



PRINCIPLES OF MISTAKEPROOFING AND INVENTIVE PROBLEM SOLVING (TRIZ)

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Taichi Ohno House of Toyota

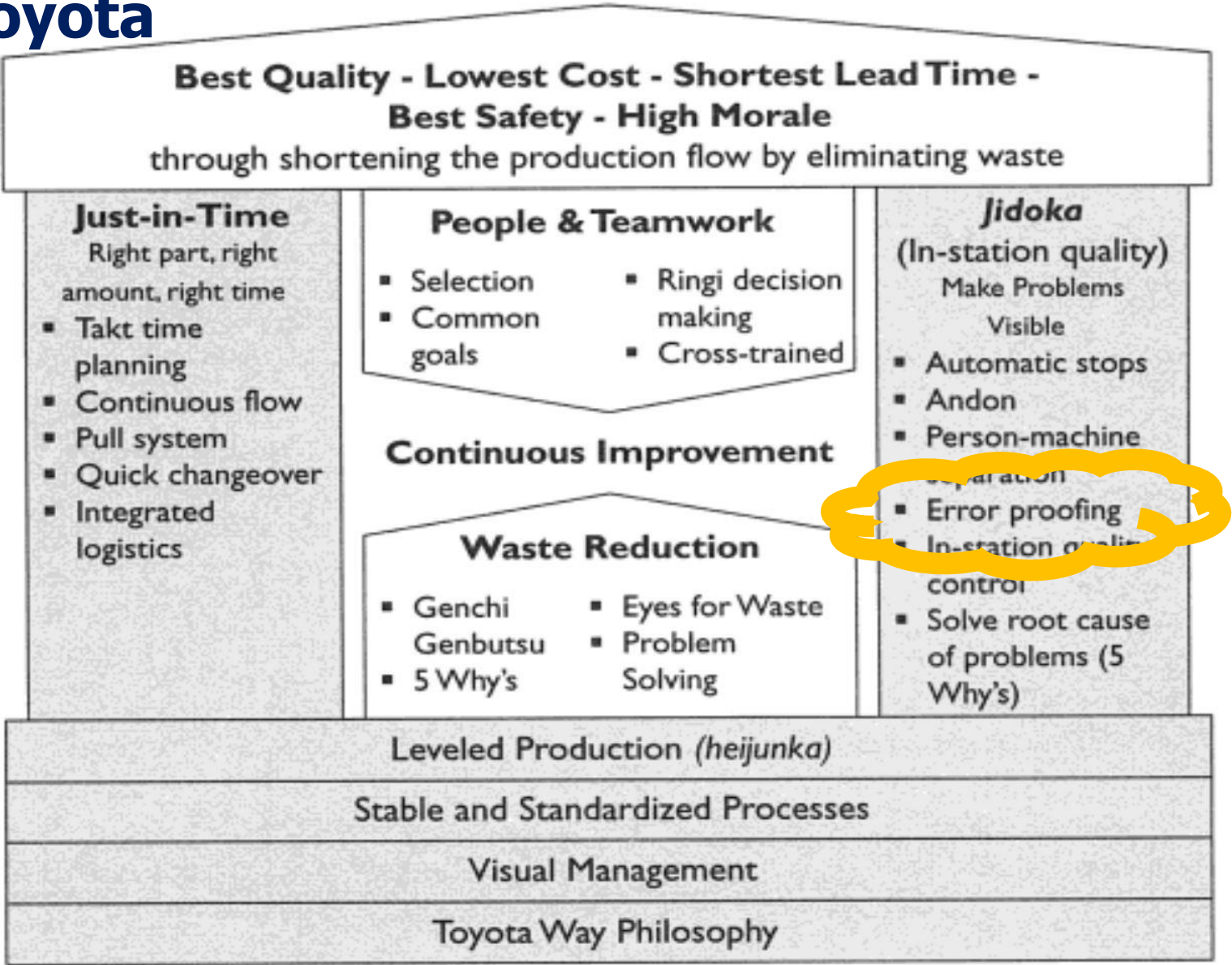
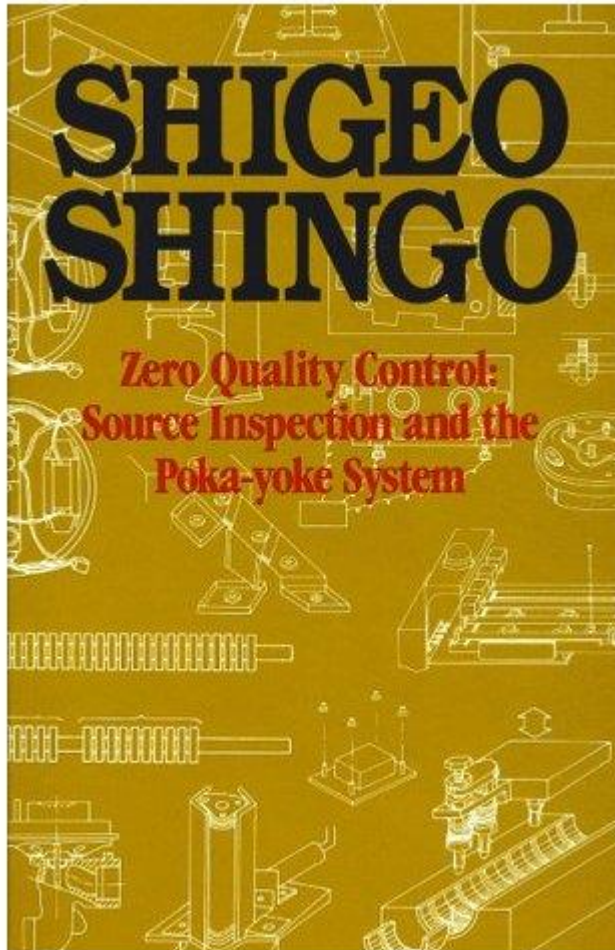


Figure 3-3. The Toyota Production System

Shigeo Shingo (1986)

Zero Quality Control: Source Inspection and the Poka-Yoke System



Paraphrased

- “Inspection and statistical quality control come too late in the process to totally eradicate all quality problems.”
- Quality must be tackled up-front. It must be built into each process.

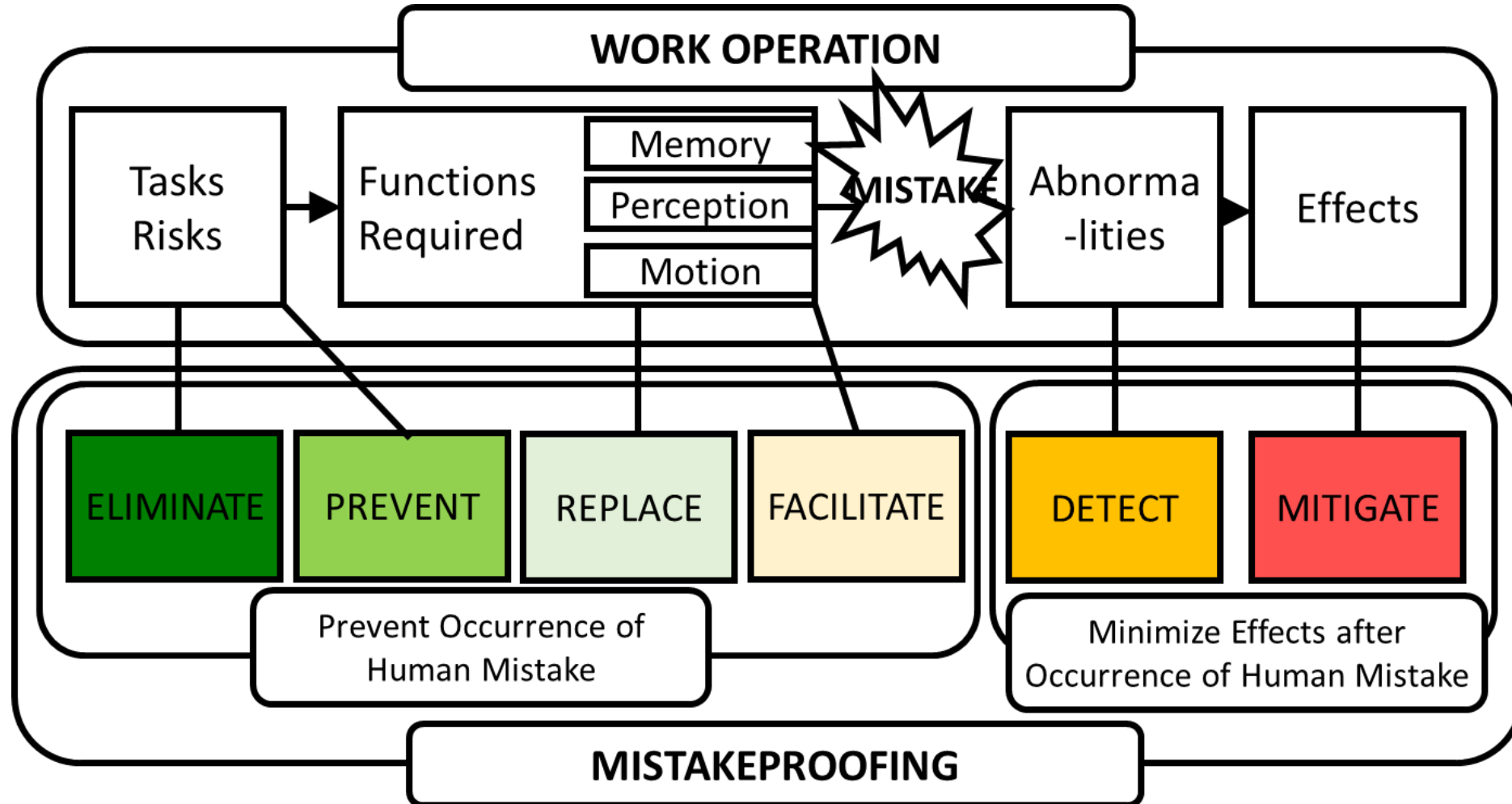
To err is human.

People can

- *and despite their best intentions* -

will make inadvertent errors (mistakes).

ERROR → DEFECT



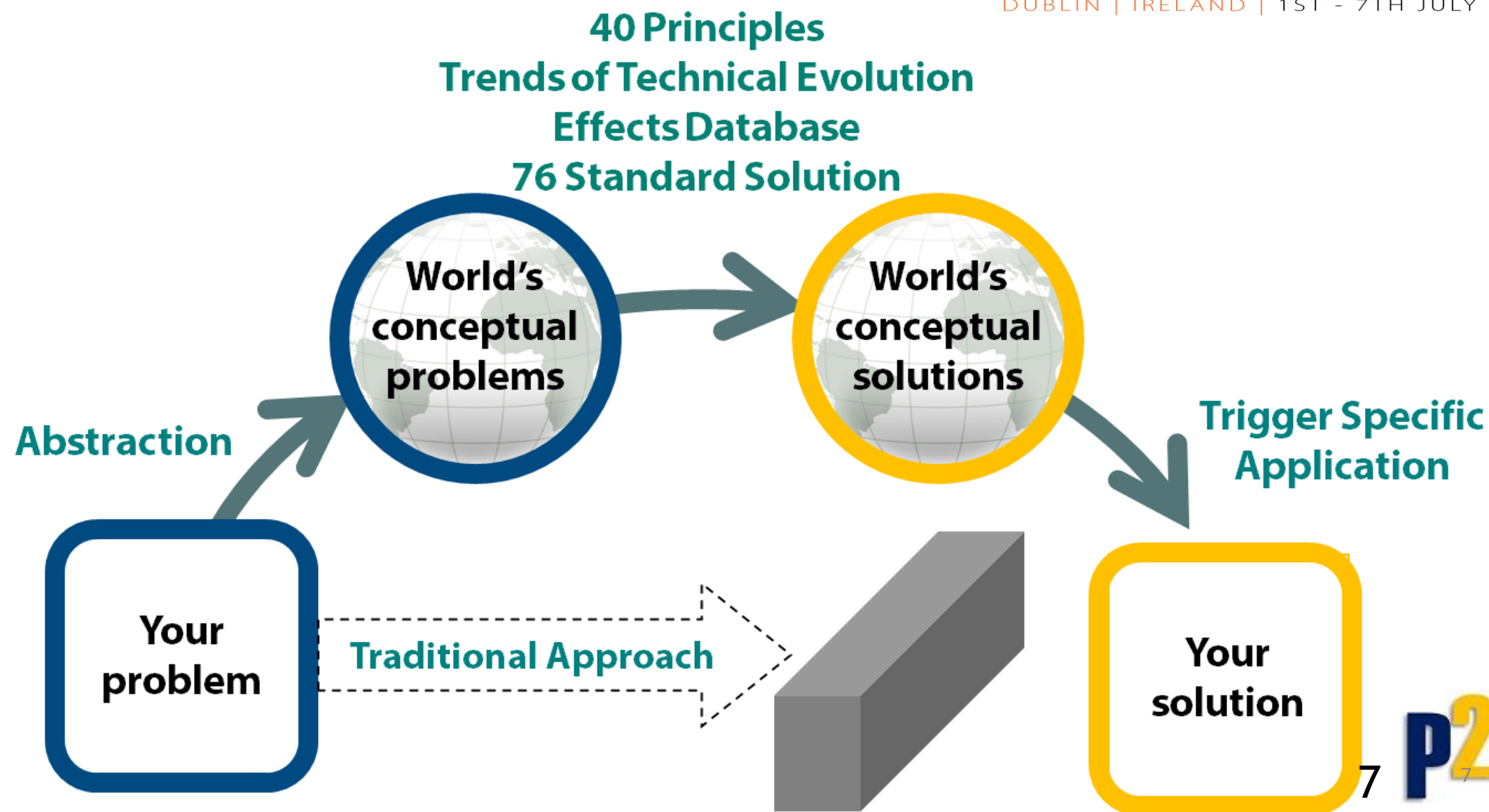
Applicability of Mistakeproofing Principles to Work Operations
(after Figure 1 in Godfrey et al. 2005, attributed to Prof. Takeshi Nakajo,
redrawn and color-coded by Tommelein)



Genrich Altshuller

**Theory of Inventive Problem
Solving (TRIZ)**

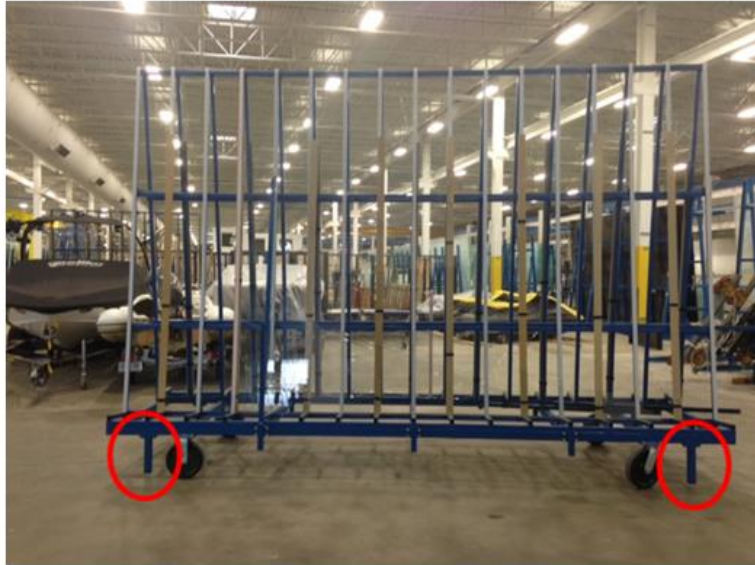
Prism of TRIZ Problem Solving Solutions



40 TRIZ PRINCIPLES, a sample:

- 2 Taking Out:** Separate an interfering part or property from an object, or single out the only necessary part (or property) of an object.
- 3 Local Quality:** 3.3 Make each part of an object fulfill a different and useful function.
- 4 Asymmetry:** 4.1 Change the shape of an object from symmetrical to asymmetrical.
- 6 Universality:** 6.1 Make a part or object perform multiple functions; eliminate the need for other parts.
- 11 Beforehand Cushioning:** Prepare emergency means beforehand to compensate for the relatively low reliability of an object.
- 12 Equipotentiality:** Change the condition of the work in such a way that it will not require lifting or lowering an object.
- 14 Spheroidality (Curvature):** Instead of using rectilinear parts, surfaces, or forms, use curvilinear ones...
- 18 Mechanical Vibration:** Cause an object to oscillate or vibrate.
- 23 Feedback:** 23.1 Introduce feedback (referring back, cross-checking) to improve a process or action.
- 32 Color changes:** 32.1 Change the color of an object or its external environment.

Wheeled Cart with “Dead Man” Legs



CONCERN: Cart (as shown, loaded with ~1,600 kg or 3,500 pounds of glass) may tilt over or collapse due to wheel/caster failure, and crush or kill a worker.

COUNTERMEASURE: Added a “dead man” concept (circled in red) to each of the 4 corners of the fabricated cart to prevent cart from tilting over or collapsing in case of wheel/caster failure.

Image source: Stoker, I. and Stearns, L. (2017). “Harmon Glass Handling Kaizen-Report Out (Event Dates: 1/12 to 1/14).” Harmon, Inc. Mfg. Facility, Cincinnati, OH, 30 Nov. 2017; Powerpoint slides provided by Chad Hoffmann, 23 pp.

Mistakeproofing Principle:

MITIGATE

TRIZ Principle 3 Local Quality: 3.3 Make each part of an object fulfill a different and useful function.

Table Saw Stop



Image Source:
www.sawstop.com visited 10
Oct. 2018

CONCERN: People use their hands to push material and cut it with the table saw. Their hand may get caught by the blade.

Table saws have blade guards to reduce the likelihood of a hand getting caught, but workers may find these to be impractical and remove them.

COUNTERMEASURE: “The SawStop saw detects contact with skin. The blade carries a small electrical signal, which the safety system continually monitors. When skin contacts the blade, the signal changes because the human body is conductive. The change to the signal activates the safety system.”

Mistakeproofing Principle:

MITIGATE

TRIZ Principle 11 Beforehand Cushioning: Prepare emergency means beforehand to compensate for the relatively low reliability of an object.

Rumble Strip



CONCERN: Distracted or sleepy drivers may veer off the road.

COUNTERMEASURE: Rumble strips cause the vehicle to make a loud noise (auditory feedback) that alerts the driver, who can then avoid running off the road.

Image source: www.rumblestrips.com/resources/research-and-publications/cyclists-and-rumble-strips/ visited 2 Nov. 2017

Mistakeproofing Principle:

DETECT

TRIZ Principle 18 Mechanical Vibration: Cause an object to oscillate or vibrate.

Tension Bolt



CONCERN: Structural bolts must have the proper pretension in order to be functional. This tension is achieved by torqueing the bolt however torque is not a reliable indicator of tension.

COUNTERMEASURE: Squirter DTIs are compressible washers that show when a bolt reaches its target tension, independent of torque, by expressing orange-colored material.

Image source: Myhrum, B. (2010). "Simple QA for Wind Turbine Bolts." Windpower, www.windpowerengineering.com/construction/simple-qa-for-wind-turbine-bolts/

Mistakeproofing Principle:

DETECT

TRIZ Principle 23 Feedback: 23.1 Introduce feedback (referring back, cross-checking) to improve a process or action.

Towel Bar Installation Template

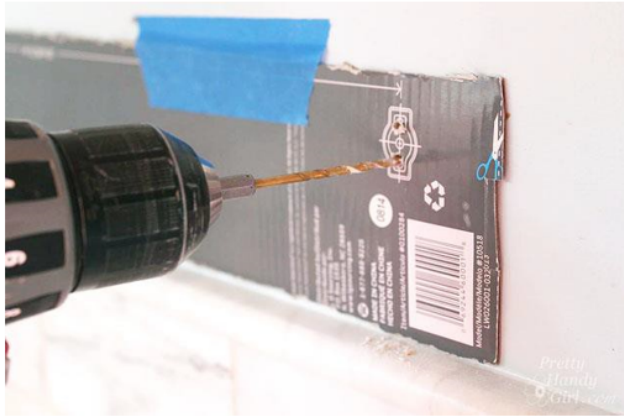


Image source: Brittany (2015). How to Install a Towel Bar Securely. www.prettyhandygirl.com/how-to-install-towel-bar-securely/ visited 1 Nov. 2017

CONCERN: Mounting a towel bar on a wall requires accurate measurement of the spacing between screws.

COUNTERMEASURE: The towel bar packaging acts as a template to facilitate installation by identifying the location of the drill holes, thereby eliminating the need to measure the distance between screws and then marking the location before drilling holes.

The template is held level and taped to the wall. The location of the 4 drill holes needed are illustrated on the template without requiring any additional work. Use of templates makes it significantly easier and faster to complete the work.

Mistakeproofing Principle:

FACILITATE

TRIZ Principle 6 Universality: 6.1 Make a part or object perform multiple functions; eliminate the need for other parts.

Rotating Jig and Clamps to Hold Welded Steel Element



CONCERN:

- Welders must bend or reach over and twist their bodies to access connections to be welded.
- Weld material runs down due to gravity.

COUNTERMEASURE: “ConXtech is the first manufacturing facility [...] to weld, in a production environment, Hollow Structural Steel (HSS) columns entirely in the horizontal position.”

- Welder works at ergonomically comfortable height and can turn by hand the column to the right position.
- Weld material is deposited horizontally.

Image source: www.prweb.com/releases/conxtech/ladbs-approved/prweb10762433.htm visited 28 Feb. 2019

Mistakeproofing Principle:

FACILITATE

TRIZ Principle 12 Equipotentiality: Change the condition of the work in such a way that it will not require lifting or lowering an object

Color-changing Paint



CONCERN: when using white paint to paint over a white ceiling, it is hard to see which areas have already been painted, so application may be uneven.

COUNTERMEASURE: Additives to the paint make the white paint look pink for as long as it is wet. When it dries, it gradually turns white.

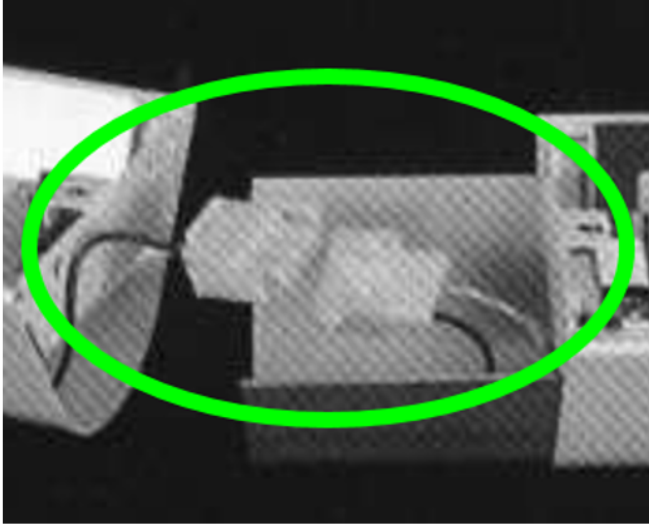
Image source: Glidden® EZ Track Ceiling Paint, [kk.org/cooltools/ glidden-ceiling/](http://kk.org/cooltools/glidden-ceiling/) visited 3 Oct. 2017

Mistakeproofing Principle:

FACILITATE

TRIZ Principle 32 Color changes: 32.1 Change the color of an object or its external environment.

Connection Plug and Wiring of Linear Light Fixture



CONCERN:

- Electrical wires may get connected wrongly.
- Electricians must work at elevation to wire linear light fixtures, which is strenuous.

COUNTERMEASURE:

In the shop, install clips to end the wiring on each fixture. Put on correctly, these clips can snap together in only one way (asymmetry) so that the wires will always be connected correctly. On site, the electrician's installation work at elevation won't take much time nor be as strenuous.

Image source: Finelite (2008). *Estimator and Contractor Guide*.
www.finelite.com/contractor/ContractorGd_m.pdf visited 22 April.

Mistakeproofing Principle:

PREVENT

TRIZ Principle 4 Asymmetry: 4.1 Change the shape of an object from symmetrical to asymmetrical.

Round Manhole Cover



CONCERN: The cover for an opening that is rectangular (e.g., a ground excavation), can be turned sideways and fall into the opening. People working underneath inside the opening would be in harm's way.

COUNTERMEASURE: A manhole cover is round because a round object cannot fall through a circular opening of at least the same diameter, no matter how it is positioned.

Image source: McCarthy (2015-01-07) "Why Are Manhole Covers Round?" mentalfloss.com/article/60929/why-are-manhole-covers-round visited 19 Oct. 2016.

Mistakeproofing Principle: PREVENT

TRIZ Principle 14 Spheroidality (Curvature): Instead of using rectilinear parts, surfaces, or forms, use curvilinear ones...

Two Nearly Identical Circular Saws: Corded and Cordless



Image source: Tim Carter -
www.askthebuilder.com/which-circular-saw-should-i-buy/
visited 17 Feb. 2019

CONCERN:

- The electrical cord on a power tool limits the worker's working range.
- The cord attached to the tool and any extension cords may get tangled or damaged in use, and create a tripping hazard.

COUNTERMEASURE: Eliminate cord and tripping hazard by using batteries to supply electricity to power tool.

LIMITATION: Relative to corded tools, battery-powered tools tend to have less power and are more limited in capacity.

Mistakeproofing Principle:

ELIMINATE

TRIZ Principle 2 Taking Out: Separate an interfering part or property from an object, or single out the only necessary part (or property) of an object.

Please share your examples!
[P2SL-mistakeproofing.berkeley.edu](mailto:p2sl-mistakeproofing.berkeley.edu)

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P2SL

