Retrospective: Introduction to Operations Management
Three Foundational Components of Operations Management

Product Development (Sega, #2)

Process Design & Management (Burger King, #3)

Supply Chain (Nokia, #1, Dell, #4)

(Alaska Air #5, Webvan #6)
Process Design & Management

- Process Design: Options & Assessment
  - Queueing Analysis
  - Capacity Analysis
  How did Nokia assess capacity in the crunch? How did they change capacity?
  - Uncertainty Analysis
  How did each company prepare for difficult-to-anticipate events?

- Inventory Systems
  - Did N&E operate Just-in-Time, or did they hold big stores of chips waiting just in case?

- Production Control
  - Was Nokia’s software the principal instrument of control?
  How did they monitor the situation?

  ERP/Software/Internet
  - Was Nokia’s software the principal instrument of communication?

- Operations Excellence
  - Continuous Improvement
  - Just-in-Time
  - Quality Management (SPC, 6σ)
Three Foundational Components of Operations Management

Product Development
(Sega, #2)

(Alaska Air #5)

Process Design & Management
(Burger King, #3)

Dell Product Features
- µP & modem speed
- CD ROM speed
- MB DRAM & HD
- screen size
- order-to-deliv time
- features range
- fulfillment accuracy

AA Product Features
- check-in time
- reservations help
- meals
- price
- flight frequency
- mileage awards
- route coverage
- baggage handling
- customer coddling

Supply Chain
(Nokia, #1, Dell, #4)
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Product Development
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Who has the advantage on each dimension?

**Webvan Features**
- selection
- price
- quality/freshness
- shop any hour
- never leave home
- choose delivery time
- save your time
- same day delivery
- fulfillment accuracy
- no lugging required

**Grocery Store Features**
- selection
- price
- quality/freshness
- shopping environment

**Product Development**
(Sega, #2)

(Arizona Air #5, Webvan #6)
Challenges of Service Interface: Grocery Stores vs. Webvan

- **Intangibility** - customer expectations vs. perceptions
  - Grocery Stores: quality, selection, **ENVIRONMENT**
  - Webvan: quality, selection, **DELIVERY**

- **Perishability** - use it or lose it
  - Grocery Stores: fresh foods (produce, meats, baked goods)
  - Webvan: fresh foods & **TRUCK CAPACITY**

- **Heterogeneity** - inherent variability of service & customer
  - Grocery: checkout people, counter people, customer needs
  - Webvan: **DELIVERY PERSON**

- **Simultaneity** - services simultaneously produced & consumed
  - Grocery: presentation in the store
  - Webvan: **DELIVERY TO THE HOME**
Supply Chain

- **Strategic Supply Chain Design**
  - Make Vs. Buy
    - Did sourcing strategy play a role in the differential performance of N & E?
  - Supplier Selection, Sourcing
    - Single vs. Dual sourcing

- **Supply Chain Management**
  - End-to-end coordination
    - Do we see here examples of integrated enterprise?
  - Supplier Relations
    - hard-nosed, polite, hostile, collaborative?

- **Delayed Differentiation**
1. What are the key DESIGN parameters for Burger King?
   A. Product
   B. Process Technology
   C. Facility
   D. Work System/HR System

2. What are the key PLANNING tasks for Burger King?
   A. Supply
   B. Demand
   C. Capacity/Workload

3. What are the key CONTROL processes for Burger King?
   A. Production Control
   B. Quality Control
   C. Process Control

4. What are the key IMPROVEMENT processes for BK?
   A. Quality Improvement
   B. Productivity Improvement
   C. Technological Improvement
   D. Systems Improvement
Volatility Amplification in the Supply Chain: 
"The Bullwhip Effect"

Information lags
Delivery lags
Over- and underordering
Misperceptions of feedback
Lumpiness in ordering
Chain accumulations

SOLUTIONS:
Countercyclical Markets
Countercyclical Technologies
Collaborative channel mgmt. 
(Cincinnati Milacron & Boeing)

How does production control work in the Beer Game?
Applying EOQ and Newsvendor models to set Reorder Points and Reorder Quantities

(s, S) (ROP, ROQ), (min, max)

\[ Q = \sqrt{\frac{2RS}{CK}} = \text{ROQ (REORDER QUANTITY)} \]

ROP=Reorder Point = Expected Demand During the order lead time + safety stock
\[ = E\{DDL\} + SS \]

\[ \text{Prob } \{DDL \leq ROP\} = \frac{Cu}{(Co+Cu)} \]

Cu=Cost of Underage \((r-c\) in newsvendor); Co=Cost of Overage \((c\) in newsvendor)
But, Co with nonperishables is \(c \times \text{cost of holding}\)
ROP=SS+E\{DDL\}; DDL = X1 + X2 + \ldots + XL; E\{DDL\} = E\{L\} \times E\{X\}

i.e., DDL has a mean of Expected lead time \(x\) Expected avg demand/unit time

Variance\{DDL\}~Var\{X\} \times E\{L\} + Var\{L\} \times E\{X^2\}
If \( Q^* = EOQ = \frac{2DS}{\sqrt{C}} \), where demand rate is \( D \) units per week,

Then \( T = \text{Time between orders} = \frac{D}{Q^*} \).

Want \( Q_1 \) units to arrive at time \( \frac{D}{Q^*} \), so order at \( \frac{D}{Q^*} - E\{LT\} \).
15.760 Class #8: Basic Concepts in Queueing

System Performance = f(System parameters)

- Output/throughput rate: \( \lambda \)
- Inventory Level/Queue Size/Line length
- Waiting Time/Cycle Time: \( W \)
- Capacity or Server utilization: \( \rho \)
- Probability that Queue is full: \( P_{\text{full}} \)
- Arrival rate: \( \lambda \)
- Service rate: \( \mu \)
- Service time: \( M \)
- Number of servers: \( S \)
- Queue/Buffer capacity: \( R \)
- Capacity or Server utilization: \( \rho \)
- Number of Service classes: \( K \)
Fish Processing Example

Ships arrive → Freezer → Fish processing facility → Processed Fish

Input Rate (Tons per month)

Time (Months)

- 0 months: 3600 tons
- 4 months: 4800 tons
- 8 months: 600 tons
ASSUMPTIONS OF THE QUEUEING MODELS

Poisson arrivals/exponential service times
steady state
\( \rho < 1 \), when computing the queue lengths
and waiting times
Constant # of servers
FIFO service
Single-line queue (to MD's)
Infinite queue capacity
Ignore special priority emergencies
Ignore special priority requests
Basic Concepts in Queueing:
Nonlinearities in Congestion in Stochastic Systems

If service times and interarrival times have exponential distributions, then

\[ L = \frac{\rho^2}{1-\rho} \]

\[ W = \frac{\rho^2}{\lambda(1-\rho)} \]

\( \Delta \rho \) = "congestion"
Management of Queues

The Psychology of Waiting Lines

Propositions

1. Unoccupied time feels longer than occupied time
2. Process waits feel longer than in process waits
3. Anxiety makes waits seem longer
4. Uncertain waits seem longer than known, finite waits
5. Unexplained waits are longer than explained
6. Unfair waits are longer than equitable waits
7. The more valuable the service, the longer the customer will wait
8. Solo waits feel longer than group waits
What is the Purpose and Logic of MRP?

- Inventory Transactions
- Inventory Status
- Master Production Schedule
- MRP: (Explosion Offsets, Nets)
- Exception Report & Schedules
- Forecasts
- Customer Orders
- Engineering Changes
- Bill of Materials
Clockspeed: The Dimension of Time on Operations Management

Study the Industry Fruitflies

**Evolution in the natural world:**

- FRUITFLIES evolve faster than MAMMALS
- MAMMALS evolve faster than REPTILES

**THE KEY TOOL:**

Cross-SPECIES Benchmarking of Dynamic Forces

**Evolution in the industrial world:**

- INFOTAINMENT is faster than MICROCHIPS
- MICROCHIPS evolve faster than AUTOS
- AUTOS evolve faster than AIRCRAFT
- AIRCRAFT evolve faster than MINERAL EXTRACTION

**THE KEY TOOL:**

Cross-INDUSTRY Benchmarking of Dynamic Forces
TOTAL QUALITY MANAGEMENT

FOUR LEVELS OF QUALITY

FOUR THOUGHT REVOLUTIONS
Customers first
Continuous Improvement
Total Participation
Societal Learning

ORGANIZATIONAL MANAGEMENT
Information & Measurement Systems
Education
Incentive Systems
Organizational Change
The Logic and Processes of JIT Improvement

Inventories & Lead Times
$L = \lambda W$

Setup Times & Setup Costs

Quality Problems

System Variability

P\{D \leq \mu + k\sigma\} = \frac{Cu}{(Co + Cu)}

Invisibility

Rapid Feedback

EOQ = \sqrt{\frac{2RS}{CK}}

L \approx \frac{\rho^2 \left[ \sigma_A^2 + \sigma_s^2 \right]/2}{(1-\rho^2) \left[ \mu_A^2 + \mu_s^2 \right]}
See Karmarkar: Getting Control of JIT, HBR, Sept-Oct 1989
From Reengineering to Process Management and Beyond

or

In the Footsteps of the Buffalo Springfield

“Something’s happening here; what is ain’t exactly clear . . . “

MIT Sloan School
Dr. Michael Hammer
March 2002

Summary:
Seven Things to Remember

- Process
- Process redesign
- Process evolution
- Process enterprise
- Process ownership
- Process as universal enabler
- Process integration across enterprise boundaries
Operations Lessons from The Goal

1. Measuring Operations Performance
2. Flow System management
3. Bottleneck Management
HP Supply Chain Problems
• Long chain with bullwhip
• Local customization needs with unpredictable demands

Possible solutions:
• Air Ship
• Europe Factory
• Universal Model
• Better Forecast
• Product Line change
• Shorten Review Period
• More Inventory

Postponing customization allows inventory pooling which provides greater coverage with less stock
A thumbnail sketch of the 20th century’s big ideas in operations management

1920’s: Ford & Taylor
    Moving Production line and standardized work
1930’s: Shewhart
    Statistical Control of Quality
1960’s: Ohno
    Lean Production System
1980’s: Goldratt & Kaplan
    Measurement & Theory of Constraints
1990’s: Hammer
    Reengineering & Process Focus
A 3-D CE decision model illustrating the imperative of concurrency
All Conclusions are *Temporary*

Clockspeeds are increasing almost everywhere

Supply Chain Relationships must anticipate Industry and Value Chain Dynamics

Proactive Relationships Design is a key organizational competency

Supply Chain Relationships must be designed concurrently with the products and systems they will deliver

Study of Fruit Flies can help with crafting strategy