

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



**2<sup>nd</sup> ESA - CNES  
SPACE COST  
ENGINEERING  
CONFERENCE**

Sebastian Ziemen  
Erik Jandt

**KOSTENKLARHEIT SCHAFFT 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

## 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.

# 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

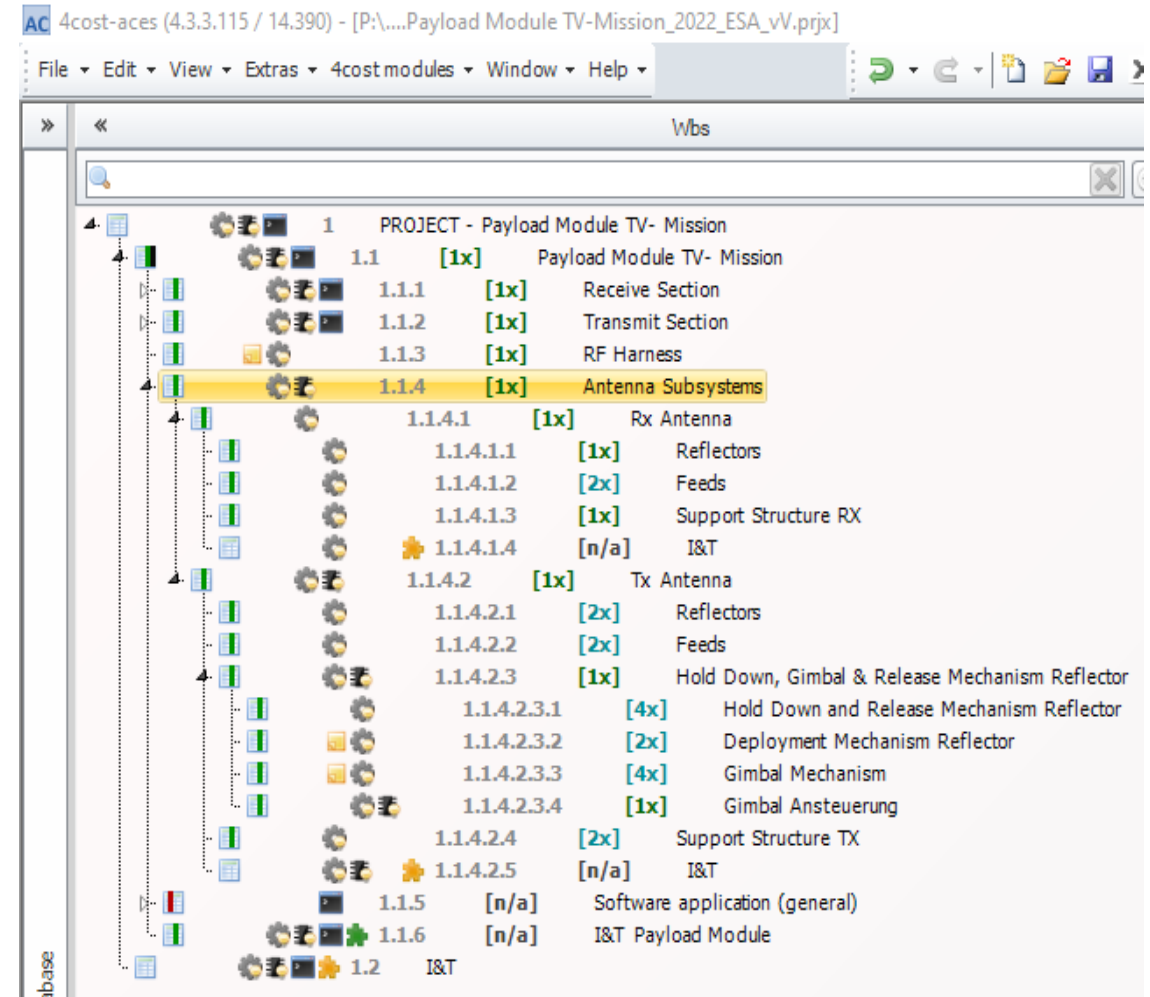
## Design to cost approach

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 interface with a hierarchical tree view on the left and a management reports dashboard on the right. The tree view includes components like 'PROJECT - Payload Module TV- Mission', 'Receive Section', 'LNA Assy', 'DOCON', 'IMUX', 'Wave Guide Assy', 'Wave guide Sw', 'Coax Switches', 'Input Filter', 'Test couplers', 'Modul1 Receive So', 'Modul1', 'Modul2', 'Transmit Section', 'EPC and LCAMP', 'TWT', 'Filter, Switches, Co', 'Wave guide', 'Output Dipole', 'DMUX', 'Test couplers', 'Isolator', 'Modul1 Transmit s', 'Modul1', 'Modul2', 'ISAT', 'RF Harness', 'Antenna Subsystems', 'Rx Antenna', 'Reflectors', and 'Feeds'.

The management reports dashboard displays key metrics for '1.1 (wbs no)':

- 14 988 391.12 € (Manufacturing costs LPMC)
- 19 154 166.87 € (Manufacturing costs AMUC)
- 10 292 452.54 € (Software costs)
- 306.12kg (Finished part weight, etc.)

Below these are two bar charts: 'Production cost analysis' and 'Cost driver analysis production'.

4cost-aces  
(top-down)

The screenshot shows the 4cost-structure interface with a hierarchical tree view on the left and a cost summary table on the right. The tree view includes components like 'Project (1 x)', 'Payload Module TV- Mission (1 x)', 'Receive Section (1 x)', 'LNA Assy (1 x)', 'DOCON (8 x)', 'IMUX (4 x)', 'Wave Guide Assy (1 x)', 'Coax Switches (36 x)', 'Input Filter (2 x)', 'Test couplers (2 x)', 'Modul1 Receive Software (1 x)', 'Isolator (40 x)', 'Modul1 Transmit Software (1 x)', 'I&T (1 x)', 'RF Harness (1 x)', 'Antenna Subsystems (1 x)', 'Rx Antenna (1 x)', 'Tx Antenna (1 x)', 'Software application (general) (1 x)', 'Basic SW (1 x)', 'DB Interface (1 x)', 'database module (1 x)', and 'Application SW (1 x)'.

The cost summary table shows the following data:

Type of cost	Current/1 Piece	Target/1 Piece	Current/1 Piece	Target/1 Piece	Inaccuracy Max	Inaccuracy Min
<b>Production</b>	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
<b>Development</b>	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

4cost-structure  
(bottom-up)

Drag and drop to 4cost-structure

# Alternative Hardware Cost Estimation – 4cost-structure

The screenshot shows the 4cost-aces interface with a hierarchical tree view of the project structure. The tree includes components like 'Receive Section', 'LNA Ass'y', 'DOCON', 'IMUX', 'Wave Guide Assy', 'Coax Switches', 'Input Filter', 'Test couplers', 'Modul1 Receive So', 'Modul1', 'Modul2', 'Transmit Section', 'EPC and LCAMP', 'TWT', 'Filter, Switches, Co', 'Wave guide', 'Output Dipole', 'DMUX', 'Test couplers', 'Isolator', 'Modul1 Transmit s', 'Modul1', 'Modul2', 'RF Harness', 'Antenna Subsystems', 'Rx Antenna', 'Reflectors', and 'Feeds'. The interface also displays various input parameters and management reports.

4cost-aces  
(top-down)

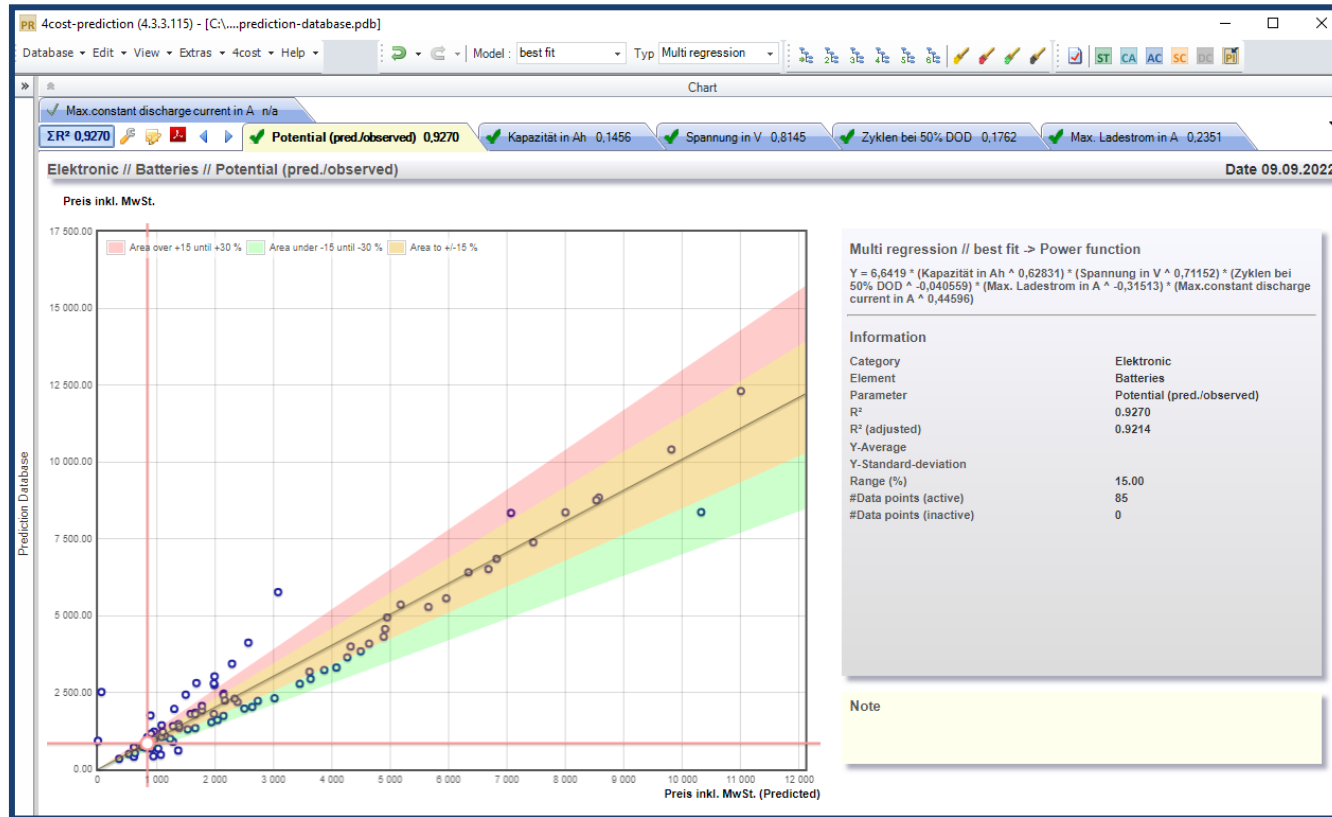
The screenshot shows the 4cost-structure interface, which provides a bottom-up view of the cost structure. It includes a tree view of the project components, a table for 'Overhead distribution', and a 'Component calculation' table. A red arrow points from the 4cost-aces interface to this screenshot, indicating the data flow.

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
<b>Production</b>	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
<b>Development</b>	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

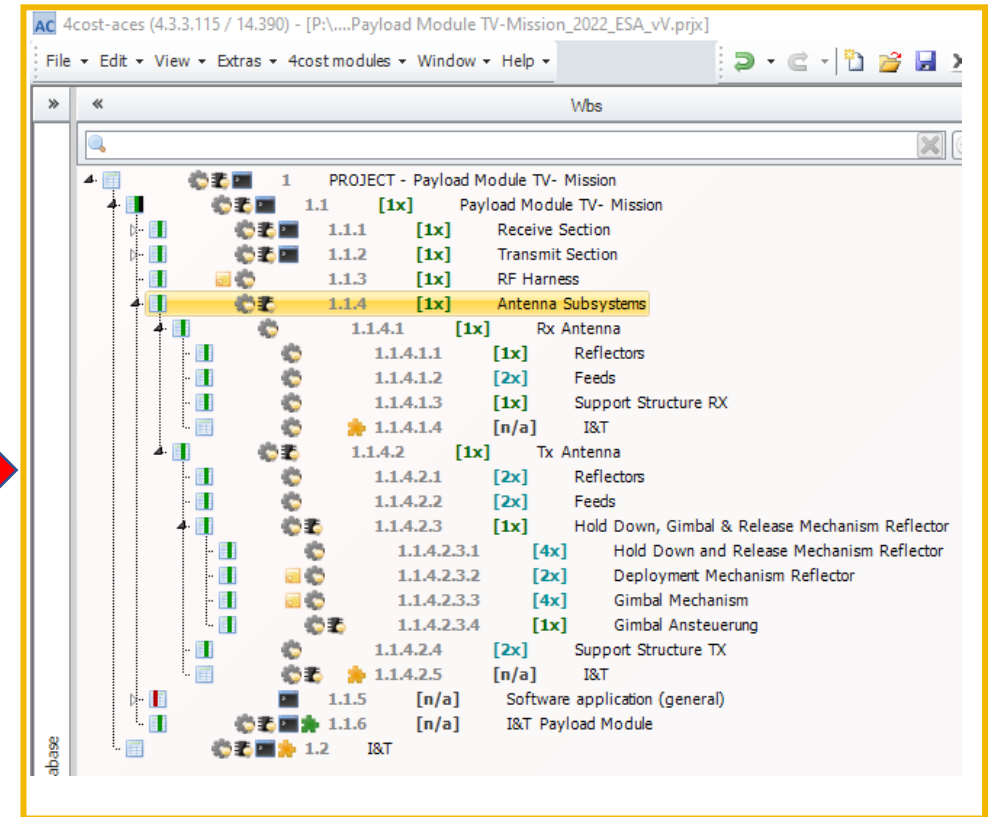
4cost-structure  
(bottom-up)

Drag and drop back to 4cost-aces

# 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

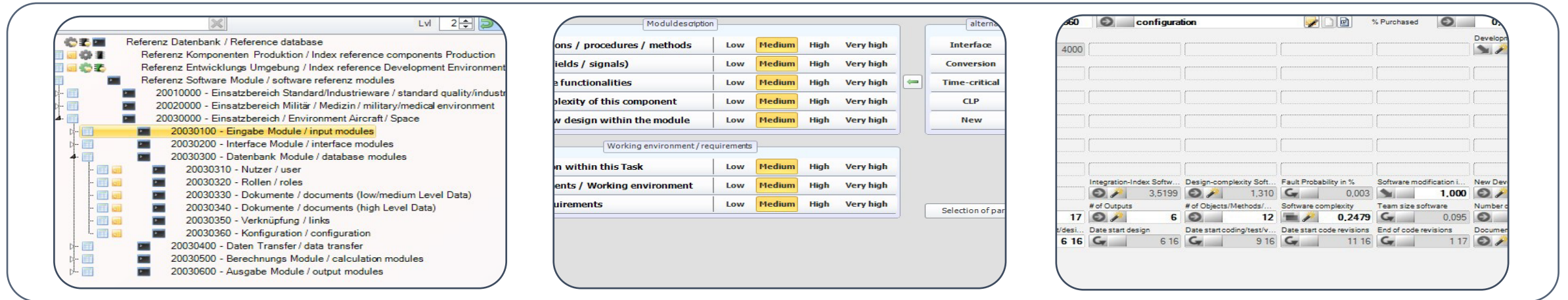
4cost-aces uses the HIPO (**H**ierarchy **I**nput **P**rocessing **O**utput) method to structure software cost like hardware.

## 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)



## 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

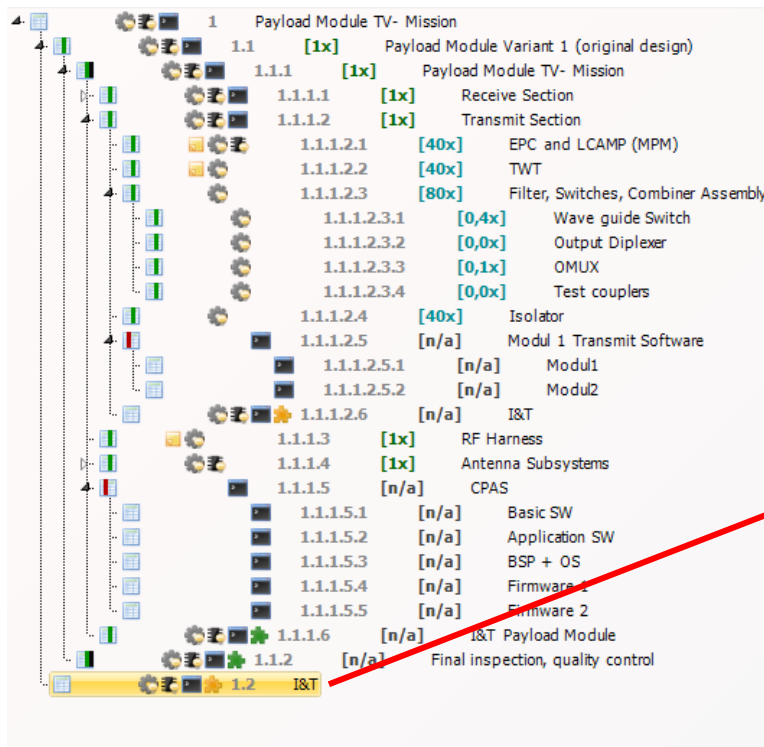
- hardware configuration ✓
- software configuration ✓

# What else?

integration and test

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

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

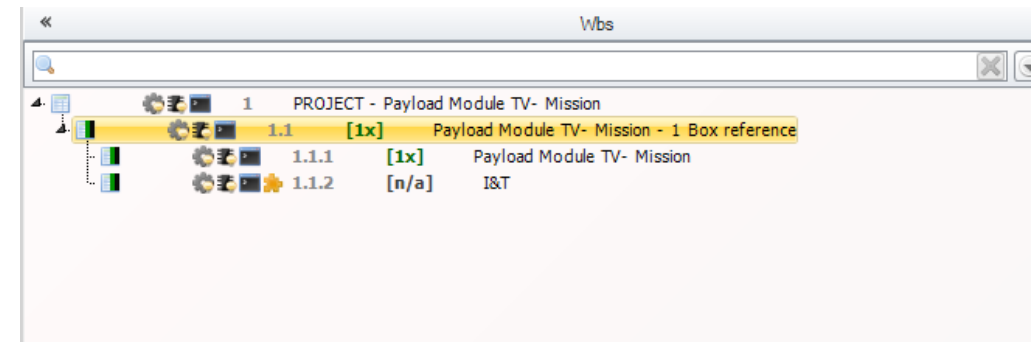
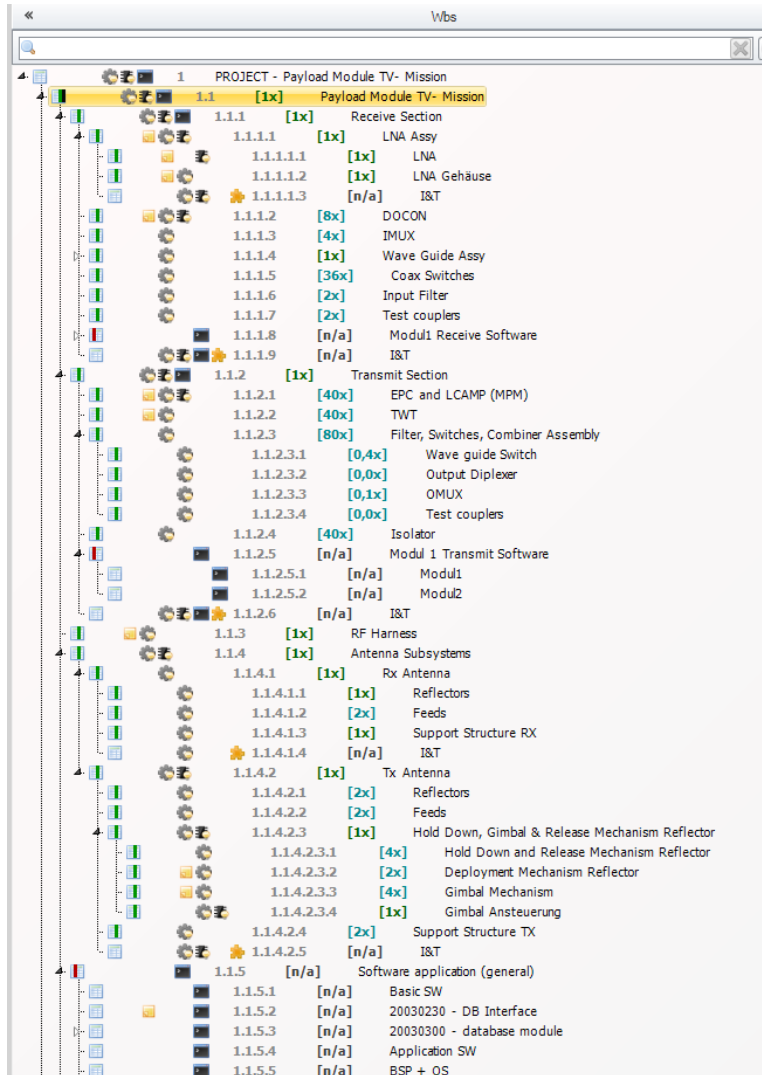


Inputs Systems Globals || Prd. potential analysis

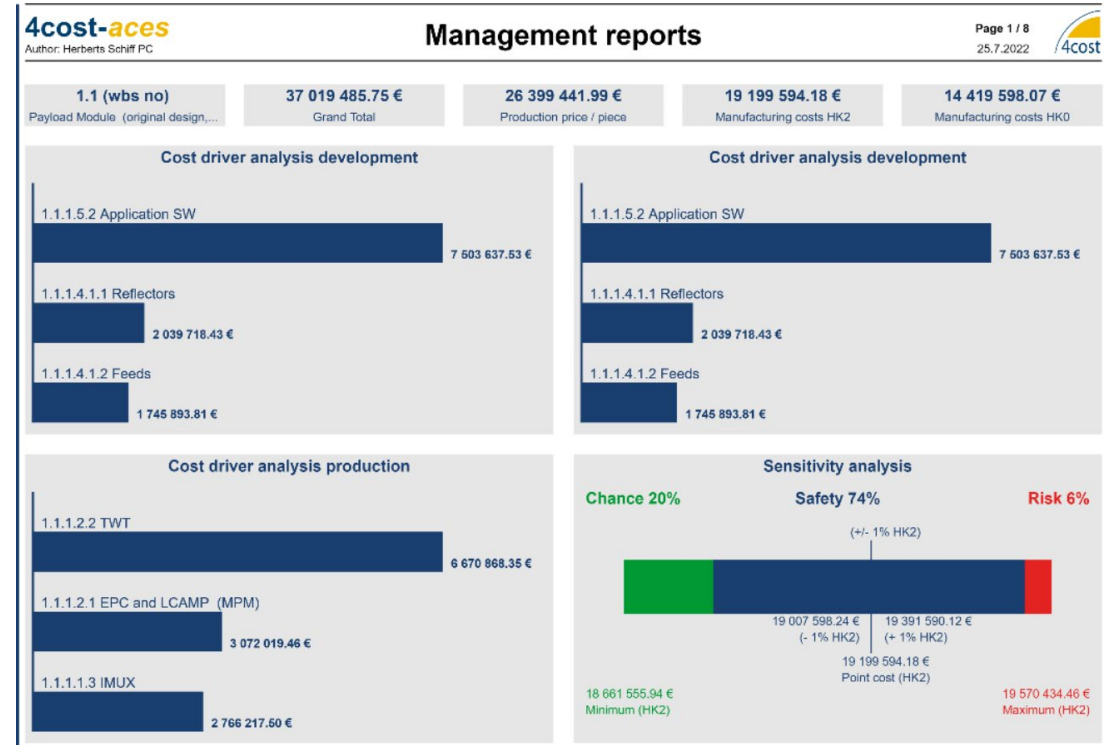
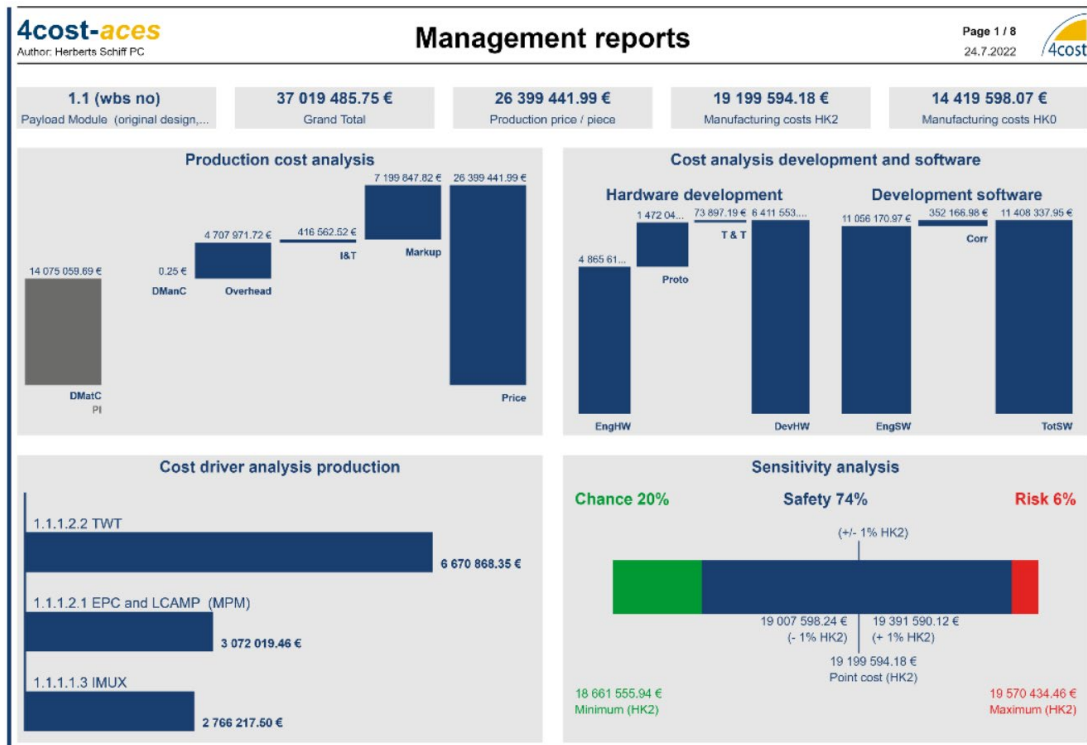
→ EAN → I&T

MODE	Electronic Weight [kg]	Mechanical Weight [kg]	Process
1020	n/a	n/a	
Production Quantity	Unit Learning Curve	Manufacturing Process Index	Tooling-
1	0,700	1,722	
Number of Prototypes	Design Iterations	New Design Electronic	New De
0,1	1,23	0,225	
Special Tooling Development	Engineering Difficulty	Team size	Electron
15,16	1,5080	2,596	
Integration-Index Electronic	Integration-Index Mechanical		Develop
6,0242	6,4397		
Start date Development	Date first Prototype	Date en	
1,07	8,07		
Integration-Index Software	Design-complexity Software	Fault Pn	
5,5313	1,426		
# of Inputs	# of Outputs	# of Objects/Methods/Procedures	Softwar
9 880	6 132	294	
Date start concept/design	Date start design	Date start coding/test/validation	Date sta
1 06	2 06	12 06	

# 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!

---