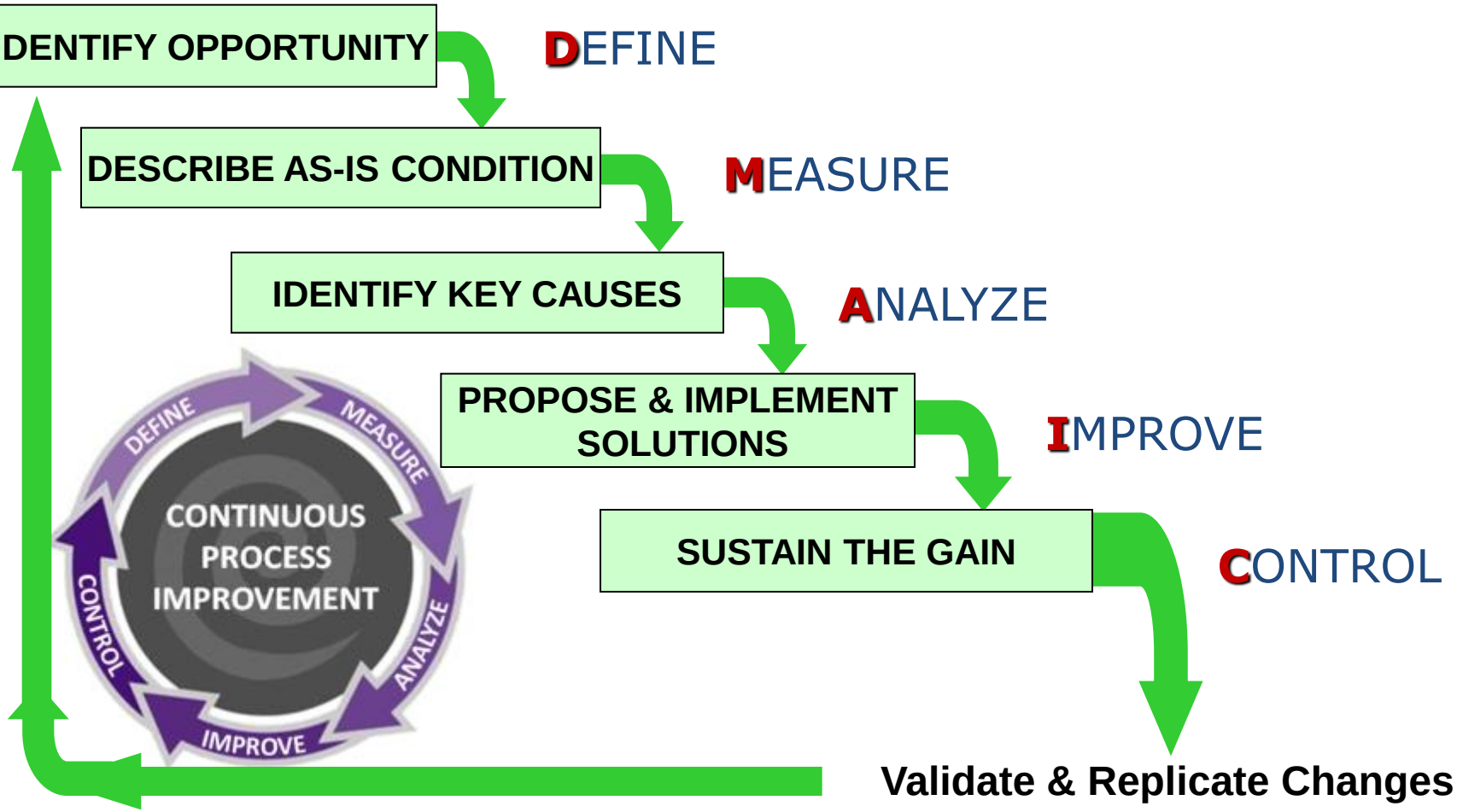
# IMPROVE PHASE

# Course Structure: DMAIC



# Learning Objectives: Improve Phase

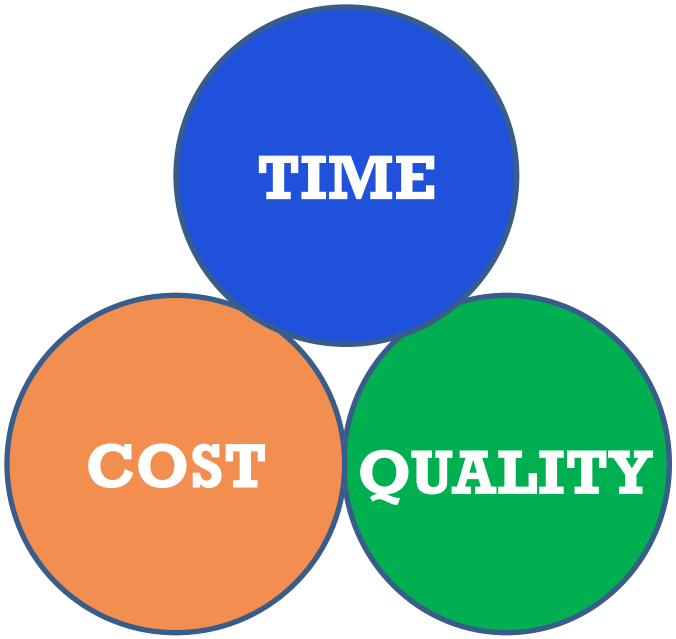
***At the end of this lesson you will be able to:***

- Understand the Lean Principles of value, value stream map, flow, pull and perfection.
- Improve workspace by implementing 5S.
- Identify opportunities for Mistake Proofing.
- Understand the importance of Standard Work within a process.
- Identify and implement visual controls in your workspace.

**"Improvement usually means doing something we have never done before." - Shigeo Shingo**

# Review: Triple Constraints of Projects

- Project Management Constraints
  - Scope (Quality)
    - Clear and Specific
  - Cost (Resources)
    - Money and Effort
  - Schedule (Time)
    - Amount of Time to complete process tasks




- Prioritizing Constraints
  - Should be based on the view of the customer.

# Lean Principles

# What is Lean?

## Tools and Methodology to:

Eliminate Waste

**WAR ON WASTE!**

Improve Flow

## By using:

Mistake Proofing

Batch Reduction

Pull/Kanban

Standard Work

Value Stream Mapping

Lean Toolbox

Set Up Reduction

Visual Controls

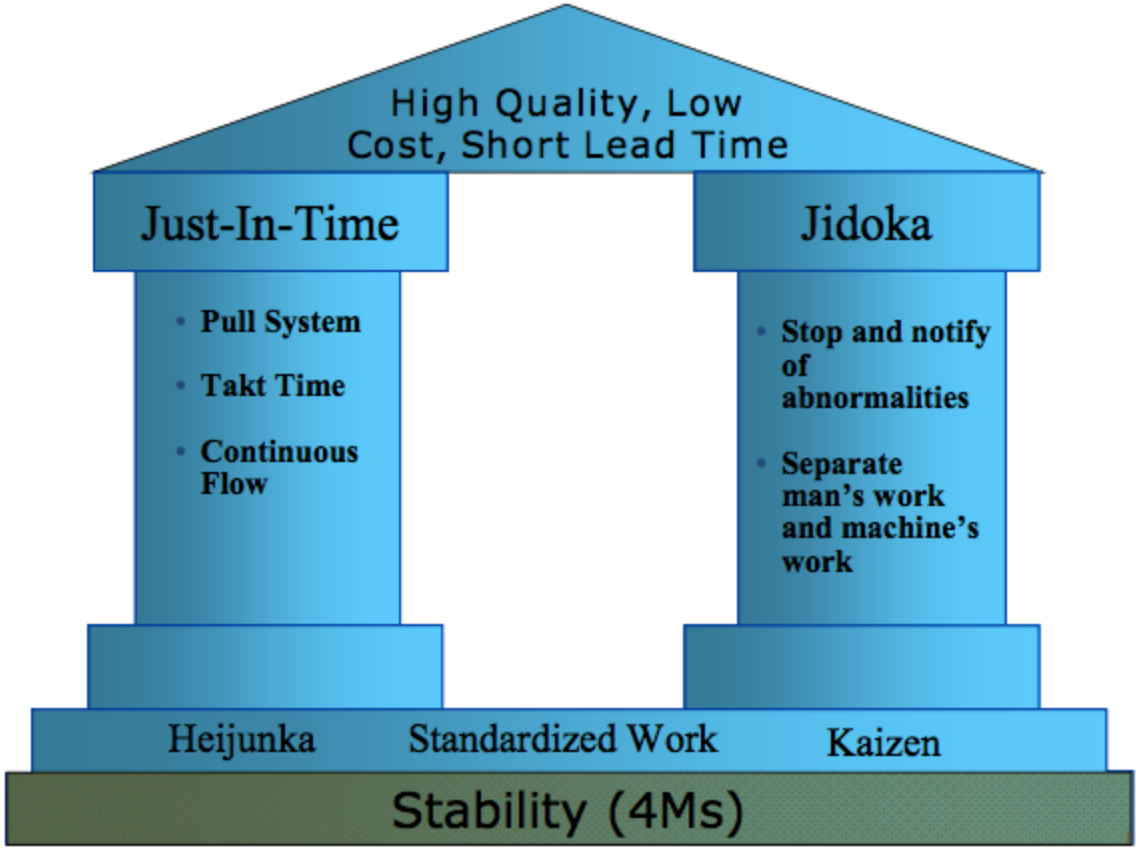
5S + 1

Point of Use System

Cellular Flow

# House of Lean

- House of Lean identifies the major concepts incorporated within Lean (TPS).




(4M's: Man, Material, Method, Machine)

# Lean Principles

**There are 5 Lean Principles.**

1. **Value** specified from the customer's perspective.
2. The **Value Stream** has been identified for each service.
3. The product/service **Flows** without interruptions.
4. The customer can **Pull** value through the process.
5. Continuous pursuit of **Perfection.**

# Value

- Critical starting point for Lean.
- **Can only ultimately be defined by the customer**.
  - NO two customers define Value identically.
- Critical questions we must ask ourselves.
  - Do we truly understand Value from our customer's perspective?
  - Are we truly focused on providing that Value?
  - What are the barriers & obstacles preventing us from focusing on and providing that Value?

$$Value = \frac{Features \ x \ Performance \ x \ Quality}{Cost \ x \ Time}$$

# Definition of Waste (Muda)

Those Elements of a process that **Do Not Increase the Value** of a Product ***as Perceived by the Customer***, but **increases Cost and Cycle times.**

Anything other than the **minimum** amount of **equipment, materials, parts, space, and worker's time** which are absolutely essential to **add value** to the product.

**"The most dangerous kind of waste is the waste we do not recognize." – Shigeo Shingo**

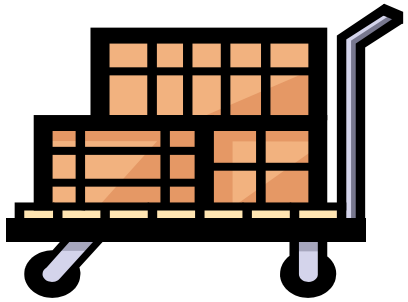
# Eight Types of Waste

## **IDENTIFY** AND **ELIMINATE** THESE WASTES:

<u>Types of Waste:</u>

**T** Transportation
**I** Inventory (Excess)
**M** Motion
**W** Waiting
**O** Over-Production
**O** Over-Processing
**D** Defects
**U** Under utilization of employees

# 8 Wastes - Transportation



Waste caused by unnecessary movement of material or product.

Primary Causes:

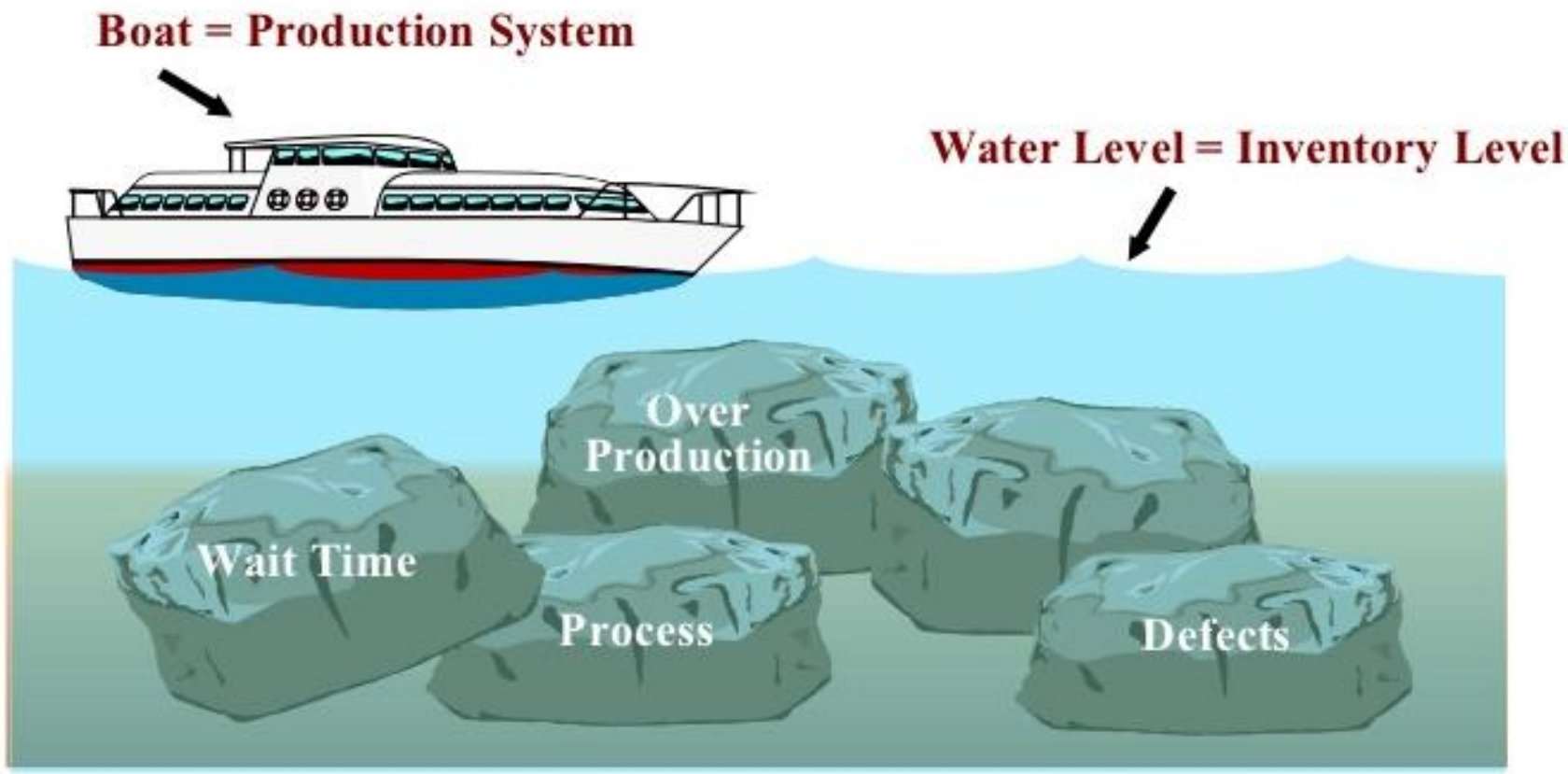
- Inefficient Facility Layout.
- Process Islands vs. Continuous Flow.
- Batch (Push) Mentality.
- Lack of Right-Sizing.
- Long Setup Times.
- Lack of Multi-Skilled Workers.

# 8 Wastes - Inventory

Waste of materials, parts and assembled goods, when purchased or produced in advance of customer requirements.

- **Increases Cycle Time & Process Lead Time.**

# Inventory Hides Problems!

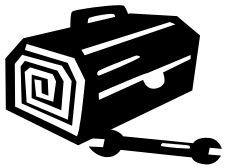


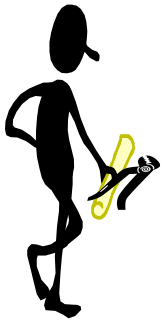

Rocks = Hidden Problems (Uncovered as Inventory is Reduced)

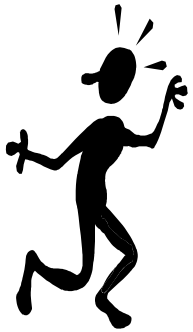
# 8 Wastes - Motion

- Waste caused by non-value added movement of workers and / or production machines.

- Primary Causes:
  - Inefficient workplace layouts.
  - Inefficient tools and / or fixtures.
  - Lack of Standard Work causing inconsistency.
  - Batch movement of product.







# 8 Wastes - Waiting & Over-Production

## Waiting

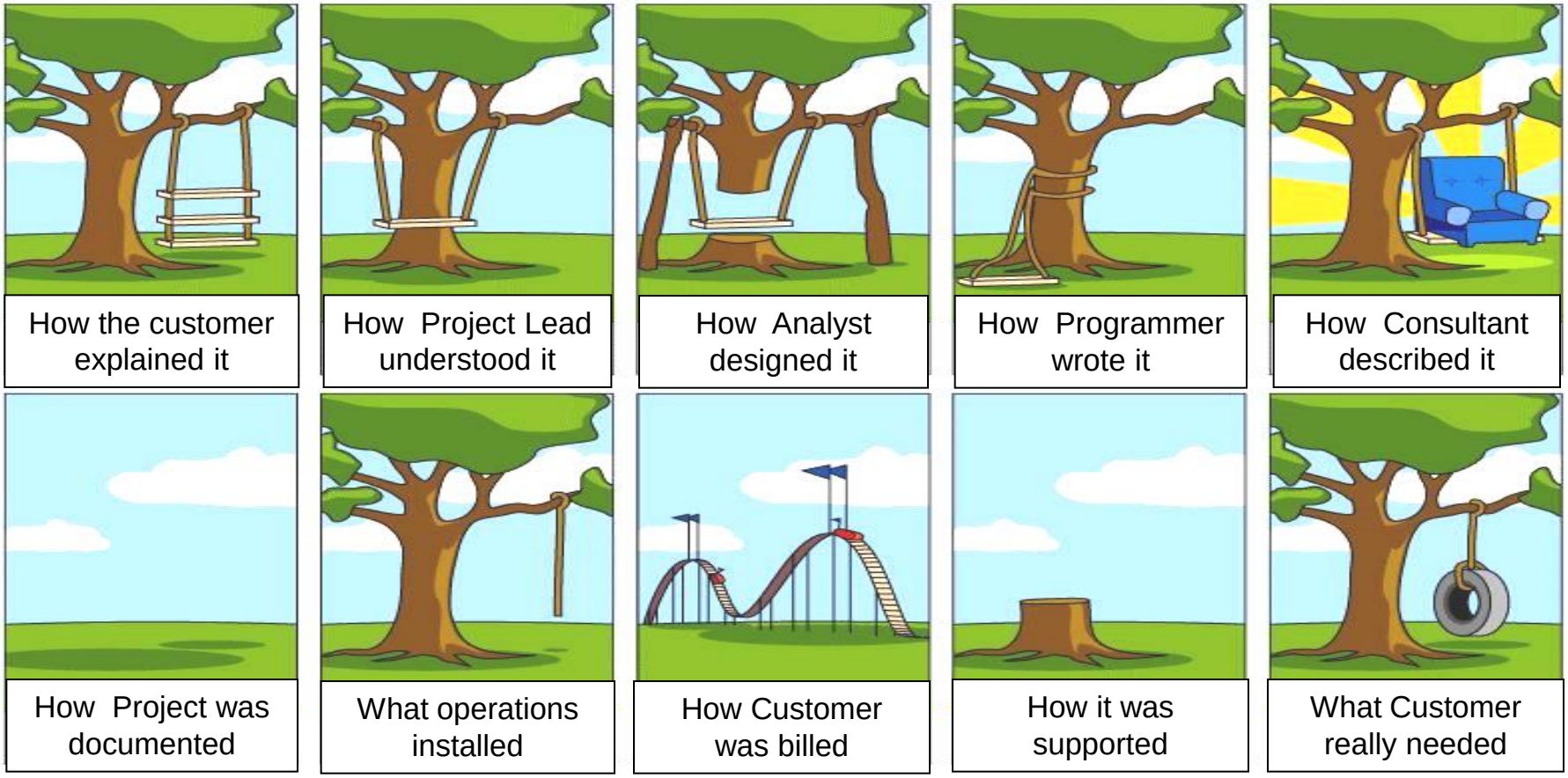
The Waste of Waiting occurs whenever the hands of an operator are idle.

## Over-production

Waste caused by producing more than the customer needs (Push). This type of waste leads to excessive inventories.

# 8 Wastes – Over-Processing

The Waste of Unnecessary or Non-Optimized Processes and/or Operations.




*"There is nothing so useless as doing efficiently that which should not be done at all."* *Peter Drucker*

# 8 Wastes - Defects/Rework

Waste that occurs when a process, product, or data does not conform to proper specifications. The result could cause product rework, scrap, or the escape of a defect to the customer.

**What Causes Defects?**

- Poor procedures or standards.
- Machines (lack of Total Production Maintenance).
- Non-conforming materials.
- Worn or out of tolerance tooling.
- Human mistakes.

# 8 Wastes – Under Utilization of Employees

## ULTIMATE WASTE

Waste of  a person's time.

# Waste (Muda) - Examples

| Type | Physical Process | Transactional Example |
|---|---|---|
| Transporting | Parts Moving to Warehouse and Back | Data Handoffs |
| Inventory | Excessive Work-in-Process | Backlog of Design or Tooling Changes |
| Motion | Retrieving Parts, Tools, Information | Poor Office Lay-Out |
| Waiting | Parts, Tools, Information | Meetings, Approval, System Down Time |
| Over-Processing | Performing Unneeded Operations | Approvals (Too Many Sign-offs) |
| Over-Production | Working Ahead of Schedule | Printing Paper Too Soon |
| Defects | Scrap or Rework | Drawing or Planning Errors, Rework |
| Under utilization of employees | More people involved than required to perform physical or transactional tasks. | |

# Lean Principles

## There are 5 Lean Principles.

1. **Value** specified from the customer's perspective.
2. The **Value Stream** has been identified for each service.
3. The product / service **Flows** without interruptions.
4. The customer can **Pull** value through the process.
5. Continuous pursuit of **Perfection.**

# Value Stream Analysis

- A “VISUAL” planning tool used to identify non-value added activity (NVA) and develop plans to eliminate the waste.
- Value Stream Analysis is the key to all improvement activities.
- Includes the entire set of activities running from requirement to finished product for a specific product or service.
- Seeks to optimize the whole from the standpoint of the final customer.
- Three Designations for Value (Measure Phase).
  - Value Added.
  - Business Value (Non-Value Added but required).
  - Non-Value Added (Waste).

# Value Stream: 12-Step Process

1: SIPOC
2: BOUNDARIES
3: VOICE OF THE CUSTOMER
4: GATHER APPROPRIATE INFORMATION

***See the Process…***

5: WALK THE PROCESS
6: CREATE CURRENT STATE MAP
7: SPAGHETTI MAP / CIRCLE DIAGRAM
8: VALUE ANALYSIS

***See the Waste…***

9: CREATE IDEAL STATE MAP

***Visualize the Perfect State…***

10: DEVELOP FUTURE STATE MAPS
11: DEVELOP ACTION PLAN
12: IMPLEMENT THE PLAN

***Lead the Way toward it…***

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- Continuous pursuit of **Perfection.**

# What is Flow?

The continuous, progressive adding of Value in the eyes of the customer.

- Starts at receipt of customer request.
- Ends at delivery to customer.

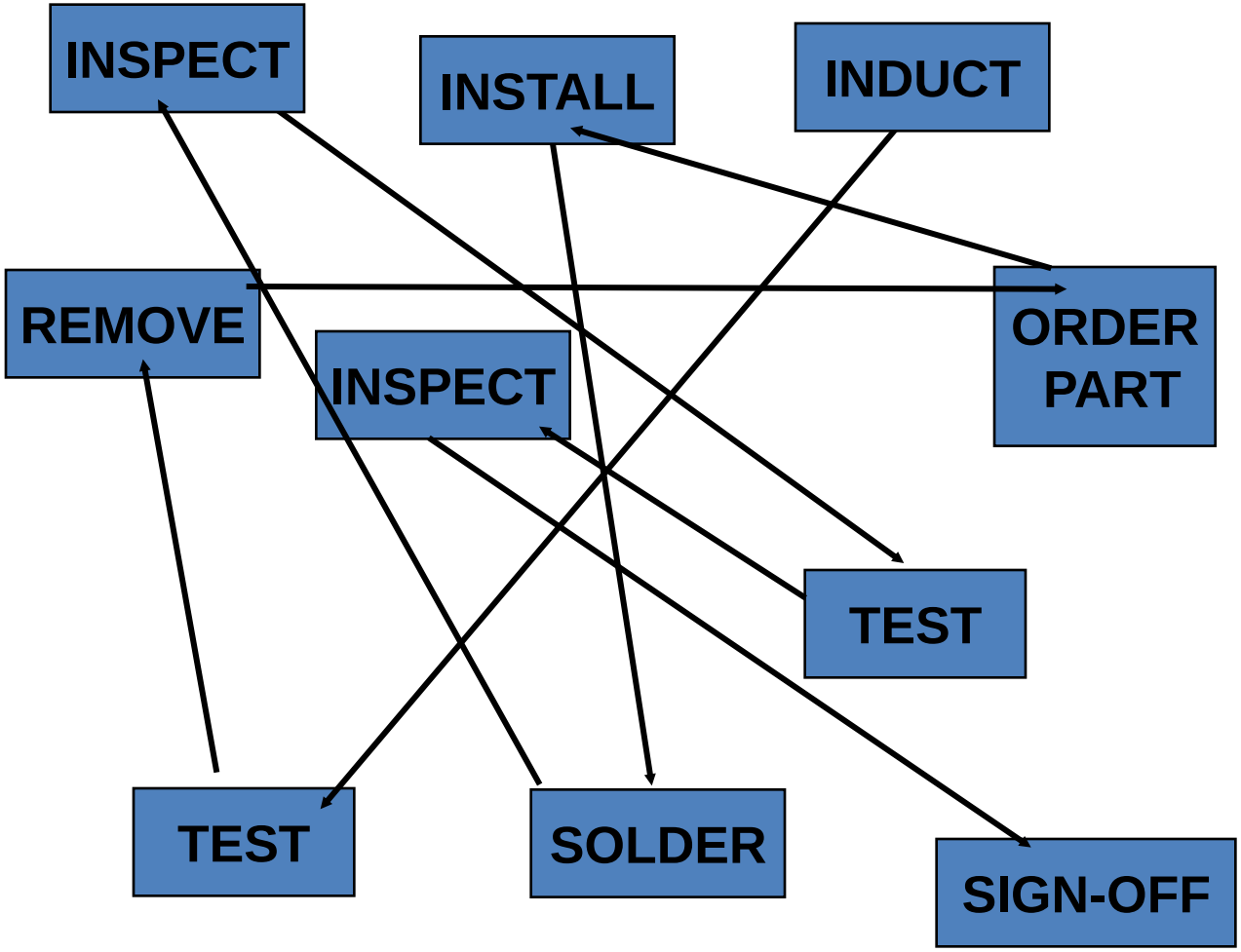
- Flow utilizes the fewest number of steps with no interruptions.
- Eliminates waste.

**People always working on the product and the product always being worked on.**

# Typical Flow – Before Improvements

***Workplace Layout***

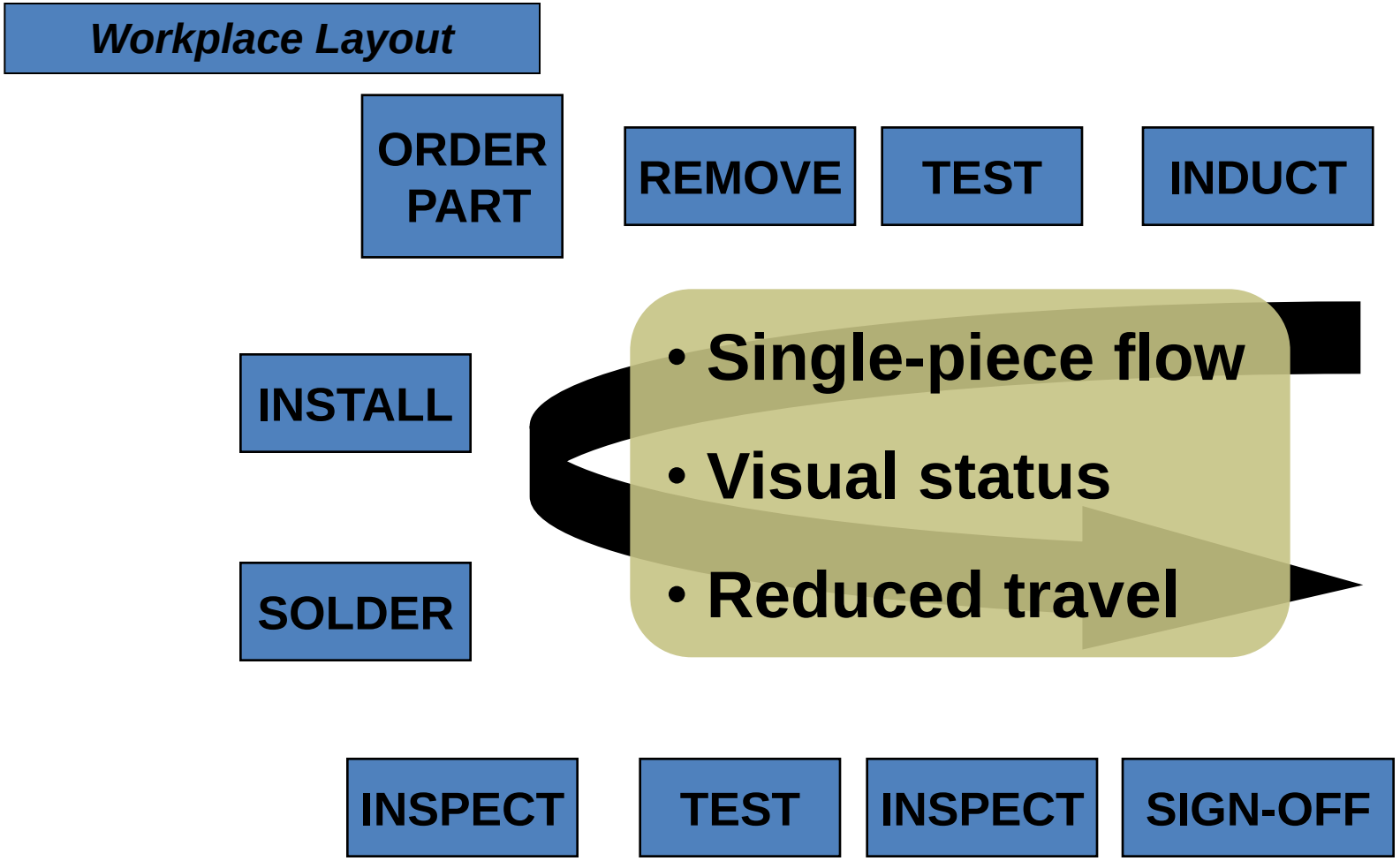
- **Batch operations**
- **Isolated processes**
- **Unknown status**



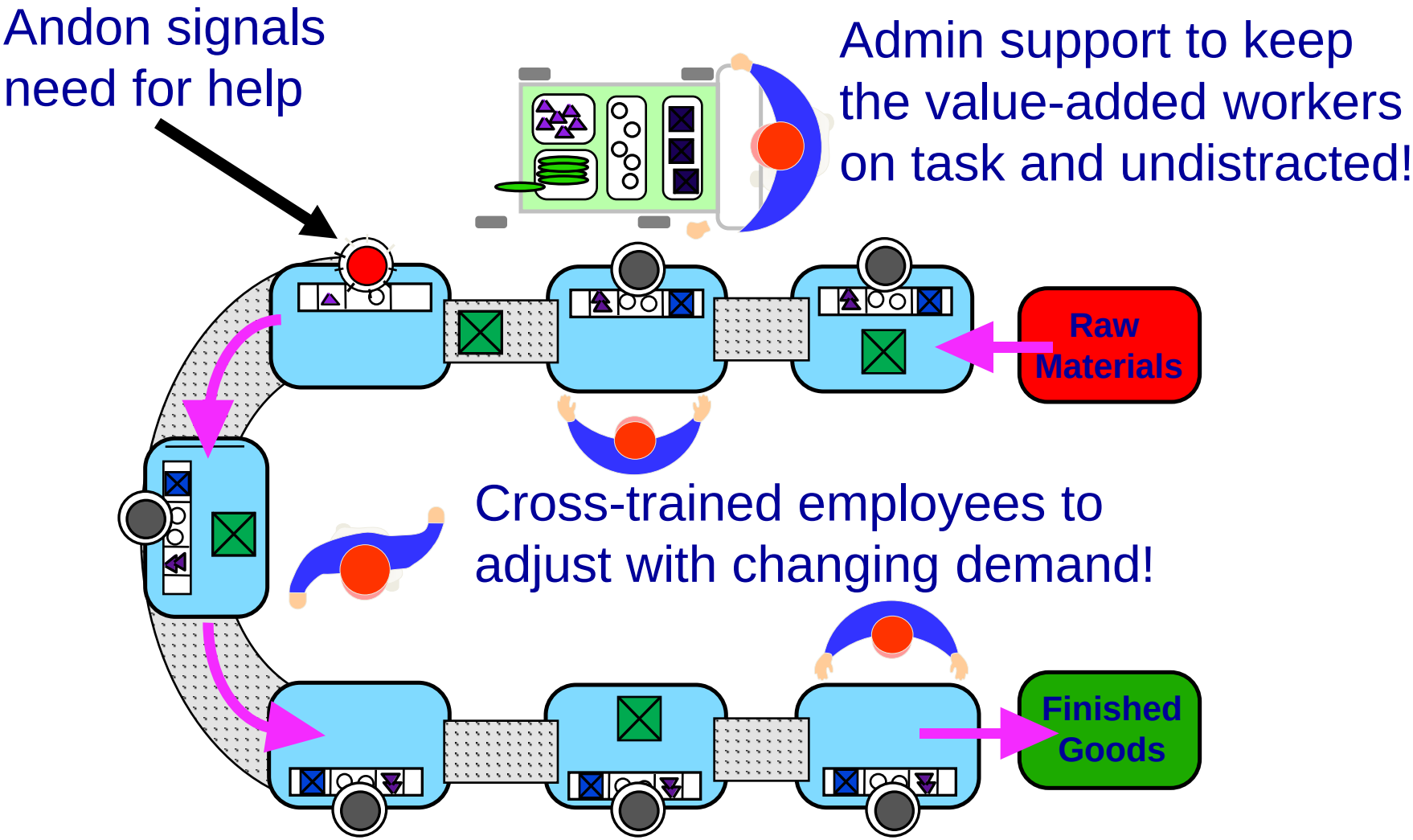
# Toyota Production System

- Taiichi Ohno / Shigeo Shingo found the real challenge was to create continuous flow in "small-lot" production.
- Ohno achieved small lot continuous flow by:
  - Aligning equipment & resources to the Value Stream.
  - Physically locating machines close together.
  - Driving down batch sizes.
    - Single Minute Exchange of Die (SMED).
    - Splitting and right-sizing of operations.
  - Cross Training.
  - Simple production control processes – Pull / Kanban.
  - Aggressive root cause analysis.
  - Application of Lean tools such as Kitting, Point of Use Systems (POUS), and visual controls.

# Typical Flow – After Improvements



# Work Cell or Office Space?



# Batch and Queue

- Production of large lots of identical items to meet anticipated demand.
  - Production is to schedule, not to demand.
- Makes great efficiencies possible for equipment amortized over large quantities.
- Increases inventory and cycle times.
- Choices limited  to those favored by the many.
- Examples of Batching
  - Waiting for a table at a restaurant (Table for 4).
  - Waiting at the doctor’s or dentist’s office.
  - On the telephone when on hold.
  - Waiting at home for the cable company.

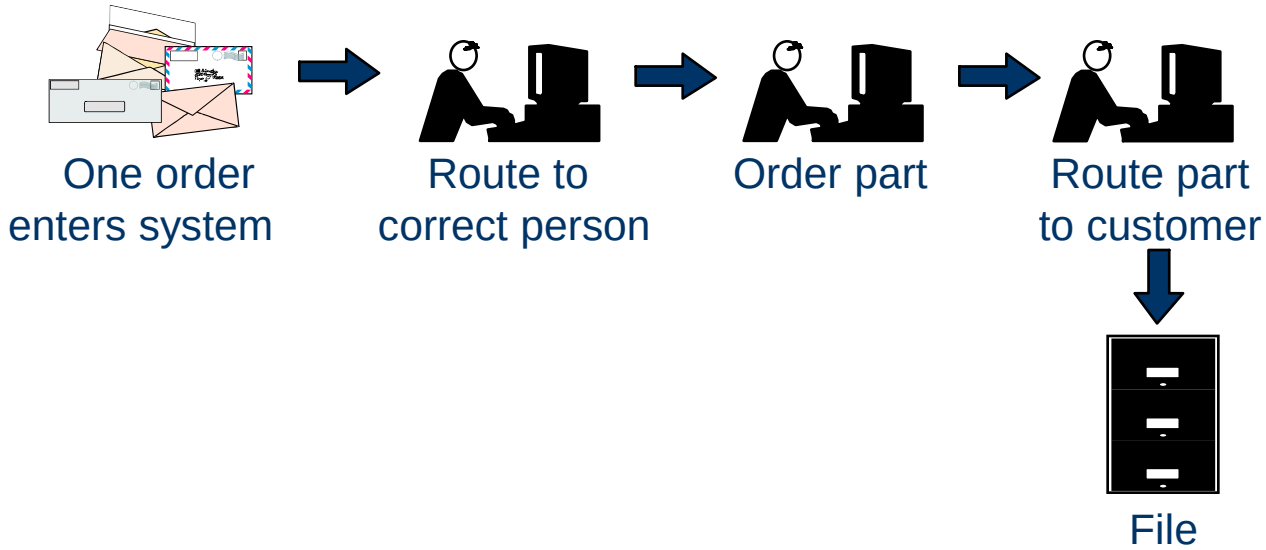
# Value Flow

- One Piece Flow (Ideal Batch Size)
  - Focuses on completing the production of one piece from start to finish with as little work in process inventory between operations as possible.
  - Items flow non-stop (no piles between steps).
  - One item is completed for each item started.
  - “One” does not need to be taken literally.
    - Should be based on customer demand
    - Could be one unit of order.
- Only process
  - What the customer wants,
  - In the quantity the customer wants,
  - When the customer wants it.

# One Piece Flow

## <u>The Ideal State</u>:

## Produce and move one piece at a time.




***Segregate excess WIP away from the improved process; develop a plan to eliminate it.***

# Exercise: Batching

## Lean Penny Game

*10 minutes*

# Exercise: Batching (The Lean Penny Game)

- Goal: Move all the coins through all the station.
- Task: Each station does their work by flipping each coin over.
- Measurements: Time measurements will be collected when the first and last batch is delivered to the customer for each round.

# Exercise: Batching (The Lean Penny Game)

## Station Tasks

- Round 1: All stations flip coins using their left hand in batches of 20.
- Round 2: All stations flip coins using their left hand in batches of 5.
- Round 3: All stations flip coins using both hands in batches of 5.
- Round 4: All stations flip coins using both hands in single piece flow.

# One Piece Flow vs. Batching

If One-Piece Flow is best – then why do we batch?

One reason is

SET-UP TIME

**Set-up Time**

The amount of time taken to change over from the completion of the previous process to the beginning of the next process … ”clock time” not labor time.

# Set-Up Reduction or SMED

**<u>You drive a car / truck</u>**

**Your vehicle needs:**

1) **Four new tires,**
2) **Full tank of gasoline, and**
3) **You need a drink of Gatorade.**

***<u>QUESTION:</u>***

***How long will it take you to accomplish these three tasks?***

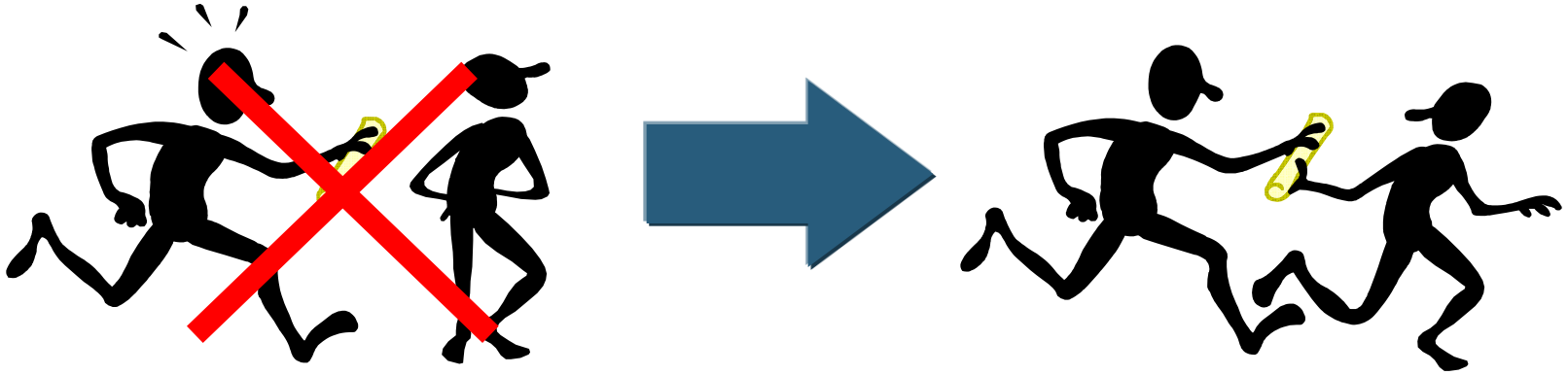
# NASCAR Pit-stops

# Set-Up Times and Lot Sizes Interact

- **Lot sizes** are made large because set-ups take a long time.
  - Attempt to increase total throughput.
  - Ignores underlying issues.
- **Set-ups** take a long time because they are not done often.
- The cycle repeats endlessly.
  - It's best to improve set-ups first.
  - Set-up reduction "feels" contradictory and so it is often ignored; spend effort improving NVA to improve VA.

# Why Address Set-Ups?

- Improve flow by reducing cycle times.
  - Allows smaller lots.
  - Resources are spent on VA activities.
- Resource flexibility
  - Increases ability to change products or services in a timely manner.
- Cost
  - Reduces WIP and carrying costs.



# Ways to Streamline Set-Up

- Change tasks: Eliminate, combine, re-sequence, put in parallel.
- Fix settings, eliminate adjustment.
- Eliminate threads.
- Unit tool changes.
- Reduce hand tools.
- Focus storage.
- Plan and stage.
- Use casters & rollers.
- Standardize

# Knowledge Check: Batch Size

**What is the ideal batch size?**

**All processes should be run with a "make one, move one" approach. True or False?**

# Knowledge Check: Set-up

**Why would we focus on reducing setup time?**

# Lean Principles

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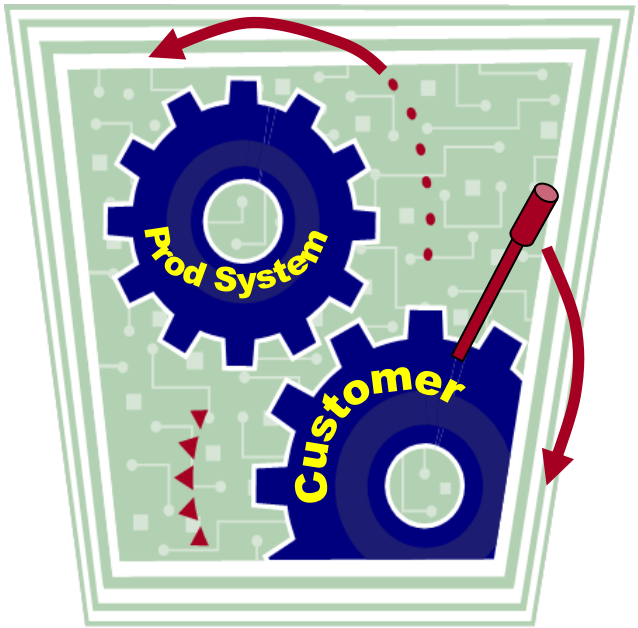
# Push vs. Pull

**Push:**

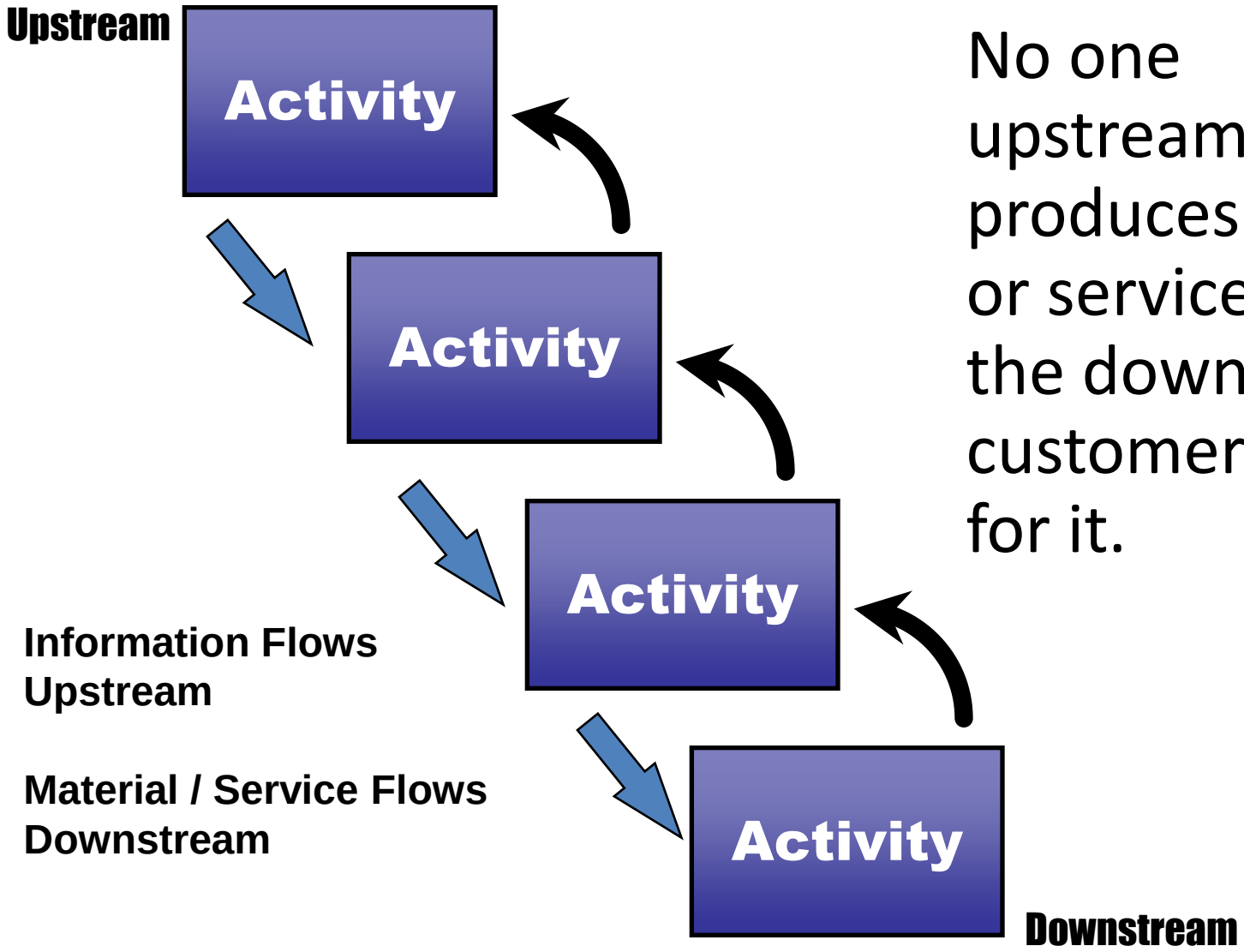
Work is pushed into the system or process based on forecasts or schedules.

**Pull:**

A customer-driven system that produces and moves a product/service *only* when the customer needs it.



# Pull Systems




No one upstream produces a good or service until the downstream customer asks for it.

# Pull Systems

**Pull**

- **Elements**
  - Upstream Supplier
  - Downstream Customer
  - Visual Trigger (Kanban)
- **Sequenced**
  - Use First In First Out (FIFO) lanes
- **Replenished**
  - Create supermarkets

# Pull System Advantages

- Increases speed to your customer.
- Reduces inventories without creating parts shortages.
- Decreases floor space.
- New thought process:  replaces “Ready or not here I come” with “OK, now I’m ready”.

# Just-in-Time

- Don’t produce something unless the customer has ordered it.
- Level demand so that work may proceed smoothly throughout the workspace.
- Link all processes to customer demand through simple visual tools (Kanbans).
- Maximize resource flexibility.

# Elements of a JIT System

- **Heijunka** – Workload balancing.
- **Kanban** – system of visual tools that synchronize and provide instruction to suppliers and customers.

**Both Heijunka and Kanban in turn depend on:**

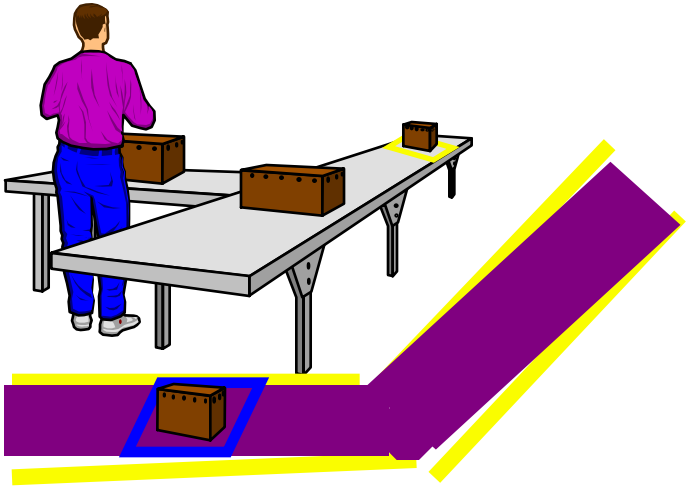
- Quick changeovers (set-ups).
- Visual Management.
- Capable processes, including methods, workers, and machines.

# Kanban Rules

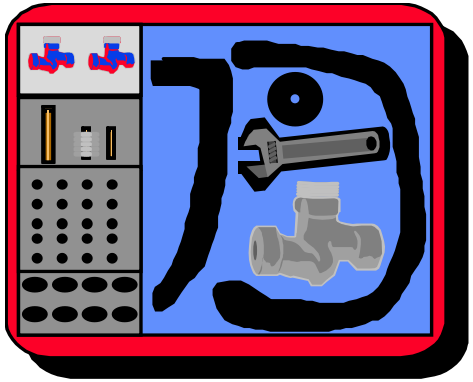
- Never move defective items.
- The customer withdraws only what is needed.
- Produce only the quantity withdrawn by the customer.
- Level production.
- Use Kanban to fine-tune production.
- Stabilize and strengthen the process.

# Types of Pull Signals (Kanbans)

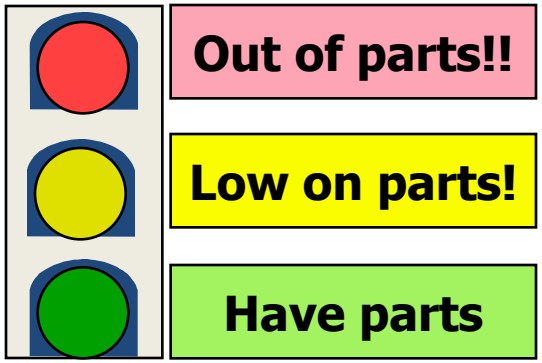
## Square on Floor



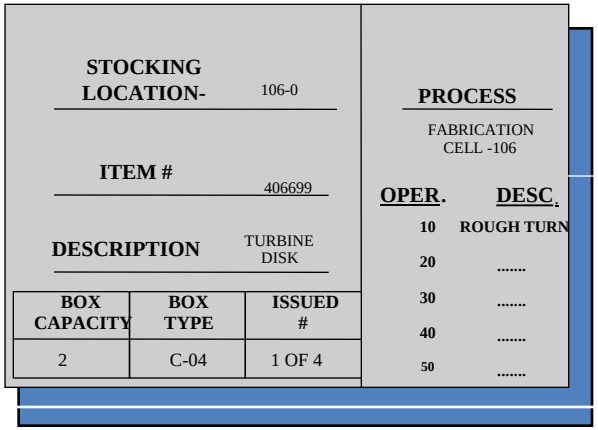
## Containers (Kits)



## Lights




## Cards



# Kanban Example

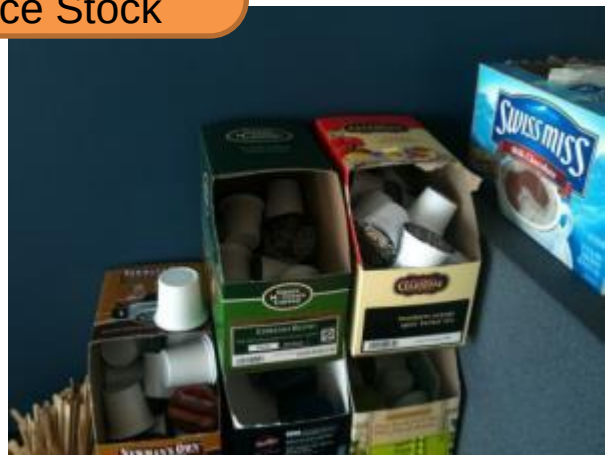
## Reordering Office Coffee

Step One: Remove Empty Box

Step Two: Locate New Box

Step Three: Pull Kanban

Step Six: Replace Stock




Step Four: Replace Box

To-Be Ordered

Awaiting Delivery

Step Five: Place Kanban in Reorder Pouch

# Heijunka (Hi-junk-a)

- Even distribution of work to meet Takt Time (Workload Balancing), especially for different products from the same process.
  - Determine pitch for each product.
  - Create a production sequence.
  - Create a production sequence table.

- A Heijunka box is the schedule of work that includes what things arrive when and when they should be done.

# Importance of Workload Balancing

**LUCY VIDEO**

*3 minutes*

# Lead Time

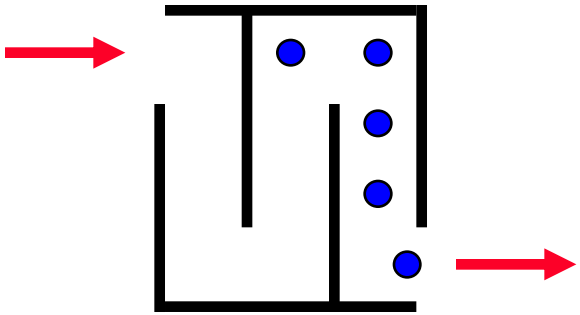
- The time required to complete an entire process (including wait times) from order to delivery.
- Measured in elapsed time (minutes, hours, etc.).
- Lead Time can be *approximated* using Little's Law:

$$Lead\ Time = \frac{Work\ In\ Process\ (WIP)}{Exit\ Rate\ (ER)}$$

- **WIP** is the "number of things in process" at any given time.
- **EXIT RATE** (or Throughput) is the amount of work completed over a given period of time, which should meet customer demand
- Common Synonyms: Throughput Time, Delivery Time, Turnaround Time.

# Lead Time - Example

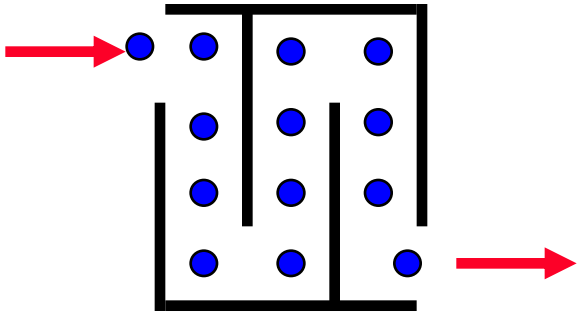
**Think about the lines at Disneyland in March…**



$$\text{Lead Time} = \frac{\text{WIP}}{\text{Exit Rate}} = \frac{\textbf{5 people}}{\textbf{1 person/minute}}$$

Lead Time = **5 minutes**

**…and then think about them in July…**



$$\text{Lead Time} = \frac{\text{WIP}}{\text{Exit Rate}} = \frac{\textbf{13 people}}{\textbf{1 person/min.}}$$

Lead Time = **13 minutes**

**…Conclusion:** Fixed Capacity (Exit Rate) + Increased People (WIP) = Slower Lead Times!

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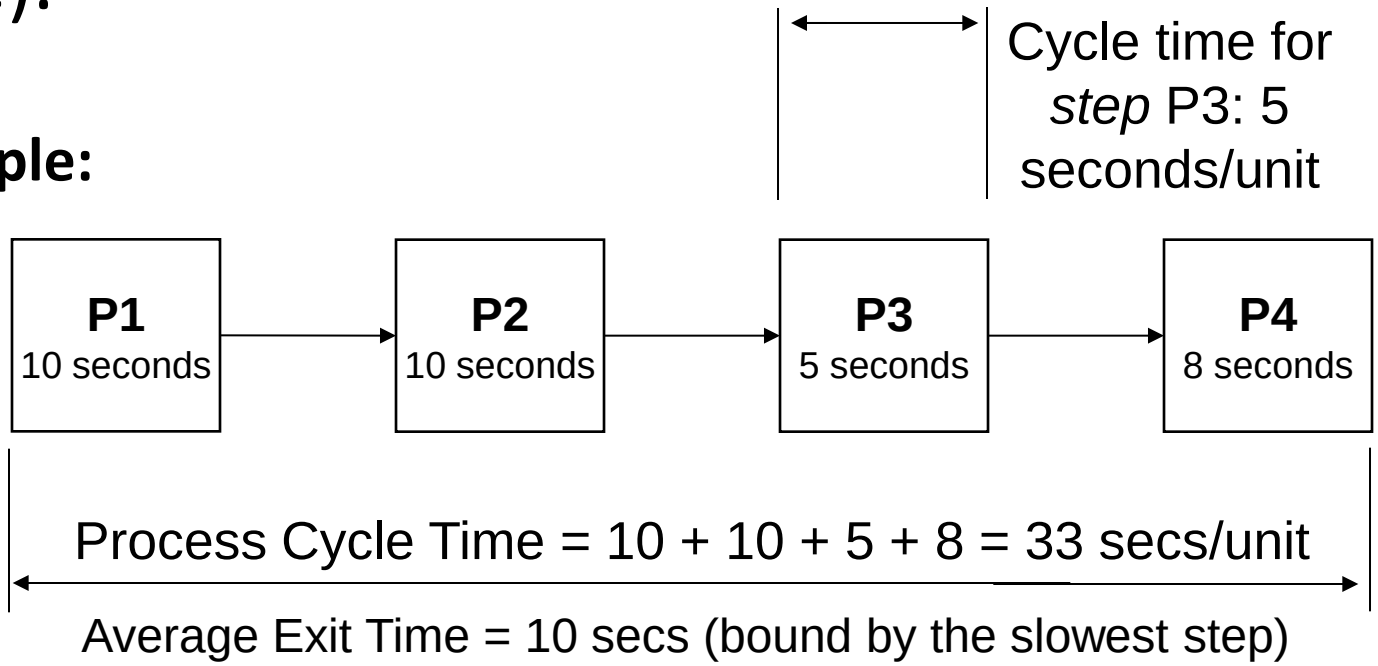
# Cycle Time - Example

- Cycle Time: The time it takes a product to move (cycle) through a *step* or a *process*, including queue and move times.
- Measured in time per unit (minutes/batch).
- Cycle Time is the inverse of Throughput (Exit Rate).

**Example:**



# Exercise: Push vs. Pull

Lean Airplane Game

*20 minutes*

# Exercise: Push vs. Pull (Lean Airplane Game)

- Goal: Deliver 20 paper airplanes to the customer.
- Task: Each station does their work by following the instructions provided.
- Measurements: Time measurements will be collected for total lead time and throughput time after each round.

# Takt Time and Definitions

- **Takt Time:** The rate at which a product or service needs to be provided to meet customer demand.

$$\textbf{Takt Time} = \frac{\textbf{Time available for work in the given time period.}}{\textbf{Customer demand for a given time period.}}$$

- **Process Sequence:** The steps necessary to produce a product or service, with some process steps being dependent upon other steps being performed first.
- **Pitch:** Customer configured delivery requirement based on Takt Time (Takt Time x batch quantity).

# Takt Time

- 250 Available Workdays per Year.
  - (assuming 5-day work week)
- Customer requires 30 Units per Year.

$$\text{Takt Time} = \frac{(250\ \text{days})}{(30\ \text{Units})}$$

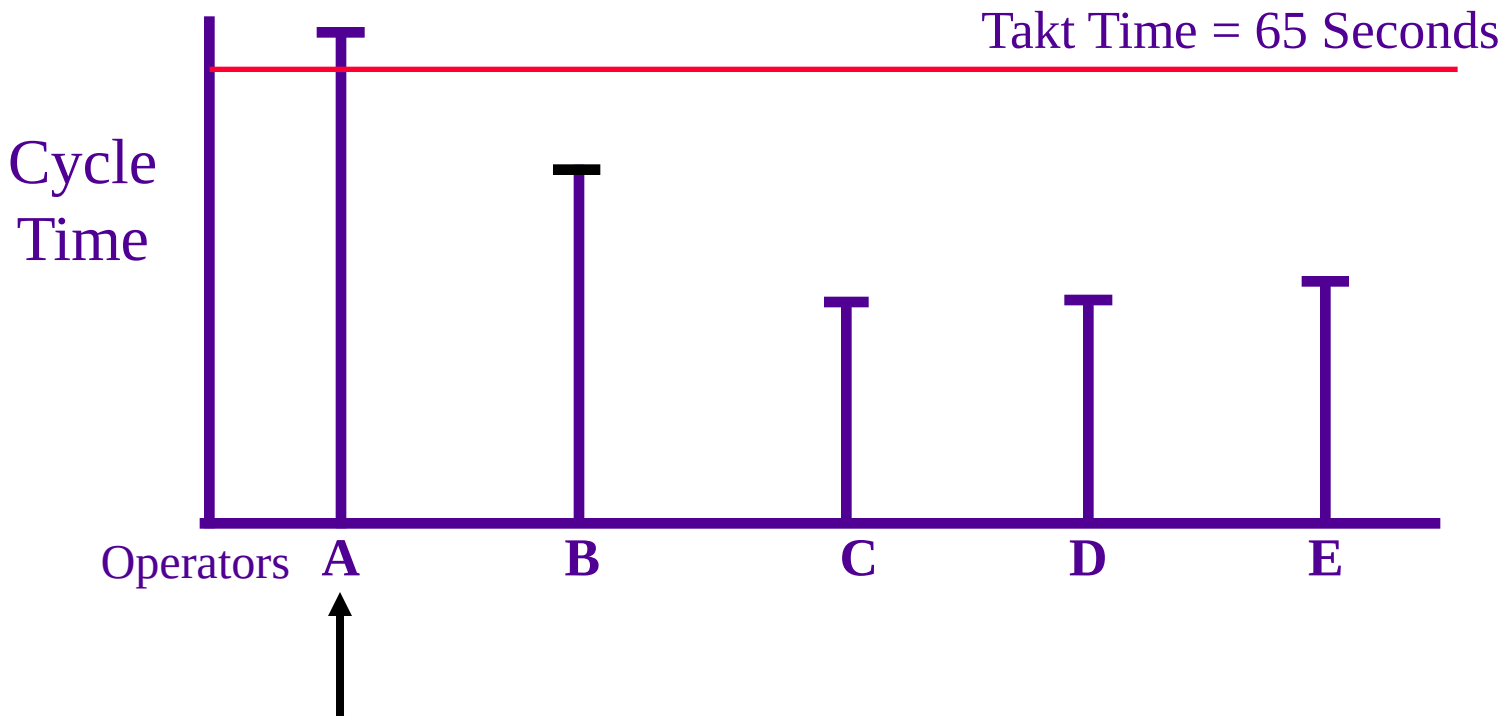
$$\text{Takt Time} = 8.3\ \text{days per Unit}$$

- With a Takt Time of 8.3 days, you must induct and sell a unit every 8.3 workdays in order to meet the Customers annual demands.

# Takt Charts

- A tool to see how the process is performing against the customer expectations.
- Helps identify constraints / bottlenecks to balance workload (Mura)
- Data for Takt Charts are drawn from the data blocks of the Value Stream Map, and from customer demand.
- Plot the steps on the horizontal axis using time as your vertical axis.

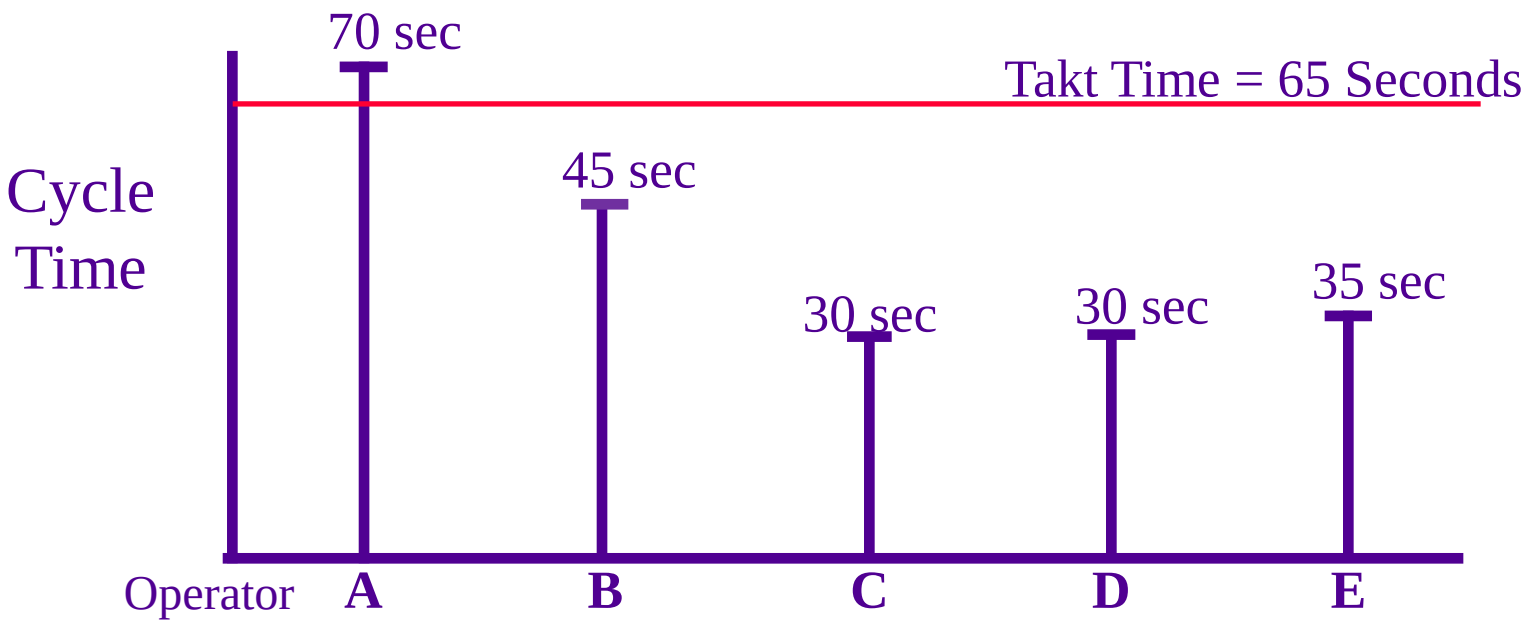
# Takt Charts - Examples




**"Operator A" is a constraint because they cannot meet the Takt Time.**

# Workload Balancing - Takt Chart Example

## Chart existing operator cycle times




***Can we reduce the cycle time of Operator A as well as reduce manning?***

# Minimum Staffing

$$* \text{ Minimum Staffing} = \frac{\text{Total time of all tasks for all operators}}{\text{Takt Time}}$$

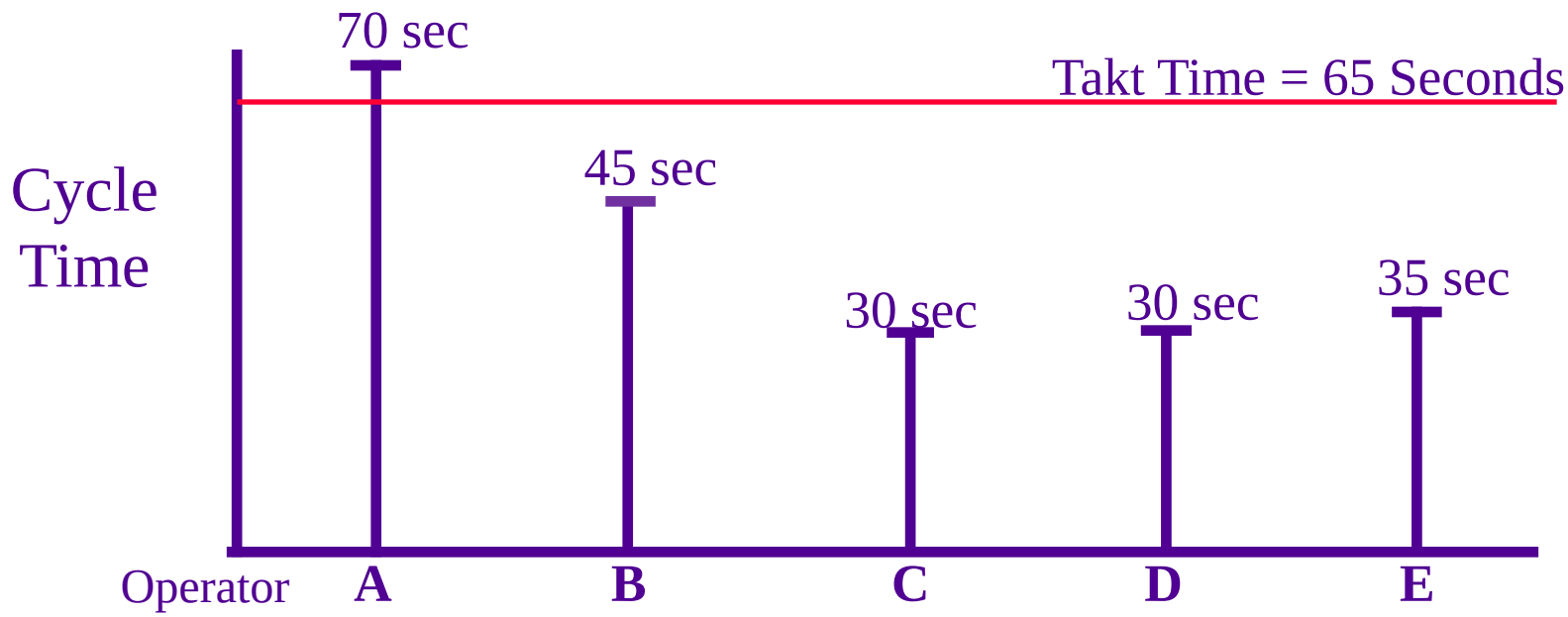
** If the numerator or denominator changes, staffing must be adjusted and work assignments rebalanced.*

***This equation is to be used to identify potential areas for improvement and not a justification for manpower reduction efforts.***

# Balanced Work

$$\text{Minimum Staffing} = \frac{(70+45+30+30+35)\text{ sec}}{65\text{ sec}} = \frac{210\text{ sec}}{65\text{ sec}} = 3.23\text{ (round up)} = 4\text{ oper}$$

## Chart existing operator cycle times




***By workload balancing we can free up personnel.***

# Theory of Constraints (TOC)

**Theory of Constraints 5 Focusing Steps**

1. Identify the constraint
2. Exploit the constraint
3. Subordinate to the constraint
4. Elevate the constraint
5. Re-evaluate, go back to step 1

***TOC experts see processes and systems as chains. The strength of the chain is dependent upon the strength of the weakest link.***

# Drum-Buffer-Rope

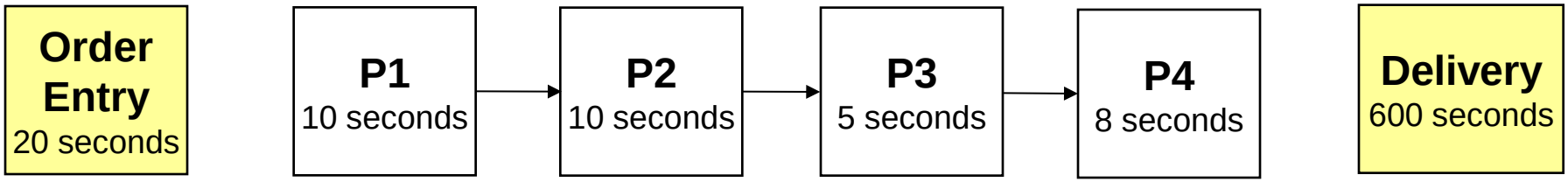
- Drum – The pace at which the system is operating
- Buffer – A way to protect the constraint from being “starved”, to ensure the constraint always has work
- Rope – the signaling system that allows work to be put into the system at the appropriate time to support efficient use of the constraint

***The aim is to protect the constraint, and therefore the system as a whole, against process variation.***

# Lead Time Example

**Consider the following set of processes:**

- A customer needs 25 units in 15 minutes (900 seconds).
- Order entry takes 20 seconds.
- Delivery takes 10 minutes (600 seconds).




Available process time = _____

Customer demand = _____

Takt Time = _____

Cycle Time = _____

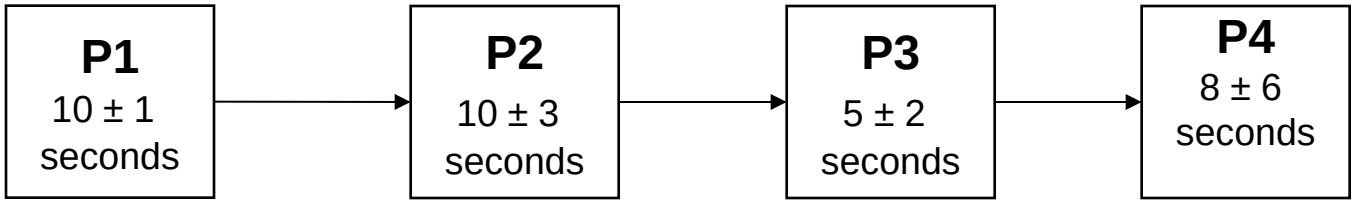
What is our average exit rate? _____

Lead Time = _____

Where is the constraint? _____

# IT'S A LIE!

- **Variation happens!**




Cycle Time = _____

Where is the constraint? _____

Average Exit Rate = _____

# Exercise: Takt Chart

Break into Simulation groups and create a Takt Chart for your Statapult process.

***10 minutes***

# Knowledge Check: Push vs. Pull

**What is the primary difference between a Push system and a Pull system ?**

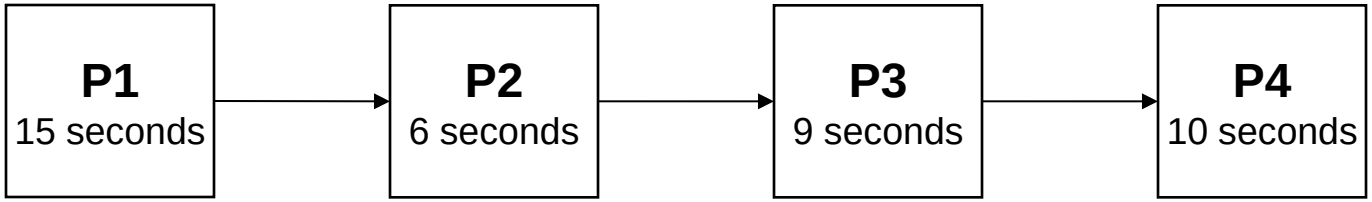
# Knowledge Check: Pull System

**What are the benefits of a pull system?**

# Knowledge Check: Kanban

**What is the purpose of using a Kanban system?**

# Knowledge Check: Cycle Time

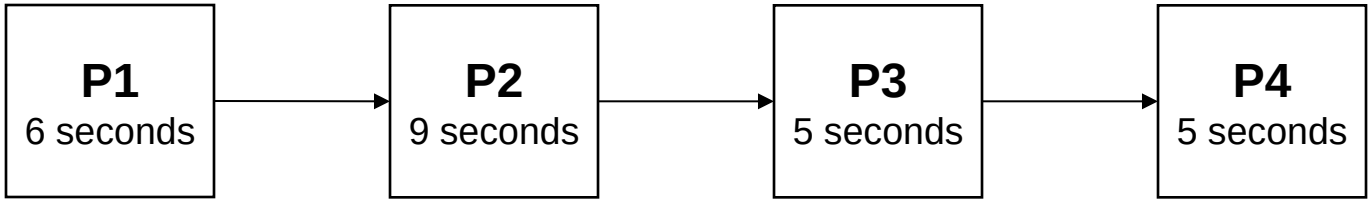



**What is the total cycle time for the above process?**

**What is the cycle time for P3 in the above process?**

**Where is the constraint in the process above and why?**

# Knowledge Check: Cycle Time




**What is the total cycle time for the above process?**

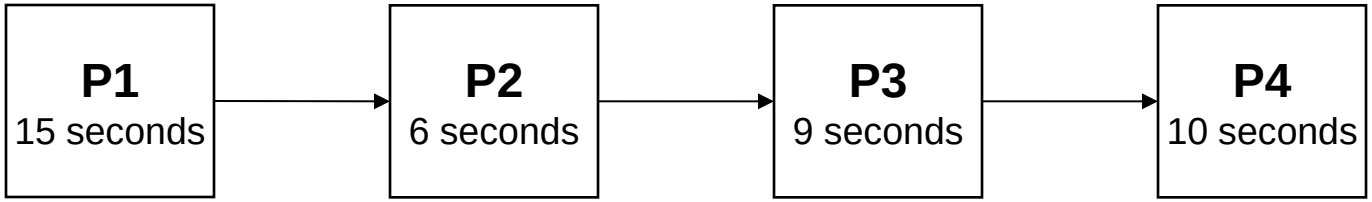
**What is the cycle time for P1 in the above process?**

**What is the expected throughput for this process?**

# Knowledge Check: Cycle Time

**What is the formula we use to calculate lead time?**

# Knowledge Check: Takt Time




**What is the Takt Time for the process above?**

**What would I need to know to calculate the Takt Time?**

# Lean Principles

## There are 5 Lean Principles.

- **Value** specified from the customer's perspective.
- The **Value Stream** has been identified for each service.
- The product / service **Flows** without interruptions.
- The customer can **Pull** value through the process.
- Continuous pursuit of **Perfection.**

# Pursuit of Perfection

- Begins with understanding Lean Principles & visualizing the "perfect" process at the outset.
- No matter how much you improve a process to make it leaner, there are always ways to continue to remove waste by eliminating effort, time, space and errors.
- Achieving the "Lot Size of 1".
- Achieving Continuous Flow.
- Achieving a CPI Culture.
  - Using Change Management

**"Perfection is not attainable. But if we chase perfection, we can catch excellence." – Vince Lombardi**

# It's Cultural

"One Million – That's how many ideas Toyota ***implements*** each year. Do the math: **3,000 ideas a day.** That number, more than anything else, explains why Toyota appears to be in a league of their own, while their competitors remain caught in a cross-fire of cost-cutting"

Here's the thing: it's not about the cars. It's about ideas. And the people with those ideas. **But not just any ideas. Mostly tiny ones**, but effective ones none-the-less – elegant solutions to real world problems. Not grand slam homeruns, but groundball singles implemented all across the company by associates **that view their role not to be simply doing the work, but taking it to the next level…every day, in some little way.** *Good enough never is.*

**When an entire organization thinks like that, it becomes unstoppable.**

# Knowledge Check: Lean Principles

## What are the Lean Principles?

# Knowledge Check: Takt Chart

**What would we use a Takt Chart for?**

# What's Next?

# Simulation
# Statapult Round 2

# Round 2

## Flow Improvements

**This round is intended to give the team experience with specific flow changes that can be implemented to improve the process. This round includes the following phases :**

- **Future State Map**
- **Baseline**
- **Shoot**
- **Calculations**

# Exercise Requirements – Round 2

- Team members cannot perform the same roles as in Round 1.
- The balls will be marked as a preparation for shooting and for rework.
  - Blue dots symbolize inputs needed to complete a job function and are considered to be value added to the process.
  - Red dots must be applied to each failed ball. The red dot symbolizes firefighting.
- No permanent markings or modifications can be made to the Statapult or balls.

# Customer Requirements – Round 2

- All shots must be fired at an angle of 167 degrees.
- All shots must land on the floor in a stationary target area +/-3 inches long and +/- 6 inches wide with respect to the nominal target.
- Ball distance must be measured to the nearest ½ inch.
- Pass / Fail data must be collected for each shot.
- The balls must be sorted based on either Pass or Fail.
- The balls must be delivered to customer with no markings (colored dots).
- All data must be collected “real time”.

# Business Requirements – Round 2

- All shots must originate from the floor.
- Must use form RUK-1D-1NG.
- Balls are aligned with blue dot facing up.

# Statapult Requirements – Round 2

- The Statapult settings and structure cannot be modified.
- The Statapult can not be aligned / modified with any tools, devices or aids.
- The Statapult can only be handled / touched by the Shooter.
- The Statapult must be placed so that the base is horizontal to the floor and in a stationary position.

# Future State Map Exercise

***Based on the new requirements and your team's value analysis of the Current State Map, design the new process layout for the next Statapult round. Consider the following:***

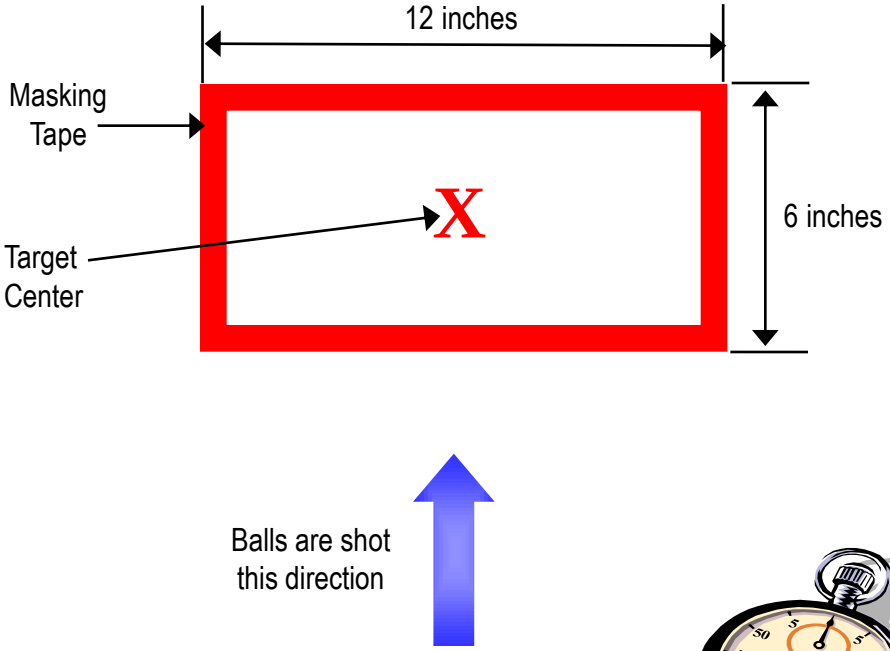
- New roles / responsibilities
- A measurement system
- Value Analysis
- VOC
- Eliminating waste
- Improving flow

***45 minutes***

# Baseline

***In order to run the simulation, you must again determine the accuracy and precision of the process in order to set up the target area.***

- Position your Statapult in area designated by instructor.
- Obtain 20 balls.
- Take 20 test shots.
- Mark the landing of each shot with an adhesive dot or piece of tape.
- Use masking tape to mark off target area.



***5 minutes***

# Round 2 Shoot

## *Are you ready to start?*

- Your Future State Map was approved.
- Statapult layout is ready.
- Target area is taped off.
- Measurement system is setup.

***The simulation will start simultaneously for all teams!***

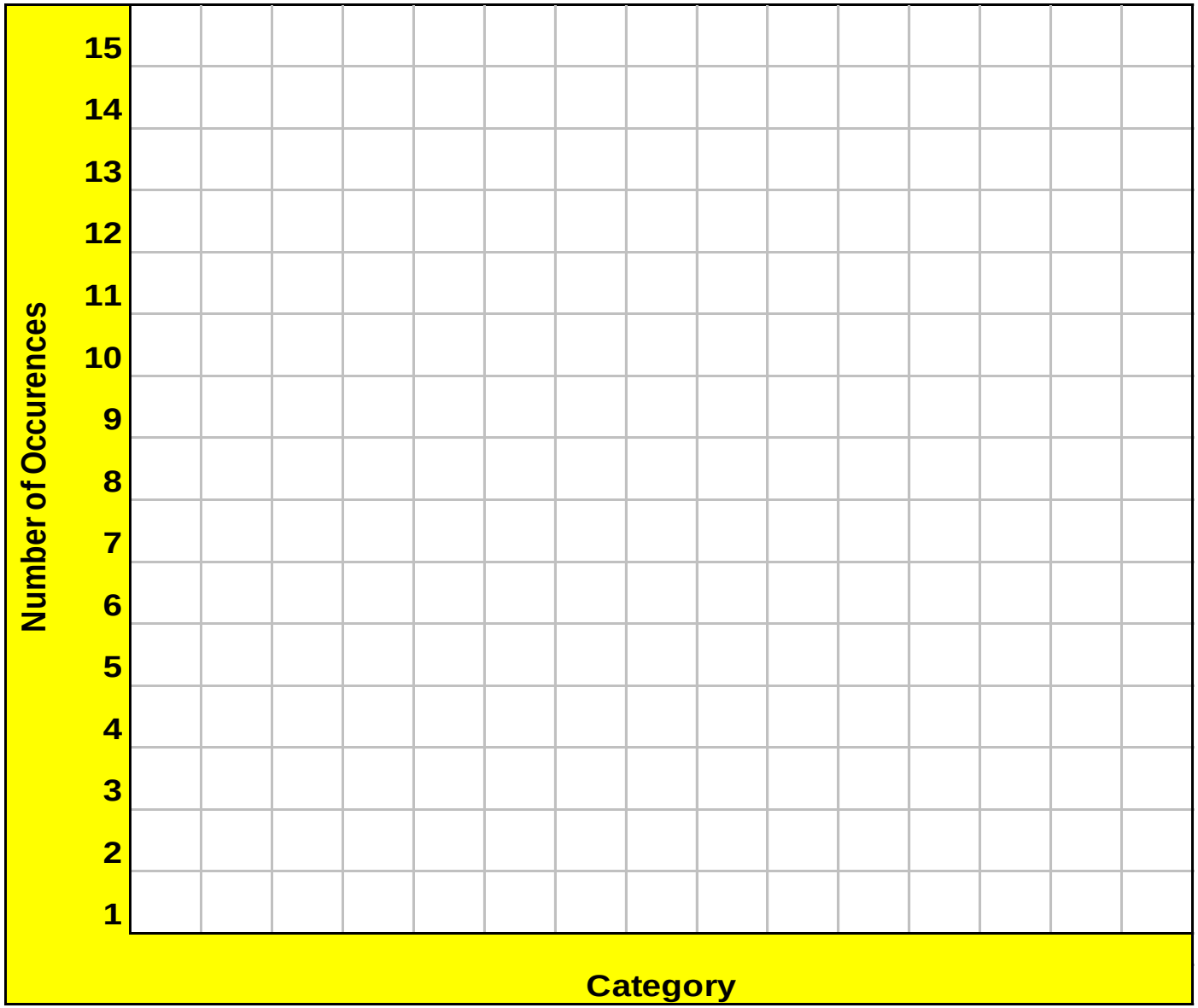
***30 minutes***

# Round 2 Histogram

## *Create a histogram to show a visual representation of your process performance*

- What is the number of data points (shots)?
  - n = ____
- What is the range?
  - $R = X_{max} - X_{min}$ =____ - ____ = ____
- Calculate k, the number of classes (columns in your graph).
  - When $n < 150$, $k \cong \sqrt{n}$
  - k = ____
  - If k is not a whole number, round up to the next highest value.
- Determine the class width (w).
  - w = R / k = ____
  - If w is not a whole number, round up to the next tenth.

# Histogram



# Simulation Summary Sheet

| | Time to First Delivery | Total Lead Time | Lead Time per Unit | WIP | Scrap | Yield | Cost of Poor Quality | Cost per Unit |
|---|---|---|---|---|---|---|---|---|
| Round 1 | | | | | | | | |
| Round 2 | | | | | | | | |
| Round 3 | | | | | | | | |

# Exercise: What Went Wrong?

- Choose a facilitator.
- Brainstorm answers to the question, “What went wrong with the process?
- Facilitator: Do not accept solutions; record only problems.

***10 minutes***

# 5S

DEFINE
MEASURE
ANALYZE
IMPROVE
CONTROL
CONTINUOUS
PROCESS
IMPROVEMENT

# 5S: A Tool to Achieve the Future State

- **5S** is a process and method for creating and maintaining an organized, clean, and high-performance workplace.
- **5S** enables anyone to distinguish between normal and abnormal conditions at a glance.
- **5S** is the foundation for continuous improvement, zero defects, cost reduction, and a more productive work space.
- **5S** is a systematic way to improve the workplace, our processes and our products through employee involvement.

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# 5S Workplace Organization

| | |
|---|---|
| Sort | Clearly distinguish needed items from unneeded items and eliminate the latter. |
| Simplify (Set) | Keep needed items in the correct place to allow for easy and immediate retrieval. |
| Systematic cleaning (Shine) | Keep the workplace orderly and clean. |
| Standardize | Standardize cleanup. This is the condition we support when we maintain the first 3 S's. |
| Sustain | Discipline, stick to the rules / continuous improvement of all principle. |

…some have added Safety to 5S and called it 6S or 5S + 1.

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# Office Space without 5S

# Sort (Seiri)

- **Establish criteria** for determining what is and <u>is not</u> needed in the area based on:
  - Usefulness of the item / equipment.
  - Frequency of use.
  - Quantity needed.

- **Red Tag evaluation.**
  - Keep in existing area.
  - Move to different spot within area.
  - Hold in red tag area.
  - Get rid of it.

**Ask the people who use the material / equipment for help – We don't want to throw anything out that we actually need!**

# Simplify or Set (Seiton)

- **Determine the location for needed items and how they should be kept.**
  - Consider how to store tools and jigs.
  - Consider principles of motion waste.
- **Identify best locations.**
  - Labels, signboards, maps, shadows.
  - 5S Map: shows location of equipment in the area.
  - Color-Code Strategy: distinguish use of tools / parts by color.
  - Outlining work areas and locations.

**Creating a place for everything and everything in its place!**
**Make it obvious at a glance!**

# Systematic Cleaning or Shine (Seiso)

- **Determine Target** *What needs to be cleaned?*
- **Determine Assignments** *Who is responsible?*
- **Determine Methods** *How will it be done?*
- **Determine Tools** *What is needed?*
- **Implement Shine** Everyone's responsibility.

**Create and maintain a neat and clean environment.**
**Make it a habit!**

# Standardize (Seiketsu)

- Establish guidelines for sort, straighten, and shine conditions.
- Bring the condition of the area up to those standards.
- Make the standard guidelines visible.
- Maintain and monitor first 3S's.
- Assign responsibilities and monitor through self audit and evaluation.

**Create a consistent way to carry out tasks and procedures.**

# Sustain (Shitsuke)

- Development of new awareness and skills.
- Support from management.
- Ongoing, company wide communication.
- Making 5S standards part of daily work.
- Total employee involvement.
- Implement Sustainment Checklist.

Managers Committed

Training

"Buy-in" from all workers

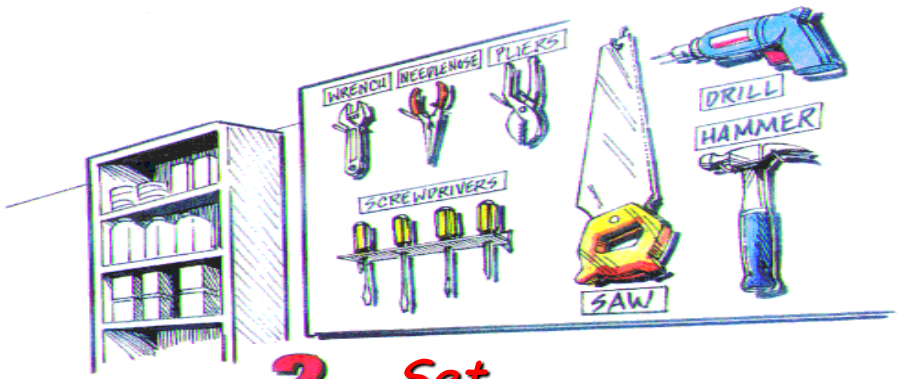
# Safety

- Include Safety in all your Improvement Projects.

Can you identify the safety issues?

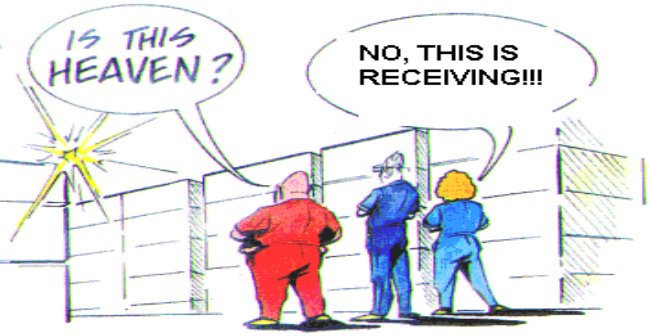
# Workplace Organization (5S)

1. Sort



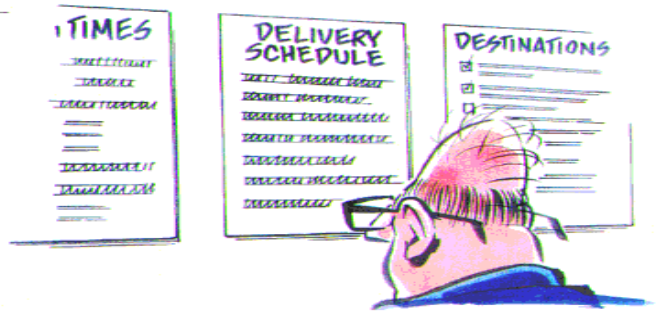

2. Set

# 5 S's



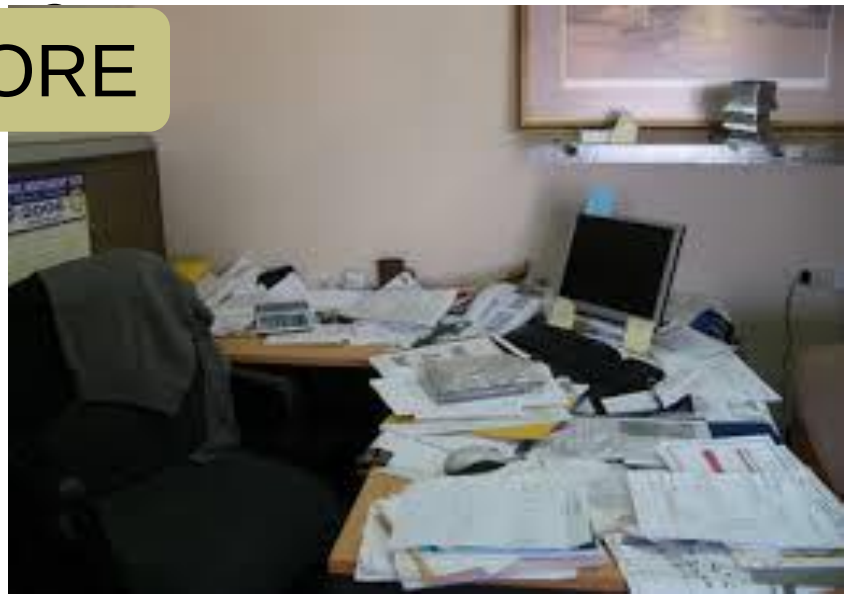

5. Sustain

3. Shine




4. Standardize

# 5S Examples Industrial & Office



# 5S Office Example

**Before**

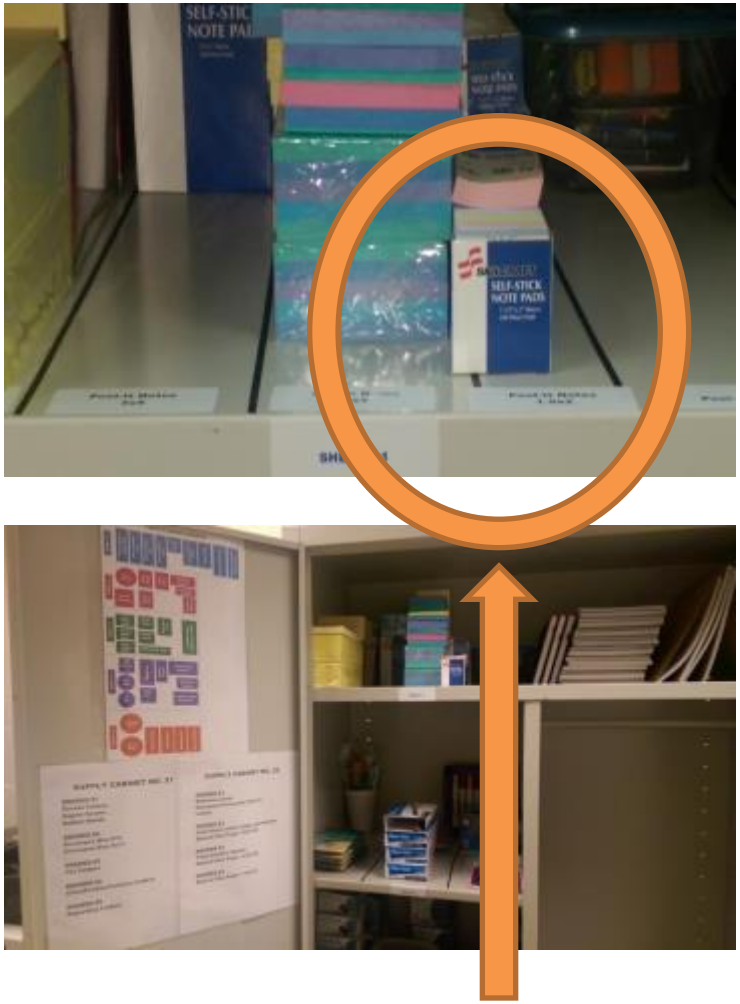
**After**

# 5S Example – P&I Supply Cabinet

**Can you identify the abnormal condition?**

**BEFORE**

**AFTER**



Item out of place

# Five Levels of Excellence

| | Sort | Simplify | Systematic Cleaning | Standardize | Sustain |
|---|---|---|---|---|---|
| Level 5 Focus on Prevention | Employees are continually seeking improvement opportunities. | A dependable, documented method has been developed to provide continual evaluation, and a process is in place to implement improvements. | Area employees have devised a dependable, documented method of preventive cleaning and maintenance. | Everyone is continually seeking the elimination of waste with changes documented and information shared. | There is a general appearance of a confident understanding of, and adherence to the 5S principles. |
| Level 4 Focus on Consistency | A dependable, documented method has been established to keep the work area free of unnecessary items. | A dependable, documented method has been established to recognize in a visual sweep if items are out of place or exceed quantity limits. | 5S agreements are understood and practiced continually. | Substantial process documentation is available and followed. | Follow-through with 5S agreements and safety practices is evident. |
| Level 3 Make it visual | Unnecessary items have been removed from the workplace. | Designated locations are marked to make organization more visible. | Work and break areas and machinery are cleaned on a daily basis. Visual controls have been established and marked. | Working environment changes are being documented. Visual control agreements for labeling and quantity levels have been established. | 5S agreements and safety practices have been developed and are utilized. |
| Level 2 Focus on Basics | Necessary and unnecessary items are separated. | A designated location has been established for items. | Work and break areas are cleaned on a regular, scheduled basis. Key items to check have been identified. | Methods are being improved but changes haven't been documented. | A recognizable effort has been made to improve the condition of the workplace. |
| Level 1 Just Beginning | Needed and not needed items are mixed throughout the work place. | Items are randomly located throughout the workplace. | Work place areas are dirty, disorganized and key items not marked or identified. | Work place methods are not consistently followed and are undocumented. | Work place checks are randomly performed and there is no visual measurement of 5S performance. |

# 5S Scorecard

| Item No. | Description | Rating Scale: 0-5 (0 = No 5S Evident, 5 = Out of the Box) | Score (0-5) |
|---|---|---|---|
| 1 | Unnecessary items are not stored in the area | 5 – No unnecessary items are in the work area<br>1 – Personal items are mixed with and may interfere with accomplishment of required work | |
| 2 | Storage of cleaning material | 5 – All required cleaning material is stored, visually marked, readily available<br>1- Cleaning material is shared between multiple work areas | |
| 3 | General tidiness of work area | 5 – Work area is kept clean at all times<br>1 – Work area is cleaned once a shift | |
| 4 | Bulletin Boards | 5 – Bulletin Boards are current and have no outdated material on them<br>1 – Bulletin Boards have outdated or torn or soiled material on them | |
| 5 | Emergency Exits | 5 – Emergency Exits marked and exit plans posted<br>1 – Emergency Exits not clearly marked or exit plans outdated, missing or soiled | |
| 6 | Process layout | 5 – General items carts, movable fixtures, etc required to perform work are labeled, have assigned places and are stored in those places when not in actual work<br>1 – No apparent storage location for movable items | |
| 7 | Aisle marked | 5- Aisle clearly marked<br>1- Aisle are not marked or markings are worn-out | |
| 8 | Aisle maintained | 5- Aisle are kept clean and free of clutter, use for transportation of material or personnel and not as a storage place<br>1- Aisle are not kept clean or used as extended work area | |
| 9 | Storage of tools | 5 – All tools have clearly marked locations with positive control<br>1 – Not all tools have clearly marked locations limited control over access | |
| 10 | Storage of technical manuals | 5 – Technical manual or publications are stored close to normal point of use and in a manner that quickly allows for inventory at anytime<br>1 – Technical manuals or publications are not stored close to point of use and/or required more than 30 seconds to verify all are present | |
| 11 | Equipment / Tooling cleanliness | 5 – Equipment / Tooling are kept clean at all times<br>1 – Equipment / Tooling are not cleaned after each use or maintenance cycle | |
| 12 | Equipment / Tooling maintenance | 5 – Periodic maintenance requirements are clearly understood, and a means of recording maintenance actions is utilized<br>1 – Periodic maintenance requirements are not know by the user | |
| 13 | Equipment / Tooling Controls ID | 5 – Operating restrictions or instructions if required are clearly marked all operators are licensed<br>1 – Operating restrictions are not posted unlicensed operators are using items | |
| 14 | Shelves, Benches, Desks Arrangement | 5 – Work area is organized in a manner that allows for flow and are clearly marked as to work performed in the area<br>1 - Work area is not organized in a manner that promotes flow | |
| 15 | Shelves, Benches, Desks Control | 5 – Kept clear of unnecessary materials<br>1 – Work surfaces are clutter or have items not required for maintenance | |
| 16 | 5S Control and Sustainment Plan | 5- Visual controls are in place to facilitate maintaining organization Check sheets are available and utilizes to maintain 5S process<br>1- Visual controls or check sheets are not available or used or maintained | |

# BOEING 5S VIDEO

*13 minutes*

The

# 5S Numbers Game

A fun and exciting way to present the 5S concepts to our team!

5S supply

# Wrap-up

- Can we apply this to the real world?
- Share an “Ah-ha” – something you learned, something that’s new, something that’s different or something that made an impression on you.
- _____
_____

# Knowledge Check: 5S

**Name the 5S's in order.**

**What is the purpose of implementing 5S?**

# Poka-Yoke

DEFINE
MEASURE
ANALYZE
IMPROVE
CONTROL
CONTINUOUS
PROCESS
IMPROVEMENT

# Introduction to Poka-Yoke

- Shigeo Shingo invented the Japanese concept called **poka-yoke** (pronounced POH-kah YOH-kay).
- Poka-yoke means to mistake proof the process.
  - The essential idea of poka-yoke is to design your process so that mistakes are impossible or at least easily detected and corrected.

Shigeo Shingo

Used to be called fool-proofing, but Toyota employees got upset that they were considered a fool.

# First Poka-Yoke Device

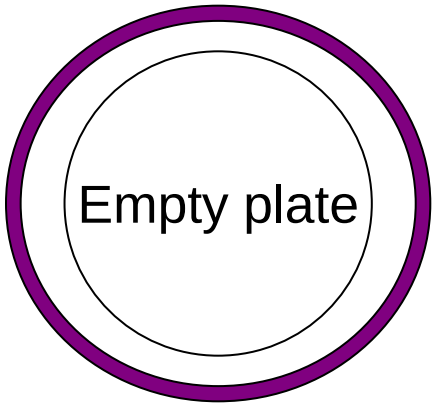
Shingo suggested a solution that became the first Poka-Yoke device.

- In the old method, a worker began by taking two springs out of a large parts box and then assembled a switch.
- Problem: Sometimes the worker failed to put both springs in the switch.

# First Poka-Yoke Device

- In the new approach, a small plate is placed in front of the parts box and the worker's first task is to take two springs out of the box and place them on the plate.
- Then the worker assembles the switch. If any spring remains on the plate, then the worker knows that he or she has forgotten to insert it.

The new procedure completely eliminated the problem of the missing springs.



# Mistake Proofing Discussion

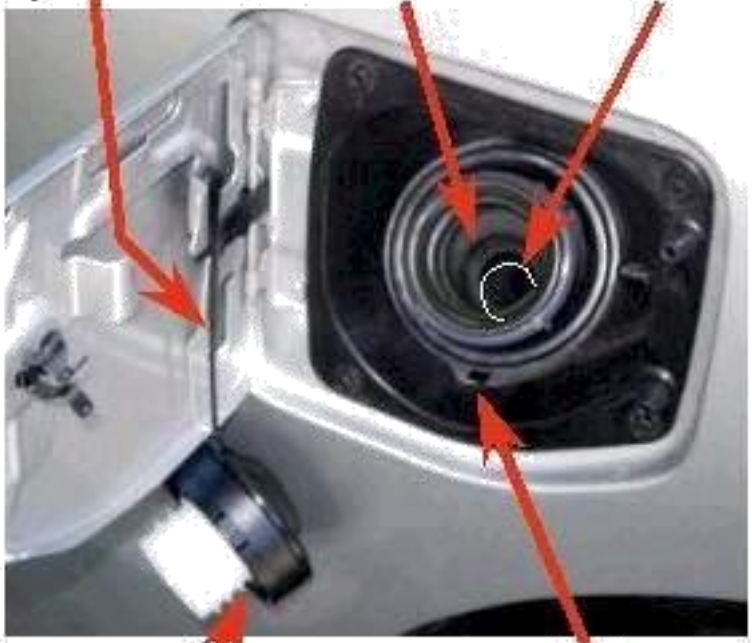
What are some examples of Mistake Proofing?

**Before**

Gas cap is lost when driver forgets to reinstall after refueling.

Older Style Gas Cap

**After**




Note: Mistake-proofing must be extensive to be effective.

# Other Poka-Yoke Examples

Gas pumps are equipped with hose couplings that break-away and quickly shut-off the flow of gasoline.

# Other Poka-Yoke Examples

This rental truck has a door latch that will not allow the loading ramp to slide out while the latch is in the closed position.

# Recognizing Mistake-Prone Situations

## Definition:

A mistake-prone situation exists when it is possible to err during the performance of work because the process being used is unreliable, unstable or prone to human error.

## Examples:

- Critical specification or dimensional requirements.
- Ineffective standard procedures and processes.
- Multiple parts, processes, or steps.
- Repetitive, fast-paced operations.
- Short-cuts and work-arounds.
- New products, processes, or people.
- Multiple suppliers.

# Mistake Proofing

## Benefits

- Easy to do the right thing the first time.
- Makes it easy to do the right things in the right order in the right way.
- Prevents accidentally doing the wrong things in the wrong order in the wrong way.

## Results

- Eliminates defects
- Improves quality
- Reduces variation
- Improves on-time delivery
- Reduces or eliminates accidents
- Improves morale

**"Amateurs work until they get it right. Professionals work until they can't get it wrong." - Anonymous**

# Jidoka

- Sakichi Toyoda first introduced the Japanese concept of Jidoka (pronounced jee-DOH-kah).
- In conjunction with Poka-Yoke, comes the concept of Jidoka.
  - Jidoka has been defined by Toyota as “automation with a human mind.”
  - It implies intelligent workers and machines identifying errors and taking quick countermeasures.
  - No product moves into the next step of the process if it contains errors (AKA: quality at the source).

# Mistake vs. Defect

**MISTAKE**

An incorrect, unwise, or unfortunate act or decision caused by bad judgment or a lack of information or care.

**DEFECT**

A failing, or flaw, especially one that still allows the affected item to function, however imperfectly.

**$$$**

**Mistakes, however small, can lead to defects which lead to rework or scrap and increased cost.**

# Cost of Poor Quality (COPQ)

**PREVENTION**

*Before it Happens*

**IN-PROCESS DETECTION**

*Before It Escapes Your Process Step*

**END OF PROCESS INSPECTION**

*After the Fact Before it Gets to Your Customer*

**CUSTOMER REJECTION**

*Too Late*

- The sooner we can catch errors, the easier and less costly it is to fix them.
- CPI helps minimize COPQ.
- A method to reduce COPQ is to develop standard work / processes.

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# Knowledge Check: Poka-Yoke

**What does Poka-yoke mean?**

# Knowledge Check: Poka-Yoke

**What are the benefits of implementing Poka-Yoke?**

# Standard Work

# What is Standard Work ?

Standard Work is…..

- A prescribed *sequence* of production steps.
- Assigned to a *single* person.
- Balanced to the *Takt Time.*

# What is meant by "Standard Work"?

The principles, tools, and techniques used to ensure process standardization in a JIT environment.

- Developed by the people who do the work.
- Focused on efficient use of resources through waste elimination.
- Establishes the foundation for CPI.

**"Where there is no Standard, there can be no Kaizen."**
**- Taiichi Ohno**

# Why Do We Need Standardized Processes?

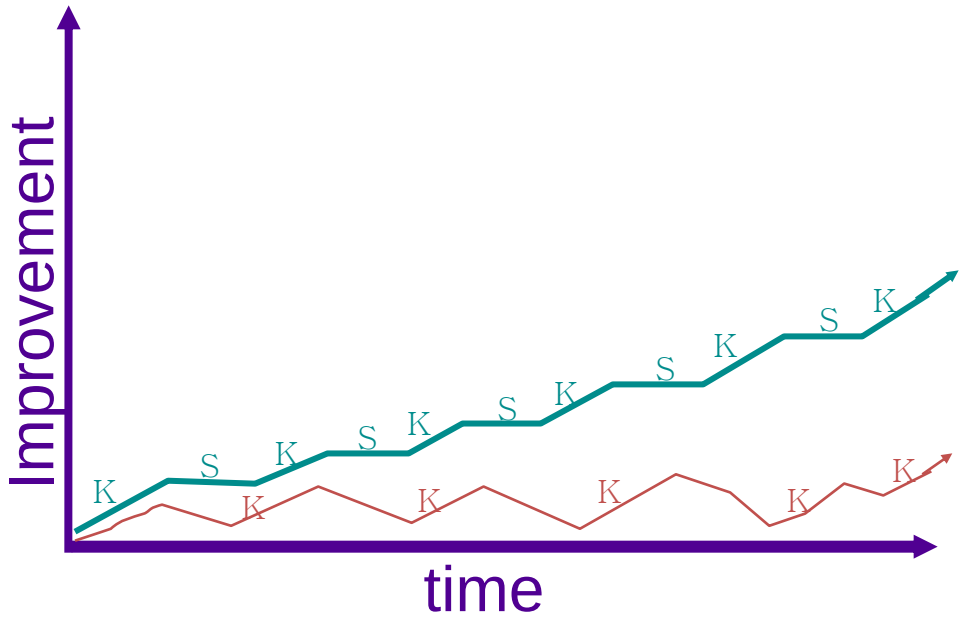
**Quality:** Standard processes produce predictable results and predictable *cycle times.*

**Time:** JIT Pull Production requires reliable *lead times* based on predictable *cycle times.*

**Cost:** Standardized processes are the foundation of CPI.

# Standard Work

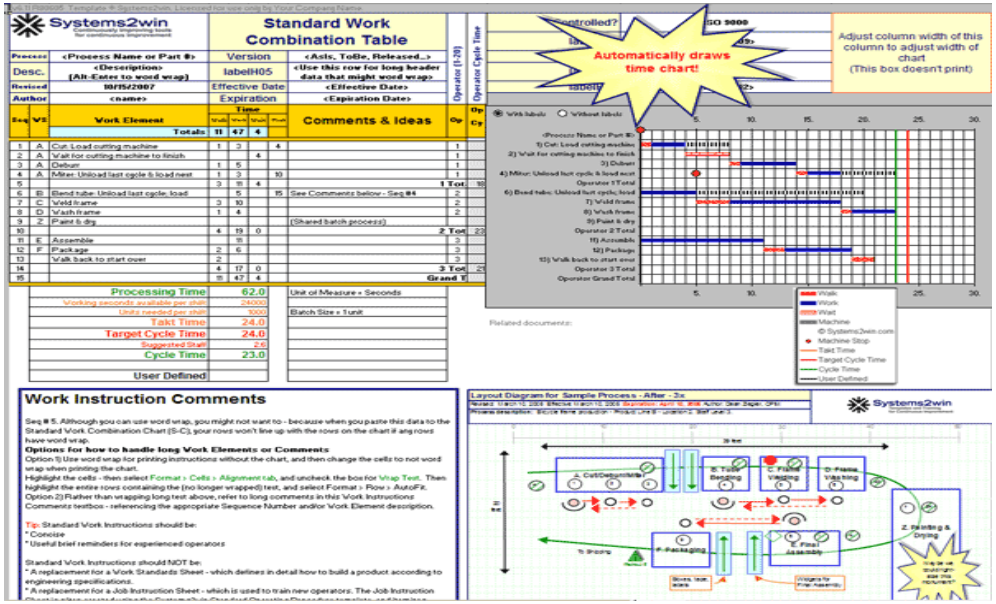
Locks in improvement and establishes a new baseline.




K = Kaizen
S = Standardization

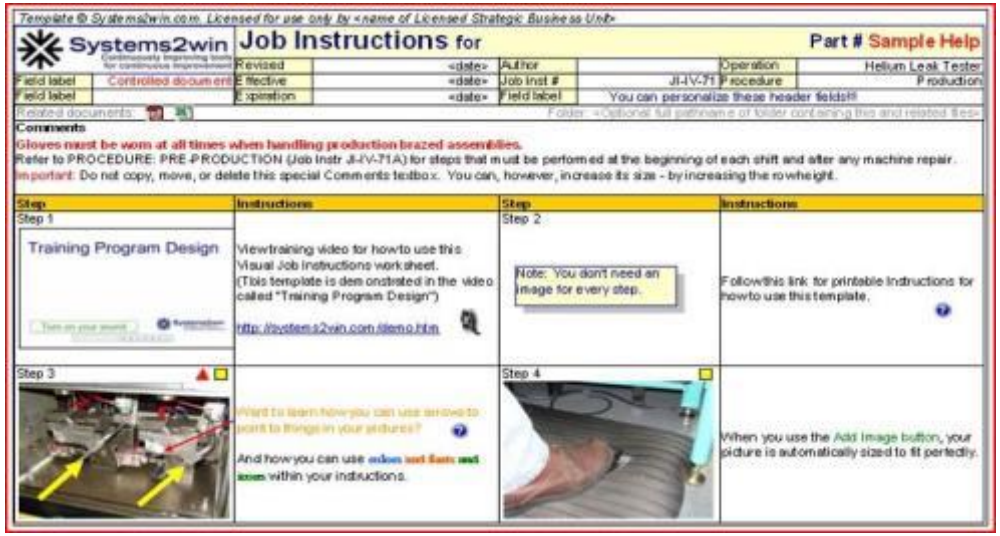
*Without Standard Work, improvements tend to dissipate over time!*

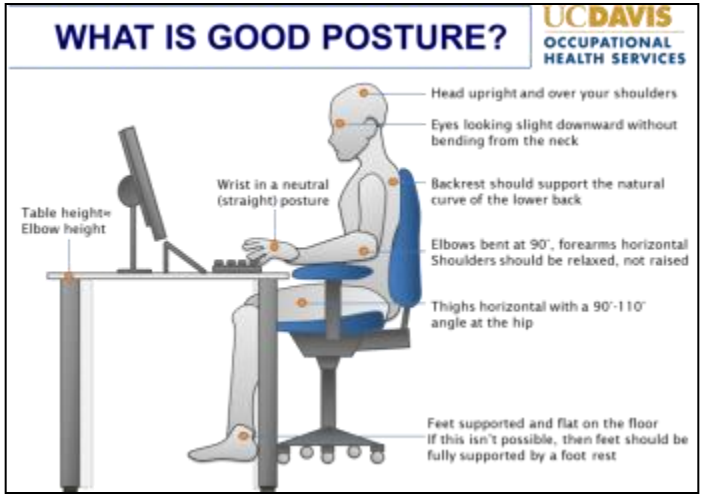
# Standard Work Example




MANUFACTURING

OFFICE



# Standard Pig Exercise

*15 minutes*

# Exercise: Standard Work (Standard Pig)

- Goal: All students draw a pig that looks the same.
- Task: Each student will hand draw a pig based on instructions provided by the supervisor (instructor).
- Measurements: Drawings of each student will be compared against the class after each round.

# Knowledge Check: Standard Work

## What are the benefits of implementing Standard Work?

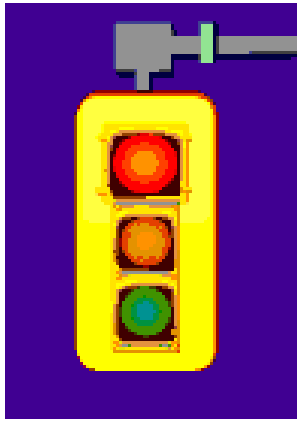
# Visual Workplace

# Visual Workplace

**"Make your workplace into a showcase that can be understood by everyone at a glance. In terms of quality, it means to make the defects immediately apparent. In terms of quantity, it means that progress or delay, measured against the plan, is made immediately apparent. When this is done, problems can be discovered immediately, and everyone can initiate improvement plans." - Taiichi Ohno**

# What is a Visual Workplace?

- When anyone can walk into a workplace and visually understand:
  - The current situation.
  - The work process.
  - Ahead, behind or on schedule.
  - When there is an abnormality.
- Use signals, lights, diagrams, charts and signs to:
  - Clearly **define** the **normal** condition or a **required action.**
  - **Expose** the **<u>abnormal</u>** undesired condition - **real time.**



# Visual Controls

- Visual Controls are communication devices used in the work environment that tell us at a glance how work should be done.
  - Communicate information quickly and clearly.
  - Locate things and places.
  - Highlight defects, over-production and / or under-production.
  - Provide instruction.
  - Spotlight abnormal conditions.
  - Communicate status to all.

# Examples of Visual Controls

- Red Tags - identify items to be scrapped.
- Signs / labels - to position tools, inventory, etc.
- White Lines - mark pathways, inventory locations.
- Alarm Lights - alert team members / supervisors.
- Kanbans - “pull production”, minimize WIP.
- Production boards - show required / actual output.
- Standardized Work Charts - process maps.
- Defective Item Displays - display defects, information on defect cause and solution.

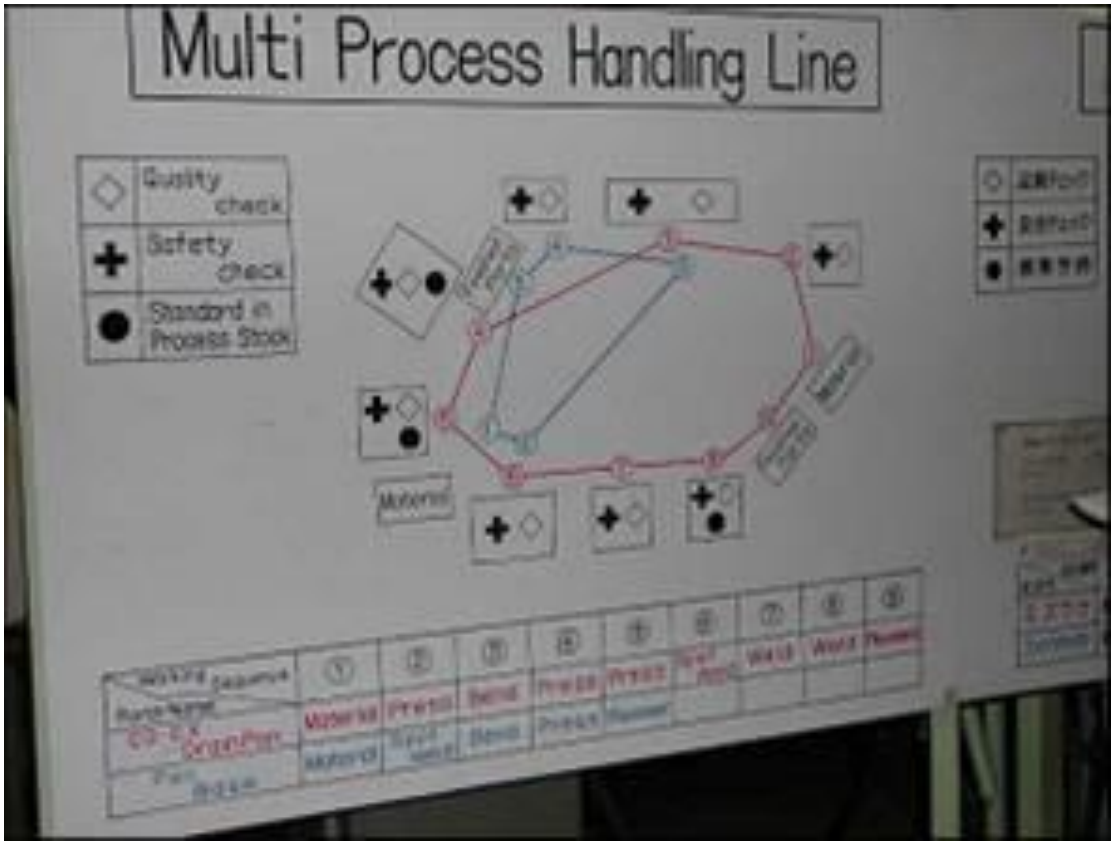
# Visual Controls

*5 seconds or less – which kit has all it's parts?*

# Effective Visuals

Create a work environment that is…

- Self - explaining
- Self - ordering
- Self - regulating
- Self - improving



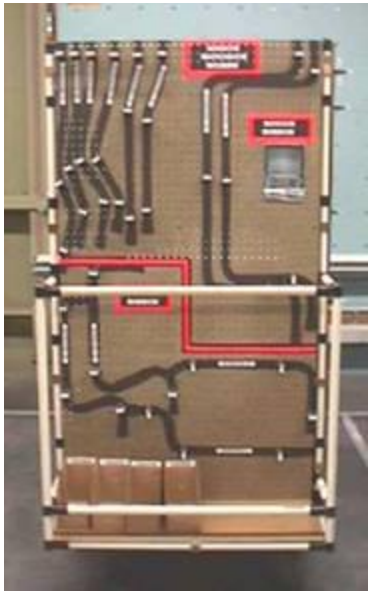
# Types of Visuals

Display – Broadcast data

Signals – Grab your attention!

Controls – Limit behavior

Guarantees – Allows for correct response.



# Transactional Visuals

Outlook Meeting Notice!

Helps to control and ensure maximum attendance!

Support Agreement Status on SharePoint – Color-coding identifies missing data or required action.

| Updated | 11/18/2016 |
|---|---|
| AGREEMENT STATUS | (Multiple Items) |

| upport Agreements Completed by Year/Mont | |
|---|---|
| Fiscal Year Signed | Quantity |
| New | 10 |
| FY17 | 1 |
| FY16 | 36 |
| FY15 | 24 |
| FY14 | 6 |
| FY13 | 4 |
| FY12 | 6 |
| FY11 | 4 |
| FY10 | 2 |
| FY09 | 2 |
| FY08 | 1 |
| FY07 | 1 |
| FY06 | 2 |
| FY05 | 2 |
| FY04 | 3 |
| FY02 | 1 |
| Grand Total | 105 |

| Support Agreements Signed by Year/Status/SAM | | | | |
|---|---|---|---|---|
| Year Signed | SAM 1 | SAM 2 | SAM 3 | Grand Total |
| New | 3 | 3 | 4 | 10 |
| FY17 | | | 1 | 1 |
| FY16 | 14 | 14 | 8 | 36 |
| FY15 | 12 | 8 | 4 | 24 |
| FY14 | 1 | 2 | 3 | 6 |
| FY13 | 1 | 1 | 2 | 4 |
| FY12 | 1 | 2 | 3 | 6 |
| FY11 | 2 | 2 | | 4 |
| FY10 | | 2 | | 2 |
| FY09 | 2 | | | 2 |
| FY08 | | 1 | | 1 |
| FY07 | | 1 | | 1 |
| FY06 | 2 | | | 2 |
| FY05 | 1 | 1 | | 2 |
| FY04 | | 2 | 1 | 3 |
| FY02 | | 1 | | 1 |
| Grand Total | 39 | 40 | 26 | 105 |

Support Agreement Status on SharePoint – Uses Status Data to develop up-to-date metrics on performance.

# Visual Controls

*Can you distinguish between normal and abnormal conditions in the above photos? Abnormal conditions should be visually obvious in 5 seconds or less!*

# Production Control Boards

- Tell how many people are needed.
- Tell who does what.
- Makes problems visual.
  - Ahead or behind Takt Time.
  - Quality issues.
  - Missing parts, materials, information, people.
  - Down time.
- Triggers the problem solving process.

# Production Control Boards

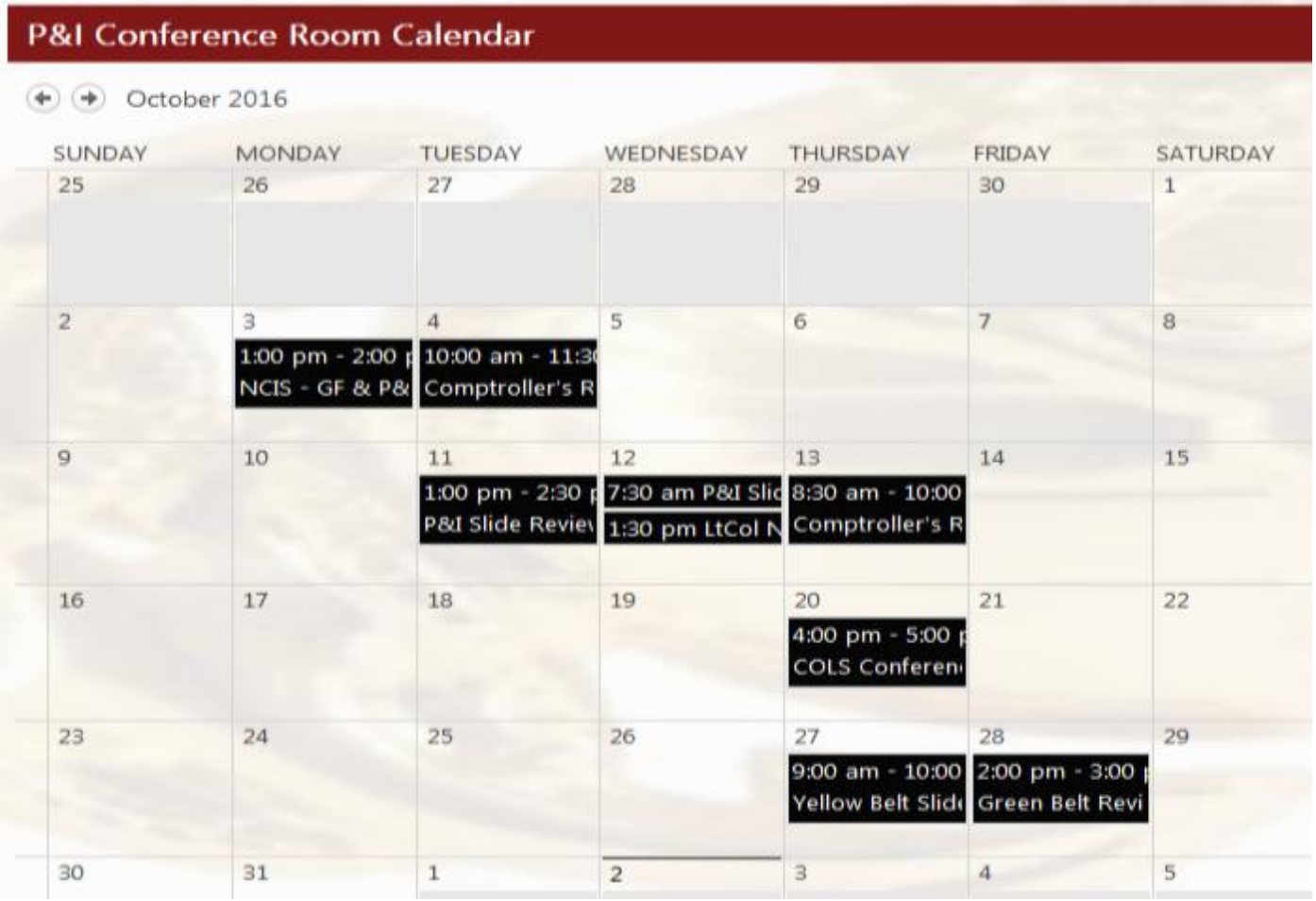
- Low maintenance.
- Easy to understand.
- Information visible at a glance.
- Priorities are readily apparent.
- Bottlenecks and WIP levels are obvious.
- Actual status of production vs. plan is evident.

Production Control Board

Electronic Control Board

# Transactional Control

Transactional Control - Using a section calendar On SharePoint to manage utilization of the P&I conference room.



# Daily Board Walk

- Managers review as employees update.
- Issues are identified, addressed, and corrective actions established.
- Exceptions can be identified clearly (priorities).
- Targets must be clearly defined.

Weekly Meetings

- A venue for the cell to discuss general operational issues and continuous improvement.

Agendas

- Keeps a meeting focused on its purpose.
- Allows participants to prepare.

# Knowledge Check: Visual Workplace

## What are the benefits of implementing Visual Controls?

# Knowledge Check: Visual Workplace

## What are the characteristics of good Visual Controls?

# Implementation

# Implementation Details

- **Pilot Implementation Plan.**
  - Run pilot trials.
  - Monitor set-up times and idle times closely.
  - Don’t let large transportation lots throw away the benefits of smaller process lots.
- **Piloting Improvement.**
  - Develop a good work release plan.
  - Monitor interactions with lot sizing.

# Purpose of the Pilot

## Pilots allow us to:

- Test run the solution in a small part of the organization.
- Evaluate the process measures for the improvement.
- Improve the proposed solution.
- Increase organizational buy-in.

## Mitigate Unintended Consequences:

- See where possible failure points exist.
- Validate and refine cost and benefit estimates.
- Modify the implementation plan.

**Overall benefit is a better solution with fewer surprises**

# Pilot Planning

- **What** – Needs to be piloted.
- **Where** – Will the pilots be run.
- **Who** – Will be involved.
- **When** – (How long) will the pilots run.
- **How** – Will the pilots be conducted.

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# Tips During the Pilot

- Make careful observation of all activities, effects, and interactions during the pilot and continue pilot long enough to establish reliable baseline.
- Manage expectations and perceptions.
  - Customers
  - Management
  - Staff
- Refine the improvement if the pilot demonstrates any weaknesses.
  - Often the pilot will show a few opportunities for improvement.

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# Lessons Learned

- At the completion of the pilot, capture what worked and what needed improvement.
- Include lessons learned in the full roll out of the new process:
  - Compile lessons learned.
  - Categorize by type; by defect type, key analysis used, key words, problem / opportunity statement, root causes, etc.
  - Communicate lessons learned to others.

Source: ASQ LSS Training Material

# What We Have Covered: Improve Phase

## Improve Phase Tools

- Lean Principles: Value, Value Stream Map, Flow, Pull and Continuous Perfection.
- 5S in your workspace.
- Identification of Mistake Proof opportunities.
- Standard Work within a process.
- Visual controls in your workspace.
- Pilot of Improvements/Implementation.

# What's Next?

# Simulation
# Statapult Round 3

# Round 3

## Variation Reduction

**Teams will focus on reducing process variation to improve quality and yield. This round includes the following phases:**

- **Baseline**
- **Control Chart Setup**
- **Shoot**
- **Calculations**

# Exercise Requirements – Round 3

- Team members cannot perform the same roles as in Rounds 1 or 2.
- The balls will be marked as a preparation for shooting and for rework.
  - Blue dots symbolize inputs needed to complete a job function and are considered to be value added to the process.
  - Red dots must be applied to each failed ball. The red dot symbolizes firefighting.
- No permanent markings or modifications can be made to the Statapult or balls.

# Customer Requirements – Round 3

- All shots must be fired at an angle of 167 degrees.
- All shots must land in a stationary target area +/-2 inches long and +/- 4 inches wide with respect to the nominal target.
- Ball distance must be measured to the nearest ½ inch.
- Pass / Fail data must be collected for each shot.
- The balls must be sorted based on either Pass or Fail.
- The balls must be delivered to customer with no markings (colored dots).
- All data must be collected “real time”.

# Requirements – Round 3

**Business Requirements**

- Balls are aligned with blue dot facing up.

**Statapult Requirements**

- The Statapult must be placed so that the base is horizontal to the floor and in a stationary position.

# Exercise - Standard Operating Procedures

***Based on the Cause & Effect Analysis done in Analyze Phase, incorporate your team's variation reduction plans into your process for Round 3.***

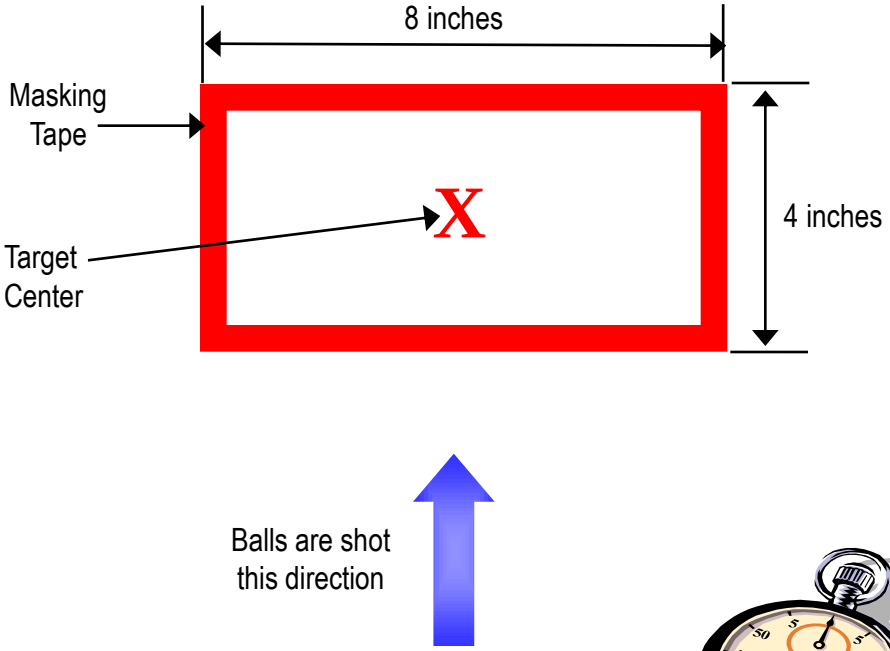
***Summarize your new procedures on flip chart paper and post for approval by your instructor.***

***15 minutes***

# Exercise - Baseline

***As in previous rounds, the target area will be set up based on 20 shots. For this round, teams will record the actual baseline shot measurements on the following page.***

- Position your Statapult.
- Obtain 20 balls.
- Take 20 test shots.
- Mark the landings.
- Measure the shots.
- Mark off target area.



***10 minutes***

# Baseline Data

| Launch Number | Distance (inches) |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| 7 | |
| 8 | |
| 9 | |
| 10 | |
| 11 | |
| 12 | |
| 13 | |
| 14 | |
| 15 | |
| 16 | |
| 17 | |
| 18 | |
| 19 | |
| 20 | |
| 21 | |
| 22 | |
| 23 | |
| 24 | |
| 25 | |

$\overline{X}$ =

(Average of the data points)

Target =

(Target = $\overline{X}$)

USL =

(Upper Specification Limit = $\overline{X}$ + 3)

LSL =

(Lower Specification Limit = $\overline{X}$ - 3)

$\sigma$ =

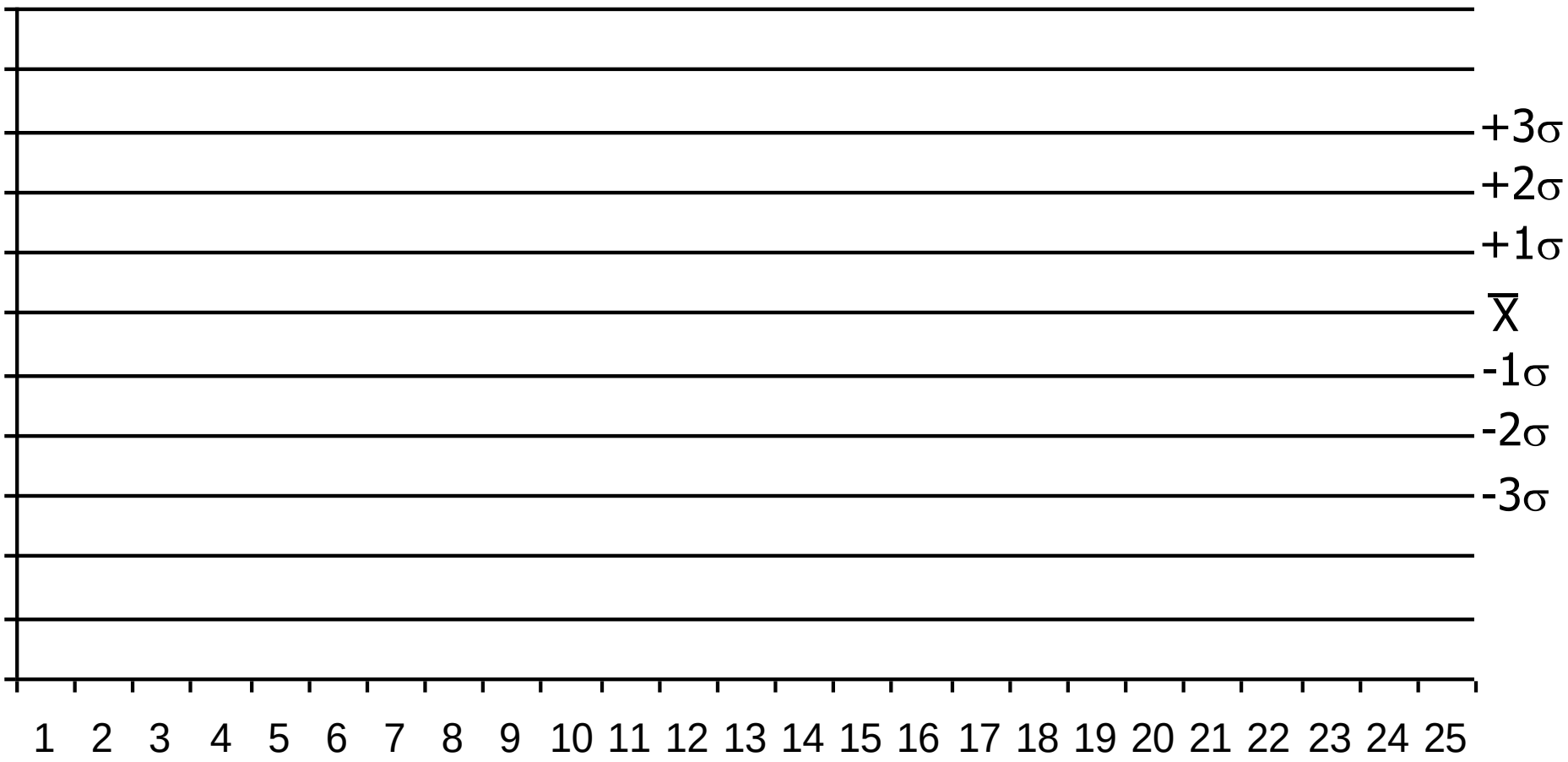
(Standard deviation of data points)

# Creating a Control Chart

- Using your baseline data, create a control chart which you will use <u>during</u> the final phase.
- Execute the following calculations and label them on the chart:
  - Centerline = $\bar{x}$ =
  - UCL = $\bar{x}$ + 3s =
  - LCL = $\bar{x}$ - 3s =
  - Also label $\bar{x}$ +/- 1s and $\bar{x}$ +/- 2s
- Plot the baseline data like a “run chart”.

***15 minutes***

# Baseline Control Chart



# Control Chart Evaluation

If you incur any of the below out of control conditions, or are not sure, inform the instructor to discuss next steps.

- 1 or more points outside of the UCL or LCL.
- 2 out of 3 in zone A.
- 7 points in a row steadily increasing or decreasing.

If the baseline is free of out of control conditions, the centerline, UCL, and LCL are locked in for Round 3.

- Transfer this information (without the run chart from the baseline) to flip chart paper. Label the centerline, UCL, and LCL on the chart. The data will be collected directly on this chart during the exercise.

# Using Control Chart During Shoot

- Plot measurements “real time”.
- Watch for the following out of control conditions.
  - 1 or more points outside of the UCL or LCL.
  - 2 out of 3 in zone A.
  - 7 points in a row steadily increasing or decreasing.
- Team is authorized to stop the process for an out of control condition.
  - If the process is stopped, the time will stop as well.
  - The team can take up to 2 minutes to discuss and implement a corrective action.

# Exercise - Round 3 Shoot

## *Are you ready to start?*

- Your SOP was approved.
- Statapult layout is ready.
- Target area is taped off.
- Measurement system is setup.
- Control Chart is ready.

***The simulation will start simultaneously for all teams!***

***50 minutes***

# Simulation Summary Sheet

| | Time to First Delivery | Total Lead Time | Lead Time per Unit | WIP | Scrap | Yield | Cost of Poor Quality | Cost per Unit |
|---|---|---|---|---|---|---|---|---|
| Round 1 | | | | | | | | |
| Round 2 | | | | | | | | |
| Round 3 | | | | | | | | |

# Exercise: What Went Wrong?

- Choose a facilitator.
- Brainstorm answers to the question, “What went wrong with the process?
- Facilitator: Do not accept solutions; record only problems.

***10 minutes***