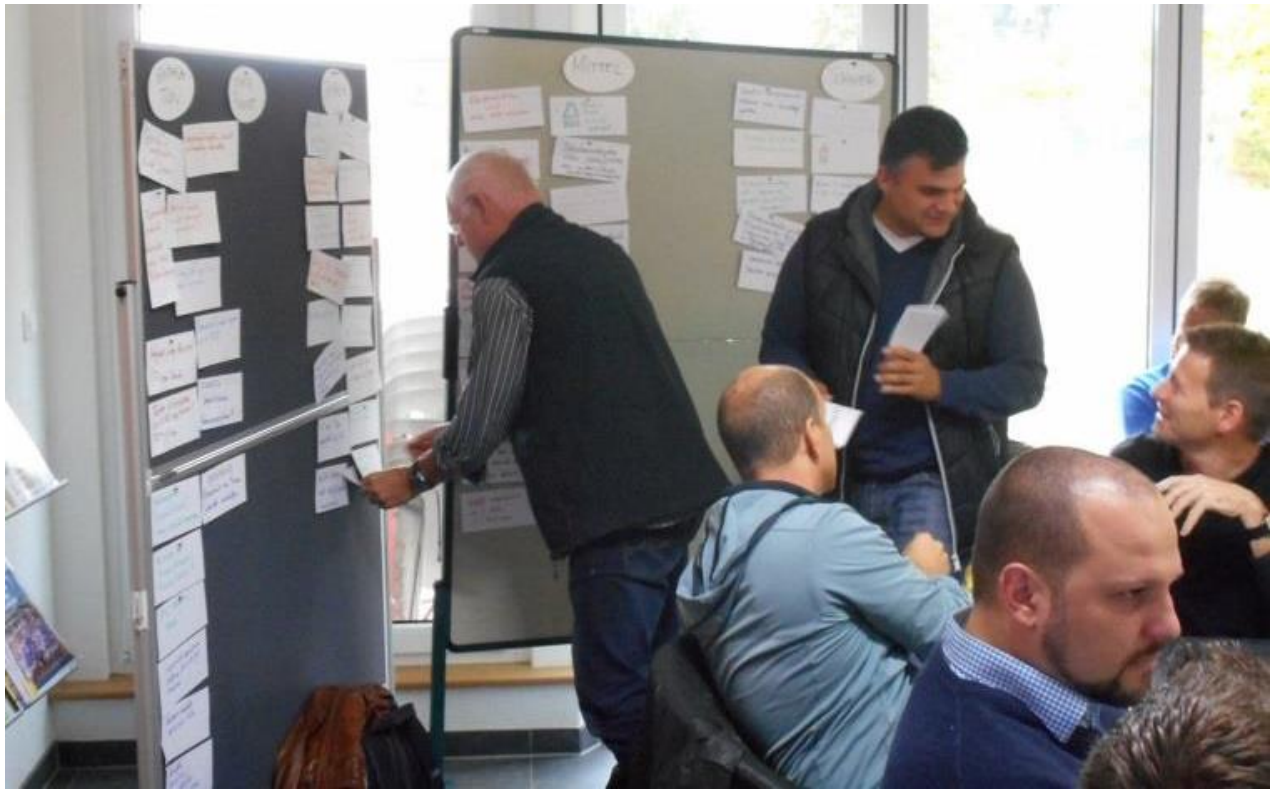
The One Million Dollar Story

Our Endress+Hauser way to success with DfMA

DFMA

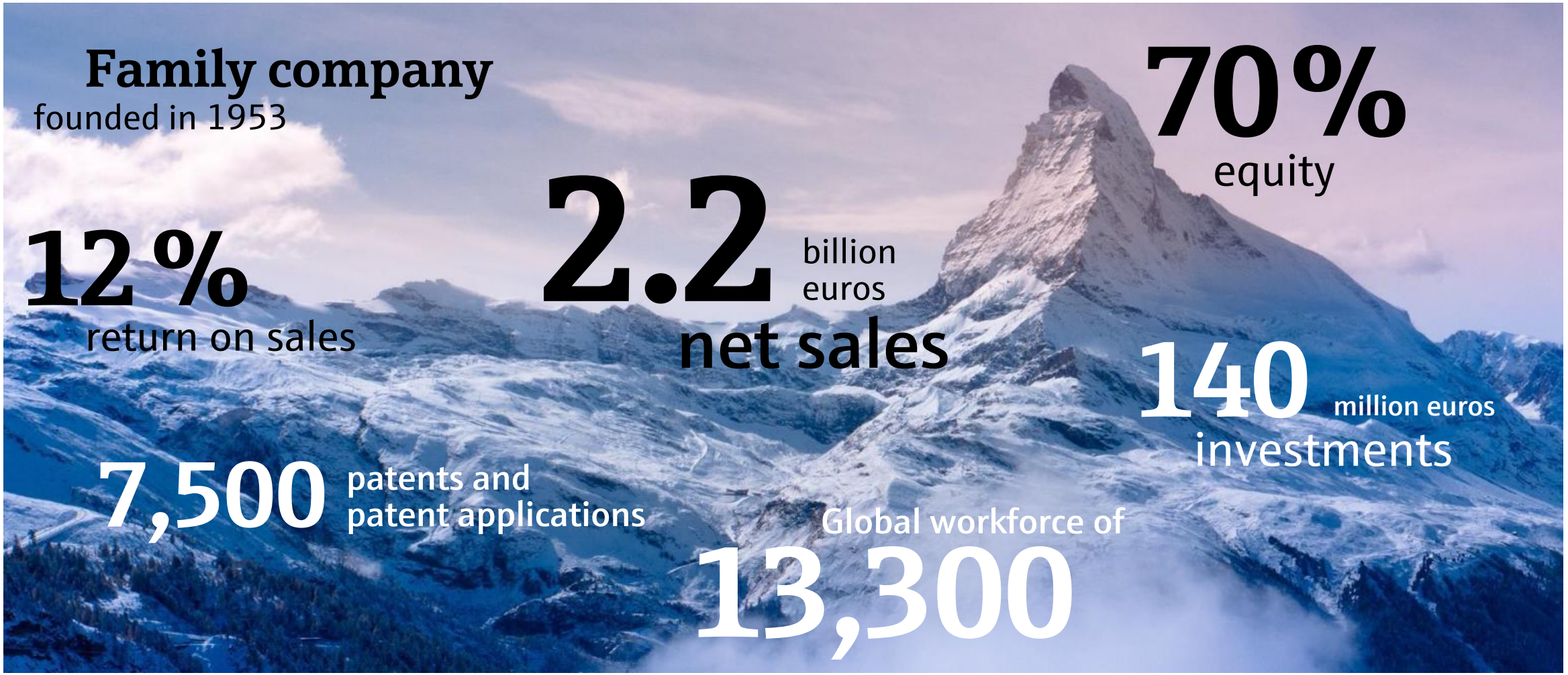


Agenda

- Introduction to Endress+Hauser
- Best Cost Position as a strategic target
- The importance Change Management when you implement DfMA
- Our DfMA Process
- Facts and numbers
- The acceptance of DfMA at E+H
- Further outlook

The world of Endress+Hauser

Facts and figures 2017



The Endress+Hauser network

- Sales centers in 50 countries
- Representatives in over 70 other countries
- Production in 12 countries and at 26 locations
- Holding company headquartered in Switzerland
- International and regional support structures
- Worldwide uniform quality standards

Our product offerings

- **Level measurement**
- **Pressure measurement**
- Flow measurement
- Analytical measurements
- Temperature measurement
- System products and data managers
- Software solutions

Endress+Hauser

Fields of activity at Endress+Hauser in Maulburg

- Level measurement
- Pressure measurement
- Inventory Management Solutions

Research and Development · Strategic Marketing · Production · Quality Management · Logistics



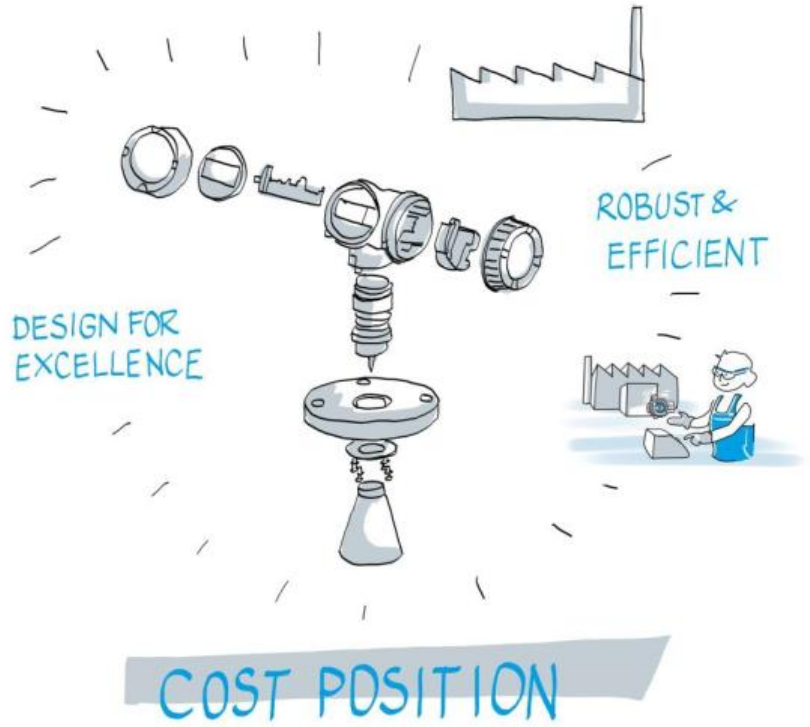



The variety of level and pressure measurement technology

The right solution for each application to guarantee plant safety, product quality and economic efficiency.

Customized products with up to 33 Mio variants per product line.

Our strategic Framework



We want to **improve our product related cost position** further more to be competitive on a long term.

To achieve this goal **our products have to be producible** as easy as possible.

The single parts have to be fabricable to the **best cost possible** or have to be purchased for the **best price possible**.

We have to change our mentality synchronously: its about … ***Excellence not about Perfection*** …. .

In matters of **Quality** (=keep what we promise) we will **not** make **any deduction**.

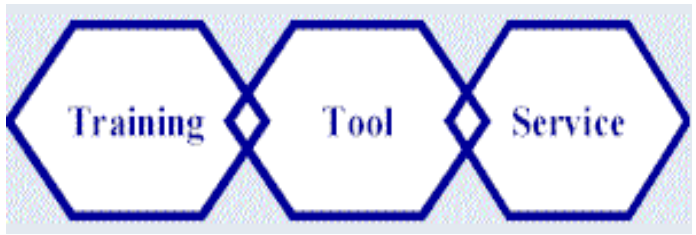
Our way to DfMA

- Selection of the tool and the implementation partner BDI / amc
- First contact April 2016
- First Pilot-Workshop October 2016
- Basic -Training of Moderators March 2017
- Moderators Training on the Job March-November 2017
- Individual Process-adaptions and integration into our product development process

Our Partner for the implementation of DfMA

amc →

- European Partner of BDI
- BDI is the US consultant and service company focused on DfMA
- Experienced Consultants help
  - In the setup of a implementation strategy
  - Installation of the BDI – Software-tool
  - Training of the moderators and DfM specialists of the DfMA Method
  - BDI Software – Training
  - Provide three core competences in the areas of:

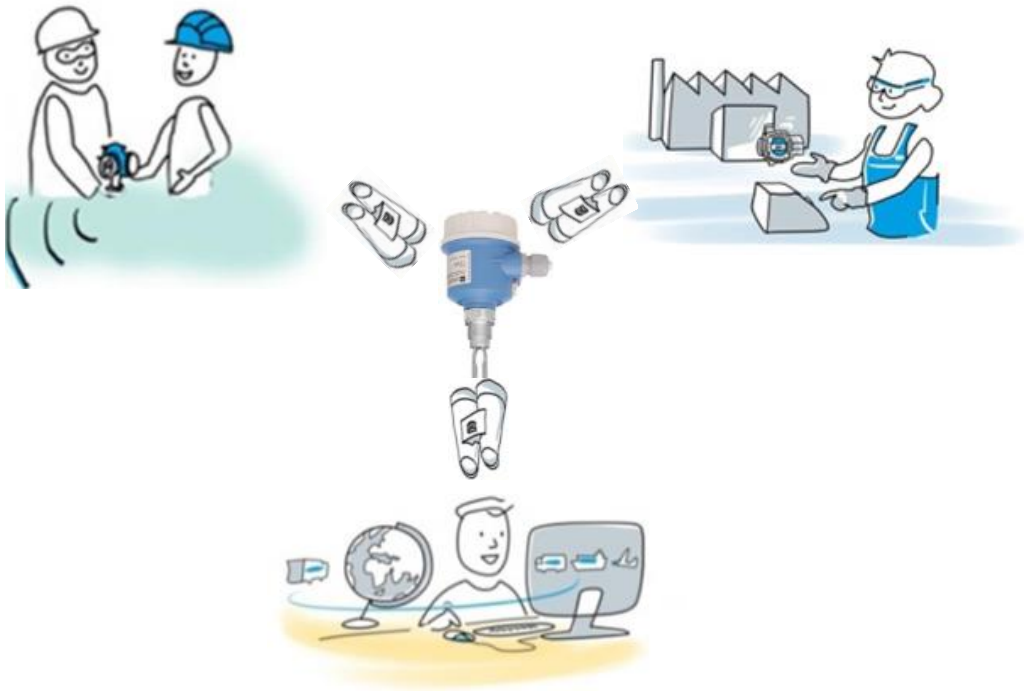


1975	Basic research on the DfMA Method "preventive cost optimization" by Prof. Dr. G. Boothroyd
1981	Foundation of BDI USA 30 active teams in industry segments
2000	DFA 9.1 DFM 2.0 Concurrent Costing

Represented in Europe by amc
600 customer companies with thousands of users

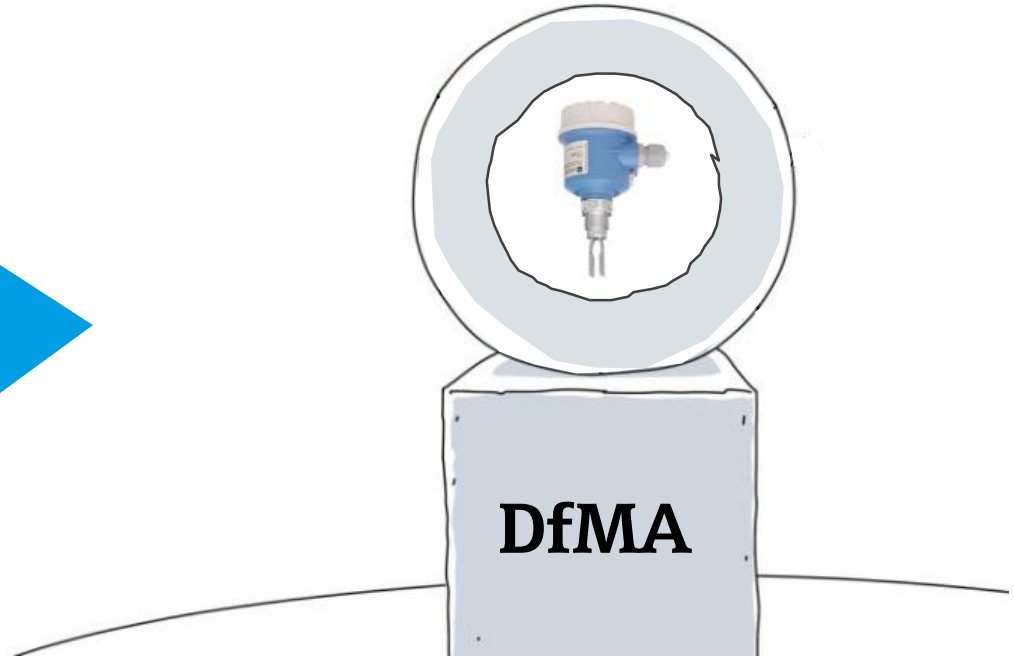
Our Target

„Every discipline has its own view on the product which is influenced by its own field of activity.“



From a narrow view on the product…

…to a holistic understanding via DFMA



„Use the knowledge of the many and thus involve everyone.“

Our basic understanding of DfMA

Use the interdisciplinary know how of the many for the search of the best solution during the concept phase of a project

Marketing + Development + Production

Wrestle with the developer in a constructive manner as long as he works in the virtual space. Thrive for the best compromise between function and ease of production.

Our Organizational Set-Up

- DfMA - coordinator
- 4 DfMA moderators trained
- 8 DfM Specialists trained (one advanced training session for 4 super-specialists open)
- 121 different participants overall

DFMA Core TEAM

Our Core Team (Coordination und Moderation)

Strategic Expert

Department Head Final Assembly

Developer Designer Sensors

Developer Designer Mechanics

Developer Designer Transmitter

Our DfM Team

Design Engineer Mechanics Sensors

Purchasing Engineer Plastics

Planning Engineer Cutting processes

Quality Engineer

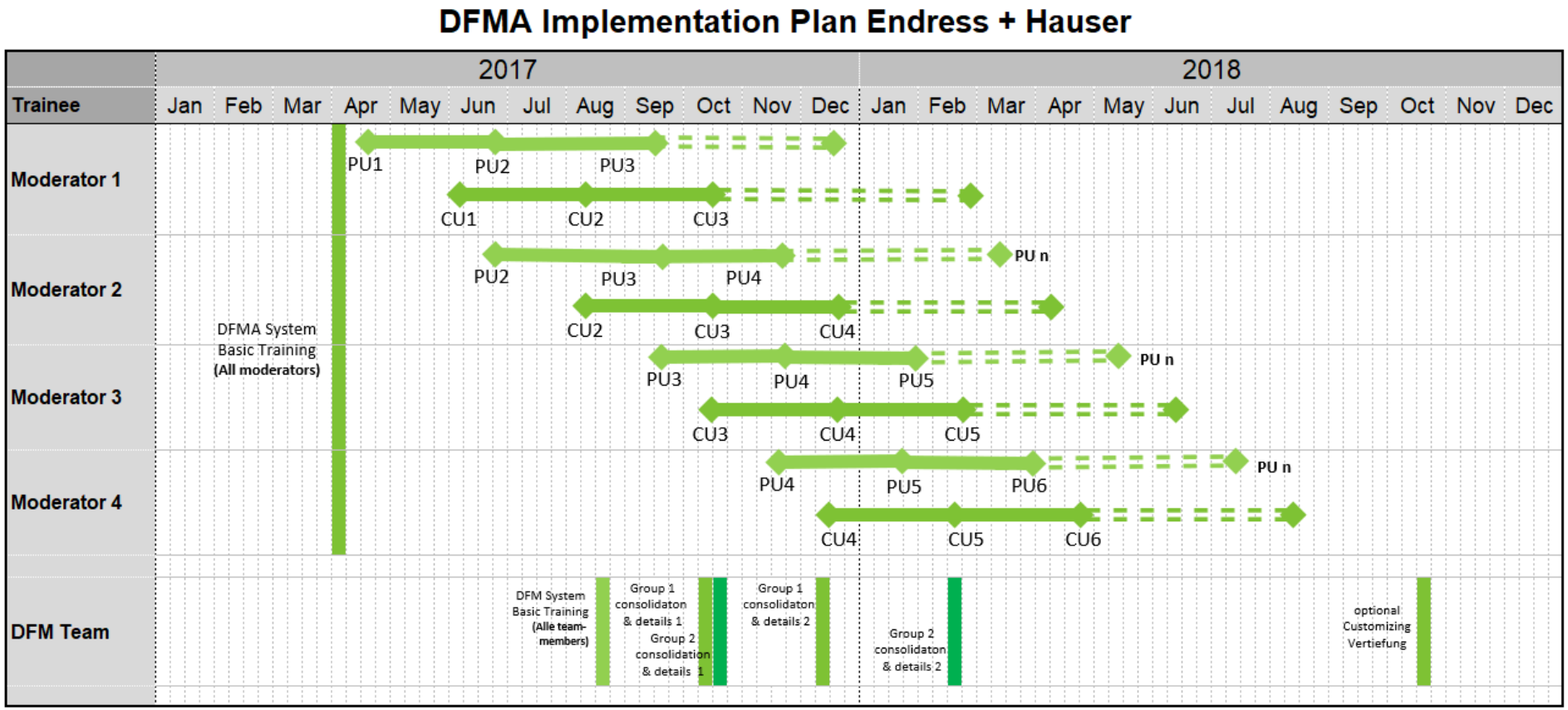
Purchasing Engineer Metals

Design Engineer Electronics

Purchasing Engineer Electronics

Department Head Final Anssembly

Our Implementation Plan



Coaching
PU Pick Up - First Optimization (Kick-Off)
CU Check Up - Fine optimization (1-n)

Workload for Moderator approximately 30% of h 10 AT je Projekt + x
Training on DfMA Basics for all Moderators together

50 work-days effort for full training

Endress+Hauser

Our E+H Process

Set-up	Pick-up	Check-up	Phase Out
			
Preparation, team structure, variant selection **New:** lessons learned, competition analyses	Base line (parts and processes) and development of ideas 3 days workshop	Follow-up and further elaboration of ideas every four weeks	Review of the process and documentation Store all generated ideas for reuse in the future projects

Pick Up Workshop - DfA Phase 1 und 2

Phase 1:

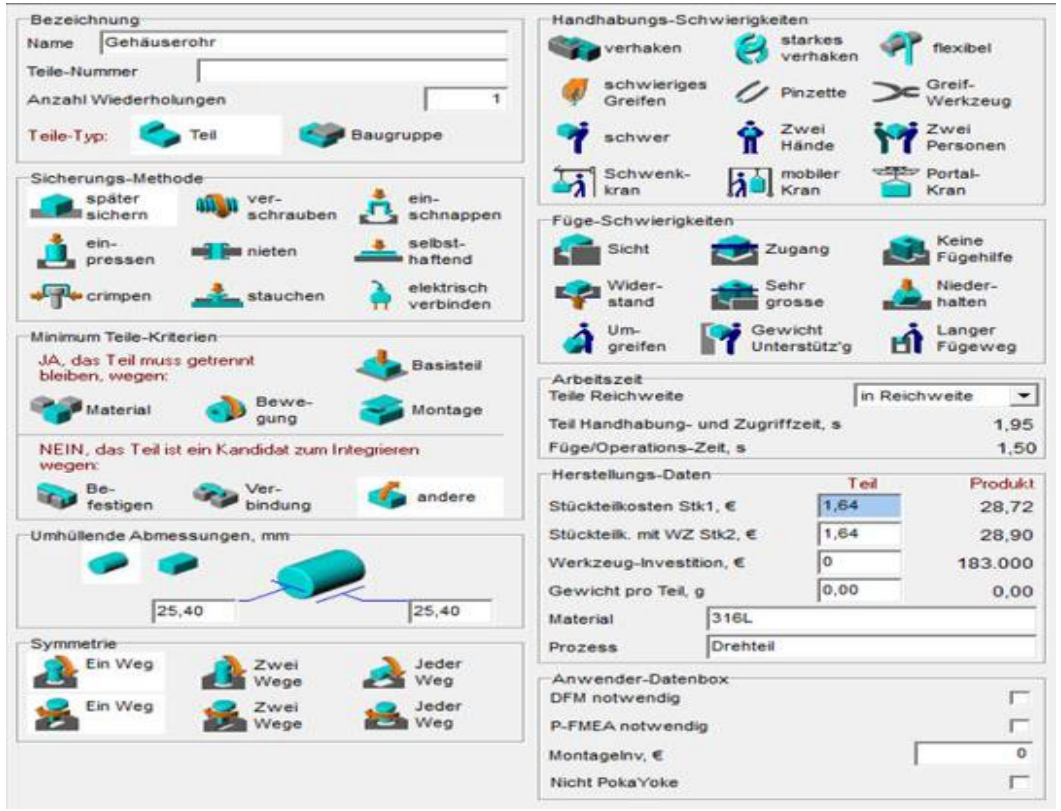
Dissemble the Product → to understand the function of each part of the product.

- Generate ideas and write them down
- No discussion only questions

Phase 2:

Assemble the Product → to make visible the structure, complexity and potential savings

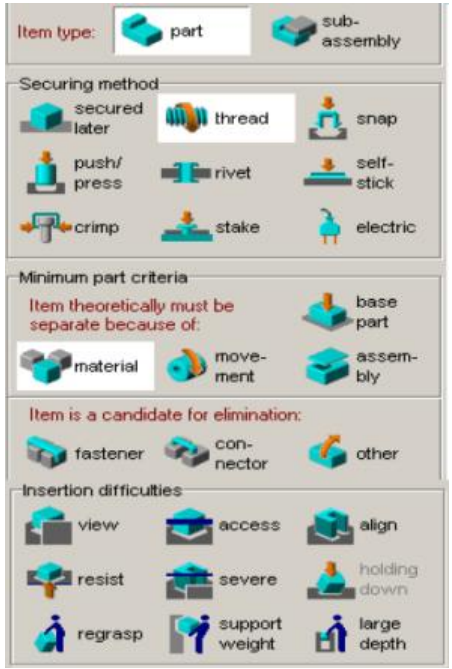
- Generate Ideas and pin them to the wall
- No discussion only questions



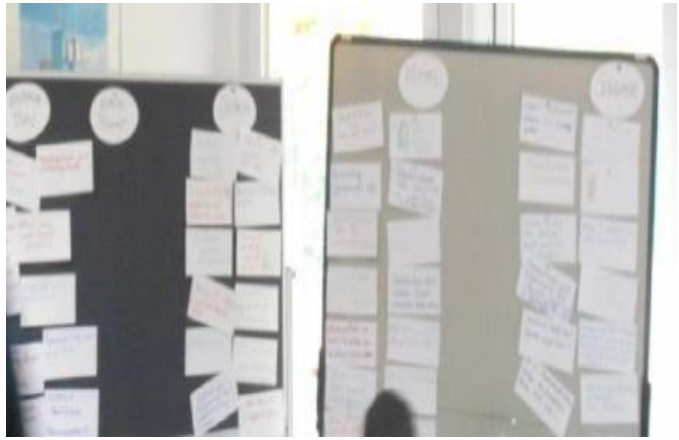
Pick up Workshop - DfA Phase 3

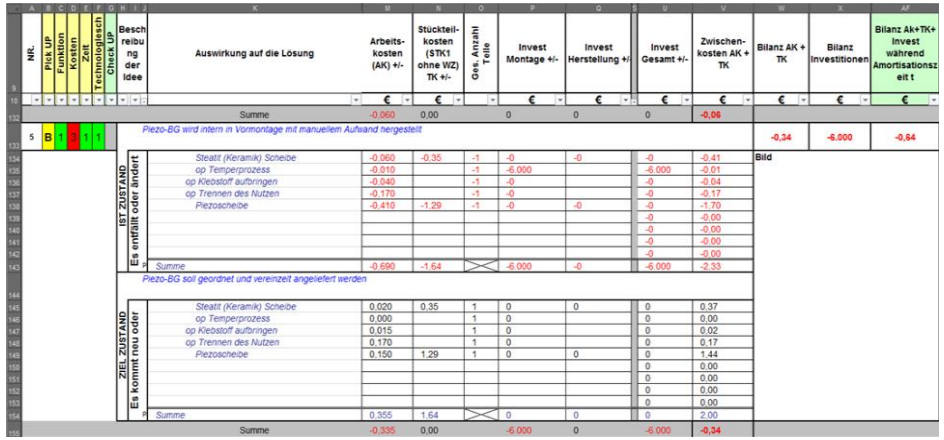
Minimum parts criteria:

- Is there motion in between other preassembled parts?
- Is the part necessarily of other material than the others?
- Is the next part to be divide from the other parts due to assembly and disassembly reasons?



Delta-Analysis – the European way





NR.	Pick UP	Funktion	Kosten	Zeit	Technologisch	Check UP	Beschreibung der Idee	Auswirkung auf die Lösung	Arbeits-kosten (AK) +/-	Stückteil-kosten (STK1 ohne WZ) TK +/-	Ges. Anzahl Teile	Invest Montage +/-	Invest Herstellung +/-	Invest Gesamt +/-	Zwischen-kosten AK + TK	Bilanz AK + TK	Bilanz Investitionen	Bilanz Ak+TK+ Invest während Amortisationszeit t
									€	€		€	€	€		€	€	€
								Summe	-0,060	0,00		0	0	0	-0,06			
5	B	1	3	1	1			*Piezo-BG wird intern in Vormontage mit manuellem Aufwand hergestellt*								-0,34	-6.000	-0,84
								Steatit (Keramik) Scheibe	-0,060	-0,35	-1	-0	-0	-0	-0,41	Bild		
								op Temperprozess	-0,010		-1	-6.000		-6.000	-0,01			
								op Klebstoff aufbringen	-0,040		-1	-0		-0	-0,04			
								op Trennen des Nutzen	-0,170		-1	-0		-0	-0,17			
								Piezoscheibe	-0,410	-1,29	-1	-0	-0	-0	-1,70			
														-0	-0,00			
														-0	-0,00			
														-0	-0,00			
														-0	-0,00			
								Summe	-0,690	-1,64		-6.000	-0	-6.000	-2,33			
								Piezo-BG soll geordnet und vereinzelt angeliefert werden										
								Steatit (Keramik) Scheibe	0,020	0,35	1	0	0	0	0,37			
								op Temperprozess	0,000		1	0		0	0,00			
								op Klebstoff aufbringen	0,015		1	0		0	0,02			
								op Trennen des Nutzen	0,170		1	0		0	0,17			
								Piezoscheibe	0,150	1,29	1	0	0	0	1,44			
														0	0,00			
														0	0,00			
														0	0,00			
														0	0,00			
								Summe	0,355	1,64		0	0	0	2,00			
								Summe	-0,335	0,00		-6.000	0	-6.000	-0,34			

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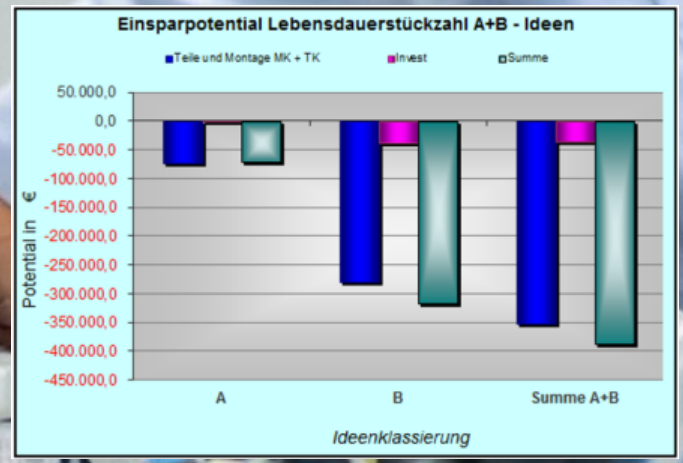
The delta evaluation to gain transparency of the idea´s effects

NR.	Pick UP	Funktion Kosten	Zeit	Technologiesch	Check UP	Beschreibung der Idee	Auswirkung auf die Lösung	Arbeits-kosten (AK) +/-	Stückteil-kosten (STK1 ohne WZ) TK +/-	Ges. Anzahl Teile	Invest Montage +/-	Invest Herstellung +/-	Invest Gesamt +/-	Zwischen-kosten AK + TK	Bilanz AK + TK	Bilanz Investitionen	Bilanz Ak+TK+ Invest während Amortisationszeit t
								€	€		€	€	€	€	€	€	€
							Summe	-0,060	0,00		0	0	0	-0,06			
5	B	1	3	1	1		Basic idea from Designer (original design)								-0,34	-6.000	-0,64
						IST ZUSTAND Es entfällt oder ändert	Steatit (Keramik) Scheibe	-0,060	-0,35	-1	-0	-0	-0	-0,41	Bild		
							op Temperprozess	-0,010		-1	-6.000		-6.000	-0,01			
							op Klebstoff aufbringen	-0,040		-1	-0		-0	-0,04			
							op Trennen des Nutzen	-0,170		-1	-0		-0	-0,17			
							Piezoscheibe	-0,410	-1,29	-1	-0	-0	-0	-1,70			
													-0	-0,00			
													-0	-0,00			
													-0	-0,00			
													-0	-0,00			
							Summe	-0,690	-1,64		-6.000	-0	-6.000	-2,33			
							Alternative idea from DfMA Team										
						ZIEL ZUSTAND Es kommt neu oder	Steatit (Keramik) Scheibe	0,020	0,35	1	0	0	0	0,37			
							op Temperprozess	0,000		1	0		0	0,00			
							op Klebstoff aufbringen	0,015		1	0		0	0,02			
							op Trennen des Nutzen	0,170		1	0		0	0,17			
							Piezoscheibe	0,150	1,29	1	0	0	0	1,44			
													0	0,00			
													0	0,00			
													0	0,00			
													0	0,00			
							Summe	0,355	1,64		0	0	0	2,00			
							Summe	-0,335	0,00		-6.000	0	-6.000	-0,34			



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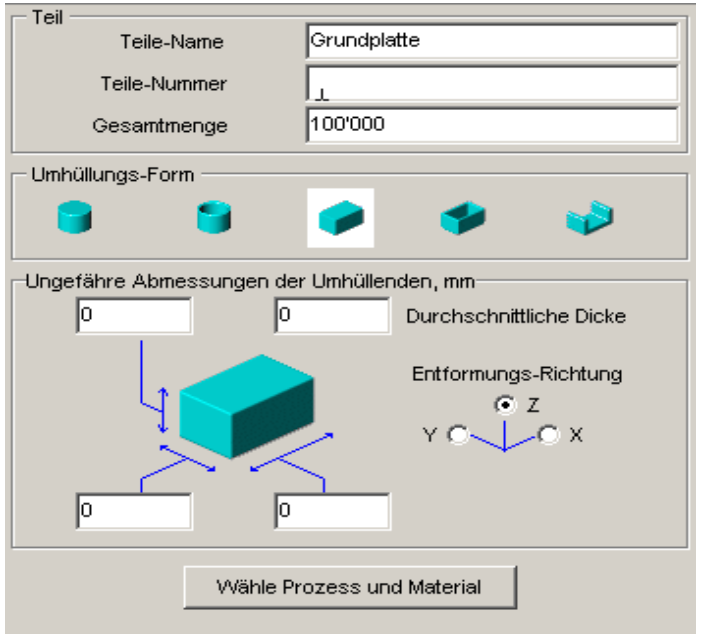
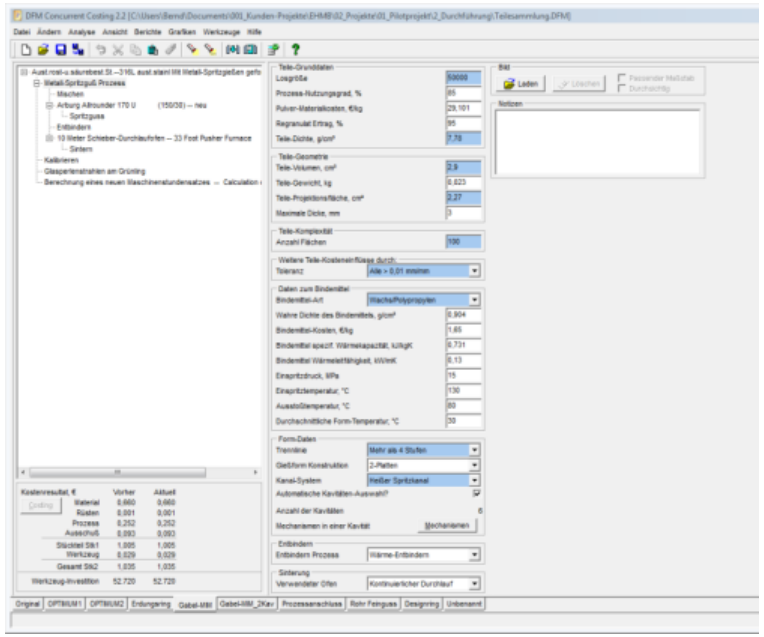
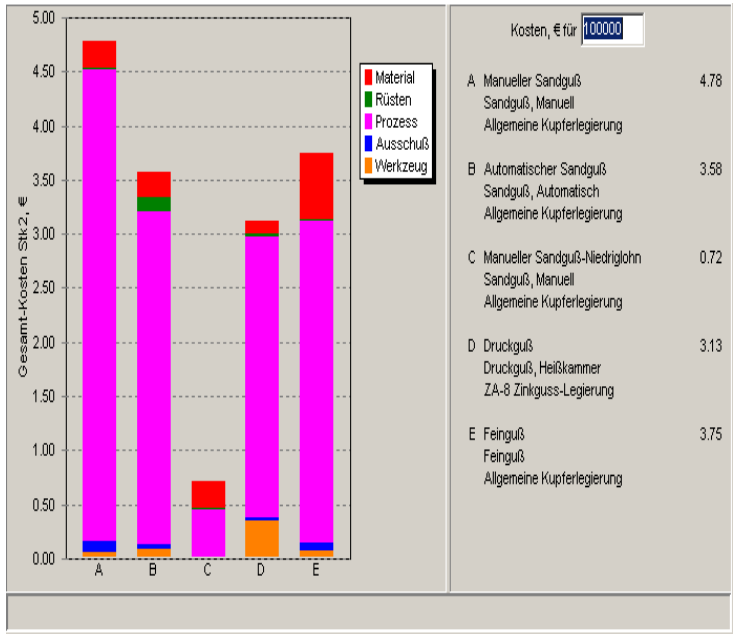
Pick Up Workshop - DfM Phase 4

DfM

- Cost analysis and estimation for parts and tools
- Evaluate alternative production processes
- Optimize part costs



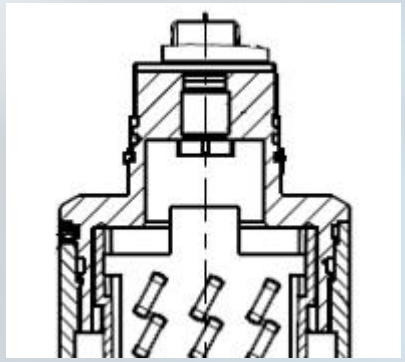




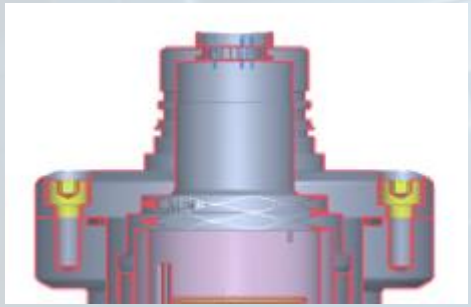
DfM - Design of Manufacturing

- **Regular weekly meeting** with purchasing, design and manufacturing
- **Team-oriented** optimization of product design to reduce costs and improve quality
- Gain **transparency** of cost structure of suppliers
- Comparing different **manufacturing methods**, especially machining vs. casting
- Goal is not to find the cheapest supplier, but to find the **cheapest design** that fulfills the requirements

DfM Example – Optimization of cover plate in early development stage



DFM



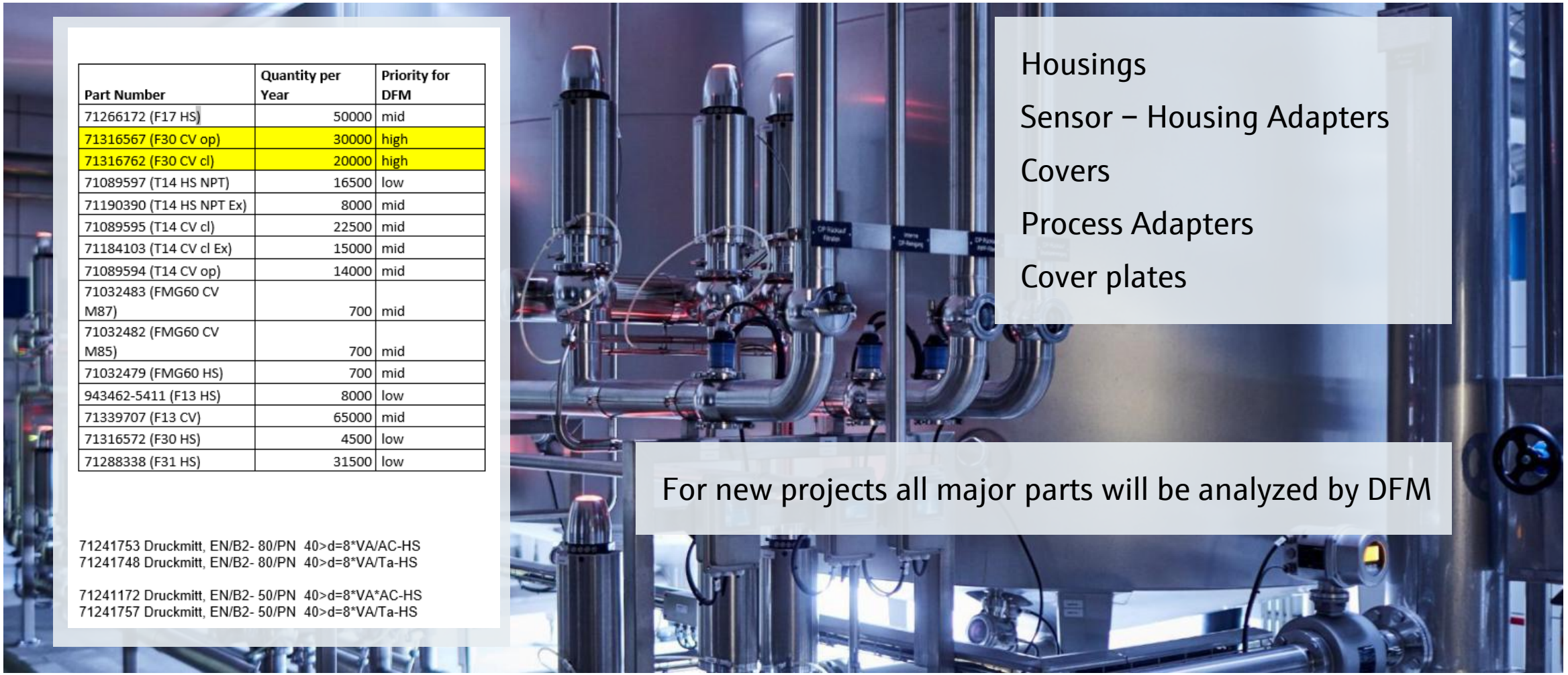
- Precision casting
- Fewer parts
- Spherical design requires only half the welding depth
- Poka Yoke

DfM running evaluations to optimize Design and purchasing cost

Part Number	Quantity per Year	Priority for DFM
71266172 (F17 HS)	50000	mid
71316567 (F30 CV op)	30000	high
71316762 (F30 CV cl)	20000	high
71089597 (T14 HS NPT)	16500	low
71190390 (T14 HS NPT Ex)	8000	mid
71089595 (T14 CV cl)	22500	mid
71184103 (T14 CV cl Ex)	15000	mid
71089594 (T14 CV op)	14000	mid
71032483 (FMG60 CV M87)	700	mid
71032482 (FMG60 CV M85)	700	mid
71032479 (FMG60 HS)	700	mid
943462-5411 (F13 HS)	8000	low
71339707 (F13 CV)	65000	mid
71316572 (F30 HS)	4500	low
71288338 (F31 HS)	31500	low

71241753 Druckmitt, EN/B2- 80/PN 40>d=8*VA/AC-HS
71241748 Druckmitt, EN/B2- 80/PN 40>d=8*VA/Ta-HS

71241172 Druckmitt, EN/B2- 50/PN 40>d=8*VA*AC-HS
71241757 Druckmitt, EN/B2- 50/PN 40>d=8*VA/Ta-HS

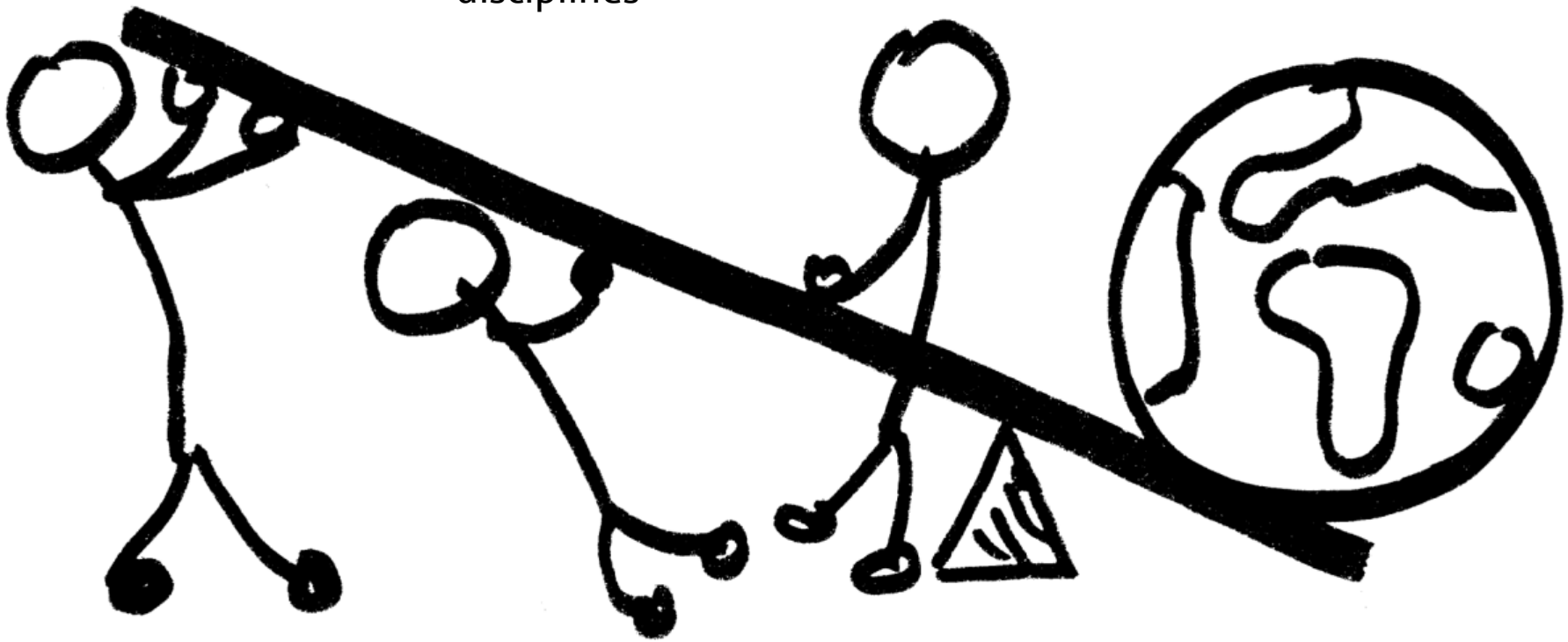


- Housings
- Sensor – Housing Adapters
- Covers
- Process Adapters
- Cover plates

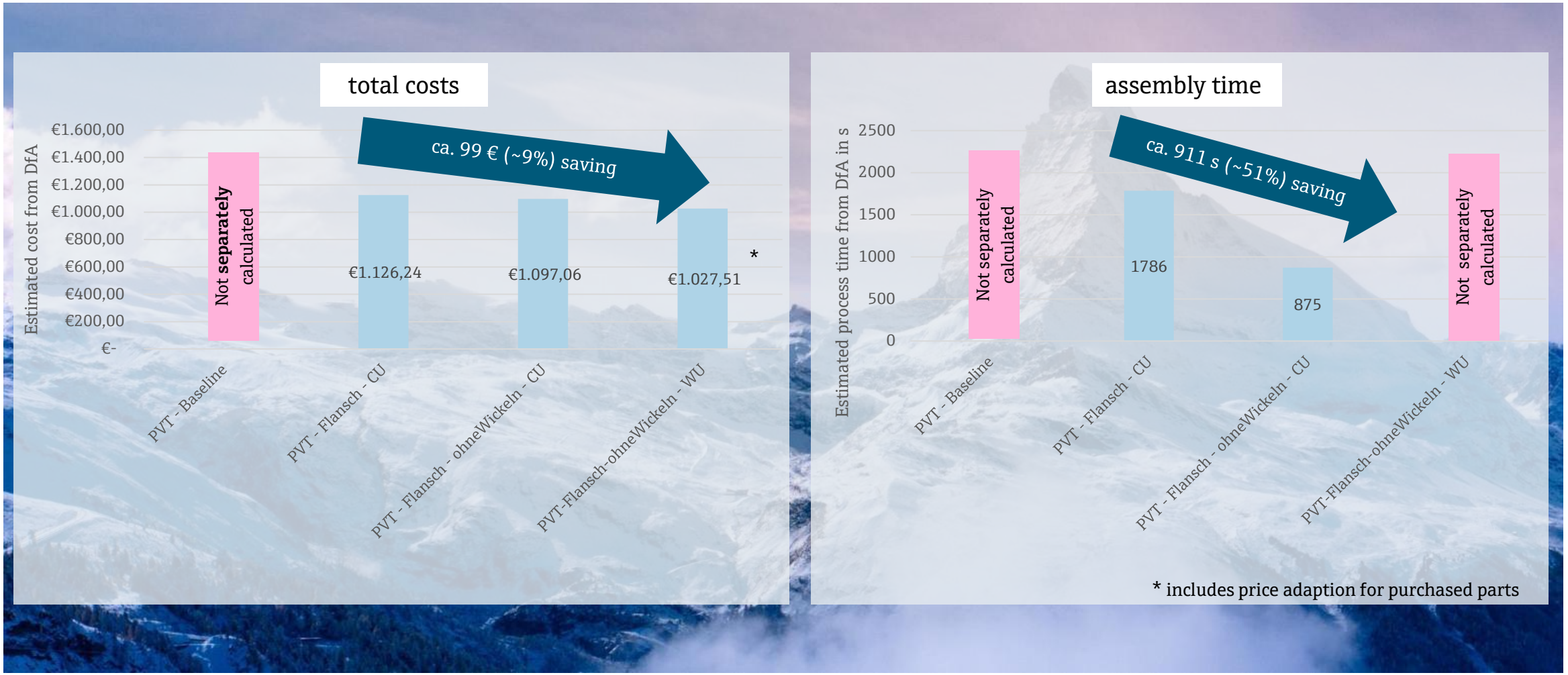
For new projects all major parts will be analyzed by DFM

DfMA in use at different project stages

- **Concept**
  - general ideas
  - technology concerns
  - team building
- **Prototype**
  - detailed ideas
  - savings in $
  - needs of all disciplines
- **In production**
  - precise pricing
  - workflow optimization
  - no big design changes



Example: One development Project before and after major changes



Numbers, Data, Facts

- **Numbers**
  - 3 DfMA cost evaluations
  - 6 DfMA Workshops
  - 26 DfM evaluations
  - 583 ideas generated
  - 1.070.679 $/a cost saving potential generated

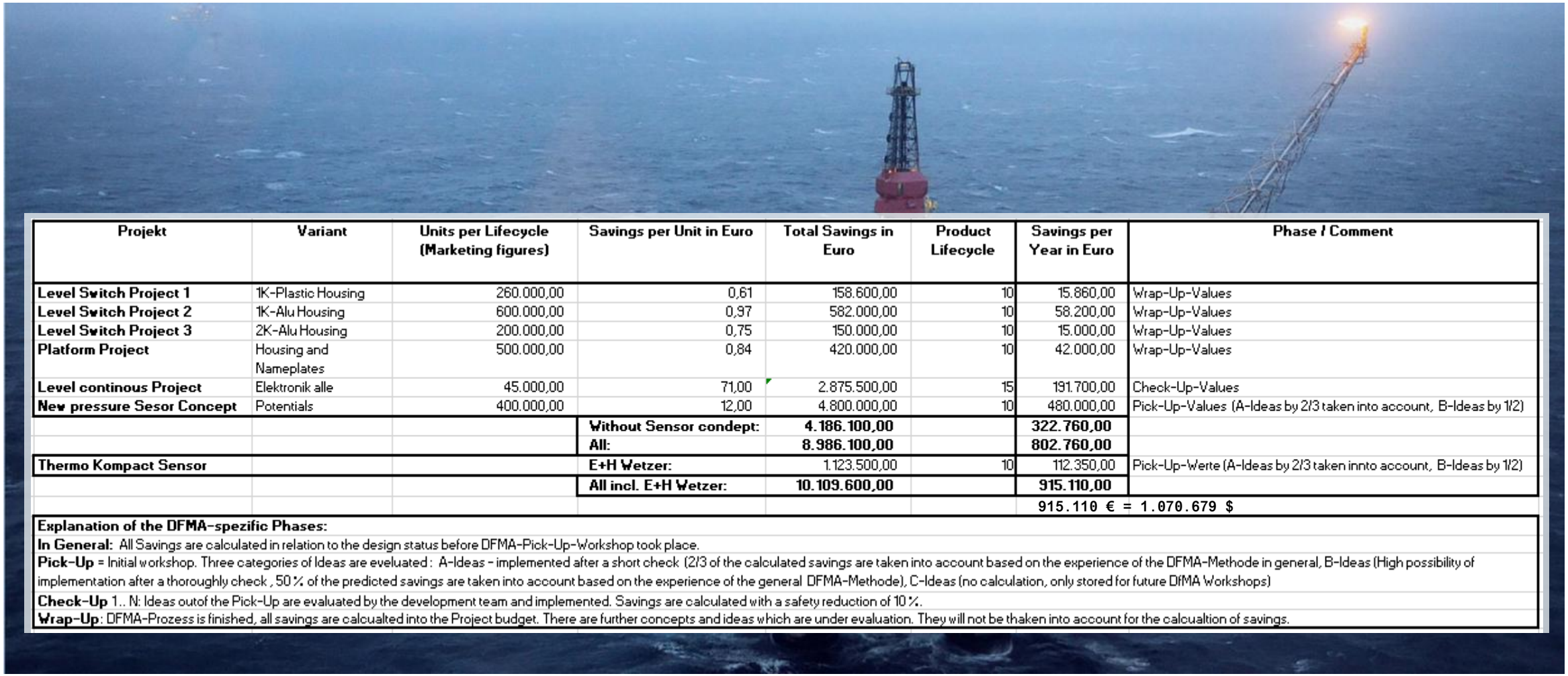
- **Further results**
  - Increase of cost transparency and awareness
  - Mutual understanding of development, production, procurement, service, marketing
  - Reduction of development times
  - More ergonomic assembly, increased quality and process stability in production

Feedback of the Workshop-members

Beurteilung Zielerreichung		
☺	😐	☹
76%	23%	2%

- Each Workshop is still a real progress in my development project (System Architect)
- This is the best tool we ever implemented at E+H (Design Engineer)
- One Pick-up workshop saves me 6 weeks in my project timeline (Project Manager)
- Now we understand that everything possible was done to make our life easier (Production Team Leader)
- …

Achieved results from DfMA (monetary evaluation only)



Projekt	Variant	Units per Lifecycle (Marketing figures)	Savings per Unit in Euro	Total Savings in Euro	Product Lifecycle	Savings per Year in Euro	Phase / Comment
Level Switch Project 1	1K-Plastic Housing	260.000,00	0,61	158.600,00	10	15.860,00	Wrap-Up-Values
Level Switch Project 2	1K-Alu Housing	600.000,00	0,97	582.000,00	10	58.200,00	Wrap-Up-Values
Level Switch Project 3	2K-Alu Housing	200.000,00	0,75	150.000,00	10	15.000,00	Wrap-Up-Values
Platform Project	Housing and Nameplates	500.000,00	0,84	420.000,00	10	42.000,00	Wrap-Up-Values
Level continous Project	Elektronik alle	45.000,00	71,00	2.875.500,00	15	191.700,00	Check-Up-Values
New pressure Sesor Concept	Potentials	400.000,00	12,00	4.800.000,00	10	480.000,00	Pick-Up-Values (A-Ideas by 2/3 taken into account, B-Ideas by 1/2)
			Without Sensor condept:	**4.186.100,00**		**322.760,00**	
			All:	**8.986.100,00**		**802.760,00**	
Thermo Kompact Sensor			**E+H Wetzer:**	1.123.500,00	10	112.350,00	Pick-Up-Werte (A-Ideas by 2/3 taken innto account, B-Ideas by 1/2)
			All incl. E+H Wetzer:	**10.109.600,00**		**915.110,00**	
						915.110 € = 1.070.679 $	

Explanation of the DFMA-spezific Phases:

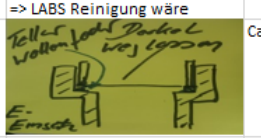
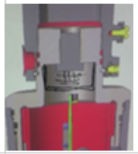
In General: All Savings are calculated in relation to the design status before DFMA-Pick-Up-Workshop took place.

Pick-Up = Initial workshop. Three categories of Ideas are eveluated : A-Ideas - implemented after a short check (2/3 of the calculated savings are taken into account based on the experience of the DFMA-Methode in general, B-Ideas (High possibility of implementation after a thoroughly check , 50 % of the predicted savings are taken into account based on the experience of the general DFMA-Methode), C-Ideas (no calculation, only stored for future DfMA Workshops)

Check-Up 1.. N: Ideas outof the Pick-Up are evaluated by the development team and implemented. Savings are calculated with a safety reduction of 10 %.

Wrap-Up: DFMA-Prozess is finished, all savings are calcualted into the Project budget. There are further concepts and ideas which are under evaluation. They will not be thaken into account for the calcualtion of savings.

Well documented supplementary ideas are stored for upcoming projects

Project-name	A	B	C	Classification	Idea	Value-Potential	€	Action
Transmitter 1 Project		X		Sensor	U.a. zwischen Sensorhals und Gehäuse wird gefettet, dies muss hinterhier wieder entfernt werden um LABS konform zu sein.	Nicht schmieren.. (siehe Ideen 1.x) => LABS Reinigung wäre	-	Check N.N. Open
Transmitter 2 Project		X		Electronics housing	Große Feder, dann keinen Deckel		Ca. 1,50€	Check N.N. done
	X			Temperature label	Statt Messstreifen einfacher Index	Kostenersparnis	Ca. 6€	Check N.N. done
	X			NaJ housing	Bei Drehteil: Hinterschnitt einplanen, damit montierter (	Bei Montage und Demontage würde O-Ring fixiert sein	+/- 0	Check N.N. not possible due to sealing
	X			Flange cover	Kabel im Deckel wird durch zusätzliche Kappe zurückgeh	Kabel müssen bei Montage nicht zurückgehalten werden 	+/- 0	Check N.N. Further Tests necessary not free for implementation
	X			Flange cover	Flanschdeckel als Guss oder Drehteil	Kostenersparnis	Ca. 50€	further DfM-evaluation planned
Transmitter 3 Project		X		Sensor	Sondenringe offen	Geringere Kosten (Führung möglich) Aber: Schlagrobustheit geringer zwei Ringe!! (im Vgl zu FTW23)	2x 0,5€	Check N.N. will be implemented Done
		X		potting	Einsparung SilGel durch Expansionselement oder Verdrä 	Geringerer SilGel-Bedarf Ziel 16g Delta-Analyse	0,12	Check N.N. still undere evaluation will not be implemented
		X		potting	Spritzteil hat Abtrennwand zur Vergussvolumenreduktion	Geringerer SilGel-Bedarf Delta-Analyse	0,12	Check N.N. under evaluation
	X			Dokumentation	BA/KA durch Zweiseiter ersetzen und bei Ex nur XA dazu legen	Weniger beizulegende Doku	0,4	Check N.N will be checked in trail order Done
		X		Cover	Desige ring too expensive	cost reduction	0,14	Check N.N. done
Sensor Cost-reduction		X		Insulation wires	Vier Silikonschläuche als Isolierung der Drähte durch	Max. 1,37 €		Check N.N.

Introduction of DfMA at our Sister Company E+H Wetzer

- facts:
  - 12 participants
  - 51 ideas
  - 110.000€/a potential saving total
  - Considerable easier and fail-safer assembly
  - Exposure and clarification of disadvantageous assembly and machining steps

Findings out of DfMA introduction at out sister company E+H Wetzer

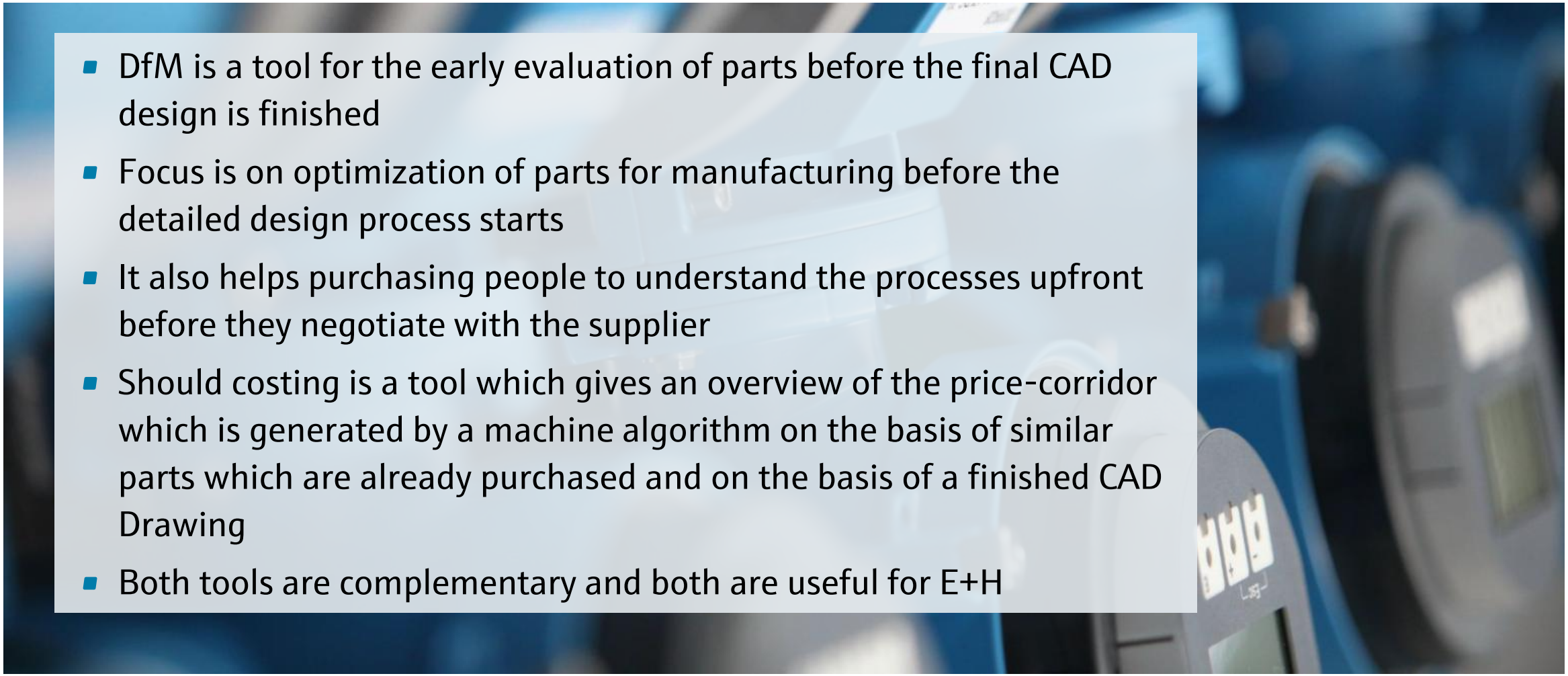
- Using DFMA to gain a deep insight in products of other PCs
- Transfer and share knowledge, experience and best practice across PC borders
- Get to know products of other PCs to consider reusing parts, principals or processes
- Build and strengthen relationships between employees of different PCs who have to deal with the same issues

→ “Do the same things the same way… and right from the beginning!”

Outlook

- PC Wetzer
  Pilot in cooperation with amc and E+H Maulburg already and successfully run
  Start of implementation planned in 2019 (tbd)
- PC Flowtec
  Started with a Pilot DfMA in cooperation with amc based on our prework
- Bachelor Thesis to finalize open topics
  i.e. integration of Should costing, Complexity Management for variant selection
- Research project funded by BMBF together with KIT, FU Berlin, Daimler
  Machine Learning driven Engineering - CAx goes AIAx

DfM and Should Costing



- DfM is a tool for the early evaluation of parts before the final CAD design is finished
- Focus is on optimization of parts for manufacturing before the detailed design process starts
- It also helps purchasing people to understand the processes upfront before they negotiate with the supplier
- Should costing is a tool which gives an overview of the price-corridor which is generated by a machine algorithm on the basis of similar parts which are already purchased and on the basis of a finished CAD Drawing
- Both tools are complementary and both are useful for E+H

Summary of the DfMA implementation

- Method and tools successfully implemented
- Organization set up and people well trained
- All associates accept the tool as a valuable part of the project life
- DfMA process anchored into the stage gate process and into the development check lists
- Additional studies often used for clarification of topics in the idea phases
- Two of our three sister companies already adopted the DfMA Method

Endress+Hauser Process Innovation Award 2018 for DfMA

Endress+Hauser Process Innovation Award 2018

...thank you for your attention!