Using TRIZ for Systematic Reliability Engineering

Erik Veninga – V2i (*Vors* to Innovate)

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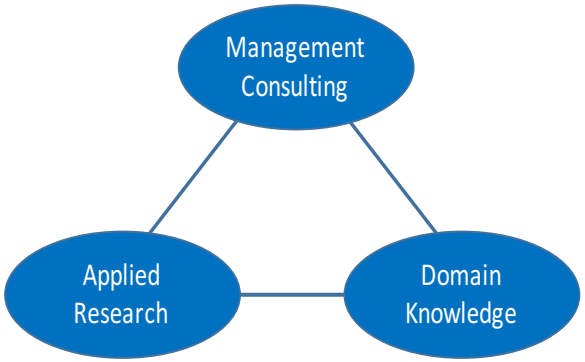
V2i (*Vors* to Innovate)

- Innovation, Reliability & Improvement



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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TRIZ, the Theory of Inventive Problem Solving

- 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

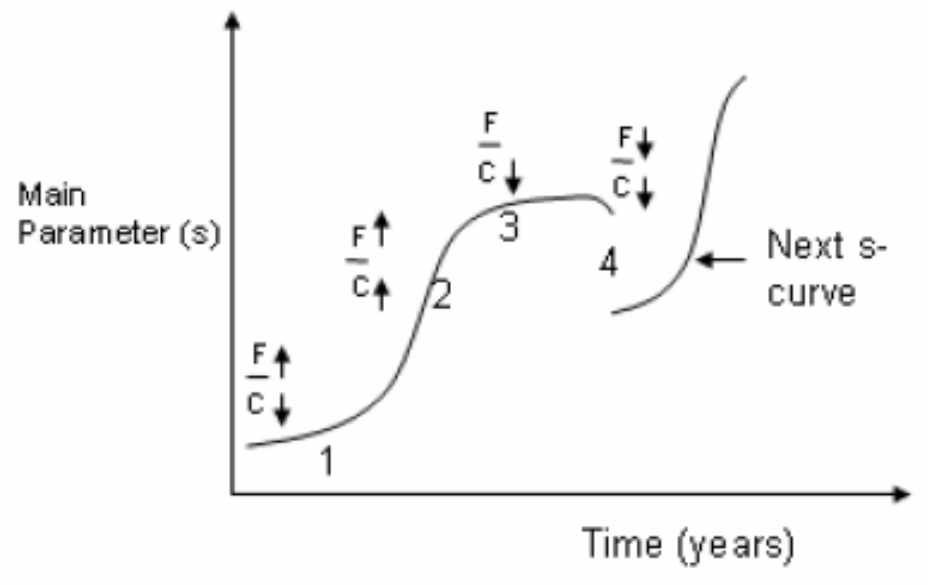
There are still only 40 Inventive principles available to solve technical problems!

All technology evolution trends are predictable!

Genrich Altshuller Teaching TRIZ 4 of 6

TRIZ, the Theory of Inventive Problem Solving

- 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 ....."

TRIZ, the Theory of Inventive Problem Solving

- "Why technical contradiction?" 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 by DOE (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

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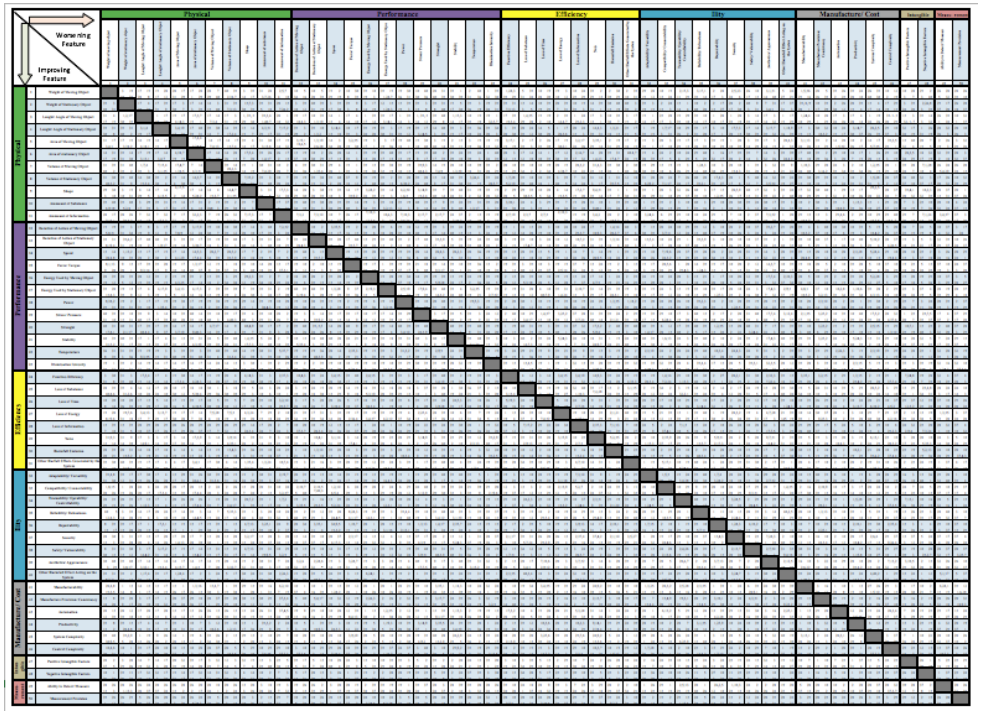
TRIZ, the Theory of Inventive Problem Solving

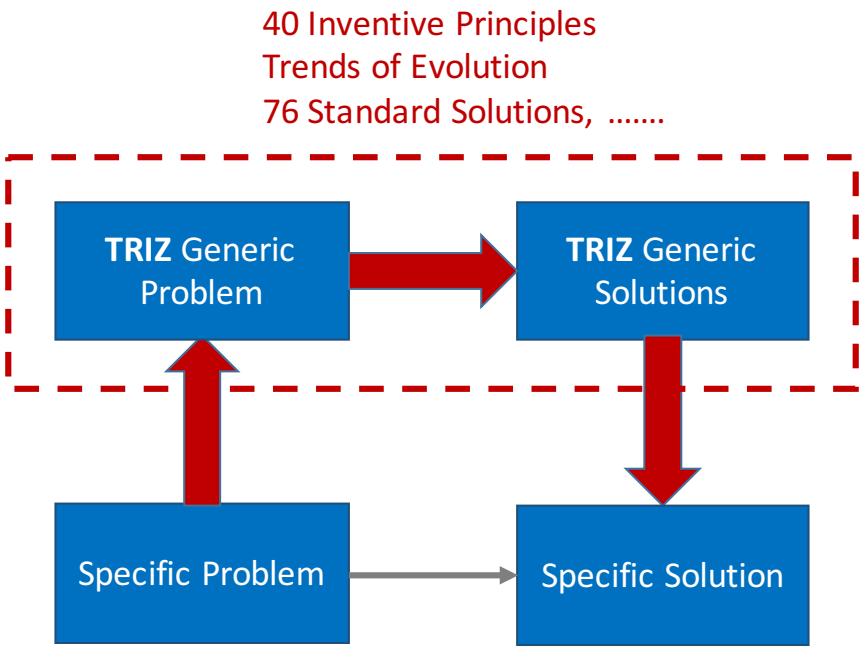
- TRIZ tool to solve contradictions: Contradiction Analysis
  - 39(+) TRIZ parameters
  - 40 Inventive principles

Contradiction matrix:



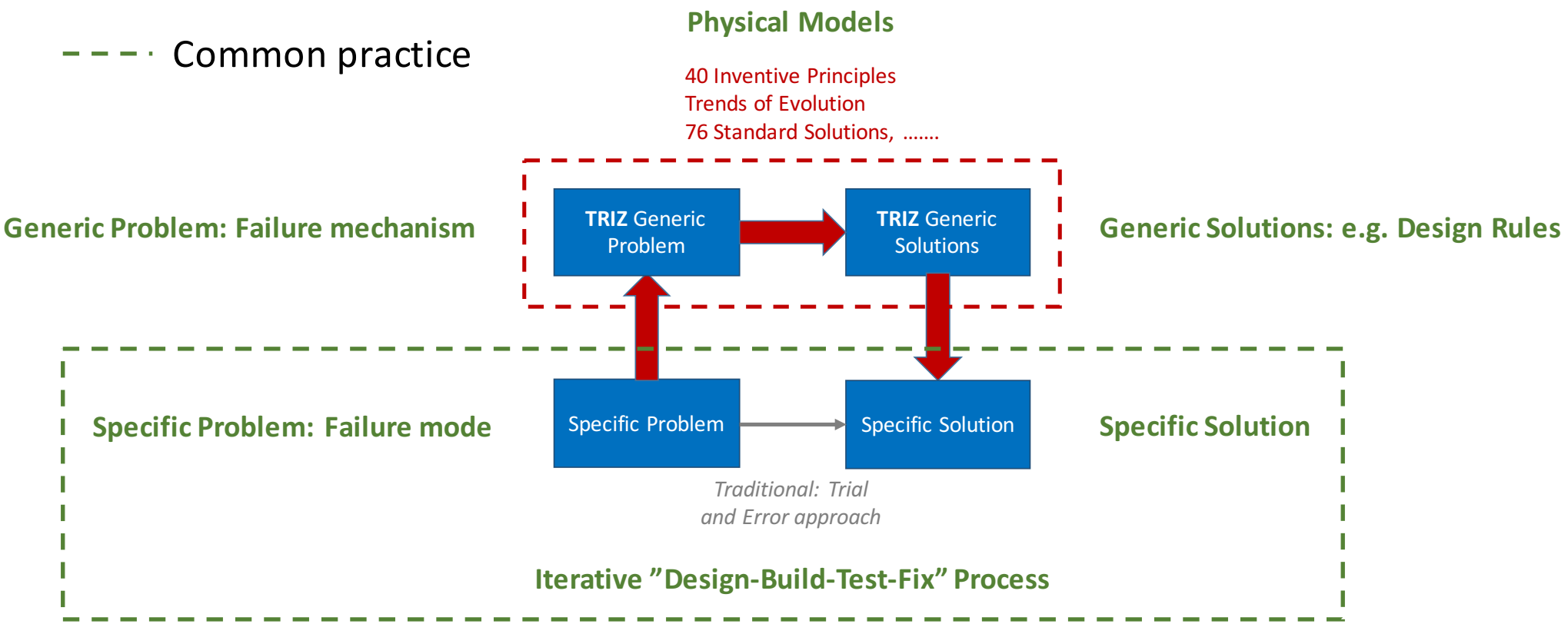
TRIZ, the Theory of Inventive Problem Solving

- General model for the TRIZ problem solving process



Traditional: Trial and Error approach

Projecting Reliability on TRIZ model



Why bringing together TRIZ and Reliability?

Because the challenge is still: **Design for Reliability (DfR)**

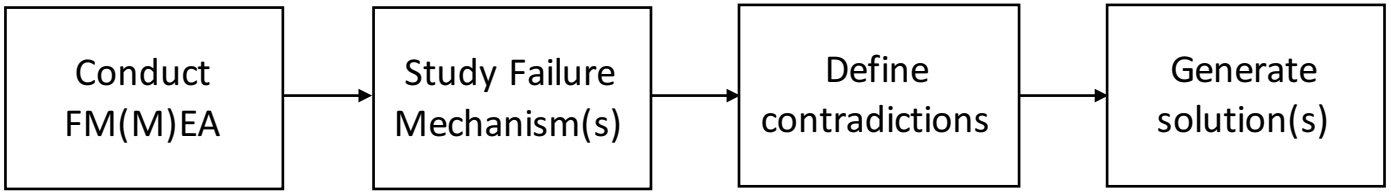
"Design for Reliability (DfR) is a process for ensuring the reliability of a product or system during the design stage before physical prototype." [DfR Solutions]

However, an iterative, more time consuming and costly ”Design-Build-Test-Fix” process is common practice!

Physics of Failure (PoF) based approaches hold the key to understanding and systematically improving reliability, including reducing the TTM (Time to Market)!

Using TRIZ in the Reliability Design Process

1) Conduct a FMEA (or encounter test / field failures)
2) Identify (potential) failure mode
3) Determine underlying failure mechanism (expansion to FMMEA)
4) Inventory influencing factors (literature, available models, ……)
5) Convert factors into TRIZ parameters (problem definition in **generic** and **contradicting** parameters)
6) Conduct TRIZ Contradiction Analysis (team effort)



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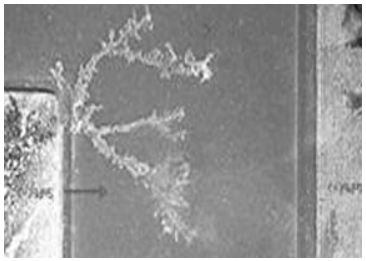
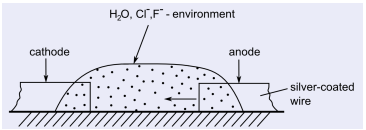
Example: Electromigration Failure Mechanism

- Failure mode: e.g. Short circuit
- Failure mechanism: Electromigration
- Influencing factors: current density, potential difference, spacing between anode and cathode, interconnect / conductor size, temperature, …….. , ……





Inventory relevant TRIZ parameters*
4. Length of stationary object
10. Force
13. Stability of the object's composition
15. Duration of action by a moving object
17. Temperature
19. Use of energy by moving object
21. Power
23. Loss of substance
26. Quantity of substance/the matter
27. Reliability
30. External harm affects the object, …….

→

Selection of contradicting paremeters
Worsening feature:
23. Los of substance

Improving feature:
21. Power (or 10. Force)

→

Inventive principles**
1. Segmentation
12. Equipotentiality
28. Mechanics substitution
30. Flexible shells and thin film

And then inventiveness, technical skills and creativity are needed to get from the abstract inventive principles to specific solutions!

* *Requires exercise, use professional literature with examples and explanations*

The IFR (Ideal Final Result)

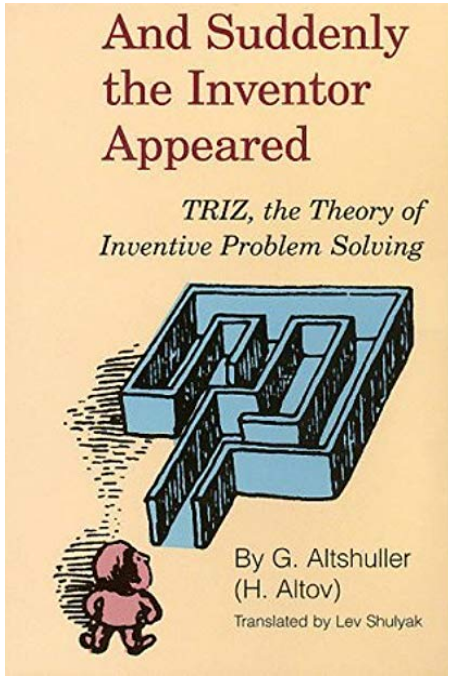
- What about the evolution of products and Reliability Engineering?
  - Self testing
  - Self diagnosing
  - Self repairing / self healing materials
  - …..
  - ….

Self designing for reliability?

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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Summarising

- Physics of Failure (PoF) based approaches hold the key to understanding and systematically improving reliability
- Using the TRIZ model at early design stages forces to think and work on fundamental failure behaviour and controlling mechanisms instead of fighting failure modes at the end of the design process
- Reliability improvement means changing (sub)systems, just find and solve the underlying contradictions!

Thank you for your Attention

Contact

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