Lean Six Sigma Toolkit
Lean Overview
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Purpose & Agenda

- The purpose of this program is to provide the key concepts and skills for understanding some of the basic tools used in evaluating a process
- Our Agenda
  - Overview of the concepts and tools used to create a lean enterprise

Objectives and Expectations

- By the end of this module, participants should understand:
  - What are the elements of a lean enterprise
  - How Lean supports Key Business Objectives
  - Strategy and Tactics of a Lean Transformation
  - Lean Methods and Tools
Today we are going to focus on the concepts and tools of Lean

Origins of Lean

- Lean has been around a long time:
  - Pioneered by Ford in the early 1900’s (33 hrs from iron ore to finished Model T, almost zero inventory but also zero flexibility!)
  - Perfected by Toyota post WWII (multiple models/colors/options, rapid setups, Kanban, mistake-proofing, almost zero inventory with maximum flexibility!)
- Known by many names:
  - Toyota Production System
  - Just-In-Time
  - Continuous Flow
- Typically based in manufacturing/production, but also highly applicable to transactional projects
- Outwardly focused on being flexible to meet customer demand, inwardly focused on reducing/eliminating the waste and cost in all processes
☐ Using Lean Tools

• The goal of “Lean” focused improvement projects is to increase the speed of a process
  • Controlling and reducing Cycle Time (and cycle time variability), will generate faster feedback cycles on improvement projects - increase process velocity and thus cycles of learning
  • In addition, controlling and reducing cycle time (and cycle time variability) is a key driver to:
    • Facilitating productivity improvements (reduced cost) and capacity improvements (increased revenue)
    • Remember: reducing cycle time shows us “where the rocks are!”
  • Install workplace organization/visual systems
  • Standardize & mistake-proof operations
  • Redesign operations for steady flow
  • Redesign operations from “push” to “pull”
  • Rapid improvement via “Kaizen events”
### Using Lean Tools

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<td>Green Belt Training, Black Belt Training, SOM-6 Champion training</td>
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Key Lean Definitions

- The following definitions are used throughout Lean Six Sigma discussions to describe the speed, efficiency, throughput, and capacity of a process:

  - **Process Cycle Time (PCT):** The time from release of a product into a process until its completion
    - Example: The elapsed time from when a customer calls, to when the ticket is issued averages 3 days

  - **Work-In-Process (WIP):** Product that is within the boundaries of the process
    - Example: There were 3300 reservation applications in process at the end of the month

  - **Exit Rate (Throughput):** The output of a process over a defined period of time
    - Example: Our process closed 500 reservation applications per day last month

  - **Capacity:** The maximum amount of service a process can deliver over a continuous period of time
    - Example: The capacity of our process is 120 reservations per hour

  - **Time Trap:** Any process step that inserts delay time into a process
    - We are concerned with the time trap that injects the MOST delay
    - Example: our quality team evaluate 120 transactions per day, all other process steps can process 145 transactions per day

  - **Constraint:** A time trap that is unable to produce at the exit rate required to meet customer demand (internal or external)
    - Example: our agents can only complete 120 reservations per day, but customer demand is currently 130 reservations per day!
The Basics of Lean

1. Determine the Voice of the Customer (VOC)
2. Identify the Process Value Stream
3. Implement Pull Systems
4. Improve Process Flow
5. Achieve Lean Perfection – Continuous Improvement

Lean Goals
Highest Quality, Lowest Cost, Shortest Time, Maximum Flexibility

1. Determine the Voice of the Customer

- The challenge is to understand how your customers define and prioritize the various needs and expectations they have of your products and services

<table>
<thead>
<tr>
<th>Quality</th>
<th>Product or Service Features, Attributes, Dimensions, Characteristics Relating to the Function of the Product or Service, Reliability, Availability, Taste, Effectiveness - Also Freedom from Defects, Rework or Scrap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>Prices to Consumer (Initial Plus Life Cycle), Repair Costs, Purchase Price, Financing Terms, Depreciation, Residual Value</td>
</tr>
<tr>
<td>Delivery</td>
<td>Lead Times, Delivery Times, Turnaround Times, Setup Times, Cycle Times, Delays</td>
</tr>
<tr>
<td>Service &amp; Safety</td>
<td>Service Requirements, After-Purchase Reliability, Parts Availability, Service, Warranties, Maintainability, Customer-Required Maintenance, Product Liability, Product/Service Safety</td>
</tr>
<tr>
<td>Corporate Responsibility</td>
<td>Ethical Business Conduct, Environmental Impact, Business Risk Management, Regulatory and Legal Compliance</td>
</tr>
</tbody>
</table>
1. Determine the Voice of the Customer

Types of Voices
- Complaints
- Compliments
- Product returns
- Product/service sales preferences
- Contract cancellations
- Market share changes
- Customer defections/acquisitions
- Customer referrals
- Closure rates of sales calls
- What other customer voices could you or do you use in your business

How do our customers communicate to us?

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2. Identify the Value Stream

- Process mapping is a lean technique first used by Toyota

Taichi Ohno’s problem

- Managed a machine shop
- Had a large area of responsibility
- Had an unsatisfied customer
- Could not see non-value add or flow at a glance

The solution

A standard method for flow mapping

Purpose of Process Mapping

- Identify problems and opportunities in the current process
- Develop and communicate what the target end state should look like and how to get there?
Value Stream Mapping

- The value stream is all of the operations/activities that are necessary to bring a specific product through critical business tasks:
  - Problem solving
  - Information management
  - Physical transformation
  - Delivery to customer

- Define Value Add along the Value Stream
  - What adds value to product (function, form, or feature)
  - What destroys value for the business (8 types of waste)

![Value Stream Diagram]

- **Value Add Analysis - Current**
  - Task #
  - Task Time (seconds)
  - CVA Time
  - BVA Time
  - NVA Time
  - Takt Time = 55 sec

- **Customer call time = 24 min**
  - Service lead time = 384 min

- **SUPPLIERS**
  - 2-5 days
  - Manual Update
  - SUPPLIERS

- **CUSTOMER**
  - Phone Call

- **Order Mgmt**
  - Screen for Acct Mgr
  - P/T = 3 min
  - Lost calls=10%
  - Volume=1200

- **SUPPLIERS**
  - Manual Update
  - 2-5 days

- **DEST**
  - Pick Pack & Ship

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Two Stages of Value Stream Mapping

- **Current State**
  - Rigorous, fact based analysis
- **Purpose**
  - Detailed visual description of the current value stream
- **Objectives**
  - Show a holistic view of the entire current system
  - Visualize material and information interactions
  - Highlight non-value add and its sources throughout the system
  - Identify problems and improvement ideas
  - Provide common framework for discussion

- **Future State**
  - Creative design synthesis
- **Purpose**
  - Detailed visual description of a redesigned best practice value stream
- **Objectives**
  - Force best practice in creating a vision of the ideal lean value stream
  - Set baseline for tactical implementation planning by identifying value stream loops
  - Prioritize improvement efforts/actions
  - Assist in quantifying improvement potential
  - Allow target setting (short-mid-long term)
**Example of Key Process Data**

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product variations</td>
<td>Number of distinct types of loans or applications in each process step</td>
</tr>
<tr>
<td>Cycle time (C/T)</td>
<td>Time elapsing between 1 completed loan and the next completed loan (includes wait time)</td>
</tr>
<tr>
<td>Wait time (Wait)</td>
<td>Time spent by the loan in a queue</td>
</tr>
<tr>
<td>Touch time (T/T)</td>
<td>Time spent actually processing the loan (i.e., the time an operator actually touches the loan or file)</td>
</tr>
<tr>
<td>Setup time (S/T)</td>
<td>Time spent prior to beginning process per FTE per shift (e.g., login time)</td>
</tr>
<tr>
<td>Working time (W/T)</td>
<td>Maximum theoretical time per FTE per shift available for each step (minus break, meeting, and clean up) in hours</td>
</tr>
<tr>
<td>Uptime</td>
<td>Actual amount of time available to process loans per FTE per shift (hours)</td>
</tr>
<tr>
<td>Number of FTEs</td>
<td>People available to fully operate a process step per shift</td>
</tr>
<tr>
<td>Number of shifts</td>
<td>Number of shifts per day</td>
</tr>
<tr>
<td>Error rate</td>
<td>Percent of applications or loan packages subject to rework as a result of the selected area</td>
</tr>
<tr>
<td>Inventory/Queue size</td>
<td>Number of applications or loan packages waiting for next process step</td>
</tr>
<tr>
<td>Distance traveled* (D/T)</td>
<td>Distance for manual transfer of paperwork</td>
</tr>
<tr>
<td>Capacity</td>
<td>Maximum number of loans processed per hour per person/machine (e.g., fax or scanner)</td>
</tr>
</tbody>
</table>
Lean Mission Statement

Develop the Ability:
• To understand that waste simply:
  • Raises cost
  • Produces no corresponding benefit
  • Threatens all of our jobs
• To recognize and identify waste
• To have the courage to call it waste
• To have the desire to eliminate waste
• To apply tools/techniques to eliminate waste
• To understand the benefits of eliminating waste
  • External (customer satisfaction, shareholder value)
  • Internal (employee satisfaction, financial improvement)

Lean Focuses on Eliminating the Eight types of Waste or Non-Value Added activities

• Eight Categories of Waste
  1. Overproduction above demand
  2. Waiting for processing, use, work
  3. Transport of products/materials
  4. Over-processing
  5. Inventory
  6. Unnecessary motion
  7. Defective parts/products
  8. Intellectual Waste

The Eight Wastes are inherent in EVERY process – the key is the methodology, tools, and techniques to reduce and eliminate them!
Waste… According to Webster

- Material left over, rejected or thrown away
- Refuse that accumulates about habitations
- Being wild and uninhabited
- To spend money or use property carelessly (syn. squander)

Waste… According to Customers

- Something that consumes resources but adds no value to a product or service
  - Value is defined by the customer
  - “Non-value-added”

The Opposite of Waste: “Value-Added”

- Any activity which changes a product or service in a way that enhances value from a customer’s perspective

“The ability to eliminate waste is developed by giving up the belief that there is ‘no other way’ to perform a given task. It is useless to say, ‘It has to be done that way,’ or ‘This can’t be helped!’

At Toyota, we have found that there is always another way.”

– Study of the Toyota Production System
Why Focus on Waste?

- Because most processes are 95–99% non-value-added, a focus on minimizing waste is the best leverage for an improvement effort

<table>
<thead>
<tr>
<th>NVA</th>
<th>95%</th>
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<tr>
<td>VA</td>
<td>5%</td>
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Overproduction

- Making more than required by next process
- Making earlier than required by next process
- Making faster than required by next process
- Causes of overproduction
  - Just-in-case logic
  - Misuse of automation
  - Long process set-up
  - Unleveled scheduling
  - Unbalanced work load
  - Over engineered
  - Redundant inspections
Waiting Waste

- Idle time created when waiting for processing, use, work...
  - Unbalanced work load
  - Unplanned maintenance
  - Misuses of automation
  - Upstream quality problems
  - Unleveled scheduling
- Examples
  - Signing documents
  - Batch Processing

Transport Waste

- Transporting parts and materials around the facility
  - Poor facility layout
  - On-line approvals
  - E-mail forwarding
- Examples
  - Walking information to post room /Scanning / Legal
  - Handoffs
Over Processing Waste

- Effort that adds no value to the product or service from the customer’s viewpoint
  - Product changes without process changes
  - Just-in-case logic
  - True customer requirements undefined
  - Over processing to accommodate downtime
  - Lack of communications
  - Redundant approvals
  - Extra copies/excessive information

- Examples
  - Duplicate Vetting Processes
  - Producing more than customer demands- Marketing Literature
Inventory Waste

- Any queuing/supply in excess of a single demand flow through the process
  - Excess forms, completed customer applications
  - Excess inventory
  - Protect company from unexpected problems
  - Unleveled scheduling
  - Poor market forecast
  - Unbalanced workloads
  - Unreliable shipment by suppliers
  - Reward system

- Examples
  - Storing items uses valuable floor space
  - Unnecessary stocks of marketing literature/ Brochures
Unnecessary Motion Waste

- Any movement of people or machines that does not add value to the product or service
  - Poor effectiveness of people/machine interface
  - Inconsistent work methods
  - Unfavorable facility or work area/cell layout
  - Poor workplace organization and housekeeping
  - Extra “busy” movements while waiting

Examples
- Check signing process
- Looking for missing files/Information

Defective Parts/Products Waste

- Inspection, rework, repair of materials, parts or products; review, rework/redo of service activities
  - Weak process control
  - Poor quality
  - Incapable processes
  - Product/process design
  - Inadequate education, training, work instructions
  - Customer needs/requirements not understood
    - First call resolution
- Defects cause waste in the form of unnecessary inspection, rework and repair
Human Intellect Waste

- Misuse of skill level
- Lack of training; for the job at hand, job progression, and to provide opportunities for more creative thinking
- Not listening to employees ideas who are involved first hand in the actual work
- Not incorporating front line workers in the process of new product design
- Not acting on employee complaints about legitimate problems and solutions
Example of Waste in your home loan process

1. Prepare for loan request
   Confusing forms, difficult to understand requirements

2. Mail loan
   Mail time

3. Contact customer
   Missing data or signatures

4. Review against Credit Underwriting Standards
   Difficult to understand

5. Conduct needs analysis
   Wrong selections, more data than needed

6. Create new loan application, if needed
   Re-key data various times

7. Review rates and prices
   Waits in in-box while pending multiple approvals

8. Agree on another time with agent/customer
   Missed settlement

9. Issue new loan
   Need to constantly verify details with customer

10. Confirm / re-agree on loan and settlement
    Little confidence in services, ability to deliver

11. Established loan on another system
    Re-key data misses critical details

12. Send bill
    Data not yet correct

13. Review bill
    Difficult to understand

14. Call in with issues
    Problem resolution call

15. Customer experience and trust is impacted by compounded issues at multiple points
    Little confidence in services, ability to deliver
Example Data Collection Sheet

Start time: _____________   End time: _____________
Distance from last queue (if applicable): _____________
Process step: _____________

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<tr>
<th>Activity</th>
<th>Number of FTEs</th>
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<td>2.</td>
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<td>5.</td>
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Touch time (minutes): __________________
Size of batch (no. of applications or reservations): _____________
Product mix in batch (percent): ______________________________
____________________________
____________________________
Distance to next step/queue (feet): _____________
Next queue wait time (minutes): _______________________

3. Implement Pull Systems

- Pull means that real customer demand pulls products through the system
  - Excess Inventory is waste
  - Producing items that are not needed is waste (forecast)
- Part shortages and expediting reduced or eliminated
- Inventory reduced (better mix)
4. Improve Process Flow

- Process Flow is the distance that a product must travel and the time it takes to be completed
- Process flow improvement seeks to eliminate waste due to:
  - Excess motion
  - Transportation
  - Waiting
- By moving resources closer together and eliminating non-value added time, movement, waiting, etc.

- The goal is to reduce handoffs and have the service or information travel as little as possible to minimize the customer wait time
  - Co-Locate Personnel
  - Focused / High Performance Work Area
  - Minimize Handoffs
Process Flow

- Improvement

Definition: Simplifying the process flow by reducing the time needed to complete the service and eliminate opportunity for mistakes (through process simplification and co-location)
Traditional Process Flow (Functional Departments)

Traditional Characteristics:
• Resources arranged in distinct functional departments
• Departments can often be in different buildings, locations or even states
• Employees dedicated to a department and a position/workstation
• Specialized knowledge “These are the screens I use”
• Departments arranged by “space required” over time, no particular flow
• Batch processing
• No visibility to the whole process, nor knowledge of a broader process (very myopic)
• Poor metrics for total process performance
• If metrics even exist, they are at the task level, leading to sub-optimization of whole process
Process Flow Improvement (Co-Location, Case Teams, Cells)

Cell Characteristics:
- Unneeded (non-value-add) steps removed
- Value-added steps simplified
- Resource layout follows ‘whole’ process sequence
- Co-located, cellular layouts (case teams)
- Multi-capable employees (can do multiple jobs) creating a flexible workforce
- One-piece flow processing (pull signals)
- Remove Authorization Barriers
- Processing paced to customer demand rate (Takt Rate)
- Standard operations defined

Simplifying the process flow by reducing the time needed to complete the service and eliminate opportunity for mistakes. This can be done physically (performance improvement) or electronically (breakthrough performance improvement!)
Create Focused Work Space

- Principle 1 – Keep trunk motions to a minimum
- Principle 2 – Use gravity instead of muscle whenever possible
- Principle 3 – Avoid zigzagging motions and quick direction changes
- Principle 4 – Move with steady rhythms
- Principle 5 – Keeps materials/supplies close and in front
- Principle 6 – Arrange material and tools in order of use
- Principle 7 – Work at the proper ergonomic height
- Principle 8 – Locate materials so they are easy to lift
- Principle 9 – Place keyboards at correct height and use ergo-typing aids

Process Flow Improvement in Transactional Processes (Example)

Before

After

Enablers of the Process Improvement
- Collocation of Necessary (cross-functional) Skill Sets
- 34” Walls Eliminate Transportation of Information
- Management Layers Decreased from 8 to 3
- Easily Identifiable Process Owners
- Central Tables Facilitate Rapid Learning Cycles

Benefits
- 50-90% Reduction in the Order Fulfillment Cycle Time
- Immediate, Informal Cross-Training
- Better Morale & Teamwork
- Faster, Seamless Flow of Information
- Rapid Response Problem Solving
- Single Point of Contact for Customer
Other Improvement Examples

- Simplification / Elimination of forms
- Eliminate multiple entry of same data
  - I.e., only enter account number one time, carries through to all account fields
- Drop down lists to eliminate errors
- Single key/field entry to other screens: do not need to back out of long tree
  - How to quickly get back to page 4 when on page 10?
- Work all jobs FIFO, or work small/easy jobs first?
- Set aside capacity for certain customers?
  - 10 item or less check-out counters
  - Doctor sees patients Mon, Tue, performs surgery Wed, Thur

5. Achieve Lean Perfection

Lean Definition:

“A manufacturing strategy that uses less of everything compared with traditional manufacturing: half the human effort, half the space, half the investment in tools, half the engineering hours to develop a new product. Also, it requires keeping far less than half the needed inventory on site, results in many fewer defects and produces a greater and ever growing variety of products.”

“The goal of lean manufacturing is **perfection**: continually declining cost, zero defects, zero inventories, and **endless product variety**.”

– The Machine That Changed the World
5. Achieve Lean Perfection

- Identify all opportunities for continuous improvement
  - Reduction of effort
  - Reduction of time
  - Reduction of space
  - Reduction of cost
  - Reduction of mistakes
  - Increasing customer satisfaction
- Improve the process through a variety of Lean tools/techniques:
  - Value Stream Mapping
  - Time Trap Identification
  - Heijunka/Leveling/Stability (S&OP)
  - Kaizen/Continuous Improvement
  - Kaikaku/Innovation
  - Jidoka/Automation
  - Kanban/Just In Time
  - 5S Organization
  - Stocking Strategy
  - Generic & Replenishment Pull Systems
  - Visual Tools, Visual Processes
  - Cellular Layouts & Line Balancing
  - Standardized Work
  - Total Productive Maintenance (TPM)
  - Make vs. Buy, Distribution Mgmt,
  - Strategic Sourcing, Tactical Purchasing
5. Achieve Lean Perfection

- Faster feedback on process performance (increased learning cycles)
- Improved first pass yield (results in improved productivity)
- Improved process stability (results in improved throughput)
- Uncovers process deficiencies (forces problem resolution)
- Less in-process and buffer inventories (reduced risk)
- Improved customer satisfaction (flexibility and responsiveness)

Traditional Processes: Lots of Stuff in Process = Long Cycle Times

Old Process
- Long Cycle Time
- Low Flexibility

Lean Improvements
- Cycle Time
- Flexibility

New Process
- Short Cycle Time
- High Flexibility
Lean Processes: Time Trap Resolution Reduces WIP & PCT

The Value of Cycle Time: What Is Our Goal?
• The goal of Lean Improvement projects is to increase the speed of a process
  • Controlling and reducing Cycle Time (and cycle time variability), will generate faster feedback cycles on improvement projects - increase process velocity and thus cycles of learning
  • In addition, controlling and reducing cycle time (and cycle time variability) is a key driver to:
    • Facilitating productivity improvements (reduced cost) and capacity improvements (increased revenue)
    • Remember: reducing cycle time shows us “where the rocks are!”

The New

The Old
Little’s Law

- Little’s Law describes the relationship between WIP, PCT, and Throughput:
  \[ \text{PCT} = \frac{\text{WIP}}{\text{EXIT RATE}} \]

- This is the most fundamental relationship for any process –
  - The “F = MA” (Force = Mass x Acceleration – accepted law of physics) for processes
  - Used to size number of people, paperwork, projects – any process!
  - Lower Process Cycle Time = More “Learning Cycles” (Learning Cycle = number of instances to learn about the process)

Cycle Time = WIP / Exit Rate: “Disney Land…”

- Think about the lines at Disneyland in March...

  Cycle Time = \( \frac{\text{WIP}}{\text{Exit Rate}} = \frac{5 \text{ people}}{1 \text{ person/minute}} \)

  Cycle Time = 5 minutes

- ...and then think about them in July...

  Cycle Time = \( \frac{\text{WIP}}{\text{Exit Rate}} = \frac{13 \text{ people}}{1 \text{ person/minute}} \)

  Cycle Time = 13 minutes

- ...Conclusion: Fixed Capacity (Exit Rate) + Increased People (WIP) = Slower Cycle Times (PCT)!
Process Cycle Efficiency (PCE)

- PCE is a measure of the relative efficiency in a process - it represents the percentage of value add time (changing form, fit, function) of a product down the critical path

- It is calculated using:

\[
\text{Process Cycle Efficiency} = \frac{\text{Customer Value Add Time}}{\text{Process Cycle Time}}
\]

- PCE is the performance indicator of how efficiently the process is converting work-in-process into exits

<table>
<thead>
<tr>
<th>Application</th>
<th>Low-End PCE Goal</th>
<th>High-End PCE Goal (World-Class PCE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creative/Cognitive Processes</td>
<td>5%</td>
<td>25%</td>
</tr>
<tr>
<td>Transactional Processes</td>
<td>10%</td>
<td>50%</td>
</tr>
<tr>
<td>Batch Transfer Assembly</td>
<td>15%</td>
<td>35%</td>
</tr>
<tr>
<td>Continuous/One Piece Flow Assembly</td>
<td>30%</td>
<td>80%</td>
</tr>
</tbody>
</table>

* Based on data from over 100 companies

**Rules of Thumb:**

- If current PCE is << Low End Target, multiply current PCE by 10 (one order of magnitude improvement) for use as Target to be conservative
- If current PCE is < Low End Target, use Low End as Target PCE
- If current PCE ≅ or > Low End Target, use High End as Target PCE
Calculating PCE Example:

What is the Process Cycle Efficiency for the process below?

PCT = 5 days

Exit Rate = 20 Units/Day

WIP = Sum of All Work Within Physical Work Area = 100 Units

Our Example PCE is:

PCE = CVA Time / PCT

PCE = 1.5 hrs / 5 days

PCE = 4.0% (assume 7.5 hrs/day)

PCT and PCE

Recall that:

- **Work-In-Process (WIP)** = “Things in Process” – Customer Orders, People In Queue, Documents, etc.
- **Exit Rate** = The output of a process, expressed in units/time (equal to the rate of the time trap (constraint) operation)
- **Process Cycle Time (PCT)** = the time from release of a product into a process until it is completed
- **Customer Value Add Time (CVA Time)** = the amount of time that value is actually being added to a product (the time that the customer is willing to pay for)
Identifying the Bottleneck and/or Constraint

What Is a Time Trap?

- A time trap limits the output of the process and therefore has less capacity than the prior or following steps
  - It limits throughput
- A time trap can change over time (monthly, weekly, even daily) based upon “service” mixes or special causes (new service introductions, special orders/requests)
- A time trap can be caused by physical problems (such as process flow, personnel availability, mistakes, etc.)
- A time trap can also be caused by non-physical problems (such as procedures, morale, unsafe environment, or training)
- There is ALWAYS a time trap in a process!
- A **constraint** is a time trap that cannot meet customer demand (a constraint is ALWAYS a time trap, but a time trap may not be a constraint!)
Time Traps: Cycle Time ≠ Capacity

- The Time Trap determines the Capacity of the process, however, Capacity does not have a direct (one-to-one) relation to Cycle Time:
  - Process Cycle Time = WIP / Exit Rate ≠ Capacity: A reduction in cycle time does not directly yield an increase in capacity (i.e., exit rate)
  - An increase in capacity is obtained by decreasing the process (“touch”) time of the time trap

![Diagram of Time Traps]

Present State
Assumes Work = 6 units (papers)
Time Trap = 10 seconds
Capacity = 6 units/minute (1 unit every 10 seconds)
PCT = 6 units / 6 units per min = 1 minute

WIP Reduction
Assumes Work = 3 units
Time Trap = 10 seconds
Capacity = 6 units/min (no improvement)
PCT = 3 units / 6 units per min = 30 seconds
(50% decrease)

Capacity Increase
Assumes Work = 3 units
Time Trap = 7 seconds
Capacity = 8.5 units/min (1 unit every 7 seconds)
PCT = 3 units / 8.5 units per min = 21 sec

Cycle Time Effect on Capacity
- Cycle time can indirectly influence throughput (and thus capacity) by:
  - Increasing productivity:
    - Less search, moving, working around work in process
  - Decrease rework & lost work:
    - Catch mistakes quicker
    - Discover lost work faster
How Are Time Traps Created?

- Poor process flow
- Lack of service/information
- Movement of service/information
- Handoffs
- Setups
- Quality issues/rework
- Resource uptime (computers, networks)
- Variability
- Process complexity
- Stress
- Absenteeism/turnover/training

Takt Rate Analysis

- **Time Trap Identification** – the process (or process step) that injects the most amount of delay into the process is the time trap
- Takt Rate Analysis compares the task time of each process (or process step) to:
  - Each other to determine the time trap
  - Customer demand to determine if the time trap is the constraint

\[
\text{Takt Rate} = \frac{\text{Customer Demand Rate}}{\text{Net Process Time Available}} = \frac{\text{Number of Units to Process}}{\text{Net Process Time Available}}
\]

\[
\text{Takt Time} = \frac{\text{Net Process Time Available}}{\text{Number of Units to Process}}
\]

**Example:** Traveler demand for reservations is 24,000 tickets per month. The net process time available is 30 days per month. The Takt Rate is: 24,000 tickets / 30 days per month = 800 tickets/day
**Takt Rate Time Trap Identification**

- TAKT is one of 3 founding blocks of the *just-in-time* philosophy
- In a continuous flow environment, TAKT is used to balance the cell/line so that inventory is minimized

---

**Example:** Calculating TAKT in a single product, multi-step operation

**Customer demand:** 642 units per shift

**Total shift time:** 8.5 hours (510 minutes)

**Total time available:** 510 minutes - 50 minutes = 460 minutes

![Lunch time](image)

\[
\text{TAKT time} = \frac{460 \text{ minutes} \times 60 \text{ seconds}}{642 \text{ units}} = 43 \text{ seconds}
\]
Using Takt Time to Balance the Line

**Current process**

<table>
<thead>
<tr>
<th>FTEs</th>
<th>Processing time/file</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key data</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>Underwrite</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>Check compliance</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>Book/fund</td>
<td>70</td>
<td>60</td>
</tr>
</tbody>
</table>

**TAKT time calculation**

- Time available = 480 minutes (8 hours)
- Customer reward = 600 files/day

\[
\text{TAKT time} = \frac{480}{600} = 0.8 \text{ minutes}
\]

**Balance line using TAKT time**

<table>
<thead>
<tr>
<th>Processing time/file</th>
<th>FTEs</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key data</td>
<td>20</td>
<td>25.0</td>
</tr>
<tr>
<td>Underwrite</td>
<td>30</td>
<td>37.5</td>
</tr>
<tr>
<td>Check compliance</td>
<td>40</td>
<td>50.0</td>
</tr>
<tr>
<td>Book/fund</td>
<td>60</td>
<td>75.0</td>
</tr>
</tbody>
</table>

I need 1 file every 0.8 minutes, therefore I need 25 people to work on a 20-minute processing job.

Line is balanced.
Takt - Instructions for use to gather relevant data

- For each step, the required input is:

  - Working time
  - Breaks, lunch

  - Number of new files received
  - Volume of automatic resolution
  - Volume of rework
  - Tasks splits and/or duplications within each case
  - Mix of simple vs complex cases

![Available processing time](Hours/day)

![Daily demand](Files/day)

TAKT time

- Hours/file

TAKT time is the central piece to calculate opportunity, as it establishes the rhythm on which each station must work, based on time availability and customer demand requirements.
Exercise – FTE Requirements using Takt Time

Data:
Customer demand: 960 files/day
Working time (8 hrs): 480 minutes/day

<table>
<thead>
<tr>
<th>Current process</th>
<th>Process Step 1</th>
<th>Process Step 2</th>
<th>Process Step 3</th>
<th>Total FTEs</th>
</tr>
</thead>
<tbody>
<tr>
<td>FTEs</td>
<td>80</td>
<td>50</td>
<td>45</td>
<td>175</td>
</tr>
<tr>
<td>Processing time (mins)</td>
<td>30</td>
<td>30</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Documents per day</td>
<td>1,280</td>
<td>800</td>
<td>1,080</td>
<td></td>
</tr>
</tbody>
</table>

Balance process

TAKT time

FTEs needed by TAKT time

Documents per day

TAKT Time = \[
\frac{\text{Total Available Production Time}}{\text{Total Customer Demand}}
\]

Equals total window of processing time available
Do not subtract unscheduled (changeovers, staffing availability, equipment, meetings)
### Exercise – FTE Requirements using Takt Time—Solution

**Data:**
- Customer demand: 960 files/day
- Working time (8 hrs): 480 minutes/day

<table>
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<td>1,280</td>
<td>800</td>
<td>1,080</td>
<td></td>
</tr>
</tbody>
</table>

**Balance process**

<table>
<thead>
<tr>
<th>TAKT time</th>
<th>0.5</th>
<th>0.5</th>
<th>0.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>FTEs needed by TAKT time</td>
<td>60</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>Documents per day</td>
<td>960</td>
<td>960</td>
<td>960</td>
</tr>
</tbody>
</table>

Takt time = \( \frac{480 \text{ min/day}}{960 \text{ files/day}} \) = 0.5

FTE = \( \frac{\text{Process time/file}}{\text{Takt time}} \)
Integration of Lean and Six Sigma

- Lean and Six Sigma can co-exist independently, but the benefits of integration are tremendous...
  - Single channel for employing limited resources
  - One improvement strategy for the organization
  - Highly productive and profitable synergy
- The pitfalls of not integrating them are formidable
  - Six Sigma does not always teach speed tools and therefore does not always attack manufacturing overhead cost and invested capital directly using available best practices
  - Lean lacks defined cultural infrastructure - without CEO engagement, deployment organization (Champions and Black Belts), and focus on customer many lean implementations fail
  - Lean lacks the consistency of the DMAIC philosophy, leading to wide variation in application of tools & techniques
  - Most lean efforts lack focus on variation elimination and simply “account for” the variability by carrying excess inventory and resources
  - Lean Tools do not intrinsically focus on bringing a process under control
- The result
  - Divided focus of the organization
  - Separate and unequal messages for improvement
  - Destructive competition for resources and projects
DMAIC Methodology and Lean

- Six Sigma is grounded in the DMAIC philosophy (Define Measure Analyze Improve Control)

- Lean Tools principally apply during:
  - Measure Phase:
    - Value Stream Mapping, Time Trap Analysis, etc.
  - Improve Phase:
    - Pull Systems, Operational Improvements, Work-Cells, etc.
  - Control Phase:
    - Visual Control Tools, Mistake Proofing, etc.

- A “mini-DMAIC” can be applied within each DMAIC phase tool to Define problem, Measure data, etc. via Kaizen!
SEVERAL LEAN AND SIX SIGMA TOOLS CAN BE APPLIED TO IMPROVE OPERATIONAL PERFORMANCE
Takeaways

• There are a variety of techniques and tools to use when attacking a process improvement project, but the DMAIC framework remains intact

• There is a definite path and decision checklist to process improvement, to help in understanding which process improvement tool to apply, and when
  • If the current process capacity is unable to meet customer demand, then the constraint operation must be identified and eliminated as a capacity constraint
  • If the process is simply unbalanced (different workloads for different steps), then it needs to be balanced

• Understand the difference between time traps and constraints and their effect on capacity

• Be able to identify time traps and constraints using takt rate analysis

• “Process Balancing” is a procedure whereby a set of process steps are “equalized” in terms of time required to accomplish them (note “effort” may not be the same!)

• Process balancing tools are used where the process is contained in a defined area
  • Examples include:
    • Order Entry Department
    • Reservation Process

• Key tools used in process balancing are the time study and takt time chart, but other tools such as skill matrix, etc., may play a significant role in the analysis

• The Process Balancing techniques are not exclusive to “one-piece flow” – small batches may be necessary between certain steps – but use of the process balancing tools is meant to drive the process to one-piece flow
Lean Enterprise

- Uses *time* and the “relentless pursuit of *waste elimination*” as competitive levers.
- Seeks to make *value flow* from the very first step of the process through to consumption of the service.
  - Using least amount of resources (time, people, materials, etc.)
- Creates a *culture* of never-ending *improvement* at all organization levels.

- Uses time and the relentless pursuit of waste elimination as competitive leverage.

  Waste: Any activity which absorbs resources but does not create *value*.

  Does the activity improve the product or service from the viewpoint of the customer? If not—it’s waste.

Principle #1: The customer defines value.

- Seeks to make *value flow* from the very first step of the process through to consumption of the service *using the least amount of resources*.

  Identify Value Streams (flows of service activity).

  No excess inventory or customer waiting
  - consumes resources, stifles flow, creates customer dissatisfaction.

Principle #2: Make value flow - “along streams”

Principle #3: Provide services to customer demand.
Lean Enterprise

- Creates a *culture of never ending improvement* at all organizational levels

  - Requires an environment where it is safe to experiment & “fail”
  - Teamwork is part of cultural fabric
  - Cannot tolerate status quo

Principle # 4: Continuous Improvement
Transactional Cycle Time Simulation

“Alphabet Soup”

A — B — C
Learning Objectives

- Demonstrate the fundamental relationship between WIP, Cycle Time, and Exit Rate
- Demonstrate the impact of increasing WIP on a process performance

What’s in it for Me?

- When performing process improvements, be able to understand the fundamental drivers of a project to improve cycle time and a project to improve throughput rate
- Understand how WIP drives process inefficiencies

Cycle Time Exercise

- Divide into teams of 5 people
- Arrange seats in an assembly line process
- Assign roles (Departments 1 through 5)
Job Responsibilities

- **Department 1**
  - At pre-defined intervals….
    - Record release time in upper right hand corner of document
    - Release document to Department 2

- **Department 2**
  - Legibly write the entire alphabet in capital letters

- **Department 3**
  - Draw circles around each letter - must be round and not overlap
  - Connect each circle with a straight line

- **Department 4**
  - Put an “X” through every other circle, beginning with “A” and ending with “M”

- **Department 5**
  - Put an “X” through every other circle, beginning with “O”
  - Record completion time in bottom right hand corner of document
  - Calculated total elapsed time for each document (seconds)

Work the documents in the order you receive them!

Example

```
A B C D E F
G H I J K L M
N O P Q R S T U V W X
Y Z

18:25 (min/sec)
```

```
A B C D E F
G H I J K L M
N O P Q R S T U V W X
Y Z

19:31
```
Exercise – Part 1a
• Pilot the process – run one document through the process

Exercise – Part 1b
• Run another document through the process
  • The first one was practice
  • This one is real

Exercise – Part 1b Results
• What was the cycle time?

<table>
<thead>
<tr>
<th></th>
<th>Team 1</th>
<th>Team 2</th>
<th>Team 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output</td>
<td>Cycle Time</td>
<td>Cycle Time</td>
<td>Cycle Time</td>
</tr>
</tbody>
</table>

Part 1

Part 2
Exercise – Part 2

• Run one document every 10 seconds through the process
• Begin with 1 document of WIP at each of Departments 2-5
• Run for 240 seconds

Exercise – Part 2 Results

• How many did we get out?
• What was the cycle time for each document?
• Do you notice a trend? Why?
• How do we get a predictable cycle time?

Exercise – Part 3

• Run one document every 30 seconds through the process
• Begin with 1 document of WIP at each of Departments 2-5
• Run for 240 seconds

Exercise – Part 3 Results

• How many did we get out?
• What was the cycle time for each document?
• Is the trend the same as Part 2 of the exercise?
• Was each Department fully utilized?
• What happens if we balance the workload throughout the process?
Exercise – Part 4

- Department 3 now only draws circles around each letter
- Department 4 connects each circle with a straight line
- Department 5 puts an “X” through every other circle (from A to Z)
- Run one document every 15 seconds through the process
- Begin with 1 document of WIP at each of Departments 2-5
- Run for 240 seconds

Exercise – Part 4 Results

- How many did we get out?
- What was the cycle time for each document?
- Observations?
- How do we reduce cycle time?
☐ Takeaways

• Cycle time is related to WIP and exit rate by Little’s Law:

  Process Cycle Time = WIP / Exit Rate

• As WIP increases, cycle time increases, but Exit Rate is unaffected
• Exit Rate is controlled by the bottleneck operation
• Exit Rate can be improved by reducing the processing time at the bottleneck workstation
• Cycle time can be improved by reducing WIP or reducing the processing time at the bottleneck workstation