Appendix: Instructor's Comments and Class Discussion

- Important issue in manufacturing leadership:
  - Presentation/outsourcing can be carried *too far!!*
    - Can result in loss of key knowledge and long term competitive advantage
    - Outsourcing is nice for price, and may lead to short-term economic efficiency, but long term cannibalization of competency
- Parts marketplace important for other parts of lean, such as ISPC and value stream mapping, etc.
  - It also depends on a PDCA, kaizen process
- Note that a parts marketplace is "necessary waste" until the supplier integration is more advanced

Heijunka
Product & Production Leveling
Module 9.3

Amy Reyner, Kweku Fleming

Mark Graban, LFM Class of '99, Internal Lean Consultant, Honeywell

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

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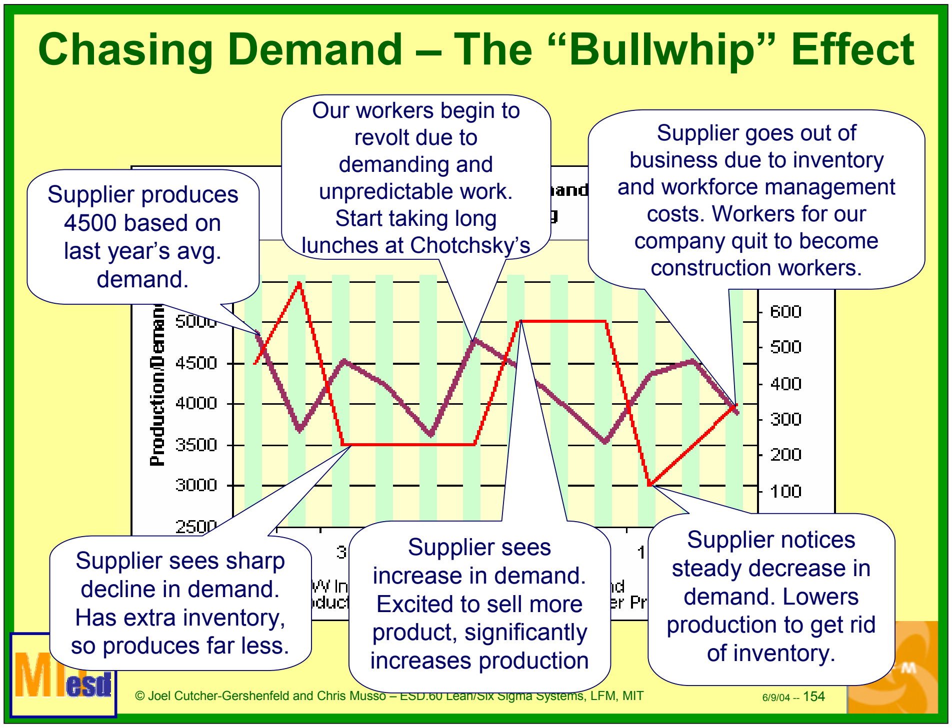
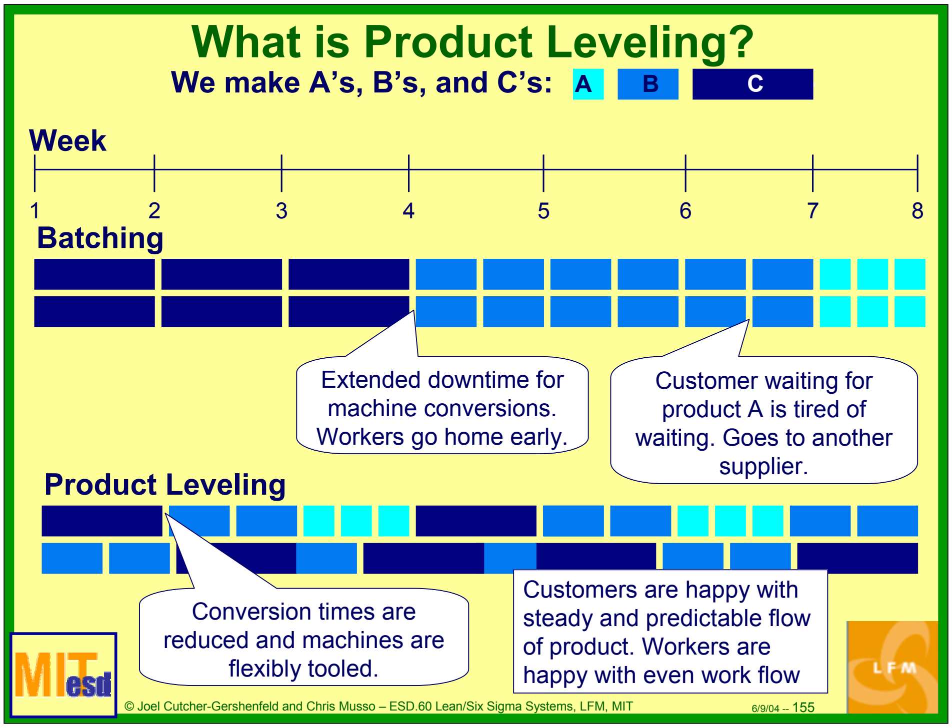
The Need for Heijunka

- There are a number of reasons for implementing Heijunka:
  - **Product Leveling**
    - large batches of the same product may reduce set-up times and changeovers, but usually result in:
      - long lead times,
      - swelling inventories
      - greater opportunities for defects.
      - excessive idle time and/or overtime.
    - An even ***mix*** of products is critical to avoiding these impacts
  - **Production Leveling**
    - Remember the "Beer Game"? Fluctuations in demand (Boller or "Bullwhip" Effect) are often highly amplified and delayed throughout the supply chain.
    - Responding to fluctuating customer demand can result in increased overtime or idle time.
    - Variable production schedules can be stressful = Unhappy workers.
    - A more ***level*** production volume eases these complications


Chasing Demand – The “Bullwhip” Effect
Supplier produces 4500 based on last year’s avg. demand.
Our workers begin to revolt due to demanding and unpredictable work. Start taking long lunches at Chotchsky’s
Supplier goes out of business due to inventory and workforce management costs. Workers for our company quit to become construction workers.
Production/Deman
5000
4500
4000
3500
3000
600
500
400
300
200
100
Supplier sees sharp decline in demand. Has extra inventory, so produces far less.
Supplier sees increase in demand. Excited to sell more product, significantly increases production
Supplier notices steady decrease in demand. Lowers production to get rid of inventory.
© Joel Cutcher-Gershenfeld and Chris Musso – ESD.60 Lean/Six Sigma Systems, LFM, MIT
6/9/04 -- 154


What is Product Leveling?
We make A's, B's, and C's:
A
B
C
Week
1
2
3
4
5
6
7
8
Batching
Extended downtime for machine conversions. Workers go home early.
Customer waiting for product A is tired of waiting. Goes to another supplier.
Product Leveling
Conversion times are reduced and machines are flexibly tooled.
Customers are happy with steady and predictable flow of product. Workers are happy with even work flow
© Joel Cutcher-Gershenfeld and Chris Musso – ESD.60 Lean/Six Sigma Systems, LFM, MIT
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Challenges for Heijunka

Technical Factors

- Tools needed for large-scale Heijunka Leveling are often lacking.
- With Heijunka, there is a need for larger Finished Goods Inventory. This can be seen as antithetical to Lean mission.
- Obsolescence of finished parts
- Can not immediately be implemented– requires predictable environment, customer data.
- Predicting demand is imperfect. Bad data can ruin process.

Social Factors

- Heijunka depends on Direct customer contact and accurate information about projected (future) events.
- Explaining why it's important to do standardized work before implementing HJ.
- Reduces operator flexibility which can draw resistance
- Requires discipline and much more planning

Concluding Comments

- If **Takt time** is described as the *heart beat* of Lean implementation, then **Heijunka** is the ***deep breathing exercise*** of Lean that brings stability (calm) to the manufacturing process, spreading it upstream to internal and external suppliers.

- " Heijunka, You won't be **HAPPY** without it!"[2]

[2] The Toyota Production System: Leaner Manufacturing for a Greener Planet. Published 1998,

Appendix: Instructor's Comments and Class Discussion for 9.3

- Heijunka reveals the limits of the label "lean" and points to a knowledge-driven process for ensuring stability, flow and pull
  - It is still about ensuring the customer has what they want, when they want it at the price they are willing to pay
- Consider the level at which Heijunka expertise needs to be established – plant-wide, departments, individual work areas?
- Most lean operations strike a balance between product leveling and production leveling
  - "Good not to have inventory, good to meet demand, but there really is some balance between the two"
- Worker happiness is an important measure of heijunka success
- Heijunka requires a lot of data, and can be tough to deal with
- Heijunka is not necessarily useful for businesses with level and dependable demand.

Kaizen-Teian Improvement Systems
Module 10.1

Yue Cathy Chang (LFM ’06)
Johnson Wu (LFM ’06)

Mr. Scott Roodvoets (LFM ’91, Algonquin Automotive)

Presentation for:
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MIT Leaders for Manufacturing Program (LFM)
Summer 2004

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YC

What is Kaizen-Teian?

- 改善 (Kaizen): improvement
- 提案 (Teian): proposal
- Characteristics of Kaizen-Teian:
  - Gradual and continuous accumulation of small improvements
  - Focus on team of collaborators (vs. team of experts/consultants), engage the entire workforce
  - Promote a maintained progress (vs. lack of continuity)
  - Implement incremental improvements in small steps (vs. big leaps)
  - Is a building block of a typical lean organization. (The other building block is identifying waste in operations.)
  - Typical setting: a small team of 8-20 people from all levels and functions/departments of the organization identifying, analyzing, and implementing a project in a matter of 4-5 days.

JW

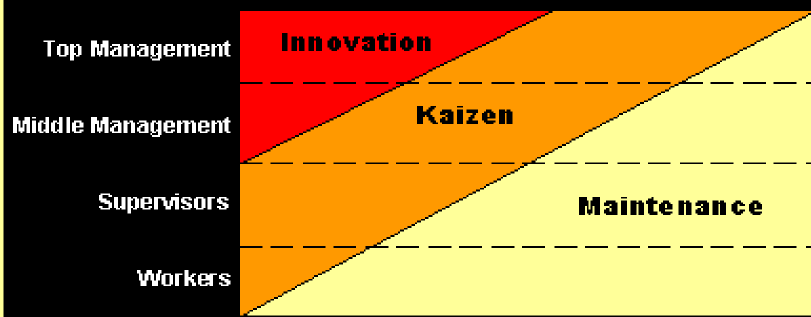
Kaizen-Teian vs. Business Process Reengineering

Kaizen-Teian (“Improvement Proposal”)	Business Process Reengineering
• Incremental, long-term improvement process driven by workforce • Empowers workers who are closer to the process and build unity in organization • Benefit from the insight of those closest to the process • Not as disruptive • Workforce may only achieve “local optimum” but not “global optimum” • Process being improved might be inherently “flawed” • Difficult to engage everyone in the organization	• Big change: enabling element to get on the next “S” curve • Lead by example: management is willing to change • See the entire system: avoid negative outcome of seemingly unrelated local improvements that are in fact related • Drastic changes are not easy • “Push” system: not necessarily customers-focused and may undermine organizational identity • May results in layoffs that might “chill” participation

Adapted from ESD.60 Systems Change Debate Results on 6/14/2004

YC

Job Functions as Perceived by Japanese Managers



Innovation – drastic improvements in current processes
Kaizen – small continuous improvements in current processes
Maintenance – activities directed to maintaining current technological, managerial, & operating standards

1000ventures.com

Adapted from www.1000ventures.com

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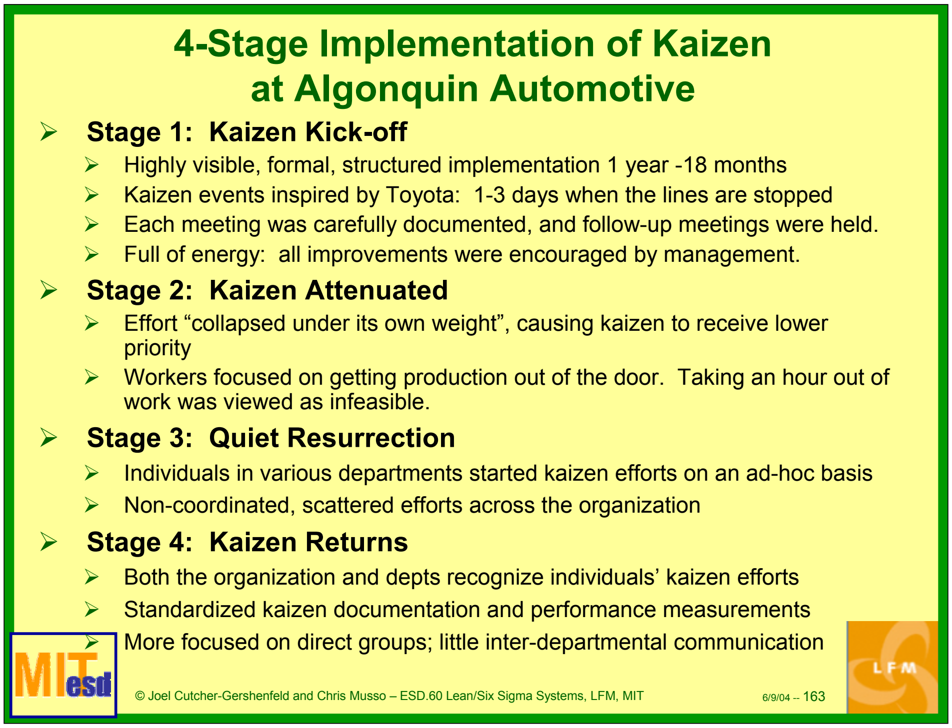
JW



•YC

•Stage 1: Push

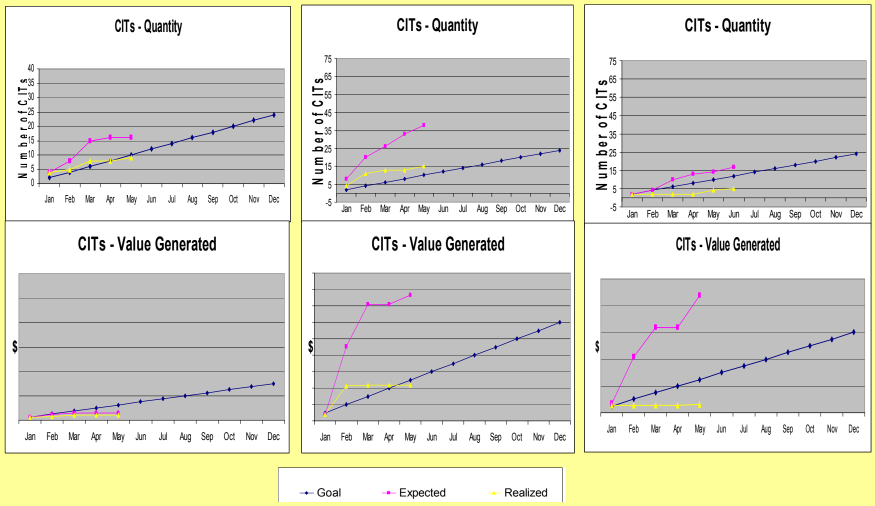
•Stage 2: Push force weakens, Toyota’s kaizen consulting group disassembled. Energy level and focus of the organization, especially management and supervision, weakens.

•Stage 3: Pull

•Stage 4: Balance of Pull and Push

Measurements: # of Ideas vs. Value Generated

Site 1: **Site 2:** **Site 3:**



Gap between expected value and realized value reflects the timing delay of kaizen proposal implementation

JW

Common Disconnects/Roadblocks in Kaizen Implementation

- **Technical Factors**
  - **Little visible technical impediment on kaizen.**
  - **Measurement metrics for kaizen efforts.**
- **Social Factors**
  - **Overly formalizing the kaizen process will collapse the improvement program.**
  - **Competition between departments on kaizen can be both positive and negative.**
  - **Negative workers-management friction will impede the kaizen process.**
  - **Lack of management commitment to kaizen can impede the improvement program.**

The constraint is not technology, it's governance.
--Thomas Homer-Dixon

JW

The quote by Thomas Homer-Dixon is from the "Lean Production Simplified" textbook.

Appendix: Instructor's Comments and Class Discussion for 10.1

- Supporting IT infrastructure is important for tracking suggestions and delivering metrics
- Re-engineering often punctuates successful kaizen programs, because incremental learning can "max out" the existing system
- Dollar values are not always the best metric for kaizen
  - 80% of suggested improvements at one auto parts factory were "intangibles"—but were important in their own right and they were necessary to build suggestion-making capability
- PDCA should be done on all suggestions—but from the bottom up.

Hoshin Planning / Policy Deployment
Module 10.2

Ian MacDonald - LFM '06
Howard Shen – LFM '06

Erik (Skip) Smith, Intel Corporation – LFM '03
Brad Lammers, Ford Motor Company

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

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What is Hoshin Planning?

Hoshin (def.) – A statement of desired outcome for a year, plus means of accomplishing that outcome, and for measuring the accomplishment. [3]

"Hoshin Kanri" [1]

- Shining metal or compass
- Ship in a storm on the right path
- Strategic policy deployment

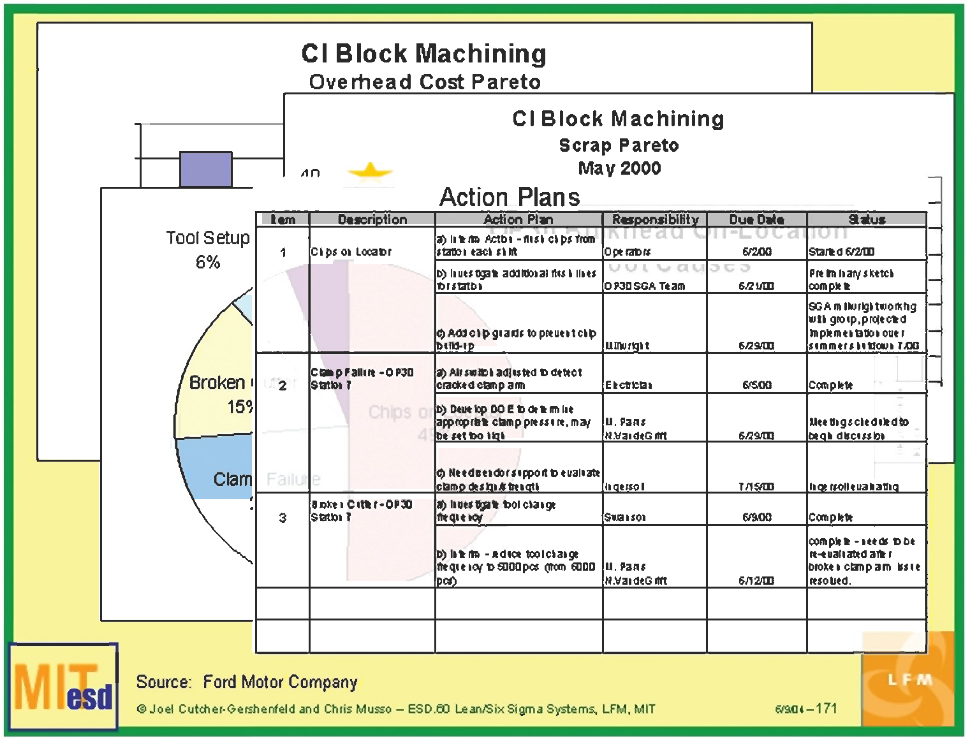
Hoshin Planning (def.) – The process used to identify and address critical business needs and develop the capability of employees, achieved by aligning company resources at all levels and applying the PDCA cycle to consistently achieve critical results.[1]

Plant Level Key Indicator Board

Source: Ford Motor Company

Team Level Key Performance Indicator Board

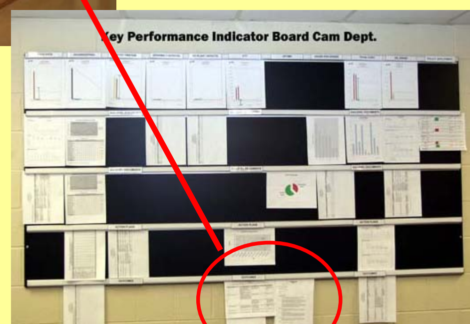
Source: Ford Motor Company



Item	Description	Action Plan	Responsibility	Due Date	Status
1	Chips on Locator	a) Interim Action - flush chips from station each shift	Operators	6/2/00	Started 6/2/00
		b) Investigate additional flush lines for station	OP30 SGA Team	6/21/00	Preliminary sketch complete
		c) Add chip guards to prevent chip build-up	Millwright	6/29/00	SGA millwright working with group, projected implementation over summers shutdown 7/00
2	Clamp Failure - OP30 Station 7	a) Air switch adjusted to detect cracked clamp arm	Electrician	6/5/00	Complete
		b) Develop DOE to determine appropriate clamp pressure, may be set too high	M. Paris N.VandeGrift	6/29/00	Meeting scheduled to begin discussion
		c) Need vendor support to evaluate clamp design & strength	Ingersol	7/15/00	Ingersoll evaluating
3	Broken Cutter - OP30 Station 7	a) Investigate tool change frequency	Swanson	6/9/00	Complete
		b) Interim - reduce tool change frequency to 5000 pcs (from 6000 pcs)	M. Paris N.VandeGrift	6/12/00	complete - needs to be re-evaluated after broken clamp arm issue resolved.

Source: Ford Motor Company

Direct Linkage from SGA Actions to Plant Performance Indicators !



Source: Ford Motor Company

Performance Planning: Intel's Fab 11-X Facility

- Intel does not use Policy Deployment in Fab 11-X
- Intel Corporate does use a similar process
- Why would Intel not have a process to deploy initiatives and projects in the plant?
  - The necessity for complete standardization – "Copy Exactly"
  - Cannot tolerate process changes without complete top-down control
  - Entire groups dedicated to developing improvements and innovations in manufacturing processes
  - Short Clockspeed – benefits from in-the plant improvements are not significant, breakthrough improvements are needed.
  - Huge market share – market is not sensitive to improving "the little things"

Disconnects

- Technical Factors
  - Forms, meetings, and protocol add to the administrative overhead.
  - Perfect information flow from lower levels is difficult.
  - Financial costs associated with implementation of Hoshin methods.
  - Proactive hoshin planning is more difficult than reactive planning.
- Social Factors
  - "Policy Deployment" is often misinterpreted as a way of telling people how to do their jobs.
  - Implementation would mean a change in the culture of the company.
  - Formality of forms and protocol may foster sense of distrust between managers and employees or working groups.

Appendix: Instructor's Comments and Class Discussion for 10.2

- Implementation of Hoshin-Kanri is never a one-time event – each year the quality of the catch-ball and the reach to front-line operations is improved
- Note the connection between Hoshin-Kanri and regular forums or meetings – were progress on the metrics is tracked and addressed
- Thing to look for in a hoshin board:
  - Are the charts current? (if not, they are for show)
  - Is there subdata that's being used for root cause analysis? (if so, they are living the hoshin)
- Hoshin may not be practical with fast clockspeed industries
  - Faster clockspeed often requires better coordination—best done from top down
- Annual hoshin does not mean that the overall mission of the organization will change every year

ERP/MRP
Module 10.3

Ray Fung, LFM 06
Malia Schoch-Rodriguez LFM 06

Chip McDaniel LFM 96, Ford
Joseph Kowalski LFM 96, Ford

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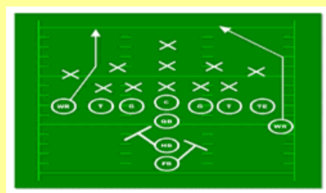
What is ERP?

- Enterprise Resource Planning
- Computer Software, again, either homegrown or commercial
- Manages all business activities - Production, Sales, Procurement, Finance, Supply-chain, Human Resources, etc.
- Promises to reduce waste, improve efficiency, provide greater visibility into your company's health, etc. etc. etc.

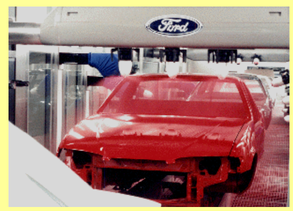


Application at Ford

- In-Line Vehicle Sequencing (ILVS)
  - Moving from a batch system of manufacturing to a "real-time" system circa 1994
  - Allows suppliers to provide parts IN SEQUENCE within hours of assembly → parts produced "Just in Time"
  - Ford centers around a 6-day fixed sequence
    - ERP system is critical in this process. This system shows suppliers real-time data on where Ford is in their assembly sequence, and thus the suppliers can plan their schedule and resources based on this data.
  - Cost savings found at Ford (less inventory/more floor space)
  - Ford also saw an improvement in overall quality of parts received from suppliers
    - This came from the shorter interval between delivery and assembly; allowed any defects from the supplier to become more visible and detrimental to Ford's assembly process

ILVS and Ford

- Dave Myron (LFM '96) did a thesis on an example of the ILVS system applied to painting cars:
  - Many believe "Paint Blocking" and ILVS do not go hand in hand
  - This practice allows multiple vehicles of the same color to be in series, a.k.a. batch painting (block sizes = 3-5)
  - Benefits of Paint Blocking were saved time (and thus $) in nozzle cleaning and changeover to next color
  - The dilemma was how to incorporate this in parallel with the sequence system that was implemented…
  - A buffer between the paint shop and trim was needed

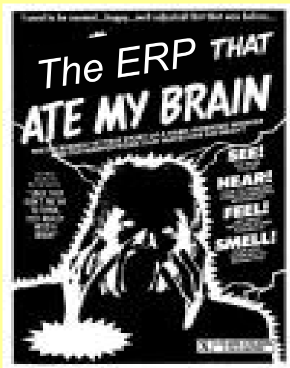


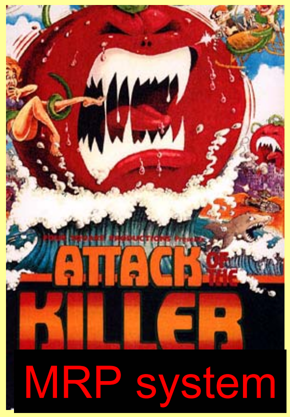
[Internal Disconnects]

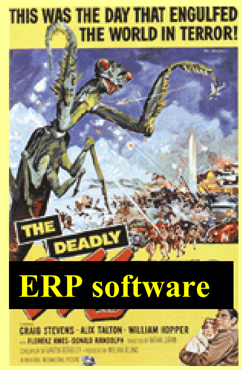
- ERP/MRP is not "Superman"
  - ERP/MRP is not really Jonah from "The Goal"
  - They can't do everything
  - Can be inflexible
  - They're not infallible
  - They're tools, nothing more, nothing less, so they're only good as your implementation
  - Reinforces existing politics – "shoot the messenger"

Disconnects, summarized

- Stories abound of bad ERP/MRP implementations that have wreaked havoc on the industry
- Must be careful how you implement ERP/MRP, otherwise your company will actually become “stupider”







Appendix: Instructor's Comments and Class Discussion for 10.3

- ERP/MRP initiatives can be a threat to lean/six sigma initiatives in that they soak up limited support resources for large-scale systems change
- ERP/MPR initiatives can be a complement to lean/six sigma initiatives in that they provide essential IT infrastructure – particularly from a jidoka standpoint
- Unfortunately, many ERP/MRP initiatives are not designed to adjust on the basis of PDCA, Kaizen improvement processes
- ERP/MRP cannot make up for bad business processes
  - If fused properly to business processes, ERP/MRP can be strategic tools enabling business success

Design For Manufacturing
Module 10.4

José Luis Landívar Chávez & Ade Obatoyinbo

Chip McDaniel, Ford Corporation

Presentation for:
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Motivations for DFM

- Cost of producing could be halved by applying DFM at the concept phase [1]
- Opportunity to influence the price of a new product is greatest early in the life cycle (70% manufacturing costs are determined before design) [2]

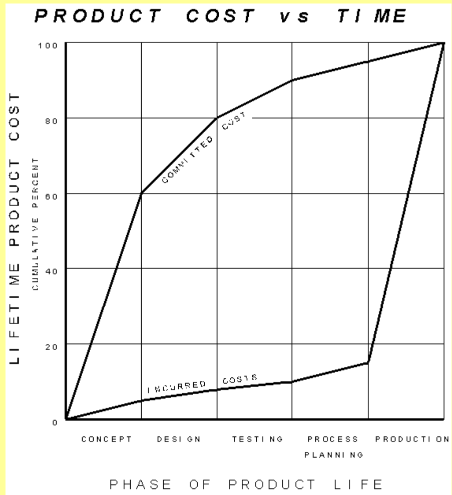


Diagram of cost vs time [1]

The 70% is data for the electronics industry as explained in [2].

TTM?

Lead time?

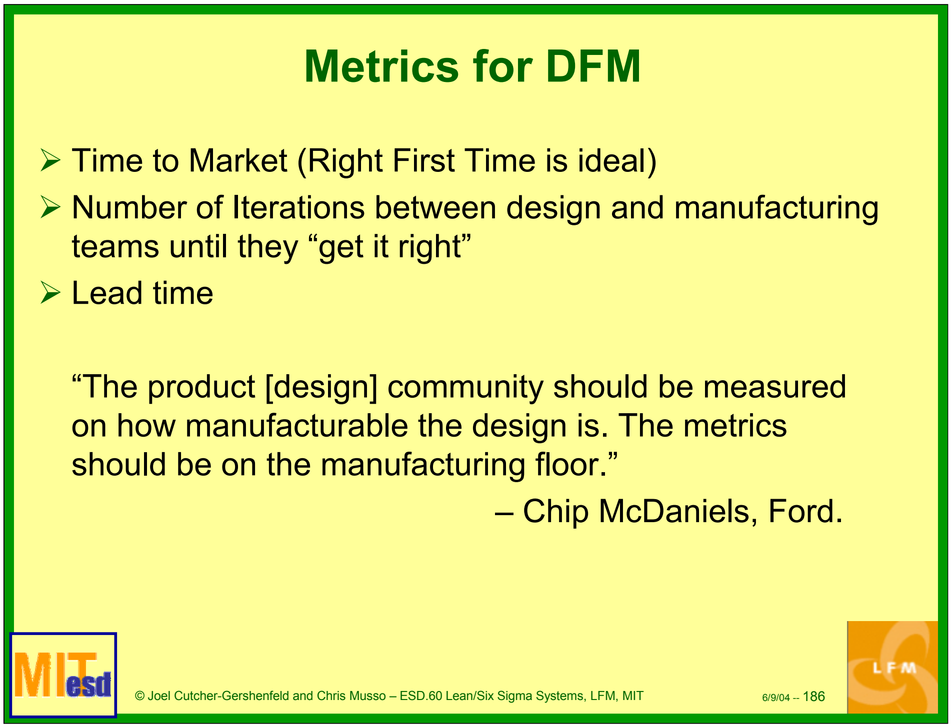
DFM Guidelines

- Use standard components
- Minimize number of parts
- Develop modular, multi-functional, multi-use designs
- Consider tolerance for variations in process (portability)
- Keep in mind current process capability
- Design for ease of handling
- Recognize design testability is a requirement for manufacturability
- Involve the manufacturing team in each of the above

This is a general process for electronics and automobile industries. There are other considerations to keep in mind such as “avoiding separate fasteners” which only apply to certain industries.

If you can’t test your design, you can have the most wonderful design in the world but won’t be able to sell it because you don’t know if it’s defective.

Manufacturing team can have input from previous failures and feed that information back to the design team.



We have been unable to gather hard data regarding TTM, Lead time or number of iterations. Perhaps this is due to the nature of this data and the competitive relevance.

In general you can evaluate DFM performance on the basis of the performance on the DFM Guidelines.

DFM Examples

- In the design of microelectronics, memories tend to have manufacturing defects which affect yields. A DFM oversight can lower the yield of the chip critically. If designers would have had manufacturing in mind, they could have included a suitable amount of redundancy to cover for the defects. Every redesign/workaround could cost the company over $1M and 12 weeks turnaround.
- In the design of complex communication modules at HRL Laboratories, regular meetings are scheduled between design and manufacturing (process) engineers to hash out the capability in the clean room and make sure designers do not send impossible masks to the clean room for production. It is not unusual to have up to 8 formal and informal meetings with the process engineers through a 10 week design cycle!

Disconnects

➢ Technical Factors

- Lack of data/knowledge from manufacturing floor
- Portability of design between different manufacturing facilities using different equipment
- Physical proximity of design and manufacturing centers

➢ Social Factors

- Design engineers see DFM as an afterthought
- Lack of support for DFM from upper management
- Different measures of performance for design engineers and manufacturing engineers causes adversary relations

In Toyota (best in DFM), design engineers ARE manufacturing engineers. In Ford, they are policed!

Appendix: Instructor's Comments and Class Discussion for 10.4

- DFM extends beyond concurrent engineering
  - Includes principles of sustainability, low cost manufacture, etc.
- Major dichotomy in DFM: pressure to integrate design process v. business pressure to disperse supply chains
- Early changes (and therefore lock-in) are *not* better if many unknowns exist—can make later changes too expensive
- Physical proximity of design teams is very important for concurrent design
  - "Best success stories in DFM involve co-location"
    - Chrysler Design Center, BMW Munich

Performance Metrics
Module 10.5

Krishnan Raghunathan / Linsey Rubenstein
Michael Miller, Amazon

Presentation for:
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Metrics Drive Behavior

- Based off of a true story from Continental Airlines after bankruptcy in 1990's
- Cost cutting became the major company strategy
- Airline rewarded pilots for keeping fuel consumption low
  - Behavior - Pilots skimping on air conditioning and flying more slowly
  - Performance - Unhappy customers and behind schedule flights
  - Results - Valuable customers moved on to competitors

Lesson 1: "What gets measured gets done." Metrics drive behavior, both good and bad.

Amazon's Corporate Score-card

Key Goal: Make online shopping preferred mode for all types of goods

Fast and Free shipping for all types of products

- Customer
  - Failed Fast Track
  - Order cycle time mean and standard deviation
- Cost/Unit
  - Throughput per labor hour
  - Units shipped per labor hour
- Quality
  - Inventory Record Defect Rate
- Operations
  - Received and Shipped units and backlog
  - Ex (S&OP adherence)
- Safety
  - Lost Time Incidents and Rate
  - Record-able Incidents and Rate
- Other Financial and Vendor negotiation metrics

Lesson 2: Metrics must be holistic and align with the business strategy

Scorecards can be applied for day to day operations as well

•Shop floor score cards

• Example of balance scorecard at shop floor: Amazon warehouse workers has to maintain both a good pickup time (orders picked from inventory) and cycle time per order and they both have opposing needs.

Traditional vs. Lean Metrics

Complex, low volume assembly in aerospace

TRADITIONAL → **LEAN**

TRADITIONAL

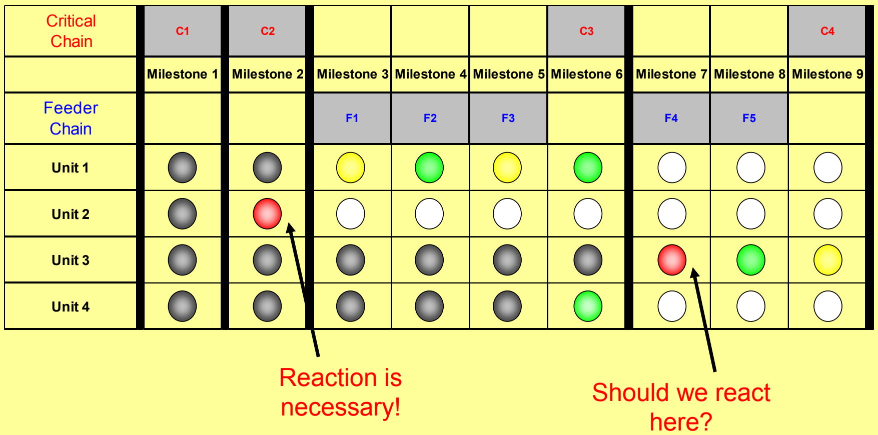
- Jobs behind schedule metrics
  - Focus on accountability and individual performance
  - Assumes every job is equally important
  - Assumes individual efficiency drives overall performance
- Behavior using traditional metrics
  - Perform "easy" jobs first to improve metric (temporarily)
  - Out-of-sequence work
  - "I completed my work…why should I help someone else"
  - Focus on every problem

LEAN

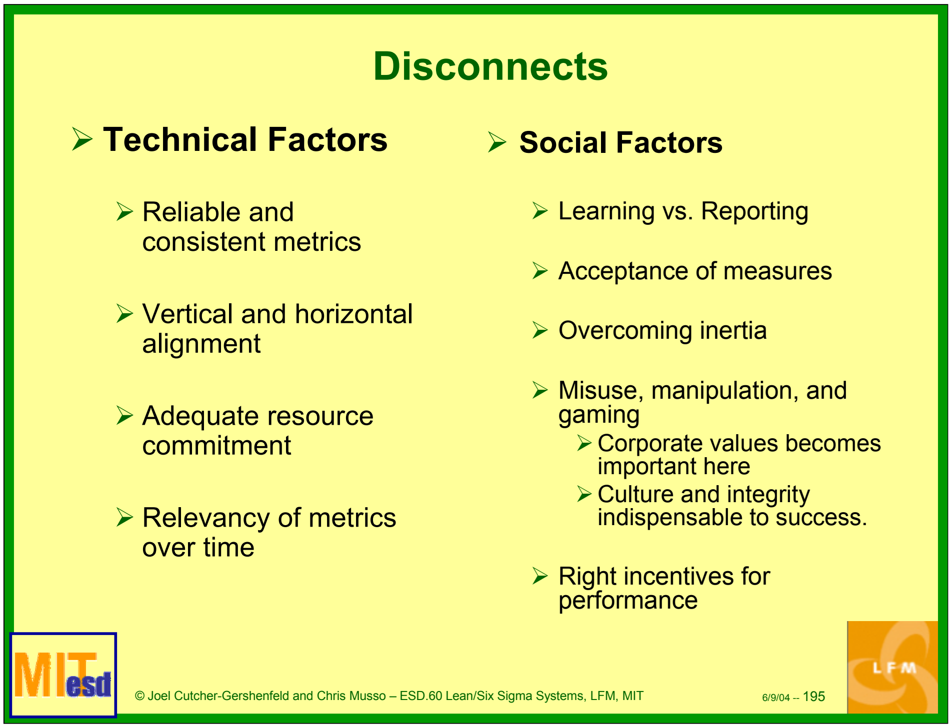
- Flow metrics
  - Focus on global rather than local optimum
  - Assumes some jobs more critical than others
  - Assumes team drives overall performance
- Behavior using lean metrics
  - Work jobs in optimal sequence
  - Identify gaps in skills
  - Teamwork
  - Focus only on problems that impact overall performance

Lean Metrics – An Example

Complex, low volume assembly in aerospace



Lean metrics help management make decisions….



Reliable Metrics : Accurate, Actionable and Timely

Consistent Metrics

Avoid confusing requirements and expectations internal and external - Balanced Score card

Vertical and Horizontal alignment

"Catchball" process to deploy metrics to all levels.

Adequate Resource commitment

Manpower, Money, Facilities and Training

Evaluate relevancy over time

Life Cycle management for metrics

Learning vs reporting

Process indicators as diagnostic data, but do not optimize the system to these measures.

Acceptance of measures

Don't know why

Don't know how metrics fit into big picture (correlation to end result)

Overcome Inertia

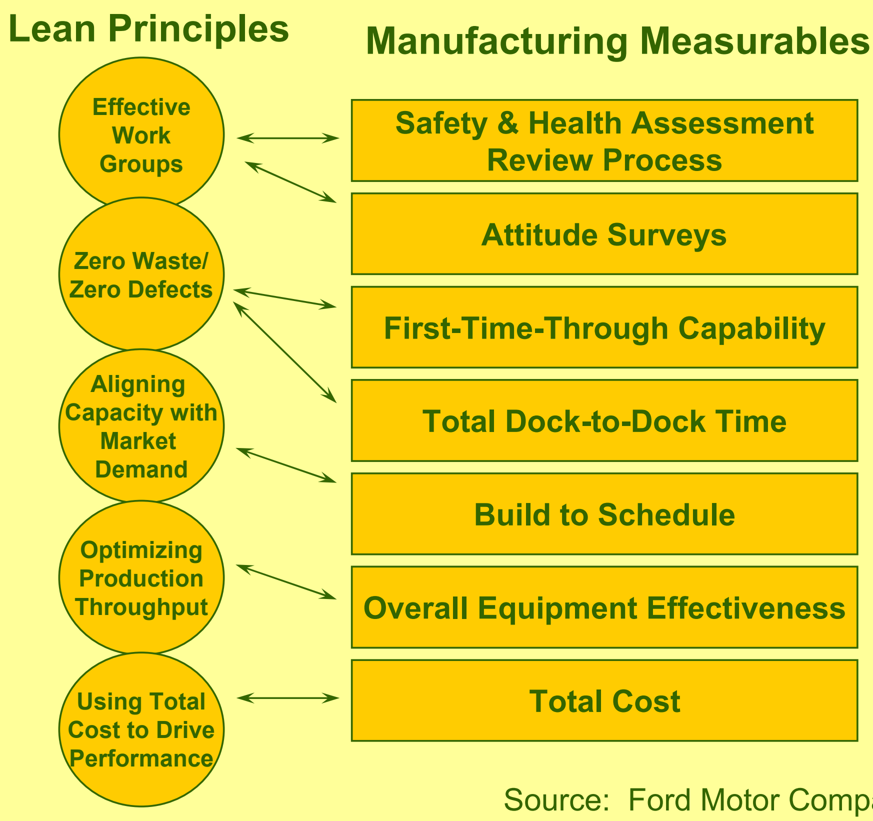
Accountability issues

Metrics are mis-used, manipulated, and gamed

They can be manipulated and used to justify present processes

Right Incentives for performance

Linking Lean Principles and Manufacturing Measurables



Source: Ford Motor Company

Source: Ford Motor Company

Build To Schedule -- What is it?

- ***In Plain Words:***
  - A way of knowing if you built the right parts, in the right quantity, in the right order
- ***A Formal Definition:***
  - Percent of units scheduled for a given day that are built on the correct day, in the correct quantity and correct mix

BTS = **Volume x Mix x Sequence**

Build To Schedule -- Why use it?

- ***Lean Principle:***
  - Aligning Capacity with Market Demand

- ***BTS can help. . .***
  - Keep changes in volume or mix from swamping or starving departments upstream or downstream
  - Operate with smaller “floats” -- which increases the need to track BTS
  - Respond to customer demand for “in-line vehicle sequencing” -- which requires BTS

Sample Lessons from Build To Schedule Data -- Volume

Overbuilding here -- probably done to achieve central performance goals; probably used up more float than expected from feeder departments

No credit for more than 100%

Volume Performance			
Week of:	Pieces Scheduled	Pieces Produced	%
6/2/99	14,650	16,303	100%
6/9/99	16,990	17,317	100%
6/16/99	16,380	15,755	96.18%

Source: Visteon Company

Sample Lessons from Build To Schedule Data -- Mix

Even with overbuilding, we did not make the mix -- so we are not serving customers and using excess resources

Mix Performance			
Week of:	**Pieces Scheduled**	**Pieces Produced**	**%**
6/2/99	14,650	13,425	91.64%
6/9/99	16,990	14,798	87.10%
6/16/99	16,380	11,662	74.02%

The mix is now way off -- we are feeling the effects of the overbuilding

Source: Visteon Company

Sample Lessons from Build To Schedule Data -- Overall Performance

As a components manufacturing plant, we have an exemption on measuring sequence performance

The performance trend is deteriorating rapidly -- all due to the way volume and mix are managed

Build To Schedule				
Week of:	Volume %	Mix %	Seq %	BTS %
6/2/99	100%	91.64%	100%	91.64%
6/9/99	100%	87.10%	100%	87.10%
6/16/99	96.18%	74.02%	100%	71.20%

Source: Visteon Company

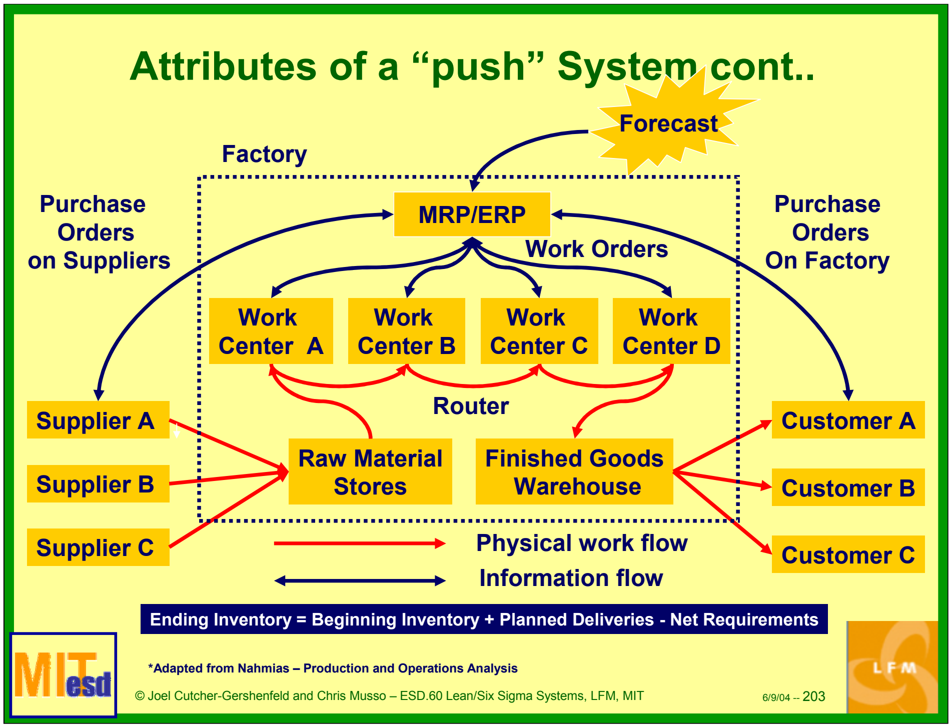
Forecast "push," customer "pull," and hybrid models
Module 11.1

Bruce Pan, LFM '06
Nicholas Svensson, SDM '03

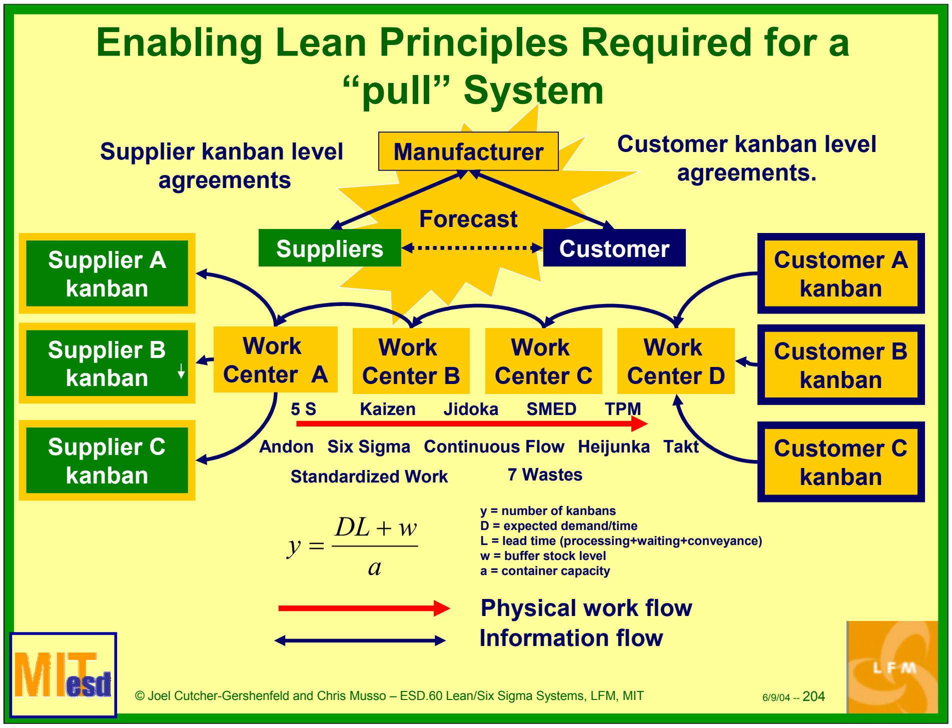
Toni Albers, LFM '00 - Honeywell

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

These materials were developed as part of MIT's ESD.60 course on "Lean/Six Sigma Systems." In some cases, the materials were produced by the lead instructor, Joel Cutcher-Gershenfeld, and in some cases by student teams working with LFM alumni/ae. Where the materials were developed by student teams, additional inputs from the faculty and from the technical instructor, Chris Musso, are reflected in some of the text or in an appendix



Extreme case of push system with centralized decision making and little to no communication between the various stakeholders. This is an extreme example intended to highlight the unique differences between push and pull.



Communication is at the working level. Forecast is used to form consensus amongst stakeholders (customer, supplier and manufacturer) about the capacity of the system and the levels of kanban to maintain. Note kanbans are owned by the supplier in each case.

Push vs. Pull

Push Strength

- general approach
- MRP/ERP software available
- Better reaction to forecast changes by anticipating demand pattern.
- Advocates say it works.

Pull Strength

- Focus on removing waste.
- Root cause corrective action.
- Minimizes WIP.
- Hands on management.
- Use of visual queues.
- Less expensive to implement

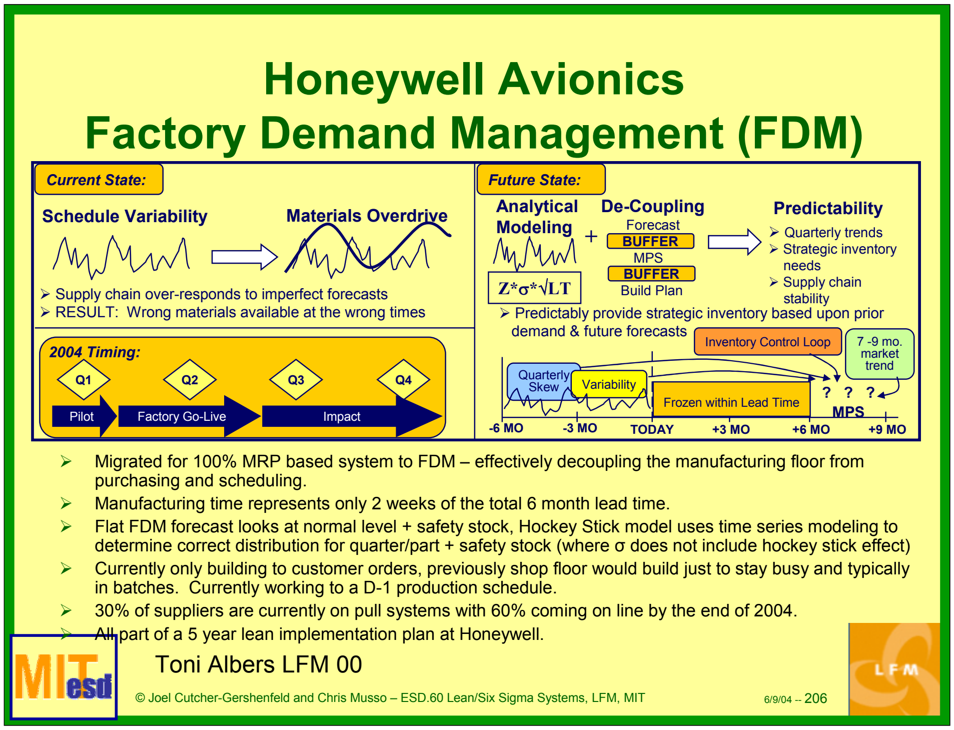
Push Weakness

- Capacity planning
- Data integrity and training
- Forecast uncertainty
- System nervousness
- Masks underlying problems.
- Authority delegated to computer.
- More expensive to implement

Pull Weakness

- Pushes inventory onto suppliers.
- Longer reaction time to changes in demand.
- Multi-sourcing more difficult.
- Requires higher supplier reliability and agility.
- Ignores future demand patterns

*Adapted from Nahmias – Production and Operations Analysis



Explanation of Honeywell's use of a new algorithm to better determine demand for their hybrid pull process.

Push/Pull system disconnects

Technical Factors

Push
- MRP/ERP complex
- Data integrity critical
- Sys nervousness issue
- Decision-making delegated to computer

Pull
- Requires multi lean factors to be in place
- Requires highly dependable suppliers
- Serial communications

Social Factors

Push
- Worker disengagement
- Root cause difficult to ascertain
- Workers not idle
- Relies on a single function group for execution

Pull
- Job security
- Heavy reliance on upstream processes and groups
- Metrics alignment critical

Some of the more common disconnects typically caused when the systems undergo dynamic change or have to deal with uncertainty. With either system it isn’t practical to discuss any aspect of change until stability has been reached. This is the first and most important consideration for both systems. How stability is achieved is based on the business realities of each company.

Appendix: Instructor's Comments and Class Discussion on 11.1

- Goal of activity: show that both pull and push can achieve similar results
  - The difference lies in how each deals with unexpected developments (prevention and reaction)
- True optimization comes from hybrid in most cases

Lean Enterprise Alignment
Module 13.1

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Executive Director, MIT Engineering Systems Learning Center

Presentation for:
ESD.60 – Lean/Six Sigma Systems
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"Islands of Success" from *Lean Enterprise Value: Insights from MIT's Lean Aerospace Initiative*

C-130J production
- Throughput of extrusion shop from 12 days to 3 minutes

Automatic code generation
- 40% reduction in time
- 80% improvement in quality

Military electronic modules from commercial lines at TRW
- 73% cost reduction

F-16 Build-to-Print Center
- 75% cycle time reduction

777 floor beam
- 47% assembly time reduction

P & W General Machining Center
- 67% reduction in lead time

Delta IV launch vehicle
- 63% reduction in floor space

GE Lynn aircraft engine facility
- 100% on time deliveries

Joint Direct Attack Munition (JDAM)
- 63% reduction in unit cost

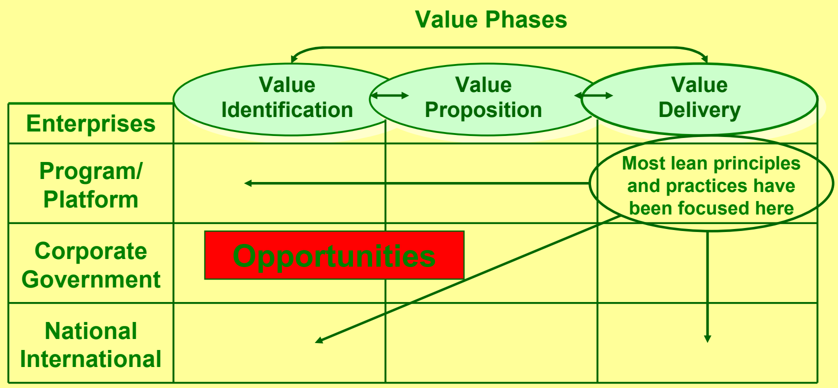
Source: Lean Enterprise Value: Insights from MIT's Lean Aerospace Initiative by Earll Murman, Thomas Allen, Kirkor Bozdogan, Joel Cutcher-Gershenfeld, Hugh McManus, Deborah Nightingale, Eric Rebentisch, Tom Shields, Fred Stahl, Myles Walton, Joyce Warmkessel, Stanley Weiss, Sheila Widnall, (Palgrave,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

Initial Evidence at the Enterprise Level

- F-16 maintained sales price and decreased order-to-delivery time by up to 42% while production rate decreased 75%
- C-17 unit priced decreased from $260M to $178 M for final 80 aircraft of 120 aircraft buy.
- Northrop Grumman ISS lean enterprise implementation reduced throughput times for major systems by 21 to 42%.
- F/A18-E/F EMD completed on time, within budget (without rebaseline) while meeting or exceeding performance requirements.
- Raytheon realized $300M FY 2000 bottom line benefits from its enterprise wide Six Sigma program

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)

Value Creation and Levels of Enterprise



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)

Additional Detail on Lean Enterprise Value

Again, the focus of most lean initiatives → III. Value Delivery

Enterprise Levels	I. Value Identification	II. Value Proposition	III. Value Delivery
Program Enterprise	**Aim:** Identify value-add opportunities for customer and end users; Assess implications for other key program stakeholders	**Aim:** Construct a mutual gains agreement on value to be delivered among program acquirer, contractor, suppliers and others; Align incentives to focus on stakeholder value	**Aim:** Implement lean principles and practices across the value stream — including product development, manufacture and sustainment (termed 'Lifecycle Processes' in Figure 6.50)
Multi-program Enterprise	**Aim:** Identify value-add synergies across programs; Assess implications for internal and external stakeholders — including strategic partners, the financial community, and others	**Aim:** Construct mutual gains agreements to develop current and future capabilities across the enterprise; Align enterprise incentives to prevent sub-optimization across programs	**Aim:** Align enterprise support systems to enable lean implementation across multiple value streams — including information systems, financial systems, human resource systems, and others
National Entreprise	**Aim:** Identifying incremental and breakthrough opportunities to advance the four core missions for the national aerospace enterprise	**Aim:** Establish overall system incentives to simultaneously ensure stability and foster innovation for the national enterprise	**Aim:** Establish flexible, robust institutional infrastructure oriented around ensuring current and future capability

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)

Key Principles

Principle 1

- **Create lean value by doing the job right *and* by doing the right job.**

Principle 2

- **Deliver value only after identifying stakeholder value and constructing robust value propositions.**

Principle 3

- **Fully realize lean value only by adopting an enterprise perspective.**

Principle 4

- **Address the interdependencies across enterprise levels to increase lean value.**

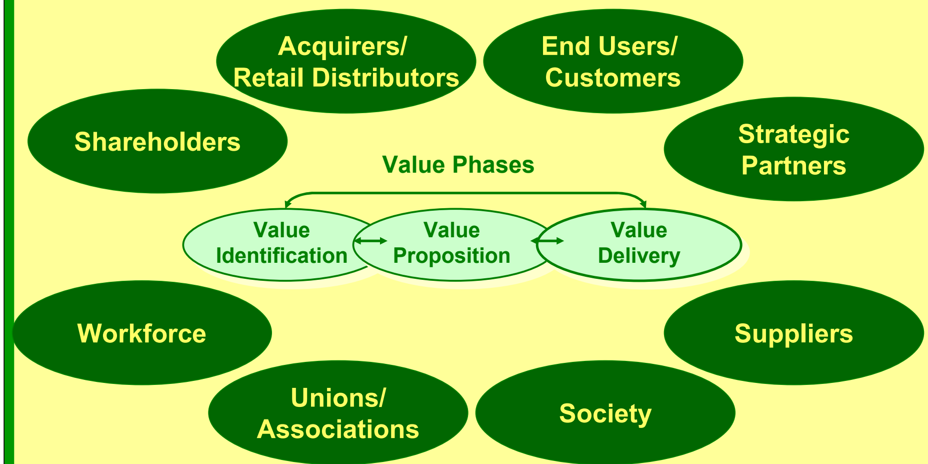
Principle 5

- **People, not just processes, effectuate lean value.**

Note: These are very simple statements – think of them as first principles – use these as a constant "touch stone" guiding implementation specifics

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)

Enterprise Stakeholders



Note: "Customer Acquirers" in Aerospace would be comparable to "Dealers" in the Auto Industry

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)

Enterprise Example: JSF Program

Centralized Control

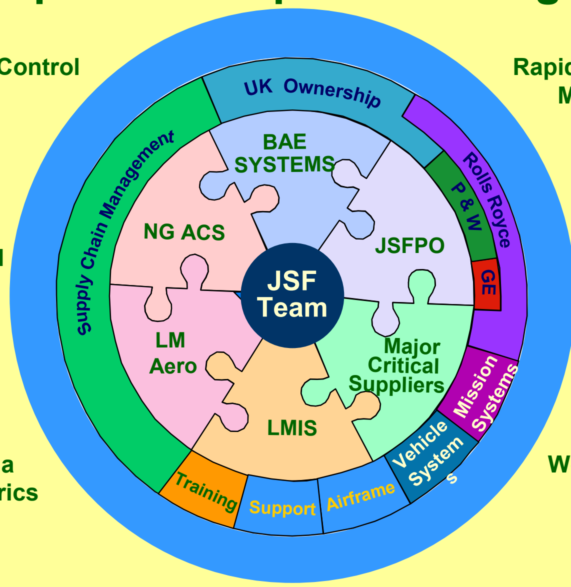
Rapid Decision Making

Decentralized Execution

Flexible Repositioning

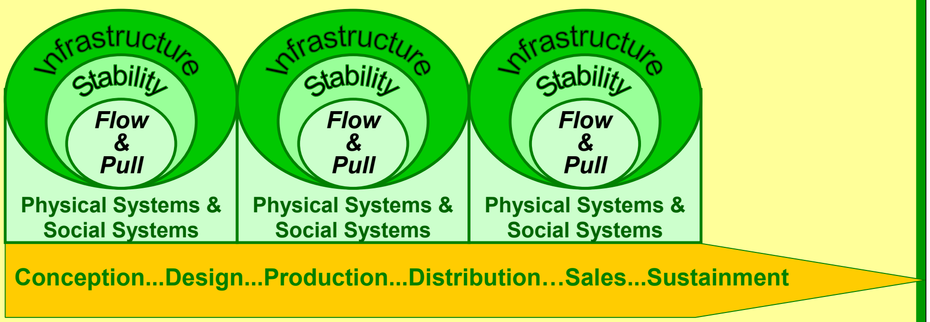
Status at a Glance Metrics

World Class Team

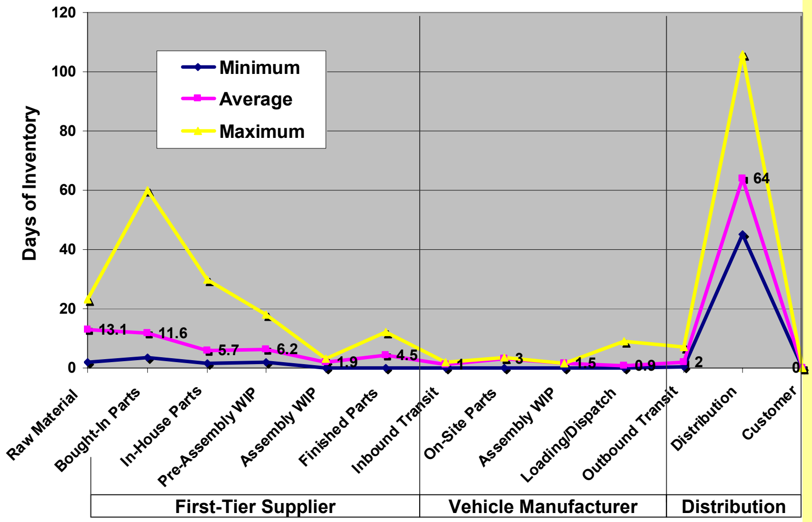


Source: Tom Burbage, Lockheed Martin Aeronautics

Applying Course Principles Across the Enterprise

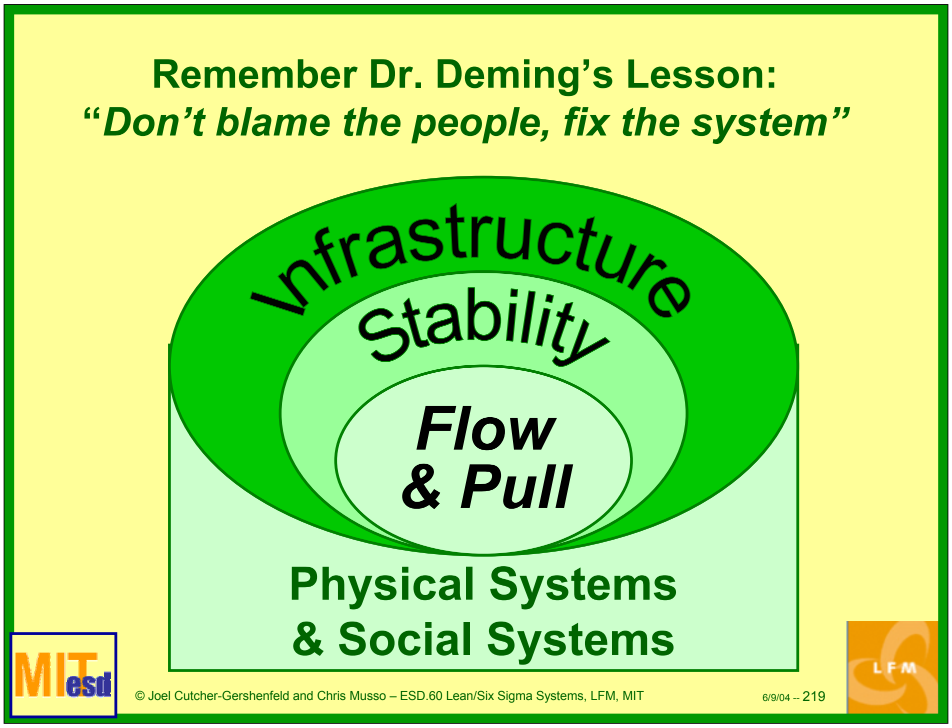


Inventory Profile Across UK Auto Supply Chain (average, min and max stock levels across six manufacturers)



(Source: Matthais Holweg and Frits Pil, "The Second Century: Reconnecting Customer and Value Chain through Build-to-Order," MIT Press, 2004)

Source: Matthais Holweg and Frits Pil, "The Second Century: Reconnecting Customer and Value Chain through Build-to-Order," MIT Press, 2004 (re-drawn from original)


Remember Dr. Deming's Lesson:
"Don't blame the people, fix the system"
Infrastructure
Stability
Flow
& Pull
Physical Systems
& Social Systems
MIT esd
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