Lean Manufacturing

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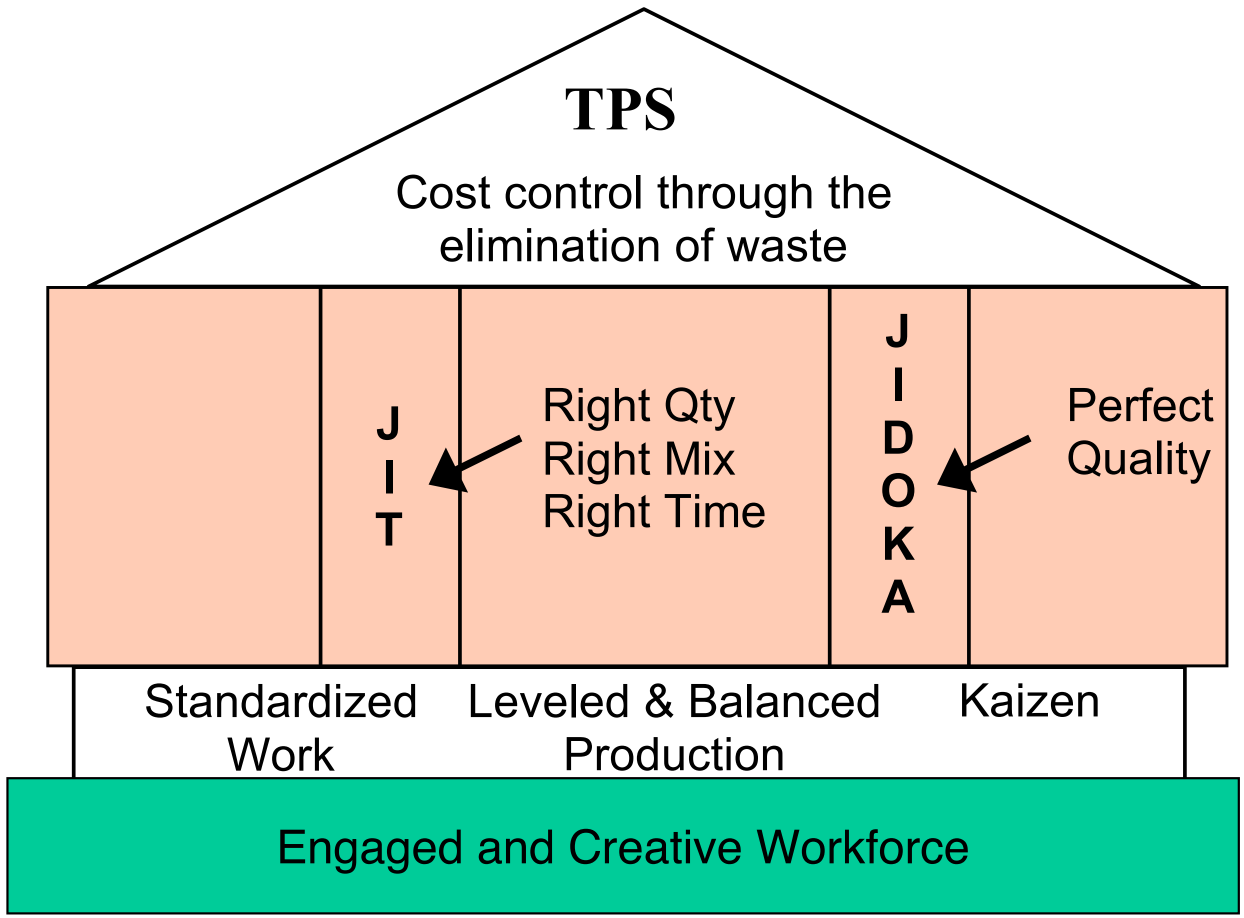
September 26, 2005

Content

- General lean concepts in factory design
- Manufacturing Video
- Manufacturing System Design Framework
- Conclusions

Lean from the Toyota Production System Shows How It All Relates



Aerospace Factory Designs Have Many Things to Consider

Inputs

- Production volume
- Product mix
- Product design
- Frequency of changes
- Complexity
- Process capability
- Type of organization
- Worker skill/knowledge

Factory Design

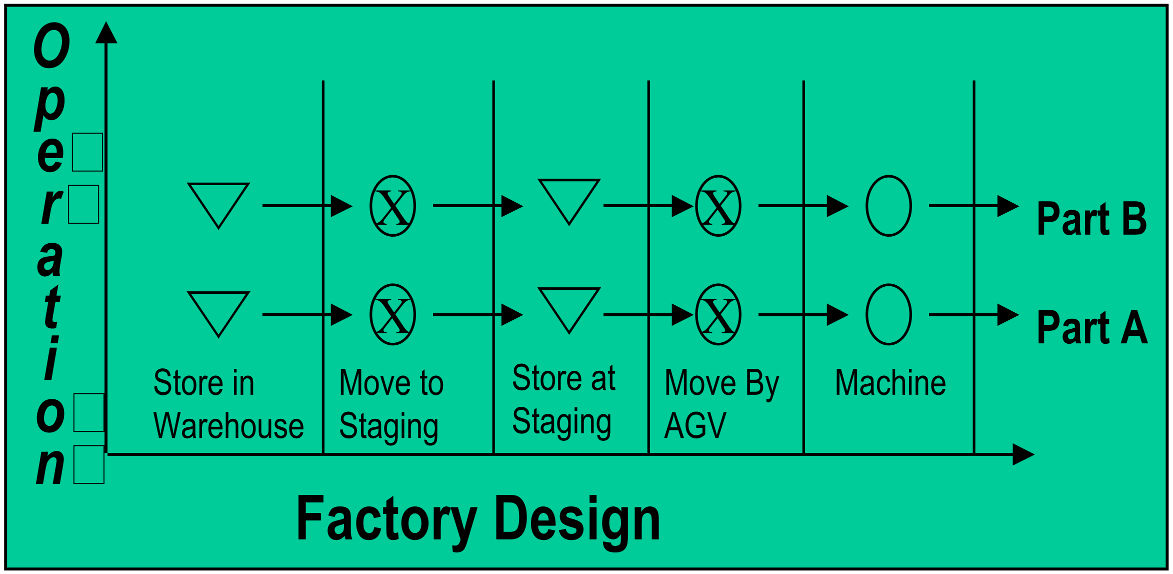
Focus Here

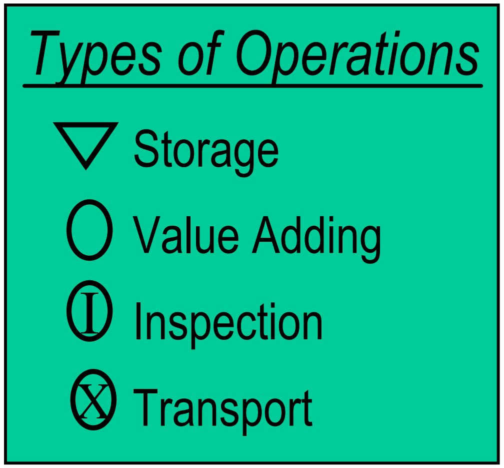
Outputs

- Cost
- Quality
- Performance
- Delivery
- Flexibility
- Innovativeness

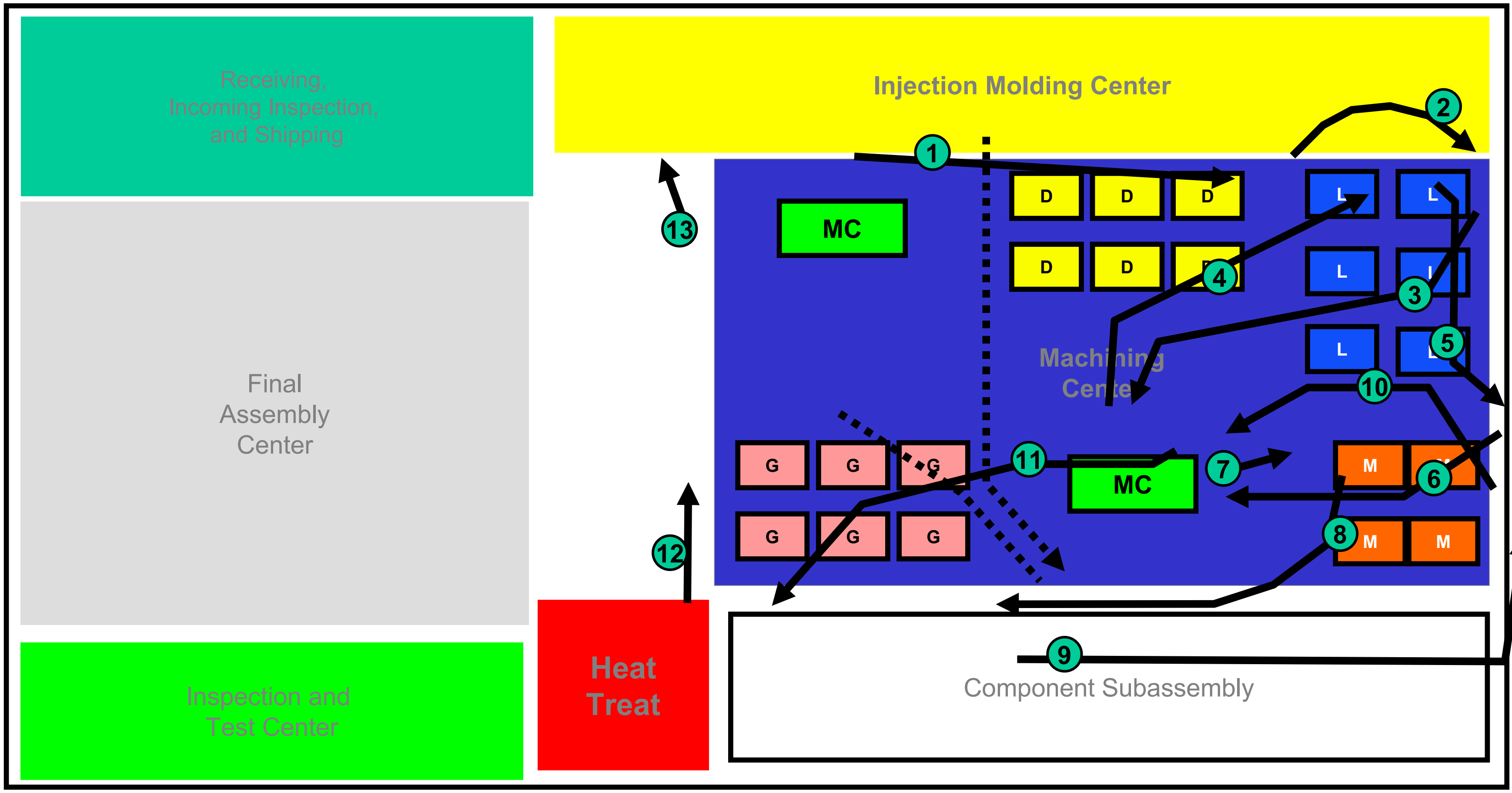
Benefits from a Focus on Process Rather Than Operation Improvements

- Operations
  - Value adding
  - Transportation
  - Delay (2 types)
  - Inspection
- Factory Design
  - Layout choices
  - Operation policies
  - Process Technology
  - Tapping human knowledge



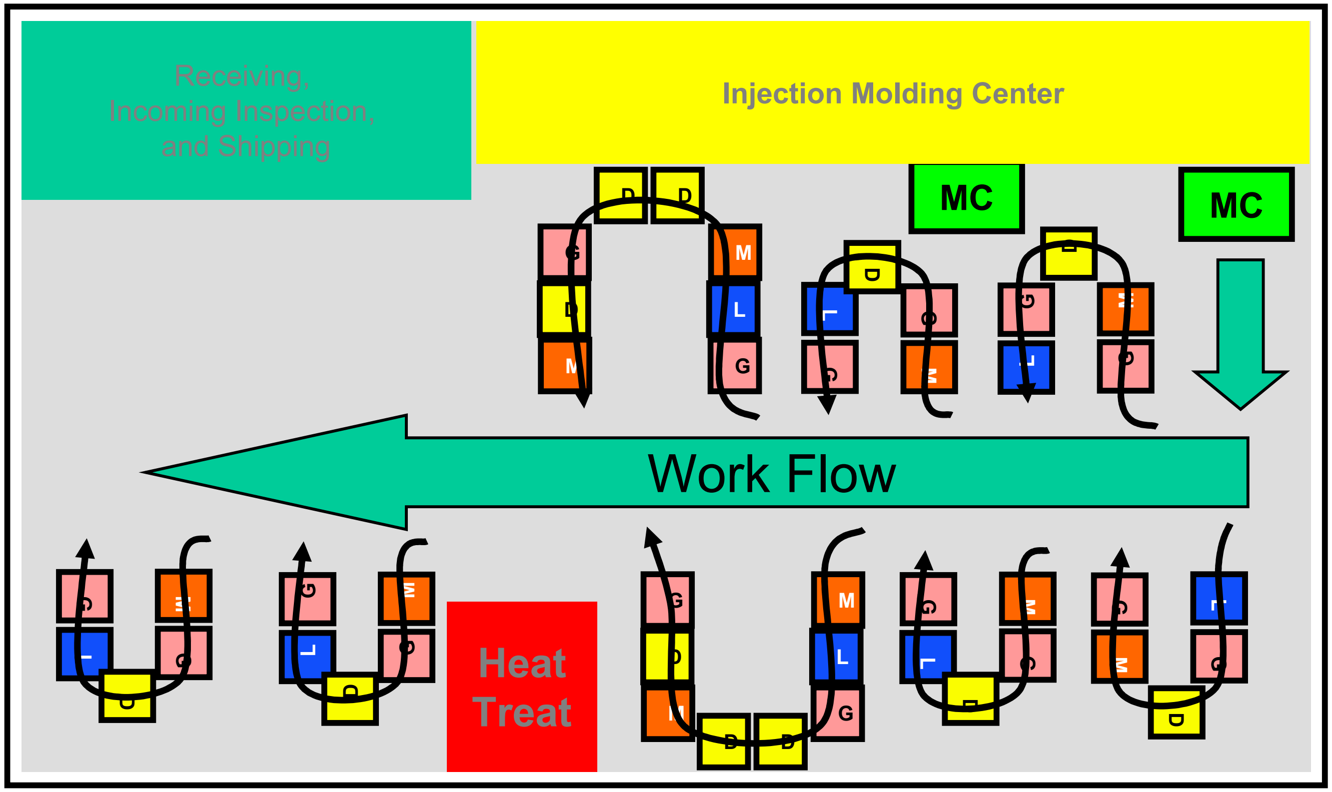


Traditional Manufacturing



The material flow could take up to millions of different paths, creating waste of transportation and waiting at virtually every step.

Cellular Manufacturing



Rather than route the materials required through the entire plant, materials flow to the head of each work cell, through each process in the cell, then to final assembly. This eliminates most of the transportation and waiting we would see in the traditional approach.

Only Understood Processes Can Be Improved

- Establish models and/or simulations to permit understanding
- Ensure process capability & maturation
- Maintain challenge of existing processes

Tools

- Five Whys
- Process flow charts
- Value stream mapping
- Statistical tools
- Data collection and discipline

Definite Boundaries Exist Between Flow and Pull

Flow

- MRP used for planning and control
- Group technology
- Reduce the number of flow paths
- Batch or single items
- Inventory to buffer flow
- Process control
- Minimize space & distance traveled with contiguous processing established

Pull

- Takt time
- Balanced production
- Level production
- Response time less than lead time
- Standard work
- Single item flow
- Correct problems immediately - STOP if necessary

Lean Tools Can Apply even if JIT System Not Logical

- Value stream mapping
- Work groups to implement change
- Visual displays and controls
- Error proofing
- Standardized work
- Quick changeover
- Total productive maintenance
- Rapid problem solving
- Self inspection
- Five S's

Source: J. Miltonburg, Manufacturing Strategy ©1995, p31.

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Production Operations Transition-To-Lean Roadmap

Supply Chain/External Environment

- *Legal*
- *Environmental*

- *Government Reqd. Systems (MMAS, EVMS, etc.)*

Enterprise / Production System Interface

- *Financial*
- *Information*

- *Procurement*
- *Engineering*

- *Quality*
- *Safety*

- *Training and Human Resources*
- *Workforce/Management Partnership*

Phase 0
Adopt Lean Paradigm

- Build vision
- Establish need
- Foster lean learning
- Make the commitment
- Obtain Sr. Mgmt. buy-in

Top Leadership Commitment

Phase 1
Prepare

- Integrate with Enterprise Level
- Establish an Operations Lean Implementation Team(s)
- Develop implementation strategy
- Develop a plan to address workforce changes
- Address Site Specific Cultural Issues
- Train key people
- Establish target objectives (metrics)

Lean Roadmap

Phase 2
Define Value

- Select initial implementation scope
- Define customer
- Define value - Quality, Schedule, and Target Cost

Target Cost

Phase 3
Identify Value Stream

- Record current state value stream
- Chart product and information flow
- Chart operator movement
- Chart tool movement
- Collect baseline data

baseline data

Phase 4
Design Production System

- Develop a future state value stream map
- Identify takt time requirements
- Review make/buy decisions
- Plan new layout
- Integrate suppliers
- Design visual control system
- Estimate and justify costs
- Plan TPM system

system

Phase 5
Implement Flow

- Standardize operations
- Mistake proof processes
- Achieve process control
- Implement TPM
- Implement self-inspection
- Eliminate/ reduce waste
- Cross train workforce
- Reduce set-up times
- Implement cell layout
- Implement visual controls

Phase 6
Implement Total System Pull

- Select appropriate production system control mechanism
- Strive for single item flow
- Level and balance production flow
- Link with suppliers
- Draw down inventories
- Reassign people
- Re-deploy/ dispose assets

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Phase 7
Strive for Perfection

- Team development
- Optimize quality
- Institutionalize 5S
- Institute Kaizen events
- Remove system barriers
- Expand TPM
- Evaluate against target metrics
- Evaluate progress using lean maturity matrices

Expand Internally/Externally

ENTRY

IMPROVED COMPETITIVE POSITION

6/5/00

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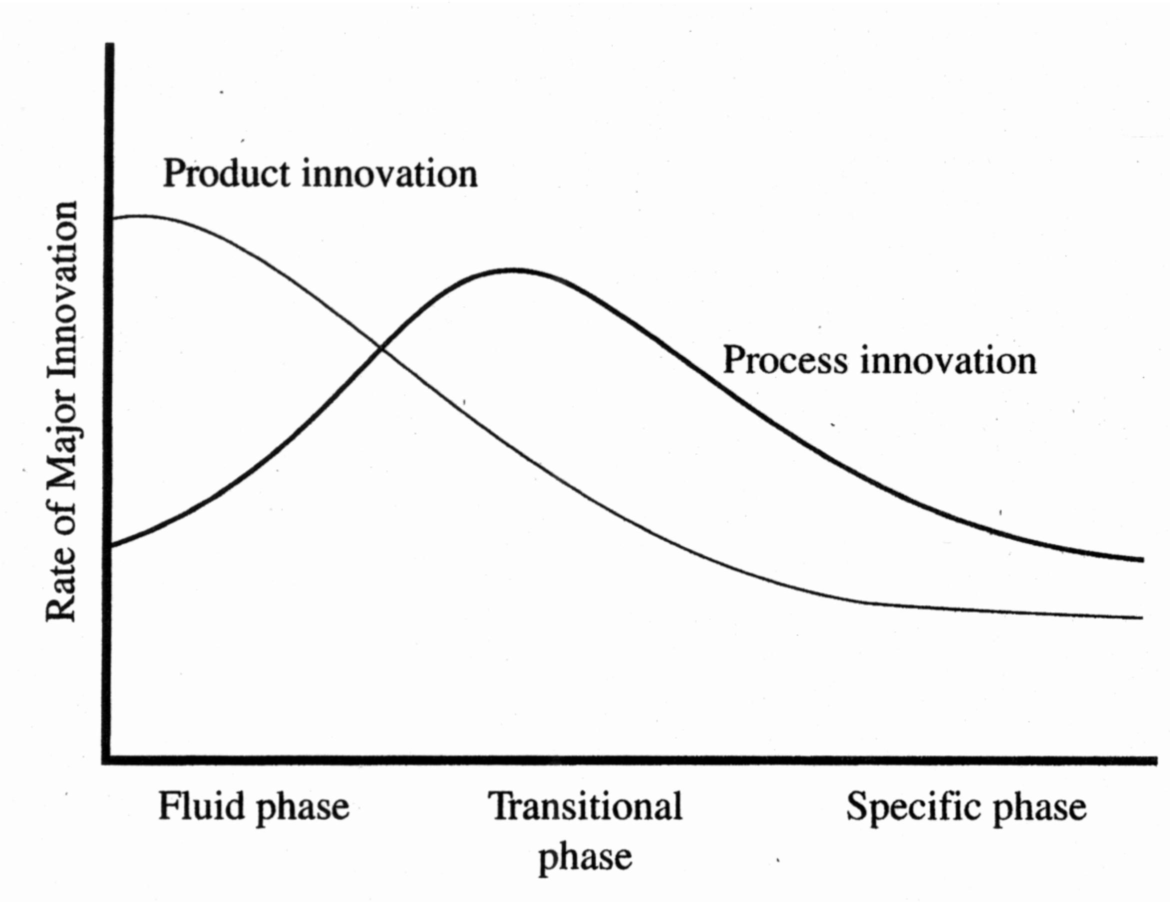
Background

- Matured aerospace industry
- Industrial innovation theory
- Implications on the aerospace industry

Matured Aerospace Industry

- Customers demanding specific capabilities
- Cost and affordability more prominent
- Innovation characteristics have changed

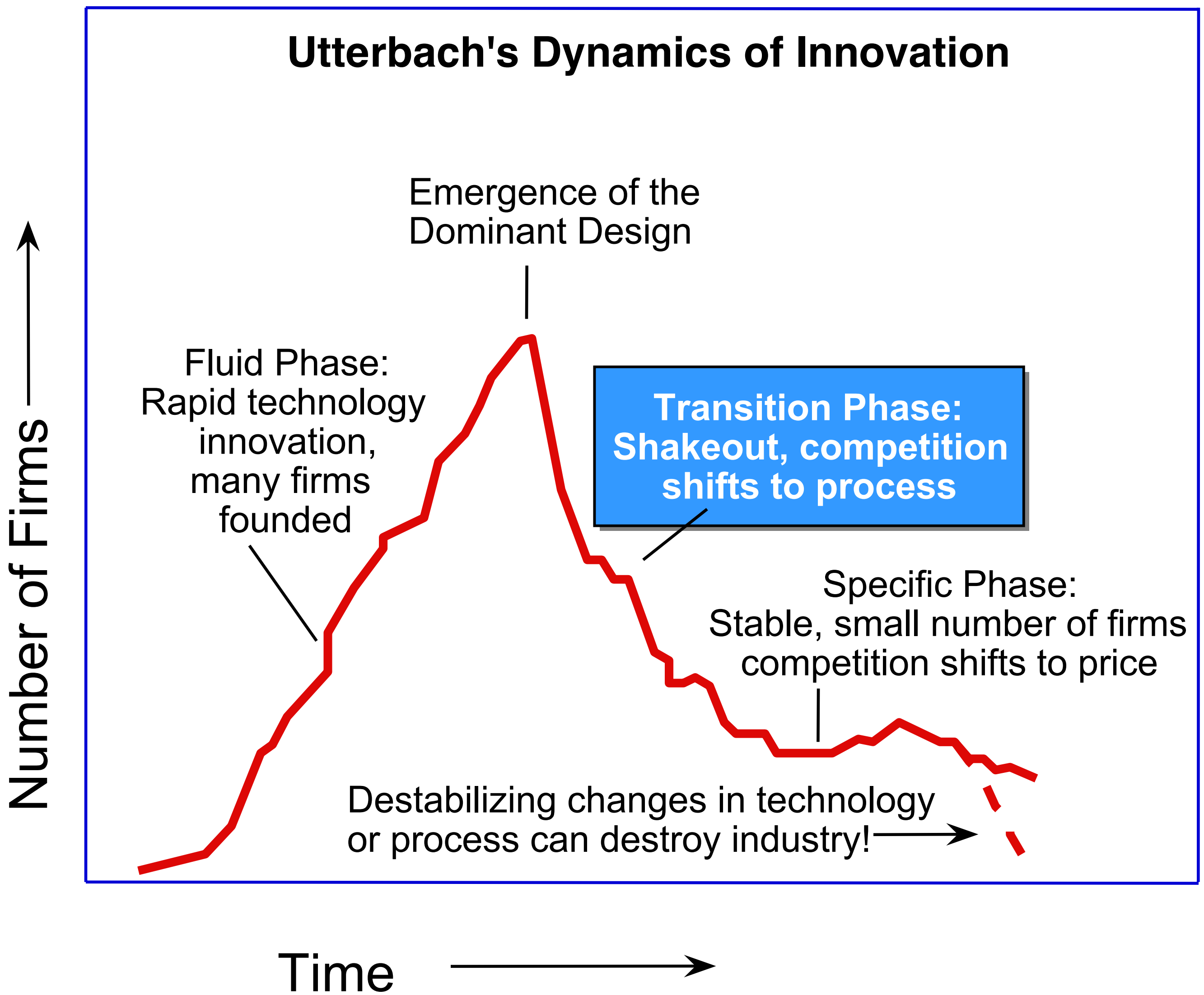
Utterback's Dynamics of Innovation Model



Source: William Abernathy & James Utterback, 1978

- Rate of product innovation highest during formative years
- As product matures rate of process innovation overcomes product innovation
- Very mature products have low levels of both product & process innovations

Theory in Application



Source: Data (cars), from Entry and Exit of Firms in the U.S. Auto Industry: 1894-1992. National Academy of Science: theory concepts from Utterback, Dynamics of Innovation, 1994

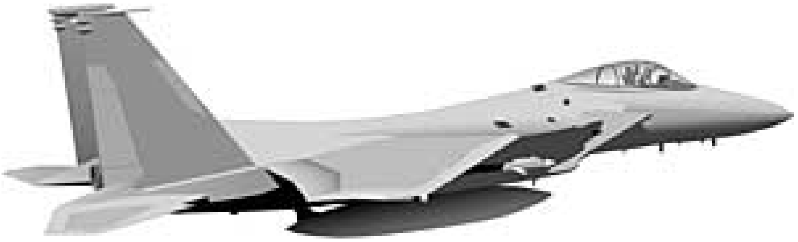
Dominant Design?

1958

1995

Dominant Design?

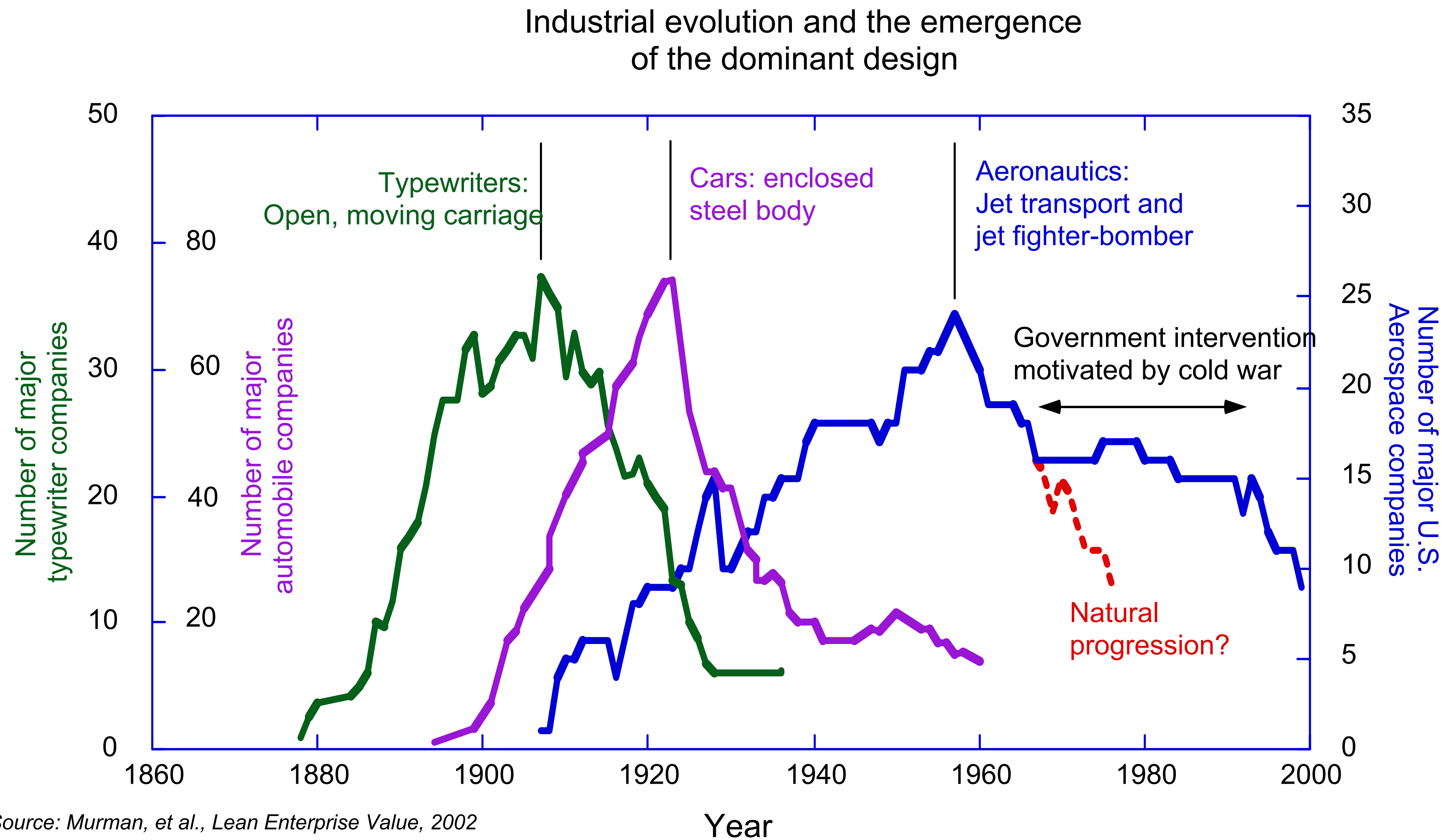
1953



1972

2002

Extension of Theory to the Aerospace Industry



Source: Murman, et al., Lean Enterprise Value, 2002

Implications for the Aerospace Industry

- Producibility and cost are more competitive factors
- Manufacturing inputs should carry more weight
- Emphasis should be on process innovation
- Firm core competencies must match industrial maturity
- Manufacturing strategy cannot be stepchild to platform strategy

Result: Heritage equipment, facilities and mindsets drive manufacturing system design

Proposal

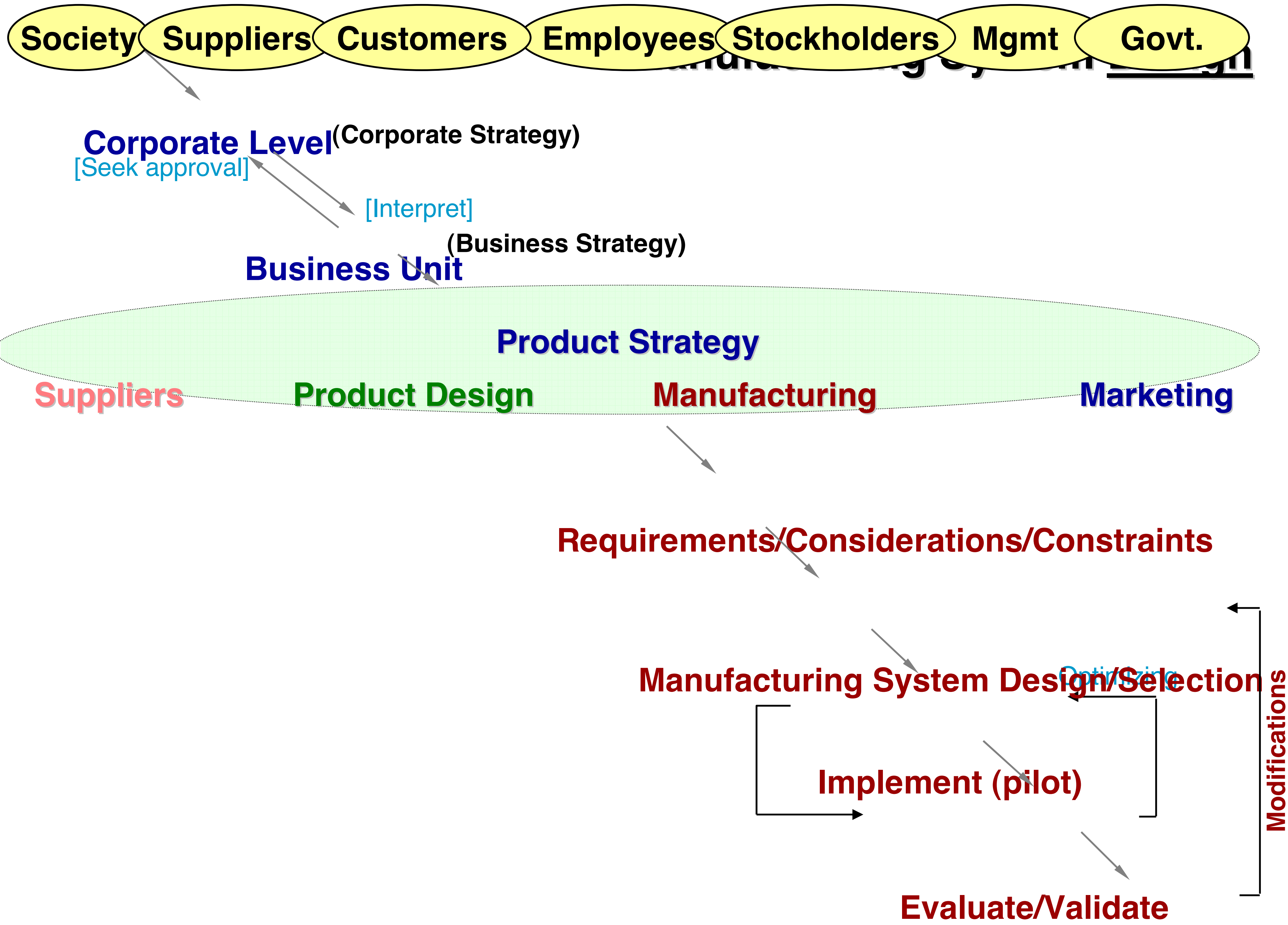
A holistic manufacturing system design framework to ensure process considerations are integral to the product development process

Characteristics

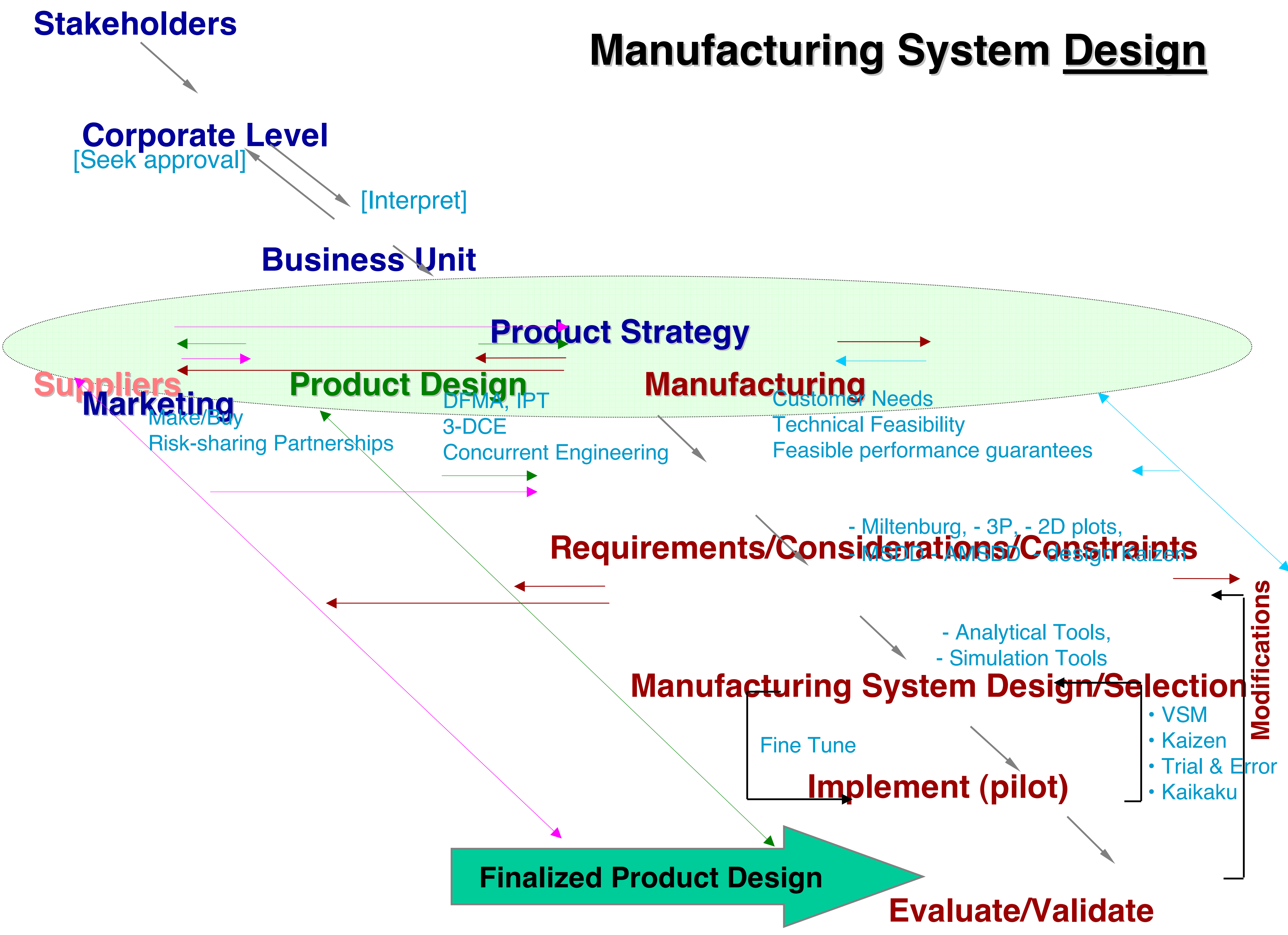
- Uses principles of systems engineering
- Visual depiction of "design beyond factory floor" ideas
- Manufacturing as part of the product strategy
- ***Manufacturing system design is strategy driven, not product design driven***
- Combines multiple useful tools
- Provides insights into order and interactions

Manufacturing System *Design*

- **Manufacturing system "infrastructure" design**
  - **Manufacturing strategy**
  - **Operating policy**
  - **Partnerships (suppliers)**
  - **Organization structure details**
- **Manufacturing system "structure" design**
  - **Buildings, location, capacity**
  - **Machine selection**
  - **Layout**
  - **WIP**



Society
Suppliers
Customers
Employees
Stockholders
Mgmt
Govt.
Corporate Level
(Corporate Strategy)
[Seek approval]
[Interpret]
(Business Strategy)
Business Unit
Product Strategy
Suppliers
Product Design
Manufacturing
Marketing
Requirements/Considerations/Constraints
Manufacturing System Design/Selection
Optimizing
Implement (pilot)
Evaluate/Validate
Modifications


Manufacturing System Design
Stakeholders
Corporate Level
[Seek approval]
[Interpret]
Business Unit
Product Strategy
Suppliers
Marketing
Make/Buy
Risk-sharing Partnerships
Product Design
DFMA, IPT
3-DCE
Concurrent Engineering
Manufacturing
Customer Needs
Technical Feasibility
Feasible performance guarantees
- Miltenburg, - 3P, - 2D plots,
- MSDD - AMSDD - design Kaizen
Requirements/Considerations/Constraints
- Analytical Tools,
- Simulation Tools
Manufacturing System Design/Selection
• VSM
• Kaizen
• Trial & Error
• Kaikaku
Modifications
Fine Tune
Implement (pilot)
Finalized Product Design
Evaluate/Validate

Insights from the Framework

- Linkage of strategy and manufacturing system design
- Three important characteristics
  - Phase presence
  - Phase timing
  - Breadth across functions

Following the framework process will result in the development of effective manufacturing system that meets the goals of the corporation *(Vaughn & Shields)*

Conclusions

- Competitive advantage from manufacturing excellence (enterprise strategy)
- Performance more closely related to how system designed (not production volume)
- Manufacturing as a true participating partner with the other functions (coequal status)