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

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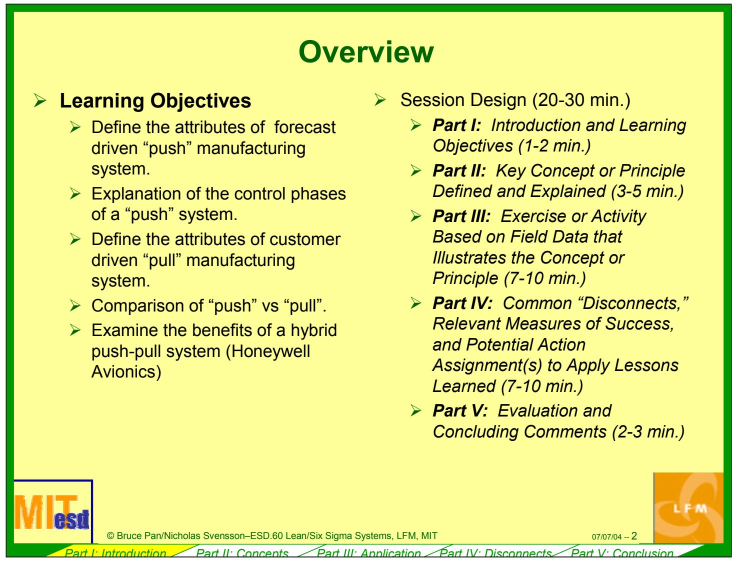
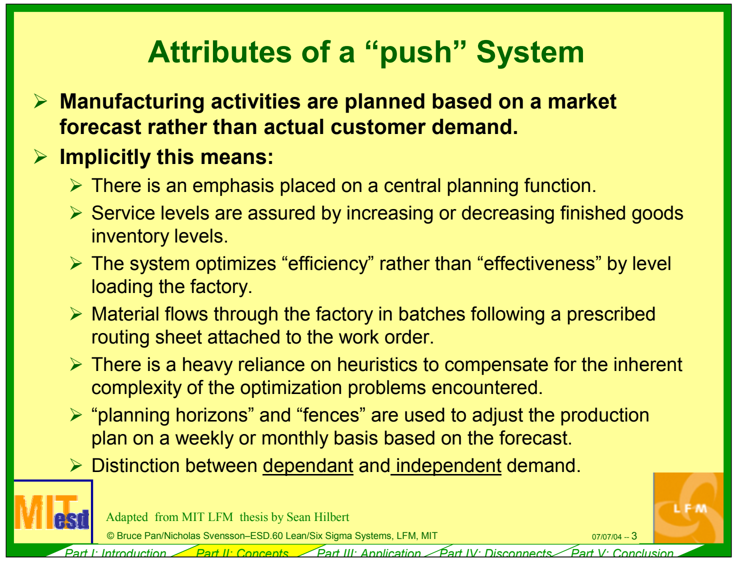
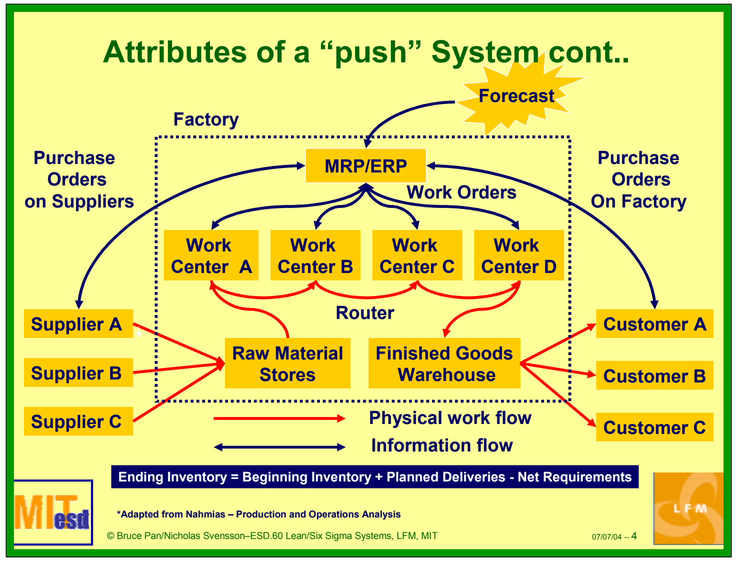
These materials were developed as part of MIT's ESD.60 course on "Lean/Six Sigma Systems." In some cases, the materials were produced by the lead instructor, Joel Cutcher-Gershenfeld, and in some cases by student teams working with LFM alumni/ae. Where the materials were developed by student teams, additional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



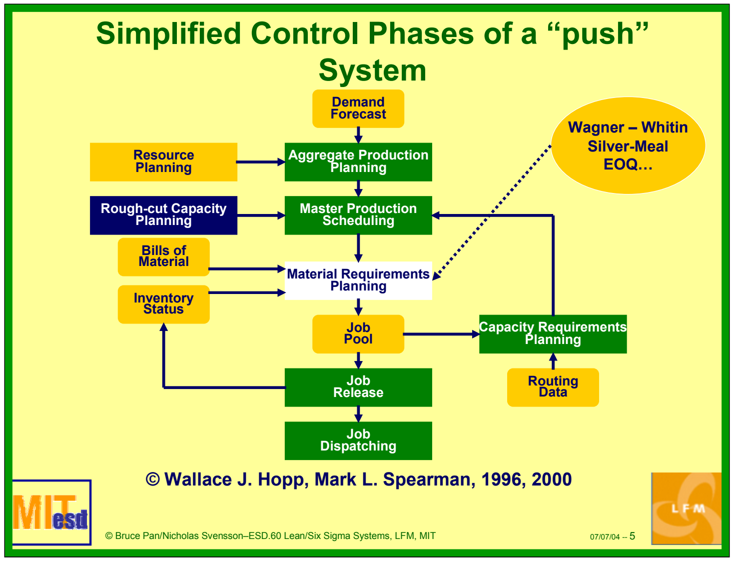
Key point – discussion of push system and its inherent attributes and a discussion of a pull system and its inherent attributes. Taken as extremes each has its own strength and weaknesses. We will attempt to show that taking the most appropriate pieces from each is the best strategy. Appropriate as defined by someone who fully understands the business model, its constraints as well as the principles of MRP and Lean.



Highlight some of the major implicit features – time fences, forecast driven, complicated heuristics and computer delegated decision making. Works very well in a stable environment – key is the discussion of how the system behaves in a changing environment. i.e. how do you deal with change and what are some of the system constraints inherent with a push system.



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.

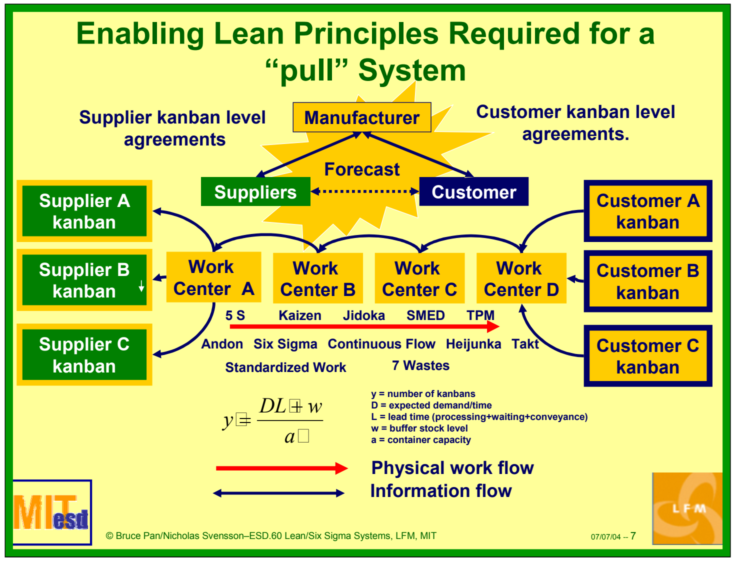


Standard MRP cycle showing capacity requirements planning. It may be worth mentioning that due to the complexity of the mathematics heuristics are often used. The classic lot size heuristics are Wagner-Whitin (1958) and Silver-Meal (~1970). The system tries to optimize for utilization not necessarily effectiveness.

Attributes of a "pull" System

- **Manufacturing plan is based on actual customer demand "pull".**
- **Implicitly this means:**
  - Control of manufacturing execution is at the working level.
  - Service levels are assured by increasing or decreasing kanban levels between workstations (WIP).
  - The system is optimized for "effectiveness" which is achieved through continuously improving "efficiency".
  - Material flows through the factory based on visual queues triggered by customer "pull" from the final kanban.
  - The system requires a very hands-on management style.
  - Culmination of all lean principles. Kanban, Andon, Kaizen, 5S, SMED…

Highlight some of the major implicit features – work is pulled through the supply chain based on visual queues at the working level. Pre arranged kanban levels are determined to deal with uncertainty and disruption. System focuses on effectiveness using continuously improving efficiency as a way of reaching its optimum state. No work is done unless it is needed by the customer. Forecasts are only used to size the kanbans but not for daily fluctuations in demand. A lean pull system utilizes all lean principles preferably throughout the supply chain.



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

Hybrid Model

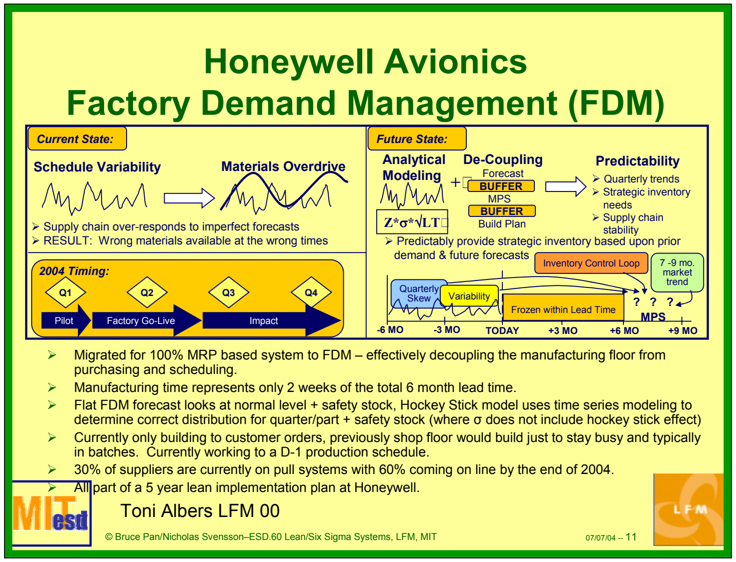
"The issue is not to make a choice between MRP and JIT, but to make the best use of both techniques."

– Karmarker (1989)

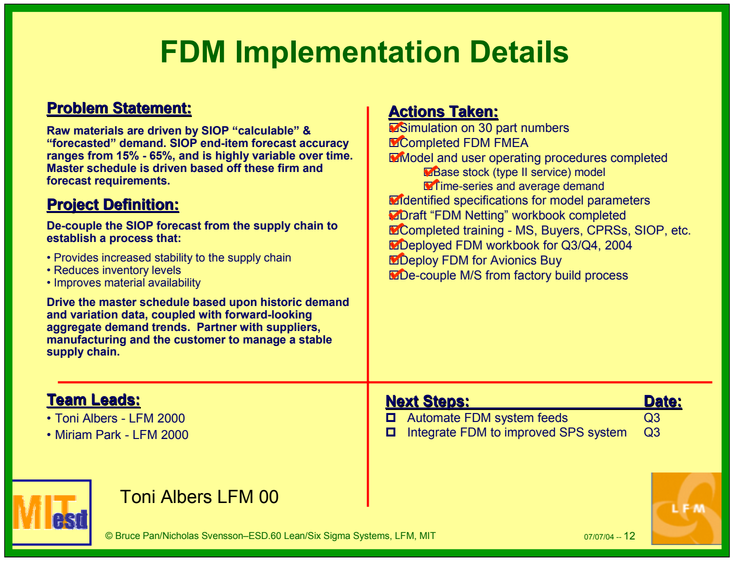
Self explanatory.

Honeywell Avionics – Toni Albers LFM 00

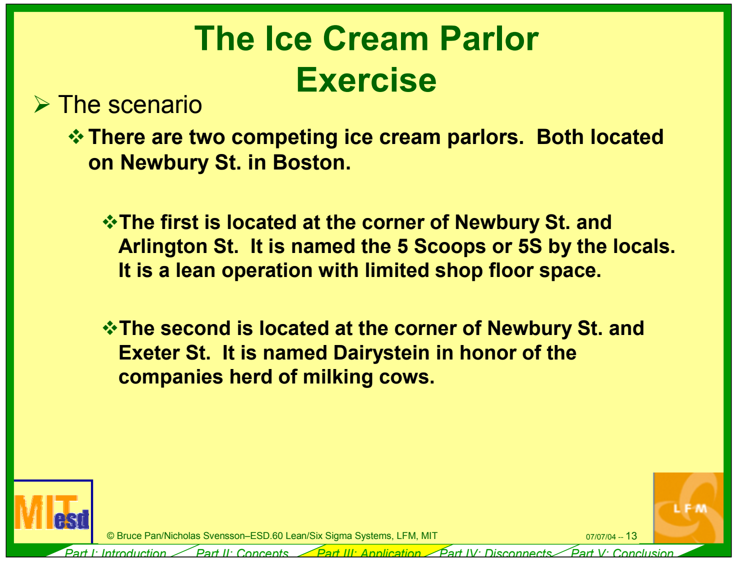
- Scenario
  - Predominantly RF hardware and electronic black box hardware with large amounts of software.
  - OEM customers representing 70% of sales typically order 100 systems at a time.
  - Dealer network representing 30% of sales typically order 1-3 parts at a time.
  - Transition from a pure MRP shop to a hybrid model.
  - Circuit card assembly lead times of 4-6 months.
  - Typical 6 month forecast accuracy of 45%, 3 month accuracy of 65%.
  - Known end of quarter hockey stick effect.
  - Mindset at plant was that “lean” was for the production floor and suppliers but not for the “middle piece”.



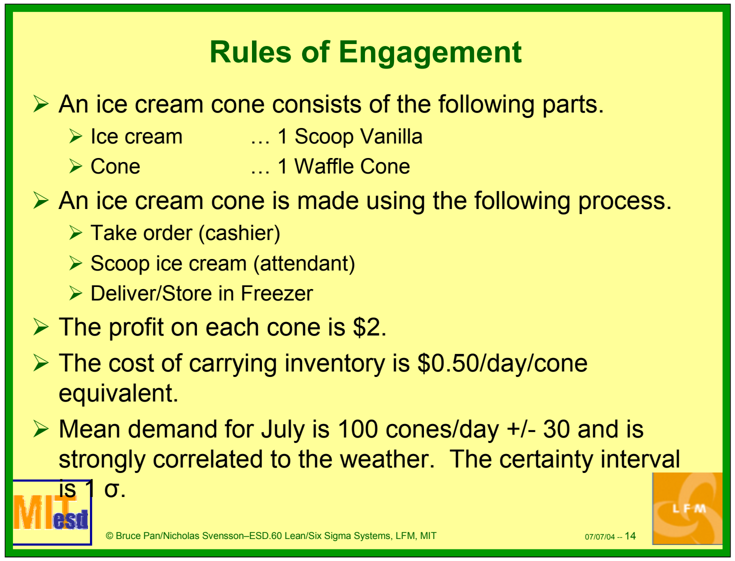
Explanation of Honeywell’s use of a new algorithm to better determine demand for their hybrid pull process.



Emphasize that this is a long term commitment to lean implementation taking many years. To fully transform a supply chain from push to pull can take 10-15 years based on Toni Albers input. Honeywell have a 5 year implementation strategy of which the FDM initiative is a part. There are also multiple challenges with mindset and overall organizational norms which need to be overcome when implementing lean in a Brownfield site. Some of these include batch building, weekly rather than daily ship targets, disconnecting Master Scheduling from Shop Orders etc.. All of these take time and the eventual implementation of many lean principles culminating in an implementation of a hybrid model.



The purpose of the exercise is to examine how two organizations within the same industry can operate given two different operating systems. The 5S parlor utilizes a pull system and the Dairystein utilizes a push system. As the demand uncertainty is the same for both each team is forced to make compromises on their business strategy based on the constraints placed upon them by their supply chain models. The inherent constraint in the lean case is the kanban replenishment rate. The inherent restriction in the push case is the herd size and the continuous requirement to milk the herd regardless of demand. It is hoped that by the end of the exercise the teams would have approximately equal profits and when asked would have similar ideas on how to improve their supply chains. Depending on the demand profile provided during the exercise it should be possible to demonstrate the benefits of a push system in dealing with short term forecast variations (hockey stick) versus the benefits of a lean system in dealing with a more even but still uncertain demand profile.

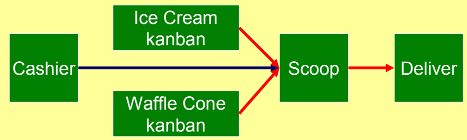


Have two teams of 5 participate. I person from each team should witness the other team during the simulation to ensure consistent adherence to the rules of engagement.

Each team fills in column 1 of the tables on charts 16-17 with their initial kanban sizes and herd sizes respectively. These "optimum" estimates should be a best guess based on the above forecast statement and other background information provided on slide 15.

The simulation starts with the initial high of the day being given and each team completes column 1. The profit is recorded and charted on the black board on an x-y chart ($profit vs. day). Once complete the second day's high temperature is provided and the days actual demand calculated. Each team can now begin to re optimize or leave their supply chains alone. The pull group can change their kanban size, which takes 5 days. This is to reflect the amount of time required to reach consensus in the whole supply chain. Alternatively the push team can choose to buy milk externally which has a 2 day delay associated with it.

Score Sheet 5 Scoops



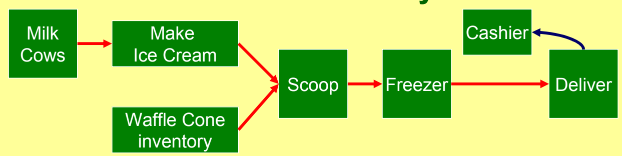
Day	1	2	3	4	5	6	7	8	9	10
kanban size										
demand										
inventory $										
sales $										
profit/loss										

- **Max kanban replenishment rate is 4 times daily.**
- **It takes 5 days to re size the kanbans**

Note: Inventory $ = $0.5 x what is left in the kanban each day.

Sales $ = (kanban-demand) x $2

Score Sheet Dairystein



Day	1	2	3	4	5	6	7	8	9	10
herd size										
milk order	-									
demand										
inventory $										
sales $										
profit/(loss)										

- 1 cow produces 20 cones worth of milk/day (cows must be milked daily.)
- milk can be ordered at $5/gallons with a lead time of 2 days (10 cones/gallon)
- inventory $ = demand - (herd size * 20 + milk order (gal) * 10)*$0.50 + previous day

Remember to add the previous day's inventory to the current days inventory. Unlike the lean model in the push model the inventory continues to grow and is carried over from day to day until consumed.

Other Factors and Predictions

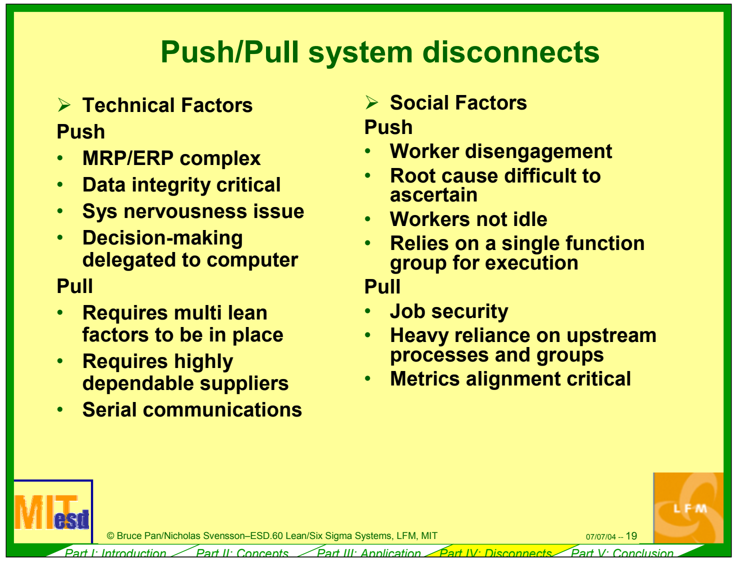
- The farmers almanac predicts a very hot and humid July with above average temperatures.
- Due to the expected heat wave many Bostonians are leaving for Cape Cod.
- The DNC is being held in Boston this year at the end of July, a large influx of visitors are expected.
- Tourism levels 15-20% below 2000 but up from last year.

The Demand

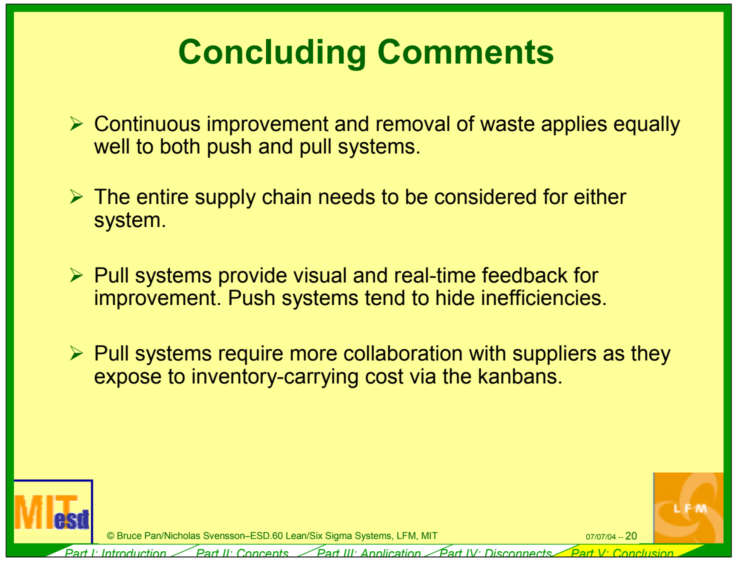
Actual Demand = (Expected High – 75)x5 +100

Boston, Massachusetts 10 Day Forecast by Intellicast

Actual equation can be modified to prove a point. This specific equation is based on the forecast for Boston July 2004, the url is directed to the actual 10 day weather forecast for the Boston area in this example.



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.



Lean principles apply equally well to both push and pull systems. Getting rid of waste and improving agility and flexibility help both systems to be effective, efficient and predictable. Typically it is easier to postpone dealing with problems in a push rather than a pull system due to the extra inventory and lack of immediate feedback of urgency. This however also tends to be one of the significant Achilles heals of the push system.

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

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Appendix: Instructor's Guide

Slide	*Time*	*Topic*	*Additional Talking Points*
1-2	2-3 min	Introduction, overview and learning objectives	• Quickly walk through the learning objectives which are to understand the principles of push and pull systems. And to evaluate a hybrid implementation at Honeywell – Toni Albers LFM00.
3-9	3-5 min	Key Concepts	• See speaker notes on each slide. Discuss how the push and pull systems deal with demand uncertainty and disruption.
10-18	7-10 min	Exercises/Honeywell Case	• The Honeywell case is an excellent example of a lean implementation in a brownfield site. The material was provided by Toni Albers LFM 00. The Ice cream parlor exercise. The intention of the exercise is to show that in the long term both systems perform relatively well. Also, the push system can react to short term changes more effectively than the pull system whereas the pull system is more effective in the long run as problems faced need to get addressed right away and are obvious. In this case the problem is either too much or too little capacity.
19	5-7 min	Disconnects	• See speaker notes on each slide. The points given highlight the most sensitive areas of each type of system.
20	1-2 min	Concluding comments	•Understand your business and use your expertise to tailor a system which optimizes your Operation.