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UMASS LOWELL

Enlightened Bites Entrepreneurship Series

Problems:

Corner Them & Measure Them

Prepared by:
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A quote…

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"Some people are more concerned with being right than getting it right."

Dr. Erik N. Schlosser, PhD

Why do we offer this information

- Because of the Start-Up Challenge
  - The clock is ticking – Start-ups are in a constant non-profitable cash burn scenario
  - No precedence in knowing what might be important or what has the highest risk
    - Literature Search and Basic Research are the norms
  - Low or No Production Volumes to gain understanding of critical requirements
    - Every Build Counts to create a collective knowledge base, but infrastructure is often absent and unable collect critical knowledge
    - Simultaneous Knowledge Accumulation in product and process development, test, and manufacturing
  - Inexperienced management team, needing to focus limited resources with strong personalities
  - Poor community habits, including inconsistent communication of direction and priority
  - Great innovators are not necessarily great organizers and managers
  - Investors need concise, quantitative messaging on results and committed work against milestones

A Definition

prob·lem

/ˈpräbləm/

Noun

A matter or situation regarded as unwelcome or harmful and needing to be dealt with and overcome.

A thing difficult to achieve or accomplish.

As I see it, it's rare when important problems are not difficult…

What we will achieve in this session

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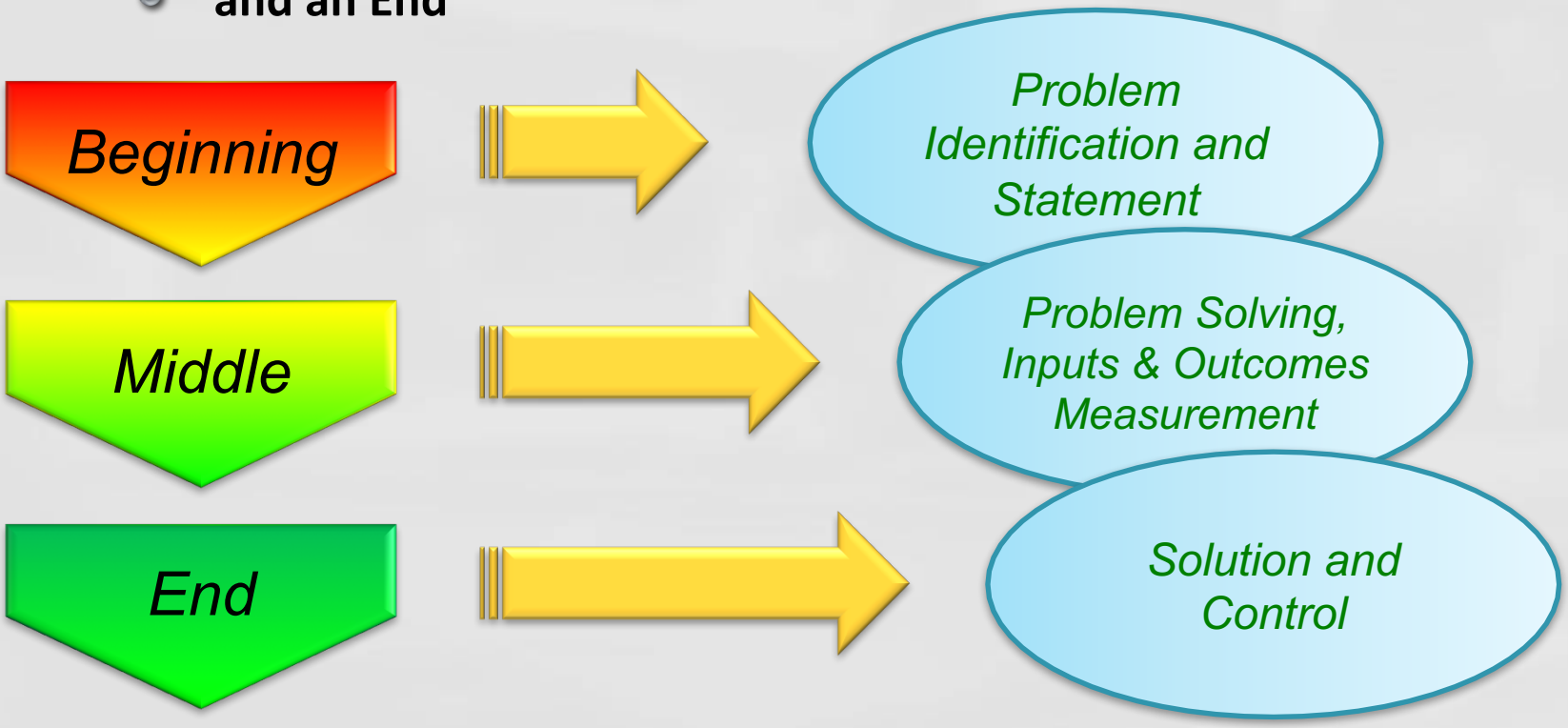
- Be able to come to an agreement that there is a problem
- Be able to write a problem statement
- Determine how to measure the problem, as defined by the problem statement
- State the desired outcome indicating the problem has been solved
- Achieve a basic understanding of measurement error's contribution to confounding interpretation of experimental responses and outcomes

We will not concentrate on methods of problem solving; this will be handled in an other session

Some thoughts on Problems

- Problems have:
  - **a Beginning**
  - **a Middle**
  - **and an End**



Some Thoughts and Pitfalls

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- Team Members do not respect the problem:
  - Fail to determine and agree on nature of a problem by always insisting the answer is obvious
  - Don't listen to customers (internal and external) about the nature of the problem
  - Waste time and resources by jumping ahead to "the solution" without objective measurement of success
- If the problem's solution was easy, it would have been solved
  - Take a step back to see who is talking about a problem, while observing the resources and salaries in the room
  - The problem is likely costing and has already cost the company significant money
- Answer the question: **Why are we in business?**

To identify, describe, define, and objectively measure outcomes as fast as possible

To follow through and learn from outcomes

To sustain achieved improvements

To increase stability, allowing us build on continual improvement

Innovation in business requires us to build a foundation of knowledge!

To make MONEY!

Problem Definition and Statement

- A Problem Definition and Statement
  - A limited and quantifiable statement of a condition that is undesirable or results in negative externality
- Scope
  - The problem statement should address the condition of interest
  - The statement should frame the current condition or behaviors, while contrasting the desired outcome
- Agreement
  - The customer who is experiencing the problem and receiving the problem solving services should approve the statement
  - Also, there should be agreement on the a successful desired outcome and the direct means of measurement, that if met, the outcome will SOLVE the problem
- Communication to Customer and Team Members
  - Experienced Problems Solver Leads sometime don't get beyond Problem Definition and Statement before someone previously left out of the communication loops explains:

"…oh that, that's been happening for years because we failed to…"

Examples (Development)

- **Bad:** Print Head Heater uniformity is causing printing inconsistency
- **Good:** From mechanical, electronic, and fluidic tolerance analysis, the print head end to end uniformity must be vary no more than +/-1°C during operation

- **Bad:** Chip's Silicon Dioxide / Silicon Nitride boundaries always fail during device burn-in
- **Good:** The Silicon Dioxide / Silicon Nitride must be able to survive with out degradation for a 50% longer duration at the specified direct current, during initial burn-in

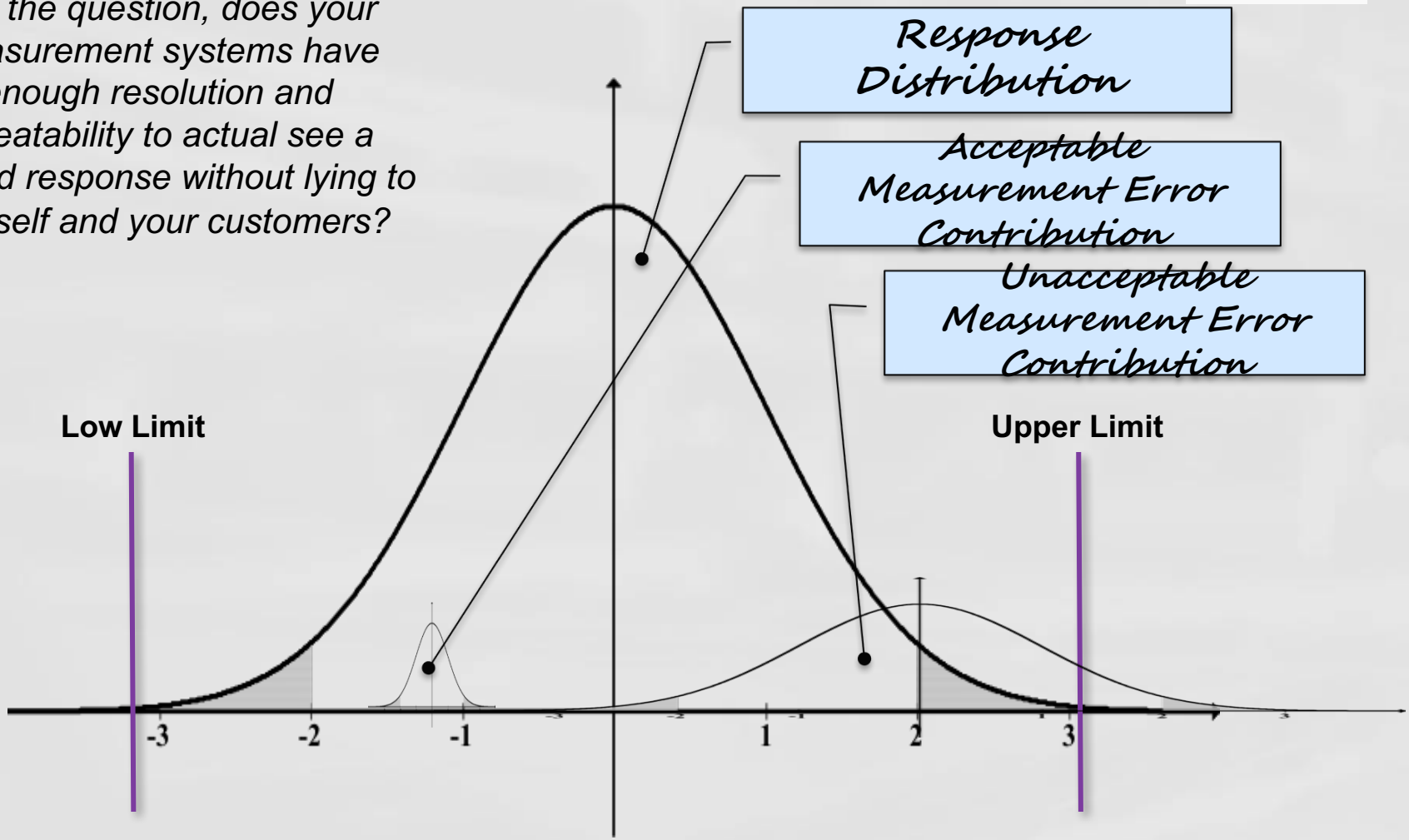
Examples (Manufacturing)

- **Bad:** Company A has too many transactions on the production floor
- **Good:** Transactions in low cycle time work areas are collecting up to 30% of their total cycle based on data input delays, impacting On Time Shipping

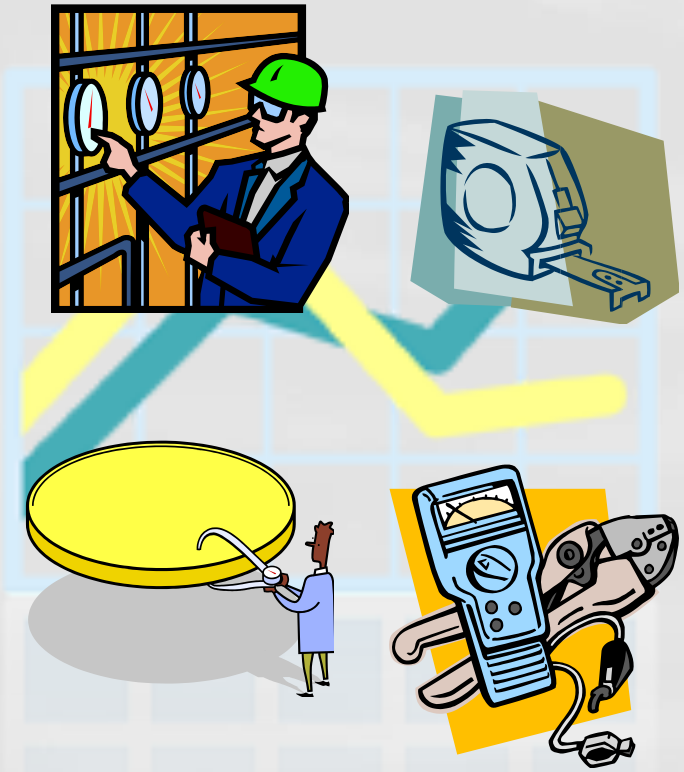
- **Bad:** We can't measure welded tubes…
- **Good:** Measuring welded tube concentricity is a time consuming process, requiring up to 5-7 minutes per part, which is 60% of the total time required

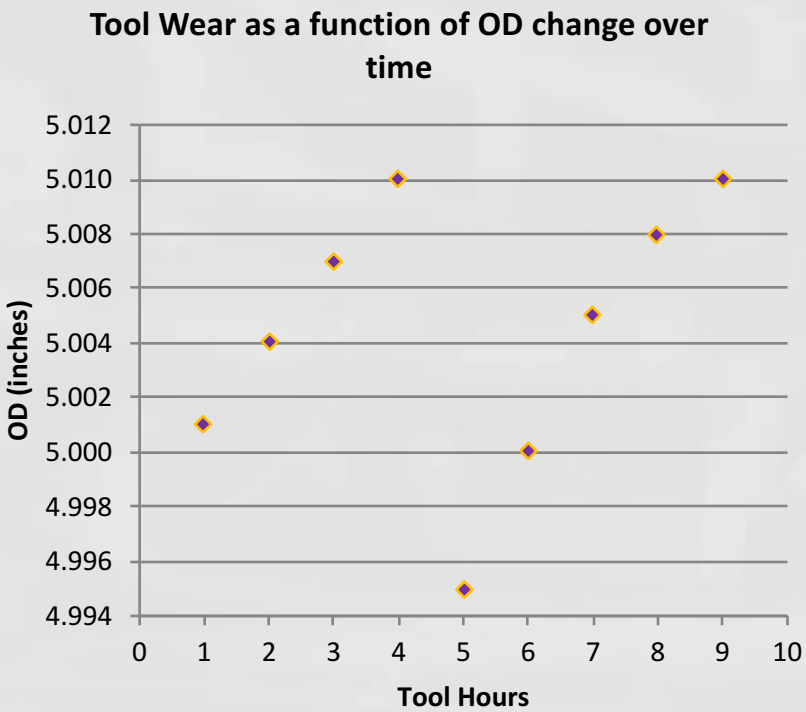
Resolution & Repeatability

Ask the question, does your measurement systems have enough resolution and repeatability to actual see a desired response without lying to yourself and your customers?



Measurements Systems





Direct Measurements
Often Quantitative

Indirect Measurements
May be Indicative, Quantitative, or Qualitative

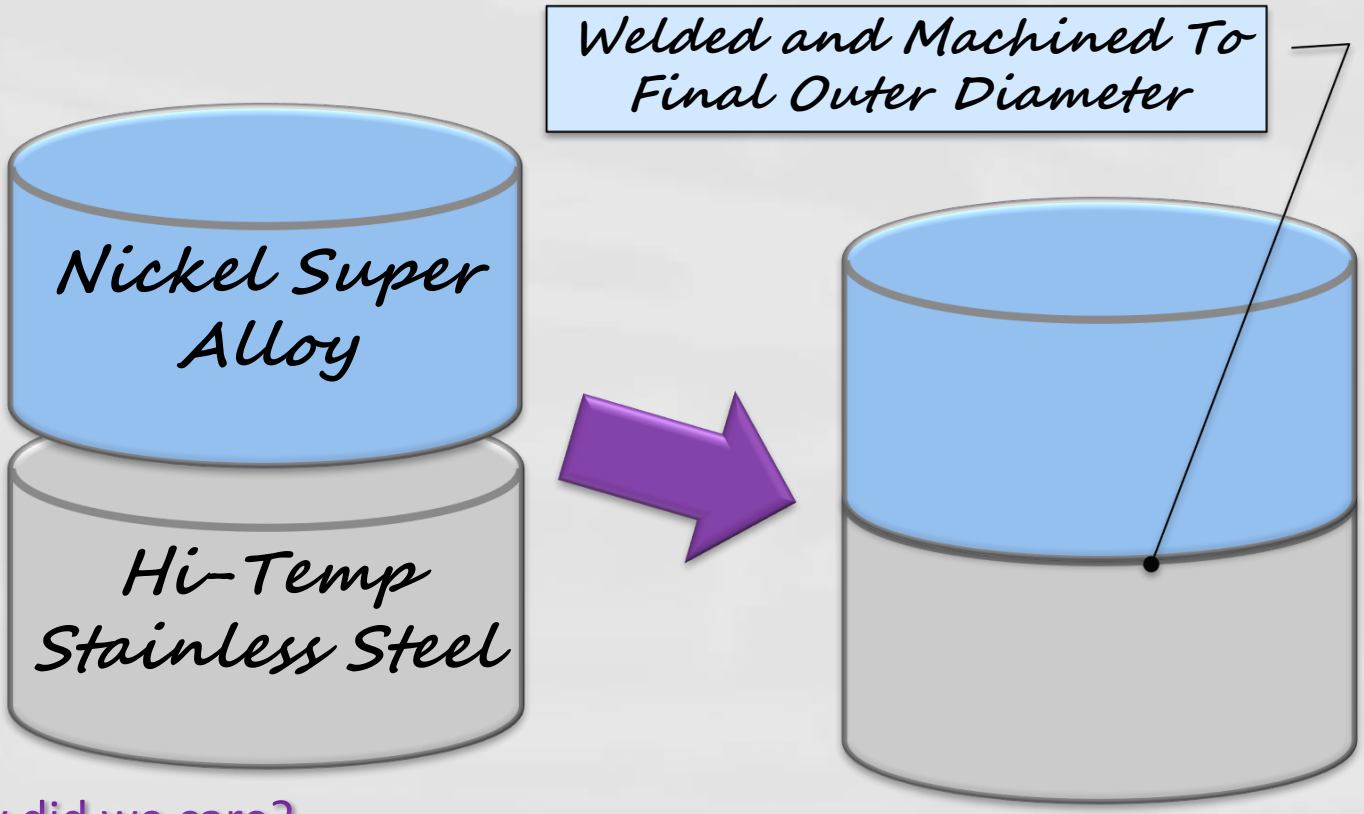
More Pitfalls

- Using Qualitative Language in a Quantitative World
  - Use direct, repeatable measurement systems, with sufficient resolution
  - Even though the team may not have a direct measurement, there are often "indicative" measurements that are hinting there's a problem
  - Use an indicative measurement until a direct measurement is established
  - For some types of problems, indicative measurement is the best way to track performance
    - Overall Device Test Yield, Thin Film Uniformity as a %, Training Efficacy in Terms of Cycle Time, Visual Defects Reduction by visual rank order correlation to parametric inputs
- Scope Creep
  - If upon studying a problem, the scope starts to creep into other related areas, the team may have to declare it has compounding problems
    - Prioritize the most highest impact candidate, and park the subordinate(s) for later consideration
      - *Executing this kind of decision split is critical to maintain focus*
    - Better to solve ONE defined problem and drain the swamp a bit, than to waste resources on an impossibly broad scope

Even More Pitfalls

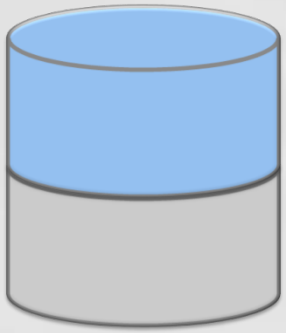
- Refusing to use the "Big Brain"
  - Accountable problem solving teams should never exceed a total of three to four assigned people
  - But the communication of the problem's definition and clues, experiments, and interim results should be shared broadly, welcoming other stakeholders to think about the problem and possible solutions
  - Progress and content should be stored in a common notebook and if needed on a server
  - Regular updates should be formalized periodically explaining status, progress, and usage of company resources
  - Ask for help when stalled; sometimes a fresh set of brains and eyes will see something when you're tired and saturated
- <u>Every process or piece of capital equipment requires a suitable direct quantitative metrology system</u> for equipment acceptance from the equipment supplier, outcome measurement, and process control

What is a Hybrid Tube?

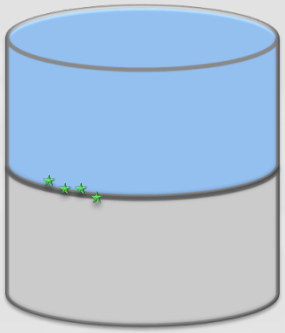


- Why did we care?
  - If this project failed, a 40% material and process cost reduction project and savings already committed to a budget would have to be backed out…
  - Also, a price reduction was committed to our customer!

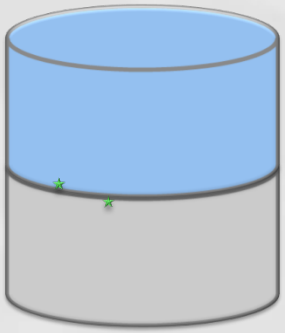
Clues the Team Saw



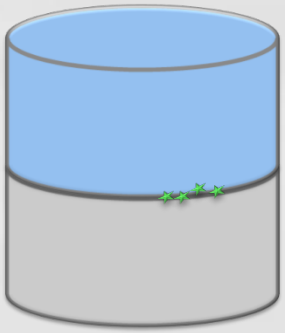
After Welding and Machining



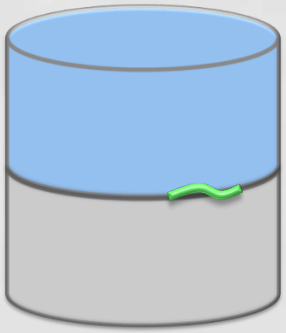
After FDT, Defects Too Close



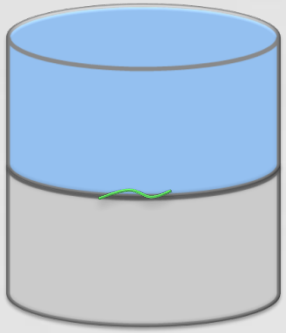
After Rework Grinding



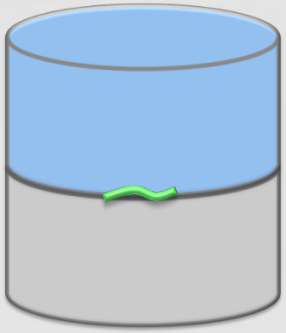
After FDT Defects Too Close



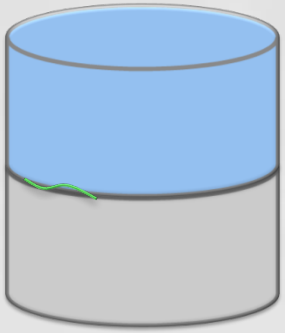
After Rework Grinding Defect Growth



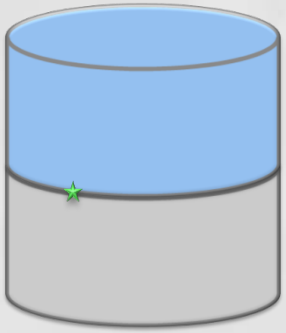
After FDT, Contiguous



After Rework Grinding Defect Growth Limited by 0.048 WT



After FDT, Contiguous



After Rework Grinding Size Failure

Quantitative vs. Qualitative can get very complicated

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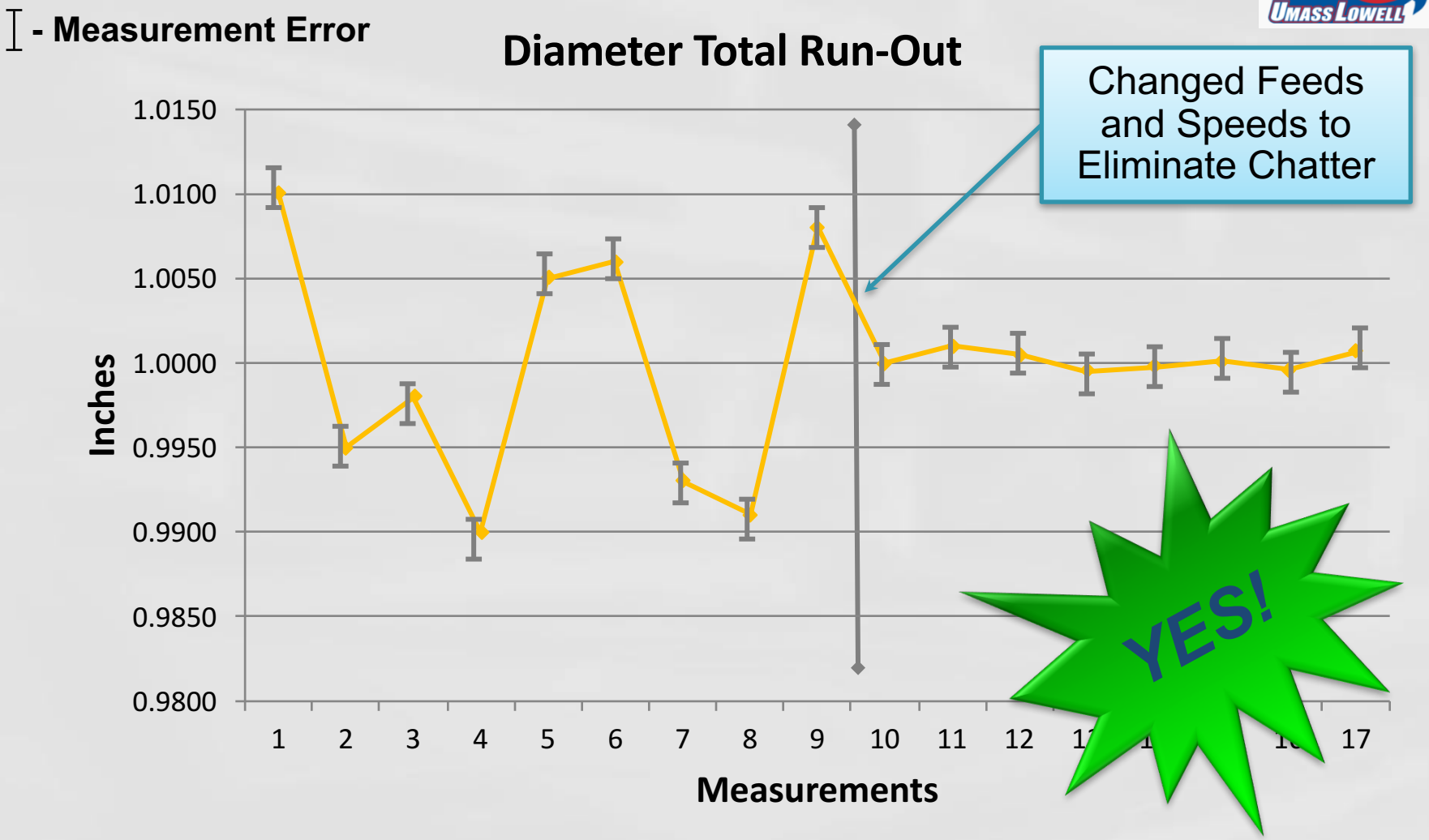
- Machining Hybrid Tubes reveals defects after dye testing
  - 80% of defects are contiguous after machining which is not allowed
  - If the defects are not connected, but they are allowed if they are small enough
  - The team's challenge is to determine if they are dealing with the same failure modes and one compounding problem to be solved -or- two conditions that need to be split and solved separately or minimized, and perhaps more quickly
- Questions the team must ask themselves:
  - Can the problem be measured directly, hence showing improvement or a solution?
    - Primary Constraint: Regardless of location and numbers, final Hybrid Tube wall thickness must be >0.048 inch, and if you grind out defect the wall thins until it's a failure. This can be measured directly.
    - Secondary Constraint: Actual frequency, location, and sizes of Dye Defects are clues to failure modes that need to be solved to improve yield; can these be quantified?
  - If problems can not be measured directly, in the beginning, perhaps it be measured indirectly by using an indicative variable to guide clue generation
    - Measuring increasing overall yield, welding efficiency increases, and scrap costs reductions because of a lower number of first time Dye Indication Defects accounts for less rework
    - Cycle Time and Total Dye Indications decreased after 2nd Shift Indication Dye QA operator was retrained to new visual standards could be another clue and possible path to solution

Which Problem is Solved?



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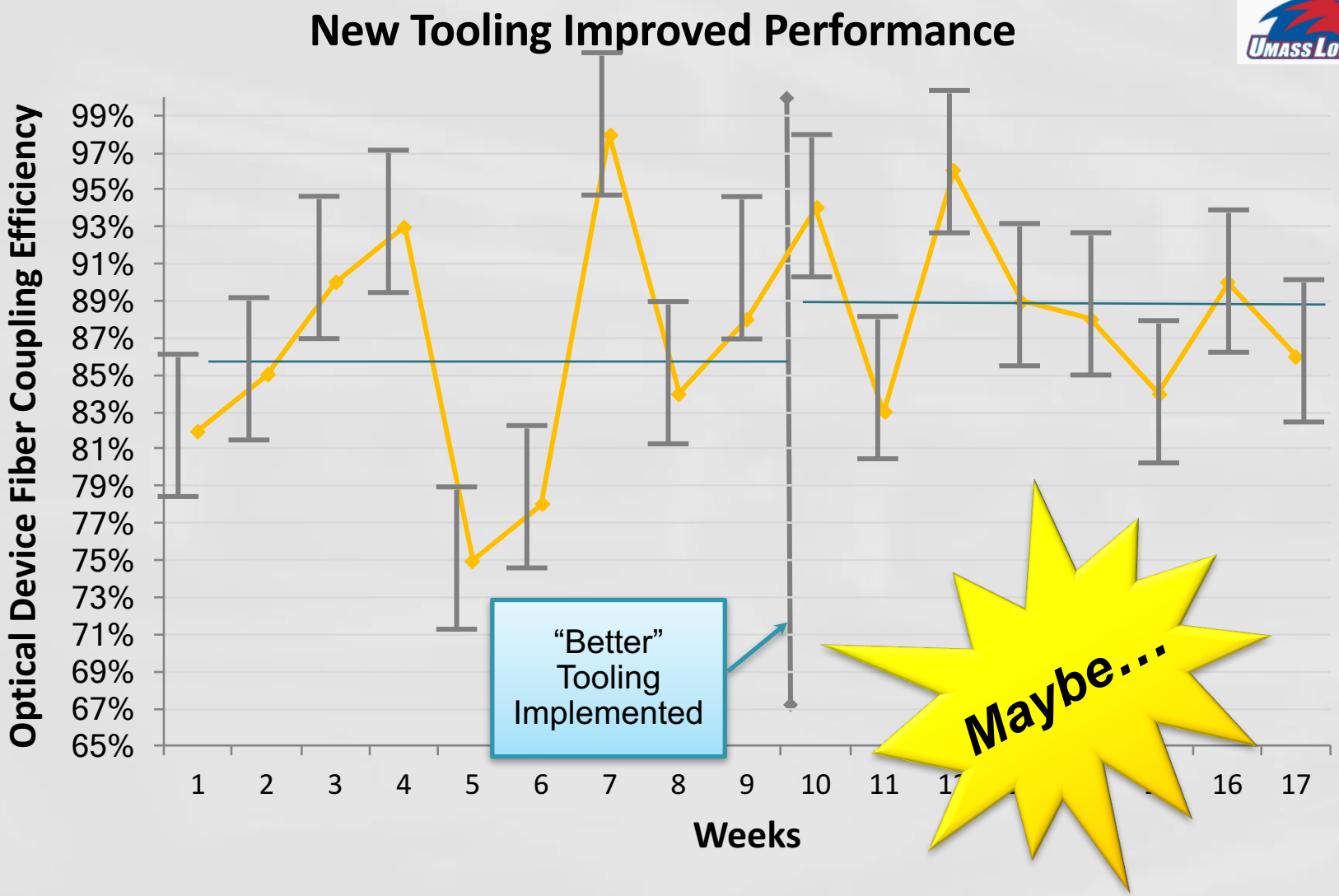
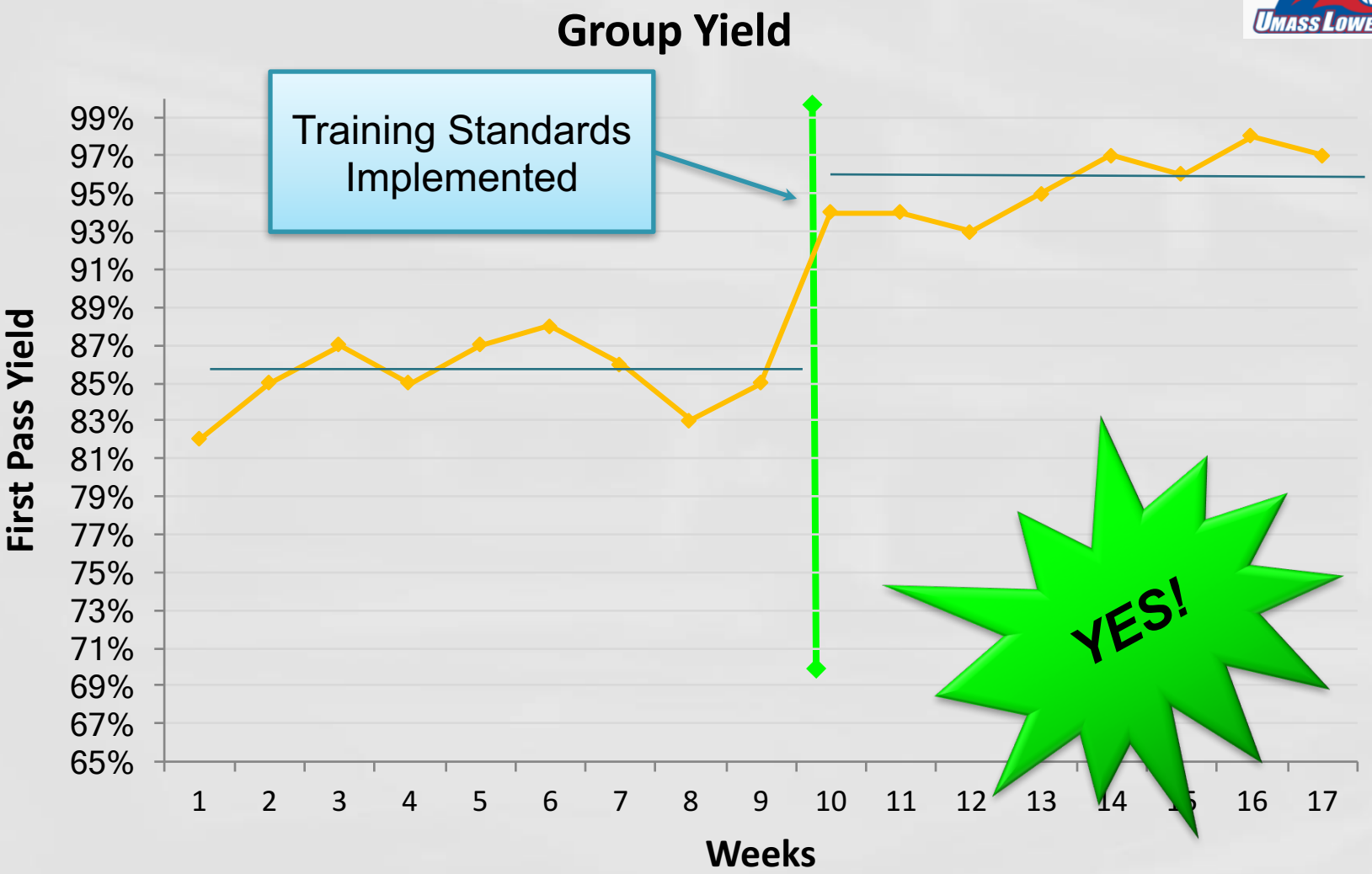


Which Problem is Solved?



Which Problem is Solved?

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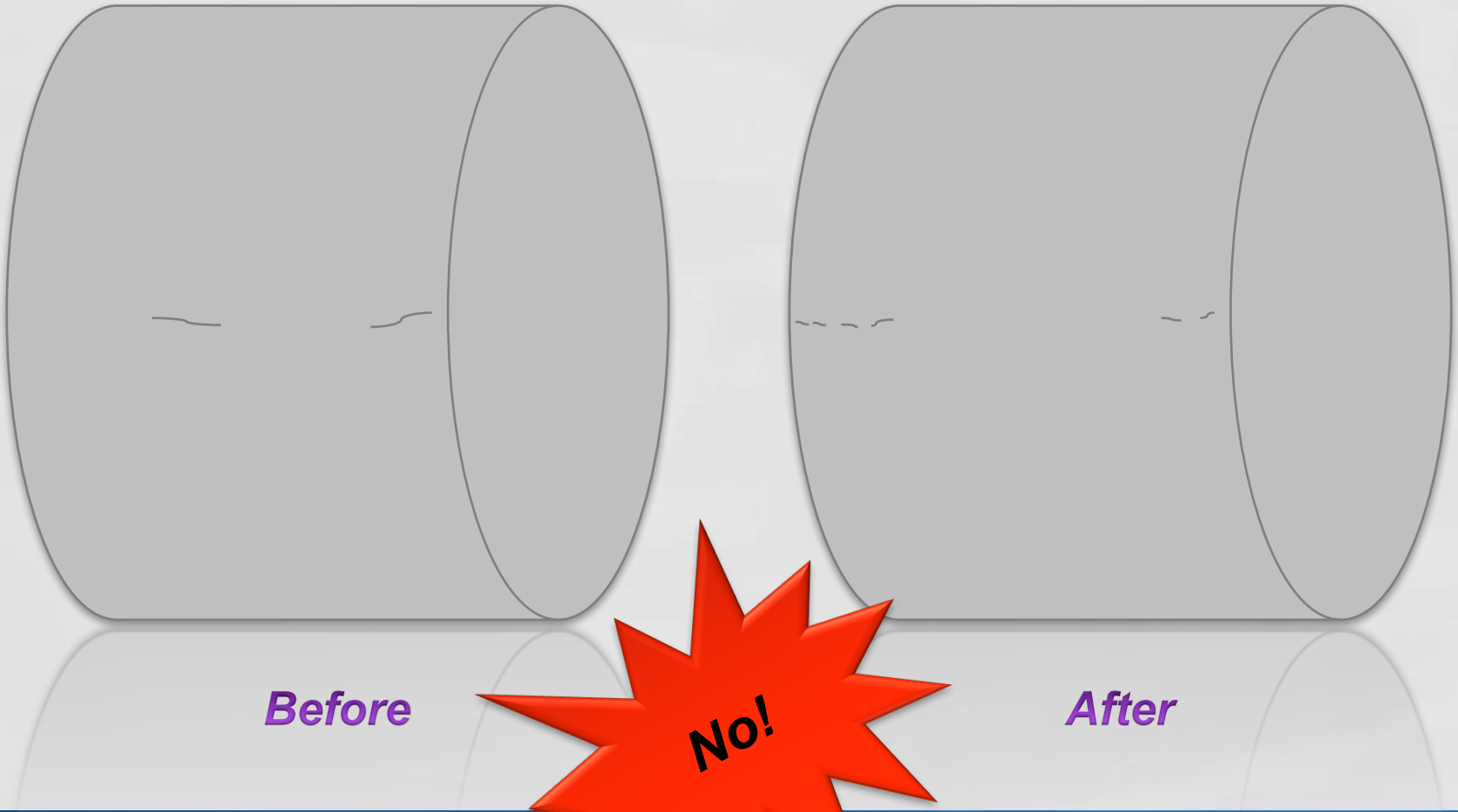
Changed extrusion parameters to reduce Within Part "Appearance of OD" defects by 50%



Solved or Not Solved Check List

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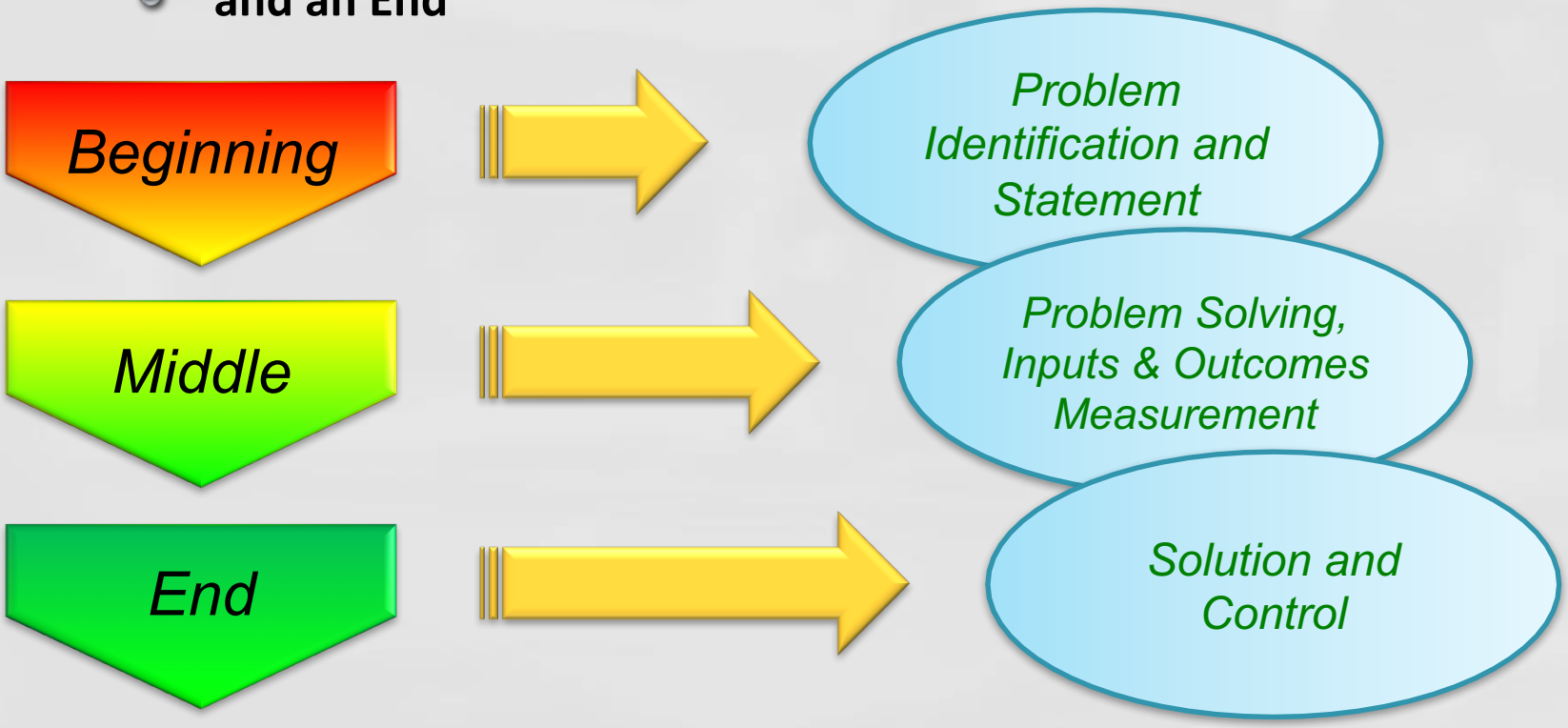
- Is the Problem Statement and measurement of the desired outcome still valid?
  - **If Yes:** Continue
  - **If No:** Determine is reduction of scope is needed -or- a split and park
- Can you discriminate between measurements with known confidence
  - **If Yes:** Continue
  - **If No:** Your measurement system either lacks resolution or repeatability (R&R)
- Can your data show a convincing difference (contrast) from before and after?
  - **If Yes:** Continue
  - **If No:** Either your measurement system lacks R&R -or- the problem was not completely solved
- Can the Solution be reproduced more than once?
  - **If Yes:** Continue
  - **If No:** Review if the measurement system is still valid and if the solution's process and work flow was executed correctly
- Can you sustain and control the change (the solution), and measure the performance over time to eliminate chance of drifting back to undesirable state?
  - **If Yes:** Problem is SOLVED!
  - **If No:** Determine what control and/or process change will sustain the solution's desired result

Remember

- Problems have:
  - **a Beginning**
  - **a Middle**
  - **and an End**



What's Next?

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Does your company need a basic foundation for success?

If so, ***The UMass Lowell Enlightened Bites Entrepreneurship Series***
presents the final part of this breakthrough series

December 8, Noon to 1 p.m. - **Moving from Tactical to Strategic Planning**

About Gary Ainsworth

My area of practice focuses on emerging technology product commercialization in hardware start-ups.

Also, I work with existing companies on new product introduction, operations, and product development performance improvement. In all instances I usually work in the gray area between R&D and Product Development -and- Operations and Supply Chain, employing methods to lower the inherent noise level allowing better decision making in a more accountable framework.

I'm currently working with UMASS Lowell's New Venture Business Development team and iHub on content around understanding start-up behaviors, leading to a higher probability of successful commercialization and profitability.

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What are the origins of this Work

- This content is a key and important subset of methods that I've applied to technical problem solving in R&D, Product Development, Manufacturing and Test Process Development, and Supply Chain Certification and Qualification
- My methods are derived from traditional statistical process control (SPC), Design of Experiments (DOE), advance statistical correlation methods of multiple metrology systems, and practical considerations in the migration of early development metrology to production usage
- The theory and practice is heavily influenced by Shainin Statistical Engineering© methods
- Shainin always states that developing a correctly sized and stated problem definition statement and having confidence in a measurement system to discriminate between Better (improved) vs. Current (the control) is the hardest part of solving problems