Sustainability and Lean Six Sigma

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Overview

- Lean Six Sigma (LSS) Overview
- How LSS adds value to Sustainability
- How Sustainability adds value to LSS
- Limits of LSS

Lean Six Sigma (LSS) Overview

- Lean
  - Efficiency
  - Speed
  - Flexibility

  - Waste Elimination
  - Kaizen
  - Flow & Pull
  - Value Stream

- Six Sigma
  - Effectiveness
  - Precision
  - Accuracy

  - Variation Elimination
  - DMAIC
  - Statistics
  - Reduced Complexity

The seven deadly wastes with examples and associated sources of variation			
Type of Waste	**Manufacturing Example**	**Transactional Example**	**Examples of Sources of Variation**
Overproduction	Making parts to keep machines and people busy	Unused or unneeded reports, reviews, approvals	customer demand
Waiting	Waiting for materials, machines, tools, people	Waiting approvals or transition from one office to another	Scheduling and processing time
Transportation (of goods)	Long distance between production steps	Hand carried documents for approval or signatures	Requirements or locations of resources
Inventory	Building stockpiles of parts	Email waiting in your inbox	Customer needs, requirements, expectations
Complexity	Unnecessary process steps	Too many hand-offs	Flow capacity, product quality, operators
Movement (of people)	Excessive operator movement	Walking into a hallway or another room in order to pick up copies or scan documents	Job requirements, people, skills, training
Defects	Scrapped or reworked products	Mistakes or omitted data on documents and reports	Raw materials, processing factors or input data

Lean Six Sigma:
Tools and Techniques

Define	Measure	Analyze	Improve	Control
• Benchmarking • Value Stream Mapping • Value Chain Mapping • IPO Diagram • Kano's Model • Knowledge Based Mgt • Task Appraisal • Project Charter • Quality Function Deployment • Voice of the Customer	• Value Stream Analysis • Value Chain Analysis • Cause and Effect • FMEA • Paired Comparison Analysis Little's Law • Process Capability Analysis • Process Flow Diagram • Process Observation • Time Value Map • Waste Analysis	• Affinity Diagram • Brainstorming • Cause & Effect Diagram • FMEA • Histogram • Historical Data Analysis • Pareto Chart • Modeling • Screening • Regression Analysis • Scatter Diagram • 5 Whys	• DOE • RIE • Line Balancing • Mistake Proofing • PF/CE/CNX/SOP • Physical Space Relationship Chart • Single Minute Exchange of Dies • Standard Work • Takt Time • Theory of Constraints • Visual Management • Work Cell Design • 5S Workplace Organization	• Control Charts • Control Plan • Reaction Plan • Run Charts • QMS

IT'S ALL ABOUT CONTINUOUS IMPROVEMENT!

The LSS Secret = People

- Climate of continuous improvement focused on the customer

- Leadership provides direction and sets expectations

- Employees empowered to make changes towards continuous improvement

LSS adds value to Sustainability
Value Stream Analysis

- A Value Stream is made up of the physical and information flows that take a product from concept to launch, order to delivery, and raw materials into the hands of the customer (Womack and Jones 1996: Lean Thinking)

- Value Stream Analyses are essential to systems thinking and the holistic nature of sustainability
  - Mission, environment, community

Value Stream Example

- When Pratt & Whitney mapped its value streams, "it discovered that activities undertaken by its raw materials suppliers to produce ultrapure metals were duplicated at great cost by the next firms downstream, the forgers who converted metal ingots into near-net shapes suitable for machining. At the same time, the initial ingot of material – for example titanium or nickel – was ten times the weight of the machined parts eventually fashioned from it. Ninety percent of the very expensive metals were being scrapped because the initial ingot was poured in a massive size – the melters were certain that this was efficient – without much attention to the shape of the finished parts. And finally, the melters were preparing several different ingots – at great cost – in order to meet Pratt's precise technical requirements for each engine, which varied only marginally from those of other engine families and from the needs of competitors."
- Womack and Jones 1996: Lean Thinking

LSS adds value to Sustainability
Efficiency and Effectiveness

- Waste is the enemy of both LSS and sustainability
- LSS helps build a waste elimination culture
- Eliminate waste to get the biggest return on the **triple** bottom line for each dollar spent

LSS adds value to Sustainability

Efficiency and Effectiveness

- Reduces the environmental costs of poor quality
- Decreases footprint through reduced inventory and work cell configurations
- Reduces the demand for materials through resource productivity

USEPA 2003

The environmental impacts associated with the seven deadly wastes (USEPA 2003).

Type of Waste	Environmental Impacts
Overproduction	•More raw materials consumed in making the unneeded products •Extra products may spoil or become obsolete requiring disposal
Waiting	•Potential material spoilage or component damage causing waste •Wasted energy from heating, cooling and lighting during production downtime
Transportation (of goods)	•More energy use for transport •Emissions from transport •More space required for work in process (WIP) movement, increasing lighting, heating and cooling demand and energy consumption •More packaging required to protect components during movement
Inventory	•More packaging to store WIP •Waste from deterioration or damage to stored WIP •More materials needed to replace damaged WIP •More energy used to heat cool and light inventory space
Complexity	•More parts and raw materials consumed per unit of production •Unnecessary processing increases wastes, energy use, and emissions
Movement (of people)	•Safety issues and repetitive motion injuries
Defects	•Raw materials consumed in making defective products •Defective components requiring recycling or disposal •More space required for rework and repair, increasing energy use for heating, cooling and lighting

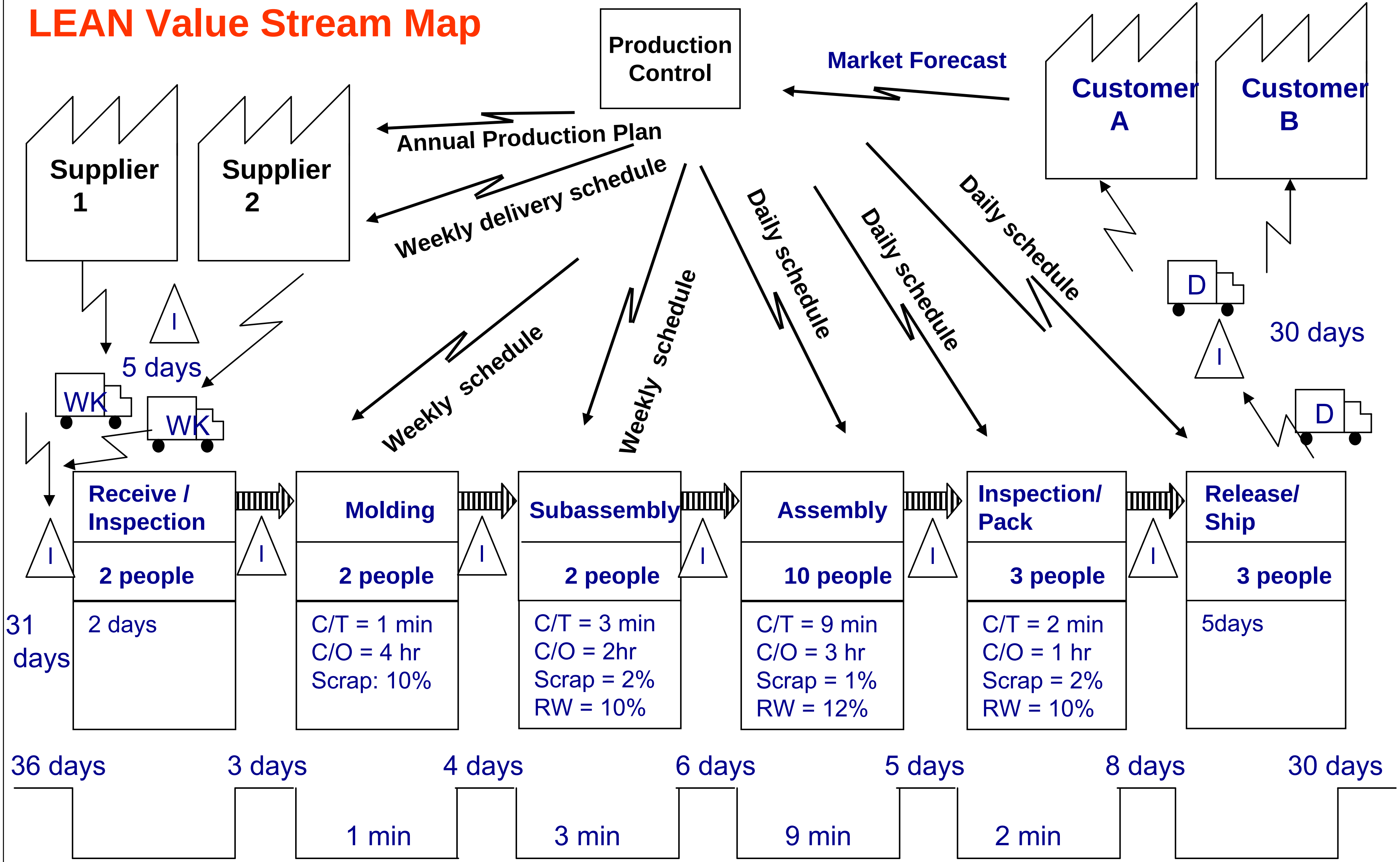
Examples

- General Motors Corporation reduced its disposal costs by $12 million by establishing a kanban system involving a reusable container program with suppliers (USEPA 2000).
- Robins Air Force Base, C-130 paint shop
  - Reduced flow days
  - Increased production and worker safety
  - Reduced VOCs
  - Reduced tools materials and equipment by 39%
  - Reduced number of chemicals used from 9 to 3
  - $373,800 in direct operating savings (USEPA 2003)

LSS adds value to Sustainability
Efficiency and Effectiveness

- Streamline the environmental function
- Use methodology and tools to achieve EMS objectives and targets
- Creatively apply tools to focus on environmental aspects

LEAN Value Stream Map

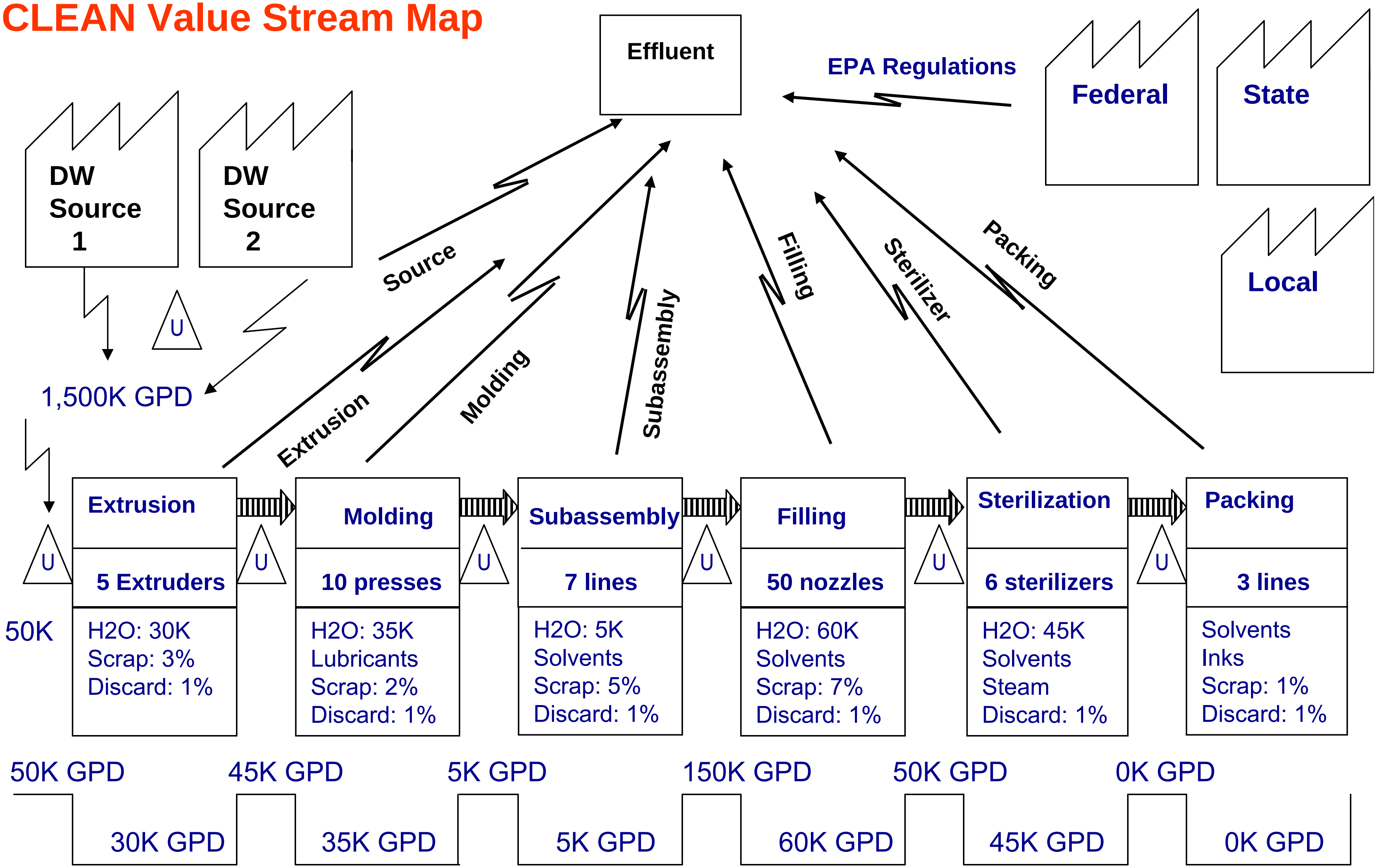


Total Lead Time = <u>92 days</u>
Total Processing Time = <u>15 min</u>

Focus is on <u>time</u>

Baxter Healthcare

CLEAN Value Stream Map



Total H_2O Usage (GPD) = 475K
Total H_2O Need (GPD) = 175K

Focus is on water usage

Baxter Healthca

Sustainability adds value to LSS

- LSS does not explicitly call out “pollution” as a targeted waste
- LSS does not consider environmental risks or liabilities
- LSS does not consider the life-cycle environmental impacts of products
- An emphasis on sustainability can help fill in these gaps in LSS methods
- www.epa.gov/lean

USEPA 2003

Limits of LSS
7 Levels of Change

(Rolf Smith 2002)

7. Do Things that “Can't” be Done
6. Do Things No One Else is Doing
5. Do Things Other Are Doing
4. Do Away With Things
3. Do Things Better
2. Do Right Things Right
1. Do the Right Things

Creative Problem Solving

3σ — **RESTRUCTURE (>30% CHANGE)** (levels 6–7)

Critical Problem Solving - LSS

2σ — **RE-ENGINEER (11-30% CHANGE)** (levels 4–5)

1σ — **INCREASE EFFICIENCY / Effectiveness (≤10% CHANGE)** (levels 1–3)

12 Green Engineering Principles

(Anastas and Zimmerman 2003, McDonough *et al.* 2003)

1. Designers need to strive to ensure that all material and energy inputs and outputs are as inherently non-hazardous as possible.
2. It is better to prevent waste than to treat or clean up waste after it is formed.
3. Separation and purification operations should be designed to minimize energy consumption and materials use.
4. Products, processes and systems should be designed to maximize mass, energy, space, and time efficiency.
5. Products, processes, and systems should be “output pulled” rather than “input pushed” through the use of energy and materials.
6. Embedded entropy and complexity must be viewed as an investment when making design choices on recycle, reuse, or beneficial disposition.
7. Targeted durability, not immortality, should be a design goal.
8. Design for unnecessary capacity or capability (e.g. “one size fits all”) solutions should be considered a design flaw.
9. Material diversity in multicomponent products should be minimized to promote disassembly and value retention.
10. Design of products, processes, and systems must include integration and interconnectivity with available energy and material flows.
11. Products, processes and systems should be designed for performance in a commercial “afterlife”.
12. Material and energy inputs should be renewable rather than depleting.

Summary

- LSS is inherently good for environmental performance
  - Value stream/holistic approach
  - Waste elimination
- LSS can be applied to specifically reduce the burden of environmental functions
- An emphasis on sustainability can fill in some gaps in LSS – environmental professionals must be involved in projects
- LSS is not a panacea – need creative problem solving

Back-up Slides

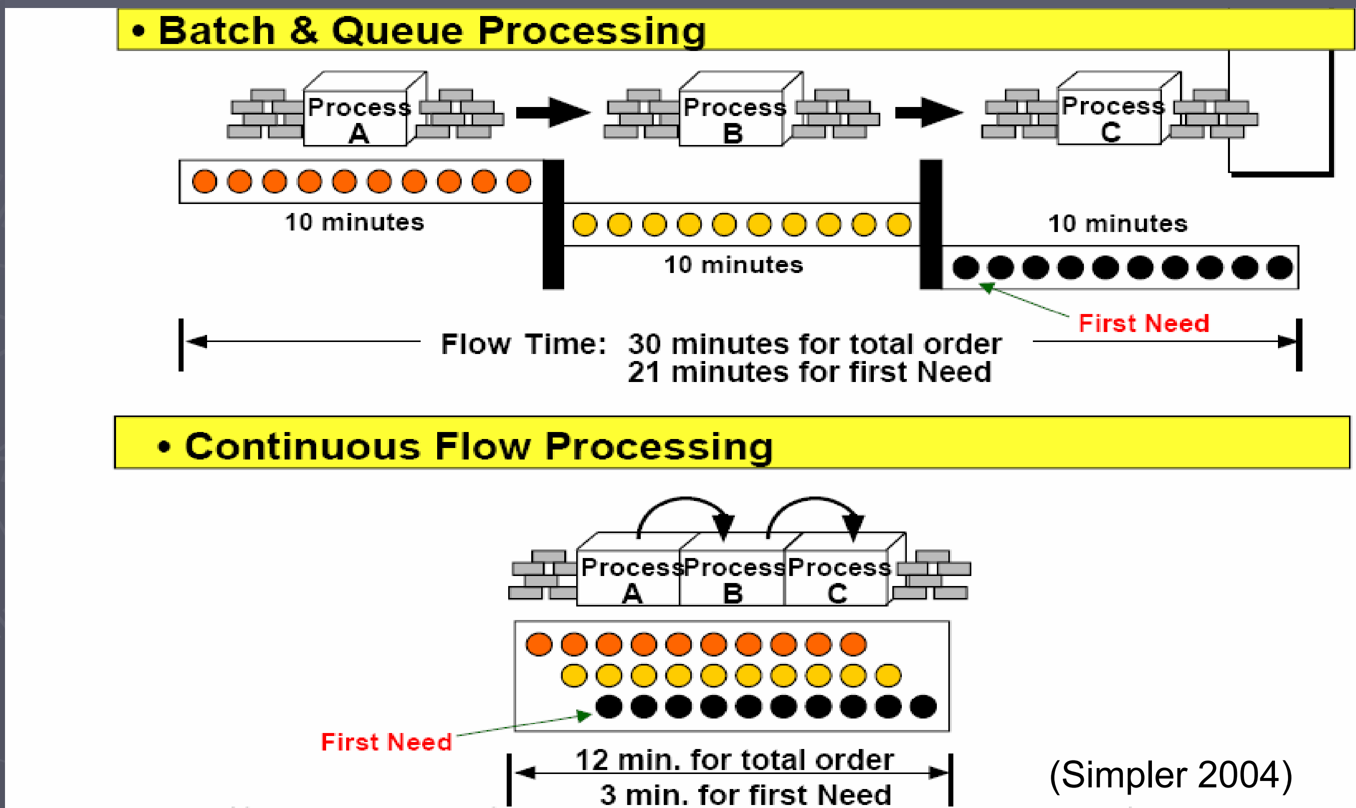
Key Concepts

- Pull
  - Goal: only produce when your customer immediately downstream needs the product
  - Benefits: Reduced inventory; Increased adaptability; No over-production

- Value-added Activity
  - Goal: pursue only value added activities (that which the customer is willing to pay for)
  - Benefits: Elimination of the 7 wastes; Flow; Speed; Lower costs

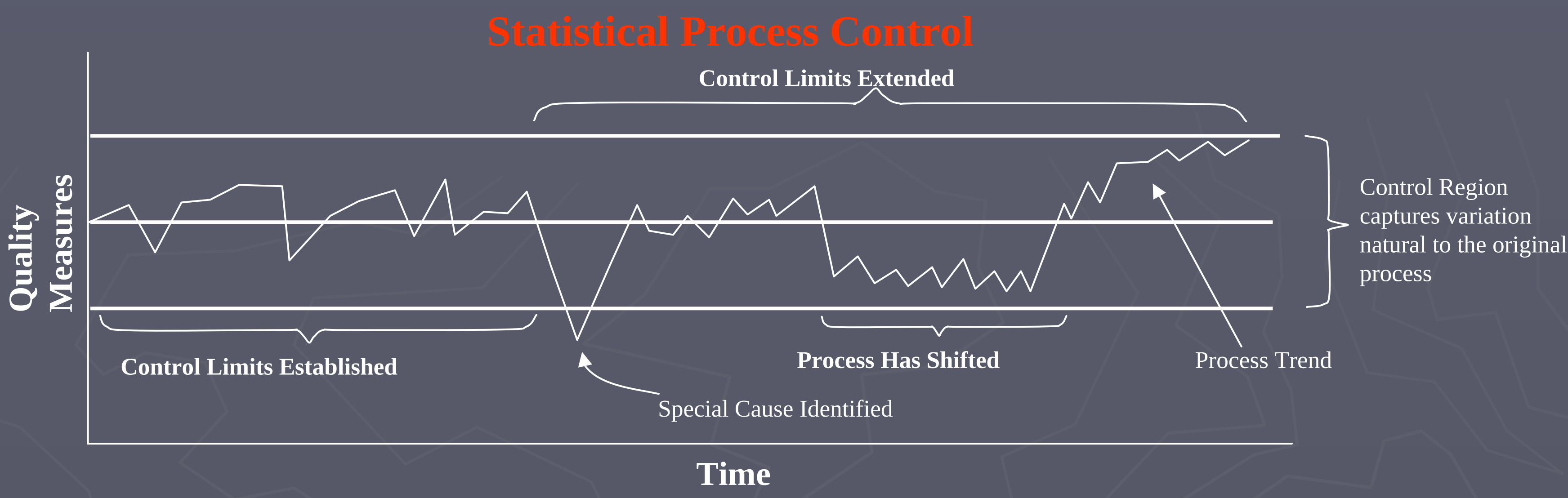
Flow

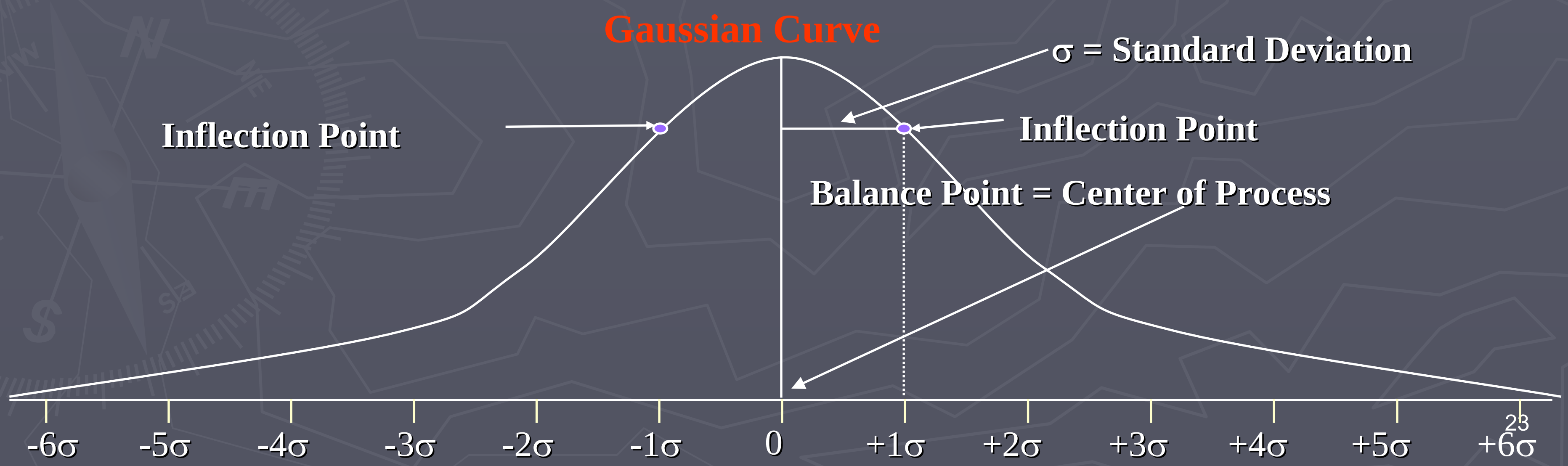
- Goal: Eliminate all work stoppages from product design to launch, order to delivery
- Benefits: No waiting; No back-flow; No expediting



(Simpler 2004)

Six Sigma: Controlling the Curve





Complexity

- Increasing the number of steps in your process significantly affects Rolled Yield
- Example: assumes all process steps have the same yield

# of Steps	FPY for all Steps	Rolled Yield
1	.933	$.933^1 = .933$
10	.933	$.933^{10} = .501$
1	.994	$.994^1 = .994$
10	.994	$.994^{10} = .940$

What is the difference between 3 and 6 sigma?

- 3 Sigma
  - 1.5 Misspelled words per page in a book
  - 20,000 Lost articles of mail per hour
  - 5,000 Incorrect surgical operations per week
  - 2 Short or long landings at most major airports each day
  - 200,000 Wrong drug prescriptions each year

- 6 Sigma
  - 1 Misspelled word in all the books in a small library
  - 7 Lost articles of mail per hour
  - 1.7 Incorrect surgical operations per week
  - 1 Short or long landing every five years
  - 68 Wrong drug prescriptions per year