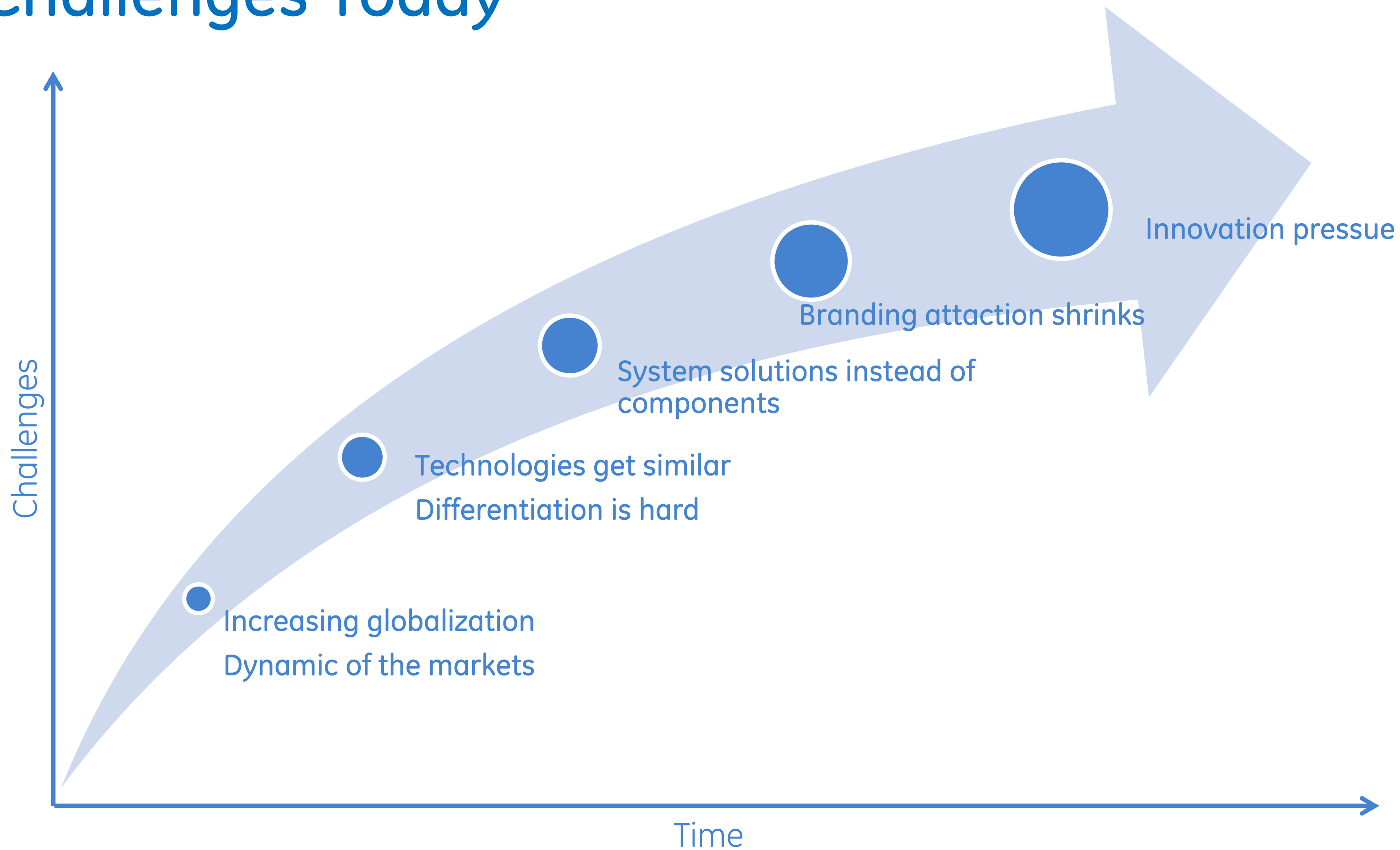
TRIZ
Inventive Problem Solving Methodology

NASA, Oliver Mayer, 21. Oct. 2014

Imagination at work.

Challenges Today



Extrapolation ↔ Retropolation

Starting today: how will it develop ↔ Coming from a vision: what does it need today

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Starting Point: DFSS Process

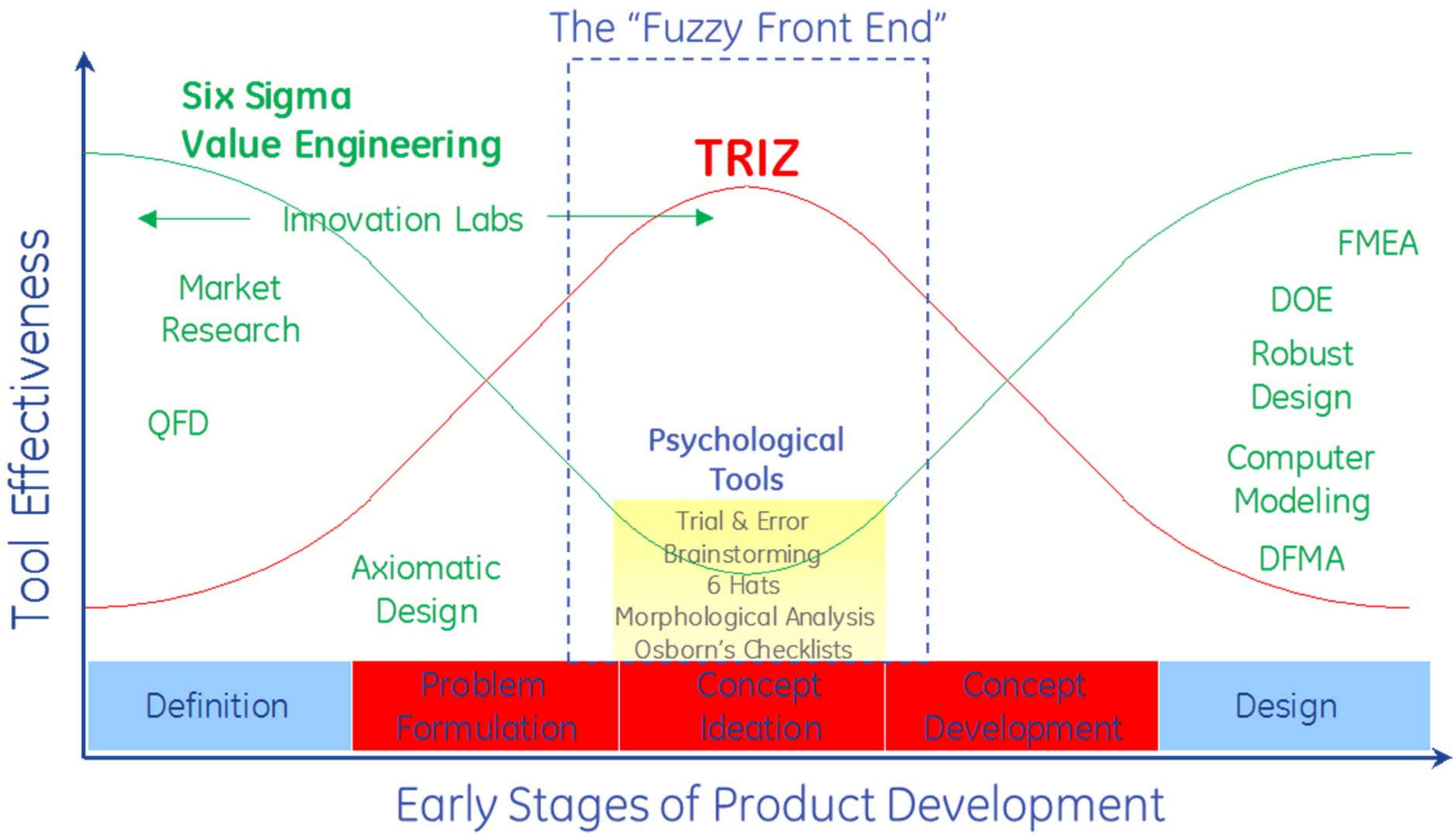
GE's Design for Six Sigma Methodology

DEFINE	MEASURE	ANALYZE	DESIGN	OPTIMIZE	VERIFY
4) Identify Product/ Process Performance & Reliability CTQ's 5) Set Quality Goals 6) VOC / QFD	4) CTQ Flowdown to Subsystems & Components 5) Measurement System Analysis & Capability	4) Develop Conceptual Designs 5) Statistical Reliability Analysis 6) Build Scorecards 7) Risk Assessment	4) Build System & Sub-System Models 5) Generate Transfer Functions 6) Capability Flow-up for All Subsystems & Gap Identification	4) Optimize Design 5) Statistical Analysis of Variance Drivers 6) Robust Design 7) Error Proofing 8) Tolerance Analysis & Allocation	4) Statistically Confirm that Product / Process Matches Predictions 5) Develop Manufacturing & Supplier Control Plans 6) Document & Transition

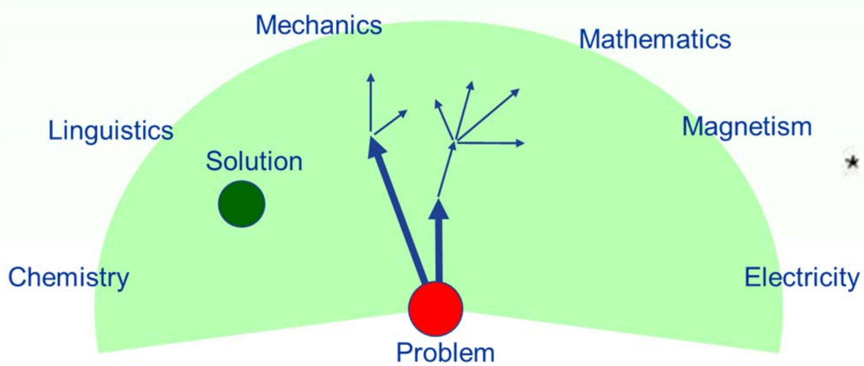
Gaps identified in Conceptual Design Phase by DFSS Council in 2006

- Current approach is primarily brainstorming and then using trade-off tools to determine best compromise
- TRIZ is mentioned as a way to <u>solve</u> technical or physical contradictions, but very limited scope covered

Where does TRIZ fit in?



Conceptual Design Needs - Challenge the Process



* Problem solving is like digging for treasure in a field

* If a hole already exists, our inclination is to dig it deeper

* The deeper the hole, the more difficult it is to see what's happening in other parts of the field

* If someone else comes along, we encourage them to jump in the hole with us

* The overall effect is called **PSYCHOLOGICAL INERTIA**

TRIZ - Theory of Inventive Problem Solving

Теория Решения Изобретательских Задач

Genrich Altshuller – Looking for a Theory of Invention

Analyzed patent literature to develop TRIZ methodology; methods have been expanded over the years

Over 200,000 Patents
(now >2M)
~ 20% Truly Inventive

Typical Solutions

TRIZ Can Help Us Get More and Broader Innovative Solutions

Levels of Inventiveness

Level	**Degree of Inventiveness**	**% of Solutions**	**Source of Knowledge**
1	Apparent solution	32%	Personal knowledge
2	Minor improvement	45%	Knowledge within company
3	Major improvement	18%	Knowledge within the industry
4	New concept	4%	Knowledge outside the industry
5	Discovery	1%	All that is knowable

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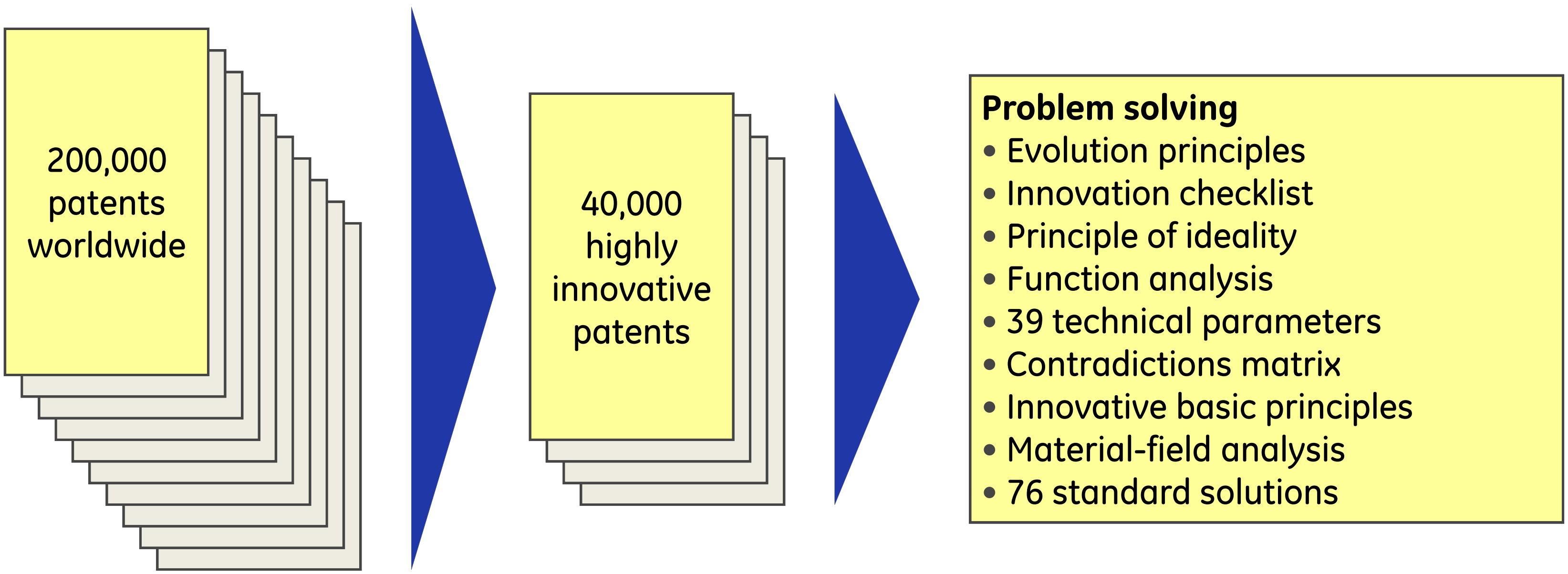
How was TRIZ Developed?

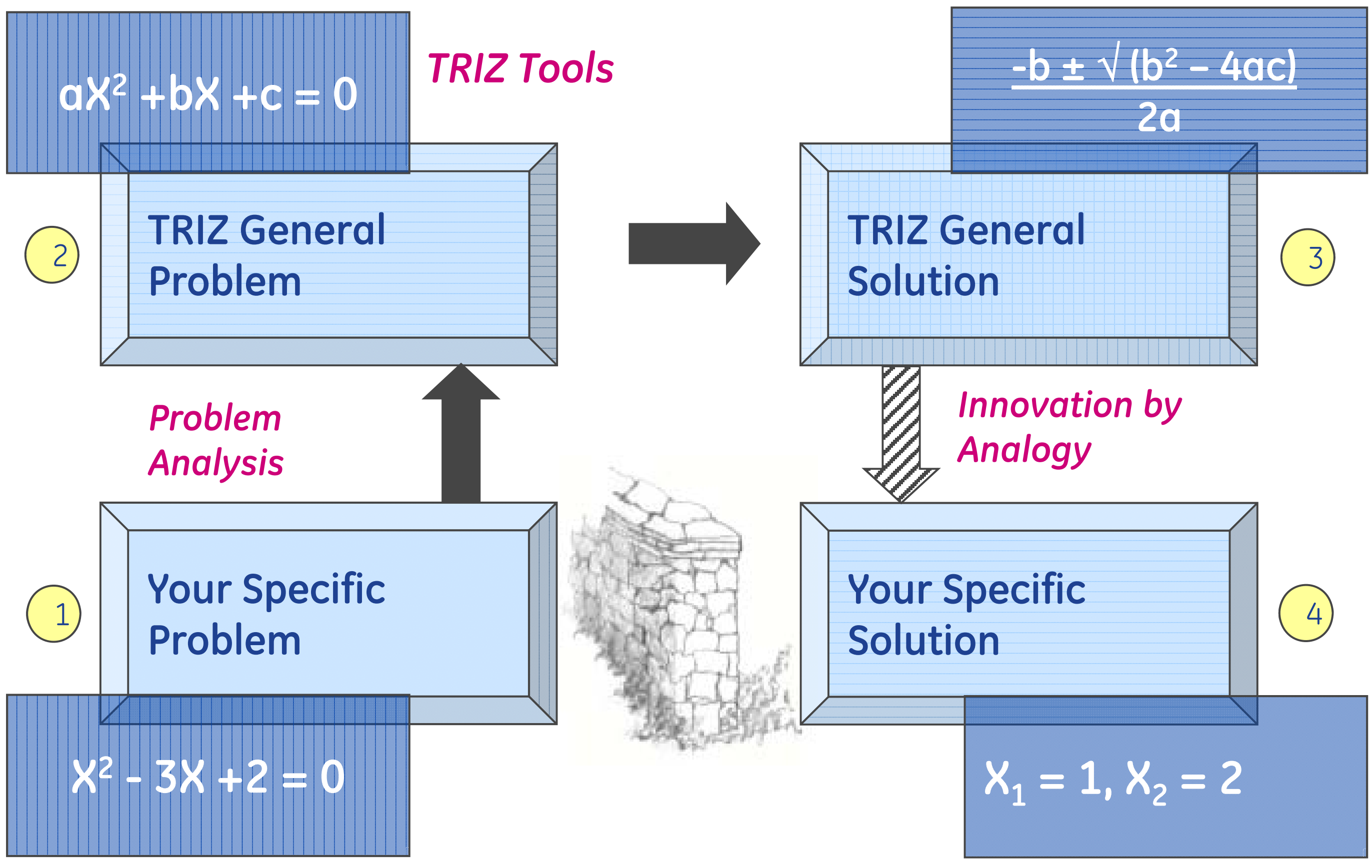
Method by Prof. Genrich Altshuller

- Evaluation of +200,000 patents
- Selection of 40,000 "highly innovative inventions"



Significant Enhancement to DFSS: It accelerates the innovation and idea finding process

TRIZ the Principle



TRIZ Methodology

If we increase length of the bus than we will improve its capacity but maneuverability will be deteriorated

TRIZ Tools

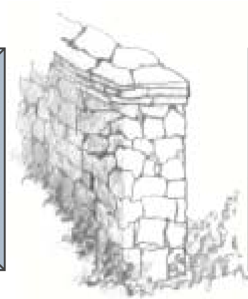
Dynamization
Flexible shell

(2) TRIZ General Problem → TRIZ General Solution (3)

Problem Analysis

Innovation by Analogy

(1) Your Specific Problem



Your Specific Solution (4)

Source: Solvis.com

Source: Ebersberg.de

Source: Frankenvorstadt.de

Source: London.com

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Who is Using TRIZ today?

- Automotive

Harley-Davidson, BMW, Valeo, Honda, DANA, Renault, bobcat, DELPHI Automotive Systems, Caterpillar, GM POWERTRAIN, PSA PEUGEOT CITROËN, LuK, INA, FAG, SCHAEFFLER GROUP, DaimlerChrysler

- Medical Technology

Medtronic, ETHICON ENDO-SURGERY a Johnson & Johnson company, Bristol-Myers Squibb Company extending and enhancing human life, BECTON DICKINSON

- Aerospace

AlliedSignal, BOEING, NASA, Litton, BFGoodrich Aerospace, Pratt & Whitney A United Technologies Company, Jet Propulsion Laboratory

- Petroleum

Phillips 66, Shell, ExxonMobil, Solutia, Eni, Saipem

- Consumer Goods

P&G, Unilever, Oral-B, COLGATE-PALMOLIVE COMPANY, Whirlpool, Johnson & Johnson, Kimberly-Clark, ETHICON INC. a Johnson & Johnson company, The Gillette Company, Groupe SEB, HermanMiller

- Optics and telecom

Motorola, Kodak, Polaroid, PHILIPS

- Electricity/ Electronics

Samsung, intel, LG Electronics, AMD, legrand, Hewlett Packard, SIEMENS, GE, Schneider Electric

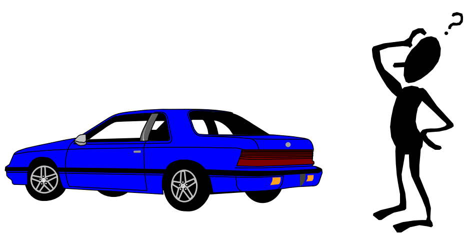
- More…

The Document Company XEROX, Seagate, Dior, DOW, ALCOA, DSM, ROLEX

Example

Engineering Contradiction Example

- You are an engineer who is in charge of designing the radiator for a new automobile. The new design specification requires you to reduce the coolant temperature without increasing the size of the radiator.
- You see that you have a technical contradiction.
- In conventional radiators, reducing the coolant temperature will require an increase the radiator volume since more fin area is needed for heat removal.
- Improving Feature: coolant temperature
- Degraded Feature: radiator volume



The Challenge:

Find an Innovative Solution to this Contradiction

Engineering Contradiction: Generalization

What Parameter is improving and which parameter is worsening as a result?

1. Weight of moving object
2. Weight of nonmoving object
3. Length of moving object
4. Length of nonmoving object
5. Area of moving object
6. Area of nonmoving object
7. Volume of moving object
8. Volume of nonmoving object
9. Speed
10. Force
11. Tension, pressure, stress
12. Shape
13. Stability of object
14. Strength
15. Durability of moving object
16. Durability of nonmoving object
17. Temperature
18. Brightness
19. Energy spent by moving object
20. Energy spent by nonmoving object
21. Power
22. Waste of energy
23. Waste of substance
24. Loss of information
25. Waste of time
26. Amount of substance
27. Reliability
28. Accuracy of measurement
29. Accuracy of manufacturing
30. Harmful factors acting on object
31. Harmful side effects
32. Manufacturability
33. Convenience of use
34. Repairability
35. Adaptability
36. Complexity of device
37. Complexity of control
38. Level of automation
39. Productivity

IF I do XXXX
THEN Par. A improves
BUT Par. B gets worse

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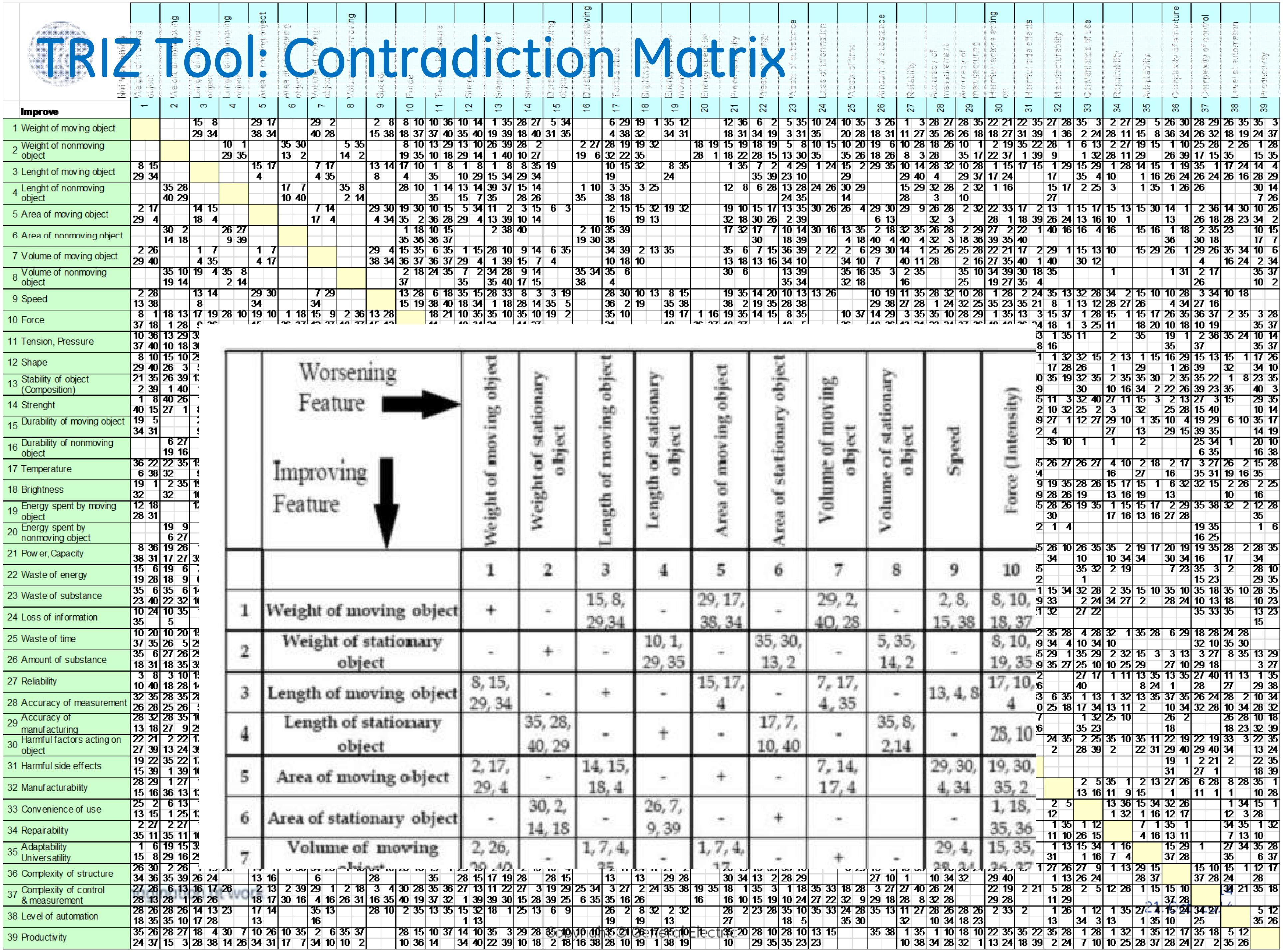
TRIZ Tool: Contradiction Matrix



	Worsening Feature → / Improving Feature ↓	Weight of moving object	Weight of stationary object	Length of moving object	Length of stationary object	Area of moving object	Area of stationary object	Volume of moving object	Volume of stationary object	Speed	Force (Intensity)
		1	2	3	4	5	6	7	8	9	10
1	Weight of moving object	+	-	15, 8, 29,34	-	29, 17, 38, 34	-	29, 2, 40, 28	-	2, 8, 15, 38	8, 10, 18, 37
2	Weight of stationary object	-	+	-	10, 1, 29, 35	-	35, 30, 13, 2	-	5, 35, 14, 2	-	8, 10, 19, 35
3	Length of moving object	8, 15, 29, 34	-	+	-	15, 17, 4	-	7, 17, 4, 35	-	13, 4, 8	17, 10, 4
4	Length of stationary object		35, 28, 40, 29	-	+	-	17, 7, 10, 40	-	35, 8, 2,14	-	28, 10
5	Area of moving object	2, 17, 29, 4	-	14, 15, 18, 4	-	+	-	7, 14, 17, 4	-	29, 30, 4, 34	19, 30, 35, 2
6	Area of stationary object	-	30, 2, 14, 18	-	26, 7, 9, 39	-	+	-	-	-	1, 18, 35, 36
7	Volume of moving	2, 26, 29, 40	-	1, 7, 4, 35	-	1, 7, 4, 17	-	+	-	29, 4, 38, 34	15, 35, 36, 37

All 40 Principles – TRIZ Tool

1. Segmentation
2. Taking out
3. Local quality
4. Asymmetry
5. Merging
6. Universality
7. "Nested doll"
8. Anti-weight
9. Preliminary anti-action
10. Preliminary action
11. Beforehand cushioning
12. Equipotentiality
13. 'The other way round'
14. Spheroidality - Curvature
15. Dynamics
16. Partial or excessive actions
17. Another dimension
18. Mechanical vibration
19. Periodic action
20. Continuity of useful action
21. Skipping
22. "Turn Lemons into Lemonade"
23. Feedback
24. 'Intermediary'
25. Self-service
26. Copying
27. Cheap short-living objects
28 Mechanics substitution
29. Pneumatics and hydraulics
30. Flexible shells and thin films
31. Porous materials
32. Color changes
33. Homogeneity .
34. Discarding and recovering
35. Parameter changes
36. Phase transitions
37. Thermal expansion
38. Strong oxidants
39. Inert atmosphere
40. Composite materials

Note: All 40 principles may apply to solving the contradiction, though statistically the top level solutions for resolving this conflict are identified in the matrix grid based on the selected parameters. More than one set of parameters may apply to the contradiction.

Focussed Search on Ideas for Solution

Two inventive principles that have been used to solve similar contradictions are: composite material and mechanical vibration.

- The *Composite Material* principle provides the basis for a potential radiator concept:
  - Augment the aluminum radiator with copper to increase the thermal conductivity and heat removal.
- Looking into *Mechanical Vibration* and heat transfer, you find that vibration increases turbulence and results in increases of over 20% in heat transfer. This leads to some ideas:
  - Vibrate the entire radiator to promote turbulence in the coolant and air.
  - Create turbulence in the air stream with surface texture on the radiator fins.

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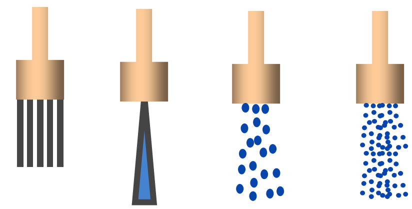
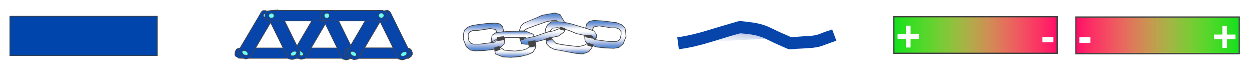
Predictable Path of Innovation: Trends

Example:



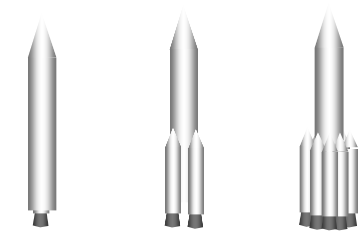
Brush | Pour/Dip Paint | Air Spray | Electrically Charged

Segmentation of tools
– Solids-particles-liquids-gases-fields



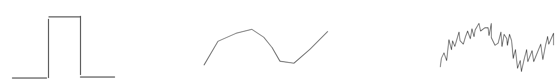
Rigid link | Jointed links | Flex Chain | Cable | Magnetic fields

Dynamization
– Rigid-jointed-chain-flexible-pneumatic-field



Low Thrust | Mid-level Thrust | High Thrust

Mono-bi-poly
– Same function
– Opposite function



Binary On off | Carrier Wave | Carried Signal

Structure of action
– Continuous-periodic-pulsed

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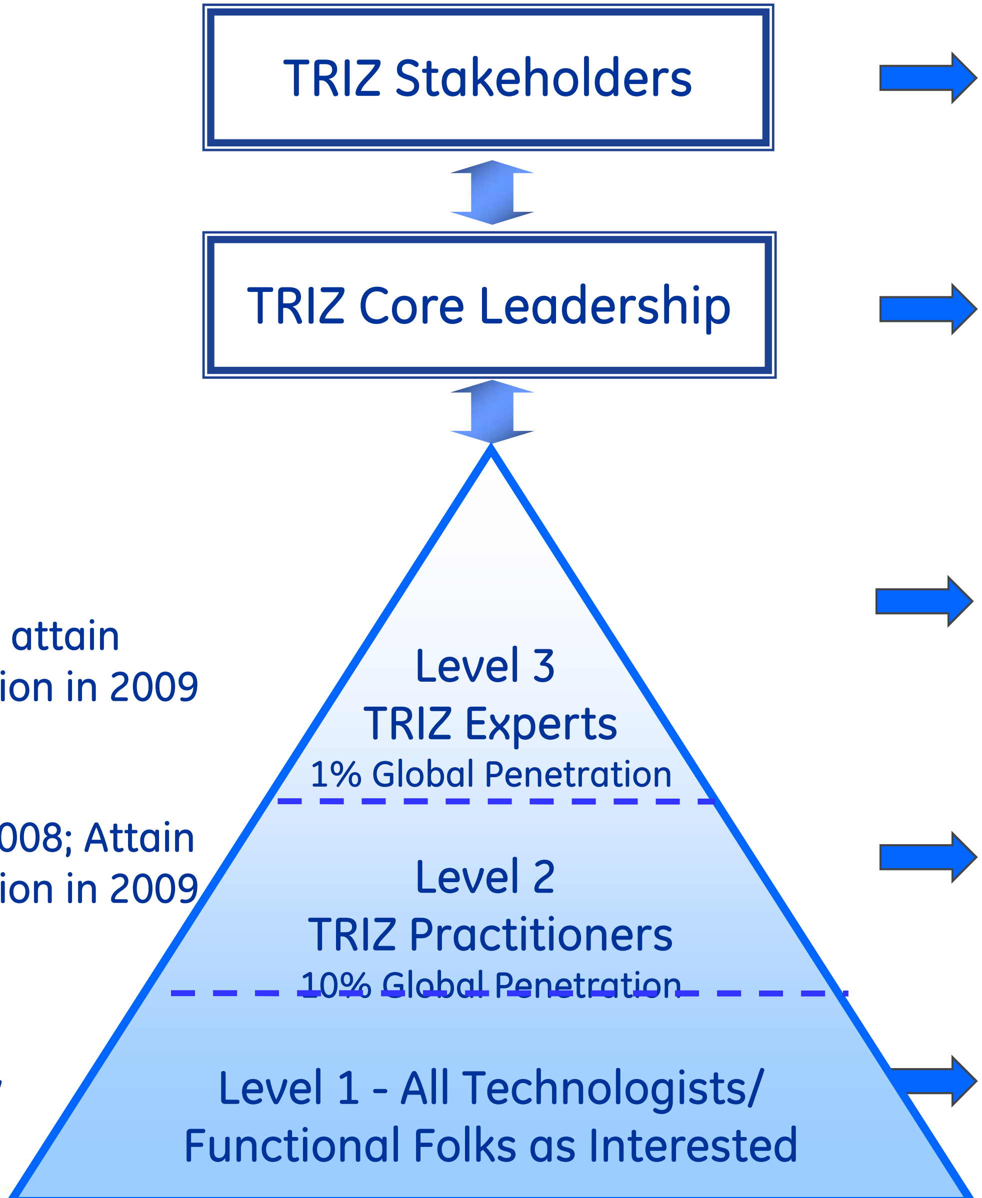
TRIZ at GE

TRIZ Administration at GE Global Research 2008+



Senior Leaders including Global Technology Leaders & BPMs – fully support program

Led by Administrator(s) who are TRIZ experts/mentors - drive all aspects of the program, serve as key points of contact across GRC, responsible for success metrics.

Pilot and attain penetration in 2009

Sought out as TRIZ "Go To" people within their organizations
– Receive Professional Training
- Lead Projects, Mentor Level 1 & 2
- Teach Level 1

Pilot in 2008; Attain penetration in 2009

Lead application of the TRIZ principles in their current role on their current and technically related projects
– Receive Advanced Training
- Lead Projects, Mentor Level 1

Conduct regularly since '08

Have basic comprehension of TRIZ principles
– Receive Basic Training
- Apply to current projects

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Summary

- Basics of TRIZ are Not New – 60+ Years Old
- Based on Successful Patents & Proven Technology
- Process for Creativity and Innovation Beyond Brainstorming Techniques
- Grounded in Fundamental Physics
- Integrates very well into DFSS – fills key gap in Concept Development methods

Innovation Methodology
Based in Science