Lean/Six Sigma Systems Concluding Review SPL 13.1

Joel Cutcher-Gershenfeld
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Presentation for:
ESD.60 – Lean/Six Sigma Systems
MIT Leaders for Manufacturing Program (LFM)
Summer 2004

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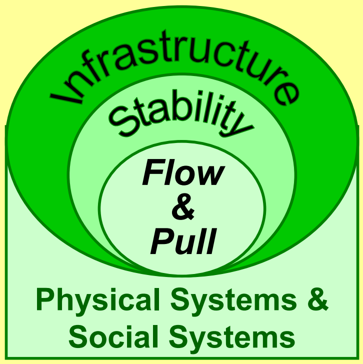
A Core Framework



Foundations – Infrastructure	
1.0	Lean Thinking
2.0	Six Sigma Principles Systems Change Principles
3.0	“Pre-Stability” Considerations
Stability	
4.0	Team-Based, Knowledge-Driven
5.0	Stakeholder Alignment
6.0	In-Process Station Control
7.0	Total Productive Maintenance
Flow & Pull	
8.0	Value Streams
9.0	Material Flow
10.0	Knowledge and Information Flow
11.0	Customer “Pull”
12.0	Industry Context
13.0	Transitions, Enterprise and Integration

A Learning Experiment

- A new course in the LFM curriculum
- Organized around 33 Single-Point Lessons (SPLs) designed for re-use
- Student teams in “Leader-as-Teacher” role for 9 of the 16 sessions (including the simulation)
- Socio-tech case studies on lean implementation
- Alumni/ae integration as coach/mentors for the SPLs and for selected socio-tech case studies
- Learning from “disconnects”

A Significant Accomplishment: 35 SPLs

Foundations -- Infrastructure		
1.1	Lean Thinking	Cutcher-Gershenfeld
2.1	Six Sigma Systems Principles	Cutcher-Gershenfeld
2.2	Systems Change Principles: Debates	Cutcher-Gershenfeld
2.3	Systems Change Principles: Socio-Tech Dynamics	Cutcher-Gershenfeld
3.1	Brownfield/Greenfield Contrast	Cutcher-Gershenfeld
3.2	Active and Passive Opposition to Lean/Six Sigma	Cutcher-Gershenfeld
Stability		
4.1	Team/Work Group Structure and Roles	Cutcher-Gershenfeld
4.2	Front-Line Leadership Capability and Motivation	Abler, Neal
4.3	Knowledge-Driven Work	Cutcher-Gershenfeld
5.1	Support Function Alignment	Cutcher-Gershenfeld
5.2	Supply Chain Alignment	Lennox, Penake
5.3	Union-Management Alignment	Cutcher-Gershenfeld
6.1	Standardized work	Lathrop, Dolak
6.2	Andon response systems	Sieg, Kahl
6.3	PDCA	Weinstein, Vasovski
7.1	5S's and Waste Walks	Hong, Fearing
7.2	Preventive maintenance principles	Hiroshige, Couzens
7.3	Lean machine tooling	Williams, Salamini
7.4	Maintenance/skilled trades work groups	Baer, Vessell

35 SPLs – cont.

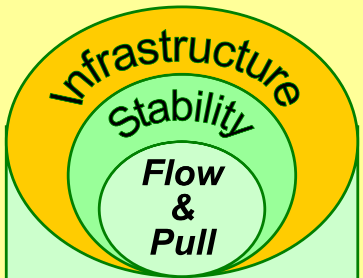
Flow & Pull		
8.1	Assembly operations – Takt Time	Ducharme, Ruddick
8.2	Machining operations – Cycle Time	Gaskins, Holly
8.3	Continuous flow operations	Hsu, Hasik
8.4	Engineering design operations Service operations – Cycle Time	Lennox, Silber
8.5	Sustainability and lean/Six Sigma	Person, Bar, Robinson
9.1	Kanban/Supply chain sequencing	Hovav, Khattar
9.2	Presentation of parts and parts marketplace	Kary, Shao
9.3	Hejunka/product leveling	Reyner, Fleming
10.1	Kaizen-Teian improvement systems	Chang, Wu
10.2	Hoshin planning/Policy deployment	McDonald, Shen
10.3	Enterprise resource planning tools	Fung, Schoch
10.4	Design for manufacture	Obatoyinbo, Landivar
10.5	Performance metric feedback	Raghunathan, Rubenstein
11.1	Forecast “push,” customer “pull,” and hybrid models	Pan, Svensson
12.1	Lean Enterprise Alignment	Cutcher-Gershenfeld
13.1	Concluding Presentation	Cutcher-Gershenfeld

Course Review and Reflections

- Selected highlights from each of the 35 Single-Point Lessons (SPLs)
  - *Note that some slides are just one of a sequential set of points and are selected for use here as a reference back to the full set of slides*
- Reinforcing core insights – with a focus in every case on the disconnects
- Adding additional helpful context – with the additional instructor's comments

This is the "C" in our PDCA cycle ("Adjust" will come with the simulation)

A Core Framework – Part I



Physical Systems & Social Systems

Look for:
- A stakeholder map
- Social/physical infrastructure
- Core assumptions
- A value stream map

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Part II: Stability	
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Parts III, IV and V: Flow & Pull	
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Lean Thinking
Module 1.1

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Redefining "lean"

Definition:

"*Becoming 'lean' is a process of eliminating waste with the goal of creating value.*"

Note: This stands in contrast to definitions of lean that only focus on eliminating waste, which is too often interpreted as cost cutting – independent of its impact on value delivery

Source: Lean Enterprise Value: Insights from MIT's Lean Aerospace Initiative by Earll Murman, Thomas Allen, Kirkor Bozdogan, Joel Cutcher-Gershenfeld, Hugh McManus, Deborah Nightingale, Eric Rebentisch, Tom Shields, Fred Stahl, Myles Walton, Joyce Warmkessel, Stanley Weiss, Sheila Widnall, (Palgrave, 2002)

Two mindsets

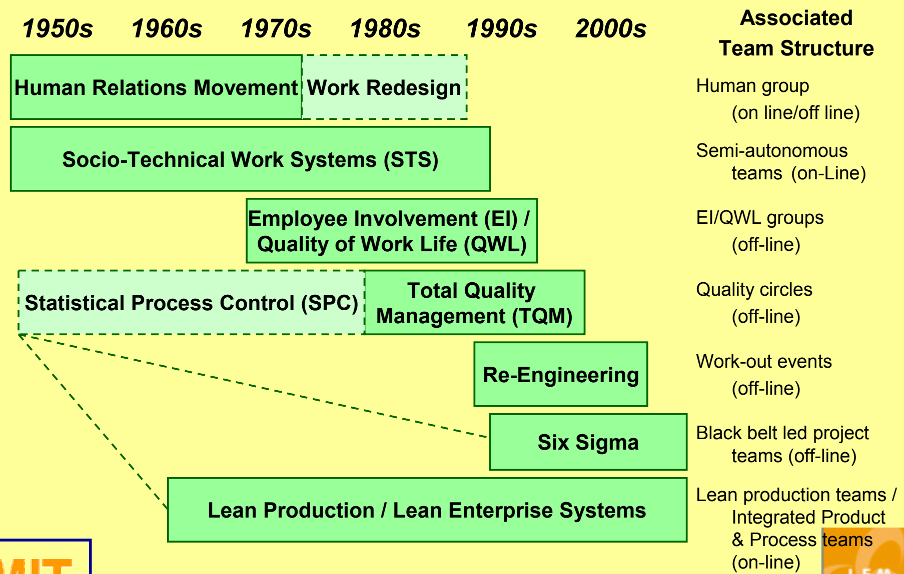
"Mass Production" Mindset

- Producer "push"
- Movement of materials
- High volume
- Inspection
- Expert-driven
- Decomposition
- Periodic adjustment

"Lean Enterprise" Mindset

- Customer "pull"
- Flow of value
- Flexible response
- Prevention
- Knowledge-driven
- Integration
- Continuous improvement

Historical context: Transformation initiatives



Source: Auto Industry System Study by Joel Cutcher-Gershenfeld and Thomas Kochan, 2000

Exercise: The Seven Wastes and the Five S's

The Seven Wastes

- Over Production
- Waiting
- Transportation
- Inventory
- Processing
- Motion
- Defects

The Five S's

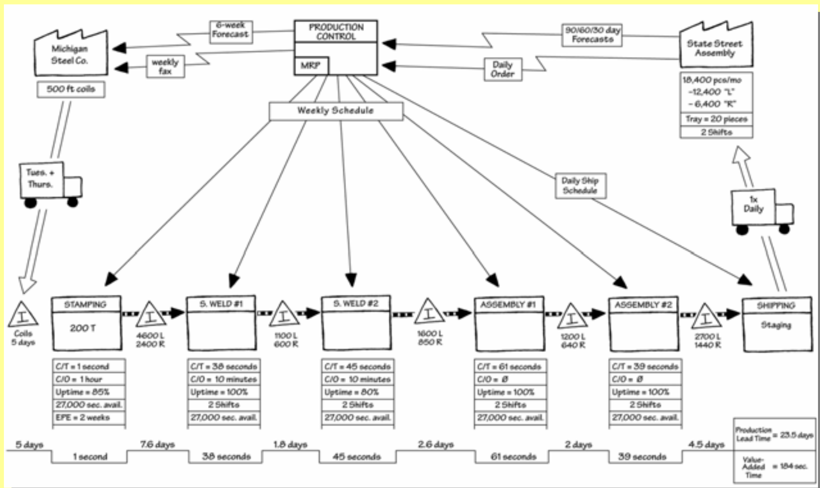
- Simplify or Sort (seiri)
- Straighten or Set (seiton)
- Scrub or Shine (seiso)
- Stabilize or Standardize (seiketsu)
- Sustain or Self-Discipline (shitsuke)

What changes are needed in technical/physical systems to address the Seven Wastes?

What changes are needed in social systems – including what new ways of thinking?

Do the same analysis with respect to the Five S's

Sample Value Stream Map



Courtesy of Matthias Holweg. Used with permission

Source: Presentation by Matthias Holweg on "Latest Developments in Lean Thinking," CMI

Six Sigma Systems Principles

Module 2.1

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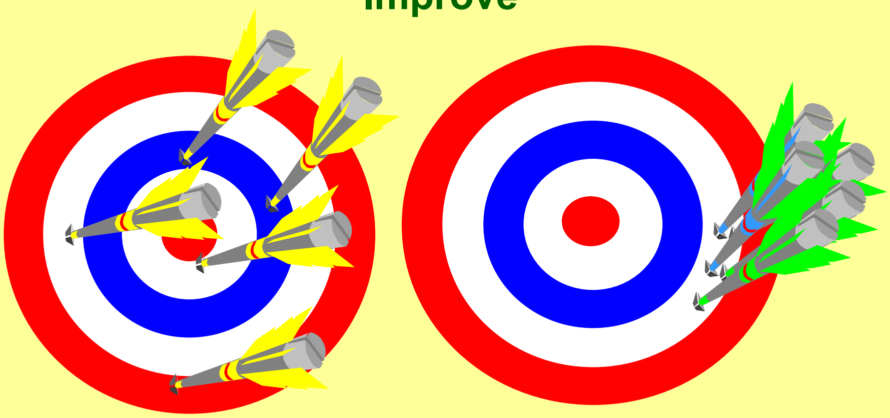
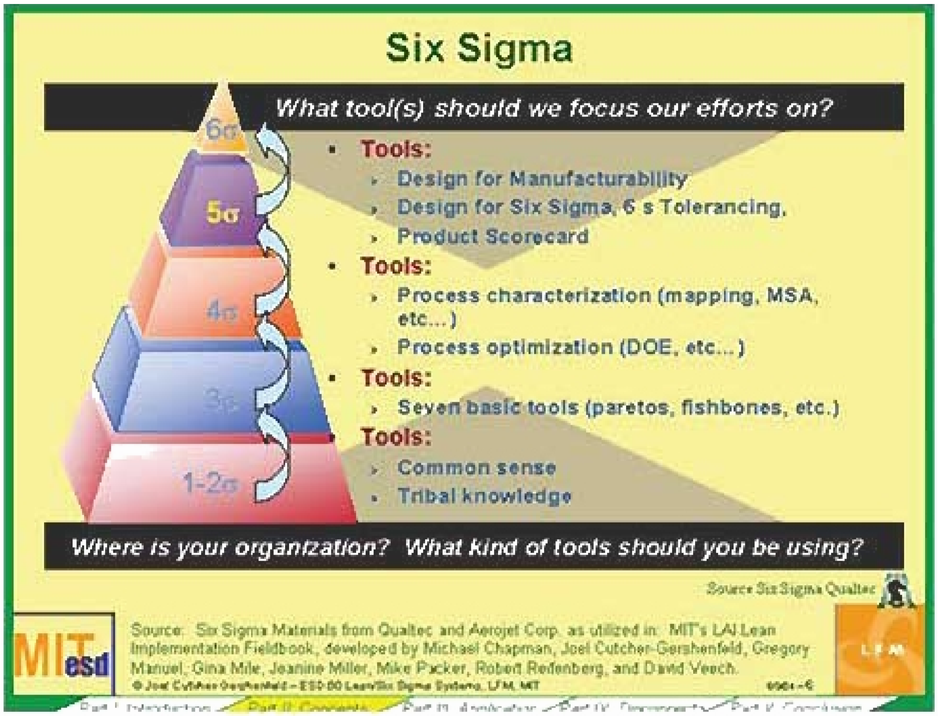
Core Concept: Stabilize Before You Improve



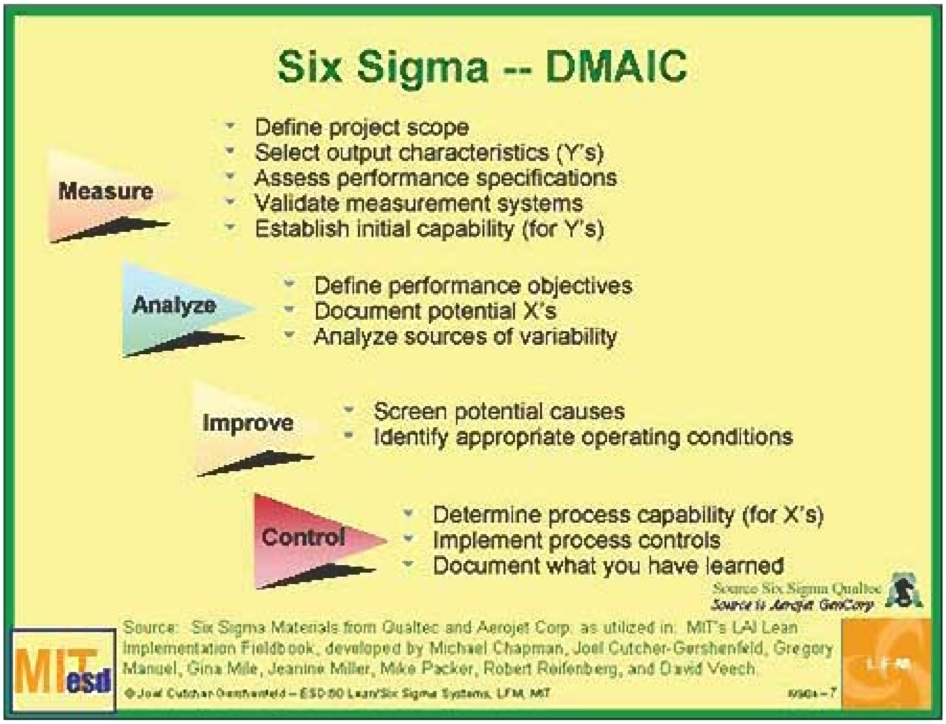
Which player did better in this round?
Who will do better in the long run?



During your project you want to use the right tool for the problem at hand

The Low Hanging Fruit can be obtained via the basic problem solving tools (check sheets. paretos, fishbones, charts, team interaction, training, etc…).

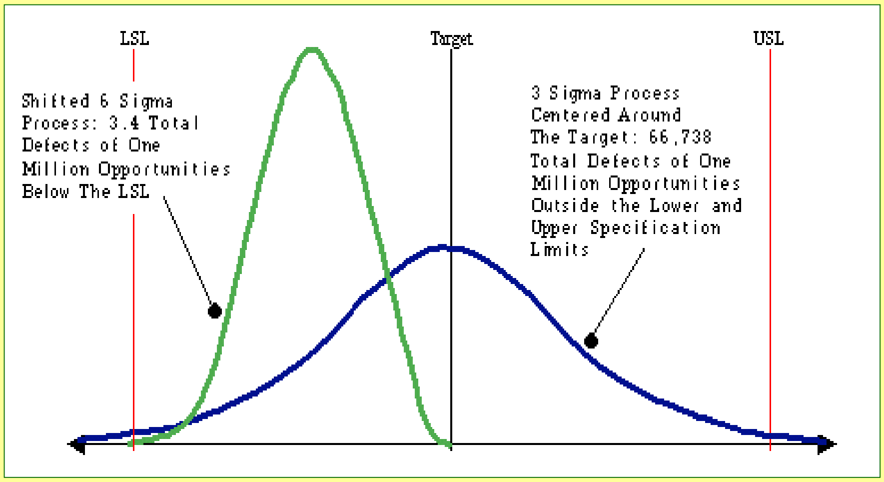
To really leverage process knowledge, we will apply new tools to take us from the 3 - 4 sigma range to 6 sigma levels.



The six sigma strategy is summarized above This is only an outline The detail behind this information will be presented later

In the next four weeks of training you will learn how to characterize and optimize any process.

Core Statistical Concepts



Source: "Statistical Six Sigma Definition" at http://www.isixsigma.com/library/content/c010101a.asp

Systems Change Principles: Key Concepts and Systems Change Debate

Module 2.2

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A Spectrum of Organizational Development Roles

Basic Skills	Competent	Expert	Master

- Facilitator . . . . Process Expert
- Trainer . . . . .Trainer of Trainers
- Mediator . . . . Shuttle Diplomat
- "Thermometer". . . . . Moral/Ethical Sounding Board
- Strategic Planner . . . . Strategic Visionary
- Systems Thinker. . . . . Systems Designer
- Organizational Assessor . . . . . . Organizational Architect

Lean implementation strategies

Top-Down "Re-engineering"

- ***Many meanings:***
  - Range from a pretext for restructuring and downsizing to a systematic review of operations with comprehensive process mapping
- ***Key quote:***
  - *"if it's not broke, break it"*
- ***Roots:***
  - Roots in private and public sectors, including "re-inventing government"
  - First driven by economic crisis in 1980's, now seen as a process for system change
- ***Archetypical Example:***
  - GE "workout" process

Bottom-up "Kaizen"

- ***Many meanings:***
  - Range from suggestion systems (kaizen-teian) to an underlying philosophy and a way of life
- ***Key quote:***
  - *"many small improvements build long-term transformation capability"*
- ***Roots:***
  - Post WWII Japan, beginning with quality circles (QC), statistical process control (SPC), and just-in-time (JIT) delivery practices
  - Increasingly seen from a systems perspective -- Total Quality Management (TQM), Six Sigma, Lean Enterprise
- ***Archetypical Example:***
  - Toyota Production System (TPS)

"Kaizen event" – A contradiction in terms?

Systems Change Principles: Socio-Technical Dynamics in Launching a Lean Work Cell

Module 2.3

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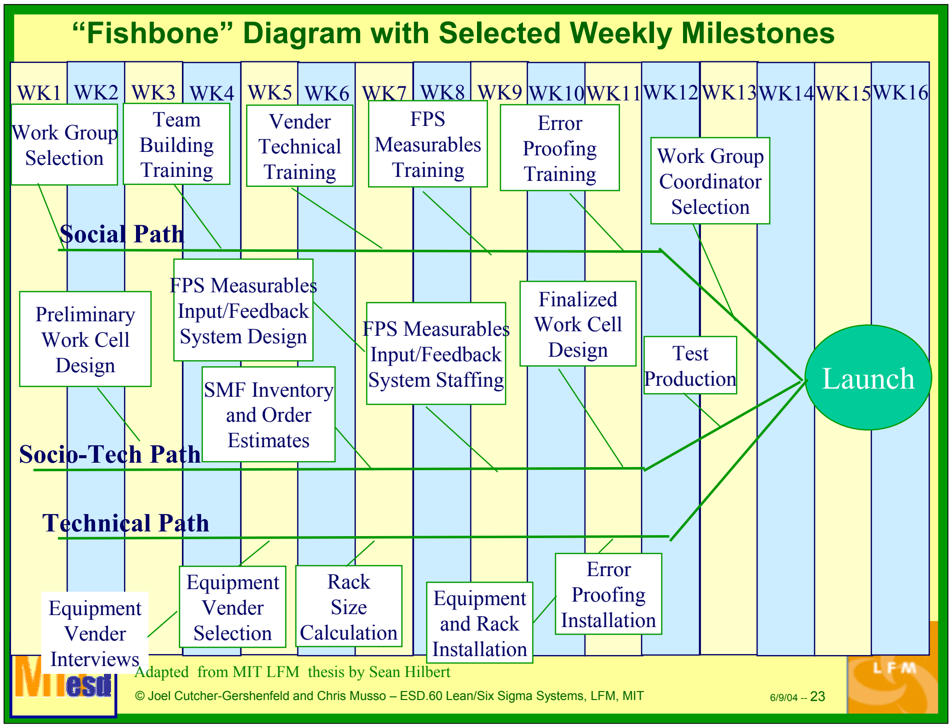
"Fishbone" Diagram with Selected Weekly Milestones
WK1 WK2 WK3 WK4 WK5 WK6 WK7 WK8 WK9 WK10 WK11 WK12 WK13 WK14 WK15 WK16
Work Group Selection
Team Building Training
Vender Technical Training
FPS Measurables Training
Error Proofing Training
Work Group Coordinator Selection
Social Path
Preliminary Work Cell Design
FPS Measurables Input/Feedback System Design
SMF Inventory and Order Estimates
FPS Measurables Input/Feedback System Staffing
Finalized Work Cell Design
Test Production
Launch
Socio-Tech Path
Technical Path
Equipment Vender Interviews
Equipment Vender Selection
Rack Size Calculation
Equipment and Rack Installation
Error Proofing Installation
Adapted from MIT LFM thesis by Sean Hilbert
© Joel Cutcher-Gershenfeld and Chris Musso – ESD.60 Lean/Six Sigma Systems, LFM, MIT
6/9/04 -- 23

Key Factors in the Launch – "Disconnects"

- **Technical Factors**
  - Length of line too short
  - Right size racks order, but held up and substitutes were wrong size
  - Cycle time in constraint machine was too long
  - "Kit" for parts didn't hold one oversize component
  - In-line repair area too small
  - Cleaning time at end of shift used instead for production
- **Social Factors**
  - Launch team split up and re-assigned half way through launch
  - Turnover among engineers throughout launch
  - Insufficient training for in-process control
  - Key Work Group members not released for training
  - Assumptions about pride in doing a complete job were overshadowed by the stress and peer pressure
  - Jealousy between working in repair area and working on line
  - Work Group Coordinator role was a "pinch" position – needing more preparation and support
  - Social contract – support to do the job right – overshadowed by high schedules

"Brownfield" / "Greenfield" Contrast
SPL 3.1

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Productivity/Quality Performance of Selected Auto Assembly Plants – Early 1980s *

	Productivity (hrs/unit)	Quality (defects/100 units)	Automation Level (0: none)
Honda, Ohio	19.2	72.0	77.0
Nissan, Tenn.	24.5	70.0	89.2
NUMMI, Calif.	19.0	69.0	62.8
Toyota, Japan	15.6	63.0	79.6
GM, Mich.	33.7	137.4	100.0
GM, Mass.	34.2	116.5	7.3

- Productivity here is defined as the number of man-hours required to weld, paint, and assemble a vehicle. These figures have been standardized for product size, option content, process differences, and actual work schedules (i.e. differing amounts of break time).
- Quality is based on a J.D. Powers survey of customer-cited defects in the first six months of ownership. The number in the column are the number of defects per 100 vehicles. Only defects attributable to assembly operations are included.
- Level of automation is a radio robotic applications in each plant divided by the production rate. These figures have been normalized with 100.0 indicating the highest level of automation in this group.

**John Krafcik and James Womack, M.I.T. International Motor Vehicle Program, March 1987. These data are preliminary and not for citation or distribution without the author's consent.*

Passing the Point of No Return: Accelerated Implementation of a Lean Manufacturing System

- A Core Challenge in the Auto Industry: Transforming "Brownfield" Operations
- A History of Joint Initiatives
- Initial Launch of a Lean Manufacturing System: The Challenge of the "Hope/Heartbreak" Cycle
- Value Stream – Within the Plant and Across the Enterprise
- Stability, Infrastructure and Continuous Improvement
- Leadership

A Week in the Life of a Coordinator . . .

- **Tuesday**
  - 4:55-5:10 Take inventory
  - 5:20-5:45 Go to office of next Department over to talk with Supervisor about washer flooding in the isle and in our department -- put in tickets for Facilities and Scrubber Truck
  - 6:45-6:55 Call to check out why an Operator wasn't paid for Monday
  - 9:40-10:52 Received bad component from Department X -- returned it and explained what was wrong
  - 9:50-10:05 Go to General Stores to check out new taps and drills for pedestals
  - 1:12-1:20 Survey Department about reduction in hours
  - 1:20-1:35 Sort and tag scrap tub for removal
  - 2:32-2:55 Line up Tool Crib for afternoons with tooling changes

Active and Passive Opposition to Lean/Six Sigma SPL 3.2

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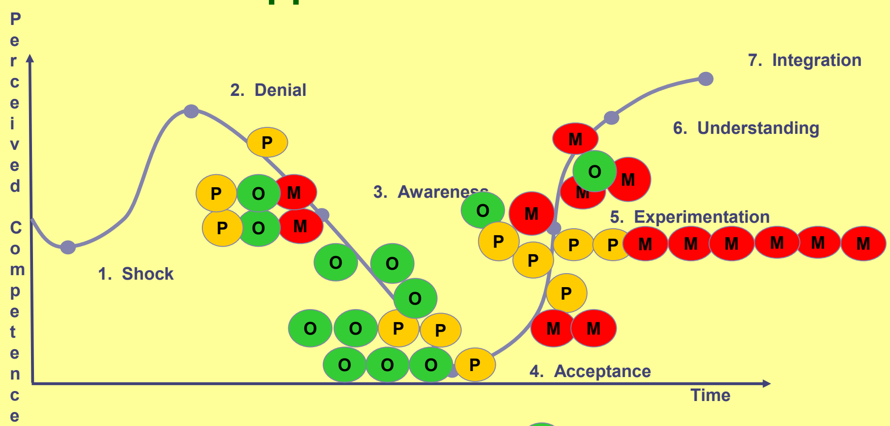
Reactions/Resistance to Change

- **Resistance is predictable and understandable**
- **Why do we resist change?**
  - *1) It's new and different -- full of uncertainty*
  - *2) It feels like it's being imposed*
  - *3) There are specific parts of the change that I don't like*
- **How do we resist change?**
  - *1) Suppressed anger -- Shut down, don't listen, sit there fuming*
  - *2) Displaced anger -- Don't get mad, get even*
  - *3) Outward anger -- Emotional outburst*
- **What can we do?**
  - *1) Ask questions -- learn more about what is involved*
  - *2) Look for opportunities -- are there aspects of the change that could help make things better? How many options can we generate?*
  - *3) Be clear about specific concerns or issues -- consider who might have similar concerns and who might have opposite preferences.*
  - *4) Build agreements that take into account everyone's interests*

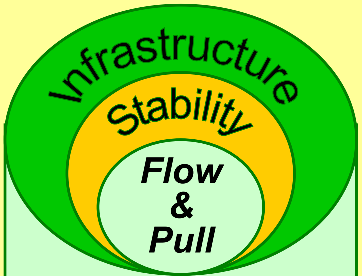
Application Exercise



How I See the plant operating committee: O
How I See Myself: M
How the people in my organization see me: P

How do you interpret these data from a manufacturing plant operating committee and the local union bargaining committee?

A Core Framework – Part II



Physical Systems & Social Systems

Look for:
- Stable team structure
- Stable stakeholder relations
- Stable quality practices
- Stable machine maintenance

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Team/Work Group Structure and Roles – Socio-Tech vs Lean Teams SPL 4.1

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Team Types

	Lean Production Teams	"Socio-Technical" Systems Teams	Off-Line Teams
Origins:	Japan (Toyota Pull System, 1960s)	Scandinavia (Volvo Kalmar, 1970s) and England (coal mines, 1940s)	U.S. (Harmon and GM/UAW QWL groups, 1970s) and Japan (Quality Circles, 1980s)
System Optimizes:	Continuous improvement in work operations	Mix of social and technical sub-systems	Ad hoc problem solving
Expected Yield:	Systematic gains in quality and productivity	Increased worker commitment and targeted gains in quality and safety	Increased worker commitment and reactive response to quality problems
Success Constrained by:	High expectations of team autonomy; Low labor/management support for continuous improvement	High levels of team interdependence; Limited resources for technical redesign	Separation from daily operations
Typically Found in:	Assembly operations (high interdependency among teams)	Continuous production operations (high autonomy among teams)	Broad range of workplaces
Leadership:	Depends on strong team leader	Depends on self-managing group	Depends on group facilitator
Membership:	Common work area	Common work area	May draw on multiple work areas
Organization Structure:	Core building block	Core building block	Adjunct to the structure
Links to Other Teams:	Tightly linked to internal customers and suppliers	Tightly linked across shifts; loosely linked with other teams	Little or no links among teams

Source: Knowledge-Driven Work: Unexpected Lessons from Japanese and United States Work Practices, Cutcher-Gershenfeld, et. al., 1998.

Y=F(X): Structure, Strategy and Process

Y = Effective Team-Based Work System

- **X = Strategy**
  - Teams and the business model
  - What are we optimizing:
    - Cost, Quality, Continuous Improvement, Involvement. . .
- **X = Structure**
  - Team size
  - Team leader role
  - Team member roles
  - Supervisor role
  - Support function roles
  - Internal and external customer and supplier roles
  - Team meeting time
  - Team problem-solving time
- **X = Process**
  - Team meetings
  - Daily team operations
  - Shift-to-shift hand-offs
  - Problem-solving process
  - Issue resolution process
  - Policy deployment process
  - Quality control process
  - Preventative maintenance process
  - Preventative safety process
  - Work re-design process
  - Value stream mapping process

Team Leader Role Exercise

You are a newly appointed production superintendent, committed to lean/ 6 σ transformation. On your first day in the work area, you are handed the following role definition for a team leader. How might this help or hinder you?

1. Plan, schedule and facilitate team meetings.
2. Facilitate communications between shifts and teams.
3. Solve problems using authority delegated.
4. Plan and coordinate team activities, ensure proper job rotation.
5. Plan and provide or arrange for team member training (OJT or classroom).
6. Promote safety, quality and housekeeping.
7. Promote and ensure constant improvement in the team (e.g., quality, cost and efficiency).
8. Obtain materials and supplies for the team.
9. Be knowledgeable of all operations within team, provide coverage for team members who are away from the work area (i.e., absent, relief, emergency, first aid, etc.)
10. Maintain team records, such as overtime scheduling/equalization, preventative maintenance, attendance, training, etc.
11. Participate in management meetings and communicate the needs of the team.
12. Participate in the evaluation of team members, however, does not have the final word.
13. Responsible for the morale and performance of the team.
14. Schedule vacation of group members.
15. Check on health and welfare of group members.
16. Encourage group to meet responsibilities.
17. Promote suggestion process.
18. Other tasks as determined by the work team.

Team Measurables

- Translate the following plant-level metrics into team-level metrics:
  - Safety
    - OSHA first-time visits
    - OSHA lost-time incidents
  - Quality
    - Average First-Time Through performance (FTT)
    - Top ten customer concerns
    - JD Power Quality Rating
  - Cost
    - Hours per “X” (x=plant’s primary product)
    - Performance to budget
    - New product launch performance to schedule
  - Maintenance
    - Operational Equipment Effectiveness (OEE)
    - Average Change-Over Time
  - Flow
    - Dock-to-Dock

Front-Line Leadership Capability and Motivation SPL 4.2

Craig Abler / Thomas Neal

Alumni/Mentor/Coach Lynn Delisle – Plant Manager

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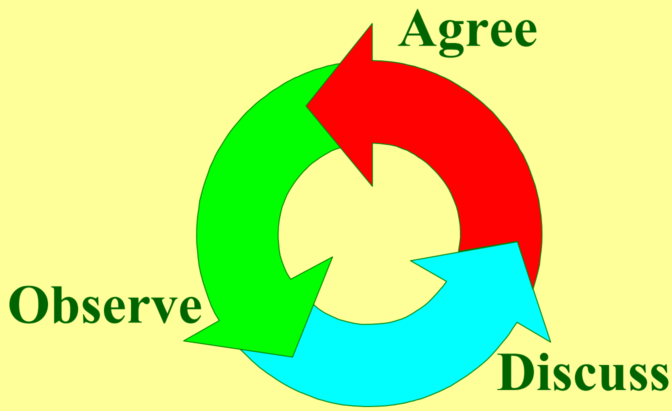
Coaching/Mentoring Cycle

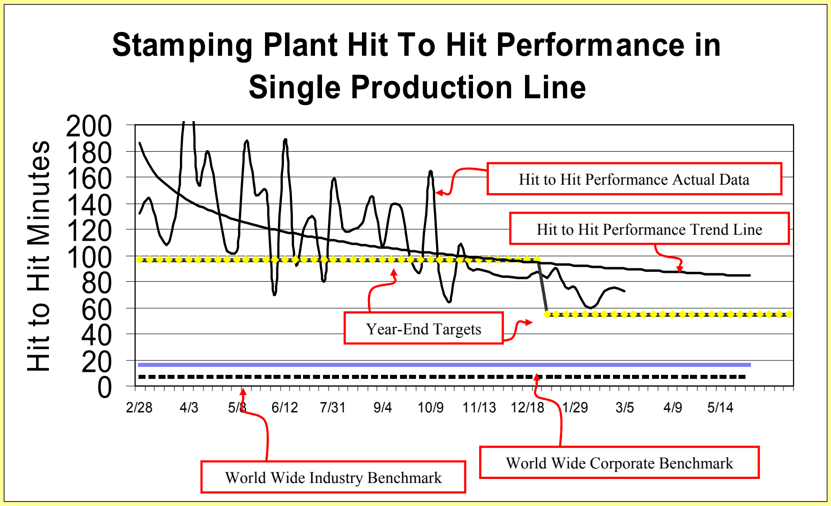


Source: *Valuable Disconnects in Organizational Learning Systems: Integrating the Bold Visions and Harsh Realities* by Joel Cutcher-Gershenfeld and Kevin Ford (Oxford University Press, forthcoming)

Front-line Leadership Illustrated (Slide 5 of 5)

- Utilizing Front-line Leadership (a real world story, concluded):
  - The morale of the story: CULTURAL CHANGE IS DIFFICULT; YOU NEED A GOOD LEADER
  - When you move into a lean cell structure, you can plan the 80% solution and "just do it" or you can plan the 100% solution and you'll never change. front-line leadership must be capable of working through the 20% that you couldn't foresee during the planning process. This is a much more difficult task for senior leads because all the little work rules that developed over the years must be re-established. When you change the way people work by rolling out a lean cell, something as simple as the placement of the coffee pot is a really big deal. These are the issues that will stop your initiative -- if you have a leader who can resolve them, great. If not, you must coach your leader. If your leader can't deal with the ambiguity of an 80% solution, you must step in.

Front Line Leadership Illustrated with Data



Note: This chart was on the wall in a work group meeting room (the organization's name has been masked). The reduction in variance around 11/13 corresponds to the addition of hourly work group leaders, hourly scrap representatives and committeepeople to the daily shift start meeting for the work group. Also, the Industry and Corporate Benchmarks are both in "Greenfield" Plants with newer presses designed for quick changeover. The reduction in variance and continued downward trend line after 11/13 provide a tangible indication of the way social systems can impact production operations.

Appendix: Instructor's Comments and Class Discussion on 4.2

- Key Enablers for lean/six sigma front line leadership:
  - Lean/six sigma knowledge
  - Career paths that reward success with lean/six sigma
  - Coaching and mentoring on lean/six sigma from direct management and skip-level management
  - Forums for dialogue and agreement appropriate to lean/six sigma (such as forums for ensuring prompt action on employee improvement suggestions)
- Important point: Good leaders can often keep people in positions—firing can may seem easier than coaching and helping people to grow, but what are the implications for the system?

Knowledge-Driven Work
SPL 4.3

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Presentation for:
ESD.60 – Lean/Six Sigma Systems
MIT Leaders for Manufacturing Program (LFM)
Summer 2004

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Diffusion of Knowledge-Driven Work Systems

Towards a theory of diffusion:

I. **Strategy**
   - **Piecemeal, Imposed, Negotiated**

II. **Structure**
   - **Primary, Secondary Reverse**

III. **Process**
   - **Knowledge-Driven**

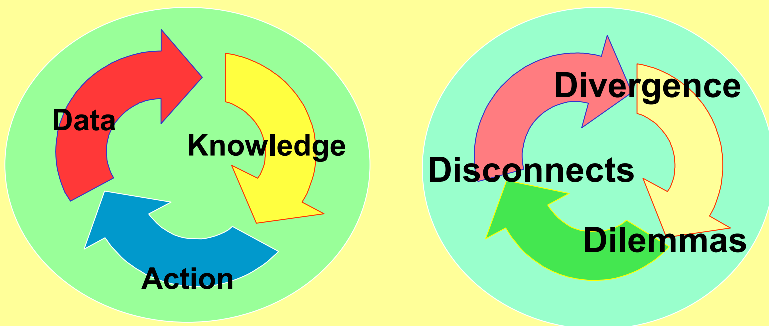
II. Structure -- An Example of Reverse Diffusion

トヨタ基本理念

Guiding Principles at Toyota

1) Be a company of the world
2) Serve the greater good of people everywhere by devoting careful attention to safety and to the environment
3) Assert leadership in technology and in customer satisfaction
4) Become a contributing member of the community in every nation
5) Foster a corporate culture that honors individuality while promoting teamwork
6) Pursue continuing growth through efficient, global management
7) Build lasting relationships with business partners around the world

Disconnects in Learning Systems



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Support Function Alignment
SPL 5.1

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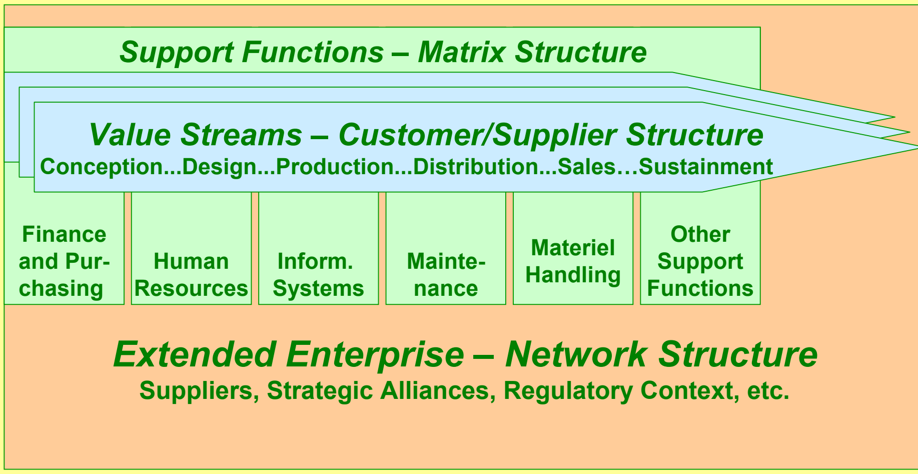
Enterprise Level: Customer/Supplier, Matrix and Network Structures to Support Lean Systems



Support-Function Analysis

- Three Potential Roles
  - Regulator/Enforcer
    - Policies, laws, contractual agreements
  - Service Provider
    - Administration of programs and activities
  - Change Agent
    - Systems change implementation and procedural fairness
- Sample Support Functions
  - Human Resources
  - Finance
  - Materials/Purchasing
  - Quality
  - Maintenance/ Engineering
  - Information Systems

Adapted from conceptual framework developed by Russ Eisenstat and further developed by Jan Klein.