

# Waste and Variation

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# Waste and Variation

- In this session, we will discuss:
  - Waste and Variation: What are they?
    - Value Added versus non-Value Added
    - Voice of the Customer
    - Cost of Poor Quality
  - Techniques for Identifying Variation and Waste
    - Root Cause Analysis
    - Brainstorming
    - Process Observation
    - Cause and Effect
  - Identifying Waste using Lean Tools
    - 7 Classic Types of Waste, plus 1 (DOWNTIME)
    - Cost of Waste (COW)
    - Cycle Time and TAKT Time
- A list of supplemental material and additional practice/review questions for this session are provided at the end of this presentation
- You can download the pdf of this presentation, along with any supporting data files, on the site where you are accessing this course



# Value Added vs. non-Value Added

- Which processes are value added in **the eyes of the customer**?
- Any activity, **DONE RIGHT THE FIRST TIME**, that transforms or converts information or raw materials by affecting the **FORM, FIT, or FUNCTION** to meet **customer requirements** is value added!
- All other activities are **WASTE** or part of the Cost of Poor Quality (COPQ). COPQ activities use up resources and cost us time and/or money needlessly.

## *Time Value Map*



Time: Traditional efforts focus on increasing the value added time

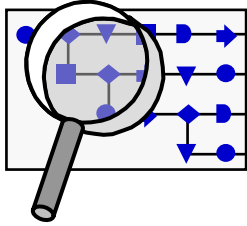


95% Non-Value Added

5% Value Added

Lean tools focus on identifying and eliminating non-value added activities and wastes

# Waste and Variation: Activity Types



When reviewing your process maps, look for and identify these 3 types of activities.

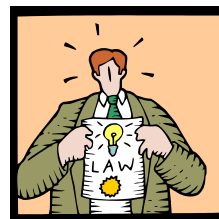
## Value Added Activities

- Activities where the product or service is transformed into a state required by the customer.
- Activities which, when asked, the customer is willing to pay for.



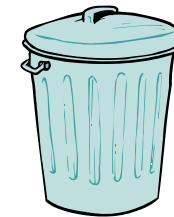
## Non-Value Added But Required

- Activities causing no value to be created but which cannot be eliminated based on current state of technology or thinking.
- Example – Regulatory requirements



## Non-Value Added Activities

- Activities which consume time and resources but create no value in the eyes of the customer.
- **Pure Waste.**



# The Categories of Cost of Poor Quality: COPQ

Where Does the Cost of Poor Quality (Waste or Muda) Come From? ...

- Internal Failure Costs
- External Failure Costs
- Appraisal Costs
- Prevention Costs
- Lost Opportunity Costs

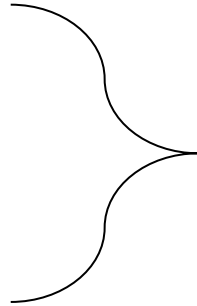


# COPQ: Internal Failure Costs

- Failure costs occurring prior to product/service delivery or shipment.

- Some examples:

- Overproduction
- Waiting
- Transportation
- Inventory
- Processing
- Motion
- Defects
- Non-productive Assets
- Design Corrective Action
- Rework-Design Change
- Scrap-Design Change
- Production Liaison Costs
- Purchasing Failure Costs
- Purchased Material Replacement Costs
- Supplier Corrective Action
- Rework of Supplier Rejects
- Uncontrolled Material Losses
- Material Review/Corrective Action
- Disposition Costs
- Troubleshooting/Failure Analysis
- Investigation Support Costs
- Operations Corrective Action
- Failure to Transfer from Design to Manufacturing
- Rework
- Repair
- Reinspection/Retest Costs



The Classic Wastes of LEAN, commonly called Cost of Waste (COW)



# COPQ: External Failure Costs

- Failure costs occurring after product/service delivery or shipment to the customer.
- Some examples:
  - Customer Complaint Investigation
  - Returned Goods
  - Retrofit Costs
  - Recall Costs
  - Warranty Claims
  - Liability Costs
  - Penalties
  - Customer/User Goodwill
  - Premium Freight (overnight)
  - Pricing Errors





# COPQ: Appraisal Costs

- Costs associated with measuring, evaluating or auditing products or services to ensure conformance to quality standards and performance requirements.
- Some examples:
  - Document Checking
  - Purchasing Appraisal Costs
  - Receiving/Incoming Inspection and Test
  - Qualification of Supplier Product
  - Source Inspection and Control Programs
  - Manufacturing Appraisal Costs
  - Planned Inspections, Tests, Audits
  - Financial Audits
  - Checking Labor
  - Inspection and Test Materials
  - Set-Up Inspections and Tests
  - Depreciation Allowances
  - Measurement Equipment Expense
  - Maintenance and Calibration Labor
  - Outside Endorsements and Certifications
  - External Appraisal Costs
  - Field Performance Evaluations
  - Special Product Evaluations
  - Review of Test and Inspection Data
  - Other Quality Evaluations
  - Special Tests
  - Process Control Measurement
  - Laboratory Support



# COPQ: Prevention Costs

- The costs of all activities specifically designed to prevent defects (poor quality) in products or services. These occur prior to production and are aimed at preventing defects before they occur.
- Some examples:
  - Marketing Research
  - Customer Perception Surveys
  - Contract/Document Review
  - Design Quality Progress Review
  - Design Support Activities
  - Product/Service Design Qualification Test
  - Field Trials
  - Supplier Quality Reviews/Ratings
  - Purchase Order Technical Data Review
  - Supplier Quality Planning
  - Operations Prevention Costs
  - Operations Process Validation
  - Operations Quality Planning
  - Operational Support Quality Planning
  - Operator Quality Education
  - Operator SPC/Process Control
  - Quality Administrative Salaries and Expenses
  - Quality Program Planning
  - Quality Performance Planning and Reporting
  - Quality Education and/or Improvement
  - Quality System Audits
  - Training without ROI



# COPQ: Lost Opportunity Costs

- Costs of missed opportunities. Some examples:
  - Delayed Market Entry
  - Lost Sales
  - Lost Customers
  - Additional Shifts, Lines, Plants Due to Poor Productivity (i.e., Low Capacity)
  - Failure to Enter a New Market Because of ...
  - Competitor Obtains Patent Rights Before We Do
  - Reliability Issues
  - Safety Issues
  - Ergonomic Issues
  - Legal Issues



# The Major Reason LSS Exists

.... to reduce the Cost of Poor Quality (COPQ) and the Cost of Waste (COW) .... by reducing the following;

- Internal Failure Costs (incurred prior to reaching customer)
- External Failure Costs (incurred after reaching customer)
- Appraisal Costs
- Prevention Costs
- Lost Opportunity Costs



....the Usual Suspects: **Waste & Variation**



# Root Cause Analysis

- Numerous Sources of Information, but data is the most valuable source of root causes
- Five (5) Why's
- Brainstorming
- Observation of processes
  - Process Maps
  - Discussion with Operators and Team Members
- Cause and Effect Diagrams

# “5 WHY” ANALYSIS



- Simple yet effective tool to develop increased understanding of an issue
- Involves asking “Why?” (up to) 5 times to uncover the root cause of the issue (along with other contributing factors) so that we can eliminate or minimize the impact of the issue
- Example: **Problem: The cylinder is moving too slowly.**



**Why** is movement too slow?  
Because there’s a clog in the strainer.

**Why** is the strainer clogged?  
Because oil is contaminated.

**Why** is the oil contaminated?  
Chips and debris enters through holes and gaps on the upper plate of the tank.

**Solution:** Prevent chips from scattering. Close the holes and gaps in the upper plate of the tank.

# 5 Why's

## Washington Monument Problem: It is deteriorating

**Why #1:** Why is it deteriorating?

A: harsh chemicals frequently used to clean the monument

**Why #2:** Why are the harsh chemicals needed?

A: to clean off large number of bird droppings

**Why #3:** Why are there a large number of bird droppings?

A: because of the large number of spiders and other insects which are a food source

**Why #4:** Why are there such a large number of spiders and other insects around the monument?

A: because the insects get drawn to the monument at dusk

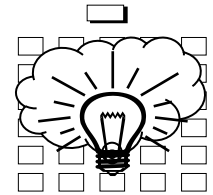
**Why #5:** Why are they drawn at dusk?

A: because the lighting in the evening attracts local insects



Solution: focus on lighting (delay turning on lights at night; 85% reduction in midges and massive drop in bird droppings and level of cleaning required. Bonus: reduced energy costs

# Brainstorming

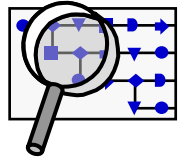


- Structured:
  - Go around the room and have each team member, in turn, give an idea
  - Accept each idea without analysis or judgment
  - If a person is out of ideas, they may pass their turn onto the next person
  - Continue, around the room, until everyone is out of ideas
  - As a group, review all the ideas. This provides an opportunity for clarification and to discard duplicate ideas.
  - Often, the review may stimulate the generation of new ideas.
  
- Unstructured:
  - Identical to the previous process except that ideas can be given at any time by anyone without the need to follow a structured rotation of the team members

Structured brainstorming tends to maximize participation and generates more ideas, while unstructured brainstorming is quicker to use. Sometimes a combination of the two is useful.



# Observing the Process and Identifying the Waste



- As you and your team analyze the process and brainstorm causes of problems, watch what really happens and document what is observed
- Observations can be made on a special data collection form designed by the team, or simply annotated on the process map
- Typical data and/or observations to record include things such as:
  - What kind of waste is present?
  - How long does a particular step take?
  - What problems or issues were observed?
  - What defects were observed?
  - Any opportunities for hard and/or soft benefits?

Sample Process Observation Data Collection Form

| Step | Description | Start and stop time | Type of waste, if any, observed | Number of people | Quantity processed | Improvement ideas |
|------|-------------|---------------------|---------------------------------|------------------|--------------------|-------------------|
| 1    |             |                     |                                 |                  |                    |                   |
| 2    |             |                     |                                 |                  |                    |                   |
| 3    |             |                     |                                 |                  |                    |                   |
| 4    |             |                     |                                 |                  |                    |                   |
| 5    |             |                     |                                 |                  |                    |                   |

# Process Observation Examples

- Simple data collection forms, such as the following, make process observation much easier and ensures that the right information is collected

**Example: Operator Observation Chart**

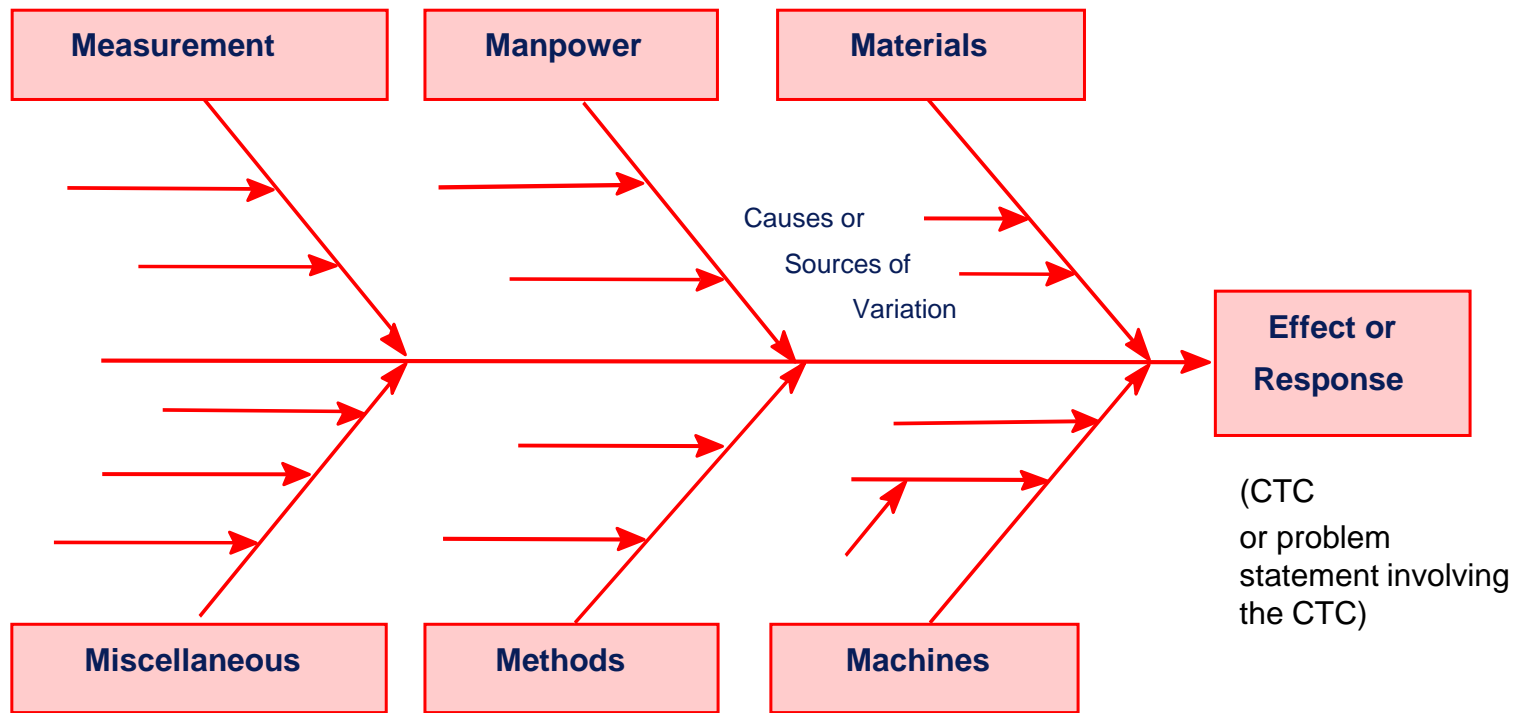
| Step No. | Task Description                               | Start Time | Stop Time | Elapsed Time | Improvement Recommendation                       |
|----------|--|------------|-----------|--------------|--|
| 1        | Walk to Cart, Pick Up Assembly, Place on Table |            |           | 3 s          | Place Cart Within Reach to Eliminate Walking     |
| 2        | Secure Assembly With Left Hand                 |            |           | 2 s          | Use a Clamp or Mount to Free Up Left Hand        |
| 3        | Pick Up Bracket With Right Hand                |            |           | 3 s          | Locate Brackets Lower to Reduce Reach            |
| 4        | Locate Bracket to Position on Assembly         |            |           | 8 s          | Use Jig to Error-Proof Positioning of Bracket    |
| 5        | Attach Bracket to Frame                        |            |           | 35 s         | Improve Workstation Setup<br>Reduce Process Time |
| 6        | Repeat Steps 3 - 5                             |            |           | 46 s         |  |
| 7        | Walk to Cart & Place Assembly on Cart          |            |           | 5 s          | Place Cart Within Reach to Eliminate Walking     |

**Example: Process Observation Chart**

| Step No. | Description                        | Operation | Transport | Inspect | Delay/Wait | Storage | Decision | Distance | QTY  | Elapsed Time |
|----------|------------------------------------|-----------|-----------|---------|------------|---------|----------|----------|------|--------------|
| 1        | Attach brackets to frame           | ●         | ➔         | ■       | ⏸          | ▼       | ◆        |          | 5500 | 368 m        |
| 2        | Move to holding area               | ●         | ➔         | ■       | ⏸          | ▼       | ◆        | 220 ft   | 5500 | 14 m         |
| 3        | Awaiting inspection                | ●         | ➔         | ■       | ⏸          | ▼       | ◆        |          | 5500 | 3 d          |
| 4        | Inspect for defects                | ●         | ➔         | ■       | ⏸          | ▼       | ◆        |          | 5500 | 65 m         |
| 5        | Decision to proceed                | ●         | ➔         | ■       | ⏸          | ▼       | ◆        |          |      | 20 m         |
| 6        | Awaiting paperwork to be completed | ●         | ➔         | ■       | ⏸          | ▼       | ◆        |          |      | 2 d          |
| 7        | Move to staging Area #4            | ●         | ➔         | ■       | ⏸          | ▼       | ◆        | 190 ft   | 5175 | 10 m         |
| 8        | Awaiting next operation            | ●         | ➔         | ■       | ⏸          | ▼       | ◆        |          | 5175 | 8 d          |
| 9        | Spray assembly With primer         | ●         | ➔         | ■       | ⏸          | ▼       | ◆        |          | 5175 | 688 m        |

# The Cause and Effect Diagram

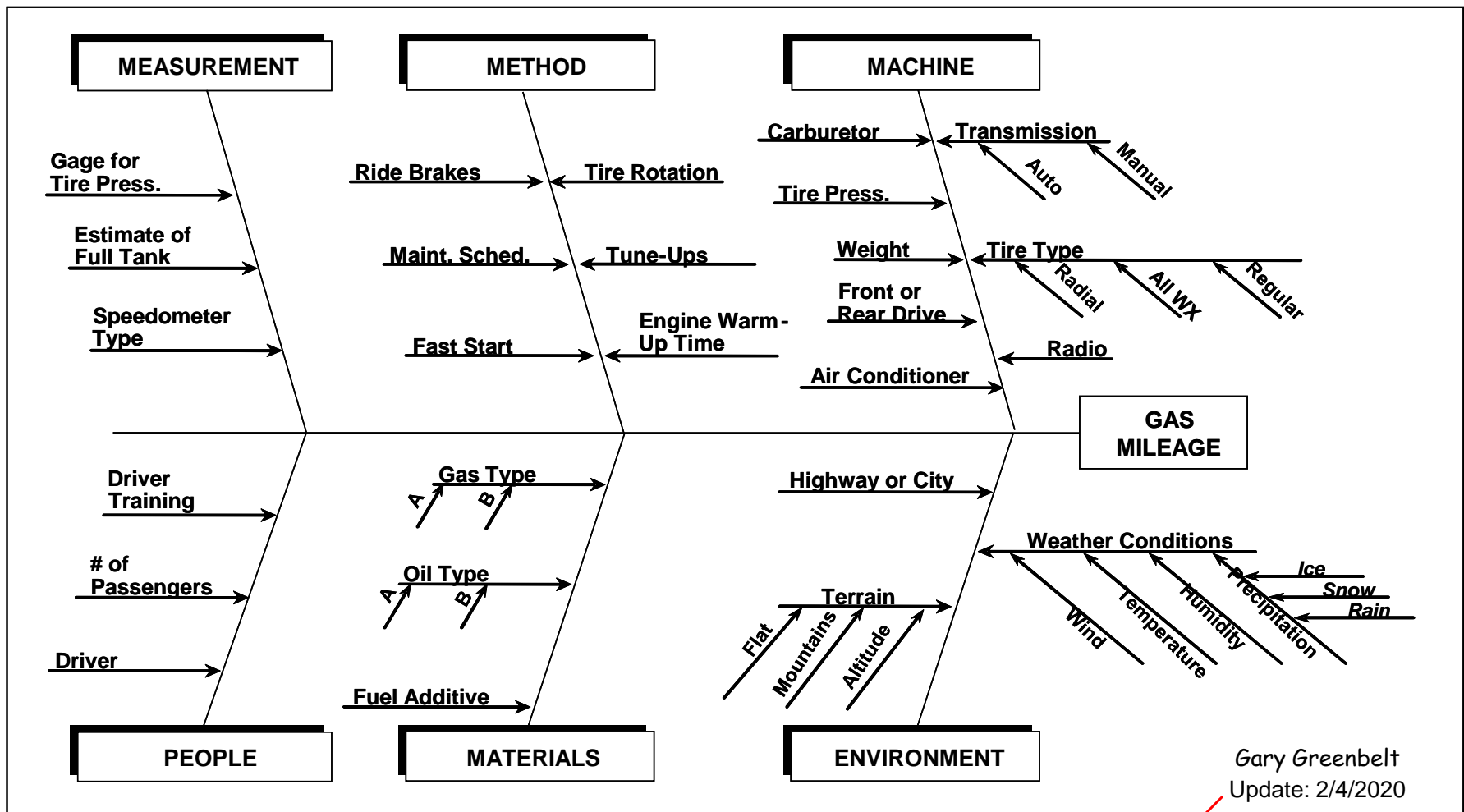
- Brainstorm all the possible variables (or causes) that the team believes may affect the output (or contribute to the problem)
- Helps identify data that may be needed



For video instruction on generating a cause and effect diagram in SPC XL go to: <https://airacad.com/our-insights/training-videos/spc-xl/>

# The Cause and Effect Diagram (Example)

What are the possible causes of variation in gas mileage?



This is a living document which should be reviewed and updated.

# Partitioning the Variables



## C = Constant

- To hold a variable as constant as possible requires controlling the variable via Mistake Proofing and SOPs to eliminate errors and reduce variation.
- Controlling a variable or holding it as constant as possible doesn't just happen. It must be engineered into the process.
- Mistake Proofing: The process of eliminating conditions (errors) that lead to variation in the CTCs and ultimately cause defects.

## N = Noise

- Noise variables are those that are not being controlled or held as constant as possible.
- Mistake Proofing is needed to change an "N" variable to a "C" variable.

## X = Experimental

- These are key variables that can be controlled and held constant at different levels or settings for the purpose of determining the effect of this variable on the CTC.

# Steps for Creating a Cause and Effect Diagram



## Method 1

1. Describe the problem or CTC (output) being discussed and place it at the “head” of the cause and effect (or fishbone) diagram
2. Determine appropriate\* cause categories (the major “bones”)
3. Brainstorm potential causes (or sources of variation) within each category, which are believed to affect the problem or CTC, and place on the diagram

\*Typical cause categories (“bones”) for production processes

- the 6M’s: manpower, machine, materials, methods, measurement, Mother Nature (environment)

\*Typical cause categories (“bones”) for non-production processes

- procedures/policies, people, materials, equipment, environments, other

\*Be flexible! Use what makes sense for your process. For example, you might find it easier to use process steps for the “bones” . There is no one best way.

## Method 2

- Describe the problem or CTC (output) being discussed and place it at the “head” of the cause and effect (or fishbone) diagram
- Brainstorm potential causes (or sources of variation) and place on sticky notes
- Cluster the causes into related groups and name the groups. Use the group names as the major “bones” on the cause and effect diagram and place the causes within each group

Goal is to get as many variables as possible identified.

More variables = More likely to discover the real root causes

# The Cost of Waste: D-O-W-N-T-I-M-E (The 8 Wastes)

1. **D**efects

8. **E**xtra processing

2. **O**verproduction

7. **M**otion

3. **W**aiting

6. **I**nventory

4. **N**on-productive assets

5. **T**ransportation



# The 8 Wastes

| Type of Waste                                  | Description   |
|--|---|
| <u>D</u> efects                                | Processes not performed correctly resulting in defects and/or rework  |
| <u>O</u> ver-production                        | Doing more than what is needed by the customer and creating excess (too many unnecessary meetings or reports) |
| <u>W</u> aiting                                | Waiting for the next event or next work activity to occur   |
| <u>N</u> on-productive use of people and ideas | Not utilizing employee talent or ideas “properly”   |



## The 8 Wastes (cont.)

| Type of Waste                       | Description   |
|-------------------------------------|---|
| <u>T</u> ransportation              | Excess movement of materials, people, equipment, and/or supplies        |
| <u>I</u> ncorrect <u>I</u> nventory | Excessive inventory or inadequate inventory                             |
| <u>M</u> otion                      | Unnecessary movement and excessive walking, reaching or motion by staff |
| <u>E</u> xtra Processing            | Required work that is not of value                                      |

# Variation .... the “Insidious” Enemy

- Variation exacerbates all other types of wastes
- Examples of variation:
  - Inputs to processes are inconsistent
  - Process steps are not performed the same way each time
  - Products and services vary in quality
- Impact of variation:
  - Customer see and feels the variation (doesn't know what to expect)
  - Customer never sees the average
  - Mistakes or defects (services not performed in accordance with customer specifications)
  - Commit dates are missed
  - Cost overruns
  - Need for excess capacity
  - Impact on lead times

# Analyzing Work (Time Analysis)



- TAKT time is the time allocated to produce one part, based on time allocated to the production of that part and the demand rate. It is the minimum pace that must be kept to meet customer demands.
- TAKT time is:
  - determined by the customer.
  - important for understanding work balance and flow.
  - NOT cycle time!

$$\text{TAKT Time} = \frac{\text{Total Available Production Time}}{\text{Demand for the product (in units)}}$$

- Available production time should consider the length of shifts, number of shifts, meals, breaks, personal time, setup, cleaning time and any other time which interferes with the actual production of the part.



# TAKT Time Example #1



## Assume:

One 8 hour shift

One 1 hour lunch break

Average customer demand 400 units per day

$$\text{Total Work Time} = 8 \text{ hours} \cdot \frac{3,600 \text{ sec}}{\text{hour}} = 28,800 \text{ sec}$$

$$\text{Non-Working Time} = 1 \text{ hour} \cdot \frac{3,600 \text{ sec}}{\text{hour}} = 3,600 \text{ sec}$$

$$\text{Total Available Production Time} = 28,800 \text{ sec} - 3,600 \text{ sec} = 25,200 \text{ sec}$$

$$\text{TAKT Time} = \frac{25,200 \text{ sec/day}}{400 \text{ units/day}} = 63 \text{ sec/unit}$$

- In order to meet customer demand, we must produce a functional part every 63 seconds!

# TAKT Time Example #2



## Assume:

Two 8-hour shifts

Each shift is given 1 hour for meals

Each shift is given 3 breaks @ 10 minutes each

Average customer demand 200 units per day

$$\text{Total Work Time} = 2 \cdot 8 \text{ hours} \cdot \frac{3,600 \text{ sec}}{\text{hour}} = 57,600 \text{ sec}$$

$$\begin{aligned} \text{Non-Working Time} &= 1 \text{ hour for meals} \\ &+ \underline{30 \text{ minutes in breaks}} \\ &= 90 \text{ minutes per shift} \\ &\cdot \underline{2 \text{ shifts per day}} \\ &= 180 \text{ minutes per day} \cdot \frac{60 \text{ sec}}{\text{minute}} = 10,800 \text{ sec} \end{aligned}$$

$$\begin{aligned} \text{Total Available} \\ \text{Production Time} &= 57,600 \text{ sec} - 10,800 \text{ sec} = 46,800 \text{ sec} \end{aligned}$$

$$\text{TAKT Time} = \frac{46,800 \text{ sec}}{200 \text{ units}} = 234 \text{ sec/unit}$$



# TAKT Time Exercise



Pause the video and calculate the TAKT time for the following data. You may use the TAKT time calculator file called [TAKT time calculator](#) or do the exercise by-hand.



*TAKT time calculator.xlsx*

- Two 8-hour shifts
- Shift #1 is given one hour for lunch and 2 15-minute breaks
- Shift #2 is not given a meal break, but is given 4 15-minute breaks
- It takes Shift #1 15 minutes to prepare the equipment in the morning for operation. It takes shift #2 30 minutes to shut down and clean up at the end of the shift.
- Customer demand is 3,000 units per month
- There are 20 workdays in the current month

Calculate daily TAKT time (in seconds)





# TAKT Time Exercise



TAKT time calculator.xlsx

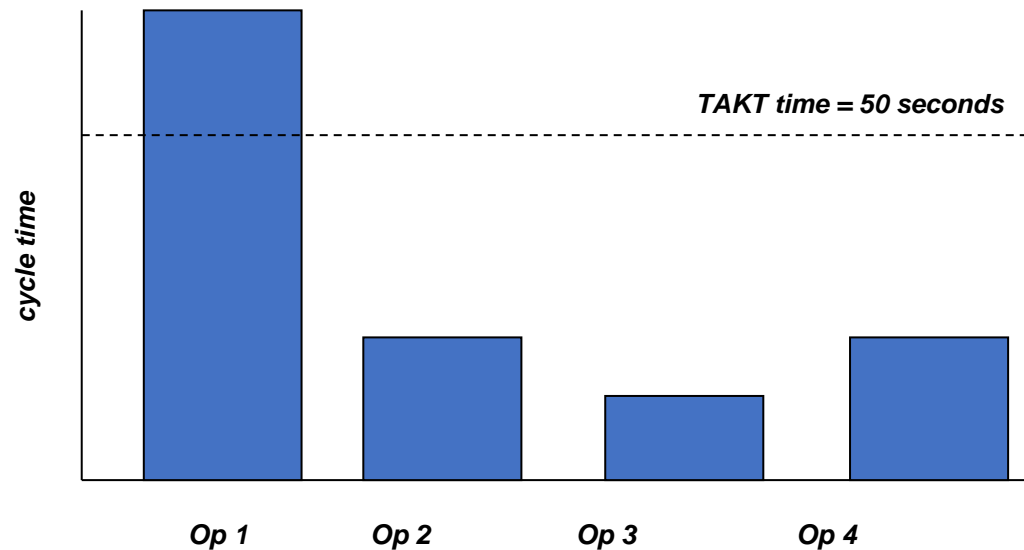
- Using the TAKT time calculator, here is the answer to the exercise from the previous page.

| Takt Time Calculator                      |            |                     |
|---|------------|---------------------|
| <b>Time Available (TA)</b>                |            |                     |
| <b>Total Work Time per Day</b>            |            |                     |
| <i>Number of Shifts</i>                   | 2          |                     |
| <i>Hours per Shift</i>                    | 8          |                     |
| <b>Total Work Time per Day =</b>          | <b>16</b>  | <b>hours</b>        |
|   | <b>960</b> | <b>minutes</b>      |
| <b>Total Non-Working Time</b>             |            |                     |
| <b>Shift 1: Number of Breaks</b>          |            |                     |
| <i>Break Time (minutes per break)</i>     | 15         |                     |
| <i>Lunch Time (minutes)</i>               | 60         |                     |
| <i>Planned Downtime (minutes)</i>         | 15         |                     |
| <b>Shift 2: Number of Breaks</b>          |            |                     |
| <i>Break Time (minutes per break)</i>     | 15         |                     |
| <i>Lunch Time (minutes)</i>               | 0          |                     |
| <i>Planned Downtime (minutes)</i>         | 30         |                     |
| <b>Shift 3: Number of Breaks</b>          |            |                     |
| <i>Break Time (minutes per break)</i>     | 0          |                     |
| <i>Lunch Time (minutes)</i>               | 0          |                     |
| <i>Planned Downtime (minutes)</i>         | 0          |                     |
| <b>Total Non-Working Time per day =</b>   | <b>195</b> | <b>minutes</b>      |
| <b>Work Time Available per day (TA =)</b> | <b>765</b> | <b>minutes</b>      |
| <b>Demand</b>                             |            |                     |
| <b>Average Demand per day =</b>           | <b>150</b> | <b>units</b>        |
| <b>TAKT Time (TA / Demand)</b>            |            |                     |
| <b>TAKT Time =</b>                        | <b>5.1</b> | <b>minutes/unit</b> |
|   | <b>306</b> | <b>seconds/unit</b> |



# Why is TAKT Time Important?

- TAKT time represents the rate at which completed units must come off the production line to keep pace with customer demand.
- TAKT time is the foundation for planning and understanding work balance and flow. It tells us the targeted work content time for completing an operation within the process.
- TAKT time, when analyzed with cycle time, is a key measure used to determine the number of operators, machines, loading, etc.





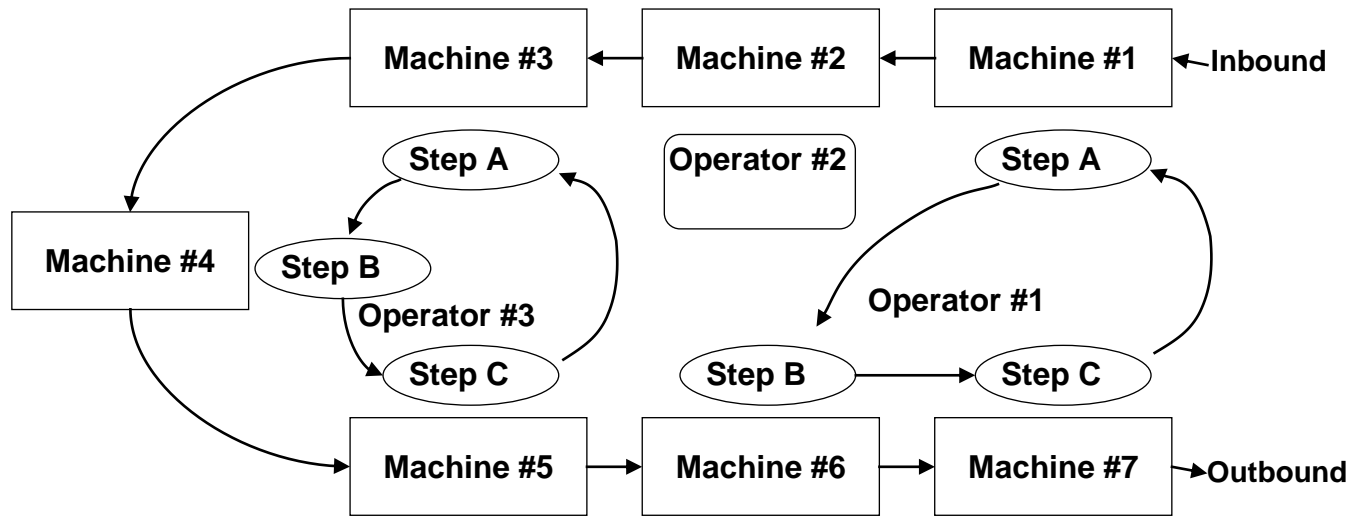
# Understanding Cycle Time

- Cycle time is NOT TAKT time
- Three types
  - Operator Cycle Time
  - Machine Cycle Time
  - Processing Cycle Time



# Operator Cycle Time

- The amount of time required for a single operator to complete one full iteration of his/her work cycle



- If it takes Operator #1 82 seconds to perform operations at Machines #1, #6, #7, and return to Machine #1, then Operator #1 cycle time is 82 seconds.
- If it takes 78 seconds for Operator #2 to perform operations at Machine #2, then Operator #2 cycle time is 78 seconds.
- If it takes Operator #3 90 seconds to perform operations at Machine #3, #4, #5, and return to Machine #3, then Operator #3 cycle time is 90 seconds.

# Determining the Number of Operators Needed

$$\text{Total Operators Required} = \frac{\text{Cumulative Operator Time}}{\text{TAKT time}}$$

From previous example:

Cumulative operator time: Assume TAKT time = 81 seconds

Operator 1 = 82 seconds

Operator 2 = 78 seconds

Operator 3 = 90 seconds

= 250 seconds total

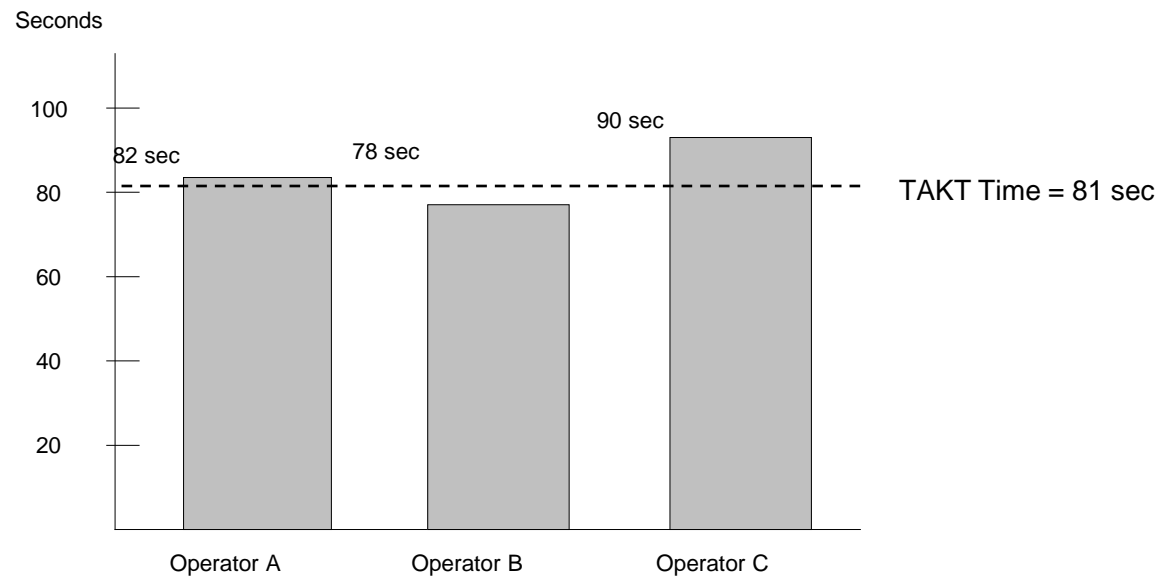
$$\text{Total Operators Required} = \frac{250 \text{ sec}}{81 \text{ sec}} = 3.09$$

## ROT for Partial Operator

| Portion of Operator (fraction) | ROT  |
|--------------------------------|--|
| < 0.25                         | Do not add another operator. Look for waste and/or assign project to reduce time         |
| 0.25 - 0.4                     | Consider adding another operator. First determine if a quick project can resolve timing. |
| > 0.4                          | Add another operator, but look to eliminate with continuous improvement                  |

# Operator Balance (Load) Chart

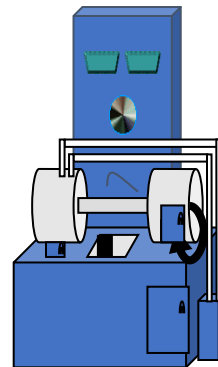
- Comparison of operator cycle time to TAKT time
- Identifies where opportunities exist for improvement
- Identifies problematic areas



**Goal: Want cycle time for every operator to be less than or equal to TAKT time!**

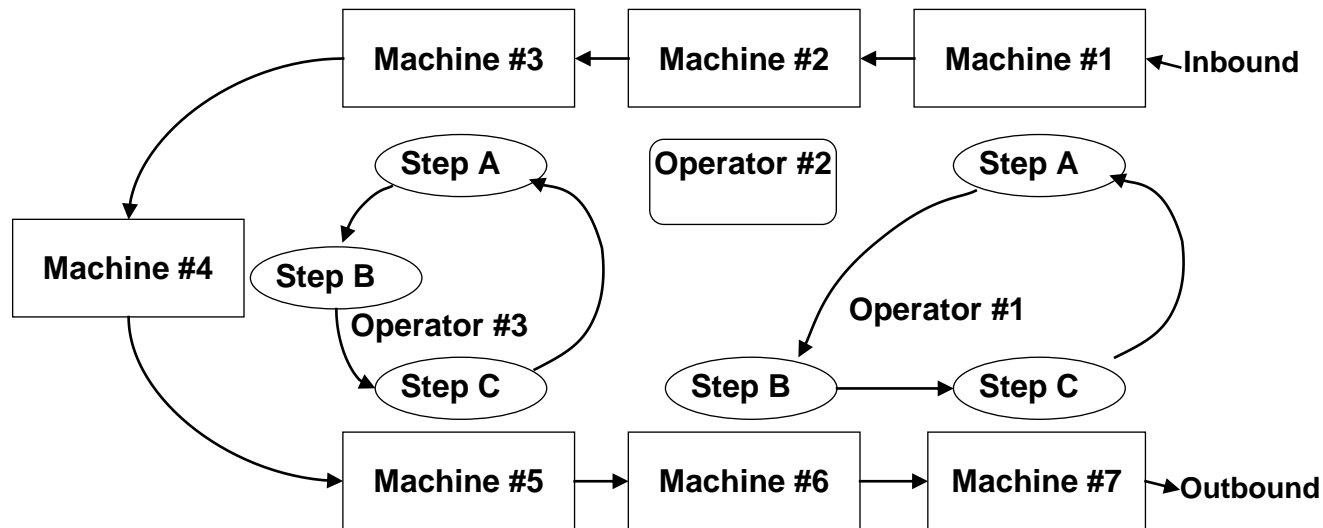
# Machine Cycle Time

- The time required for a machine to complete one full cycle
- Measured from start of cycle to when the part is available, and the machine can accept another part
- The intent is to measure how long the machine needs to cycle a part.
- The time the operator sets up, cleans, or calibrates the machine is not part of machine cycle time.
- Usually, the time required for one cycle has low variability. However, if there is a great deal of variability in the machine cycle time, take the average of seven readings.



# Processing Cycle Time

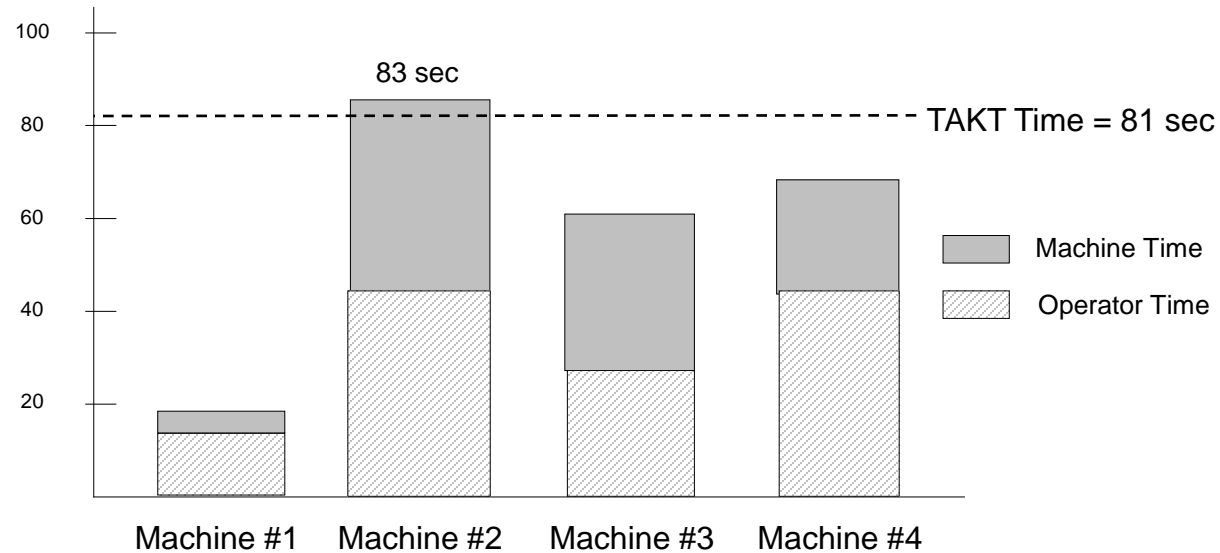
- The machine cycle time plus the time required for the operator to load, unload, start, and perform any tool change time
- A single operator can participate in multiple processing cycle times.



- Example: If it takes Operator #1 10 seconds to unload, load, and start Machine #1 and Machine #1 cycle time is 47 seconds, then the processing cycle time for Machine #1 is 57 seconds.

# Process Capacity Chart

- Comparison of processing cycle time to TAKT time
- Identifies problem areas



- How would you interpret this chart?

$$\text{Actual Capacity} = \frac{\text{TAKT Time}}{\text{Processing Cycle Time}} \cdot \text{Demand}$$

$$= \frac{81}{83} \cdot 200 = 195$$



## Key Takeaways



- As a review, you may want to pause the video at this point and summarize the key learnings from this session, at least from a high-level view. When you are finished, resume the video.



# Key Takeaways

- The main ways in which we can identify waste and variation are brainstorming, cause and effect diagrams, process observation, process maps, data, and discussion with operators.
- The eight classic types of waste (Cost of Waste) are: Defects, Over-production, Waiting, Non-productive assets, Transportation, Inventory, Motion, and Extra-processing. They are part of Internal failure costs.
- TAKT time is not cycle time but can be used along with cycle time to help use resources efficiently.
- There are three kinds of cycle time. Operator cycle time, Machine cycle time, and processing cycle time.
- Value added steps transform raw materials to meet the voice of the customer
- Non-value added steps are waste and should be eliminated if possible or done as efficiently as possible.
- The five categories of Cost of Poor Quality are: Internal failure costs, External failure costs, Lost Opportunity costs, Prevention costs, Appraisal costs.
- Variation in a process exacerbates the other forms of waste in the process.
- Most processes have very little value added time. Most or the time in a process is Non-value added or Non-value added, but required.

# Supplemental Material



- Suggested Reading:
  - ***Lean Six Sigma: A Tools Guide*** by Adams, Kiemele, Pollock and Quan (pp. 81-85, 89-93, 173-176, 235-237)
  - ***Basic Statistics – Tools for Continuous Improvement*** by Kiemele, Schmidt and Berdine, 4<sup>th</sup> edition (pp. 2-8 thru 2-14)
  - ***Knowledge Based Management*** by Kiemele, Pollock and Murrow (pp. 146-149)
- SPC XL™ software training tutorials:
  - <https://airacad.com/our-insights/training-videos/spc-xl/>
- The data files for this session can be downloaded from the site where you are accessing this course. There are no data files for this session.



## Additional Practice / Review Questions



1. TAKT Time Exercise. Calculate daily TAKT time for this process (in seconds)
  - Two 8-hour shifts
  - Shift #1 is given one hour for lunch and 2 15-minute breaks
  - Shift #2 is not given a meal break, but is given 4 15-minute breaks
  - It takes Shift #1 15 minutes to prepare the equipment in the morning for operation. It takes shift #2 30 minutes to shut down and clean up at the end of the shift.
  - Customer demand is 3,000 units per month
  - There are 20 workdays in the current month



The daily TAKT time is:



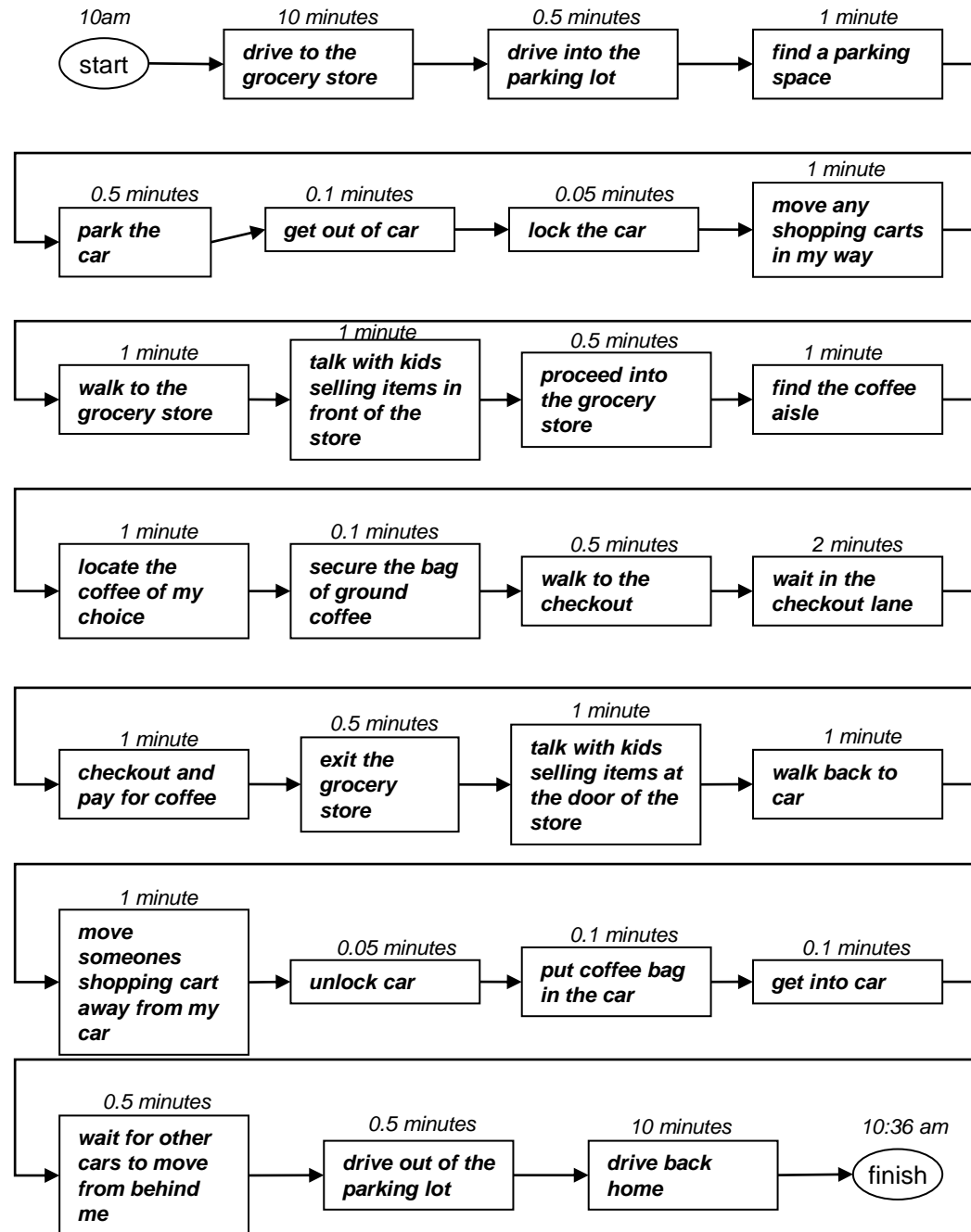


## Additional Practice / Review Questions (cont.)

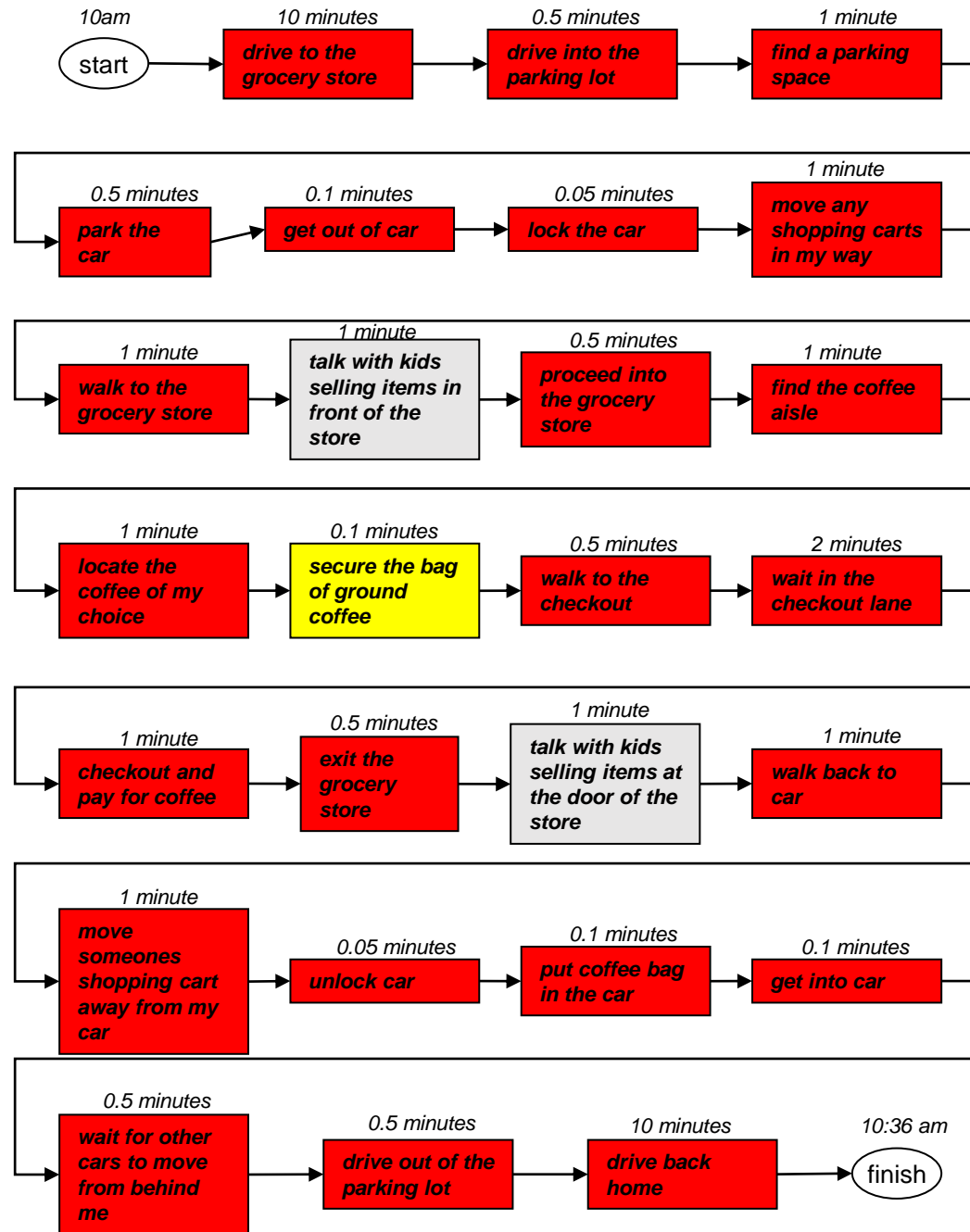


2. Consider the process flow, shown on the next page, which depicts the process of going to the grocery store to pick up a bag of ground coffee.
  - a. Review each step and identify the value added (VA) steps, the non-value added (NVA) steps and the non-value added but required (NVA-R) steps. Hint: There is only one value added activity or step.
  - b. What examples of waste (Cost of Waste or COW) do you observe?
  - c. What extra data might be useful to collect on a process observation sheet?
  - d. Calculate the process cycle efficiency:  $\frac{\text{VA time}}{\text{Total Lead Time}} =$

# Process Flow for procuring ground coffee at the store

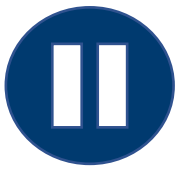


# Process Flow for procuring ground coffee at the store



Value Added  
 NVA – Required  
 NVA

$$\frac{\text{VA time}}{\text{Total Lead Time}} = 0.1/36 = 0.002778$$



## Additional Practice / Review Questions (cont.)



3. Choose a process/product from your workplace. What are some examples of COPQ that are identifiable in this process/product. Try to identify at least two examples from each category of COPQ.

4. What is the main purpose of identifying the TAKT time of a process?



5. How can TAKT time and cycle time(s) be used in a process to determine resource needs and usage?



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