16.660 / 16.853 / ESD.62J Introduction to Lean Six Sigma Methods
January (IAP) 2008

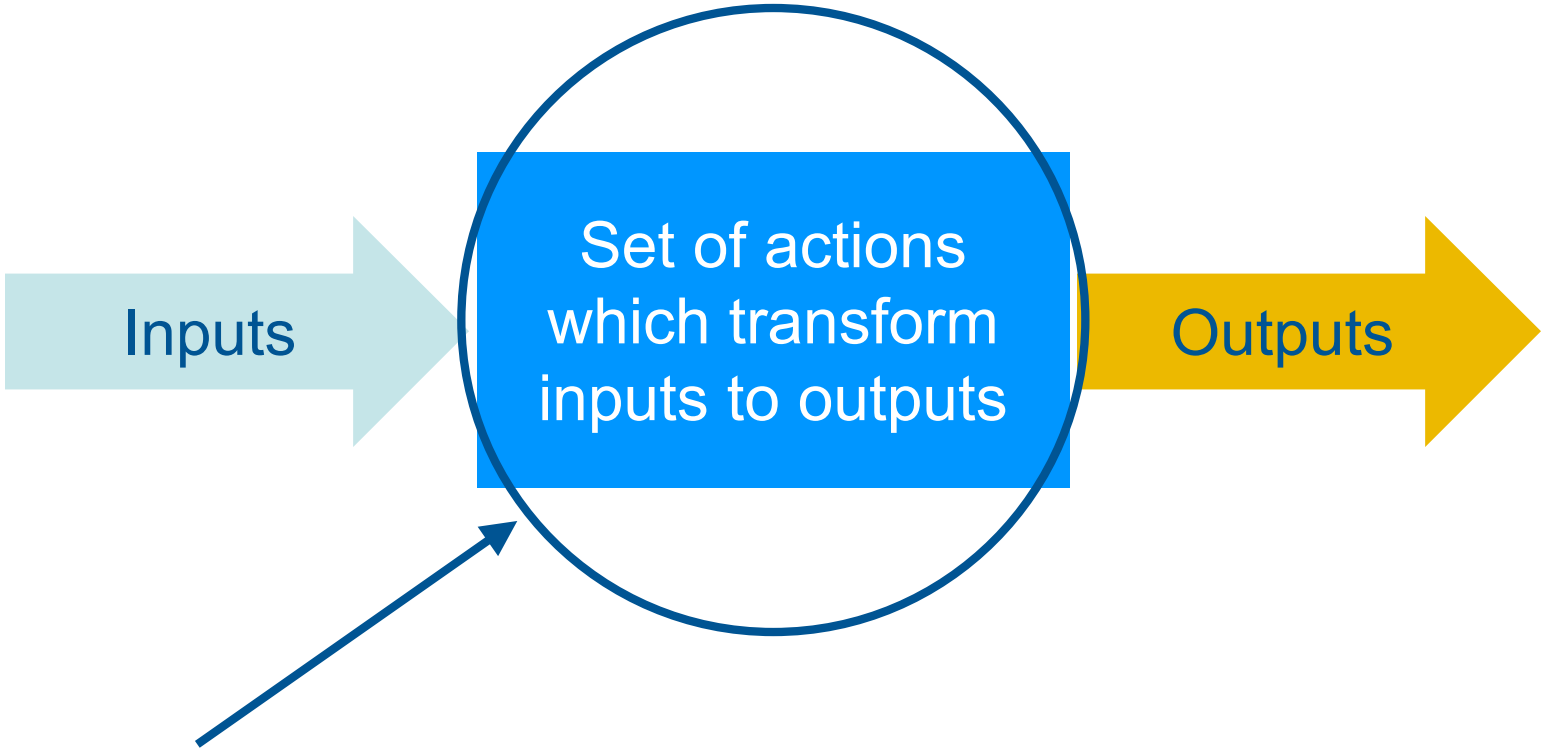
Lean Thinking

Learning Objectives

At the end of this module, you will be able to:

- Describe the elements of a process
- Draw a process map
- Explain what constitutes value in a process
- List the five fundamental lean principles
- Give a description several concepts and tools for implementing lean principles

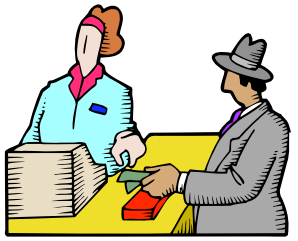
What is a Process?



Process: **A series of actions, changes, or functions bringing about a result**

Ref: http://www.dictionary.com, Jan. 8, 2003

Identify the Customer

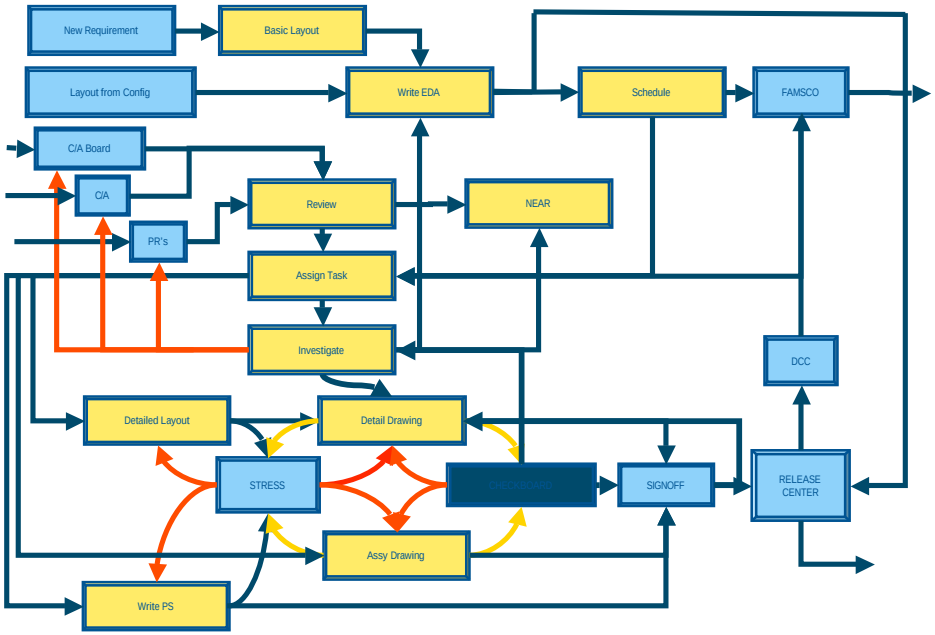


- What happens to the outputs of a process?

They go to a CUSTOMER!

- External customers - are outside an organization, money is typically exchanged with external customers
  - End users are customers who pay for an operational or consumable product or service
- Internal customers - are inside an organization, money is typically not exchanged directly with internal customers
- Customers also drive the inputs to a process through their needs and requirements

Process Maps

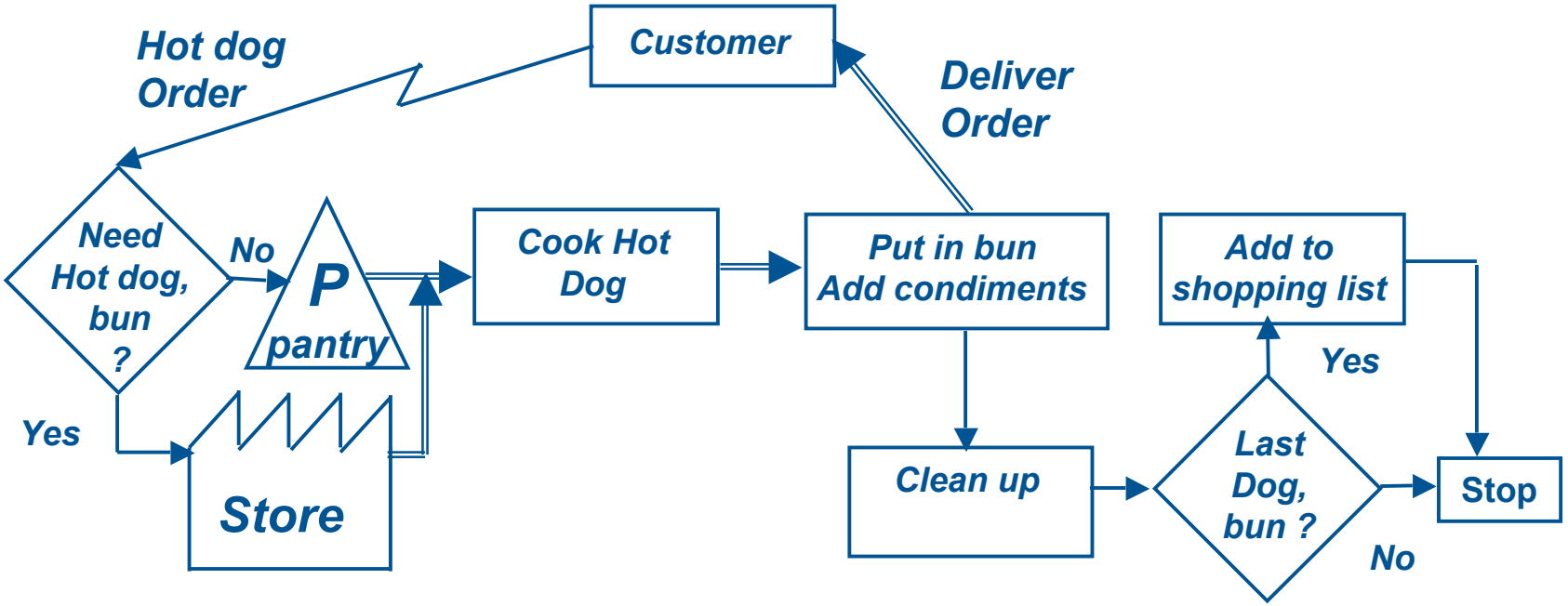


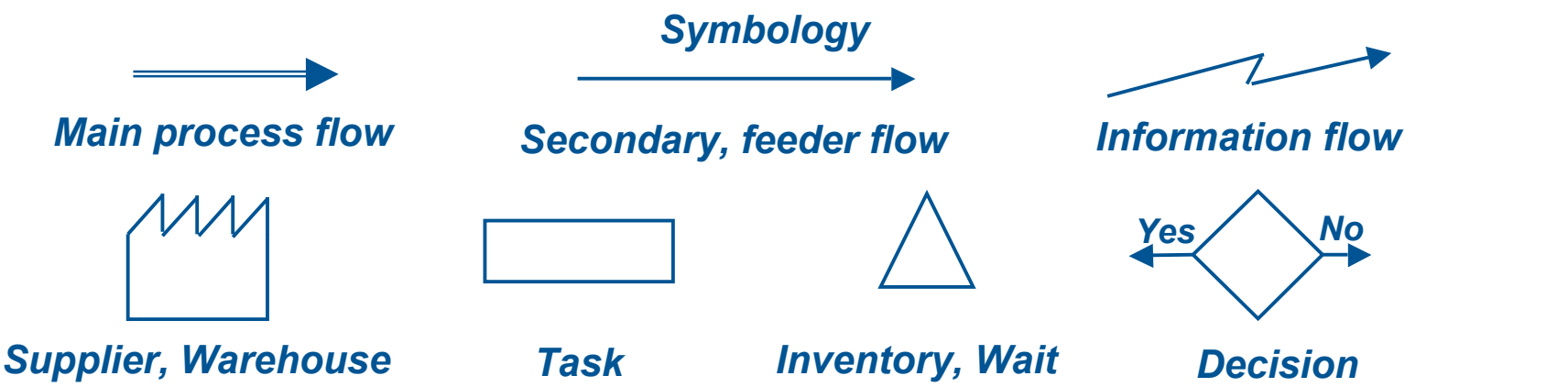
Process map for pre lean engineering drawing release

Courtesy of Lockheed Martin. Used with permission.
Source: "Lean PD Efforts for F-22", LAI Product Development Winter Workshop, January 27, 2000.

- **Only understood processes can be improved**
- **Understanding a process is easier when it can be visualized**
- **A Process Map is an organized visualization of all the interrelated activities which combine to form a process**

Process Map For Fixing a Hot Dog





Hot Dog Stand Process Map

Sasha

Andy

- With your team, develop a process map for S&A Hot Dogs
  - Use post-it notes for processes elements
  - Put post-its on easel chart or white board
  - Draw lines for process & information flow
  - Don’t get hung up on symbology
- Identify inputs, outputs & boundary of the process
- In 15 minutes, be prepared to explain your process map to the class

Process Wrap Up

- Processes underlay everything we do
- The fundamentals of lean thinking provide the foundation to modern process improvement
- Understanding and improving processes is the key to improving productivity

Five Lean Thinking Fundamentals

- Specify *value*: Value is defined by customer in terms of specific products and services
- Identify the *value stream*: Map out all end-to-end linked actions, processes and functions necessary for transforming inputs to outputs to identify and eliminate waste
- Make value *flow* continuously: Having eliminated waste, make remaining value-creating steps "flow"
- Let customers *pull* value: Customer's "pull" cascades all the way back to the lowest level supplier, enabling just-in-time production
- Pursue *perfection*: Pursue continuous process of improvement striving for perfection

Ref: James Womack and Daniel T. Jones, Lean Thinking (New York: Simon & Schuster, 1996).

Value Added and Non Value Added

Value Added Activity

- Transforms or shapes material or information or people
- And it's done right the first time
- And the customer wants it

Non-Value Added Activity – Necessary Waste

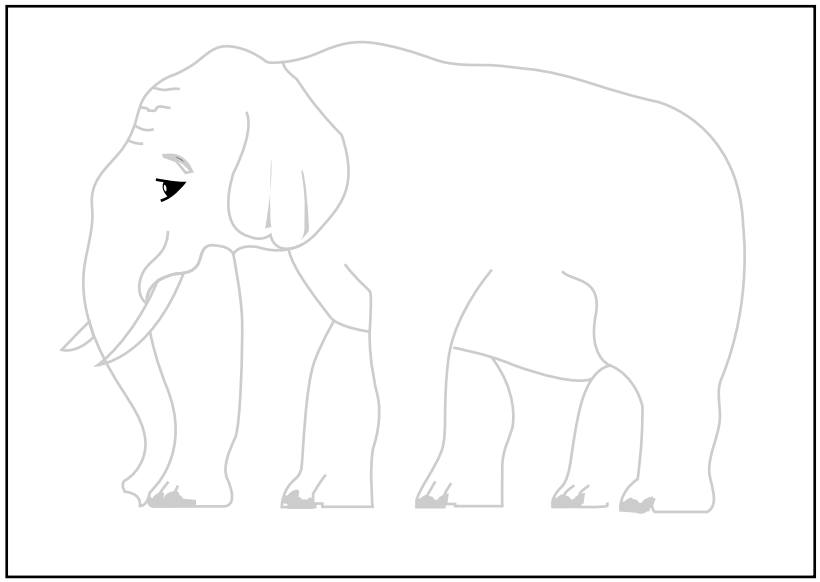
- No value is created, but cannot be eliminated based on current technology, policy, or thinking
- Examples: project coordination, regulatory, company mandate, law

Non-Value Added Activity - Pure Waste

- Consumes resources, but creates no value in the eyes of the customer
- Examples: idle/wait time, inventory, rework, excess checkoffs

Inspection: An Example of Waste

Can you see any mistakes?



Figures by MIT OpenCourseWare.

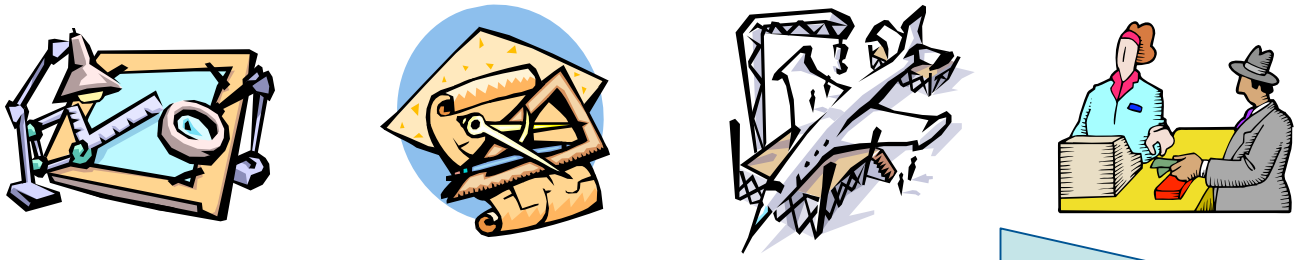
Inspection is not a good way to prevent or eliminate mistakes!

What is a Value Stream?

Value | **Value Stream** | Flow | Pull | Perfection

- **A value stream is…**
  - **ALL activities that create value**
  - **Starts with raw materials or initial information**
  - **Ends with the end customer/user**

Customer needs/reqts., Schedules



Material or information or people

product or service valued by the customer

What Moves In a Value Stream?

Value | **Value Stream** | Flow | Pull | Perfection

In manufacturing… material flows

In design & services…information flows

In human services…people flow

Seven Types of Waste

1. Over-production	Creating too much material or information
2. Inventory	Having more material or information than you need
3. Transportation	Moving material or information
4. Unnecessary Movement	Moving people to access or process material or information
5. Waiting	Waiting for material or information, or material or information waiting to be processed
6. Defective Outputs	Errors or mistakes causing the effort to be redone to correct the problem
7. Over-processing	Processing more than necessary to produce the desired output

Making Value Flow

Value | Value Stream | **Flow** | Pull | Perfection

Flow requires:

- Understanding of time
- Process control
- Eliminating bottlenecks and stoppages
- Eliminating unplanned rework

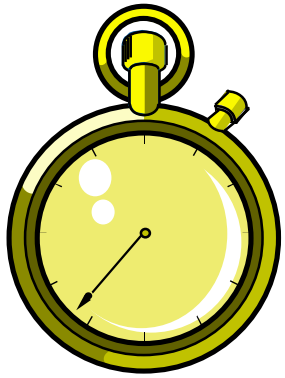
Creating flow:

- Focus on the product or service that is flowing through the process
- Don’t be limited by organizational or functional boundaries

Time

Value | Value Stream | **Flow** | Pull | Perfection

- **Time is an essential metric for lean improvement**
- **There are different ways to measure time**
  - **Wait time**
  - **Processing time**
  - **Cycle time**
  - **Customer Demand or Lead time**

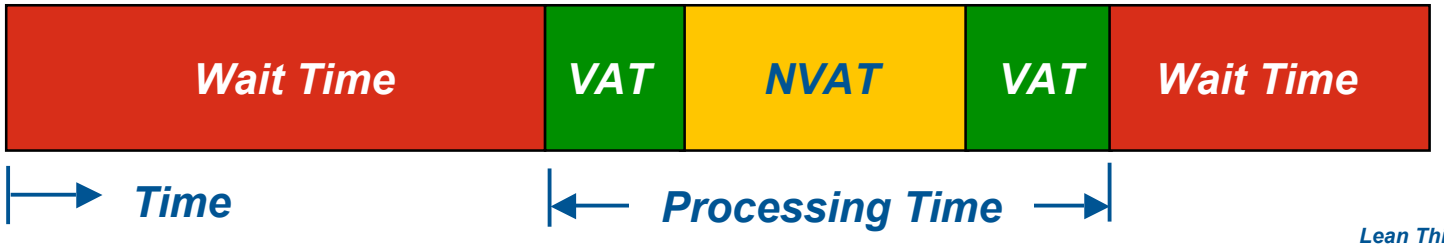


- **The key is to understand the local definition of how time is measured**

Wait and Process Time

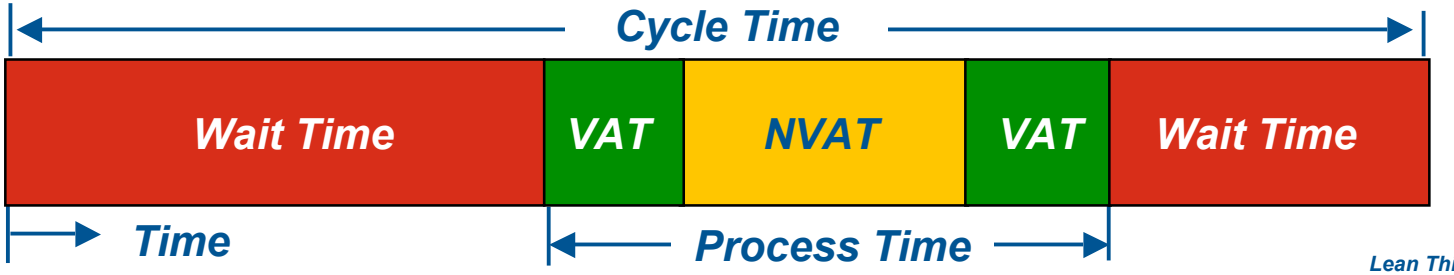
- **Wait time**
  - Time Work in Process (WIP) is idle - in queues, buffers or storage
  - Other Names: Queue Time, Delay Time

- **Processing time**
  - Time that activities are being performed on WIP
  - Processing time may consist of Value Added Time (VAT) and Non Valued Added Time (NVAT) activities.
  - Other names: Touch time (TT), In Process Time (IPT), Response Time (RT)



Cycle Time

- The time required to execute activities in a process
- It can be measured for:
  - A single task or activity
  - A group of tasks or activities
  - A single process
  - A group of processes, e.g., customer order to customer delivery
- Cycle time includes processing time and wait time
- Other names: Lead time or span time or throughput time



Hot Dog Stand Times

Sasha

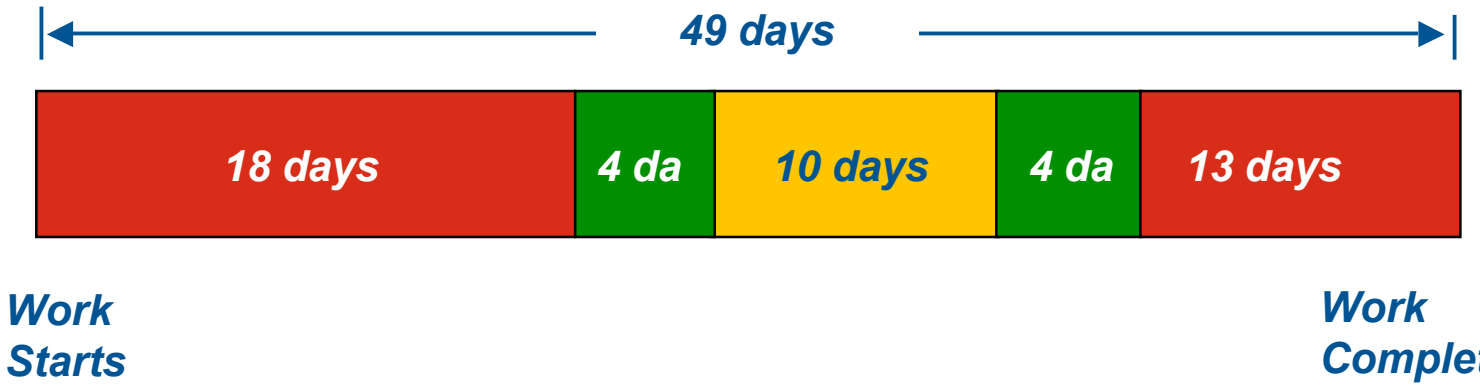
Andy

- Calculate the time in seconds for the 11 process steps and the total cycle time.
  - Note: make sure to convert everything to time per order
- Allocate the work to each member of the team (balance the workload - a lean practice!); e.g.
  - 1 member to record results on flip chart
  - 1 person calculate T/O for steps 1-3, another for 4-6, a third for 7-9 and the fourth for steps 10-11.
  - Give calculated T/O to recorder to calculate CT

Time Value Charts

Value | Value Stream | **Flow** | Pull | Perfection

- **Visual display of the breakdown in time for a given process**
- **Actual numbers must be measured or estimated**

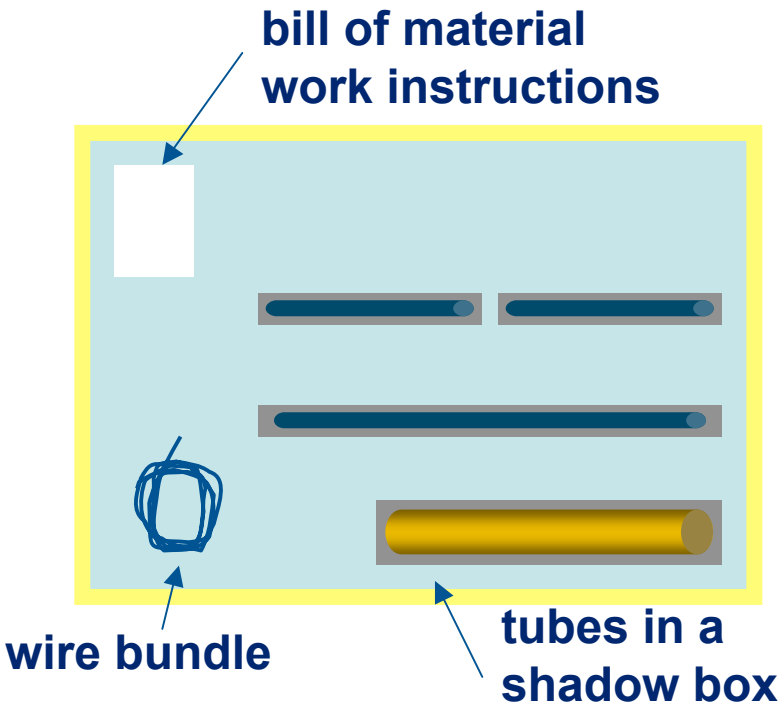


Big cycle time savings comes from removing wait and non-value added time out of a process!

Kitting

Value | Value Stream | **Flow** | Pull | Perfection

- **Combining all relevant material, parts, and/or information into a single package which can be delivered to the point-of-use (POU) in a process**



Two photographs of kits removed due to copyright restrictions.

Mistake Proofing

- A way to prevent errors from occurring and to prevent errors that have occurred from moving downstream in a process or causing accidents
- Examples
  - Locating pins to prevent wrong assembly of a die
  - Color matching for assembly
  - Automatic shut off timers on appliances
  - Operator activated interlock switches on power equipment
  - Can you think of others?

Photo by Earll Murman

What is a Pull System?

Value | Value Stream | Flow | **Pull** | Perfection

- Pull means that no one produces a good or service or processes material or information until someone downstream has requested it
- All value is pulled by the end customer or user of the product or service
- Inherently, there is very little waste in a pull system
- Pull systems are agile and responsive to customer demand

Moving from Flow to Pull

Value | Value Stream | Flow | **Pull** | Perfection

Pull requires Flow plus predicable cycle time, using

- Takt time
- Balanced work
- Standard work
- Single piece flow
- Kanban system
- Just in time delivery of all material and information

Creating Pull:

- Start with the customer and work backwards through the system
- If cycle time <= lead time then Pull can be accomplished
- If cycle > lead time then buffer inventory is used that can be pulled immediately

Pull System: DELL COMPUTER

Value | Value Stream | Flow | **Pull** | Perfection

- DELL encourages "ORDER PLACEMENT" / "OPTIONS DECISIONS" on-line or via phone
- Credit Card # Initiates the "Pull" Process
- Suppliers are on-line with DELL re: Order Placement / Computer Configuration
- Production Of 27,000 Computers / Day
- Orders Shipped in 1 Day
- Zero Inventory carry costs

Takt Time - Measure of Customer Demand

Takt Time is…

- from the German word for meter which establishes the pace or beat
- a reference number that provides a drum beat for the process

$$\text{Takt Time} = \frac{\text{available time}}{\text{customer demand}}$$
$$\text{rate for available time}$$

Example:
The available time is a year or 235 days.
There are 40 orders for this year.

What is the Takt time?

235/40 ~ 6 days

Hot Dog Stand Takt Time

Sasha

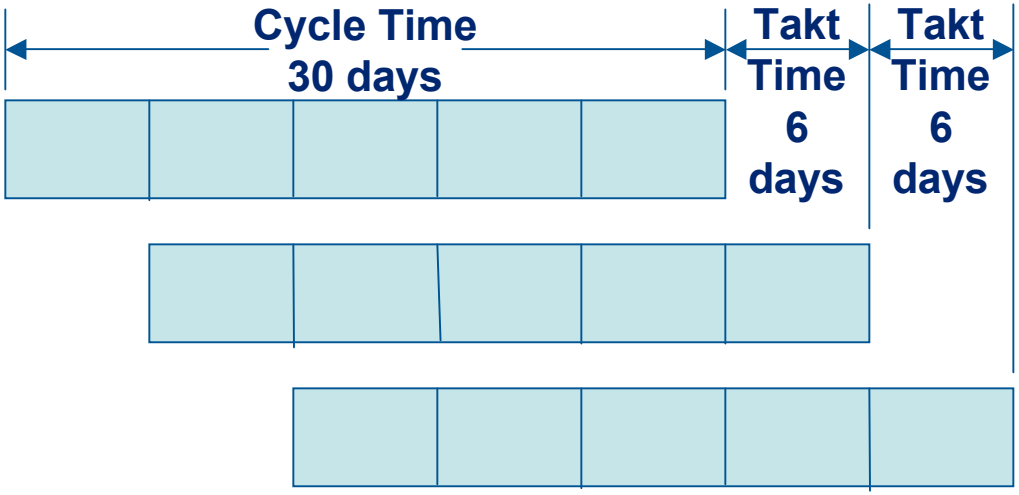
Andy

- What is the takt time for S&H Hot dogs for
  - 50 customers?
  - 75 customers?

Balanced Work

Takt Time example, continued…

To meet Takt time, a product has to be delivered every 6 days. But if it takes 30 days to build, how is this possible?



Standard Work

Value | Value Stream | Flow | **Pull** | Perfection

- Best process currently known, understood, and used today
- Tomorrow it should be better based on continuous improvement
- Standard work is the key to repeatability

Single Piece Flow

Single Piece Flow

- Processing one unit at a time
- Only one unit in work at any step in the process
- Low inventory levels

Batch and Queue

- Processing multiple units at the same time
- Number of units in work optimizes the efficiency at each step in the process
- High inventory levels

Kanban

Value | Value Stream | Flow | **Pull** | Perfection

- **Visual cuing system to indicate material, parts, and/or information are authorized to move downstream**

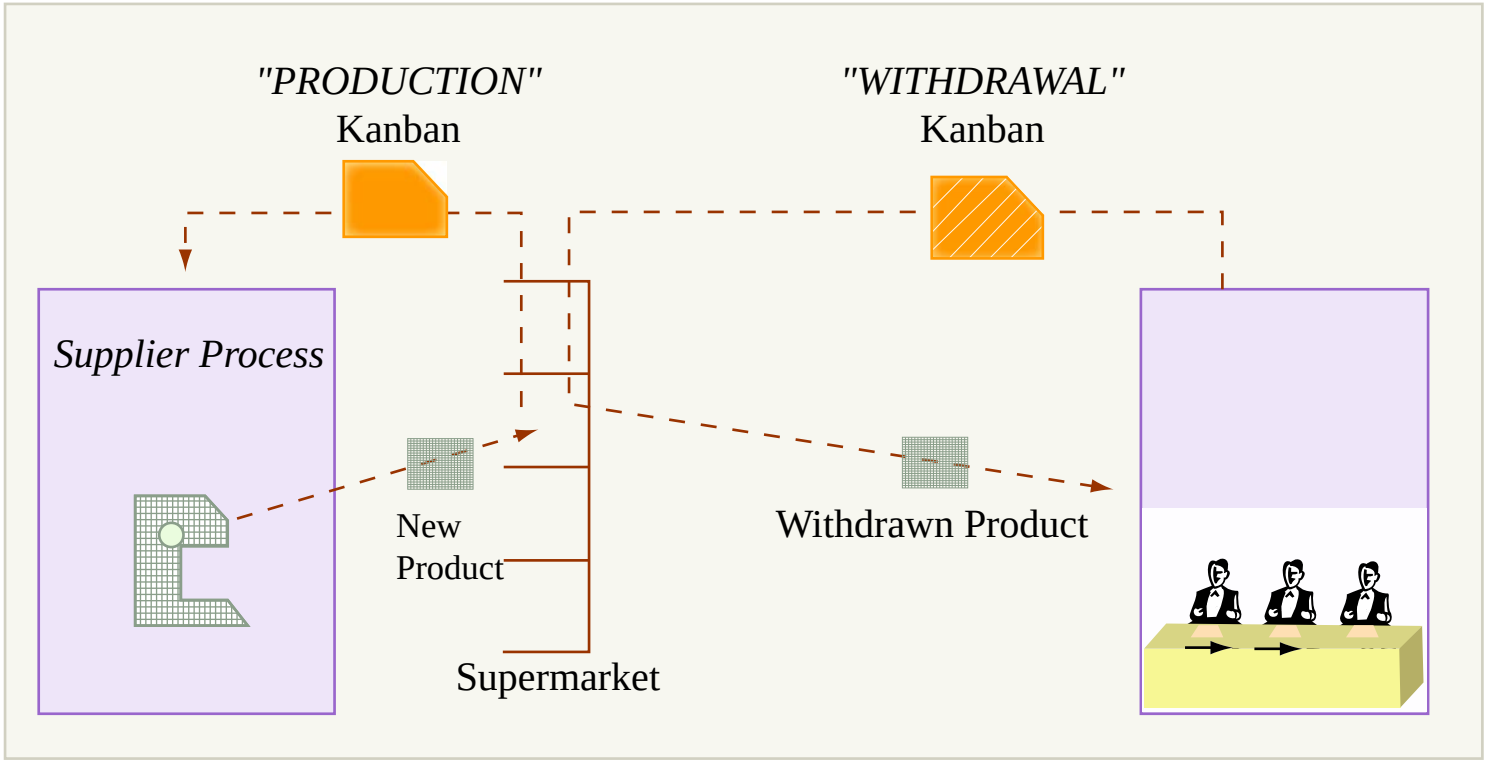


Figure by MIT OpenCourseWare.

Adapted from: Hirohito, "Just In Time"

Visual Control and Andon

- *Visual control* helps identify the status of the process at a glance
  - Makes the process apparent to everyone involved with or observing it
  - Only valuable if used for active process management

Photograph of work control board removed due to copyright restrictions.

- *Andon* is a specific visual control device, typically a group of lights indicating the current status of the process
  - Each step has a set of lights which indicates whether the step is proceeding as planned, needs monitoring, or requires immediate attention
  - In a pull system, if action is required, the entire process stops to correct the problem

Andon Systems Help Prevent Mistakes

Employee has found a part that doesn't fit right.

The employee pulls on the line-stop cord overhead.

LINE STOPPED!

Team leader sees the lamp and comes to help.

The team leader discovers a ring that has slipped out of place. He solves the problem before the production line reaches the next fixed position. The line continues moving.

Photographs illustrating each of these steps removed due to copyright restrictions.

Source: http://www.toyota.co.jp

Pursuing Perfection

Value | Value Stream | Flow | Pull | **Perfection**

- Let customer demand pull value through the value stream
- Completely eliminate waste in a process
- Design and build quality into the product and service
- Ensure transparency to everyone involved
- This is a journey…don't give up!

5 Whys Help Achieve Perfection

5 whys can be used to help determine the root cause of mistakes

5 Whys Example:

The Jefferson Monument is deteriorating!

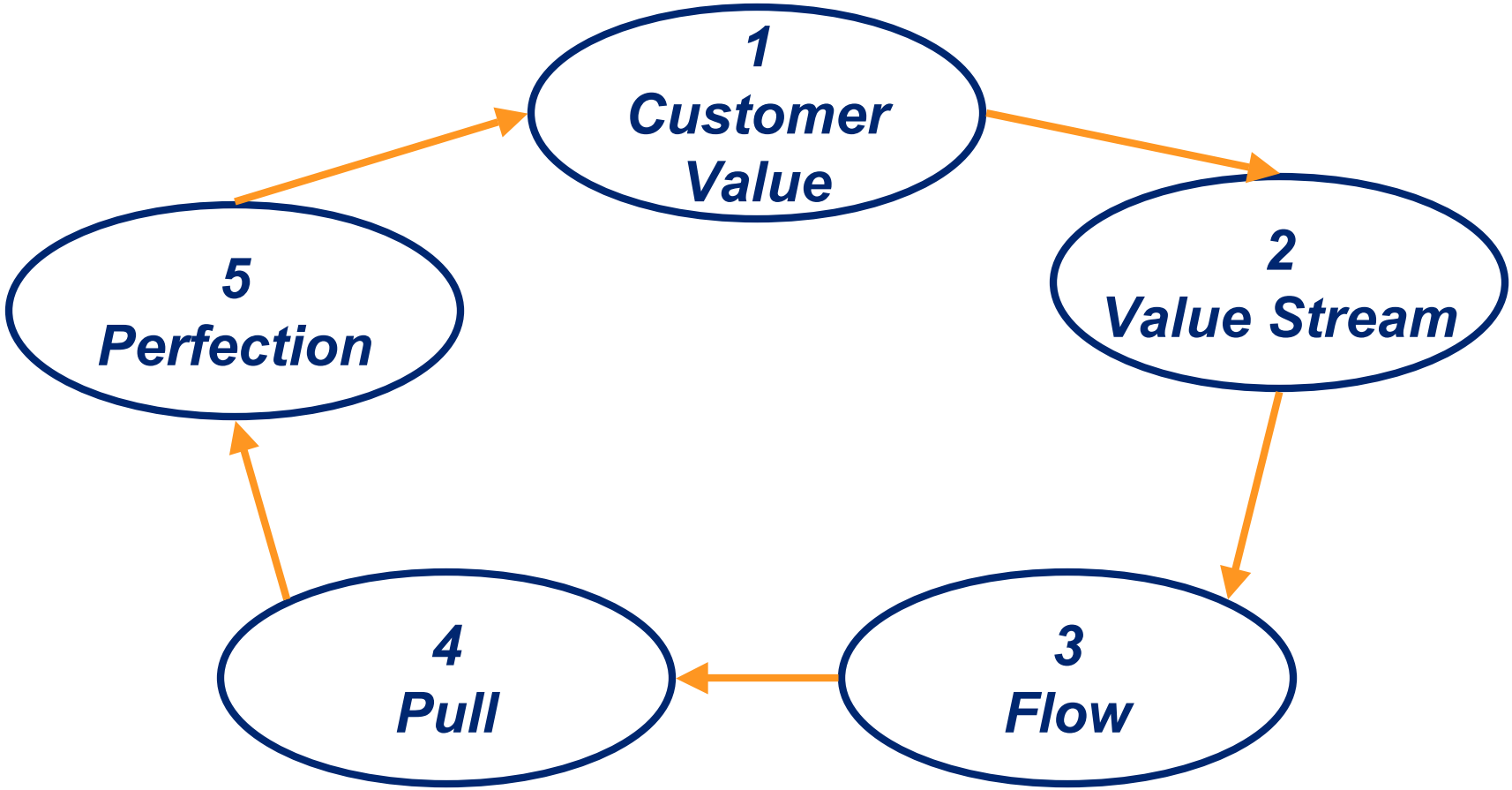
Why? It gets washed all the time.
Why? It always has bird droppings on it.
Why? The birds come into the monument to feed on spiders.
Why? The spiders are there feeding on gnats.
Why? The gnats are there because the lights are left on all the time.

Lean Concepts Introduced So Far

Value	Value Stream	Flow	Pull	Perfection

- Value and non-value added
- 7 types of waste
- Value Stream
- Cycle time
- Wait time
- Process time
- Time value charts
- Takt time
- Balanced work
- Single piece flow
- Standard work
- Kitting
- Kanban
- Visual control
- Andon
- 5S
- Mistake proofing
- 5 Whys

Five Lean Fundamentals Work Together



Take Aways

- The concepts of process, customer and value are essential to lean thinking
- There are fundamental principles behind lean thinking based on making value flow
- A number of simple tools and concepts underlie lean thinking

Reading List

Murman, E., Allen, T., Bozdogan, K., Cutcher-Gershenfeld, J., McManus, H., Nightingale, D., Rebentisch, E., Shields, T., Stahl, F., Walton, M., Warmkessel, J., Weiss, S., and Widnall, S., *Lean Enterprise Value: Insights from MIT's Lean Aerospace Initiative*, Palgrave, New York, 2002

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Womack, J. and Jones, D., *Lean Thinking*, Simon & Shuster, New York, 1996

Acknowledgements

- Venkat Allada - University of Missouri-Rolla
- Sharon Johnson - Worcester Polytechnic Inst.
- Earll Murman - MIT
- Bo Oppenheim - Loyola Marymount University
- Alexis Stanke - MIT
- Ed Thoms - The Boeing Co., IDS