

# Component Misplacement Prevention on the ICOS Tape & Reel process using TRIZ & Lean

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## Abstract

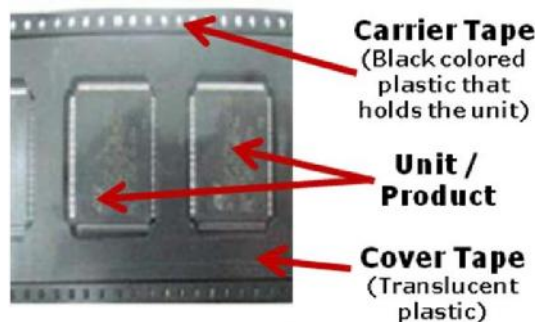
The paper discusses on the problems faced by the Assembly, Test Manufacturing (ATM) plants of Intel Corporation for a certain Tape and Reel Process. The problem is generic across the other sister factories around the world. The complexity and high occurrence of the problem result in high customer returns and complaints. The problem was looked at by using Lean and TRIZ. We came up with a potential solution that was both elegant and at the same time would potentially solve the menacing issue at the same time the solution proposed surprisingly yields good returns.

*Keywords: ICOS; Component Misplacement; Lean; Tape and Reel ;*

## Introduction

Component misplacement in the Tape and Reel process, especially for small form factor products, are very tricky. The tendency for units to be misplaced, out of pocket or totally missing is much higher compared to the bigger form factor products. This is due to design limitations of the tool used. The products being manufactured are getting smaller and smaller at a faster rate compared to the tool that operate these products; tool sizes remained the same for the last 5-10 years. This is a known dilemma that is faced by many organizations and this problem also is no stranger to Intel's manufacturing as well.

Component misplacement leads to the empty pocket scenario that is caught at the customer's Incoming Quality Control (IQC) side. If the customer receives inaccurate (lesser than purchased) quantity, the credibility of Intel in the customer's eyes will be tarnished and this will be bad for the business in the long run if it continues to happen. However there have been numerous improvements executed both by the tool manufacturer as well as by Intel, but till today no one has successfully solved this issue from reoccurring.



**Figure 1:** Unit inside the carrier tape

At the moment there is system installed that gives an alarm when component misplacement is noticed. On average the alarm is triggered approximately 25 times/tool/day and in some cases the warning is genuine as at times it is a false alarm (unit is present but the tools wrongly indicates it as absent). The system installed serves as a temporary solution to address the component misplacement issue, but it is still not fool proof.

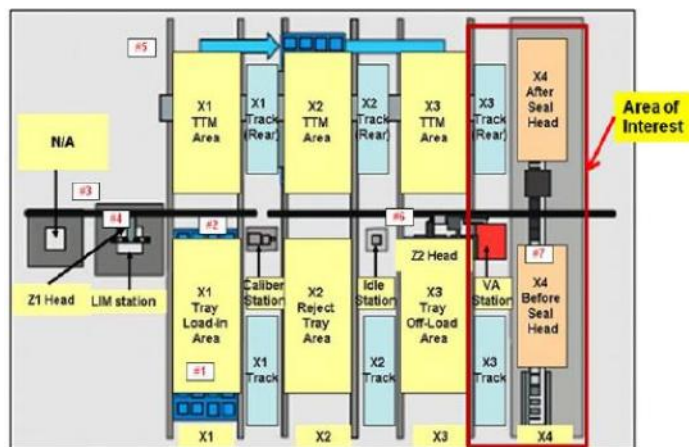
By coupling TRIZ and LEAN, we have come to a method to model the problem and look at the root cause by performing numerous Direct Observation (DO) and validating all the findings and uncertainties by experiments to differentiate the actual root cause vs the symptoms of the problems. The process of transferring the units from the tray after inspection and placing the units onto the carrier tape was scrutinized using DO and then TRIZ was used to analyze the Process and mechanism of the overall Tape and Reel process. The details of the findings will be discussed in the following sections of the paper.

## Challenges/Problems

The fact of the matter is that the Tape and Reel process is a simple process on paper but the many customer complaints that have come as a result of inconsistencies of the process shows that it is a concern that needs to be addressed quickly. The main types of issues are component misplacement/missing units issues and sealing inconsistencies that lead to component falling from between the carrier and cover tape.

Across the different Intel Manufacturing sites around the world, 2 main production problems have been identified for the Tape and Reel manufacturing process. The second problem, the sealing of the cover tape onto the carrier tape becomes relevant when the quality is not there i.e. the cover tape doesn't completely hold onto the carrier tape. This can potentially cause units to drop out of the carrier tape.

The criticality of the issue is seen when this type of missing units are detected at the customer's side. It will trigger a chain of events for investigation and RC determination and Action plans that must be put in place quickly to fix the problem at least as a temporary measure.



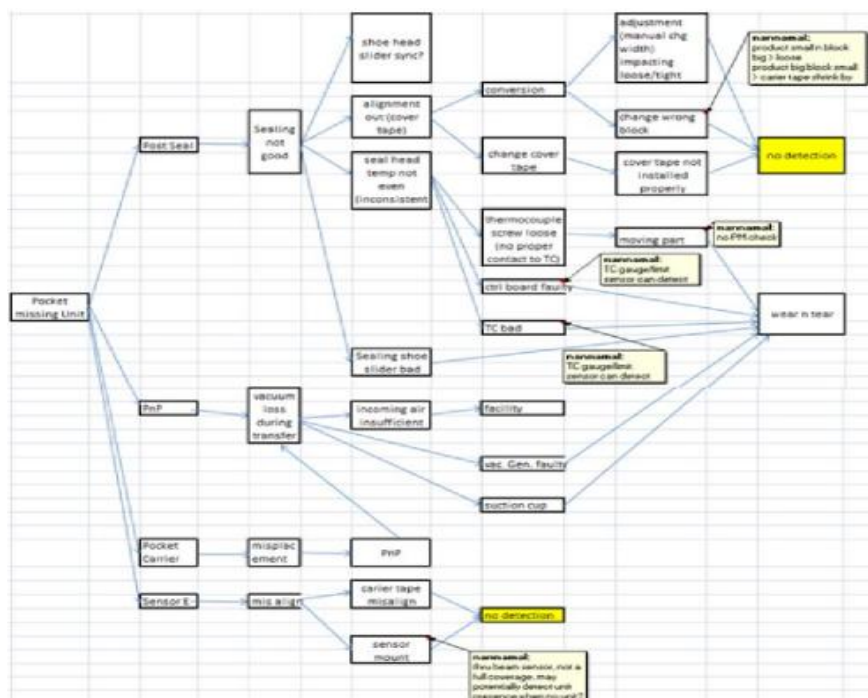
**Figure 2:** Overview of ICOS tool layout

In the manufacturing line on the other hand, there are many component misplacement alarms for this tool; about 30% - 40% are false alarms. False alarms happen due to the fact that the design of the sensor and position of it causes debris from the units to easily accumulate.

## Lean & Process Analysis

We had to look objectively on the overall process and see what was working fine and what was not. The overall detection process looked sufficient as there was a detection point before the unit is placed into the carrier tape, there is another detection system after the unit is placed into the carrier tape as well as another detection point after the unit is sealed into the carrier tape (before the unit is being rolled into the reel). Still there were units missing in the reels sent to the end customer.

By using Cause and Effects Chain Analysis (CECA), we manage to identify 2 focal areas of the project. The first one was to improve the detection capability as the current detection system in the tool. This system was not taking into account the side effects of processing small form factors products that is far lighter from the previous generation products. These products were already pushing the envelope of the tool's capability itself. The second focus area was that we also had to look into how we could prevent component misplacement from happening altogether.



## TRIZ

The ICOS component and reel placement process is executed in an area labeled as X4. The main component of the problem area X4 is the main track where the units are placed on the carrier tape from the trays (*See figure 2*). The main track is made up from (in general) the rail that holds the carrier tape, the sensors to detect empty pocket as well units present, a moving Pick and place arm that moves the units from the tray to the carrier tape, the Seal Head mechanism and a post seal sensor.

In order to improve our system & process we came across a few contradictions that didn't allow us to do so. As the problem was component misplacement as well as missing units in the carrier tape, we came up with the following contradiction:

If a robust detection system is put in place then the measurement accuracy will improve but intermittent missing units still happens (loss of substance) as well as Productivity loss due to additional step in the process and additional cost for the purchase of the items.

**Improving parameter:** Measurement accuracy (#28)

**Worsening Parameter:** Loss of Substance (#23) & Productivity (#39)

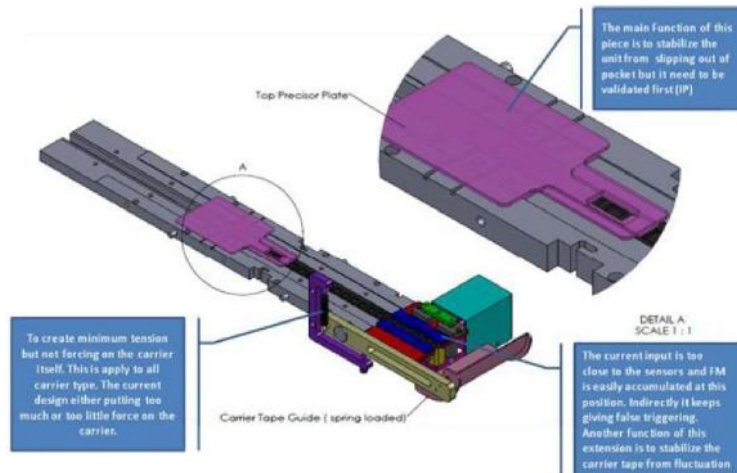
With these parameters we mapped the information back to the contradiction matrix and found the most applicable Inventive Principle to our problem was using Inventive *Principle #10: Preliminary Action*.

## Solution

Preliminary Action fitted our problem well. Preliminary Action means we designed a sort of fixture that ensured precision on the placement of the units from the tray to the carrier tape even though the mechanism was running on motors and pneumatics that were not designed for precise tools. This step made sure that at all times the parts will always be placed at the same end location even though there is a slight drift in the placement from the pick and place arm.

As for the vibration, the design of the tool used many small parts at certain locations. The problem was seen to originate from the parts where the carrier tape moved freely. The solution for this was to elongate the track of the tool so that all parts of the carrier tape is supported and thus the internal vibration reduced significantly. This helped with the intermittent issue of component misplacement. The thru beam sensors that was designed for this tool had a flaw that it didn't take into account the build up dust/particles from the process that could potentially block the receiver or transmitter of the sensors and cause false alarm. The redesign eliminated the buildup of dust and eliminated false alarm due to this issue.

So in short, the redesign helped solve our problem of not having a specific location for the units to be placed into the carrier tape from the tray by the pickup arm, at the same time the internal vibration that was present when the carrier tape is being moved (feed) inside the tool was also drastically minimized and finally the redesign of the detection sensors was done so that false alarm due to sensor being blocked by dust is eliminated.



**Figure 4.** Re-Design of the X4 area

## Results

This prototype redesign has just been put in place in the factory on one of the tools and currently is under data collection mode. In its early stages we already see positive results of 0 false alarm triggers and so far we do not see any misplaced components and also no missing components. The tool handles about 50,000 units in a week and we are in progress of collecting the data.

The approximate ROI (Return of Investment) forecasted from the project is about USD600K within one quarter itself. This value is tabulated by taking into account the number of tools and the upgrade cost as well as the number of units being manufactured.

## Summary

Direct Observation in Lean is a very powerful tool as it triggers the mind to look to abnormalities as well as understand the exact problem and not rely on hearsay or hypothesis alone. DO also may provide the observer the high level information on where the potentially problem can be or is at. TRIZ on the other hand helps with understanding the way the tool works as the Component Model is a great way to identify the interaction of the parts and its functions and at the same time provide idea on where to focus our efforts at.

With the help to Lean and TRIZ the intermittent issue that causes us customer complaints has been thoroughly examined and we have come up with elegant solutions that is providing very positive results during the data collection stage. The issue of having component misplacement, missing component that goes undetected as well as false alarm trigger area are all addressed by our approach.

The next step for this project is to validate the solution physically and statistically so that we take into account the potentially fall outs in future to determine the tools accuracy, capability and stability.

## Acknowledgments

Intel Penang TRIZ team and co-authors comprising of Nagappan Annamalai ; Paul Devaraj, Song Chia Li, Fred Chan and Angelia Ng as well as the module owners CT Ong, Jessey Yeoh. On top of all that I would like to also thank the entire management of Intel PG as there were open to the new ideas and provided us the opportunity to test this out.

## **References**

Items that were used and referred to were:

- [1] Contradiction Matrix from <http://www.triz40.com/>
- [2] TRIZ 39 Parameters from <http://www.triz40.com/>



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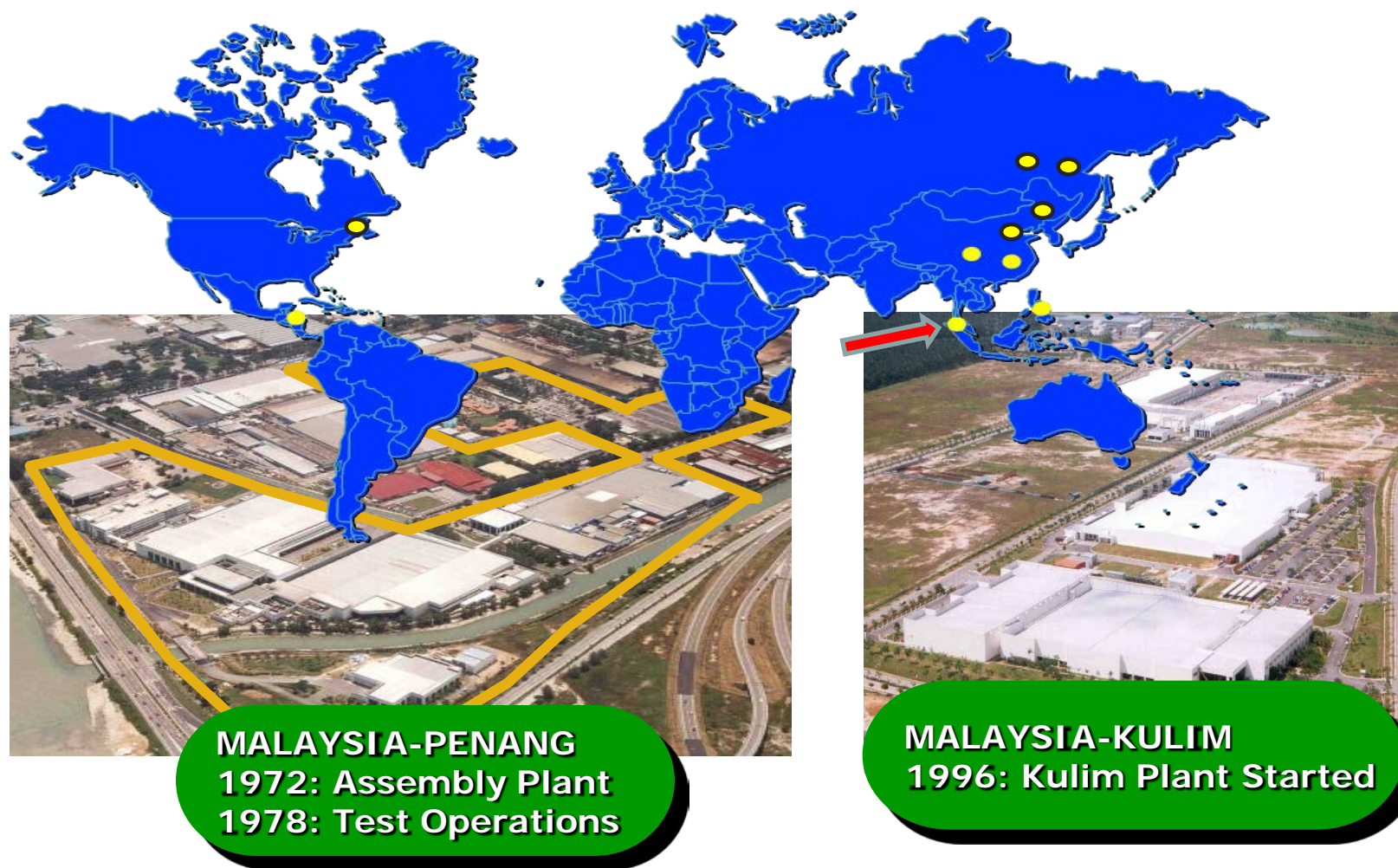
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**Malaysia**



## Overview of Intel Malaysia







# Overview of Intel Malaysia

**ASSEMBLY**



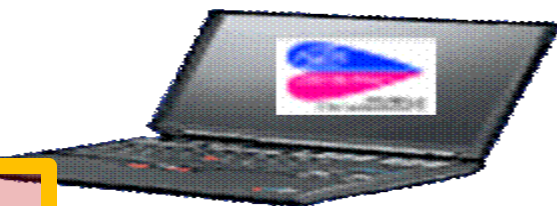
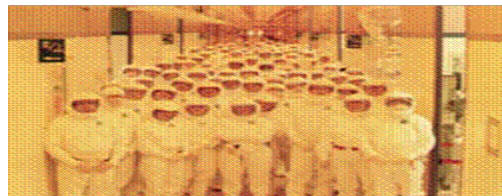
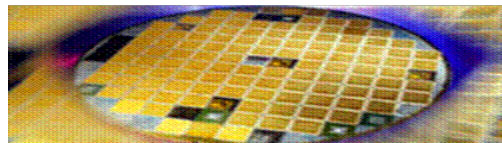
**TEST**



**BACK END**



**DISTI**

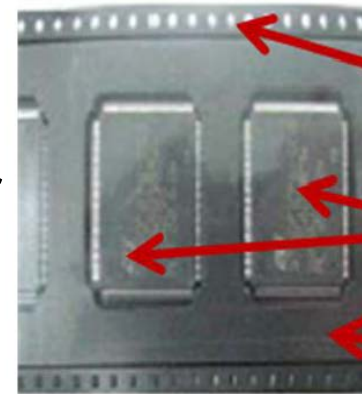
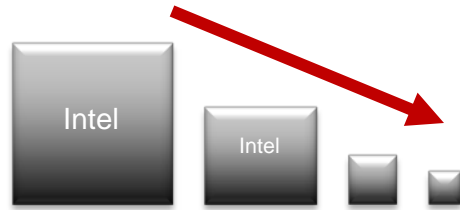




# Introduction

## Overview

- Tape & Reel Process (media of shipment)
- Packages (product form factor) getting smaller



**Carrier Tape**  
(Black colored plastic that holds the unit)

**Unit / Product**

**Cover Tape**  
(Translucent plastic)

## At Intel

- High volumes at the factories weekly (2-4 million units)
- High Mix of products as well
- Unstable process i.e. lots of error from tool (25 times/tool/day)
- Tool manufacturer has done many improvement projects but still unable to resolve this issue





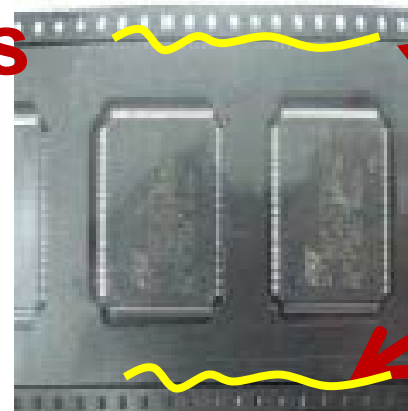
# Challenge/Problem

- **Component Misplacement**

- Placement of the PnP arm for small packages (Repeatability of the tool)
  - Only suitable for packages > 17mm x 17mm
- False alarm trigger (High Assist) for Component mismatch error

- **Sealing inconsistencies**

- Sealing line broken
- Sealing Alignment out

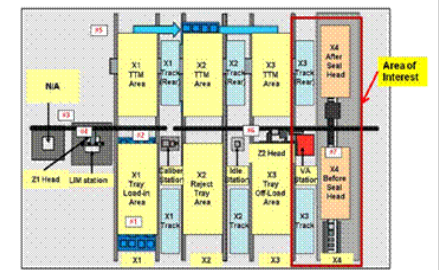


Sealin  
Line

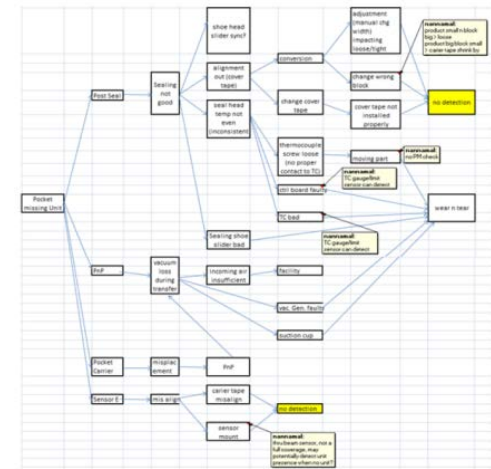


# LEAN & CECA

- **LEAN** = creating more value with usage of fewer resources.
- **Direct Observation (DO)** is done on the area of interest
  - **Outcome:**
    - Understand what is really happening
    - Identify areas of improvement in the process
      - Look for waste or provide suggestions on how to make it better
    - Get Strong Agreement on where the team will focus on
  - Study the interaction and formulate the CECA



No Robust Detection

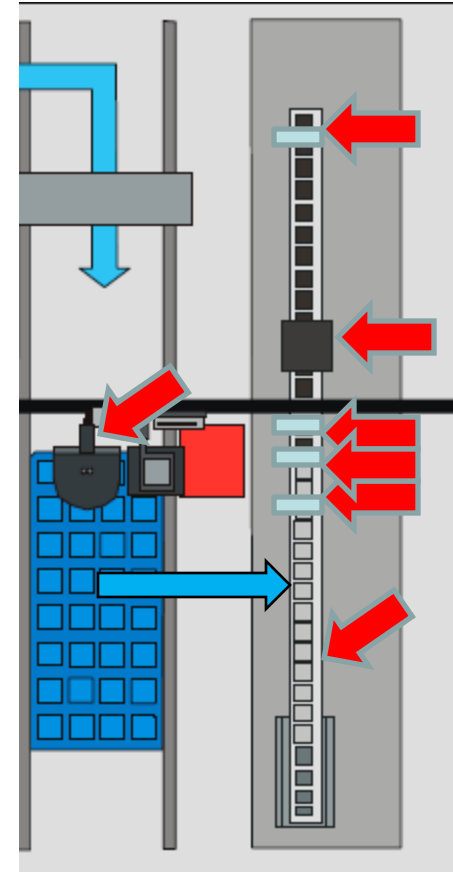






# TRIZ

- **TRIZ** = Theory of Inventive Problem Solving
- Focuses on the area of interest
  - The main component of the problem area X4 is the main track where the units are placed on the carrier tape from the trays
  - The main track is made up from (in general) the rail that holds the carrier tape, the sensors to detect empty pocket as well units present, a moving Pick and place arm that moves the units from the tray to the carrier tape, the Seal Head mechanism and a post seal sensor.



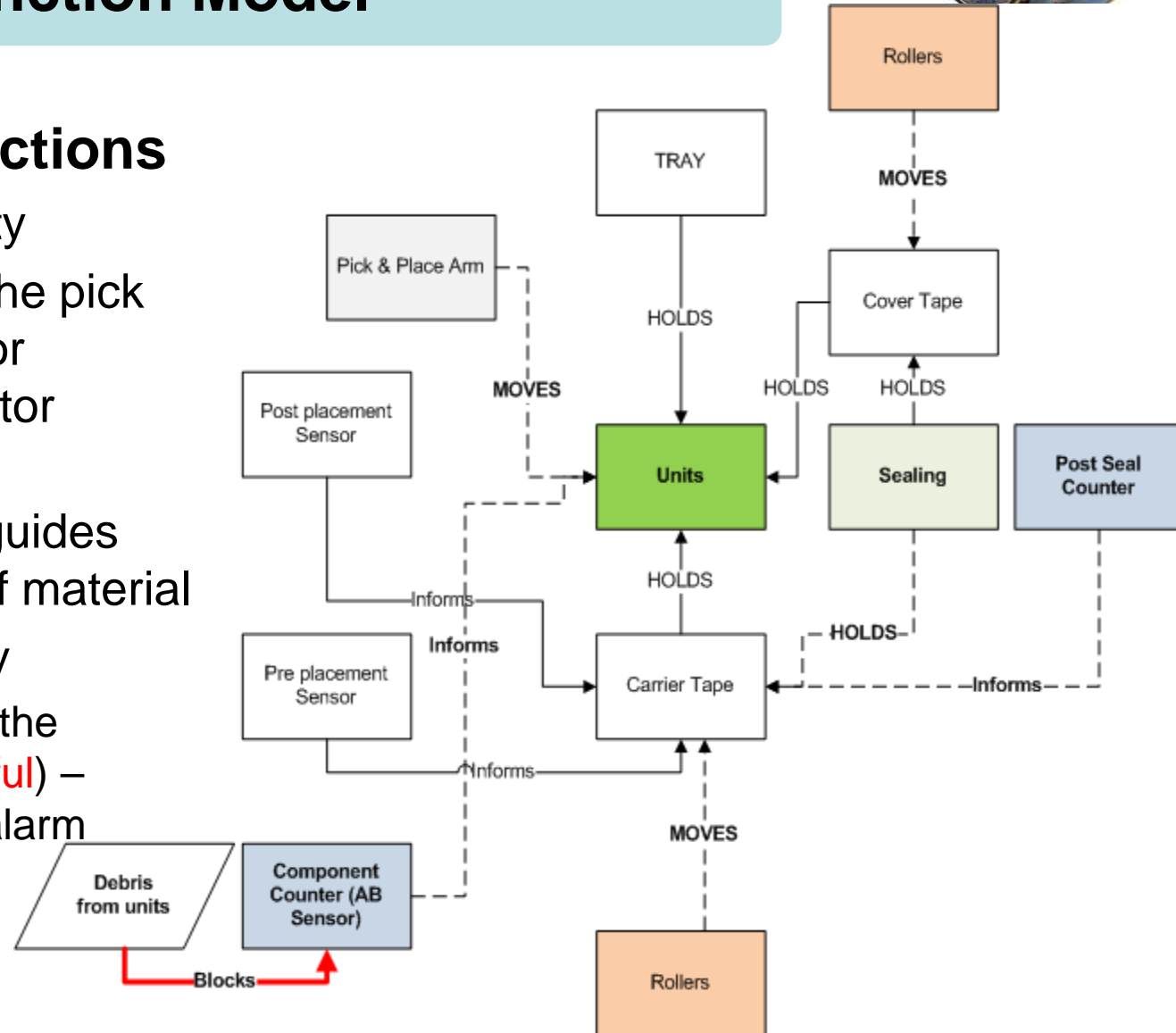
**Main Track**



## Function Model

### Insufficient or Intermittent functions

- Sealing capability
- Consistency of the pick and place arm for <17mm form factor packages
- Rollers loosely guides the movement of material
- Sensor accuracy
  - Debris blocks the sensor (**Harmful**) – causes false alarm







# TRIZ & Model of solution

## Contradiction Matrix

- Improving parameter: Measurement accuracy (#28)
- Worsening Parameter: Loss of Substance (#23) & Productivity (#39)

**What is and how to use the Interactive Matrix?**

TRIZ is a theory that considers engineering problems and suggested solutions based on their structure. TRIZ states that:

- Technical systems evolve towards the increase of ideality by OVERCOMING CONTRADICTIONS, mostly with minimal introduction of resources.
- Most of the innovations are transpositions of KNOWN SOLUTIONS in other fields.

The TRIZ Matrix is a database of KNOWN SOLUTIONS (principles) able to OVERCOME CONTRADICTIONS.  
I.e. You need a static object to be longer without becoming heavier. This is a contradiction. The improving feature is ' #4, length of stationary object ' and the worsening factor is ' #2, weight of stationary object '. Use the matrix to discover possible ways of solutions, the PRINCIPLES.

**Interactive TRIZ Contradiction Matrix:**

28: Measurement accuracy

23: Loss of substance

TRIZ Matrix Lookup

Tip: Select the features then click on the TRIZ lookup button

**The TRIZ Matrix proposes the following Principles to solve this contradiction:**  
**Improving 28: Measurement accuracy without damaging 23: Loss of substance**

**10. Preliminary action**

- Perform, before it is needed, the required change of an object (either fully or partially).
- Pre-arrange objects such that they can come into action from the most convenient place and without losing time for their delivery.

**16. Partial or excessive actions**

- If 100 percent of an object is hard to achieve using a given solution method then, by using 'slightly less' or 'slightly more' of the same method, the problem may be considerably easier to solve.

**31. Porous materials**

- Make an object porous or add porous elements (inserts, coatings, etc.).
- If an object is already porous, use the pores to introduce a useful substance or function.

**28. Mechanics substitution**

- Replace a mechanical means with a sensory (optical, acoustic, taste or smell) means.
- Use electric, magnetic and electromagnetic fields to interact with the object.
- Change from static to movable fields, from unstructured fields to those having structure.
- Use fields in conjunction with field-activated (e.g. ferromagnetic) particles.

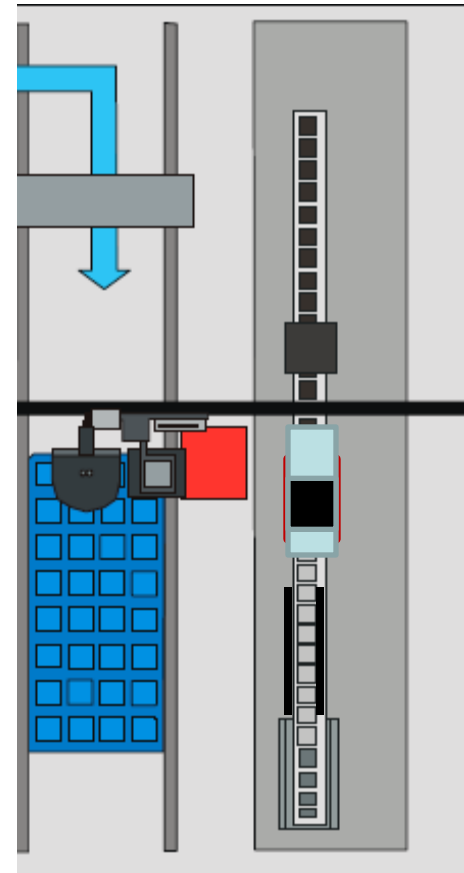
Principle #10:  
**Preliminary  
Action**



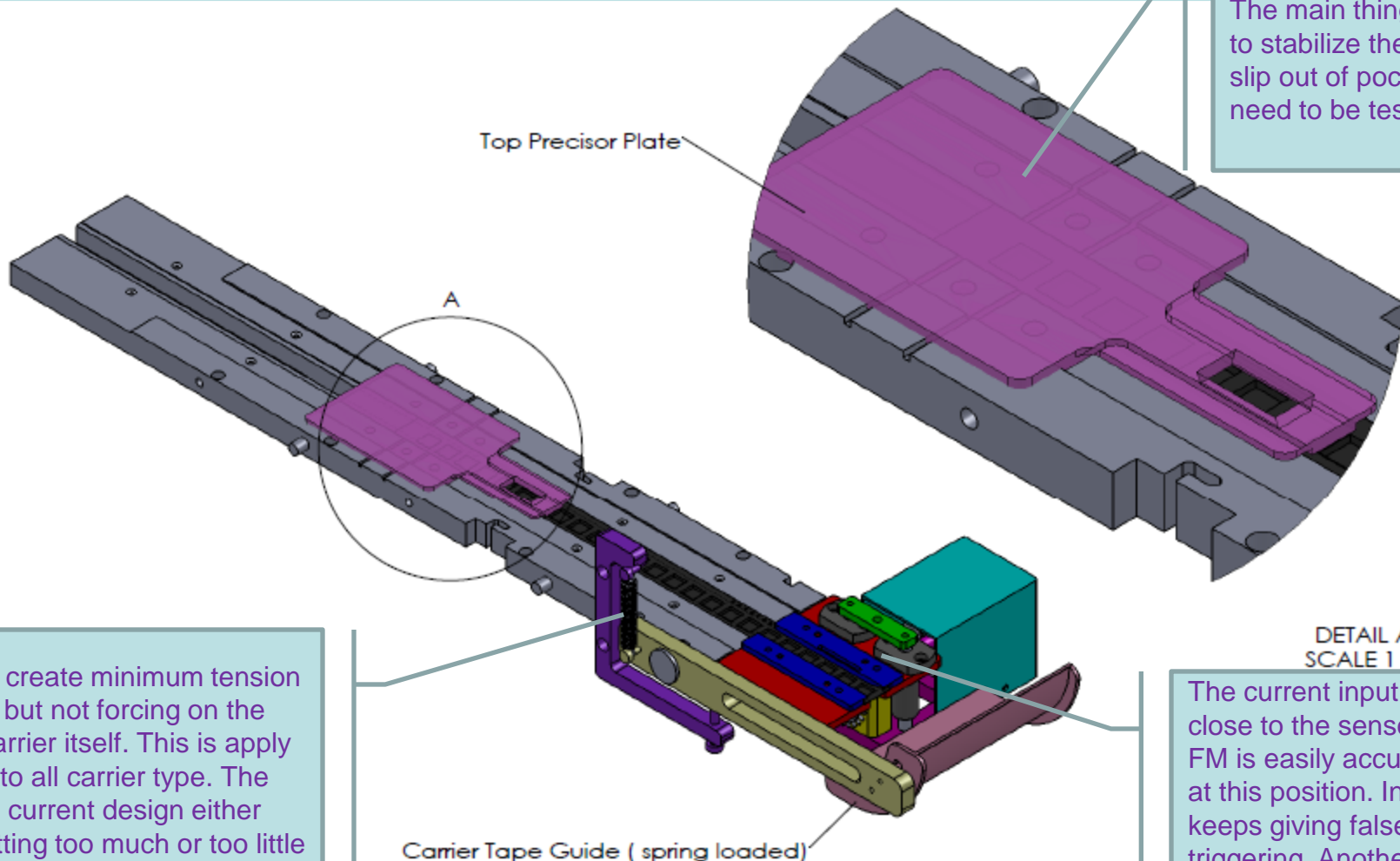
# Inventive Principle #10

## Preliminary Action

- **Top protection cover extension** (between the unit dropped to the magnetic sensor)
- **Pocket guidance to prevent misplacement** (attach together with the extended cover)
- **Extended track and spring loaded guide** (stabilize the pocket movement and minimize the potential misplacement due to potential vibration created by the flexi guide (POR))



# Solution Prototype



Top Precisor Plate

A

Carrier Tape Guide ( spring loaded)

The main thing of this is to stabilize the unit from slip out of pocket but it need to be tested first

To create minimum tension but not forcing on the carrier itself. This is apply to all carrier type. The current design either putting too much or too little force on the carrier.

DETAIL A  
SCALE 1 : 1

The current input is too close to the sensors and FM is easily accumulated at this position. Indirectly it keeps giving false triggering. Another function of this extension is to stabilize the carrier tape from fluctuating



# Results & Return of Investment

- \* 0 false alarm triggers, 0 misplaced components & 0 missing components
  - Much lesser vibration from the movement of the carrier tape
  - Specific Location for placing units and auto alignment
  - Single direction Valve effect – One way in ONLY
- Approx USD500K savings within 1 quarter

\* Data based upon prototype system that is installed on 1 tool





# Summary

- **LEAN**

- Look for areas of improvements in the process – what is not working right or what can be done better vs. Current Standard
- Eliminate waste where possible – teaches the person to look out for the various waste while performing Direct Observation
- Provides high level information on what and where the problem is potentially happening

- **TRIZ**

- Provides better understanding of the interactions at the area of interest (Function Model)
- Provides suggestion that can lead to an elegant solutions to the area of interest
  - Contradiction Matrix
  - 40 Inventive Principles



# Acknowledgement

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**THANK YOU**