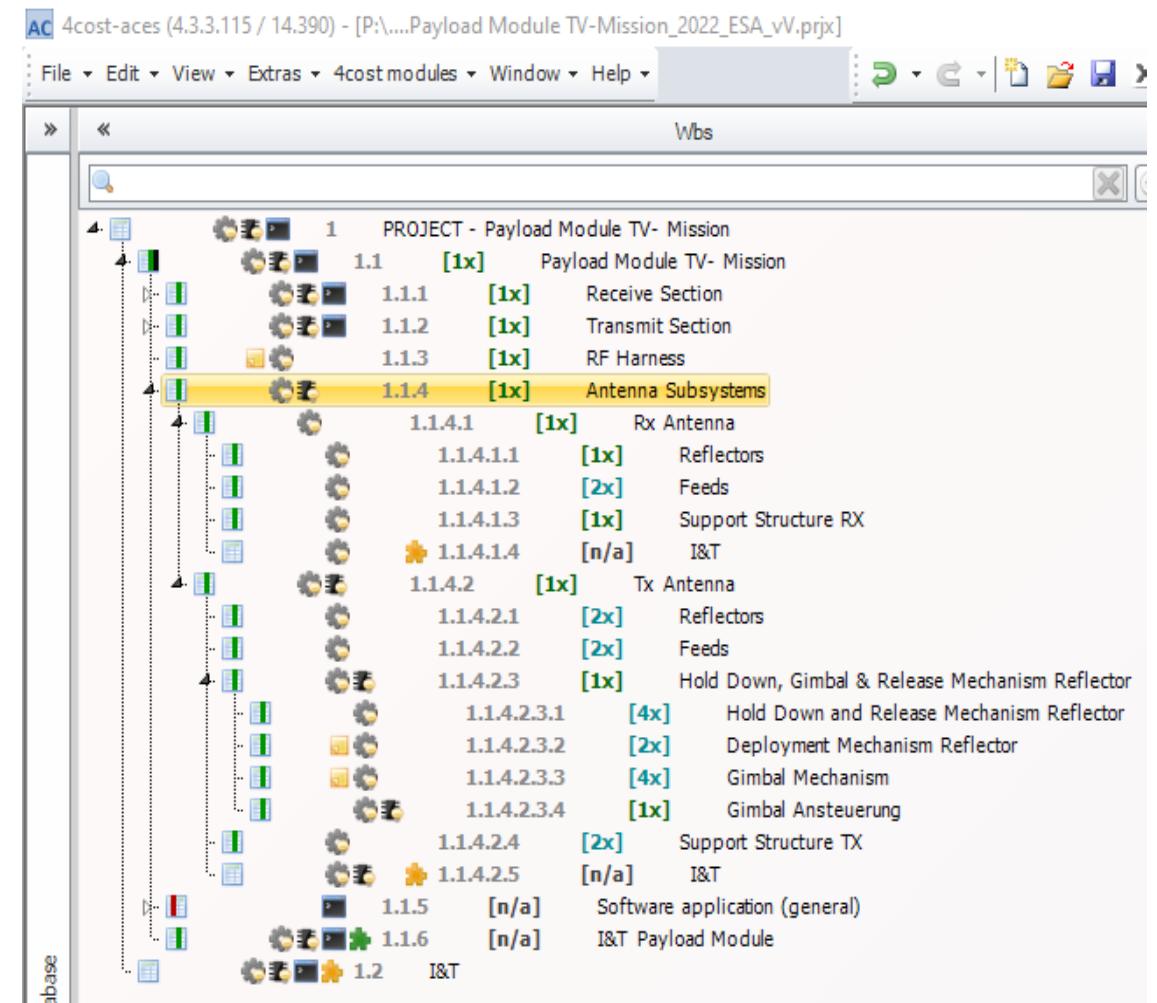
Design to cost approach

Adjusting an existing parametric model of the TV satellite payload module.

- restructuring of WBS
- addressing differences to old design
- supporting parametric model with other estimation methods

Hardware Cost Estimation – 4cost-aces

- 4cost-aces as leading tool
- WBS – freely adaptable changes
- first step – hardware adjustments (parametric)



Alternative Hardware Cost Estimation – 4cost-structure

The screenshot shows the 4cost-aces software interface. On the left is a hierarchical tree view of the product structure. In the center is a detailed cost summary table for the 'Payload Module TV-Mission'. At the bottom is a 'Management reports' section with various charts and data tables.

4cost-aces
(top-down)

The screenshot shows the 4cost-structure software interface. It features a detailed breakdown of costs by component, including overhead distribution and cost summaries. A red arrow points from the 4cost-aces interface towards the 4cost-structure interface, indicating the flow of data or the relationship between the two methods.

4cost-structure
(bottom-up)

Alternative Hardware Cost Estimation – 4cost-structure

4cost-aces (4.3.3.115 / 14.390) - [P:\...\Payload Module TV-Mission_2022_ESA_vv.pjx]

Inputs | Systems | Globals | LCC element-data | Sensitivity | Prd. potential analysis

Payload Module TV-Mission

Mode	Electronic Weight [kg]	Mechanical Weight [kg]	Process Quantity	Documentation level prod.	Development requirements	Operational environment
1020	19.2399	288.8800	1	2.06	1.936	1.999
Production Quantity	Unit Learning Curve	Manufacturing Process Index	Tooling-MD	Facility(Faci) factor	Unit Production Cost	Total Production Cost
1	0.749	1.729	0.6609	0.8156	14.113.982,40	18.821.958,68
Number of Prototypes	Design Iterations	New Design Electronic	New Design Mechanical	Documentation level prot.	Technology Year	
0,1	1,23	0,194	0,154	1,91	1,19	
Special Tooling Development	Engineering Difficulty	Team size	Electronic Technology-Index	Mechanical Technology-Index	Prototype Cost	Total Development Cost
15,16	1,7050	6.3168	6.3168	6.9872	1.413.743,24	5.589.930,23
Integration-Index Electronic	Integration-Index Mechanical	Development-Index Electro	Development-Index Mecha			
6.0263	6.4420	0,4117	0,8874			
Start of Development	Date first Prototype	Date end of Development	Date Start Production	Date First Production Unit	Date End Production	
	5.08	5.08	6.08	12.08	1.09	
Integration-Index Software	Design-complexity Software	Fault Probability in %	Software modification in %	New development Software	Cost Multiplier	
5.8079	1.421	0,011	0,514	0,303	1,0733	
# of Inputs	# of Outputs	# of Objects/Methods/Proc...	Software complexity	Team size software		
8.049	4.273	306	0,2635			

Management reports

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9.9.2022 //4COST

4cost-aces
Author: OFF-(217-PC-SZ)

Management reports

1.1 (wbs no) 14 388 391.12 € 19 154 156.87 € 10 292 452.54 € 306.12kg

Production cost analysis

14 113.982,15 € 14.388.391,12 € 14.388.391,12 € 14.388.391,12 € 14.388.391,12 €

Cost driver analysis production

7.192.808,81 € 26.206.905,70 € 4.707.678,88 € 3.532.168,18 € 6.670.886,35 €

DMNC Overhead I&T Markup Price

4cost-aces
(top-down)

4cost-structure (4.3.3.115) - [Structure1]

Default variant

Project (1x)

Payload Module TV-Mission (1x)

- Receive Section (1x)
 - LNA Assy (1x)
 - DOCON (8x)
 - IMUX (4x)
 - Wave Guide Assy (1x)
 - Coax Switches (36x)
 - Input Filter (2x)
 - Test couplers (2x)

Overhead distribution

Cost summary of the assembly

Type of cost	Current/1 Piece	Target/1 Piece	Current/1 Piece	Target/1 Piece	Inaccuracy Max	Inaccuracy Min
Production	14.388.389,24	14.388.389,24	14.388.389,24	14.388.389,24	14.388.389,24	14.388.389,24
Material	14.114.641,95	14.114.641,95	14.114.641,95	14.114.641,95	14.114.641,95	14.114.641,95
Process	273.747,29	273.747,29	273.747,29	273.747,29	273.747,29	273.747,29
Development	4.685.173,45	4.685.173,45	0	0	4.685.173,45	4.685.173,45
Process	4.685.173,45	4.685.173,45	0	0	4.685.173,45	4.685.173,45

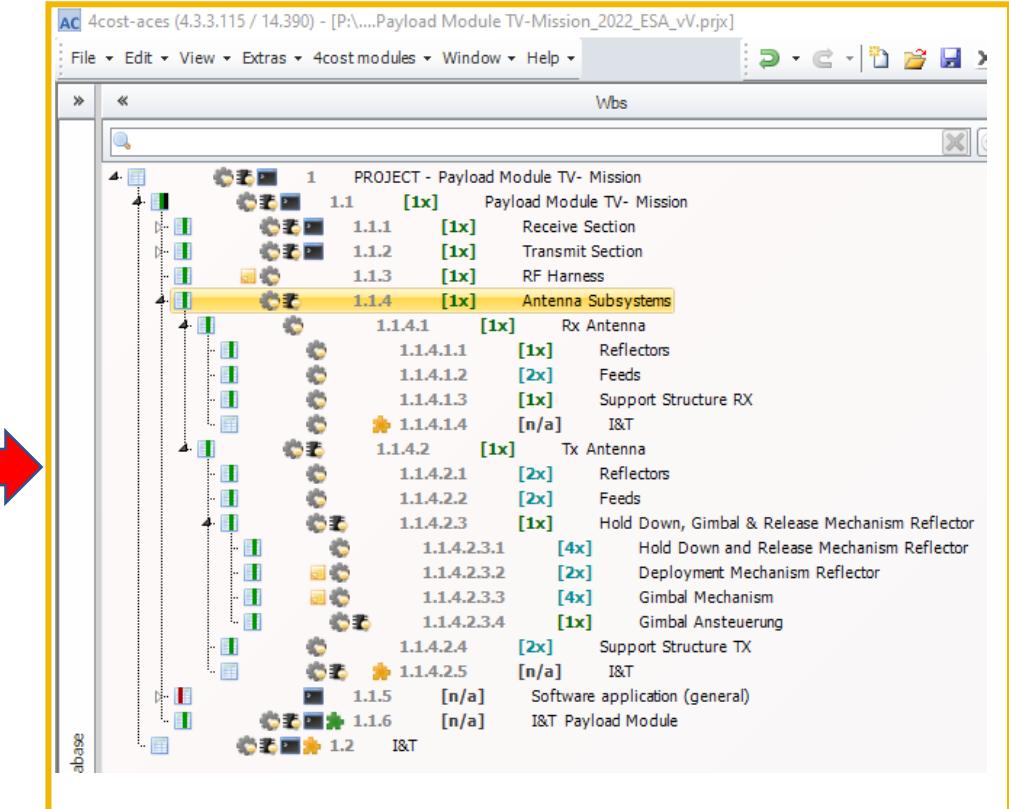
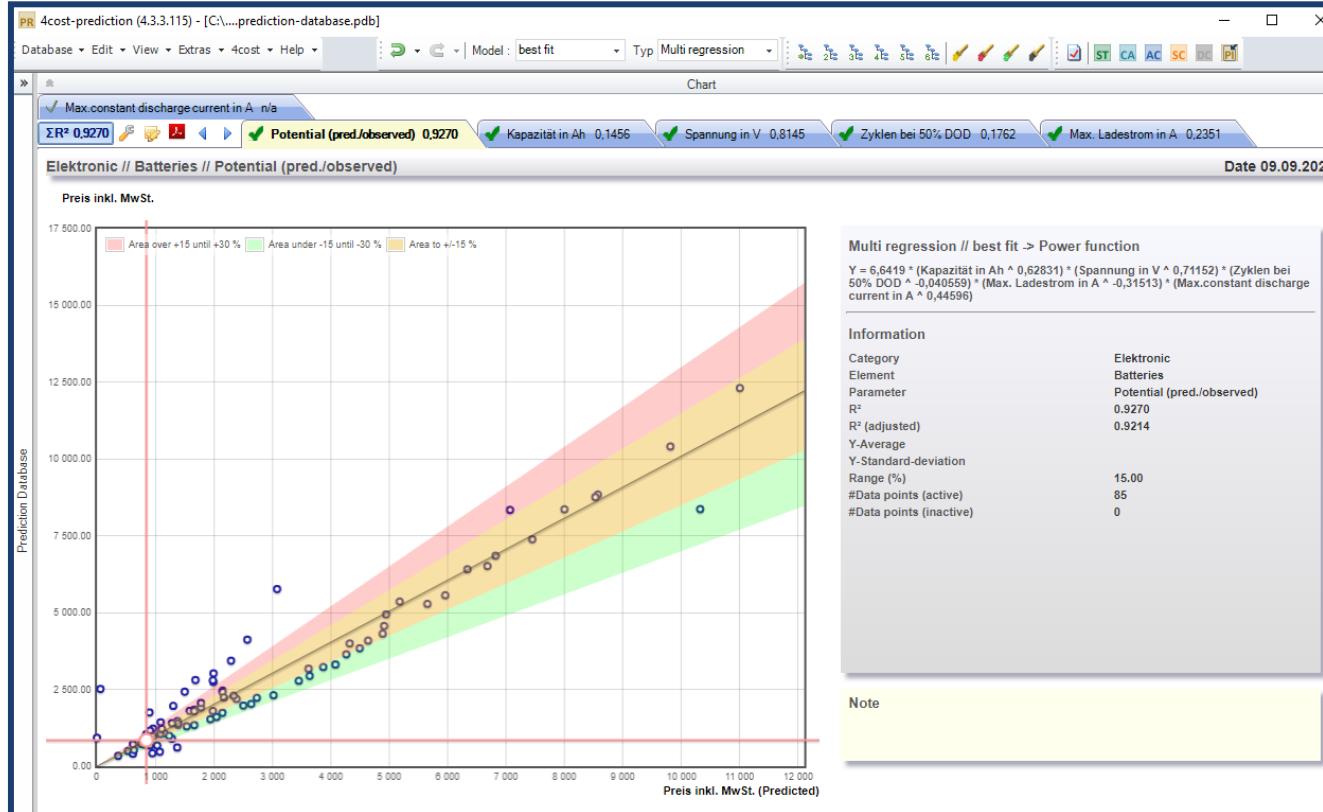
Component calculation

Material

Current Values	Material	Imported
Quantity	105,90	
Actual	0	
Base costs	0	
Target	0	
Currency	EUR	
Production location		
Gross Weight	0	
Net Weight	0	
Unit	kg	
Inaccuracy		

4cost-structure
(bottom-up)

Alternative Hardware Cost Estimation – 4cost-prediction



4cost-prediction
(regression analysis)

4cost-aces
(top-down)

The Hardware vs. Software on new Equipment “Design to Cost” Struggle

Project Status

- hardware configuration



What else?

software modification

Software Cost Estimation – 4cost-aces

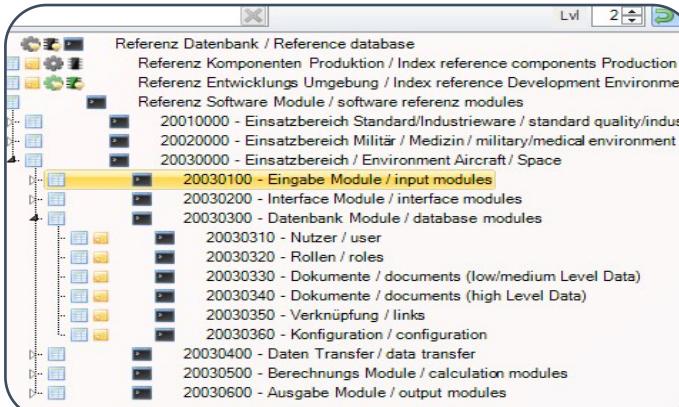
4cost-aces uses the HIPO (**H**ierarchy **I**nput **P**rocessing **O**utput) method to structure software cost like hardware.

Advantages of HIPO

- software language and methods independent
- usability at every design step (rough, very early phase, using the software-assistant (SW Expert))
- one box of a software-structure (WBS) may represent a function, an object or summation of objects within a software-program

Software Cost Estimation – 4cost aces

Consider Software Modifications (adjust or add)



The screenshot shows a software interface titled "Modulbeschreibung" (Module Description). It contains two main tables: "Modulbeschreibung" and "Working environment / requirements". The first table has columns for "Modulbeschreibung" (with rows for "functions / procedures / methods", "fields / signals", "functionalities", "Complexity of this component", and "New design within the module"), and "Working environment / requirements" (with rows for "within this Task", "Working environment", and "Requirements"). Each row includes four rating levels: Low, Medium, High, and Very high. To the right of these tables is a vertical sidebar with buttons for "Interface", "Conversion", "Time-critical", "CLP", and "New". A button labeled "Selection of par..." is also present.

The screenshot shows a software interface titled "configuration". It displays a table with various configuration parameters. The columns include "Integration-Index Software", "Design-complexity Soft...", "Fault Probability in %", "Software modification i...", and "New Dev...". Below this table, there is a section for "Parameter Settings" with fields for "# of Outputs", "# of Objects/Methods/...", "Software complexity", "Team size software", and "Number of...". At the bottom, there are sections for "Date start design", "Date start coding/test/v...", "Date start code revisions", "End of code revisions", and "Document...".

Reference Database

- large selection of modules already available

Software Expert

- alternative descriptions
- automatic translation
- transformation into parameters

Parameter Setting

- no. of inputs/outputs
- software modification %
- new development %
-

The Hardware vs Software on new Equipment “design to cost” struggle

Project Status

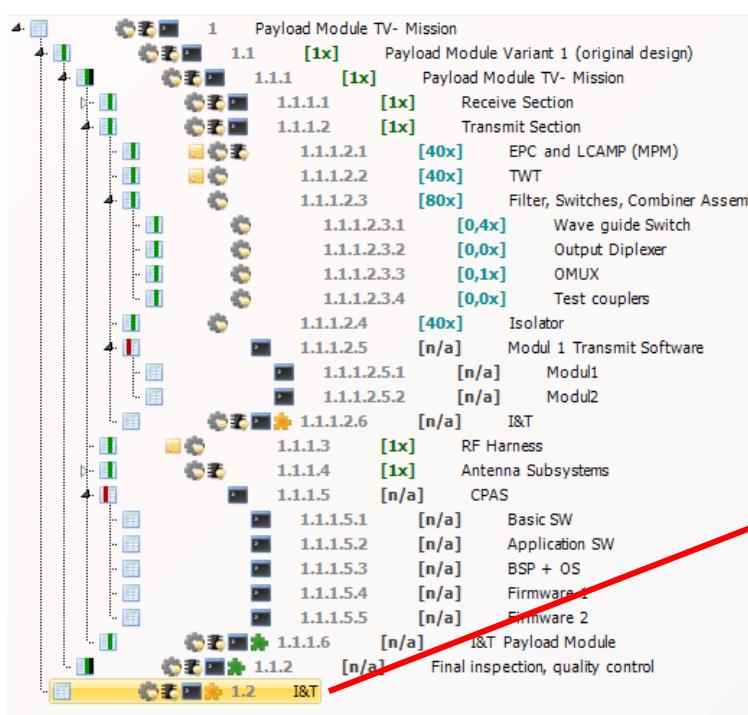
- hardware configuration ✓
- software configuration ✓

What else?

integration and test

Integration & Test of Hardware and Software – 4cost-aces

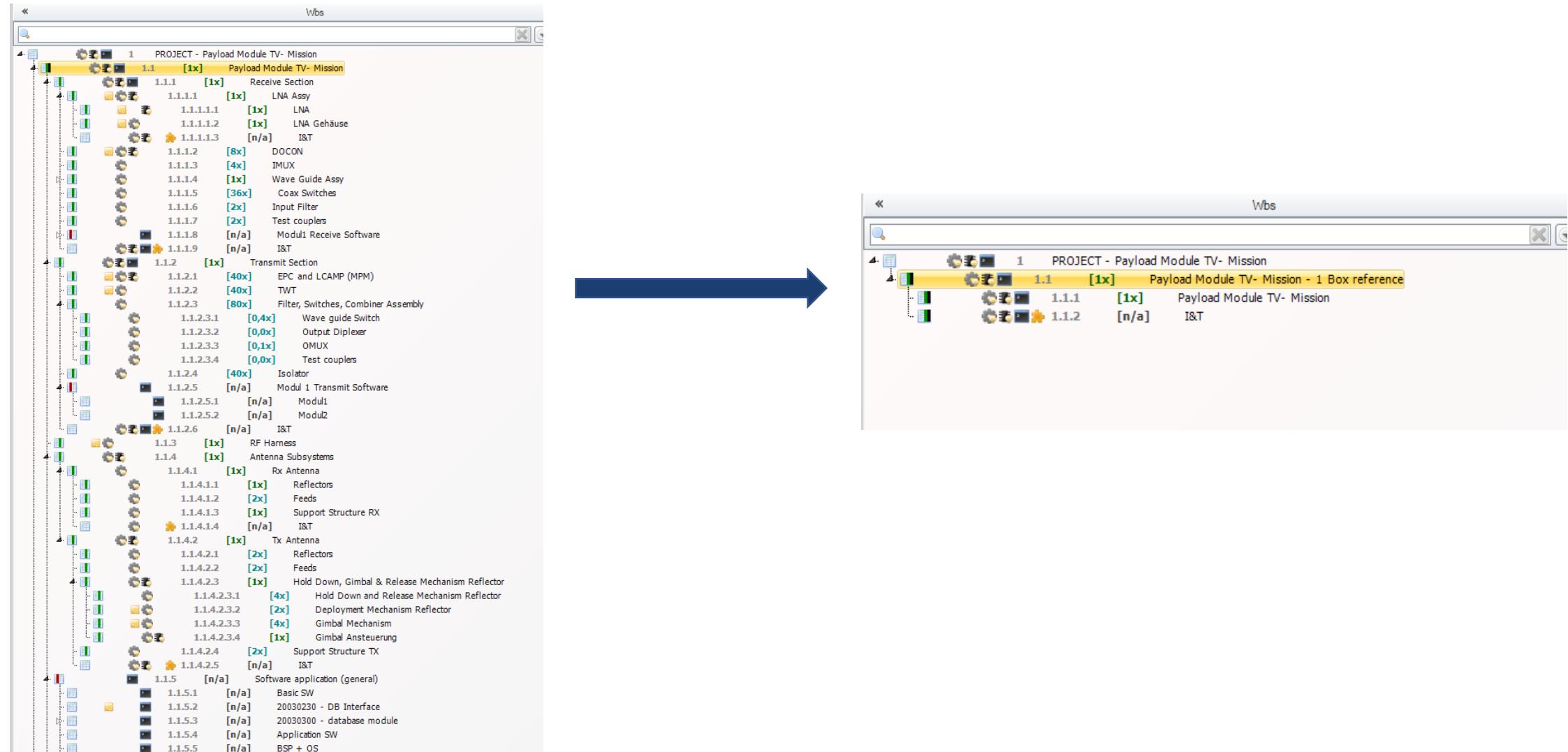
- hardware to hardware
- software to software
- software to hardware



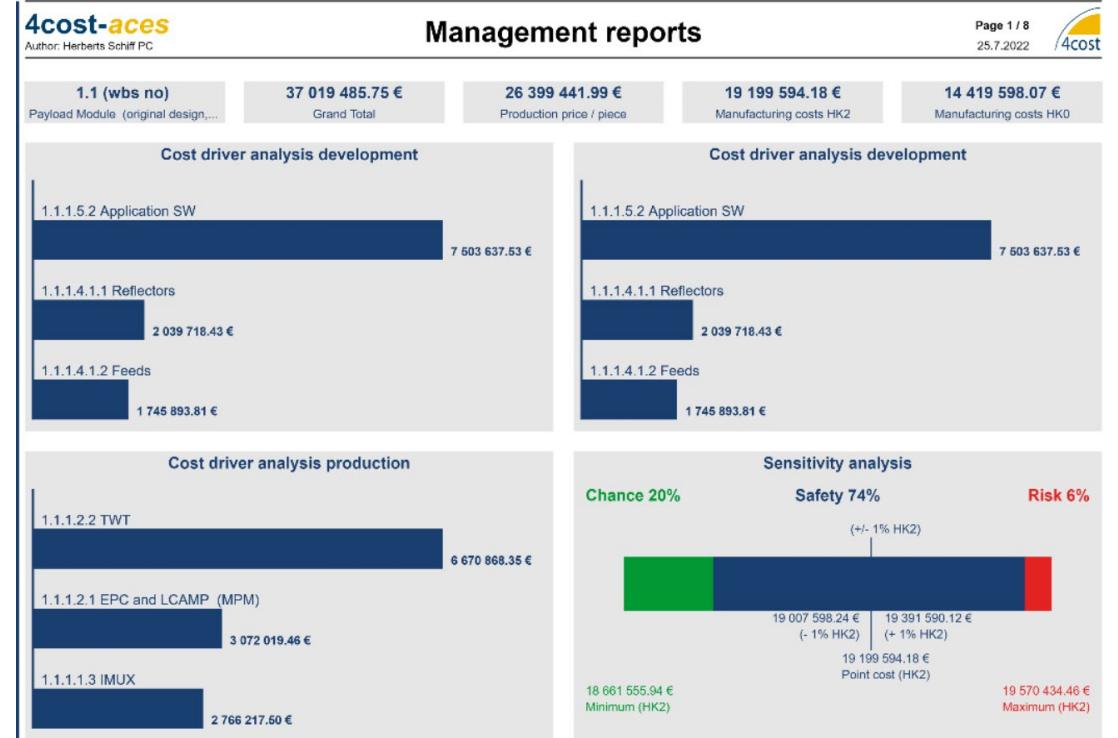
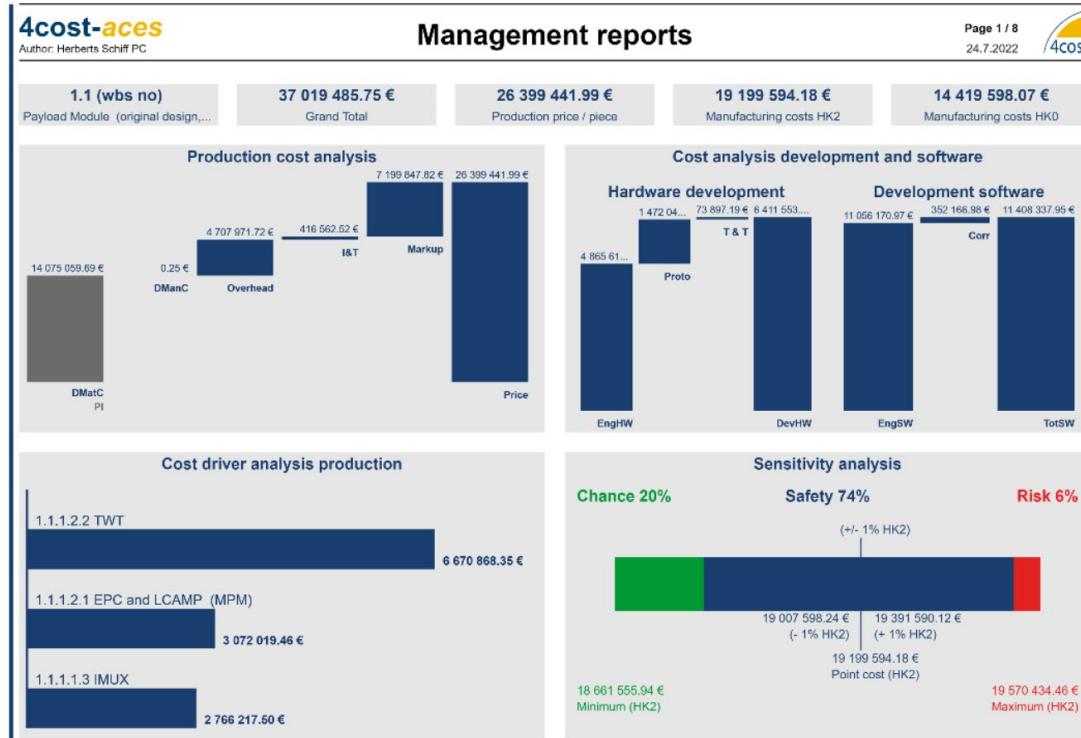
Screenshot of the 4cost-aces software interface. The top navigation bar includes 'Inputs' (selected), 'Systems', 'Globals', and 'Prd. potential analysis'. Below the navigation is a search bar with 'EAN' and a 'I&T' button. The main area displays various parameters:

Mode	Electronic Weight [kg]	Mechanical Weight [kg]	Process
1020	n/a	n/a	n/a
Production Quantity	1	0,700	Manufacturing Process Index
Number of Prototypes	0,1	1,23	New Design Electronic
Special Tooling Development	15,16	1,5080	Tooling-...
Integration-Index Electronic	6,0242	Integration-Index Mechanical	1,722
# of Inputs	9 880	# of Outputs	6 132
Date start concept/design	1 06	Date start design	2 06
Date first Prototype	8 07	Date end...	12 06
Design-complexity Software	5,5313	# of Objects/Methods/Procedures	294

Merge and Calibration into one Box – 4cost-aces



Meaningful Reports immediately available – 4cost-aces



Bottom Line

Challenge

Evaluate cost effects of design changes in a space industry project.

Design to Cost Struggle

Usable data?
Reasonable detail level?
Affected cost elements?
Suitable methods & tools?

Target

Valid and transparent cost estimation considering all relevant cost effects including hardware and software cost.



Bottom Line

Challenge

Evaluate cost effects of design changes in a space industry project.

Design to Cost Struggle

Modify a parametric cost model to consider all redesigns regarding hardware, software and integration.

Support by bottom-up calculation or regression analysis, depending on available data.

Merge and calibrate whole structure to one-box model.

Target

Valid and transparent cost estimation considering all relevant cost effects including hardware and software cost.



Thank you – please raise your questions!
