USING “TRIZ” TO MAKE SYSTEMS MORE RELIABLE

WNY Society of Reliability Engineers

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Agenda

- “TRIZ”: What is it and how does it apply to improving reliability?
- TRIZ Principles
  - Ideal Final Result
    - Trimming and resource use
    - Separation principles
  - TRIZ in reverse: Predictive Failure Analysis™
- Recommendations and resources
- Q&A
What is “TRIZ”? 

A Russian acronym:
Theoria Resheneyva Isobretatelskehuh Zadach

(Theory of Solving Inventive Problems)

What are these?
The History of TRIZ

- Result of work by a brilliant patent examiner for the Russian navy, Genrich Altshuller, late 1940’s to early 1950’s
- Originated from the study of thousands of the world’s most inventive patents--now in the millions
- Methodology emigrated to the west after Perestroika (~1990)
- Recognized that development of technological systems followed predictable patterns that cut across ALL areas of technology--the speed of technical evolution can be accelerated. **Invention and problem solving are learnable sciences and not governed solely by genetics and being in the shower! There is an algorithm!**
- Established schools to teach after a Stalin 5+ yr. prison term--deceased in 1999 at age 71
Algorithms: Generalizing Problems in Math

It’s Rome, 1100 A.D...

Specific problem

\[3x^2 + 5x + 2 = 0\]

Specialized solution

\[x = ???\]

**ALGEBRA DOES NOT EXIST--HOW DO WE SOLVE?**
Generalizing Solutions

Problem Solving Principle Example

Abstract problem

\[ ax^2 + bx + c = 0 \]

\[ \text{Abstract solution} \]

\[ x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \]

Specific problem

\[ 3x^2 + 5x + 2 = 0 \]

\[ \text{Specialized solution} \]

\[ x = -1, -\frac{2}{3} \]

**TRIZ DOES FOR PROBLEM SOLVING AND FORECASTING WHAT ALGEBRA DOES FOR EQUATION PROBLEM SOLVING!**
TRIZ: What is it?

• A “left brained” problem solving process
  • Based on the study of the inventive patterns in the breakthrough global patent literature
  • 40 Inventive Principles
  • Algorithm (as in algebra)
    • Vs. “brainstorming”, psychology, and “quantity”
    • Effort spent in problem definition vs. evaluating large quantity of irrelevant solutions
• Generalized problem models and solutions
  • Su-Field, cause and effect
Visualizing Contradictions

Parameter A

- Good
- Bad

Parameter B

- Bad
- Good

Normal Design Tradeoff or Current Performance Barrier Curve
Constant Design Capability

TRIZ Moves Performance Barrier Curve away from the origin
Examples

- Reflux ratio on distillation column
- Safety factors
- Amount of ice melting salt
- Number of wheel bolts
- Surface active agents
- Organizational communication
- Safety inspections
## TRIZ Contradiction Table

<table>
<thead>
<tr>
<th>Undesired Result (Degraded Feature)</th>
<th>1</th>
<th>2</th>
<th>14</th>
<th>38</th>
<th>39</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feature to Improve</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight of Moving Object</td>
<td></td>
<td></td>
<td>28, 27, 18, 40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight of Nonmoving Object</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strength</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level of Automation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Productivity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Possible contradictions represented in 39 x 39 table
- Intersections of contradicting rows and columns are references to 40 inventive principles for contradiction elimination

**Proposed Solution Pathways:**

- 28 Replace a mechanical system with a non mechanical system
- 27 An inexpensive short-life object instead of an expensive durable one
- 18 Mechanical vibration
- 40 Composite materials

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Contradiction Table

- Contradiction table
    - Has been updated in the past 5 years to a 48X48 table

- Useful for simple contradictions that are obvious

- Modeling and software tools available for complicated systems
How Does This Apply to Reliability?

- Great emphasis in TRIZ on elegant simplicity in product, system, or service design
  - “Ideal Final Result”
  - Something performs its function and doesn’t exist
    - If something doesn’t exist, it is 100% reliable
    - Doesn’t require maintenance or monitoring
  - A function controls “itself”
  - A resource that is totally reliable and predictable
    - Ex: gravity
The Boeing Corporation

What’s the Best Way to Hoist Seats up into the Body of a 757 Jet?
Hoists and Chains? Maintenance and Reliability?

If you’re a MechE, don’t you just *love* to design this stuff? Maintain it?
Lean Times: With Airbus on Its Tail, Boeing Is Rethinking How It Builds Planes Old Hay Loaders, New Resins Play Roles as Firm Tries To Build Faster, Cheaper

09/05/2001 The Wall Street Journal (Copyright (c) 2001, Dow Jones & Company, Inc.)

RENTON, Wash. -- Not far from the steady blatt-blatt of the rivet guns on its 757 assembly line just outside Seattle sits what Boeing Co. calls its moonshine shop: The people here distill work-saving ideas into contraptions that make it easier to build jets.

Consider the hay loader next to an almost-completed 757. Normally, this cross between a ladder and a metal-spiked conveyor belt would be dumping bales of hay onto waiting trucks. **But to veteran mechanic Robert Harms, the hay loader is the perfect way to get bulky passenger seats from the factory floor up 13 feet to the door of a plane without having to use an overhead crane. **"It might look funny, but when you see it work, you wonder why we didn't do it this way all along," he says.
Mr. Harms, the 52-year-old mechanic who led the effort to modify the hay loader to move seats, recalls the day when he arrived for work and found a note attached to his contraption. It read: "Idiots running amok."

"That sign kind of serves as our inspiration because once it started running, that loader has made believers out of people," he says.

Gordy Laborde, a 48-year-old mechanic who has been installing interiors in Boeing 757s for 13 years, counts himself among the converted. "I looked at that hay loader from every angle and I could not see how it was going to work. You do something for so many years one way, and something like this really takes you out of your comfort zone."
Boeing Discovers Hay Loaders... Reliability vs. Overhead Crane Systems?

Question: If you were a Boeing engineer, would you ask and would your boss let you go to an agricultural equipment show?
Ball Bearings: They *have to work!*

You are in the ball bearing business and want some new ideas for monitoring and controlling quality and uniformity—where would you look?
Ball Bearings: How Inspected?
Caviar Eggs
Caviar and Bearings
Inspecting Caviar Egg Hardness (Used Since 1945)

Eggs

The real hard eggs bounce up and over
Two Key Questions

1. How reliable is gravity?

2. Does it require any maintenance or inspection?
Gravity is Discovered.....Again
MACHINE REPLACES MAN

CASE STUDY

A robot was brought to a plant to operate a machine. After it was rigged up and switched on, the elderly worker who had operated the machine for years was amazed at seeing the nimble “iron man” performing all the necessary steps.

A half an hour later, however, the robot came to a standstill, to the bewilderment of the service team of electronic engineers. What happened? As it turned out, some chips had fallen from the workpiece into the moving elements of the machine. This situation where a human worker would simply flip the chips away with a broom and continue working brought the robot to a deadlock. The engineers cleaned the machine with a broom, switched on the robot…only to see the robot stop again. How could this problem be solved? Obviously, one cannot attach a human worker with a broom to the robot……

Source: TRIZ: The Right Solution at the Right Time, p3, used with permission
System Oscillation: Phones and Remote Controls

Complexity

Add “useful complexity”: features

Time

TRIZ: Trimming

Phones that only receive calls
Trimming

- Arbitrarily removing a physical or functional part of a:
  - Process
  - System
  - Product

- How its function can be replaced

- Most useful in systems that have grown complex over time but useful at any time as a simple “brainstorming” concept
The Keyboard Performs its Function and Doesn’t Exist
Flash Drive: Ever Lost a Cap?
Who Needs Steps?
Black and Decker Paint Stick™: Where is the Bucket? Ladder? Spill?
Trimming a Restroom Entrance

Doors are cumbersome for people with luggage.

Function of the door – privacy
Use geometric shape to replace FUNCTION of the door.
Door is eliminated.
Classical Approach to Design

- “Optimize” and minimize pain
- Ex: Number of bolts on a tire
  - More: more secure wheel
  - Less: Easier to change tire
The Tire Bolt Optimization: Minimizing the Pain of Maintenance and Reliability

Number of Bolts Used to Hold the Wheel

Likelihood of Wheel Loss

Minimal Loss of Wheels
The “TWEEL” from Michelin: “Trimming” the Tire
**TiroGage™: The Stem is the Gage**

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**How Do You Handle Pressure**

- The only analogue gauge that locks onto the valve stem
- Inflates right through the "no touch" TiroGage
- A Simple Solution to Multiple Problems
  - Safety, convenience, fuel efficiency, tire longevity, roadside breakdowns
- 1/2 the price or less than other TPM systems
- Accurately check all 18 tires in just 3 - 4 minutes
- Gauges for both duals display from outer wheel

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Manufactured by WIKA Instrument Corporation
TRIZ Separation Principles to Eliminate Contradictions

- Separate in time, space, system/super-system, and upon condition
- Separation frequently improves reliability when multi-tasking is required
McDonald’s Drive Through: Reliability in Orders

Robi Garcia, 17, of Santa Maria, Calif., hands out an order that was taken by a remote call center and sent by Internet to the restaurant. The customer may never have known that the person on the line was not nearby.
Separate in Space: Sacramento vs. Santa Maria

Robi Garcia, 17, of Santa Maria, Calif., hands out an order that was taken by a remote call center and sent by Internet to the restaurant. The customer may never have known that the person on the line was not nearby.
Predictive Failure Analysis™: TRIZ in “Reverse”

- Normal approach to failure prediction/analysis is “checklisting” of possibilities
  - Asking “what could go wrong?”
  - Slowly get better as the list gets longer from experience
    - Our brains normally can’t see beyond a list
- Alternative: “How to make it go wrong?”
  - Make sure a system fail?
  - Mis-schedule something?
  - Make sure we install the wrong part?
Predictive Failure Analysis™ Algorithm

- State the desired result
  - “I want the webinar to go smoothly”
- Invert the desired result
  - “I want the webinar to go poorly”
- **Exaggerate** the inverted result
  - “I want this webinar to be the worst ever hosted by ASQ and chapter charter is revoked and Dave Auda is blacklisted on Facebook and Plaxo
- How would we make this happen?
- What resources would we need?
  - Are they available? Can they be synthesized?
Volkswagen recalls all its New Beetles

- Battery trays rub wiring, may spark engine fires

By Knight Ridder Newspapers

Volkswagen's New Beetle already has a bug.

Just two months after the long-awaited cars hit the streets amid wild hoopla, Volkswagen of America announced a voluntary recall on all 8,500 Beetles sold in the United States and 1,600 sold in Canada thus far.

The 1998 New Beetle — starting at $15,700 — has not gone on sale overseas yet.

The German automaker is bringing the cars back to dealerships in North America to replace battery trays and insulate wiring to avert stalling and possible engine fires.

VW spokesman Steve Keyes said three complaints of an air-conditioning compressor malfunctioning alerted VW to the problem. The engine wires were damaged from rubbing against the edge of the car's battery tray.

To correct the problem, dealers will replace the battery tray to get rid of the sharp edges and insulate the wiring with a fabric coating in a one-hour procedure at no cost to consumers. All new vehicles on dealer lots will be equipped with the corrected parts, Keyes said.

The chafed wires have never caused an engine fire, nor any accidents or injuries, but VW engineers realized they could, Keyes said.

"We saw certainly the potential (for fires) and said 'Let's just fix it right now,'” Keyes said. The worn wires could also affect the fuel pump and cause the engine to stall, he said.
Areas Used

- Chemical plant control and releases
  - Vs. HAZOP
    - How to make sure we have a release
- Software coding
  - How to make sure coding never works
- Food safety
  - How we make sure everyone is poisoned
- Mechanical failures
  - How to make sure it never runs
- Emergency and military communications
  - How to make sure communication is never received and/or misinterpreted
TRIZ Learnings and Recommendations

- Always balance and question the addition of what is believed to be “useful complexity”
  - Useful to user or repair person?
- Arbitrarily “trim” a system
  - Force/assign the rest of the product or system to perform the function
  - One less part to maintain, monitor
- Separate conflicting requirements
  - Space, time, system/super-system, upon condition
- Minimize energy conversions
  - Every one loses energy and uses a system to convert and requires maintenance
  - Invention history teaches that energy conversions are minimized
- Use of a “reverse” algorithm can identify failure points difficult to find with check listing
RESOURCES

• Altshuller Institute for TRIZ studies (www.aitriz.org)
  • Annual meeting, fall 2011, location and date TBD
• On line TRIZ Journal (www.triz-journal.com)
• www.innovation-triz.com, newsletter available
• European TRIZ Association (www.etria.net), fall 2011 meeting, location TBD
• Mexican TRIZ Association (www.ametriz.mx), fall, 2011 meeting, location TBD
• Books:
  • “And Suddenly the Inventor Appeared” (Altshuller)
  • “Hands on Systematic Innovation” (Mann)
  • “TRIZ: The right Solution at the Right Time” (Salamotov)
  • “Simplified TRIZ” (Rantanen/Domb)
  • “Engineering of Creativity” (Savransky)
• Chemical Engineering Progress (CEP)
  (April, May, June 2005)
• 3 Day Intro TRIZ courses for ASME and AIChE
  • http://www.innovation-triz/events
  • Las Vegas (3/21-23/2011)
  • San Francisco (5/9-11, 2011)
  • Other courses at http://www.triz-journal.com