Using TRIZ for Systematic Reliability Engineering (Part II)

PLOT Showcase – Koningshof Veldhoven

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V2i *Vors* to Innovate

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  - Effective additional tools

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V2i (*Vors* to Innovate)

- Innovation, reliability and improvement services

Process Improvement
- Process capability studies
- Yield improvement
- Product and process audits

Product Reliability
- DfR: Transition to built-in reliability
- RCA: Solving long lasting / complicated failures
- Designing Accelerated Lifetime Tests and reliability programs

Systematic Innovation
- TRIZ: Making innovation tangible and predictable
- NPI Optimisation: Accelerating TTM (Time to Market)

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Systematic Reliability Engineering

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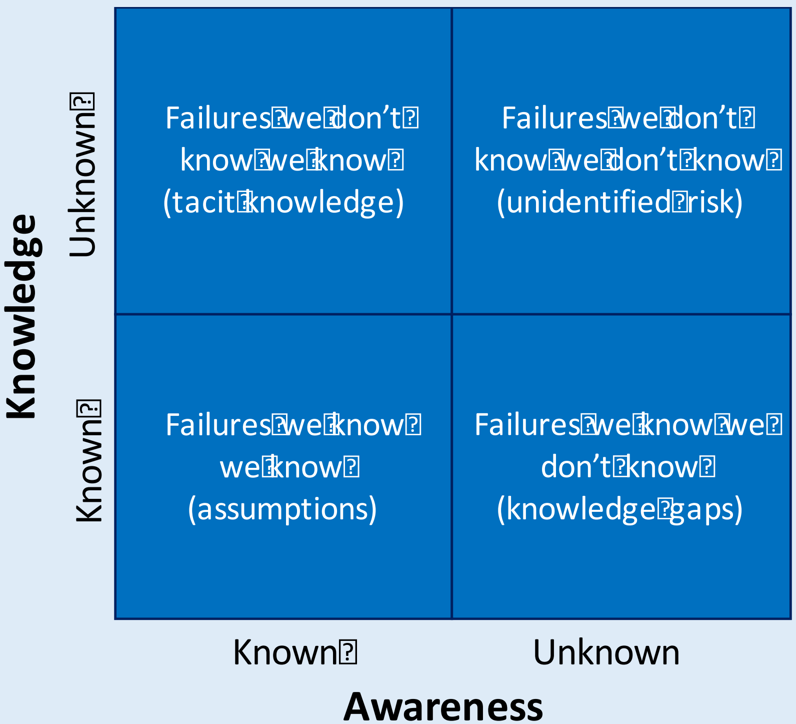
- Upfront responding to potential failure behaviour



Failures we know we know:
- Manageable if formalised in design rules

Failures we know we don't know:
- **Main focus new designs (new conditions, functions, components, materials, ….)**
- Literature, aimed testing, external knowledge

Failures we don't know we know:
- Knowledge in minds (not formalised)
- FMEA to unlock existing knowledge
- Previous designs, field data, benchmarking, ….

Failures we don't know we don't know:
- Robustness analyses, inducing failures, overstress testing, ….
- Anticipatory Failure Determination (AFD)

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Systematic Reliability Engineering

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- Costs of (Un)reliability
  - The ”Factor of 10 Rule” is often used to illustrate the costs of repairing a failure at a specific design stage or in the field, a perfect way to emphasis the importance of DfR (Design for Reliability) / Built-in-Reliability
  - However, field failures are seldom a single event. Costs of a reliability issue in the field can be enormous and easily break the “Factor of 10 Rule”! E.g. costs of Root Cause Analysis (RCA), redesign and testing, logistics / exchanging parts, claims, damaged reputation, ……

Identifying, understanding and managing potential failure behaviour as early as possible during the design phase!

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Systematic Reliability Engineering

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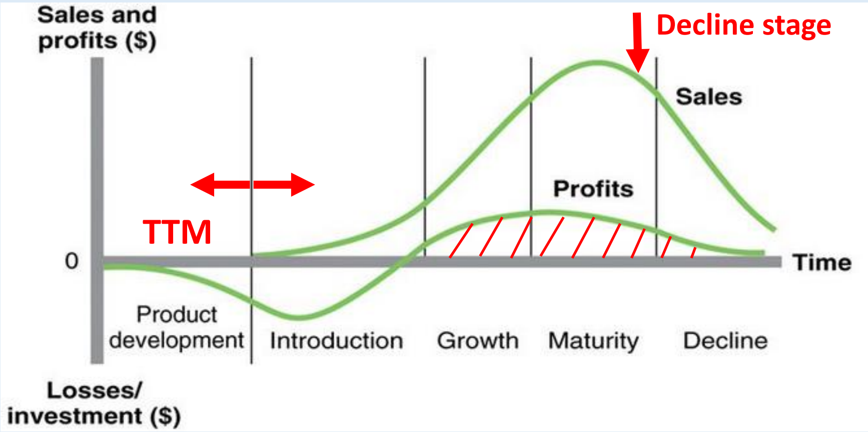
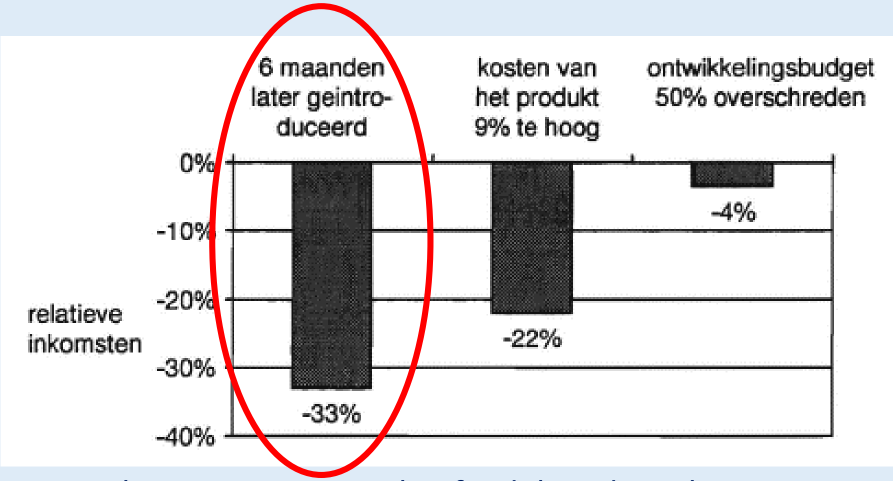
- Important parameter to reduce Time to Market (TTM)
  - "Innovation Reliability Paradox"
    - New, unproven technologies ↔ proven reliable solutions
    - Key solution: Innovating reliability processes



TTM, product decline stage and Time in Profit (TiP).



Relative costs example of a delayed market introduction compared to higher product costs and an R&D budget overrun.

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TRIZ, the Theory of Inventive Problem Solving

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- A problem-solving, analysis and forecasting methodology derived from patterns of invention in patents
- Developed by Genrich Altshuller (1926-1998) who started with TRIZ in 1946

There are still only 40 Inventive principles available to solve technical problems!

All technology evolution trends are predictable!

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TRIZ, the Theory of Inventive Problem Solving

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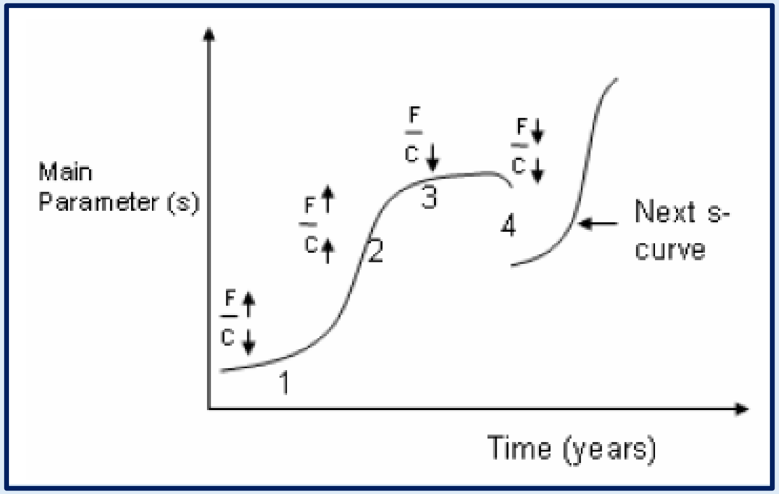
- Technical systems evolve in a direction that increases ideality > Progress to the IFR (Ideal Final Result)



Ideality "Value" = $\frac{\sum(\text{Perceived) Benefits}}{(\sum\text{Cost} + \sum\text{Harm})}$

"Self ……….."

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TRIZ, the Theory of Inventive Problem Solving

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- "Why technical contradictions?" Almost all technical problems (at any level of a system) can be reduced to contradictions, contradicting characteristics that also tend to block innovations!

"The most effective solutions / innovations (and reliability improvements) can be achieved when technical contradictions are solved"

Common engineering practice	Improving parameters at the cost of other parameters
Optimization (e.g. Design of Experiments)	Improving multiple parameters and interactions (still at the cost of other parameters)
TRIZ	New level of improvement and innovation by solving contradictions

TRIZ tool:
Contradiction Analysis

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TRIZ, the Theory of Inventive Problem Solving

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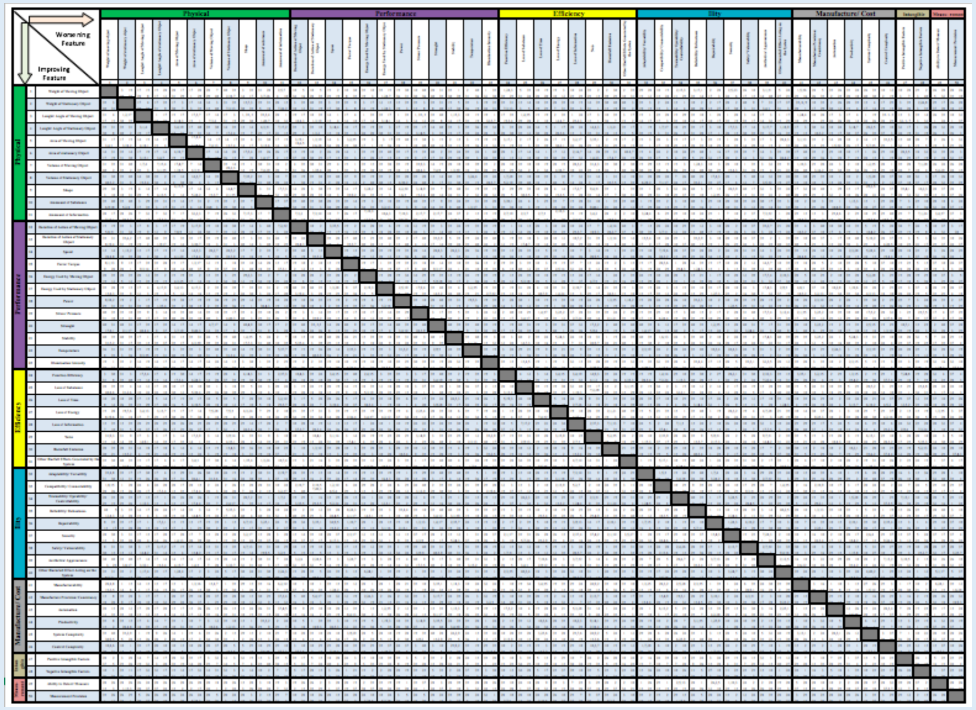
- Tool to solve contradictions: Contradiction Analysis
  - 39(+) TRIZ parameters
  - 40 Inventive principles

Your technical problem has been thought through and the direction for possible solutions can be given!

Contradiction matrix:



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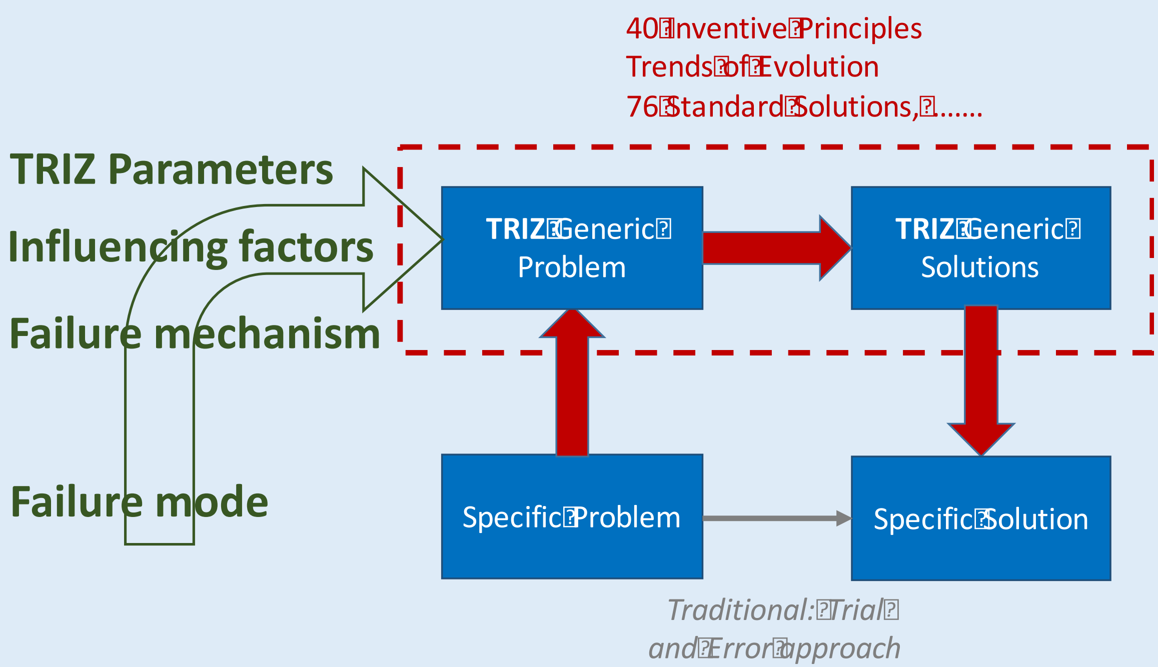
General Model of TRIZ

- Important benefit of applying TRIZ: thinking and acting on the basis of failure mechanisms → Physics of Failure



Understanding underlying failure mechanisms can help making systems predictable!

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TRIZ throughout the Design Process

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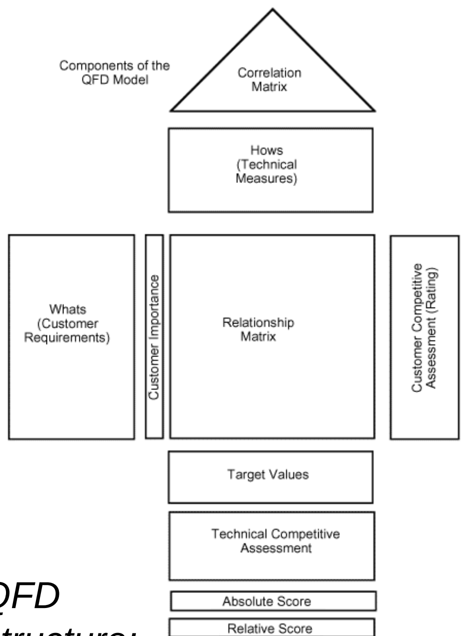
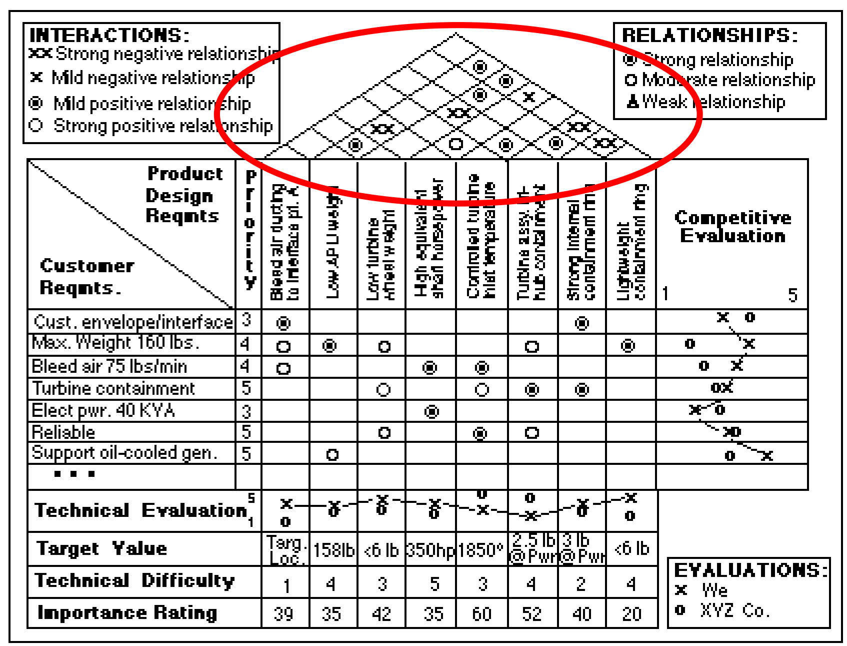
- Quality Function Deployment (QFD) "House of Quality": Translating the Voice of the Customer (VOC) into design requirements



QFD structure:



Contradicting design characteristics to unlock innovation potential and reliability improvement instead of making trade-offs!

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TRIZ throughout the Design Process

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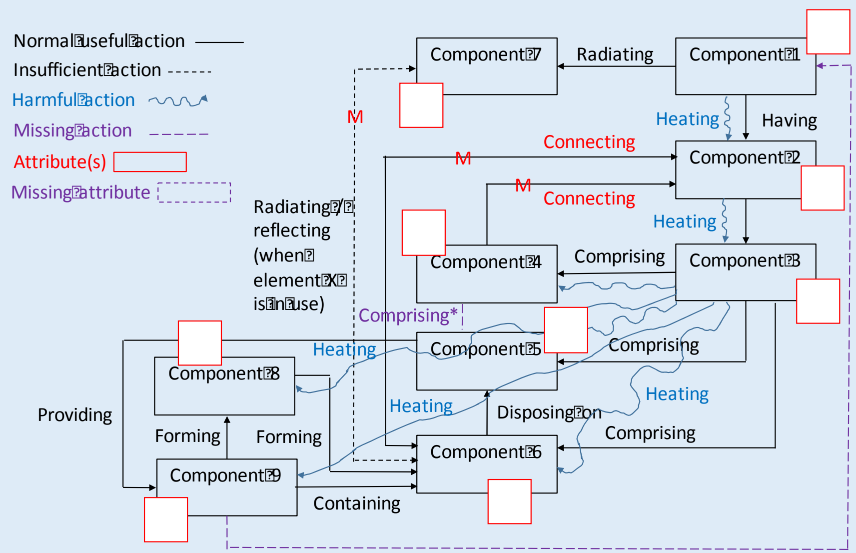
- Identifying potential failure modes:
  - FMEA (Physics of Failure approach: FMMEA) +
  - TRIZ Function Attribute Analysis (FAA)

Potential Failure Modes and Effects Analysis

System ____________ FMEA Revision ________
Subsystem ____________ FMEA Prepared By ________
Part Number ____________ FMEA Date ________
Designer ____________ FMEA Revision Date ________

Item/ Function	Potential Failure Modes	Failure Mode Effects	SEV	Potential Failure Causes	PF	Current Controls	DET	RPN	Actions Req'd	Owner/ Target Date	Actions Taken	SEV 2	PF 2	DET 2	RPN 2

FMEA: BOM based list without a clear coherence. Definition of the function of parts is crucial for a adequate analysis!



FAA: Analysis of components plus functions and attributes including their coherence in the design.

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TRIZ throughout the Design Process

- Parts reduction during the design phase to further improve reliability (e.g. series structure: $R_S=R_1xR_2x\dots xR_n$)
  - TRIZ: Trimming
    - Used after the FAA (Function Attribute Analysis)
    - Set of rules to investigate whether designs can be made simpler, cheaper, more reliable, …..

Trimming Rule A:
The function carrier can be trimmed if the object of the function is trimmed (object is eliminated from the system).

Trimming Rule B:
The functions carrier can be trimmed if the object of the function can perform the useful function by itself.

Trimming Rule C:
The functions carrier can be trimmed if another existing component in the system or super system can perform the useful function performed by the current function carrier.

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TRIZ throughout the Design Process

- Analysing and predicting failures
  - TRIZ Tool: Anticipatory Failure Determination (AFD)*
    - Specific procedures for analysis and prediction
    - Main question: How can I let the system fail?
    - Some key aspects of the approach: 1) Formulating and amplifying the inverted problem, 2) Inventing failure hypotheses and 3) Utilizing TRIZ Resources (components which need to be available to induce the failure mechanism)

TRIZ Resources: Vacant Space, Free Time, Required Function, Similar Substance, Source of Energy and Required Information

** Also known as Diversionary Method, Diversionary Analysis, Subversion Analysis, Anticipatory Failure Identification and Anticipatory Failure Prediction.*

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Finally

- Only planned, structured and method driven approaches are able to bring products / new innovations on time to the market with a targeted and robust product reliability
- TRIZ provides problem solving, analysis and prediction tools which can help improve product reliability from early design stages. However, robust / tolerance design techniques and adequate parts and process control are still needed achieve and maintain predictable product reliability!

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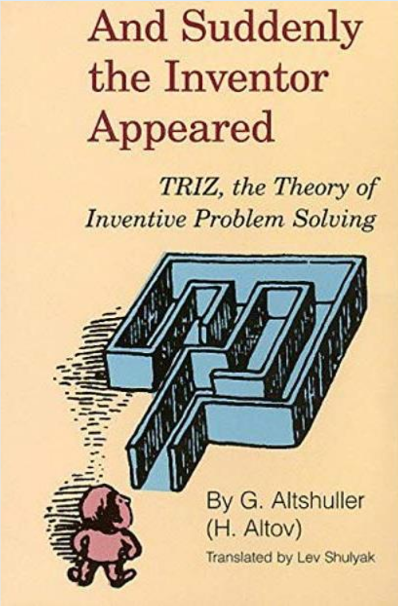
Further reading (and doing)

- Two essentials



Great problem solving examples given by the inventor.

Excellent Hand Book to really get started and generate results.

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Thank you for your Attention

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