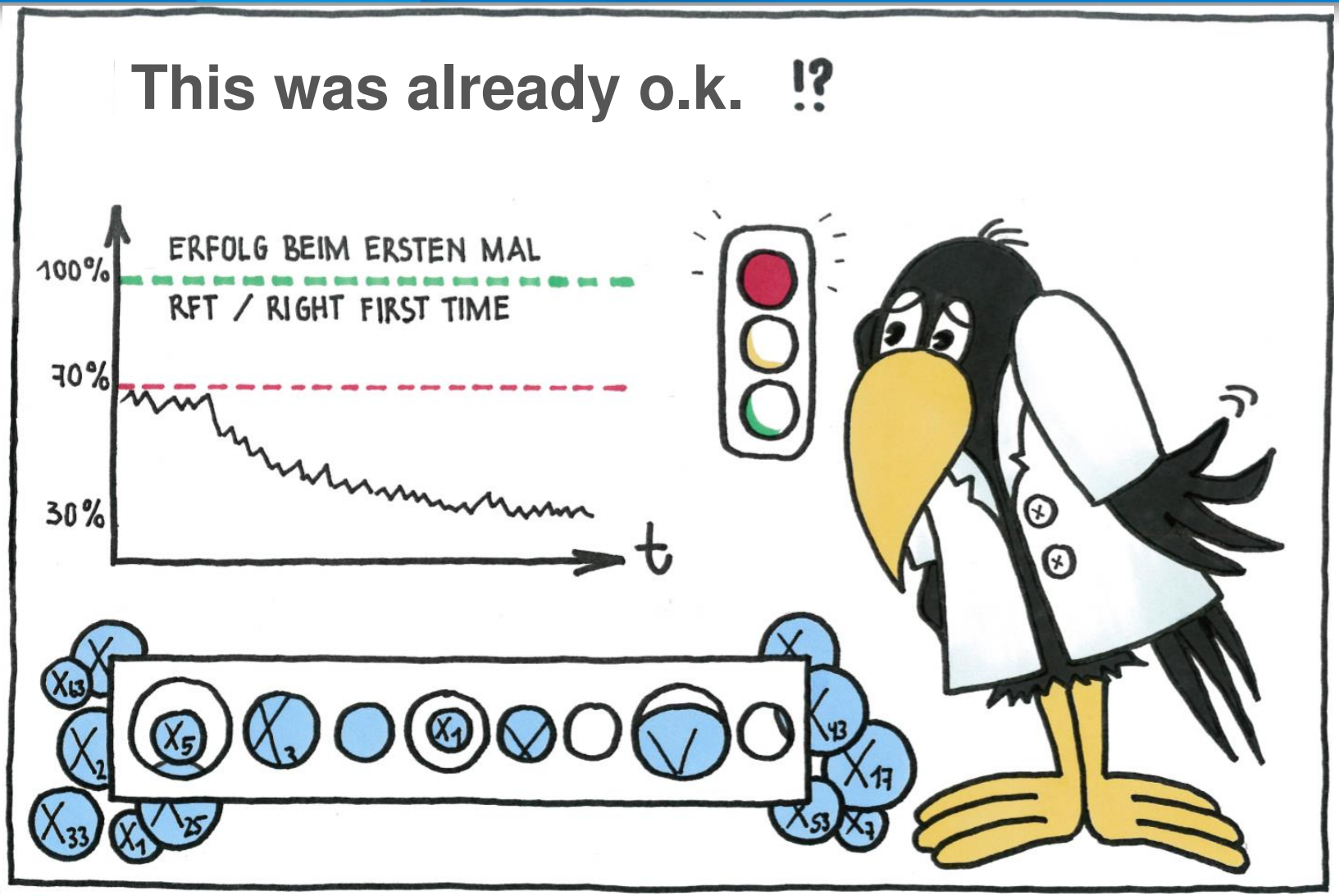
mts Consulting & Engineering GmbH

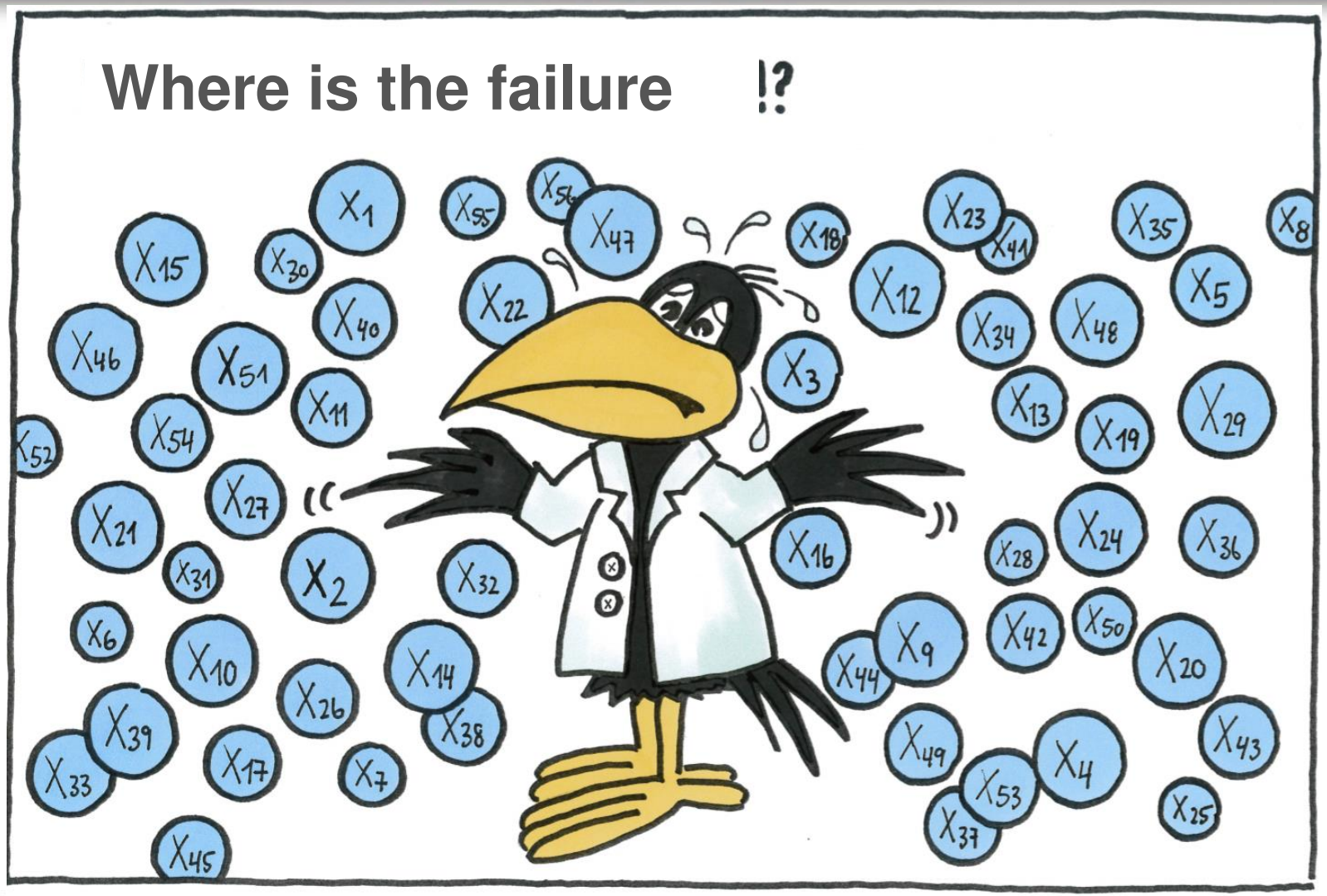
Robust Design

Concepts for Products and Processes / Facilities
develop, rate and select

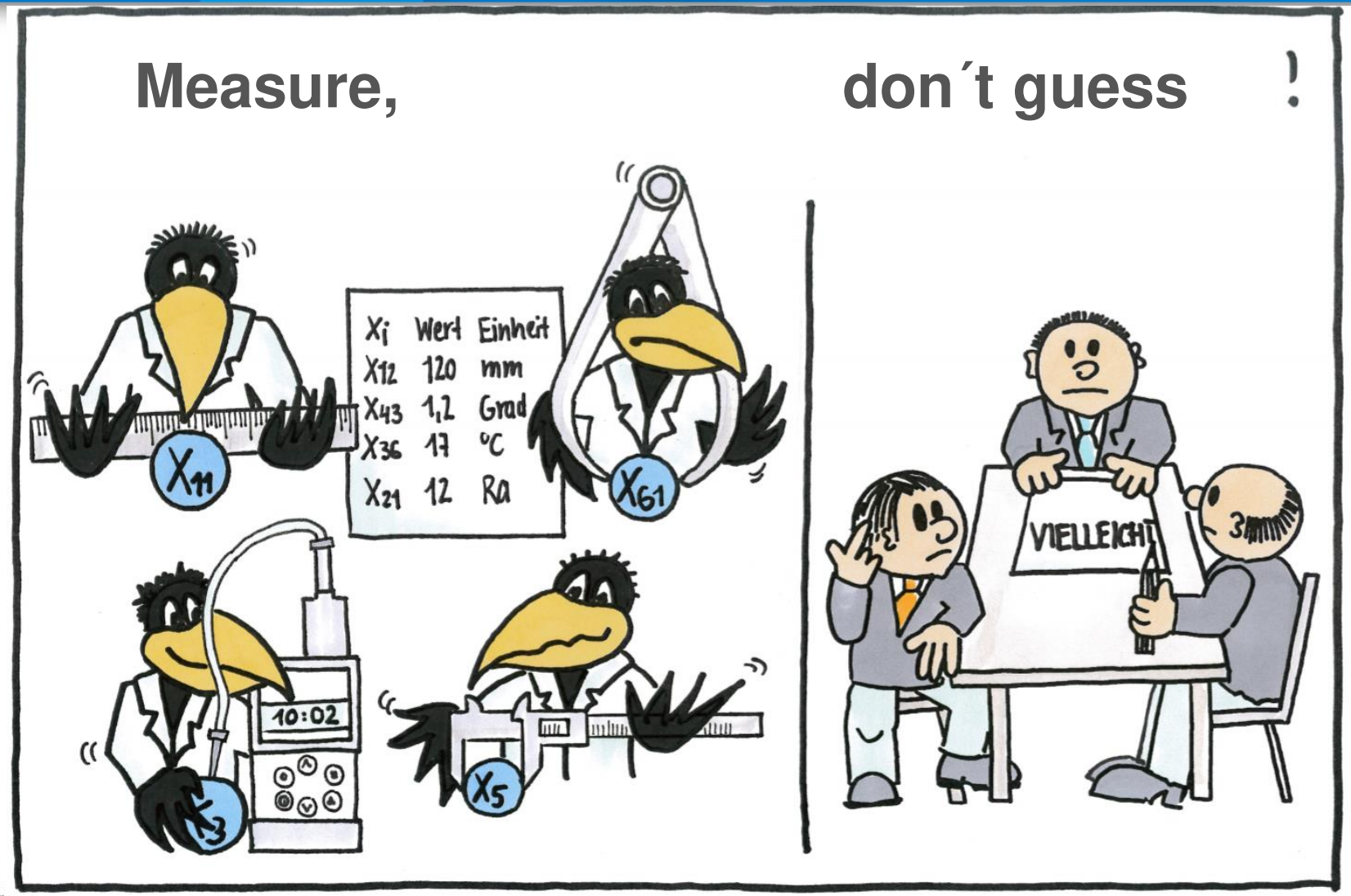
The Issue



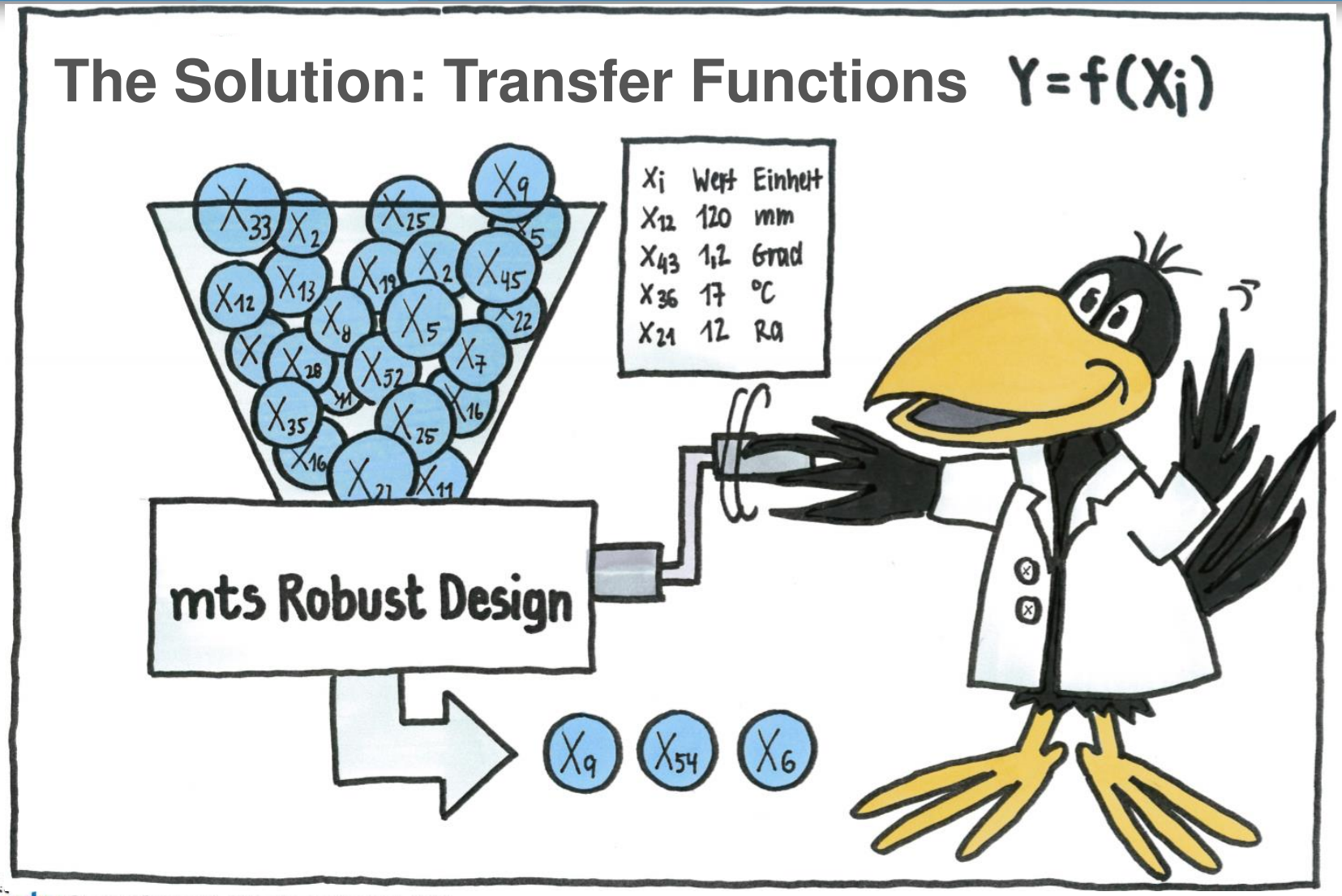
Attempts to improve



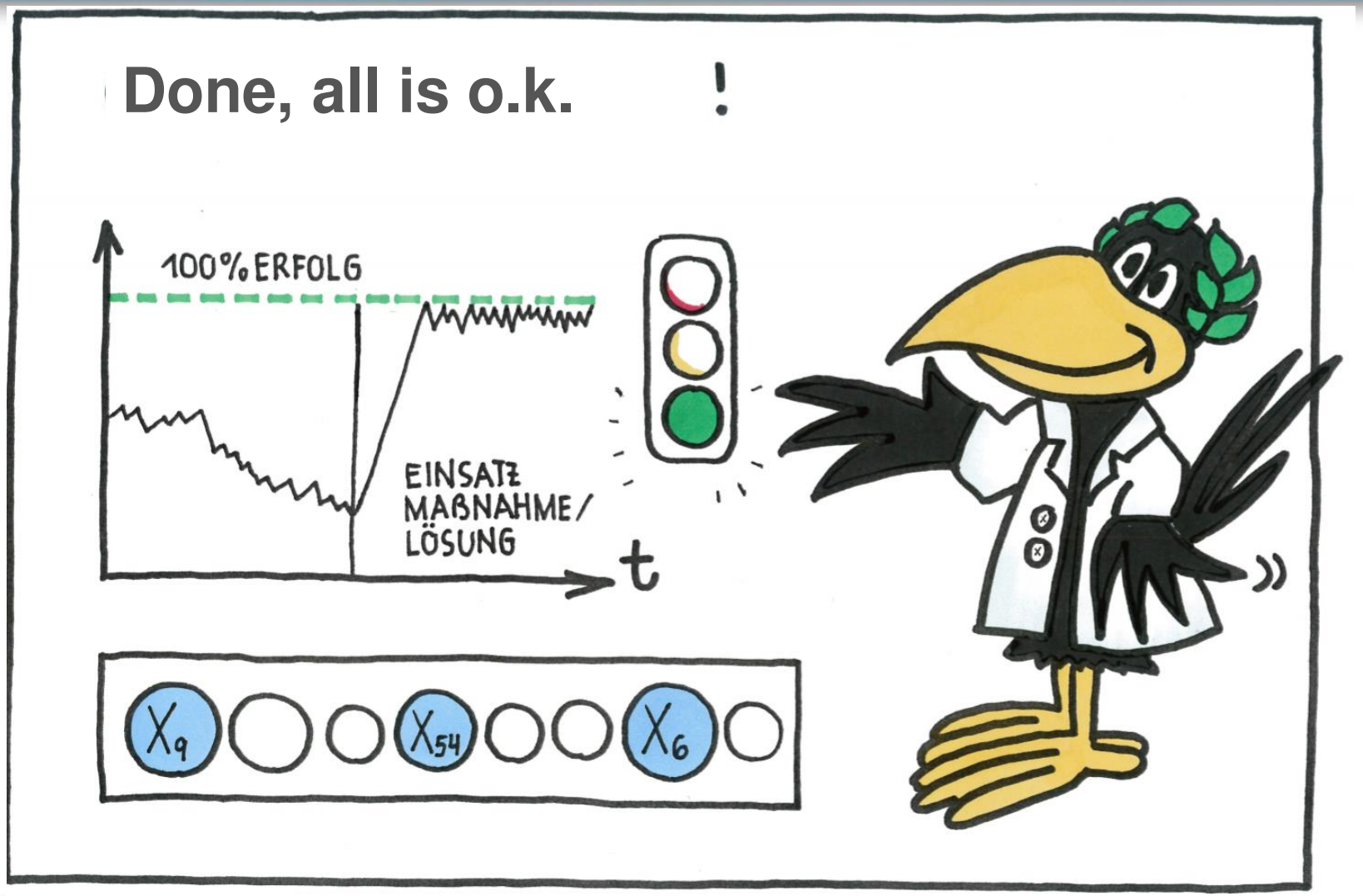
Roadmap for Improvement



Method of Solution – Transfer Functions with Robust Design for Products & Processes



The Improvement

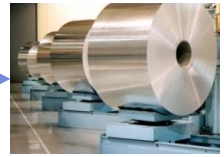


Robust Design – Causal Chain

Goal: Set up a causal chain from final product to process parameter

CTQ = f(Yi) = measurable requirements to the product

Yi = f(Xi) = f (measurable process parameter)

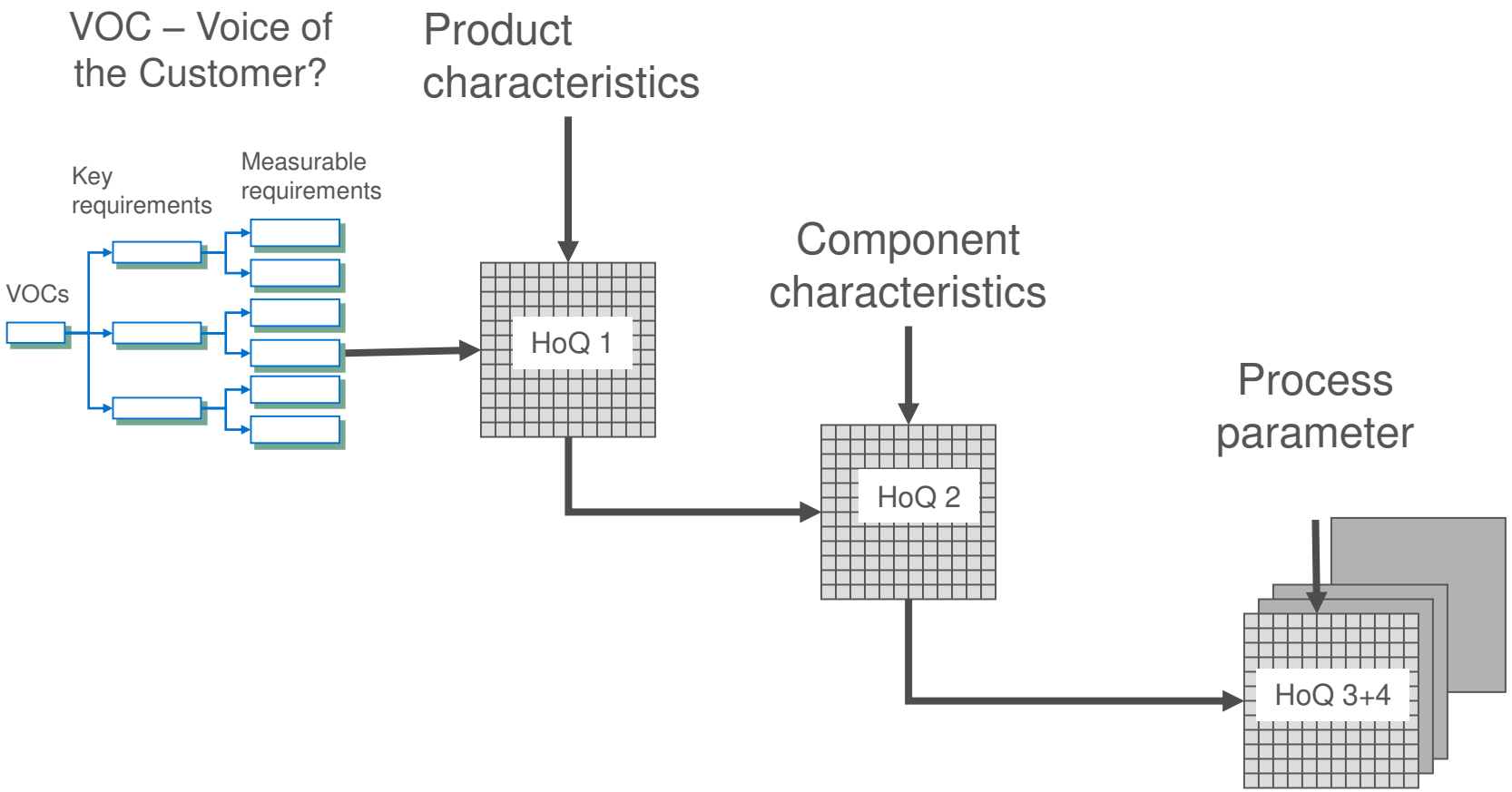


X's = $f(X_{Supplier})$ = f (measurable product parameter of the suppliers)

Benefit:

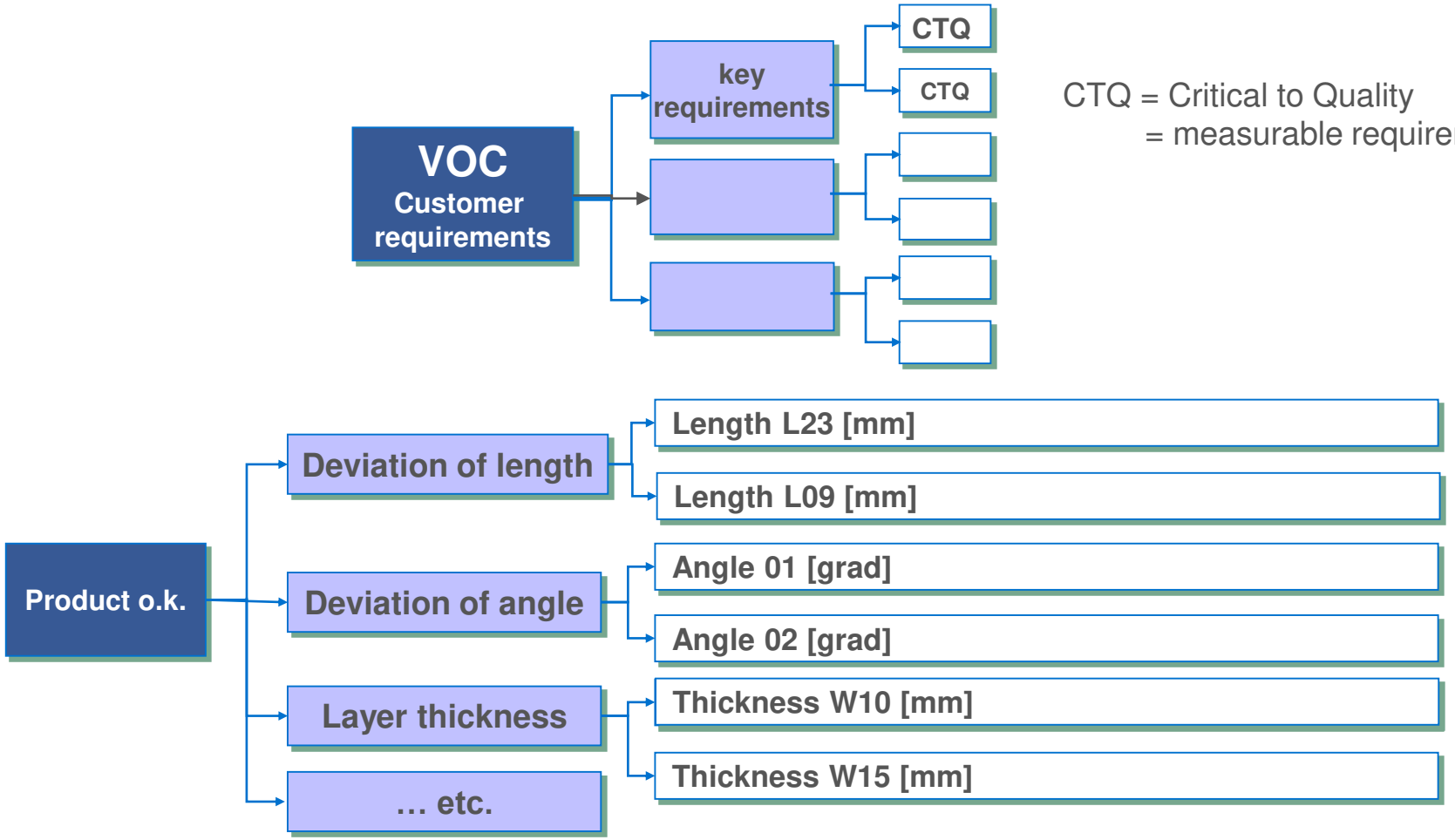
- Know transfer functions Yi = f(Xi) for products and processes
- Reductions in costs by optimized parameterisations and tolerances
- Know risks (products & processes)

Robust Design – The Way to robust Products



Robust Design – 1. Requirement Management

Transfer requirements to measurable values



Robust Design – 2. Differentiate Functions with Function Diagramm and Analysis

Requirements ➡ Functions ➡ Product characteristics

Critical to Quality

- Lightness
- Dimensions
- No failures like gaps, etc.
- Colour
- Slip force
- .....

Measurable Product characteristics

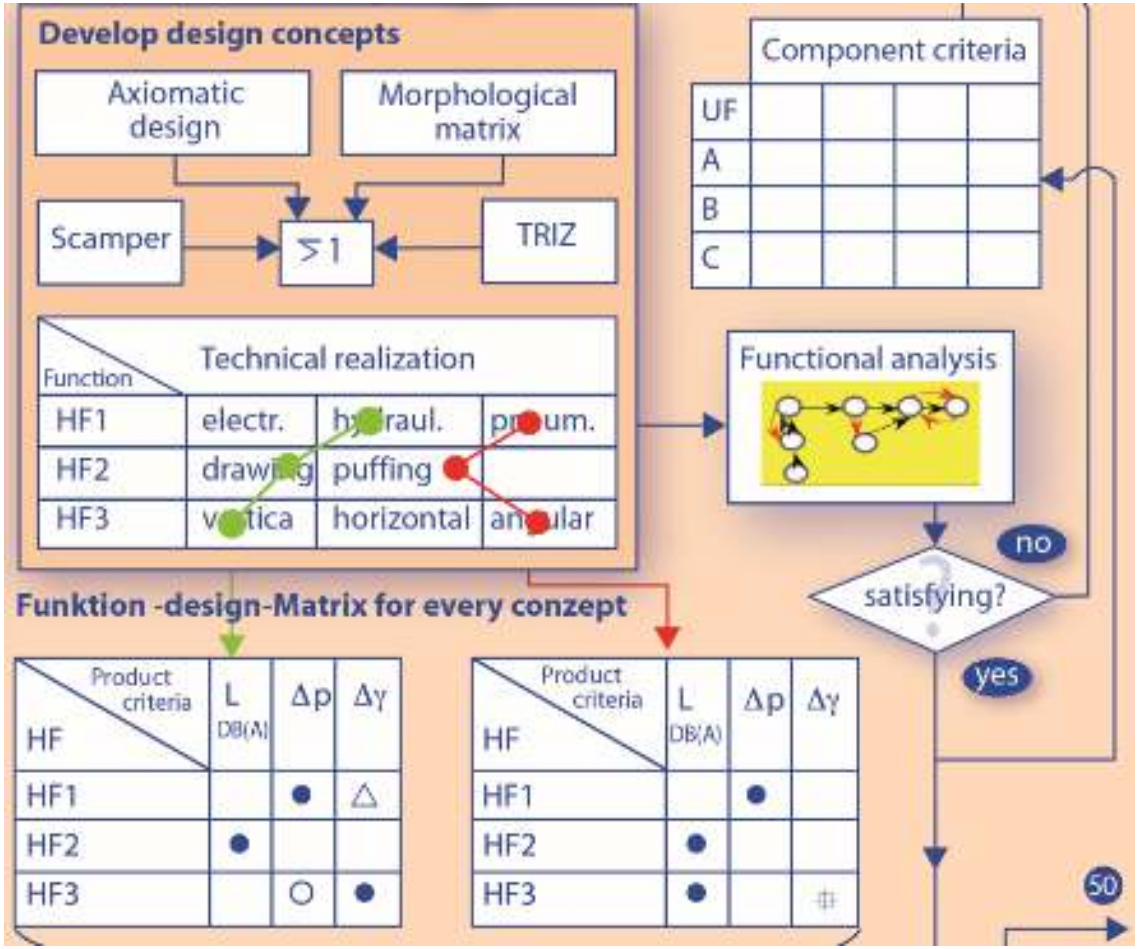
- Gap [mm]
- Length [mm]
- colour
- Waviness
- Force [N/mm²]
- .....

Key Question: Which functions the new product has to yield in the future, that all measureable requirements - CTQ's will be fulfilled?

Independent from Technology!

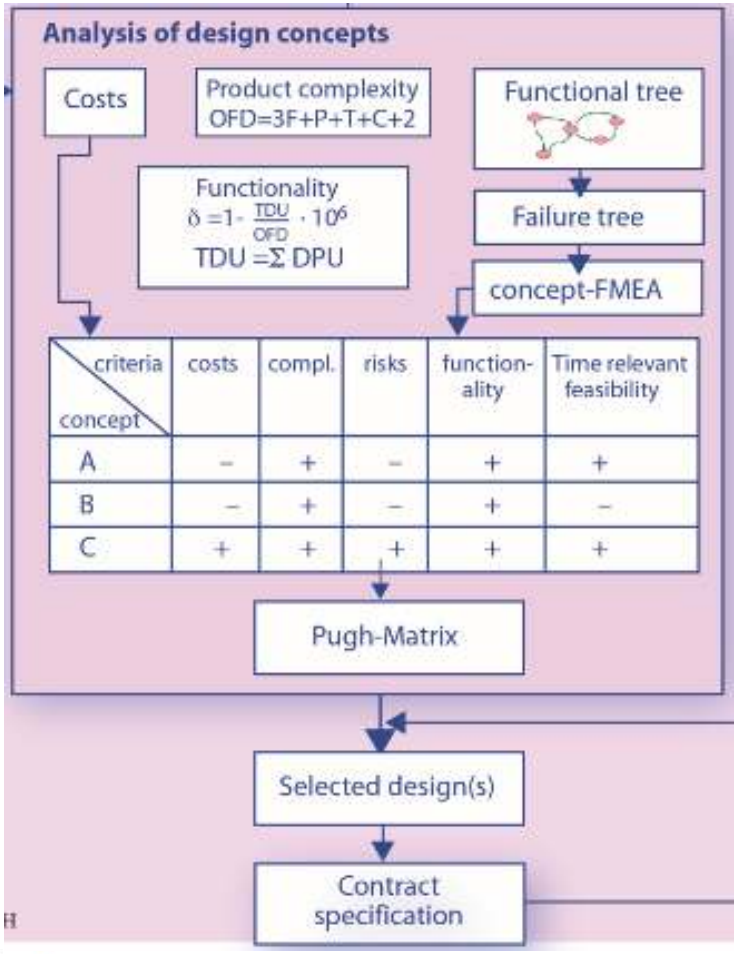
Robust Design – 3. Develop Concepts based on Functions

With creative technologies, morphologic box , scamper, TRIZ and Axiomatic Design ideally good and suitable performing concepts will be developed.



Robust Design – 4. Analyse and rank concepts

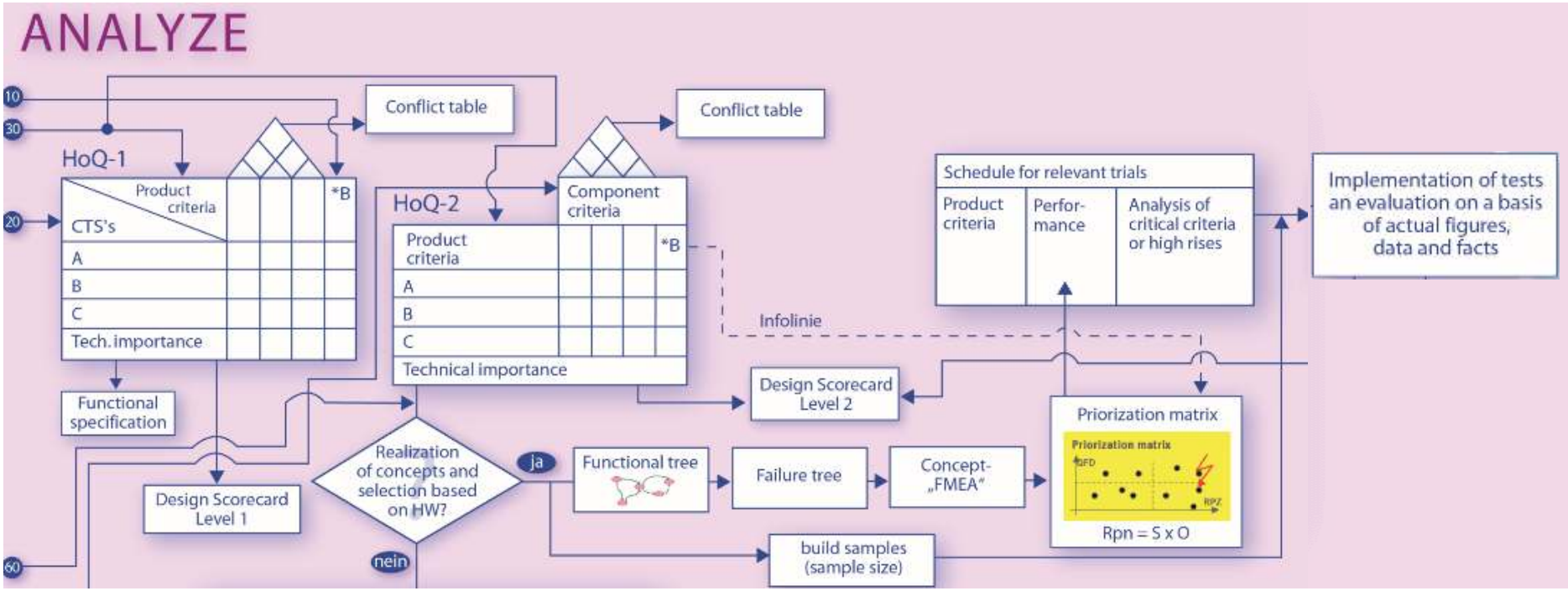
Suitable concepts will be ranked according there functionality, risks, complexity, costs, time schedule and feasibility and compared in a Pugh Matrix.



As well FMEA – Failure Mode and Effect Analysis - as FTA – Fault Tree Analysis will attended.

Robust Design – 5. Build up and measure concepts

The selected concept will be build as model or low volume production. Statistical analysis based on measurement data work out correlations of the causal chain.



Robust Design – 6. Document possible Correlations

HoQ – House of Quality documents possible correlations and therefore possible causal chains for products and processes.

Produktmerkmal / Prozessparameter Critical to Quality / Zielgrößen Gesamtsystem	Priorität	Gießen	Formnnendruckverlauf [bar] 1.DS/2.DS/DM	Werkzeugtemperatur [°C]	Komponententemperatur ISO [°C]	Komponententemperatur POLY [°C]	Entlüftungszeit [s]	Geschlossene Zeit [s]	Mischungsverhältnis POLY:ISO	Schusszeit [s]	Teilehandling	Trennmitteleintrag aufs Bauteil [y/n]	Materialalterung POLY [h]	Materialalteru
Farbhelligkeit	0,6		3	9	3	9	3	3	9	3	3	3	9	3
Farbton vor PUR	4,7		1	3	3	1	9	9	3	9	3	3	3	3
Gleichmäßigkeit der Farbe	1,8		3	9	1	3	1	9	9	9	1	1	9	1
Sichtbare Fehler (Risse, Fugen, Leimdurchschlag, Beizränder) vor PUR	8,8		9	9	9	1	9	9	9	1	9	9	9	9
"Sperrgrund" Blasen [cm²]	8,8		9	9	9	9	9	1	9	9	9	9	9	9
Farbton nach PUR	6,5		3	3	3	1	3	3	3	3	3	3	3	3
Sichtbare Fehler (Risse, Fugen, Leimdurchschlag, Beizränder, Einschlüsse, Blasen (Schaumränder)) nach	9,4		9	3	1	9	3	1	3	3	1	1	3	1
Oberflächenaufbauhaftung Störung: Wölbung/Lackblasen	10,0		3	3	1	3	1	3	3	3	1	3	3	3
Technische Bedeutung			425	332	215	345	262	267	332	286	215	235	332	235

Robust Design – 7. Prioritize Influence Factors

Produktmerkmal / Prozessparameter Critical to Quality / Zielgrößen Gesamtsystem	Priorität	Gießen	Forminnendruckverlauf [bar] 1.DS/2.DS/DM	Werkzeugtemperatur [°C]	Komponententemperatur ISO [°C]	Komponententemperatur POLY [°C]	Entlüftungszeit [s]	Geschlossene
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Farbton vor PUR	4,7		1	3	3	1	9	9
Gleichmäßigkeit der Farbe	1,8		3	9	1	3	1	9
Sichtbare Fehler (Risse, Fugen, Leimdurchschlag, Beizränder) vor PUR	8,8		9	9	9	1	9	9
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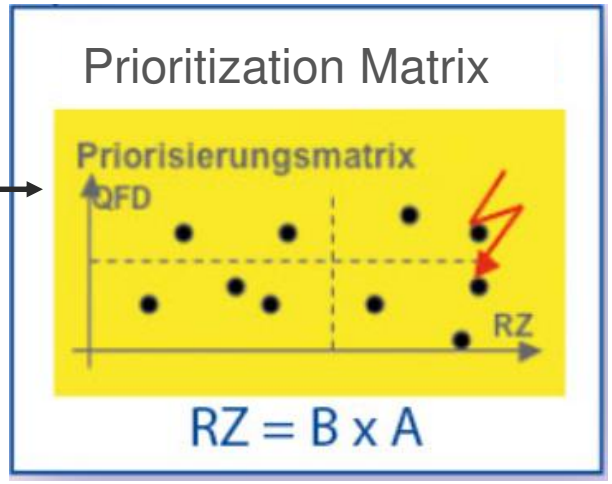
Technische Bedeutung			425	332	215	345	262	267

QFD: Technical Importance for HoQ 1, 2 or 2+4
RZ: from product Design FMEA and/or Process FMEA



Robust Design – 8. Plan experiments to investigate product- / process-transfer functions

Experiments to investigate product transfer function

Produkt-merkmal	Daten-art	Komp. Merkmal	Daten-art	Hypo-these	beabsicht. Einstellung	n	Tool
L [dB(A)]	stetig	ra - HR	stetig	je rauher HR, umso lauter	6µ, 8µ, 10µ...	15	Regression

For data from current production / series / zero series

For experiments / DoE – Design of Experiments during R&D, zero series or within the PEP / PPAP

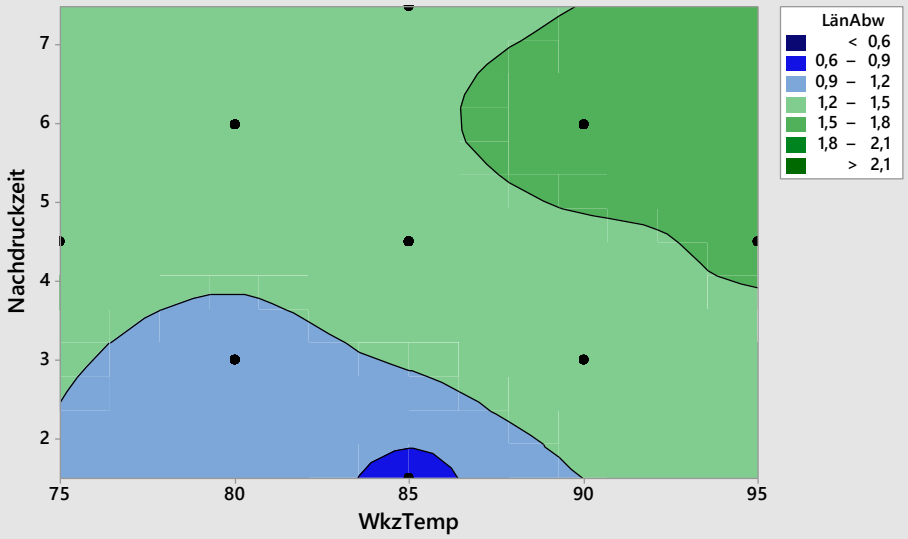
Komponentenmerkmal (X)	Importance	TB	Bemerkung/ Messverfahren	Stufe1	Stufe2	Hypothese
Deckfurnier Qualität	9	263	Vergleichsmuster	quer	längs	
Klebefilmtyp	9	219	Messung nach GS 2015	Lieferant A	Lieferant B	
Deckfurnier Dicke (Rohfurnier vor Kaschieren)	9	173	Plattentaster / Dickenschwankungen	0,4	0,7	je dünner desto besser; je gleichmäßiger desto besser
Holzkitt Typ	9	156	Messung gemäß GS xxxx	Typ 1	Typ 2	Typ 2 ist besser als Typ 1
Vlies - Typ	9	144	Messung gemäß GS yyyy	VC 1	VC 2	VC 1 ist besser als VC 2
Vlies-Grammatur	9	144	Messung gemäß GS uuuu			je dicker desto welliger ;

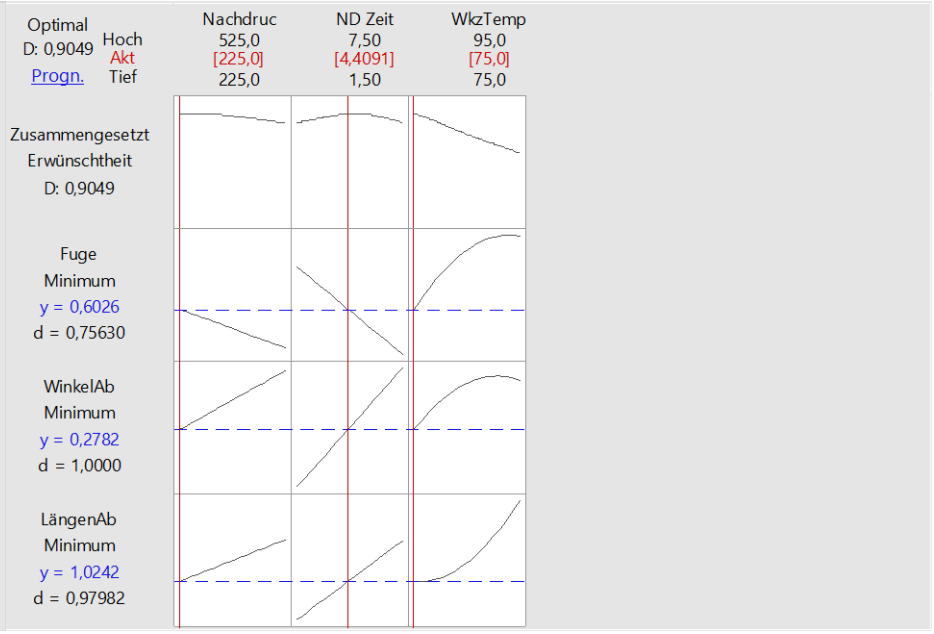
Robust Design – 9. Statistical analysis and transformation of results to real life

Transfer Functions Y = f (Xi) documents correlations from results of experiments and/or measurements of production series.

Optimization of product and process with knowledge of these correlations.

Deviation of Length = f (pressure time; tool temperature





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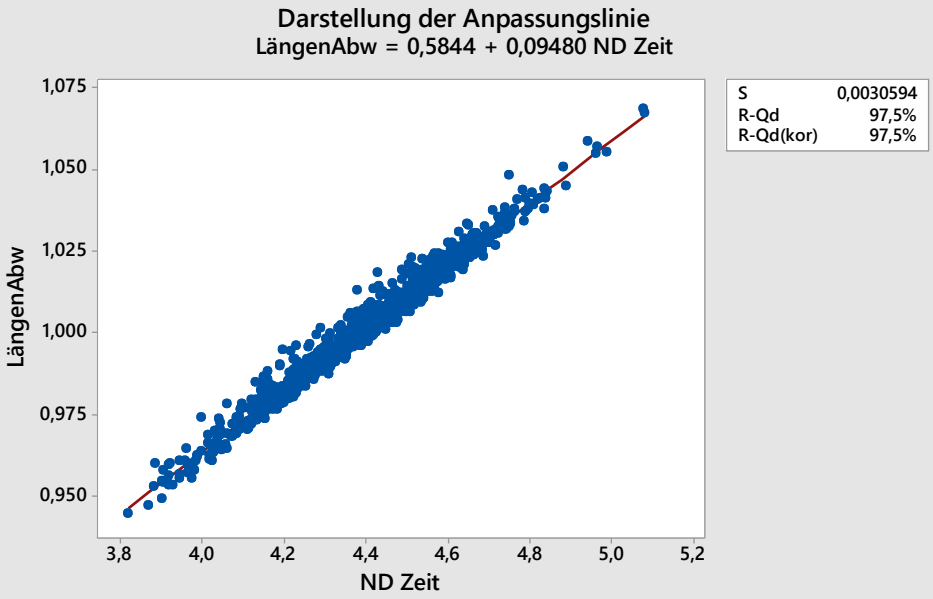

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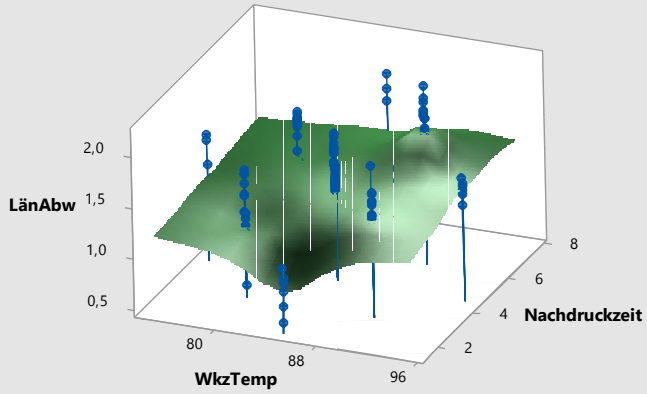
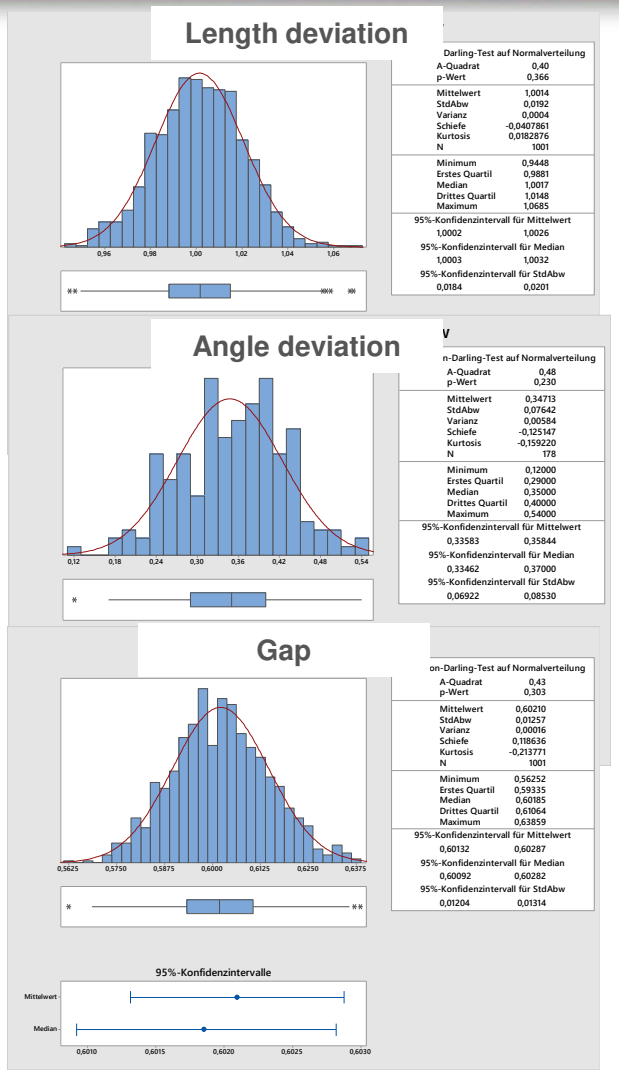
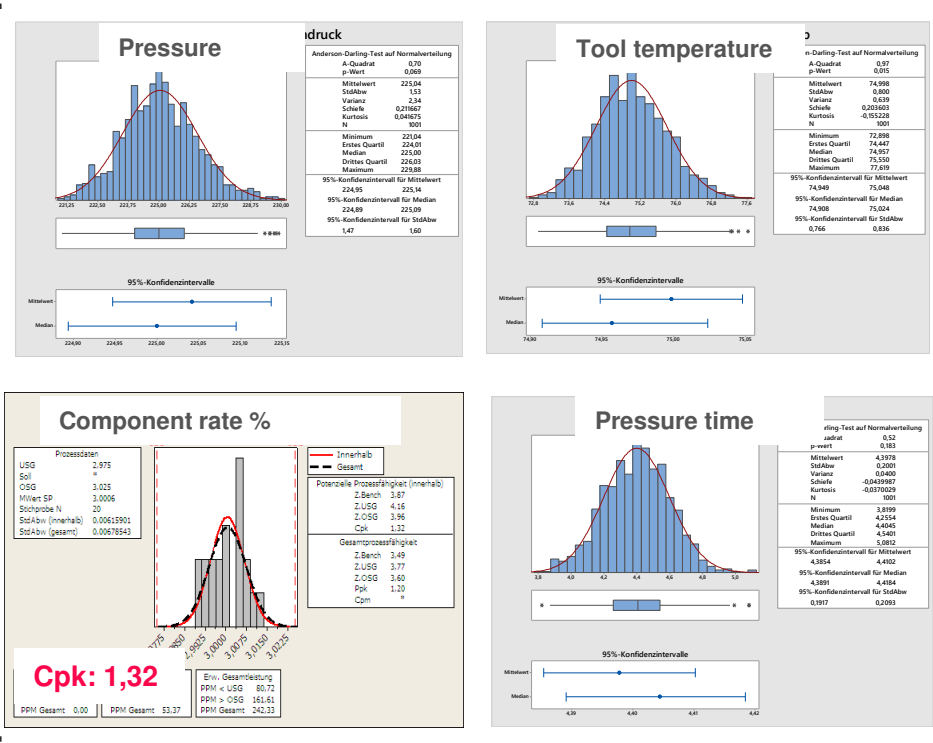


Robust Design - 10. Parametrization and statistical tolerances of influence factors



Avoid over-engineering by statistical parametrization and tolerances for product characteristics and process parameter

= f (



Key projects

Synthetic materials and injection moulding (choice)

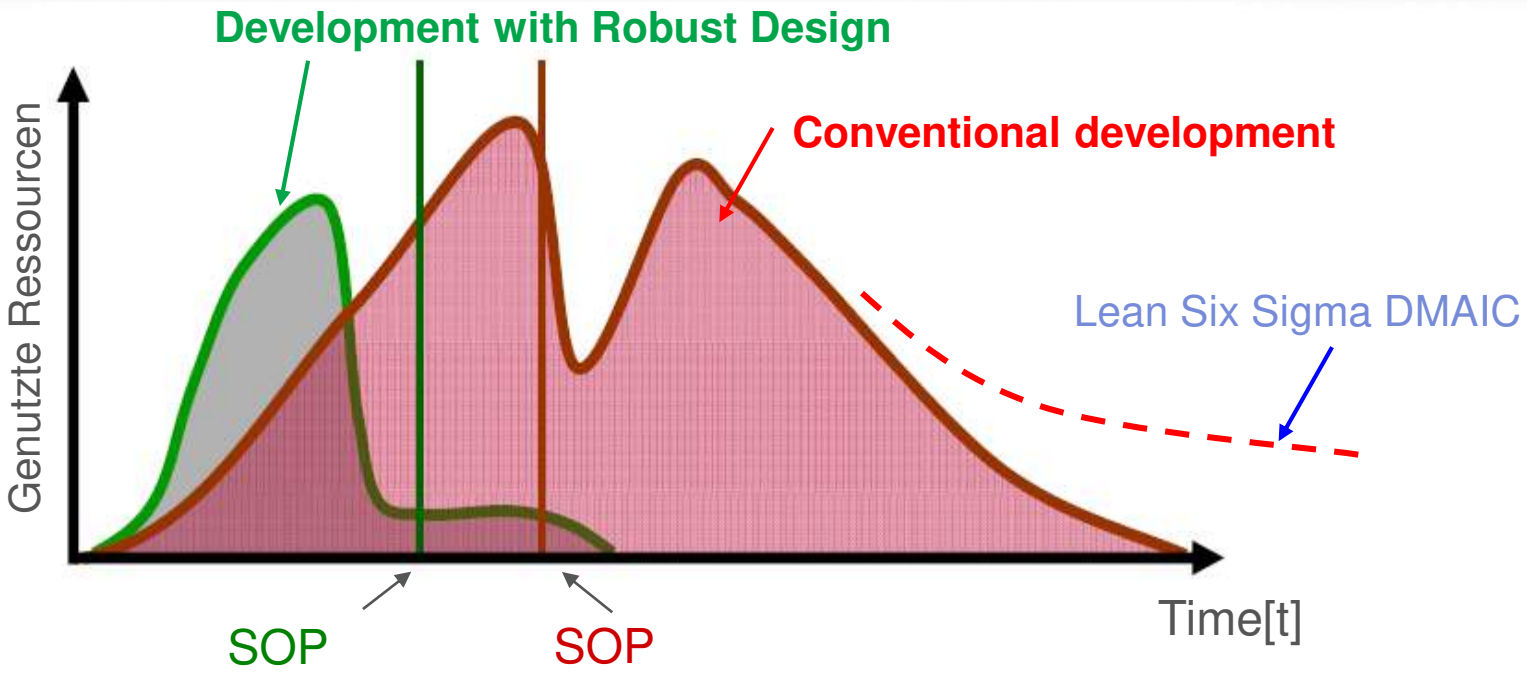
- Reduce failure rate injection moulding and extrusion
- OEE - Overall Equipment Effectiveness projects at several lines/customers
- Plastic-hybrid-components: task force during SOP and reduction of failure rate at security related issues of electrical steering systems
- Overmoulded components: RFT for full automatic assembly
- Laser welding of plastic components: process optimization
- Interior doors: SOP and optimization of synthetic material injection moulding
- Interior: SOP and optimization of synthetic material injection moulding facilities
- Vehicles: I-Tafel: SOP and robust product design
- TPE- and PVC- extrusion
- Injection moulding process (contact systems): reduce failure and time problems

Schlüsselprojekte

Extrusion: Gummi und Kautschuk (Auswahl)

- Aufbau und Inbetriebnahme einer Fabrik zur Herstellung von Hydraulikschläuchen
- Fertigung von Reifenkomponenten, Schlauchfertigung
- Kontinuierliche Vulkanisation via Mikrowelle und Salzbad
- Dimensionierung und Layout von Kautschuk-Extrudern, und -Extruderschnecken
- Kalander- und Rollerheadprozesse: Inbetriebnahme der weltgrößten Rollerhead-Anlage zur Transportbandherstellung
- Layout und Inbetriebnahme einer Douplex-Rollerhead-Anlage
- Walzenbeschichtung
- Layout und Konzeption einer neuen Generation von Warmfütterextrudern
- Kontinuierliches Compounding von Kautschuk auf Zweischneckenextrudern
- Compounding auf Zweischneckenextrudern: Recycling von Gummi

Robust Design – Demand of resources



What is new with Robust Design?

- Pro-active, reliable and predictable development process
- Treat customer´s requirements more comprehensive, work for risks
- Identify critical design parameter and understand correlations
- Understand causal chain → Robust Design for products & processes

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