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TRIMMING & DFA

Finding Synergies

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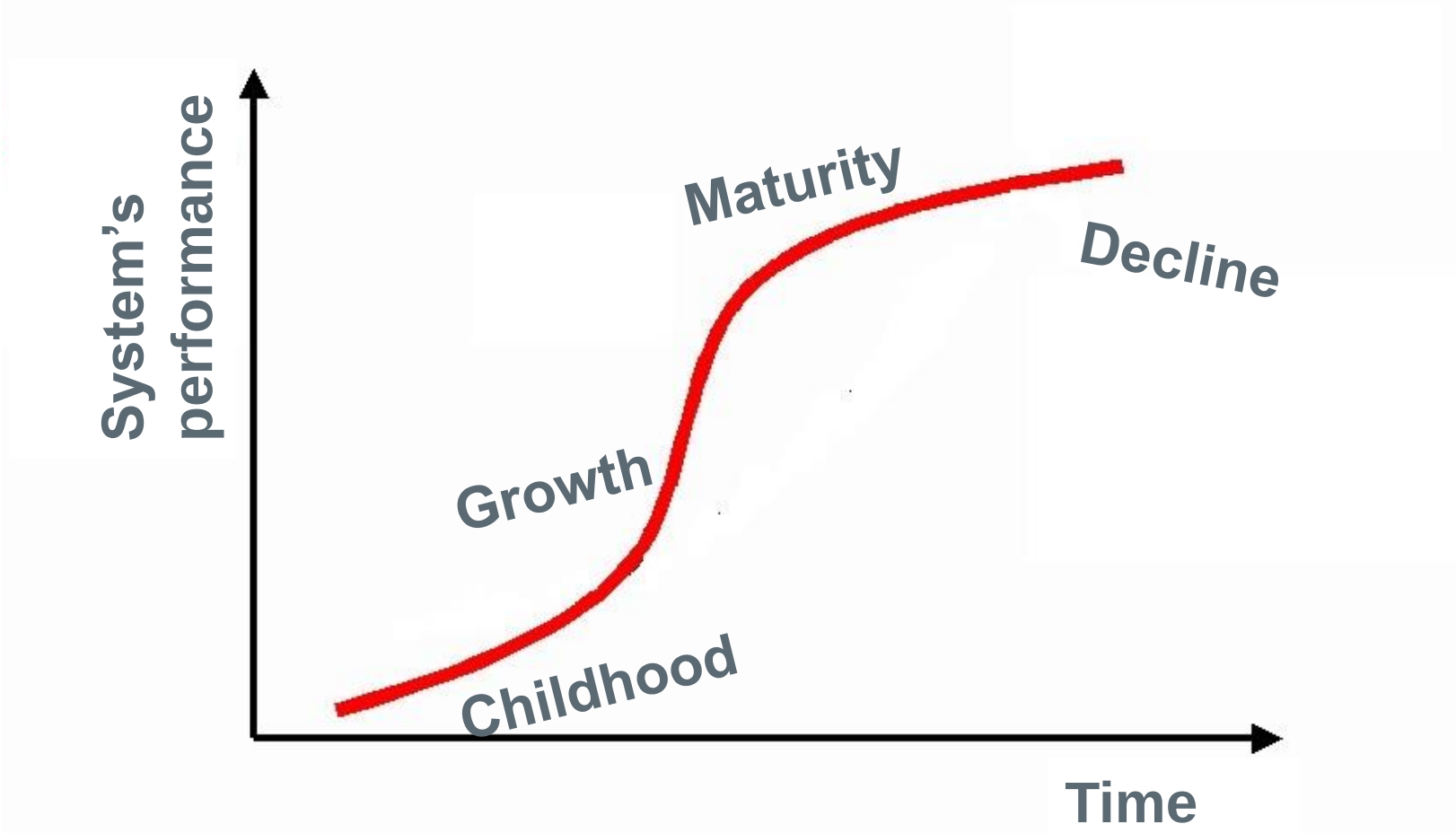
The Primary TRIZ Postulate

- Engineering (technological) systems evolve not randomly, but according to objective patterns developed by Genrich Altshuller (Explained in more detail the paper in the proceedings).
- These patterns can be identified from the patent archives and decisively used for systems development, product design or evolution without numerous blind trials.

System's Performance Evolution

1. Stages Of Evolution: When a new product (system) starts its performance is increased at the expense of simplicity, adding supplementary sub-systems. This is the expansion period of the technical system**.**



System Evolution

- Later evolution is confronted with objective constraints on physical, dated, economical, ecological complications.

- A simplification of the technical system is then required.

System Evolution

- Two techniques are known that help in simplifying:

DFA & Trimming

- Following is a comparison of both techniques, presented looking for possible synergies.

Definitions:

Trimming & Design for Assembly

- **Trimming** is removing elements or replacing parts, features, or the components functions with other constituents.
- **DFA** is related to trimming in that most times you need to remove parts to make product easier to assemble, easier to repair and more competitive.

DFA

Minimum Part Criteria

The main function of Design for Assembly is helping in identifying the ways for simplifying the structure of the systems by minimizing the number of parts and to streamline the assembly, design and or manufacturing processes.

DFA Minimum Part Criteria

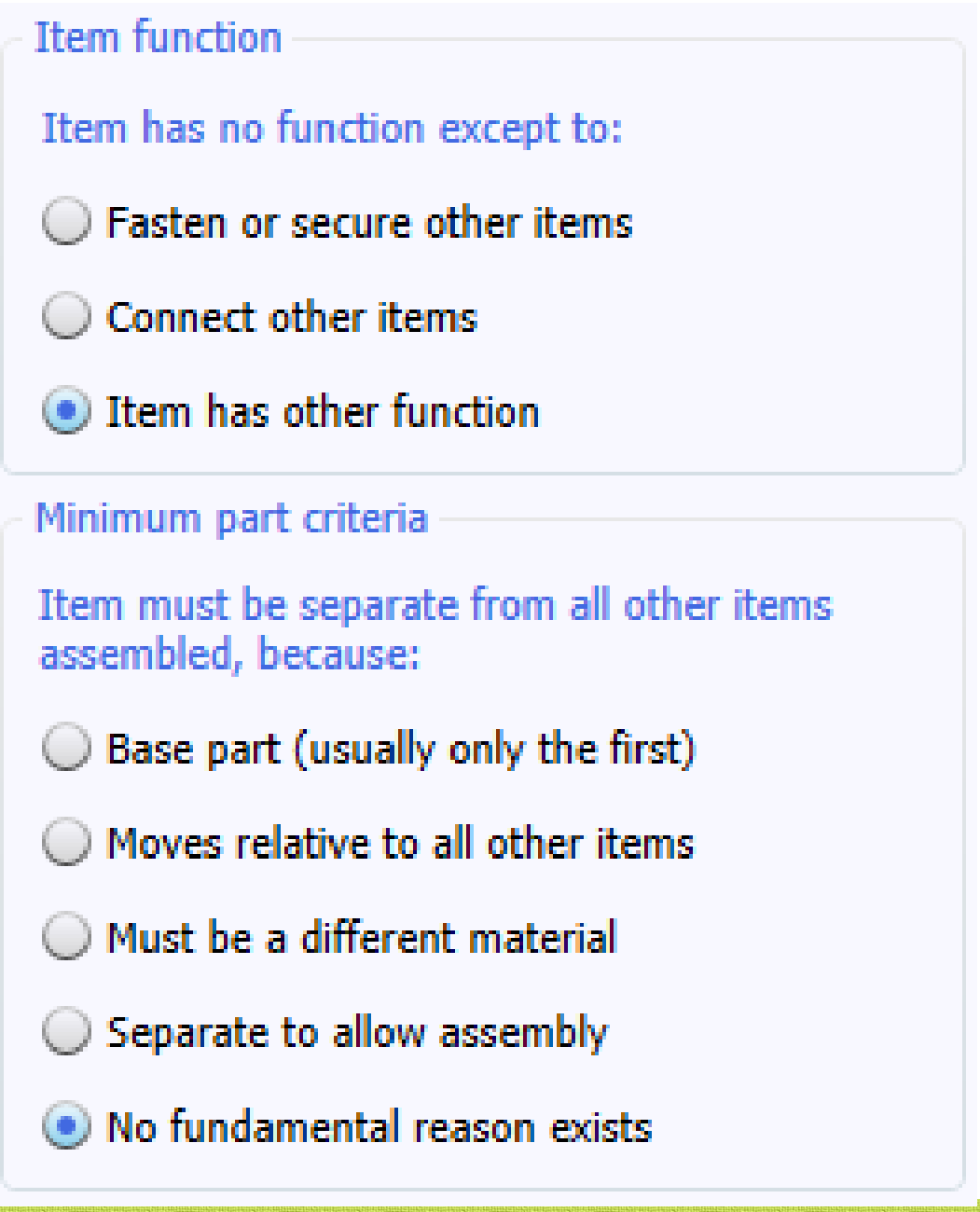
1. Is it the base part, or must the part be separate from other parts for purposes of assembly or disassembly?
2. Does the part move relative to other parts already assembled?
3. Must the part be of a different material or be isolated from the other parts already assembled?
4. Can parts or operations be eliminated & their functions be incorporated in other parts?

Minimum Part Criteria

Candidate for Elimination

Theoretically Necessary

Candidate for Elimination



TRIZ TRIMMING

The TRIZ trimming concept means that a component of a system or a process is eliminated and its useful functions transferred to other components.

Function model: definition

- A function model describes the relationships between system elements in terms of the functions that they perform.
- When a function model represents a device, it captures what each component of the device does, as well as how well it does it, to promote the overall goal of the device.

Function model

- Furthermore, the function model captures the unnecessary and harmful functions that are also performed, or the poorly executed required functions.
- Note: The function model is not a flowchart, but it might look like one. The function model does not capture WHEN the various interactions occur in time. Instead, it emphasizes all the states or relationships of the system throughout its operation cycle.

What component to trim?

- The trimming decision may be made based on the three inputs:

1. functional significance,

2. cost and

3. the “headache index”, which is an integral measure of complications related to operation and maintenance of the component.

Functional Significance

- The **target** of a device is the primary reason why the device was designed.
- The main function of a device is performed on the target.
- The target is an element that exists outside the device that you are analyzing.
- Use the following guideline to identify the device target: The target is the recipient, or the object, of the main function of an engineering system.

Function Rank

- The Function Rank is an indicator of the relative importance of the functions that are performed by the device components .
- The components that function on the target most directly are considered to be more valuable in the device, and have the highest Functional Rank.

What component to trim?

One of the trimming rules can be formulated as follows:

- " If functional significance of a component is low, and its cost is medium, and its trouble index is medium, **then it is a likely candidate for trimming".**
- This is usually done by ranking components on a scale from 0 to 1 (or, 0 to 100), with the first candidate to be trimmed having the highest rank (the largest number).

Function Rank

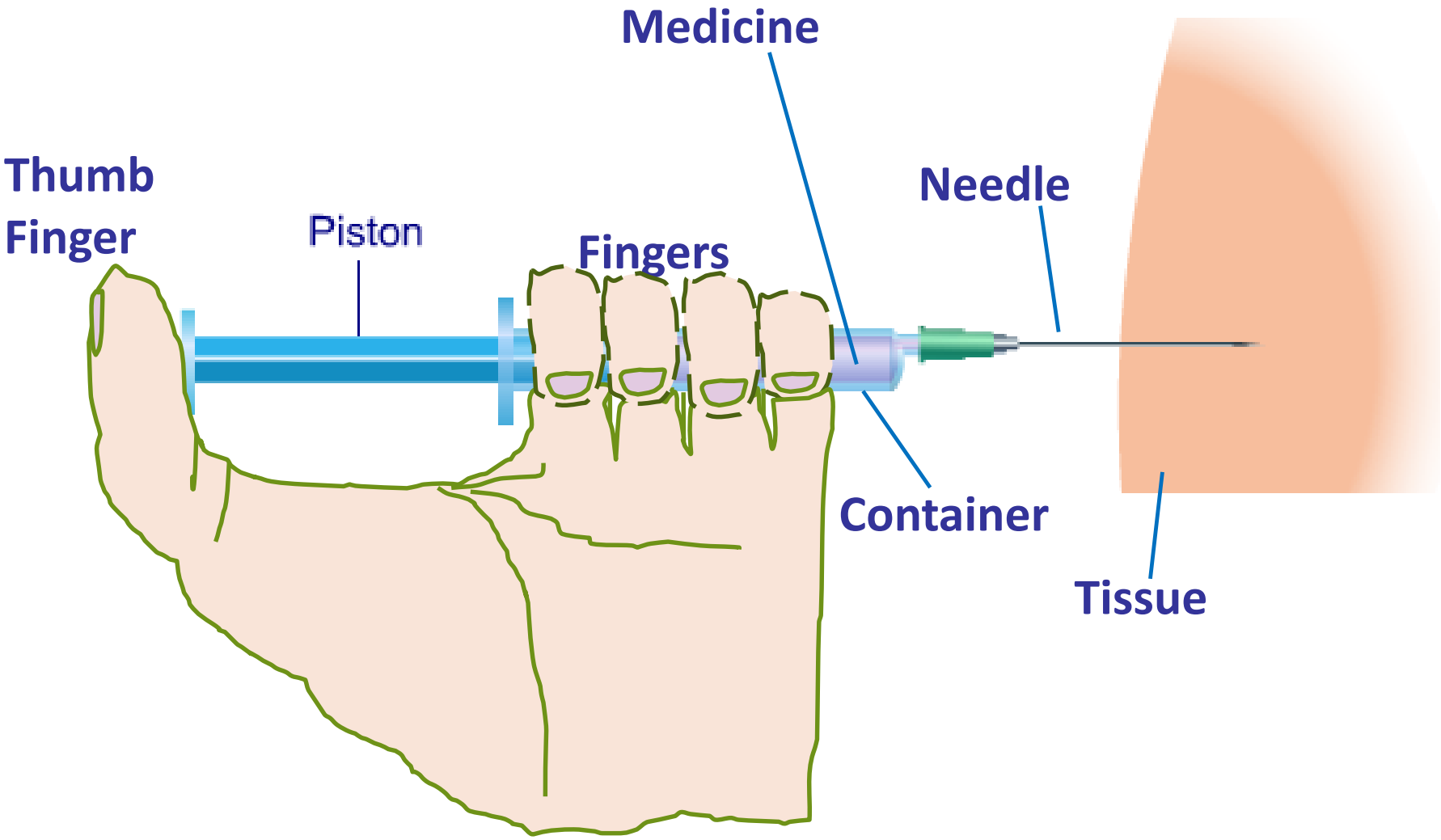
- If a component is "functionally distant" from the target (that is, it acts on the target through many other model elements), it is considered less important to the device and is therefore assigned a higher priority for being simplified (or trimmed) from the design.

Example: Toothbrush

- What is the main function of a toothbrush system?
- Contrary to everyday thinking, it is not to brush teeth. If you consider teeth carefully, no parameter of the teeth is modified by the toothbrush.
- In fact, the toothbrush is designed to act on the plaque which coats the teeth.
- Plaque is the element on which the toothbrush acts directly.

- Therefore the main function of the toothbrush system is to remove plaque.
- The parameter of the plaque that is affected by its removal is the amount of plaque.
- Since plaque is the object of the main function, it is the target of this system.
- A system can have several main functions, and therefore it can have multiple targets.
- For example, a toothbrush can also be designed to massage gums.

Example Syringe



Device model: definition

- A device model is an abstract representation of a device in terms of its components and its environmental elements (or elements of the super system), as well as the functions that are performed by these elements.

Device Model Syringe

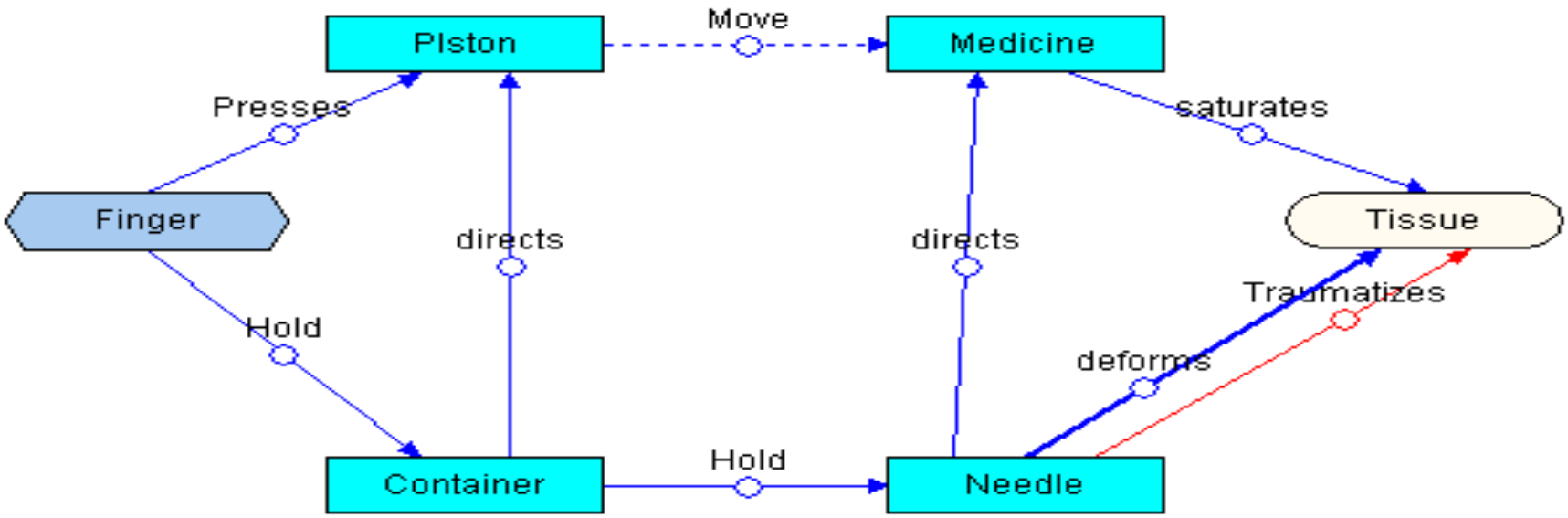
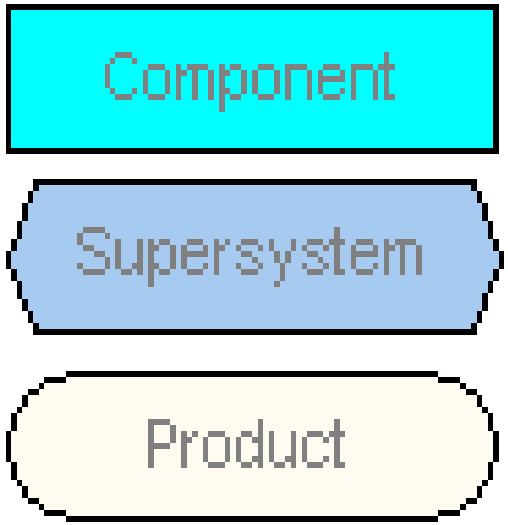


Diagram Symbols

Elements



Actions

useful normal action

useful insufficient action

useful excessive action

useful action with parameters

harmful action

harmful action with parameters

Table of interactions

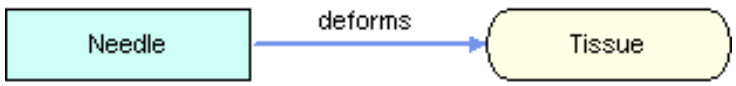
Interaction matrix	Finger	Needle	Tissue
Finger			
Needle			EH
Tissue		EH	
Medicine		U	U
PIston	U		
Container	U	U	

Legend

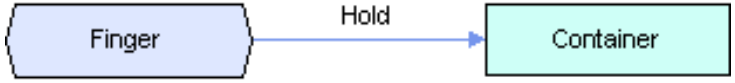
U	useful interaction
I	useful insufficient interaction
E	useful excessive interaction
H	harmful interaction

Link Analysis

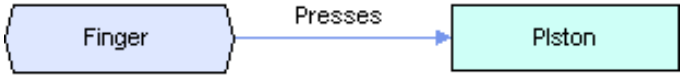
Useful action **deforms**



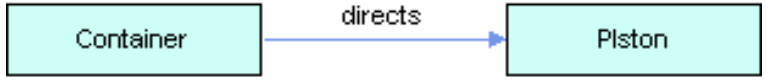
Useful action **Hold**



Useful action **Presses**

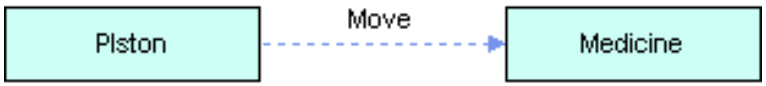


Useful action **directs**

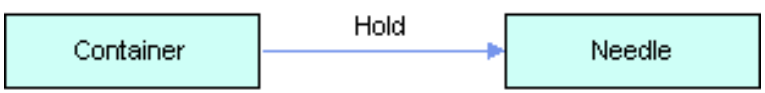


Link Analysis

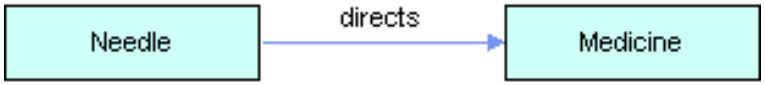
Useful action **Move**



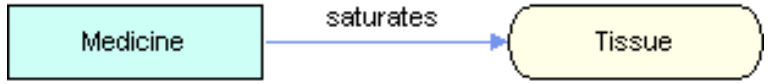
Useful action **Hold**



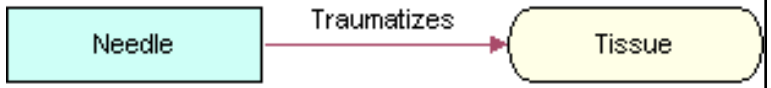
Useful action **directs**



Useful action **saturates**



Harmful action **Traumatizes**



Link Analysis Matrix

Element	Action	Target Node	Rank	Performance
Finger	Hold	Container		adequate
	Presses	PIston		adequate
Needle	deforms	Tissue	B	n/adequate
	directs	Medicine	A1	adequate
	Traumatizes	Tissue	H	
Medicine	saturates	Tissue	B	adequate
PIston	Move	Medicine	A1	n/adequate
Container	directs	PIston	A2	adequate
	Hold	Needle	A1	adequate

Legend

B - basic function

An - auxiliary function of rank **"n"**

H - harmful function

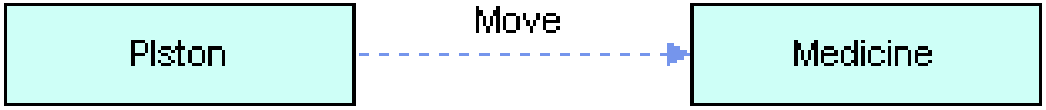
Problem list

Problem List Table

Nr	Name	Group
3.1	Improvement of "deforms" (Needle - Tissue)	Efficiency increase
3.2	Improvement of "Move" (PIston - Medicine)	Efficiency increase
4.1	Elimination of "Traumatizes" (Needle - Tissue)	Quality increase

3.1 Problem name: Improvement of "deforms" (Needle - Tissue) *Problem description:*

3.2 Problem name: Improvement of "Move" (Plston - Medicine) *Problem description:*



Functional Parameters of components

Function Rank

	Value
Container	5.00
Medicine	10.00
Needle	6.50
PIston	3.33

Problem Rank

	Value
Container	0.00
Medicine	0.00
Needle	10.00
PIston	5.19

Cost Rank

	Value
Container	0.09
Medicine	0.05
Needle	0.06
Piston	0.12

Trimming Criteria

Maximum Value

- V = F*F/(P+C). The most valuable components have the highest Function Rank and the lowest Problem Rank and Cost. To use this formula, you must enter the approximate values or actual values of the Cost parameter for each component.

Minimum Cost

- V = 1/C. The highest-rated components have the lowest Cost. To use this formula, you must enter the values of the Cost parameter for each component.

Minimum Problems

- V = 1/P. The highest-rated components have the lowest Problem Rank. Since the Problem Rank is calculated automatically by the software, you do not need to enter any values manually.

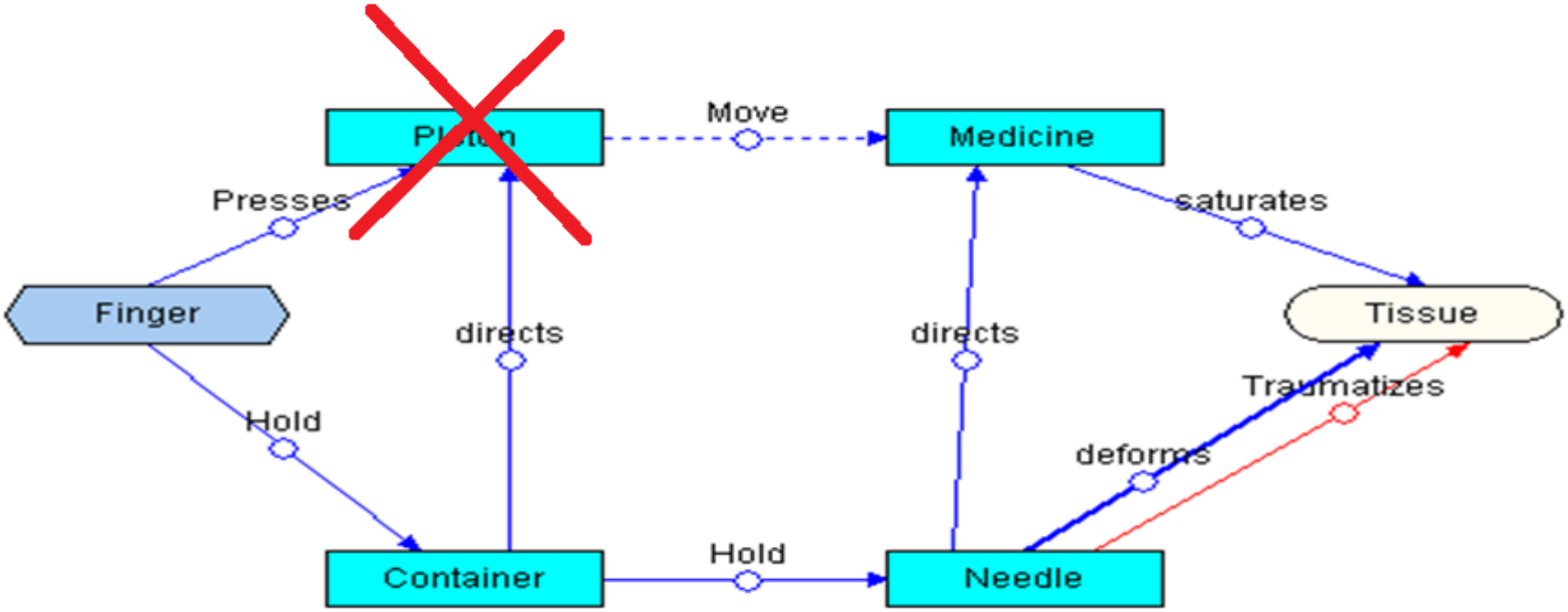
Device analysis steps

- In this step you do the following:
  - Define the parts of the device and their interactions
  - (Optional) Define any custom diagnostic parameters for the model components and enter their values (most likely you'll find the predefined parameters are sufficient)
  - Select or define the formula that will be used to calculate the relative value of the components in your model.

Solve in Solution Manager.

- In this step you solve problems, validate concepts, and rank solutions either by hand or using software.
- This example was run using Solution Manager in Goldfire Innovator Software from IHS.

Functional Model Syringe



Piston less Syringe

3.1 Problem name: Elimination of "Traumatizes" (Needle - Tissue)

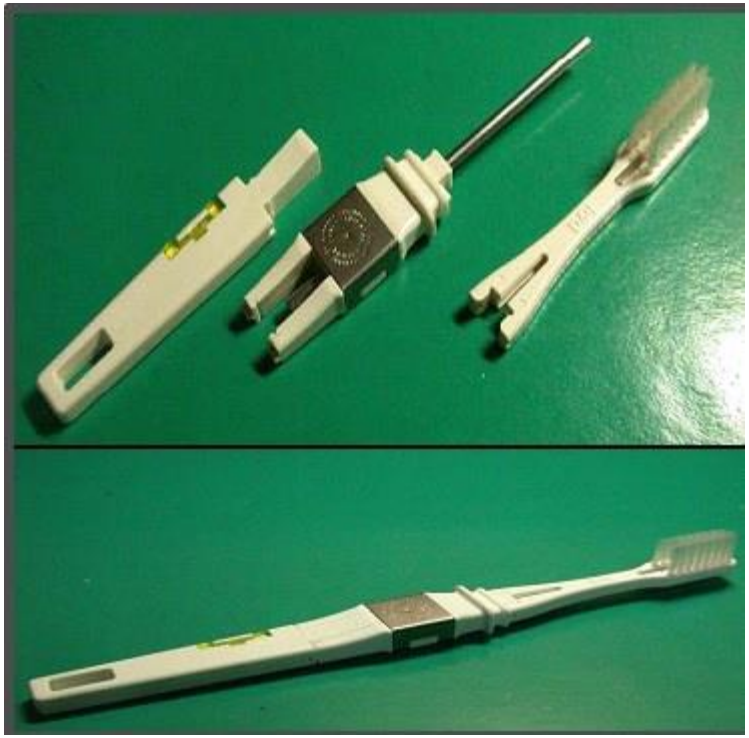
Problem description:

How to eliminate function Traumatizes Tissue?

KEY TAKE AWAY- Function Models got you to this point.
The Needle actually traumatizes the tissue.
This a Problem Statement.

That is something your TEAM can find solutions for instead of just making smaller and sharper needles!

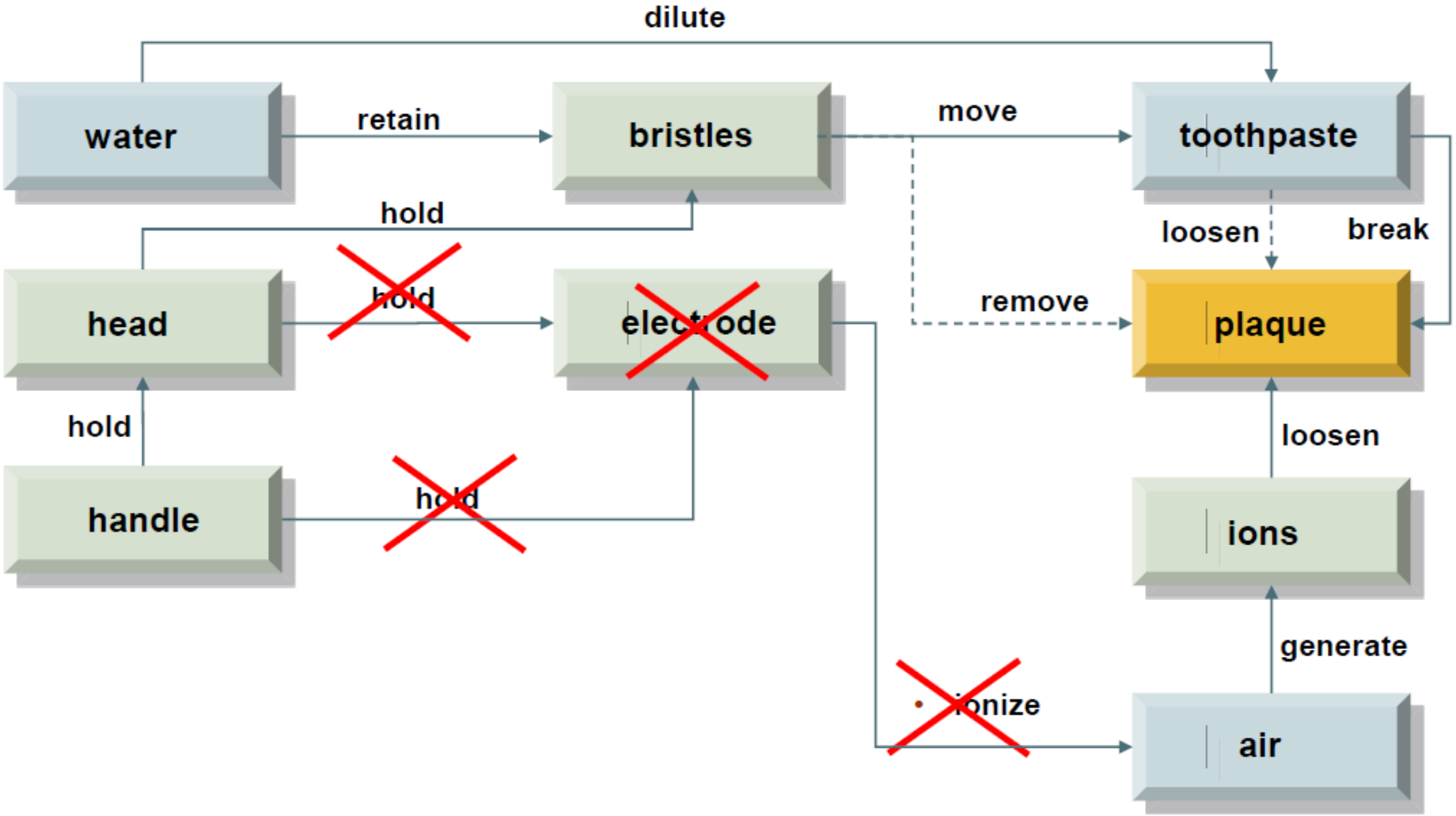
Example: Ionic Toothbrush (*)



- A toothbrush described in a patent, consists of a head containing bristles, and a handle that holds the head.
- The handle and head also hold an electrode that is powered by a battery inside the handle
- The electrode ionizes air and aids in easy plaque removal

(*) With permission from TRIZ for Patent Strategies from Sergei Ikovenko, TRIZ Master ,Dr-Eng, PhD, professor (adjuncts), MIT

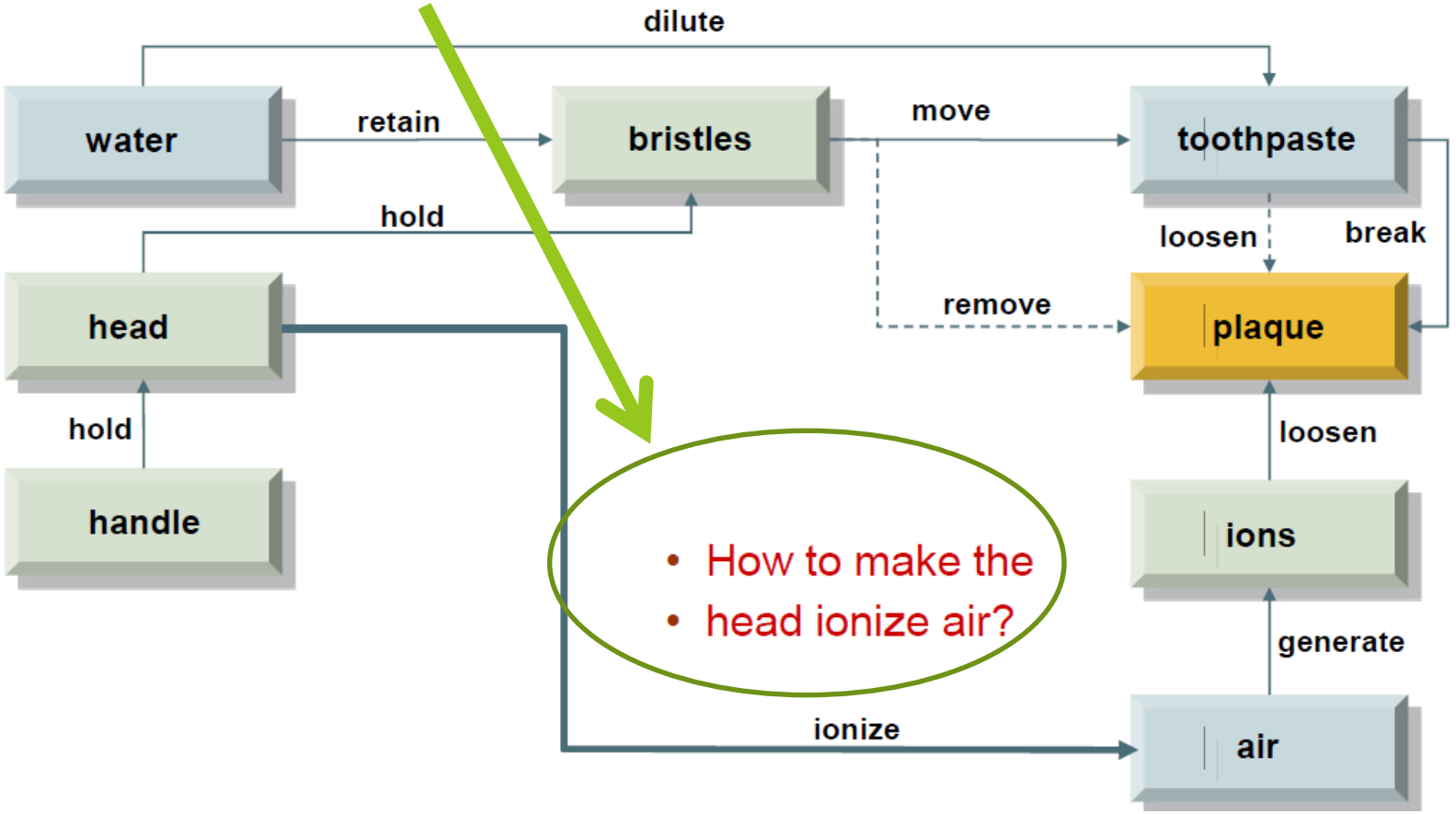
Ionic Toothbrush: Function Model and Trimming



(*) With permission from TRIZ for Patent Strategies from Sergei Ikovenko, TRIZ Master ,Dr-Eng, PhD, professor (adjuncts), MIT

Ionic Toothbrush: Function Model and Trimming

KEY TAKE AWAY- Function Models help show what needs to be solved now. NOT "HOW to remove plaque." Plaque removal will be end result! This Problem Statement can change a team's direction and approach to solving this problem. How to ionize something is a different direction your TEAM will research instead of just creating new bristles.



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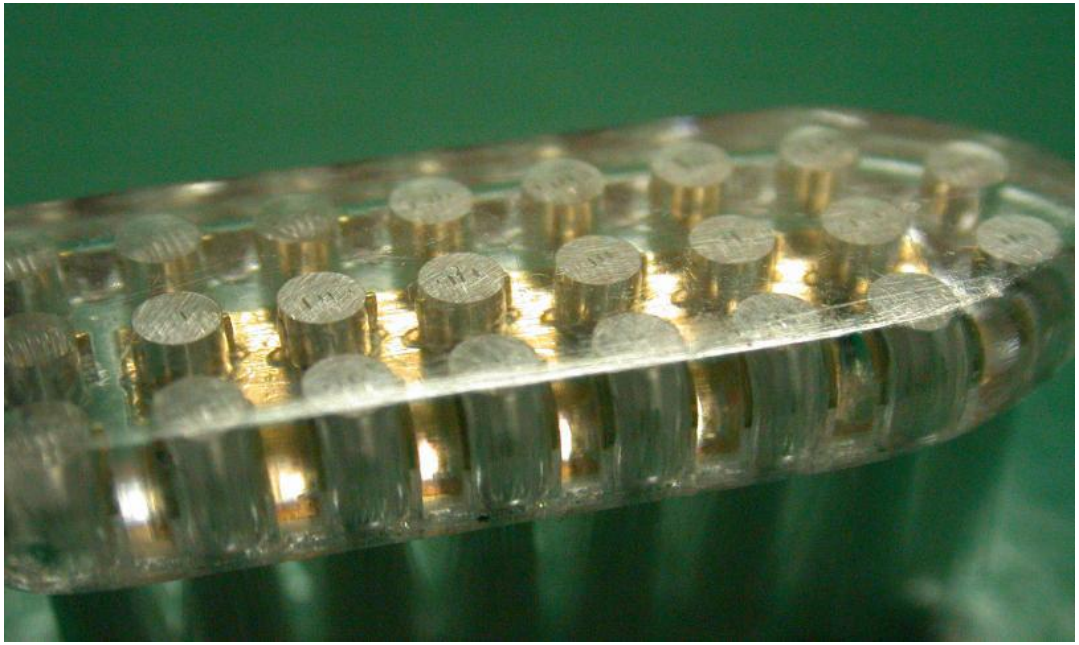
Solution



The toothbrush head surface is covered with an alloy that, when in contact with toothpaste and water, works as an active couple and generates voltage.

As a result, the head itself ionizes the air near the plaque.

(*) With permission from TRIZ for Patent Strategies from Sergei Ikovenko, TRIZ Master ,Dr-Eng, PhD, professor (adjuncts), MIT

Example Labels

Problem: Labels fall off power tools over time & don't stick well to plastic housings.

DFA-Mold or cast the label information in the plastic housings, no need to assemble label, because the label is part of the housing now produced at injection molding process level and now permanently marked, no need for label, no label storage, no concern about loss and no mis-labeled products.

Example: Metal Frame of solar panel

Problem: Metal Frame of solar panel are difficult to assemble, screwed together, glued or taped to glass panel and must be grounded to metal frame (rack) on roof.

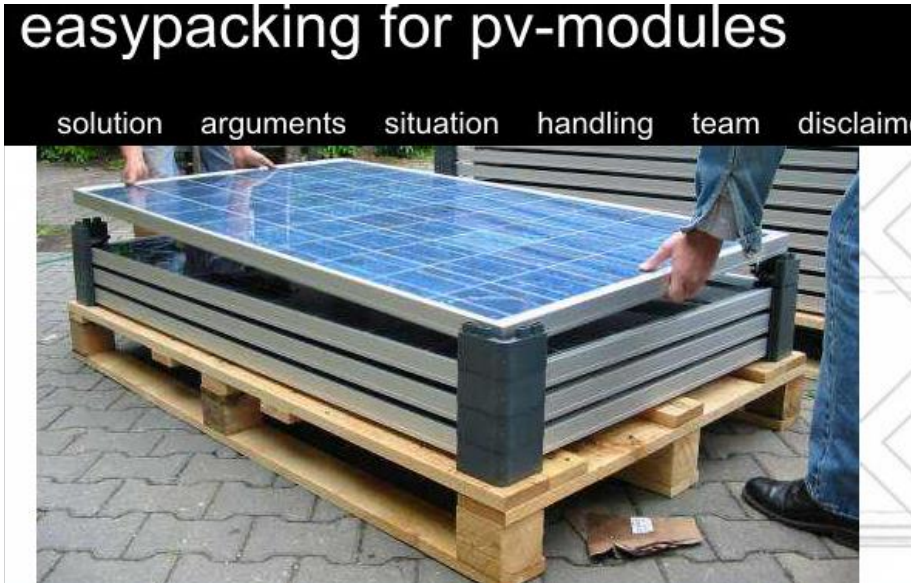
DFA-What if glass was formed in Pyrex cake pan shape? Now glass could act as frame as well. No need to ground (since no metal frame), no glue, no screws, and no frame assembly.

Huge cost savings.

TRIM and DFA

Solar Frame Assembly & Packaging Issues

- **Trim “un-needed” parts to evaluate what could be eliminated in solar panel design and solar panel packaging for DFA.**



Recommendations

- Implement DFA, and TRIZ Trimming
- Lunch-n-Learns with diverse teams, breakdown problems and the company's walls.
- Find and use problem solving Champions & successes to spread the word within your company.
- Break problems down to functions (nouns) and list relationships between components into Useful, Harmful, Necessary, Adequate, Inadequate actions (verbs).

Recommendations

- Conduct more internal specific DFMA, Trimming, and TRIZ related training and use it when problem solving.
- Identify Action Words used in your industry: heat, vibrate, excite, support, burn, insulate, corrode, dissolve, align, isolate, penetrate, detonate, wear, hold, reflect, contain, protect……
- Identify Functions that are reoccurring issues, then start with your of components around that problem component or area.

Recommendations

- Create Function Models for your problem areas, your most challenging processes, the habitual RCAs, the company's or vendor's most costly parts or assemblies.
- You know which parts I am talking about, and you're thinking about them right now.

Conclusions:

- DFA, TRIMMING, and TRIZ along with other simple methods of problem solving and function modeling can help you and your company produce better products in less time, that cost less to produce, manufacture and assemble.
- Better, Cheaper, Faster and more Robust- If you are not doing it for your industry's products, your competitors probably are.

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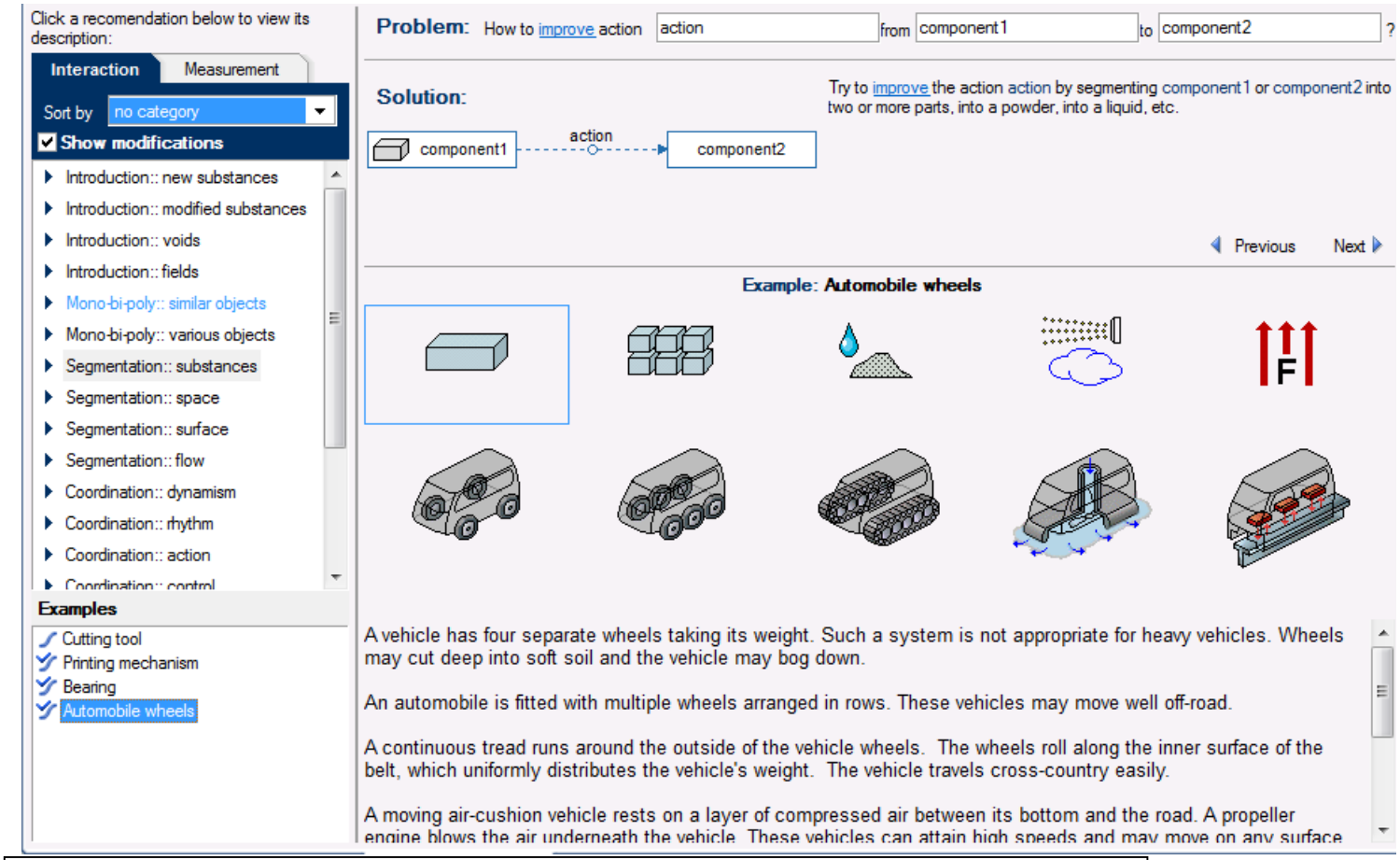
- IHS Engineering 360, Inc. makers of Goldfire Innovator Software
- Altshuller Institute for TRIZ Studies, Worcester, MA

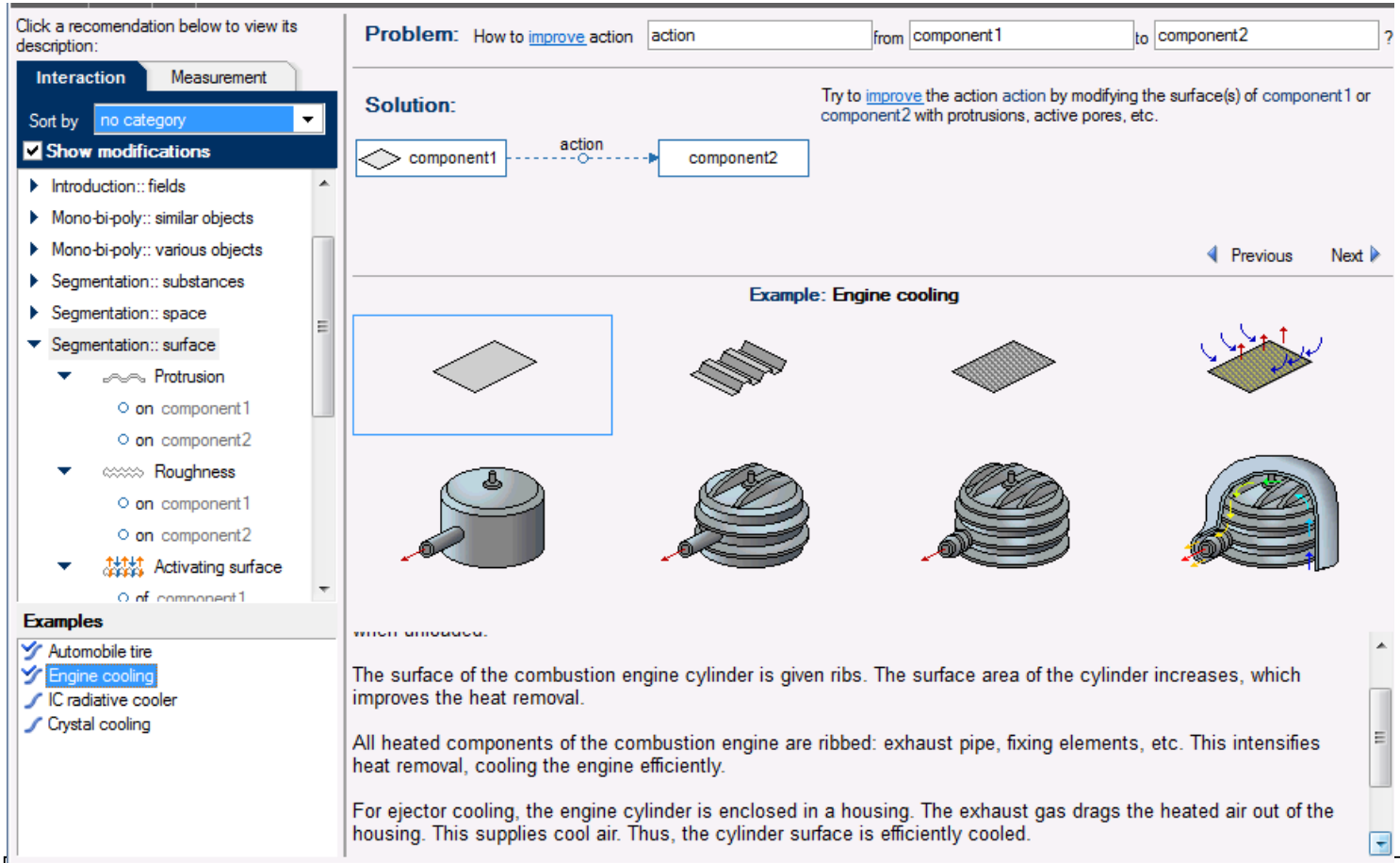
Questions:

TRIZ-19 kinds of System Modification Patterns to “predict” future evolutions



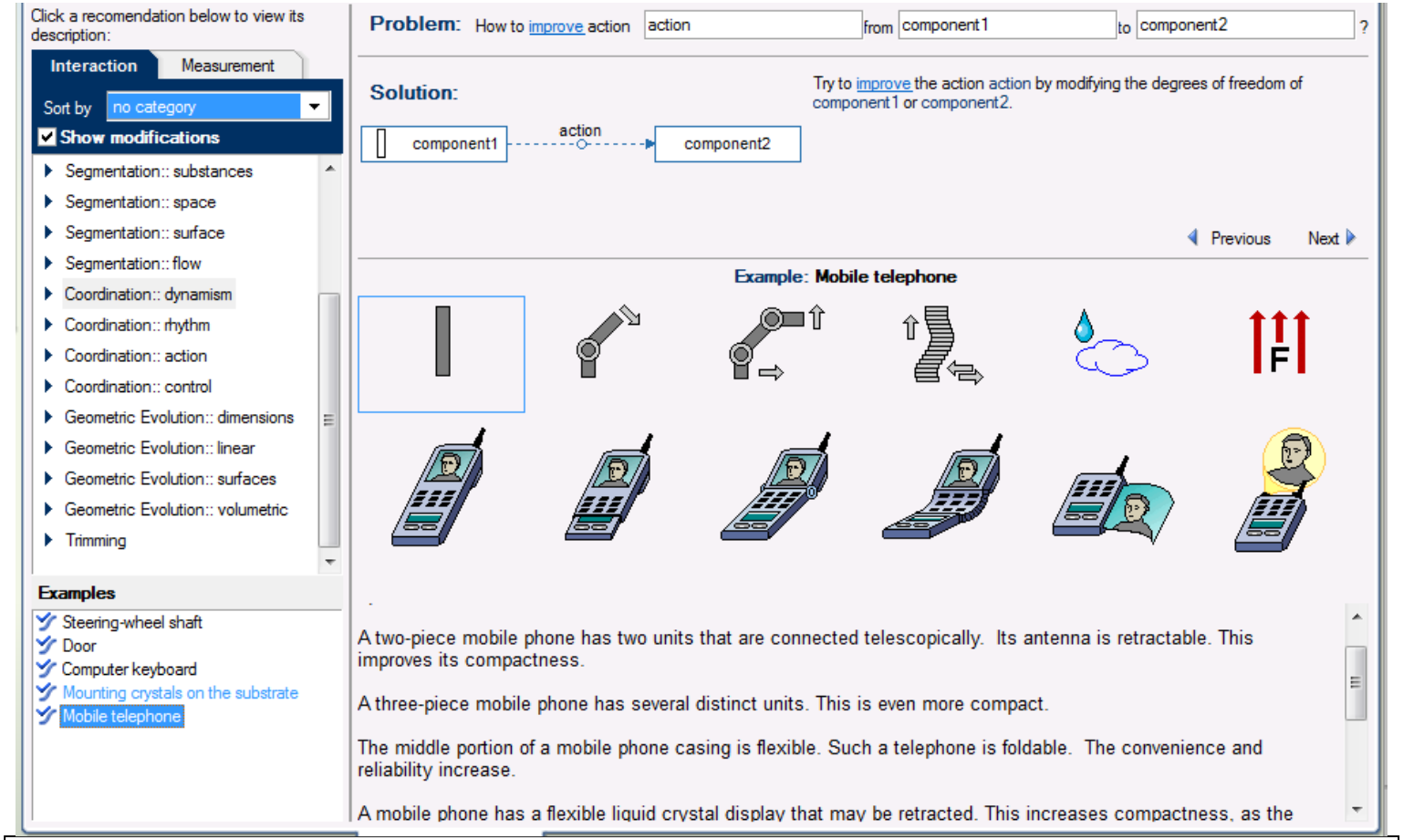
TRIZ Patterns of Evolution for IDEAS

TRIZ-System Modification Patterns to "forecast" future evolutions of your designs



TRIZ Patterns of Evolution for CONCEPTS

TRIZ-System Modification Patterns to "imagine" your Competitor's future evolutions



TRIZ Patterns of Evolution for PRODUCTS

What is TRIZ? How are Trimming and DFA Related?

- Recommended Book: "***And suddenly the inventor appeared: TRIZ, the theory of inventive problem solving***"
  - Altshuller, G. (2004), Worcester, MA Technical Innovation Center www.aitriz.org

- TRIZ originated in USSR developed by Genrich Altshuller (1926-1998).
- After WWII, the Soviet Government agreed to give the German Patent Library to the US in exchange for various pieces of industrial equipment. Altshuller claimed equipment will be worthless in 20 years, but the patents would remain valuable for MANY years past the 20 years.
- TRIZ is considered an empirical method of innovation. Step by step methodology that can lead to a repeatable process. It is based upon an exhaustive patent search that was conducted by Altshuller.
- Its premise is innovation can be taught.
- This goes contrary to popular opinion. Most people feel innovation is emotionally based and only happens as a Eureka! moment. That it cannot be structured and you must be gifted with a creative mind.

Trimming and DFA are both ways to approach an Ideal Final Result, the best or most simple way to do something.

Facing a contradiction- begin with identifying some of the 39 TRIZ engineering parameters

What physical things can change, what can designers CHANGE?

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. Reparability
35. Adaptability
36. Complexity of device
37. Complexity of control
38. Level of automation
39. Productivity

What Parameter improves and which parameter worsens as a result?

Select which parameter number is improving, and which is getting worse.

TRIZ-Contradiction Matrix to Generate Ideas You Can Use the 40 Principles

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

Ways or concepts to make those changes or to spark NEW ideas

Note: Multiple principles may apply to solving the contradiction, the top level solutions for resolving this conflict can be identified in a matrix grid. More than one set of parameters may apply to the contradiction.

TRIZ-use the 19 kinds of System Modification Patterns to "predict" future evolutions

Shows Patterns of Evolution

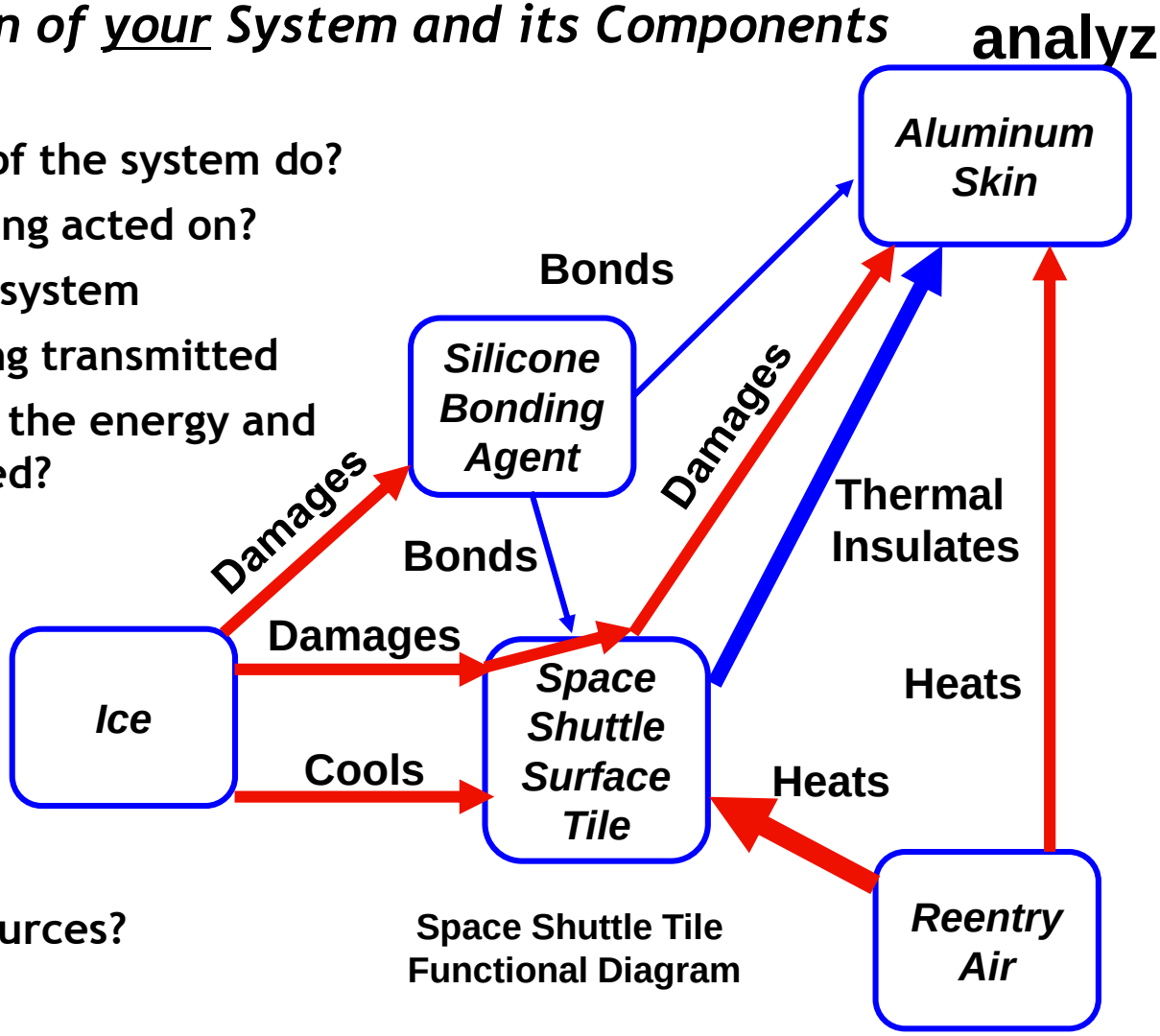
1. Introduction: New Substances
2. Introduction: Modified Substances
3. Introduction: Voids
4. Introduction: Fields
5. Mono-BI-Poly: Similar Objects
6. Mono-Bi-Poly: Various Objects
7. Segmentation: Substances
8. Segmentation: Space
9. Segmentation: Surface
10. Segmentation: Flow
11. Coordination: Dynamism
12. Coordination: Rhythm
13. Coordination: Action
14. Coordination: Control
15. Geometric Evolution: Dimensions
16. Geometric Evolution: Linear
17. Geometric Evolution: Surfaces
18. Geometric Evolution: Volumetric
19. Trimming

Goldfire Software has these TRIZ patterns with examples

Analyze the Problem – Use Functional Models

Understand the Function of <u>your</u> System and its Components

- What does the system do?
- What does each element of the system do?
  - What is the object being acted on?
- What is the energy in the system
  - How is the energy being transmitted
  - What tool is delivering the energy and how is it being controlled?
- Are the actions
  - > Useful?
  - > <u>Harmful?</u>
  - > Necessary?
  - > Adequate?
  - > <u>Inadequate?</u>
- Where are there idle resources?



Space Shuttle Tile Functional Diagram

KEY TAKE AWAY- Build and Use Function Models

1. What is a Function Model?

A visual pictogram that breaks a problem down to its key component features and then links relationships of one feature to other features.

2. When and Where should you use Function Models?

Product Design, Competitive analysis, Value analysis, cost savings, understanding steps in current Systems or Process or Product RCAs, **Trimming,** FMEAs, problem solving, **DFA**, DFM, LEAN, **TRIZ**, and Project Management.

3. Why should you use Function Models?

Break problem down to solve-able pieces and use digital public domain and existing corporate knowledge to help you find cause and effect relationships. Helps everyone UNDERSTAND the relationships components have on each other and the systems.

4. Who should use Function Models?

Engineers, managers, designers, marketing, manufacturing

5. How much could companies save using Function Models in daily problem solving?

10-20% of Research analysis and problem solving could = $millions per year