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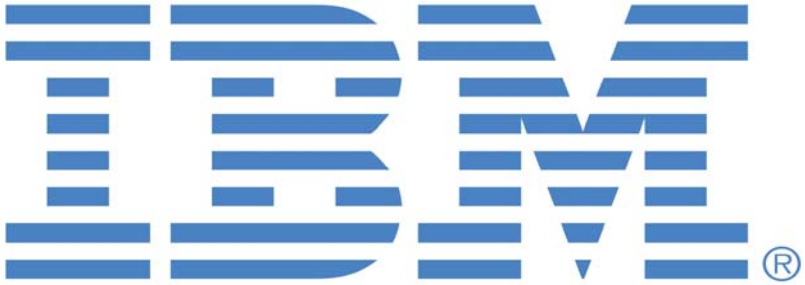

Best Practices for Global Supply Chain and Operations Management

APICS The Association for Operations Management®

Manuel Parente, CPIM, CSCP

Manuel Parente currently is a consulting engineer with the Advanced Microelectronics Solutions Lean Transformation Core Team, IBM. His responsibilities include a flow-and-pull community of practice-team lead with end-to-end design and implementation of consumption-driven production flow and control systems, which support multiple manufacturing modes. Parente's recent work has focused on development and deployment of multiple WW product value streams. Parente has an M.S. degree in metallurgical engineering.

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Satyadeep Vajjala

Satyadeep Vajjala is currently a supply chain process architect at IBM Microelectronics division. Responsibilities include designing and implementing and end-to-end enterprise information flow and providing thought leadership to the business transformation efforts at IBM MD in support of lean manufacturing practices. Recent work has been focused on bridging the gap between ERP/MRP systems and manufacturing systems based on lean principles and development of IBM Dynamic Inventory Optimization Solution (IBM DIOS). Vajjala's education background includes an MBA in supply chain management.

Ulrich Schimpel, Ph.D.

Dr. Ulrich Schimpel joined the business optimization group at IBM Research in 2004. Current responsibilities include development and client consulting in the area of IBM Dynamic Inventory Optimization Solution (DIOS), a highly sophisticated tool for optimizing inventories and replenishment orders at clients worldwide. Project experience with IBM DIOS ranges from tactical and strategic assessments to delivering operationally integrated solutions with various ERP systems. Schimpel's educational background includes a Ph.D. in logistics and a Master's degree in information systems and management.

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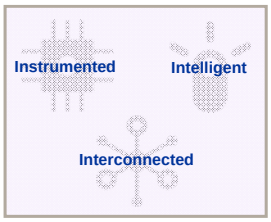
Lean Execution: Lessons Learned



Manuel Parente, CPIM, CSCP
Satyadeep Vajjala
Ulrich Schimpel

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Agenda

- Introduction
  - Presenter Bios
  - IBM Microelectronics Business Overview
  - MD Supply Chain Architecture
- Case Study
  - Problem Description
  - Solution
    - Our Approach
    - Simulation / Results
    - Challenges /Key Messages / Summary
- Contact Information

About the Presenters …

Manuel Parente

- Current Role: Advanced Microelectronic Solutions LEAN Transformation Core Team
- Team Lead Flow/Pull Community of Practice. End to End design and implementation of consumption driven production flow and control systems supporting multiple manufacturing modes.
- Recent work focused on deployment of multiple WW Product Value Streams
- Education Background: MS Metallurgical Engineering
- Certified APICS CPIM , CSCP

Satyadeep Vajjala

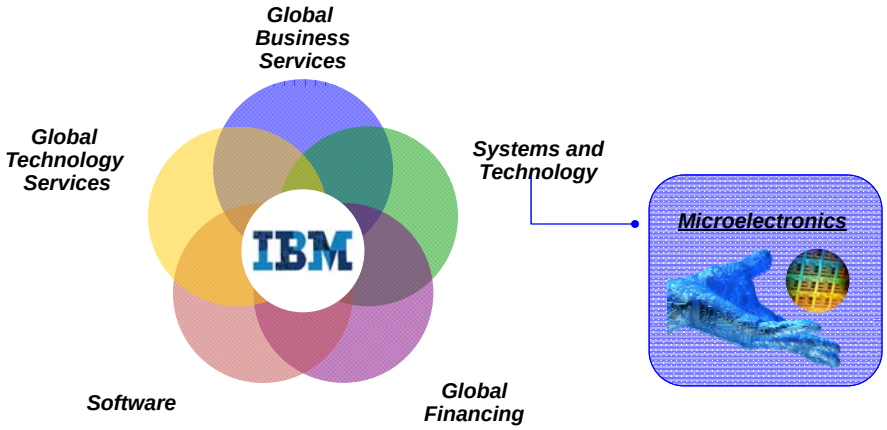
- Current Role: Supply Chain Process Architect at IBM Microelectronics division.
- Responsibilities include designing & implementing an end to end demand / Supply enterprise information flow, provide thought leadership in support of the business transformation to LEAN.
- Recent work, focused on bridging the gap between ERP systems and MFG Floor Control systems, developing the IBM Dynamic Inventory Optimization Solution (IBM DIOS) Solution
- Education: MBA in SCM

Ulrich Schimpel

- Current Role: Business Optimization group at IBM Research.
- Responsibilities include development and consulting on the IBM Dynamic Inventory Optimization Solution (DIOS).
- Project experience with IBM DIOS ranges from tactical and strategic assessments to delivering operationally integrated solutions with various ERP systems.
- Education: Ph.D. in Logistics and Masters in Information Systems and Management.

IBM

Products, services, software, and technology



A diverse portfolio of applications

Skills and expertise supporting blue-chip clients and their needs

Networking and Communications

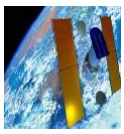
Routers Switches

WiFi, WiMAX Infrastructure

Wireless Base Stations

Communications Satellites

Radio Network Controllers



Data Processing

Storage

Optical Networks

Servers

Consumer Electronics

Digital Video Cameras

Digital Still Cameras

Game Consoles

Video Processors

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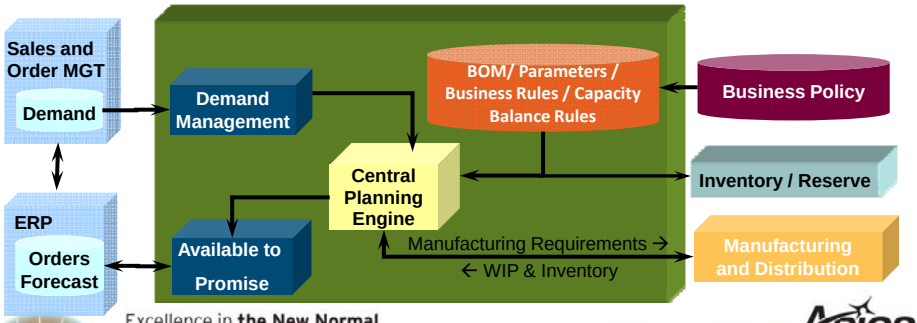
MD Supply Chain – Top-Level View

- End-to-end integrated supply chain organization
- Dedicated to our clients' success – prototype/EUH planning and execution, demand planning, supply planning, order management, fulfillment execution, post sales execution
- WW integrated planning and execution – incorporates in-house and outsourced partners and suppliers. Weekly plan; daily execution, Fully B2B enabled. EDI, Rosetta Net, WEB Portals.
- Total *Factory View* for clients via IBM Customer Connect, our web-based, online portal. Customizable to client needs.
- WW logistics and distribution – shipping, distribution, hubs



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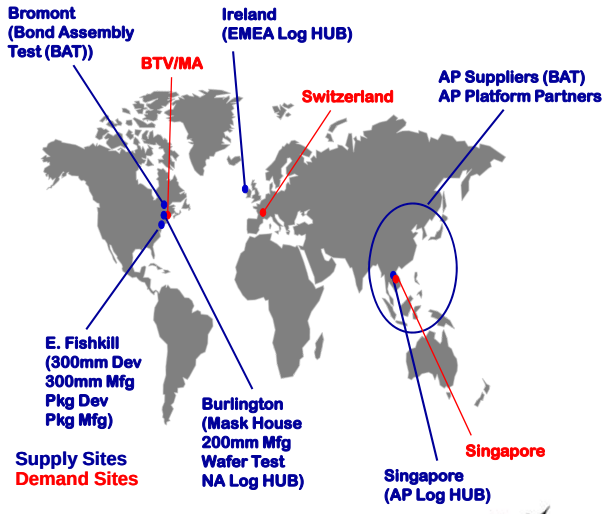
Worldwide Semiconductor Supply Chain

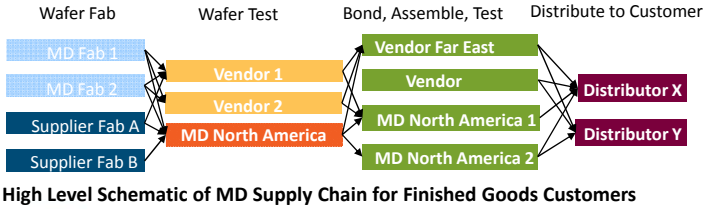
- WW demand sources
  -NA, EMEA, AP
- WW order management
  -NA, EMEA, AP
- Vendor supply sites integrated into the sourcing strategy
- Support for varied WW logistics models, laws, and currencies

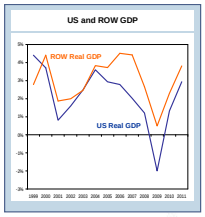


Supply Chain Facing Numerous Business Challenges…

MD Business Challenges	MD Supply Network
Manufacture semiconductor devices and modules o Asset-intensive business o Inventory both pipeline and finished goods > $600m o 1200 active PN with an average of 4 stock node= 5000 potential stock nodes to be planned/ executed	**Complex global supply chain network** o With multiple internal manufacturing sites o Contract manufacturers o Multiple global suppliers o Deterministic planning >>> leading to huge "bullwhip effect" in execution

Supply chains continue to become more global and complex... And have to deal with increased economic volatility





High Level Schematic of MD Supply Chain for Finished Goods Customers

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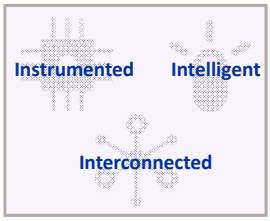
We Must Be Smarter

The Smarter Supply Chain



Instrumented, Interconnected, and Intelligent

The smarter supply chain has three new characteristics. Firms across the globe are beginning to see the benefits of building a new vision of supply chain excellence.

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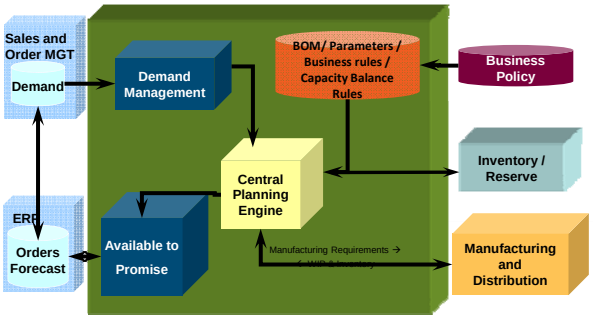
At Transformation Crossroads, MD Supply Chain was a Mature Process..



But Tough to Align Planning & Execution

- **Deterministic Plan** Out of Synch with Real Time Execution: What, How Much, When
- MRP Based: Sectors are **Scheduled** Expecting Alignment
- **Variability** in Demand and Supply **not Addressed**...
- Focused on Customer Service: High Variability in Build Plans
- **Not a LEAN Mfg Enabler**...

Migration to LEAP: Lean Planning and Execution

- Leverage What Works Evolve TOM (Total Order Management) so as to be Relevant and Enabling in a LEAN Manufacturing Environment.
- **Flow Policy / Consumption Based**
- **Anticipate and Plan for Variability**
- **Stable** and **Leveled** Build Plans

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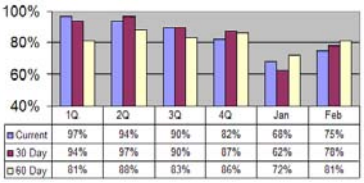
Poor Alignment: The Facts !

Issues

- **Plan was not executed, too many manual changes to plan**
  - Too many changes made to the plan after it has been published
  - Too many expedites to recover (20 to 30%)
  - Longer lead times
  - Wrong mix of inventory /WIP
- **Culture**
  - Manually intensive
  - No trust in the system
  - Constant fire fighting
- **Schedule / Priority-driven execution *(What , When and How Much)* process decouples quickly from centrally aligned Plan, promoting silo behavior**

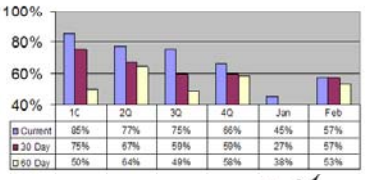
Build Plan Accuracy (Volume)

Lag	Target	Feb
Current	98%	75%
30 Day	95%	78%
60 Day	92%	81%
Avg	95%	78%



Build Plan Accuracy (To Mix)

Lag	Target	Feb
Current	85%	57%
30 Day	80%	57%
60 Day	75%	53%
Avg	80%	56%



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Simulation Analysis of an MRP Based Execution Process

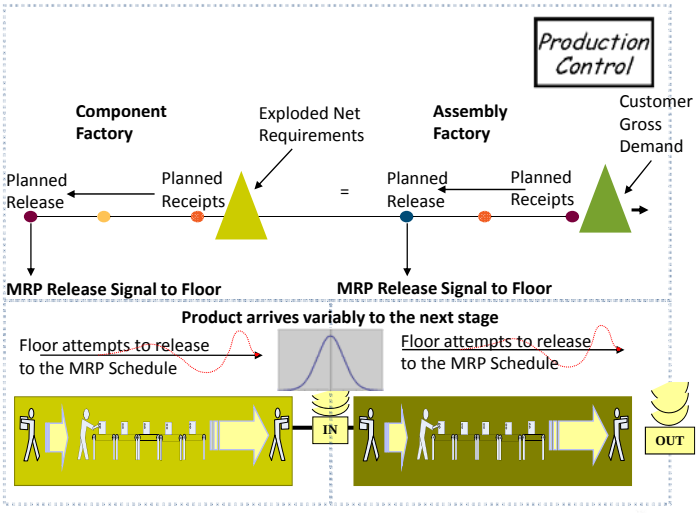
Step 1: Gather the Gross Requirements and MFG LT

Step 2: Simulate the MRP Based Production Control Process and generate Release Schedule

Step 3: Floor Execution Releases based on the schedule

Step 4: Variability is simulated and propagated Forward

Step 5: Service is measured



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Simulation Analysis Of An MRP Based Execution Process

Production Control Using an MRP Generates the following Schedule for the 2 Level Mult… …ry Network

Component PN	Week	Week	Week	Week	Week	Week	Week	Week	Week	Week
MRP Record	1	2	3	4	5	6	7	8	9	10
Gross Requirement	2	30	20	50	10	0	25	25	0	0
Beginning on-hand inventory	87	85	55	35	0	0	0	0	0	0
Ending on-hand inventory	85	55	35	0	0	0	0	0	0	0
Net Requirements	0	0	0	15	10	0	25	25	0	0
Planned Order receipts	0	0	0	15	10	0	25	25	0	0
Planned Order releases	0	15	10	0	25	25	0	0	0	0

Assembly PN	Week	Week	Week	Week	Week	Week	Week	Week	Week	Week
MRP Record	1						7	8	9	10
Gross Requirement							10	0	25	25
Beginning on-hand							0	0	0	0
Ending on-hand						0	0	0	0	0
Net Requirements						30	20	50	10	0
Planned Order receipts					2	30	20	50	10	0
Planned Order releases				30	20	50	10	0	25	25

A Model built to Si… …MRP schedule with one element variable (Lead Time)

Week	Release
1	0
2	15
3	10
4	0
5	
6	
7	
8	
9	
10	

Gross Req
2
30
20
50
10
0
25
25
0
0

+

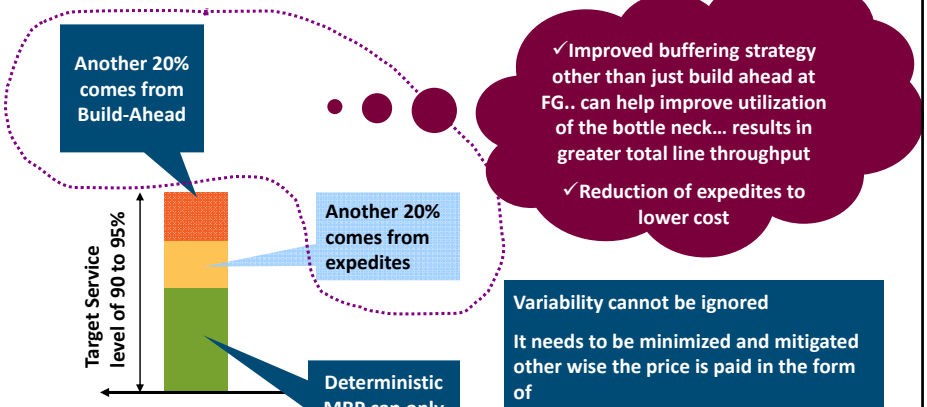
Week	Release
1	2
2	30
3	20
4	50
5	10
6	0
7	0
8	50
9	0
10	0

Variable Receipts

Receipts	Ending Inv	Beg Inv	Gross Req
0	83	83	0
0	73	83	10
2	0	73	75
0	-30	0	30
50	0	-30	20
50	0	0	50
0	-10	0	10
10	0	-10	0
0	-25	0	25
0	-50	-25	25

Based on a Monte-Carlo Simulation with Variable Lead times, the Simulated end of Pipe Service Level is 50% , with Average WIP in line is about 20 pieces

So, How does an MRP Ecosystem achieve it goals?



Analysis of the action items that help achieve the desired service level components

✓Improved buffering strategy other than just build ahead at FG.. can help improve utilization of the bottle neck… results in greater total line throughput

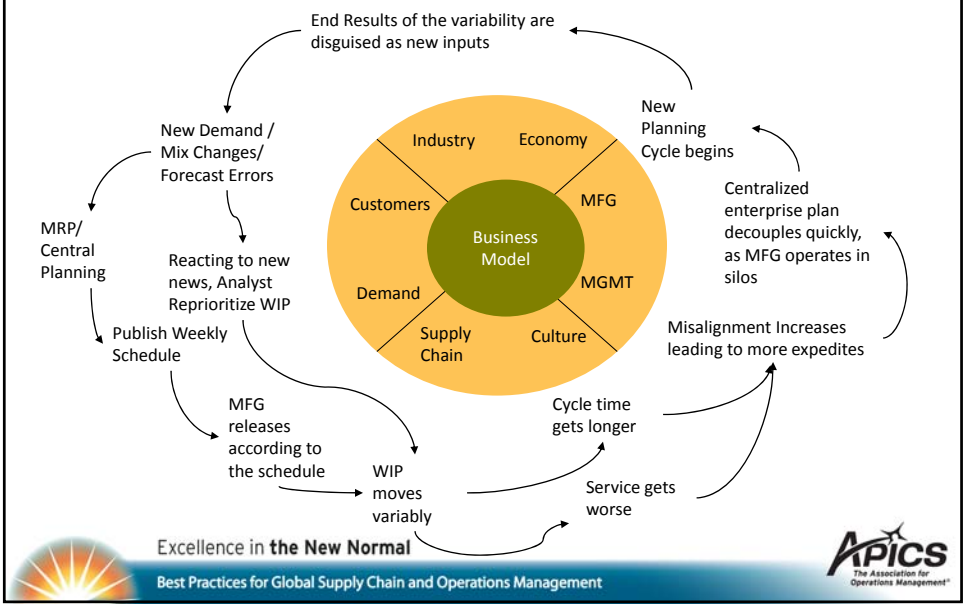
✓Reduction of expedites to lower cost

Variability cannot be ignored

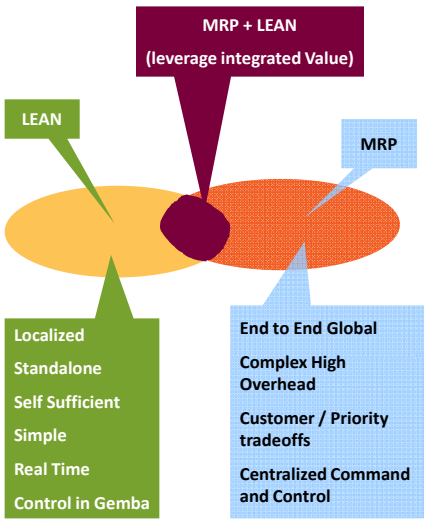
It needs to be minimized and mitigated other wise the price is paid in the form of

1. **Long lead times / Expedites**
2. **Capacity Buffer**
3. **Build Ahead's**

" Day in the Life" of an MRP Information System



Can Lean MFG and MRP Planning Coexist?



MRP

- ❑ Aligned to Customer Priority
- ❑ Centralized planning based on a common set of business rules for trade off management
- ❑ Provide parametric guidance to Lean Planning

+

Lean Planning

- ❑ Real Time Consumption Based Coupling between flow segments
- ❑ Variability accounted for in Flow Policies
- ❑ "Localized" event Management and autonomous Manufacturing

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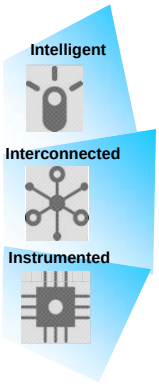
Solution/ Recommendations

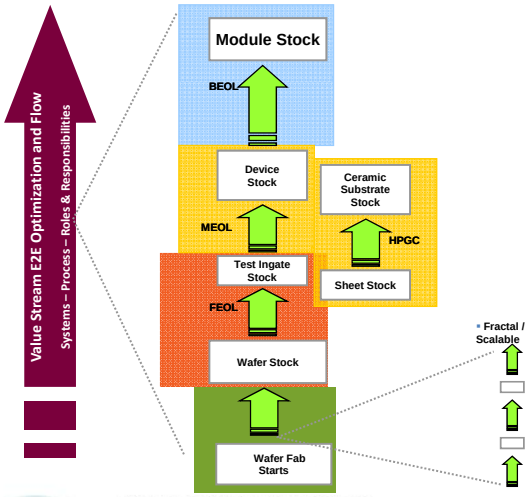
Smart: Demand Flow Propagation with Dynamic Execution Capability



- Process integrating customer requirements, planning and Execution
- Function/ IT Tools provide models and analytics
- Networked LEAP (S&OP + Lean) architecture with forecast, optimized build plans and stochastic Flow Policy communication to MFG
- Organization and Culture aligned to the E2E Value Stream Optimization
- Value Stream based Product Flows
- Execution signals for real-time synchronization

Value Stream Planning

Segmenting the Enterprise into Interconnected Product Flow loops



- ❑ Enterprise Production Value Stream as a Multi Echelon Inventory Network (MEI)
- ❑ Set of E2E Connected *Flow Segments*
  - ✓ Incrementally Add Value
  - ✓ Flow Value To End Customer
  - ✓ In Support of Customer Demand (Pull)
- ❑ Explicit System. Process and Organizational Alignment with E2E Value Stream Focus

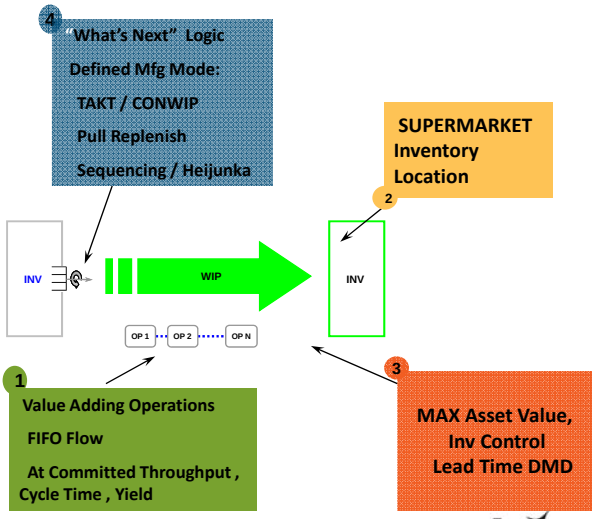
Flow Loop

Inside the Basic Functional Unit of a Value Stream

Interconnected

Flow Loop

- Execution and planning agree on a prescribed script or operational rules of behavior
- "Script" based on Lean Principles
- Flexible to accommodate local Manufacturing constraints like different operational Takts, different replenishment modes



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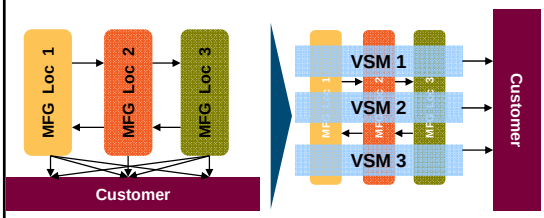
Organization Design

Building an VSM Organization

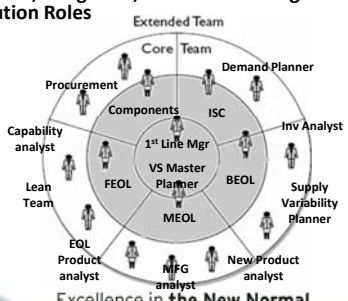
Interconnected



Two Tiered MGT Model

- Flow Segment: "Wall 2 Wall"
  - ✓Segment Managers: Optimize the Segment; Minimize Variability and Waste
- Enterprise: E2E
  - ✓VSMgr: Stitch the Segments Together
  - ✓Enterprise Planning / Execution Tradeoffs
  - ✓ETE Inventory Policy / Flow Policies

Collaborative, Integrated, Value Stream Aligned Planning and Execution Roles



Value Stream CELL Team

- Facilitate Information Flow /Shared Learning / Awareness /Cross Training
- Value Stream Optimization Versus Customer
- Accountable for VS Performance
- *Deliverables:*
  - ✓ Flow Policies / Performance Monitoring / Variability Management

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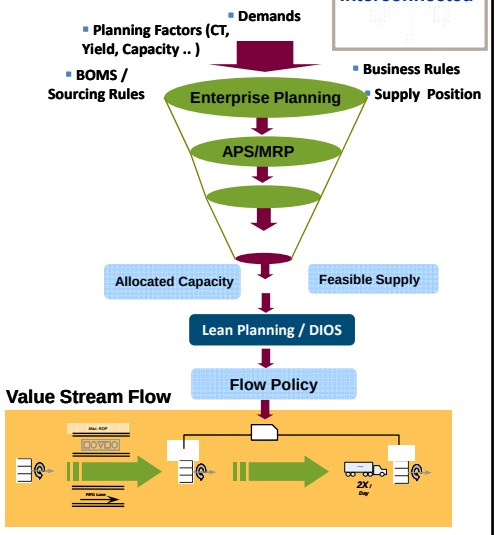
Value Stream Design : Work Flow

Interconnected

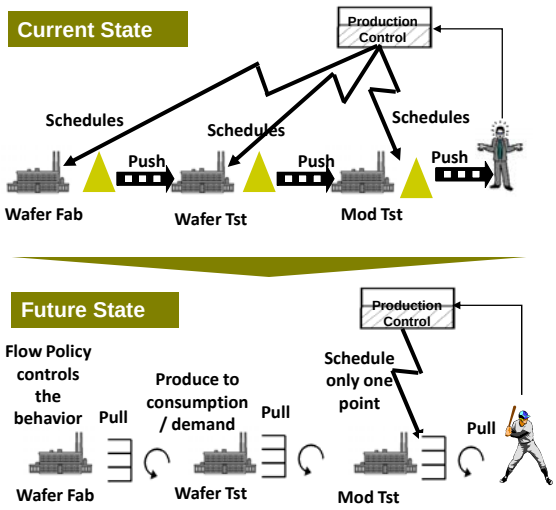
- **Step 1: Product Segmentation**
  - Value Stream Segmentation (Understand Common Flows / Shared Resources)
- **Step 2: Value Stream Design**
  - Segment the Common Flows into Manageable Flow Segments
  - Decision: Value added Inventory Stocking Points
- **Step 3: Enterprise Rough Cut Capacity Plan**
  - Manage Cross Value Stream Issues based on business rules
  - Business Rules
    - Apply Customer Segmentation methods around Profit, strategic Value or customer demand confidence
    - Apply Demand Type rules: Orders / Forecast / Buffers
  - Recommend the **Business Model**
    - BTO / BTF / ATO
  - Recommend a High Level "Build Plan" of what is feasible
    - Leveling is a key Criteria



New End-to-End Information Flow Architecture
Interconnected ERP and LEAN Execution Architecture

Value Stream Design: Work Flow

Interconnected



- **Step 4: Value Stream Demand Scheduling Points**
  - Based on Build Plan recommend Scheduling points
  - Build Plan Consumption Driven Upstream demand
- **Step 5: Identify /Manage Constraints**
- **Step 6: Optimize Flow in the value streams**
  - Decide on Manufacturing Modes like Takt/DGR, CONWIP, Sequencing
  - Publish **Flow Policies**
- **Step 7: Manage Flow**
  - Visual Controls/ FIFO
  - Ensure Standards / Accountability / Discipline
- **Step 8: Continuous Improvement**
  - Waste Management
    - Value Stream Mapping
    - Structured Problem Solving
  - Process Standardization

Simulation-Based Planning Tools

Dynamic Inventory Optimization System (DIOS)

Intelligent

- Connected Flows, Multi-echelon, Lean Environment
- Addresses stochastic Demand, lead time, Quantity-Per and Yield!
- Recognizes and Leverages Operational TAKT
- Simulation with. **operative restrictions** like capacity, Co Product (Binning)
- Multiple Kanban types for **better protection against stock out**:
- **Integrated Capacity Management**

	Kanban Logic	WIP	Sophisticated control mechanisms
	Shared resources	Transient state support	
Stochastic yields	TAKT conversion	Production restrictions	
Stochastic lead time	Co-product Logic	Capacity manager / prioritization	
Stochastic demand	Complex sourcing / BOM explosion	Sequencing / build-to-order	
Combined production logic (sequencing & Kanban)			
Stochastic production simulation			
Multi-echelon demand propagation			

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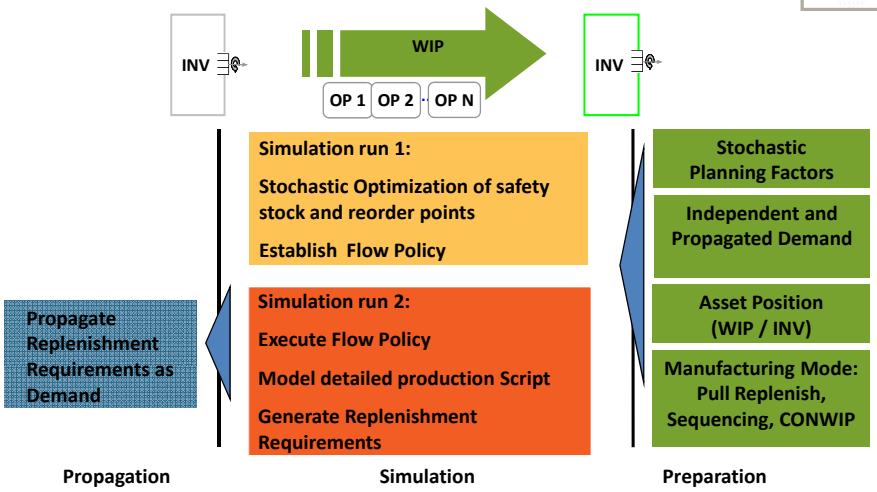
Flow Propagation Algorithm:

Establishing Flow Policy and upstream requirements based on simulated consumption

Intelligent



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Flow Propagation: Safety Stock Algorithms

Intelligent

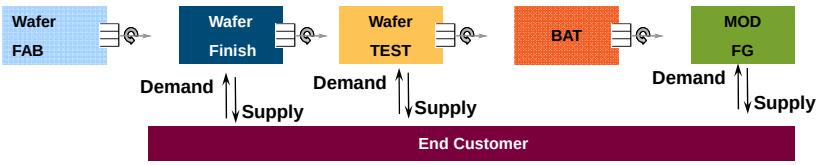
Safety Stock Attributes	Industry Practices	Our Approach
❑ Demand	❑ "deterministic" Independent and MRP exploded requirements	❑ Stochastic Simulation of Flow Policy to generate upstream requirements in support of downstream replenishment requirements
❑ Supply Variability	❑ Focused on a limited set of supply attributes like lead time and yield	❑ Factor in multiple forms of variability like lead time, yield, form factor, and speed sorts
❑ Calculation Methods	❑ Typically industry practices only deal with Normally distributed calculation methods: some factor in EOQ	❑ A patented " numerical Simulation" method for calculating Safety which also considers the impact of multiple replenishment and release methods

Planning Value Stream

MRP Guides Lean Planning on Build ahead Conditions

Intelligent

❑ **Problem Statement: Managing Flow in a Value Stream is a challenge**
- ✓ Capacity in the various Flow Loops are usually not balanced ("Floating Bottle Necks")
- ✓ With Product Mix changes in the value Stream it is difficult to keep the Flow Loops Balanced
- ✓ In these complex networks, managing a "pure" consumption driven model is very challenging



❑ MRP identifies capacity imbalance situations and suggests build ahead strategies

❑ Use the MRP to Schedule at multiple points in the value stream

- ✓ Primary / Single E2E Scheduling Point with Upstream Requirements Propagation.
- ✓ Secondary Scheduling Points with Upstream Propagation
  - ➢ Multiple Customer Entry
  - ➢ Operational Independent Demand (Selective Ramps / Build Ahead…)

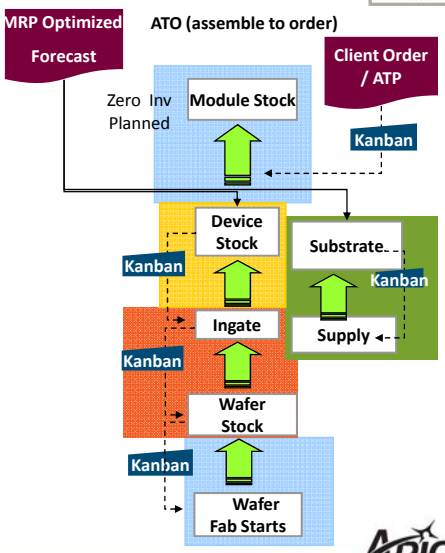
Postponement + Lean Models

Advanced MRP + Lean Planning Strategies

Intelligent

Planning Complex Situations

- ❑ Use the MRP analysis to make decisions like
  - ✓ What Manufacturing mode the Product should run to?
  - ✓ For example: Postponement or ATO , BTF
- ❑ Once the MFG Mode decision is made, use the MRP to firm up a "rough cut build plan" or optimized forecast
- ❑ Lean planning uses the optimized forecast and the capacity bounds from MRP coupled with real time variability information to prescribe a Flow Policy
- ❑ MFG executes to the Flow Policy
  - ✓ Flows product to the ATO stocking point
  - ✓ Waits for the real customer orders from ATP before the release into the final flow loop



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Simulation Analysis of an MRP Guided Flow Propagation System

Intelligent

Component Part

Week	Releases
1	0
2	7
3	75
4	30
5	20
6	50
7	10
8	0
9	25
10	25

Receipt	Beg Inv	End Inv	Gross Req
0	87	87	0
0	87	77	10
2	77	4	75
30	4	4	30
39	4	23	20
39	23	12	50
26	12	28	10
36	28	64	0
16	64	55	25
10	55	40	25

Assembly Part

Week	Releases
1	0
2	10
3	75
4	30
5	20
6	50

Receipt	Beg Inv	End Inv	Gross Req
0	83	83	0
0	83	73	10
2	73	0	75
32	0	2	30
41	2	23	20
38	23	11	50
	11	28	10
	28	62	0
	62	54	25
	54	39	25

	alpha0 SL	beta SL
	100	100
	100	100
	100	100
	100	100
	100	100
	100	100
	100	100
	100	100
	100	100
	100	100
Service	100%	100%
Simulation av	100%	100%

Service increases to 100% vs 50% in the MRP case

Key Reason: Flow Policy provides for Proactive event driven replenishment and positioning of assets

Asset in the Pipe increased by 20 pieces in each flow loop vs. the MRP

Results of the Previous MRP example

Alpha SL	Beta SL
100	100
100	100
100	100
100	100
100	100
100	100
0	0
100	100
100	100
100	100
90.00%	**84.57%**
vg 75.78%	74.14%

Alpha 0	Beta SL
100	100
100	100
100	100
0	0
100	100
100	100
0	0
100	100
0	0
0	-100
service **60.00%**	**53.06%**
simulation avg 50.42%	50.32%

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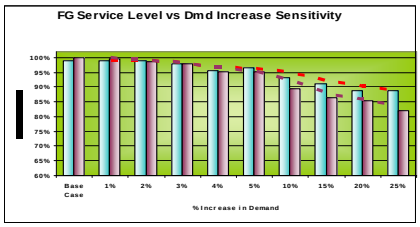
Simulation Analysis: Robustness of Flow Policy vs Demand Changes

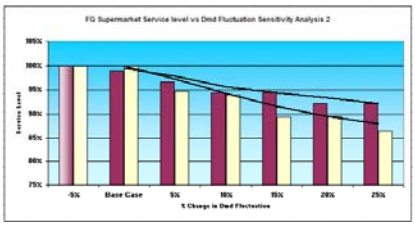
Sensitivity to Demand Upsides

- Service level to the customer still >80% even if demand increases by 25%
- Service level between supplying factories drop to <60%

Sensitivity to Demand Fluctuations

- Service level to the customer still >85% even if demand fluctuation increases by 25%





Service level to the customer using an MRP in the same experiment fell to 30% as execution was subjected to sudden demand upsides of 25%

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"Day in a Life" for the Flow Propagation Information System

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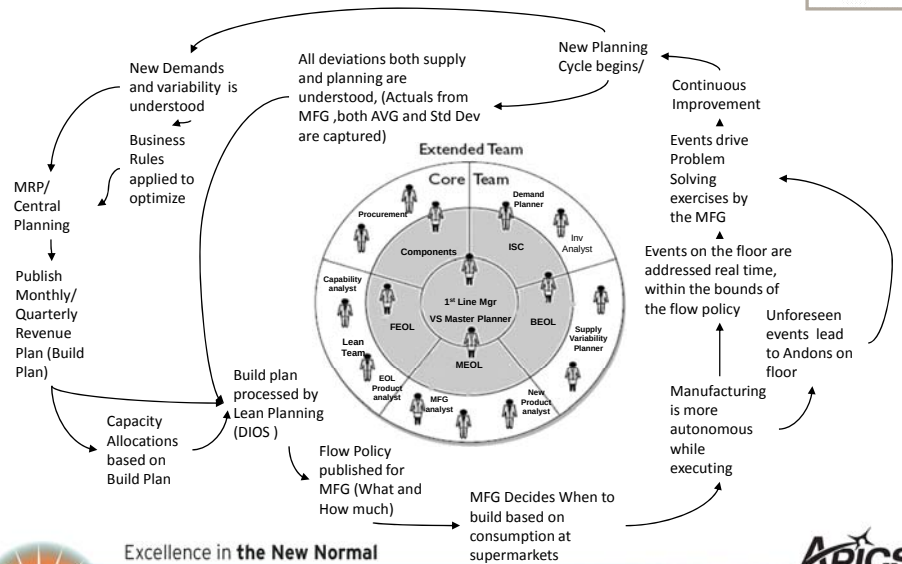

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Real Time ePull + Floor Visuals + E2E Metrics

Instrumented

- ❑ Single Metrics and Planning data source for the entire enterprise
- ❑ Automated Real Time Actuals data collection (Nominal and Deviation)
- ❑ ePULL: Consumption driven electronic Kanban signals across multiple factories
- ❑ Visual Execution signals on the floor for real-time Event Monitoring and response

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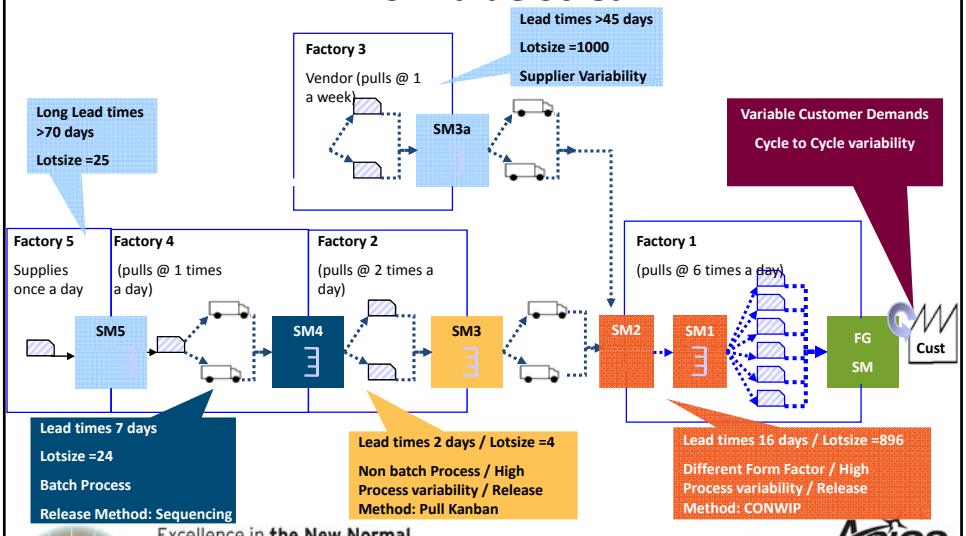
Managing Demand Variability Propagation in a MEI or Value Stream



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Managing Demand Variability Propagation in a MEI or Value Stream

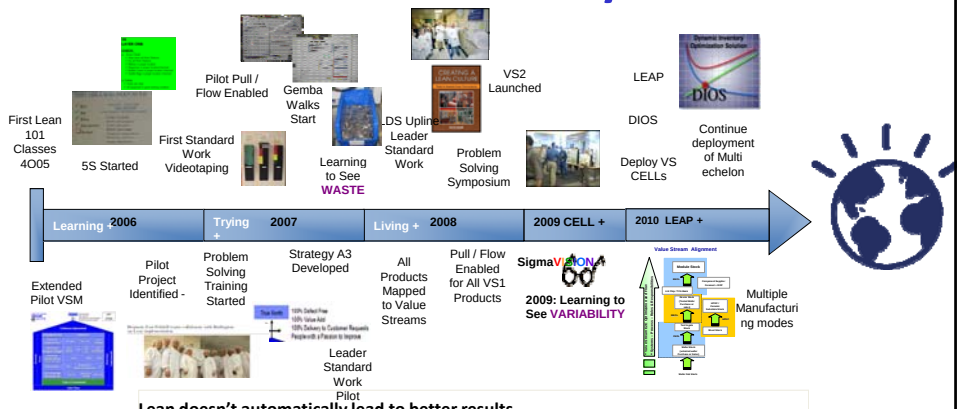
Results from Modeling (next 90days) the baseline case (Note: a form factor changes between SM1 & SM2)

Attribute	SM5	SM4		SM3	SM2	SM1	FG SM
Safety (Qty)	231	146		80	46	4428	48629
Safety (days)	13	8		4	3	1	7
ROP (QTY)	1850	288		136	72	4430	95090
Expected Avg WIP + INV (Qty)	2133	160		76	37	4569	49902
Avg Daily Demand (Qty)	17	17	?	18	18	6793	6832
Demand Fluctuation (Qty)	+ /- 14.2	+ /- 11	!	+ /- 11.5	+ /- 11	+ /- 4211	+ /- 3962
Actual LT (Days)	93	7.5		6.4	3	1	6.8
Actual LT Fluctuation (days)	+ / - 10	+ / - 2	!	+ / - 2	+ / - 1	+ / - 0	+ / - 3

Alpha 0 SL	100%	100%	100%	98.33%	96.67%	98.89%
Beta SL	100%	100%	100%	98.52%	98.51%	99.90%

Note: How demand variability propagates through the supply chain, even after trying to minimize variability propagation using special algorithms. Variability can be minimized but not eliminated. MRP would assume no variability and demand is same…through out the supply chain

Our Lean Journey…



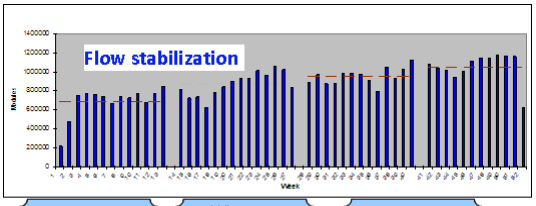
Lean doesn't automatically lead to better results

Of 100 U.S. companies, 70 use lean as their improvement method

- **52 see no improvement**
- **16 achieve significant results**
- **2 meet all their desired objectives**

Some Results from our Pilots

- ❑ Established basic management process for a multi-site Value Stream
- ❑ Reduced quarter-end build skew by **50%**
- ❑ **30-50%** cycle time reduction on 4/5 products
- ❑ End to End Inventory reduced by **10 X**
- ❑ and Service Levels **> 90%**
- ❑ **Early Life Cycle "Treasures"**



Value Stream Pilot 2008-2009 (C/T in days)

Product	1Q '08 Actuals	Target 2008	*4Q '08 'Real' Actuals	% Change
Product 1	41.3	20	19	54%
Product 2	54.9	22	25	54%
Product 3	58.9	25	33	44%
Product 4	53.1	25	66	+ %
Product 5	54.0	22	61	+ %

**''Real'' actuals from Nov 1st thru Dec 12 2008

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The Supply Chain of the Future must be SMARTER....

It will be instrumented, interconnected and intelligent

Instrumented

Automated Information Flow

- Supports ***real-time data collection and transparency*** around flow of goods from POS to manufacturing to raw material
- Floor visual signals allow for quicker ***Sense-and-respond*** to events

Interconnected

Optimized Flows

- ERP to Lean Planning to Lean Execution ***system integration*** across the network. Standardized data and processes.
- ***Push system to Pull systems***
- ***CELL planning and execution teams which provide Collaborative decision making*** support and business intelligence
- ***Value Stream Planning*** managing the entire supply network as a series of interconnected Flow segments

Intelligent

Networked Planning, Execution & Decision Analysis

- ***Simulation models to evaluate trade-offs*** of cost, time, quality, service and carbon and other criteria
- Stochastic-based planning and ***predictive analysis***
- Flow Propagation based Networked planning/execution with ***optimized*** forecasts & decision support

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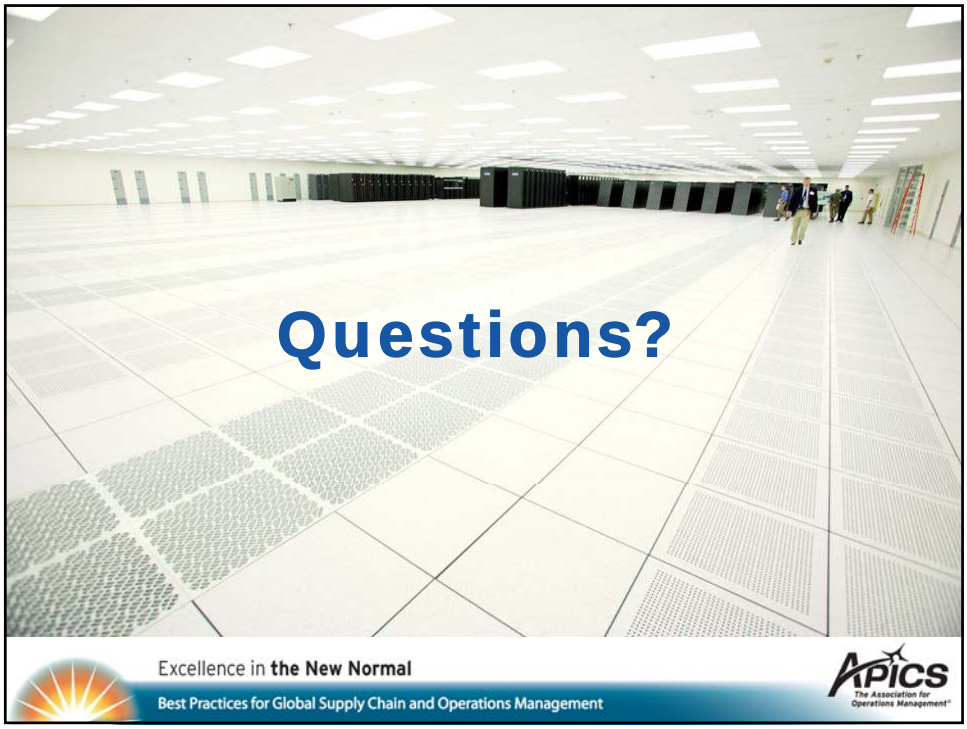
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