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

Excellence in the New Normal
Best Practices for Global Supply Chain and Operations Management
## About the Presenters ...

<table>
<thead>
<tr>
<th>Manuel Parente</th>
<th>Satyadeep Vajjala</th>
<th>Ulrich Schimpel</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Current Role:</strong> Advanced Microelectronic Solutions LEAN Transformation Core Team</td>
<td><strong>Current Role:</strong> Supply Chain Process Architect at IBM Microelectronics division.</td>
<td><strong>Current Role:</strong> Business Optimization group at IBM Research.</td>
</tr>
<tr>
<td>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.</td>
<td>Responsibilities include designing &amp; implementing an end to end demand / Supply enterprise information flow, provide thought leadership in support of the business transformation to LEAN.</td>
<td>Responsibilities include development and consulting on the IBM Advanced Cross–Inventory Optimizer (AXIO)</td>
</tr>
<tr>
<td>Recent work focused on deployment of multiple WW Product Value Streams</td>
<td>Recent work, focused on bridging the gap between ERP systems and MFG Floor Control systems, developing the IBM Advanced Cross–Inventory Optimizer (AXIO)</td>
<td>Project experience with IBM AXIO ranges from tactical and strategic assessments to delivering operationally integrated solutions with various ERP systems.</td>
</tr>
<tr>
<td>Education Background: MS Metallurgical Engineering</td>
<td>Education: MBA in SCM</td>
<td>Education: Ph.D. in Logistics and Masters in Information Systems and Management.</td>
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<tr>
<td>Certified APICS CPIM, CSCP</td>
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**Excellence in the New Normal**

*Best Practices for Global Supply Chain and Operations Management*
IBM

Products, services, software, and

Global Business Services

Global Technology Services

Systems and Technology

Software

Global Financing

Microelectronics
A diverse portfolio of applications
Skills and expertise supporting blue-chip clients and

Networking and Communications
- Routers
- Switches
- WiFi, WiMAX
- Infrastructure
- Wireless
- Base Stations
- Communications
- Satellites
- Radio Network
- Controllers

Data Processing
- Storage
- Servers
- Optical
- Networks

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
- Total Factory View for clients via IBM Customer Connect, our web-based, online portal. Customizable to client needs.
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

**MD Business Challenges**
- Manufacture semiconductor devices and modules
  - Asset-intensive business
  - Inventory both pipeline and finished goods > $600m
  - 1200 active PN with an average of 4 stock node = 5000 potential stock nodes to be planned/ executed

**MD Supply Network**
- Complex global supply chain network
  - With multiple internal manufacturing sites
  - Contract manufacturers
  - Multiple global suppliers
  - 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 has three new characteristics. Firms across the globe are beginning to see the benefits of building a new vision of supply chain excellence.
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:

**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
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**

**Build Plan Accuracy (Volume)**

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<td><strong>Avg</strong></td>
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<td><strong>78%</strong></td>
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**Build Plan Accuracy (To Mix)**

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<td><strong>Avg</strong></td>
<td>80%</td>
<td><strong>56%</strong></td>
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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
Simulation Analysis Of An MRP Based Execution Process

Production Control Using an MRP Generates the following Schedule for the Multi Echelon Inventory Network:

Simulation Analysis Of An MRP Based Execution Process

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.

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

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So, How does an MRP Ecosystem achieve it goals?

Deterministic MRP can only result in 50% service level. Another 20% comes from expedites. Another 20% comes from Build-Ahead.

- 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 expedite to lower cost.

Target Service level of 90 to 95%.

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

- Deterministic MRP can only result in 50% service.
- Improvements from expedites.
- Another 20% comes from expedites.
- Another 20% comes from Build-Ahead.

Variability cannot be ignored. It needs to be minimized and mitigated otherwise the price is paid in the form of:

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

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“Day in the Life” of an MRP Information System

End Results of the variability are disguised as new inputs

New Demand / Mix Changes / Forecast Errors

Reacting to new news, Analyst Reprioritize WIP

Publish Weekly Schedule

MRP / Central Planning

New Planning Cycle begins

Centralized enterprise plan decouples quickly, as MFG operates in silos

Misalignment Increases leading to more expedites

Cycle time gets longer

Service gets worse

WIP moves variably

End Results of the variability are disguised as new inputs

Customer Service gets worse

WIP moves variably

Cycle time gets longer

Service gets worse

WIP moves variably

Cycle time gets longer

Service gets worse

Economy

Industry

Customer

Demand

Supply Chain

Business Model

MFG

MGMT

Culture

Deman Model

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APICS
Can Lean MFG and MRP Planning

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

Localized, Standalone, Self Sufficient, Simple, Real Time, Control in Gemba

End to End Global, Complex High Overhead, Customer / Priority tradeoffs, Centralized Command and Control

MRP + LEAN

Leverage integrated Value
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

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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

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Flow Loop
Inside the Basic Functional Unit of a Value Stream

- 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

“What's Next” Logic
Defined Mfg Mode:
TAKT / CONWIP
Pull Replenish
Sequencing / Heijunka

SUPERMARKET Inventory Location

MAX Asset Value, Inv Control Lead Time

Value Adding Operations
FIFO Flow
At Committed Throughput, Cycle Time, Yield

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Organisation Design
Building an VSM Organization

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

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
Value Stream Design : Work

- **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

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

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Value Stream Design: Work

- **Step 4: Value Stream Demand Scheduling Points**
  - Based on Build Plan
  - 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

---

**Current State**

- Schedules
- Wafer Fab
- Wafer Tst
- Mod Tst
- Push

**Future State**

- Flow Policy controls the behavior
- Produce to consumption / demand
- Schedule only one point
- Pul
- Push
- Pull

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Interconnected
Simulation-Based Planning Tools
Dynamic Inventory Optimization System (AXIO)

- 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:

Kanban Logic
- Stochastic yields
- Stochastic lead time
- Stochastic demand

WIP
- Temporal state support
- Production restrictions
- Capacity manager / prioritization
- Sequencing / build-to-order

Sophisticated control mechanisms

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

Simulation run 1:
Stochastic Optimization of safety stock and reorder points
Establish Flow Policy

Simulation run 2:
Execute Flow Policy
Model detailed production Script
Generate Replenishment Requirements

Propagate Replenishment Requirements as Demand

Stochastic Planning Factors
Independent and Propagated Demand
Asset Position (WIP / INV)
Manufacturing Mode: Pull Replenish, Sequencing, CONWIP

Preparation

Simulation

Propagation

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Flow Propagation: Safety Stock Algorithms

Safety Stock Attributes
- Demand
- Supply Variability
- Calculation Methods

Industry Practices
- “deterministic” Independent and MRP exploded requirements
- Focused on a limited set of supply attributes like lead time and yield
- Typically industry practices only deal with Normally

Our Approach
- Stochastic Simulation of Flow Policy to generate upstream requirements in support of downstream replenishment requirements
- Factor in multiple forms of variability like lead time, yield, form factor, and speed sorts
- 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

- 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

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**Intelligent**

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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
Simulation Analysis of an MRP Guided Flow Propagation System

Component Part

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Assembly Part

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Results of the Previous MRP example

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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

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Simulation Analysis: Robustness of Flow Policy vs Demand

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

- New Demands and variability is understood
- Business Rules applied to optimize

New Planning Cycle begins/
Continuous Improveme
Events drive Problem
Solving exercises by the MFG

Events on the floor are addressed real time, within the bounds of the flow policy

Manufacturing is more autonomous while executing

Unforeseen events lead to Andons on floor

- MFG Decides When to build based on consumption at supermarkets

- Capacity Allocations based on Build Plan

- Build plan processed by Lean Planning (AXIO)

- Flow Policy published for MFG (What and How much)

- MFG: Master Planner VS Master Planner

- ISC: Inv Analyst

- MEOL: Supply Variability Planner

- BEOL: New Product Analyst

- FEOL: MFG Analyst

- ISC: Inv Analyst

- Demand Planner

- Lean Team

- EOL: Product Analyst

- New Product Analyst

- Components

- Procurement

- Capacity Analyst

- Capability Analyst

- MRP/ Central Planning

- Publish Monthly/ Quarterly Revenue Plan (Build Plan)

Revenue Plan (Build Plan)
Real Time ePull + Floor Visuals + E2E Metrics

- **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
Managing Demand Variability Propagation in a MEI or Value Stream

Factory 5 Supplies once a day
- Long Lead times > 70 days
- Lotsize = 25

Factory 4 (pulls @ 1 times a day)

Factory 3
- Vendor (pulls @ 1 a week)
- Leads = 25
- Supplier Variability

Factory 2 (pulls @ 2 times a day)
- Leads > 70 days
- Lotsize = 1000

Factory 1 (pulls @ 6 times a day)
- Leads > 45 days
- Lotsize = 1000

Variable Customer Demand
- Cycle to Cycle variability

Lead times 2 days / Lotsize = 4

Lead times 2 days / Lotsize = 4

Lead times 10 days / Lotsize = 896
- Different Form Factor / High Process variability / Release Method: CONWIP

SM3a

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APICS
The Association for Operations Management
Managing Demand Variability Propagation in a MEI or Value Stream

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

<table>
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<th>SM5</th>
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<td>!</td>
<td>+/ -2</td>
<td>+/- -1</td>
<td>+/ -0</td>
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| 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…throughout the supply chain.
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 Months)**

<table>
<thead>
<tr>
<th>Product</th>
<th>1Q '08 Actuals</th>
<th>Target 2008</th>
<th>&quot;4Q '08 'Real' Actuals</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product 1</td>
<td>41.3</td>
<td>20</td>
<td>19</td>
<td>54%</td>
</tr>
<tr>
<td>Product 2</td>
<td>54.9</td>
<td>22</td>
<td>25</td>
<td>54%</td>
</tr>
<tr>
<td>Product 3</td>
<td>58.9</td>
<td>25</td>
<td>33</td>
<td>44%</td>
</tr>
<tr>
<td>Product 4</td>
<td>53.1</td>
<td>25</td>
<td>66</td>
<td>+ %</td>
</tr>
<tr>
<td>Product 5</td>
<td>54.0</td>
<td>22</td>
<td>61</td>
<td>+ %</td>
</tr>
</tbody>
</table>

**”Real” actuals from Nov 1st thru Dec 12 2008**
The Supply Chain of the Future must be SMARTER.... It will be instrumented, interconnected and intelligent.

**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.

**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.
- **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.
Questions?