Supply Chain Systems II: Supply Chain Modules
Evolution of Supply Chain Tools

1960-1970’s
- IBM developed a Bill of Materials Processor (BOMP)
- Mainframe based database systems mainly to track materials for large manufacturers
- Closed-loop (shop floor management) functionality added
- MRP (material requirements planning) is essentially a time-phased order release system

1980’s
- MRP-II (manufacturing resource planning) introduced to integrate production with finance and marketing
- Fit in with Just-In-Time (JIT) manufacturing methodology
- Expanded ties to other functions: S&OP, master production planning, capacity planning, etc.
- Precursor of the larger and more comprehensive ERP systems
Evolution of Supply Chain Tools

- **1990’s**
  - Most MRP-II functions absorbed into large ERP suites
  - Introduction of Advanced Planning Systems (APS)
  - Introduction of function specific optimization based decision support software (WMS, TMS, MES, Inventory Optimization, Procurement, etc.)
  - Wider spread adoption of ERP systems to small and mid-sized firms mainly due to potential Y2K issues

- **2000’s**
  - Introduction of web-based interfaces
  - Improvements in communication (XML, GPS positioning)
  - Wider adoption of shared or cloud based solutions (SaaS)
  - Consolidation of supply chain software vendors
  - Emergence of supply chain ecosystems or platforms
  - Expansion of ERP systems to include essentially all SCM functions
Integrating supply chains span multiple companies

- Systems can be part of the ERP itself, a standalone application, or part of larger supply chain eco-system.
- We will focus on the functionality in this lesson.
  - Planning Applications
    - Production Planning (PP) and Advanced Planning Systems (APS)
  - Execution Applications
    - Warehouse Management Systems (WMS)
    - Transportation Management Systems (TMS)
    - Manufacturing Execution Systems (MES)
Planning vs. Execution
Planning vs. Execution

Consists of a continuum of tasks, but . . .

ROA Impact

Planning Tasks

Execution Tasks

. . . there is a gap!
# Questions Differ Based on Timeframe

## Strategic
- What carriers should I partner with and how?
- How should I flow my products?
- Should I use pool points, cross-docks, or multi-stop routes?
- Where should I use dedicated or private fleets, if any where at all?
- Which carriers provided quality service in the past?

## Tactical
- How can I quickly secure rates for a new DC/plant/lane?
- What lanes are having performance problems?
- Which carriers are complying to or exceeding their contracts?
- Are site managers complying to the strategic plan?
- Where should I establish a seasonal contract?

## Operational
- Which carrier should I tender this load to?
- How can I collaboratively source this week’s loads?
- How do I prevent Maverick/Rogue behavior?
- Should I use a contract carrier or look at the spot market?
- How can I best communicate with my carriers?
Approaches Differ Based on Timeframe

- Establishing plan & strategy
- Event based engagement
- Non-routine analysis - Value Focus

- Executing the strategic plan
- Transaction based rules & processes
- Automated actions - Process Focus

Search Time

- Weeks
- Days
- Minutes

Analysis (Risk)

Management

Strategic

Tactical

Operational
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Technologies Differ Based on Timeframe

- **Analysis Engine**:
  - Optimization
  - Simulation
  - Data Analysis

- **Communication**:
  - Web-based
  - File Exchange
  - Remote Access

- **Workflow Software**:
  - Compliance Tracking
  - Rules Engine
  - Transaction Processing
Advanced Planning Systems
Advanced Planning Systems

- Called different names by different vendors
- Most common functionality:
  - Network design,
  - Demand planning,
  - Production planning,
  - Production scheduling,
  - Distribution planning, and,
  - Transportation planning.
- Used primarily as decision support system
- Typically utilizes large scale mixed integer linear programs (MILPs) and sometimes simulation
Advanced Planning Scale & Scope

- **Planning Horizons** (rough guidelines – each firm differs)
  - <3 months out – Master Production Schedule (MRP, DRP)
    - <4 weeks out - Frozen MPS
    - 5 to 8 weeks out – Slush MPS – some changes allowed (+- 10%)
    - >8 weeks out – Water MPS – more changes are allowed (+- 30%)
  - 3-18 months out – Aggregated Planning
  - >18 months out – Long Range Planning – Network Design, etc.

- Longer range models used in “what if” analysis
- Often customized to specific industry
Advanced Planning System

- **Inputs (from ERP or other systems):**
  - Current costs, manufacturing and storage capacities, consensus forecast, sales orders, production status, purchase orders, and inventory policy recommendations, etc.

- **Decision Process:**
  - Large scale optimization (MILP) across multiple facilities and time horizons in a single planning run
  - Generates unconstrained, constrained, and optimal plans

- **Outputs:**
  - Demand forecast and plan for meeting demand
  - A feasible production plan for future periods to include allocation of production to plants
  - Allocation of orders to suppliers
  - Identification of bottlenecks
  - Root Cause Analysis
Transportation Management Systems (TMS)
Transportation Management Systems (TMS)

- **Definition:**
  - TMS is software that facilitates (1) procurement of transportation services, (2) short-term planning and optimization of transportation activities, assets, and resources, and (3) execution of transportation plans. (Gonzalez, A. 2009)
  - Often segmented or specialized by geography (domestic, international) and/or mode (ocean, air, rail, full truckload, less-than truckload, parcel, private fleet etc.)

- **Core Functionality (not all systems have all):**
  - Transportation procurement
  - Mode and carrier selection
  - Carrier communication (EDI/XML/Web)
  - Routing guide generation and maintenance
  - Fleet management
  - Audit, payment, and claims
  - Appointment scheduling
  - Yard management
  - Route planning (multi-stop, continuous move)
There were over 50 Internet Truckload Exchanges in 2000

Optimization based bidding added to every TMS solution by early 2000’s
Transportation Execution

- Connects to Order Management Systems (OMS), Payment Systems, and the ERP
- Serves as the interface to the carriers
- Objective:
  - Move products from initial origin to final destination in most cost effective manner while meeting level of service standards
  -Executes the plan using the procured carriers based on real-time information

**PLAN:** Create Shipments from Orders

**EXECUTE:** Select and tender to Carriers

**MONITOR:** Visibility of the status of Shipments

**RECONCILE:** Audit invoices and pay for Transportation
Execution Considerations

- Considerations
  - How do orders drop? Batched vs Continuous?
  - How much time is allowed between drop and must-ship? Weeks? Days? Hours? Minutes?
  - What percentage of orders change after release?
  - What is the length of haul?
  - How many orders are “in play” at any time?

- Key Decisions
  - Load Building (Consolidation & Routing)
  - Carrier Selection
1. Direct LTL from KC to 6 destinations
2. Multi-stop TL from KC to all locations
3. MSTL from KC to St. Paul to Pool Point (drop off 4 local LTL shipments) continue to Atlanta
TMS Carrier Communication & Selection
Primary EDI Transaction Sets

204 – Motor Carrier Load Tender
- Used by shippers to tender an offer for a shipment to a full truckload motor carrier. It may be used for creating, updating or replacing, or canceling a shipment.
- May contain info on: Carrier identification, Scheduling, Equipment requirements, Ship-to location, Contact at destination, Description of goods, and Shipping instructions.

990 - Response to a Load Tender
- Used by motor carriers to indicate whether it will pick up a shipment offered by the shipper.
- Five potential responses (Accepted, Declined, Accepted with conditions, Spot bid request accepted (w/ bid amount), Spot bid request declined.

214 - Transportation Carrier Shipment Status Message
- Used by carriers to provide shippers and consignees with the status of their shipments.
- May contain info on: Origin, Current location, Dates and times for pickup and/or estimated delivery, Proof of delivery, Shipment status details to include reasons for exceptions, and Shipment description.
Carrier Selection

Types of Capacity

**Primary** - Contracted Carrier
**Dedicated Fleet**
**Continuous Move**
**Spot Carrier**
Carrier Selection

Requirement

($痍#$, Timing, Service)

Capacity

Primary

Dedicated

Continuous Move

Spot

Load 1

Load 2

Load 3

Load n

Load n
Carrier Selection with Automated Escalation

Order Management System

Load

Select Carrier from Routing Guide

Select Appropriate: (1) Carrier Group & (2) Clearing Mechanism

Transportation Management System

Tender

Yes

Carrier

No

Accept?

Tender

Yes

$t_{LT} > t_{MIN}$?

No

Offer

Response(s)

OK?

Carrier

No

Yes

Done

Automated Escalation Process

Number of Carriers

Range of Pricing

Steps

Step 1

Step 2

Step 3

Step 4

Step 5

Primary

Lane Backup

All Relevant Company Carriers (Quoted Rates)

All Relevant Company Carriers (Dynamic Prices)

Public Market
Approaches Must Be Linked

How do I select each carrier?

- Tier I: Uses strategic routing guide
- Tier II: Increased flexibility in execution

How do I price each load?

- Contract
- Dynamic

How do I price each load?

- Strategic Lane Assmt
- Dynamic Carrier Selection

Dynamic Pricing in Private Exchange

Flexible Assmt Dynamic Carrier Selection

Tier III: Spot execution – highly variable

Tier II: Increased flexibility in execution

Tier I: Uses strategic routing guide
Warehouse Management Systems & Automation
Warehouse Management Systems (WMS)

- **Definition:**
  - WMS is a software system that facilitates all aspects of operations within a warehouse or distribution center and integrates with other systems.
  - Not the same as inventory management systems that determine stocking levels and replenishment policies – they complement.

- **Benefits of a WMS:**
  - real-time stock visibility and traceability,
  - improved labor productivity,
  - reduction in mis-picks,
  - reduction in returns,
  - more accurate reporting,
  - improved responsiveness,
  - greater data visibility,
  - improved customer service, and
  - minimized paperwork.

- Closely connected to automation in terms of material handling and paperless device interfaces (identification and communication)
Warehouse Automation

- Automatic identification technologies
  - Bar codes and bar code scanners
  - Radio frequency tags (RFID) and antennae
  - Smart cards and magnetic stripes
  - Vision systems

- Automatic communication technologies
  - Radio frequency data communications
  - Synthesized voice
  - Virtual displays
  - Pick to light / voice systems

- Automated material handling technologies
  - Carousels
  - Conveyors/robotics
  - Flow racks
  - AS/RS – Automated storage & retrieval systems
WMS Software Components

- **Order Processing**
  - Order checking & batching
  - Allocation
  - Auto-replenishment

- **Receiving**
  - ASN planning
  - In bound tracking
  - Delivery appointment scheduling
  - PO verification
  - Returns processing

- **Put-Away**
  - Palletizing
  - Zoning and slotting
  - Random/directed put away
  - Routing for putaway & replenishment

- **Picking**
  - Batch/Wave/Zone/Directed picking
  - Carton/pallet select
  - Assembly/kitting
  - Pick-to-light/voice

- **Shipping**
  - Pallet sequencing & Load planning
  - Pallet layering
  - Trailer management

- **Labor Management**
  - Individual/team performance mgmt
  - Labor scheduling
  - Time standards

- **Equipment Support**
  - Interface to automated equipment
  - Equipment maintenance
Manufacturing Execution Systems
Manufacturing Execution System (MES)

- **Definition:**
  - MES is a software system that manages and monitors all work-in-process (WIP) in the production process.
  - This includes integrating with an ERP to manage the execution of release of production orders to finished goods delivery, trigger supply chain replenishments, and enhance product traceability through manufacturing.

- **Functionality within an MES:**
  - Machine scheduling,
  - Process management,
  - Document control,
  - Labor management,
  - Inventory management,
  - Product (WIP) tracking,
  - Performance analysis,
  - Labor management,
  - Quality management,
  - Production reporting.

- More of an internal facing system – not usually connected to the larger supply chain network.
Key Points
SCM Applications Extend the Enterprise

- Advanced Planning Systems (APS)
  - Long range, optimization-based decision support tools
- Execution Systems
  - Transportation Management Systems (TMS)
  - Warehouse Management Systems (WMS)
  - Manufacturing Execution Systems (MES)
Planning vs. Execution: Approaches

1. **Strategic**
   - Establishing plan & strategy
   - Event based engagement
   - Non-routine analysis - Value Focus

2. **Tactical**
   - Executing the strategic plan
   - Transaction based rules & processes
   - Automated actions - Process Focus

3. **Operational**

**Analysis (Risk)**

- Search Time
  - Weeks
  - Days
  - Minutes
### Planning vs. Execution: Technology

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# Top Supply Chain Planning Vendors

## Top 20 supply chain management software suppliers

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**Total**: 6,059, 6,310

Questions, Comments, Suggestions?
Use the Discussion Forum!

“Jasper – just excited to be in the car”
photo courtesy Jennifer Sexton