

# R-TRIZ on Telescoping Rail Failures

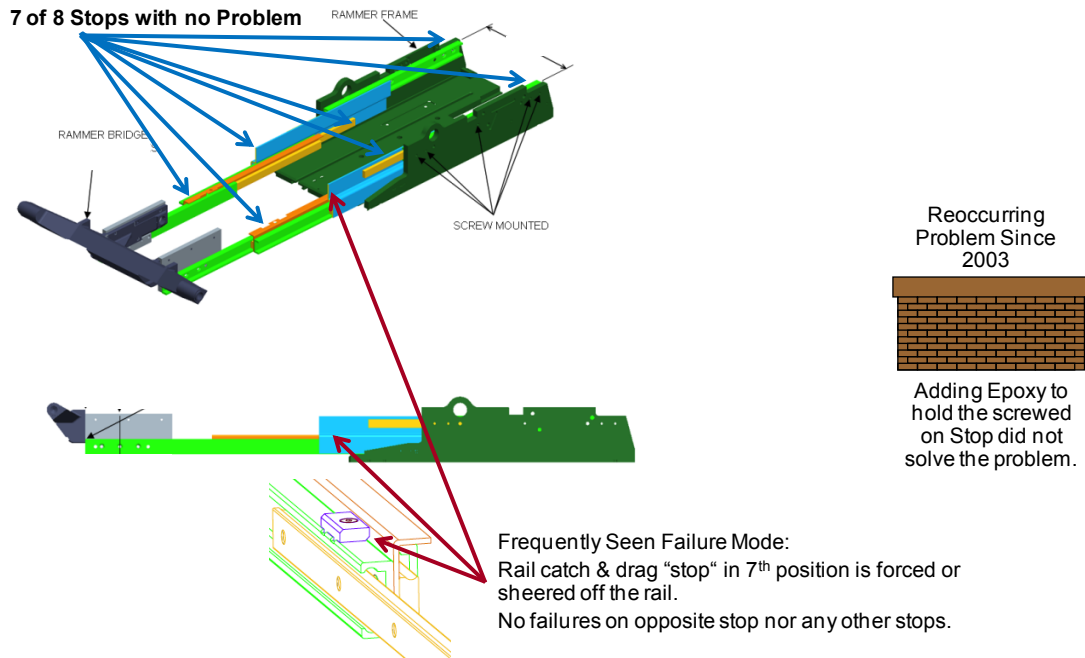
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## Problem/Solution Summary

Since 2003, occasional failure of a very expensive and mission critical ammunition handling system would fail. Over multiple failures the root cause always “boiled down” to the same one of eight “stops” on a telescoping rail support assembly. Yet, the same position “stop” on the opposite rail, serving the very same function was not failing, nor were any of the other seven “stops” on these two identical telescoping rails failing. Across 150 identical weapon systems in field test, when the failure would occur it was always the same stop, in that same right-hand mid-rail position. The left-hand rail never failed.

**Figure 1**

Drawer Assembly with telescoping rails, with unique failing stop identified



Because of replacement and repair expense, and because of mission criticality of this failure, a redesign was authorized, funded and a Design for Reliability (DFR) Engineer was placed on the design team to facilitate the design team thru traditional Design Failure Mode Effects Analysis (DFMEA) to identify and prioritize potential failure modes, root causes and corrective actions for critical failure modes. The DFR Engineer helped the

design team thru a 2-3 hour exercise to create a functional/boundary block diagram, a P-Diagram and a function-to-hardware decomposition table, in preparation to conducting a thorough 48-60 man-hour DFMEA.

However, after that first 2-3 hours of preparatory block diagrams, the DFR Engineer stopped the groups work by observing, “We have a time crunch problem here.” If the group waited for completion of the DFMEA, 48-60 man-hours (3 months down the road), it would be too late to propose solution and get solution(s) or corrective actions built into the new design. Both an understanding of the root-cause and proposed solution alternatives needed to be communicated to the sub-contractors right then, so the “subs” would have the 3 months to compare optional design approaches to their manufacturing process and capabilities to effect the most ideal solution with high manufacturability.

But, wouldn't the group need to complete their 48-60 hour failure mode effects analysis to determine most critical failure modes, and then determine corrective actions for each?

No. The only critical failure mode was already known. It was the only failure that had been happening on random weapon systems since 2003. The DFR Engineer introduced his Reliability TRIZ chart (R-TRIZ tool) to the group and within 35 minutes they had two optional design solutions to the problem.

As correct nature of the problem and applicable design principles were considered by two separate sub-contractors, two nearly ideal designs with high manufacturability were finalized, over the following 3 months, while the DFMEA was completed to serve as a dynamic reliability model and to show reliability growth as the two designs progressed and verification testing was performed.

### **Walking Through the 35 min. R-TRIZ Session to Derive Optional Solutions**

The rail stops, in original design, were notched into the rail and screwed into place so that as the rail slid along on ball bearings and got to the end of travel for that rail section, the stops would engage (make contact with) the stop on the next rail section and thus drag the next telescoping rail section along toward the end of its travel.

TRIZ suggests that the wrong question was being asked, to arrive at a solution. Rather than asking,

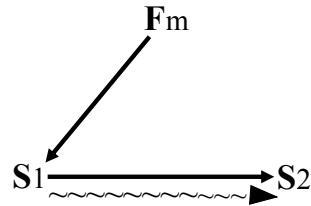
“How can we keep the Stop from sheering off the rail?”

TRIZ would ask:

What is the design parameter contradiction?  
and

How can we remove the contradiction?

Figure 2 – Su-Field Model of the Problem



Where :

$F_m$  = Mechanical Force (from “bridge” piece)

$S_1$  = Moving rail and Stop

$S_2$  = Stop on stationary rail (to be moved)

- **S1 engages S2 providing force to move S2**
- ~~~~~→ **S1 induces “shock” into S2 on initial contact**

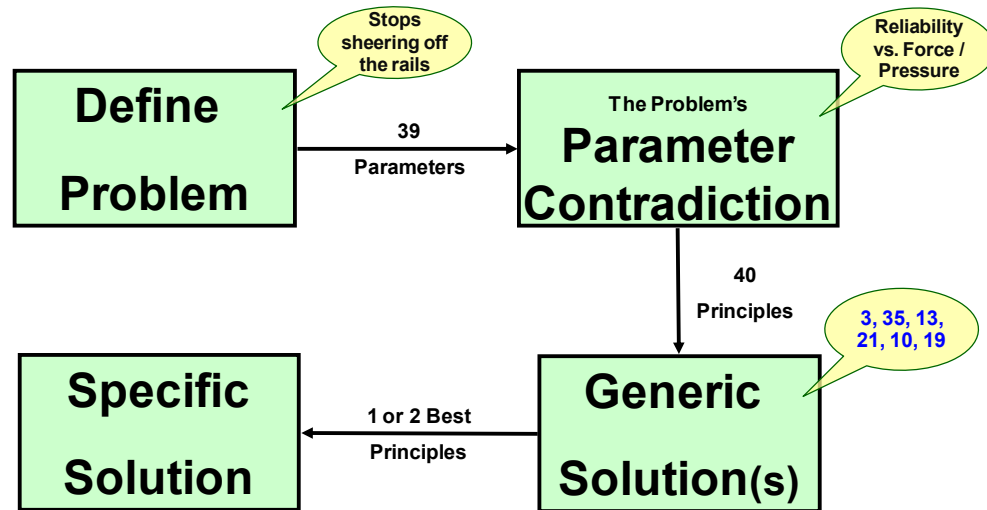
A design parameter contradiction exists. We need force, shock or pressure to engage the next telescoping rail section Stop and set it into motion, but the force or pressure was causing occasional Stop failure or low reliability. The Reliability TRIZ chart or R-TRIZ Tool (table below) was used to quickly extract the best “design principles” or approaches for solving this Reliability problem.

Figure 3 – Section view from R-TRIZ Tool (from TRIZ-Matrix)

R-TRIZ Tool					
When a design parameter or characteristic is changing in a direction that would negatively impact <b>Reliability</b> , use these <b>TRIZ</b> Principles (patent concepts) to <b>Reclaim Reliability</b> .					
TRIZ #	Parameter or Characteristic being changed (Improved).	Patent Concept	Patent Concept	Patent Concept	Patent Concept
1	Weight of a mobile object	3	11	1	27
2	Weight of a stationary object	10	28	8	3
3	Length of a mobile object	10	14	29	40
4	Legth of a stationary object	15	29	28	
5	Area of a mobile object	29	9		
6	Area of a stationary object	32	35	40	4
7	Volume of a mobile object	14	1	40	11
8	Volume of a stationary object	2	35	16	
9	Speed	11	35	27	28
10	Force	3	35	13	21
11	Tension / Presure	10	13	19	35
12	Shape	10	40	16	
13	Stability of Composition	(No help. Increasing stability increases reliability)			
14	Strength	11	3		
15	Time of action of a moving object	11	2	13	
16	Time of action of a stationary object	34	27	6	40
17	Temperature	19	35	3	10

Six Design Principles to help solve the Problem: 3, 35, 13, 21, 10, 19

Figure 4 – Four Step Problem to Solution Process, using TRIZ Matrix



The group then simply needed to consider these six design principles (3, 35, 13, 21, 10 and 19), from the TRIZ 40 Principles. By applying these six principles singly or in combination to the telescoping rails/stops design, the group should be able to produce a specific design incorporating the solution(s), thus removing the design contradiction.

Consider the simple brainstorming that took place for 15-20 minutes as the design group applied the six suggested design principles to their redesign effort.

**Principle #3 Local Quality**

- A. Transition from homogeneous to heterogeneous structure of an object or outside environment (action).

[This could mean improved “Stop,” “screw” or “epoxy.”]  
 [Maybe tougher or more flexible screw or epoxy?]

**Principle #35 Transformation of Properties:**

- A. Change the concentration or density.
- B. Change the degree of flexibility.

[Maybe tougher or more flexible screw or epoxy?]

**Principle #13 Do It In Reverse**

- A. Turn an object upside-down

[Hmmm. . . This may suggest Trimming or Simplification?]

**Principle #21 Rushing Through**

- A. Perform harmful and hazardous operations at a very high speed.

[Hmmm. . . No. Forget that!]

### Principle #10 Prior Action

A. Perform required changes to an object completely or partially in advance.

- [1. Replace Stops before every mission? X – Not Good]
- [2. Use Bolt not Screw (larger diameter)]
- [3. Add a hardened pin]
- [4. Seat Stop deeper into rail]

### Principle #19 Periodic Action

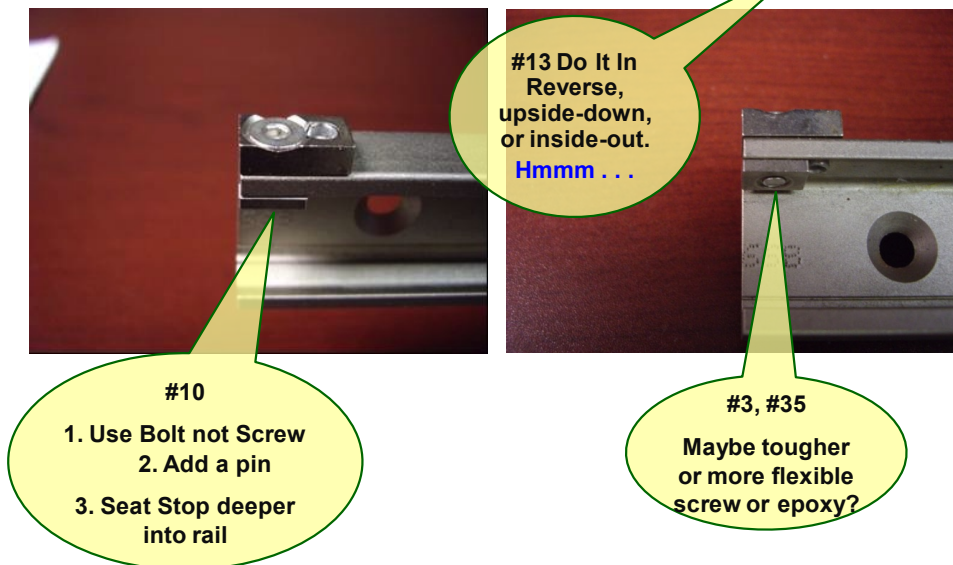
A. Replace a continuous action with a periodic action (impulse).

[No. I don't think so. . . Not practical]

Combining these ideas, a new design could incorporate a bolt rather than a screw, with wider diameter (to withstand 400% more force) and a square nut to prevent rotational loosening of the nut and by adding a hardened pin, the combination would exceed sheering shock forces and allow the removal of epoxy. Epoxy was greatly adding to assembly labor time and was adding great variability and quality issues. This combined all usable ideas above, except for Principle #13. Since no specific design idea came from #13, the group decided to “shelf that” or look at it separately. Combining the other three Principles (3, 10 & 35) might be adequate?

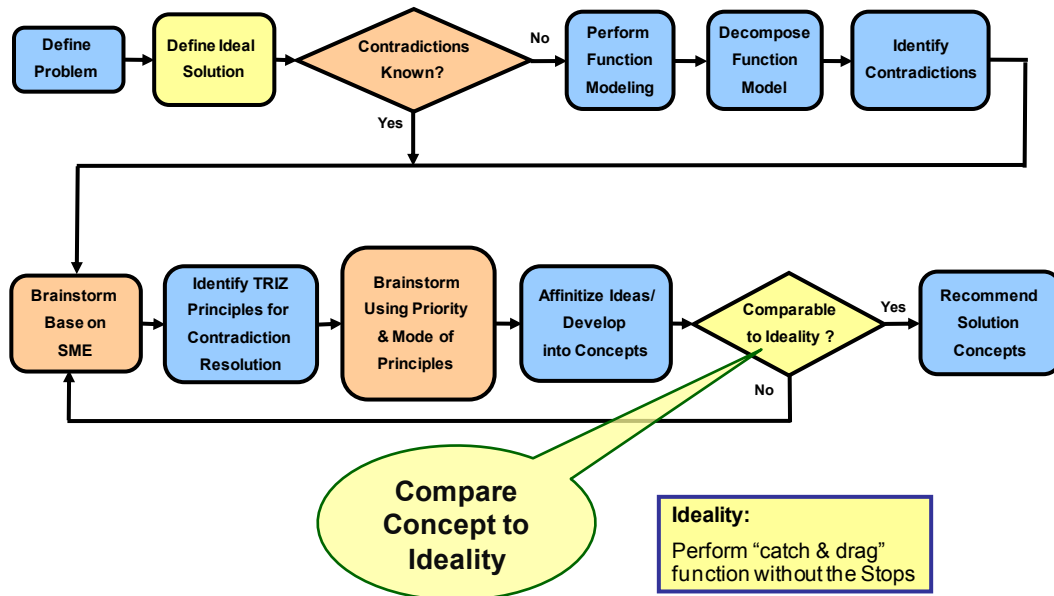
Figure 5 – Combined Principles for a New Design

## Combine TRIZ Principals 3, 10 & 35 #13 later



Then going back to the ARIZ Process for innovating and evaluating solutions against ideality, helped the team to understand Principle #13 and how Trimming could simplify the design and come closer to ideality. (see next page)

Figure 6 – Combined Principles for a New Design



Attempting to achieve “Ideality” the group re-considered Principle #13 Do It In Reverse, or turn an object upside-down, or inside-out. Also, concepts of Ideality and Trimming suggest: [Transferring function of “catch & drag” from the “Stops” to the Rails]

The team then envisioned a whole new simplified design;

Machine or mold the Stops into the Rails, which would provide:

- One piece construction
- No assembly labor for Stops or bearing ways
- Rails can easily disperse the instantaneous engagement shock/pressure

Figure 7 – An ideal solution design. Cheaper, Simpler, More Reliable

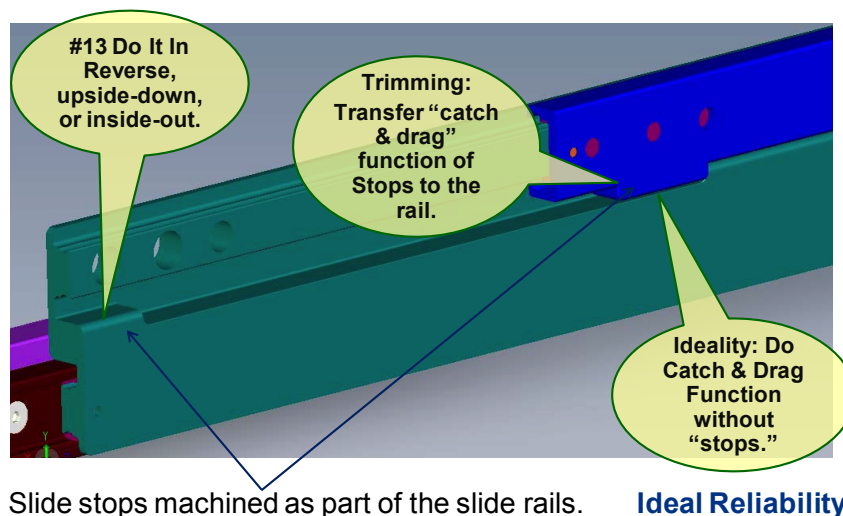
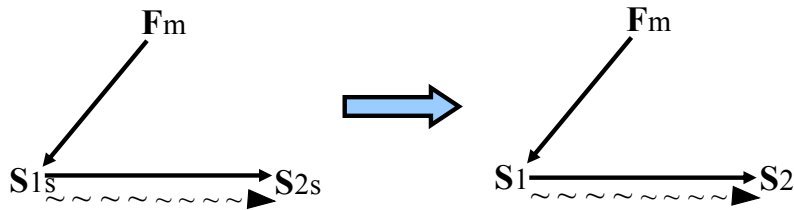


Figure 8 – Su-Field Model Showing Transition to Trimmed Ideal Solution



$F_m$  = Mechanical Force (from “bridge” piece)  
 $S_1$  = Moving rail     $S_{1s}$  (with add on Stop)  
 $S_2$  = Stationary rail     $S_{2s}$  (with add on Stop)

**S1 engages S2 providing force to move S2**

**Summary:**

A 35 minute TRIZ session, in the design concept phase, produced an ideal Reliability solution. The design was implemented into prototype build, run thru verification testing without any Stop failures (as they were now an integral part of the rails). Bearing ways were also machined into each rail section, rather than screwing on pre-cast bearing ways. The result was a design cheaper to manufacture, cheaper to assemble, more effective in function and more reliable in operation. TRIZ works.

Figure 9 – Redesigned Rails

