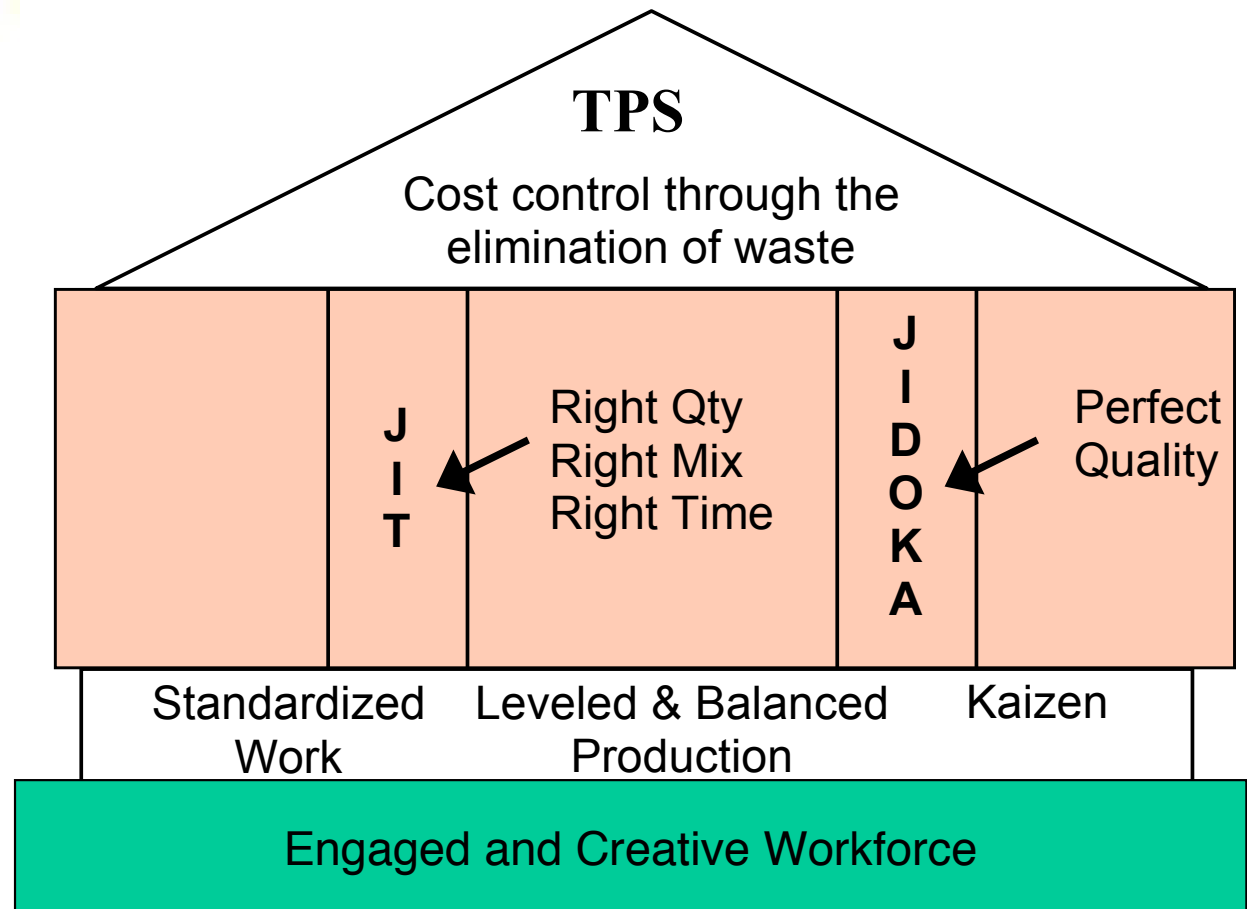


Lean Manufacturing



Professor Deborah Nightingale
September 26, 2005



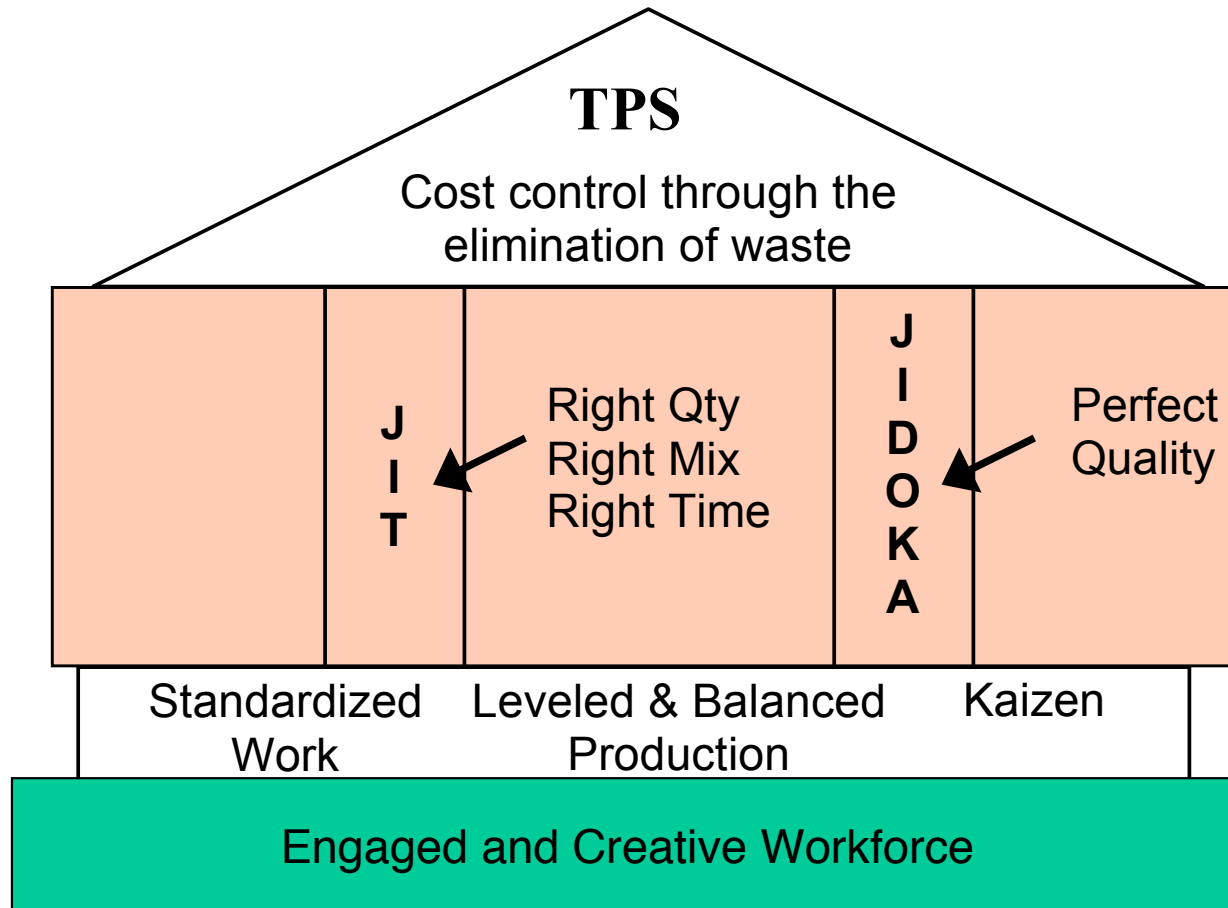


Content

- **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***

Outputs

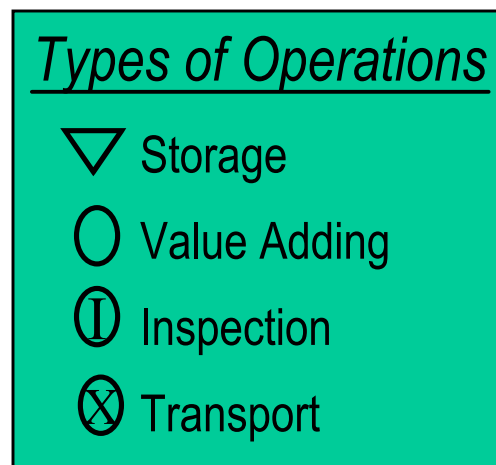
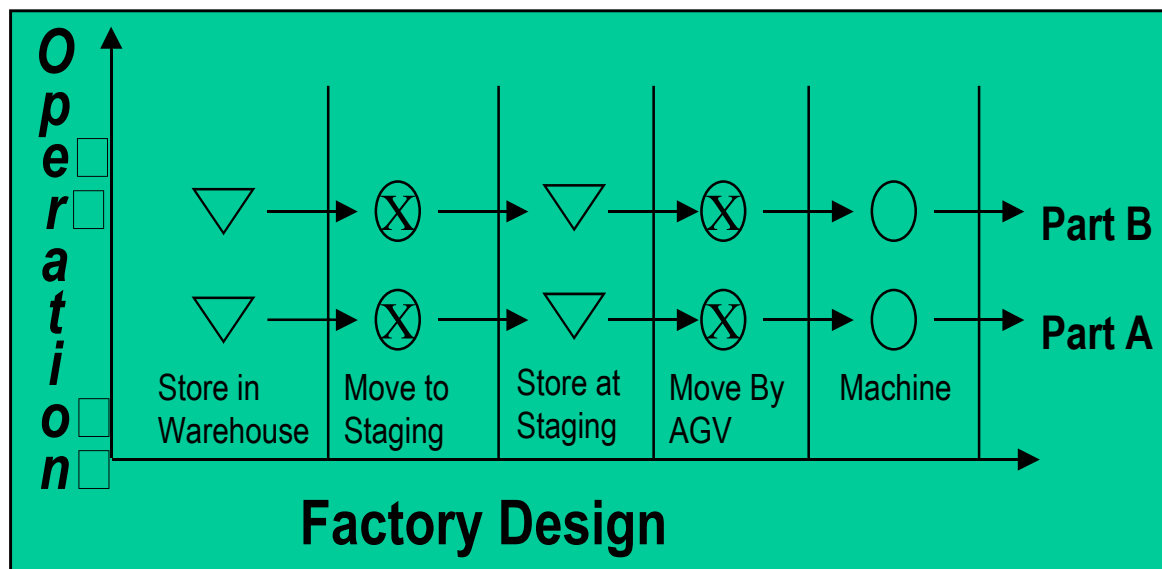
- Cost
- Quality
- Performance
- Delivery
- Flexibility
- Innovativeness

**Focus
Here**

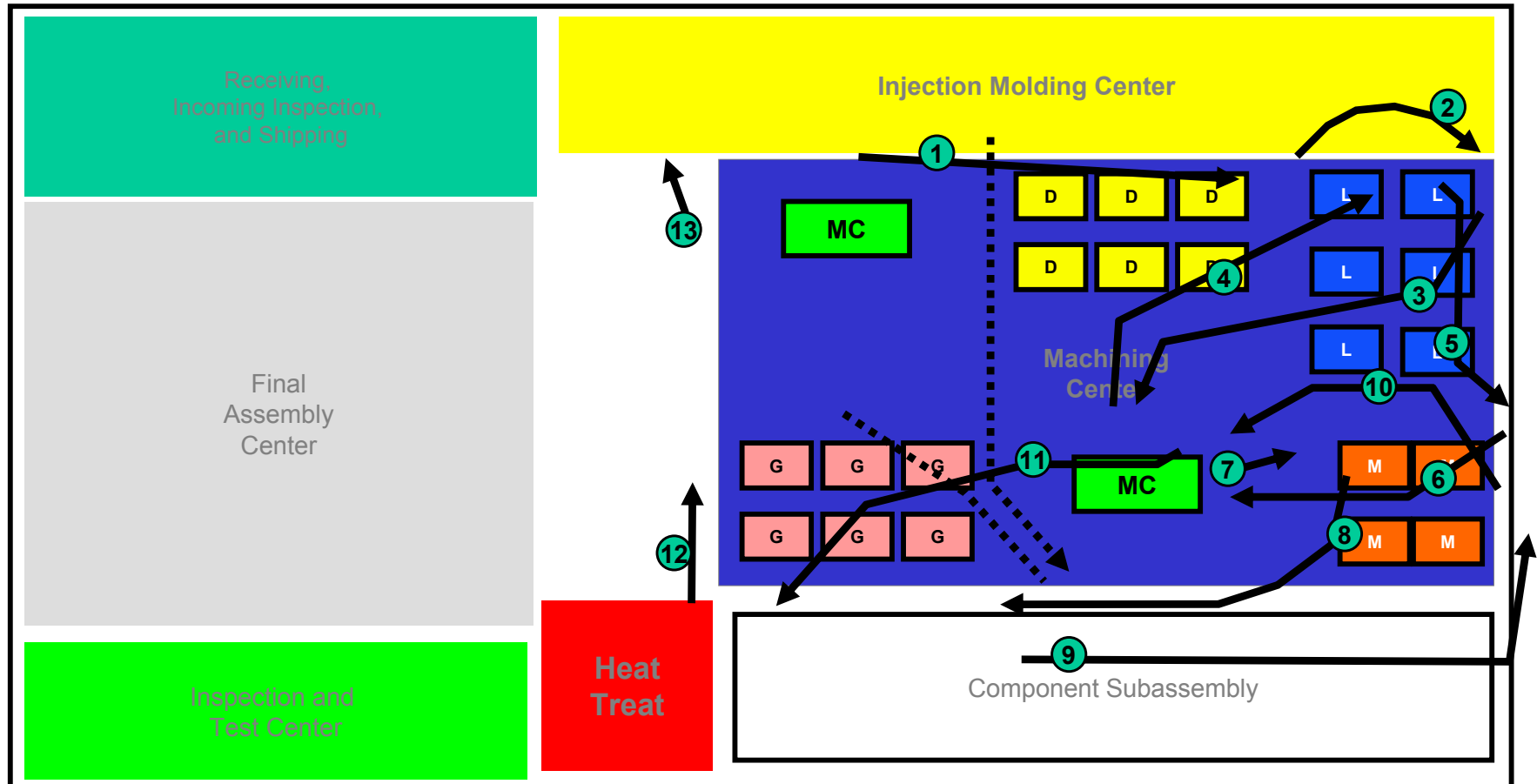
Benefits from a Focus on Process Rather Than Operation Improvements

- **Operations**
 - Value adding
 - Transportation
 - Delay (2 types)
 - Inspection

- **Factory Design**
 - Layout choices
 - Operation policies
 - Process Technology
 - Tapping human knowledge

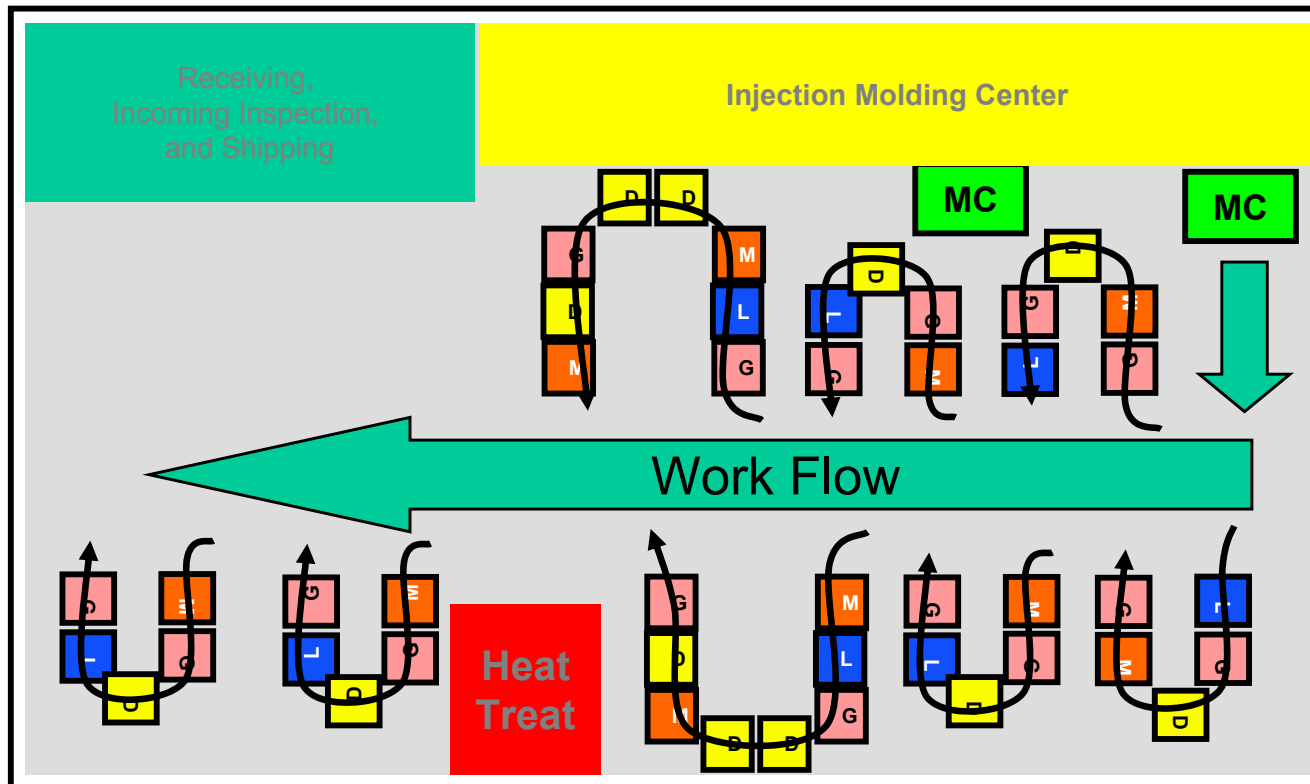


Traditional Manufacturing



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

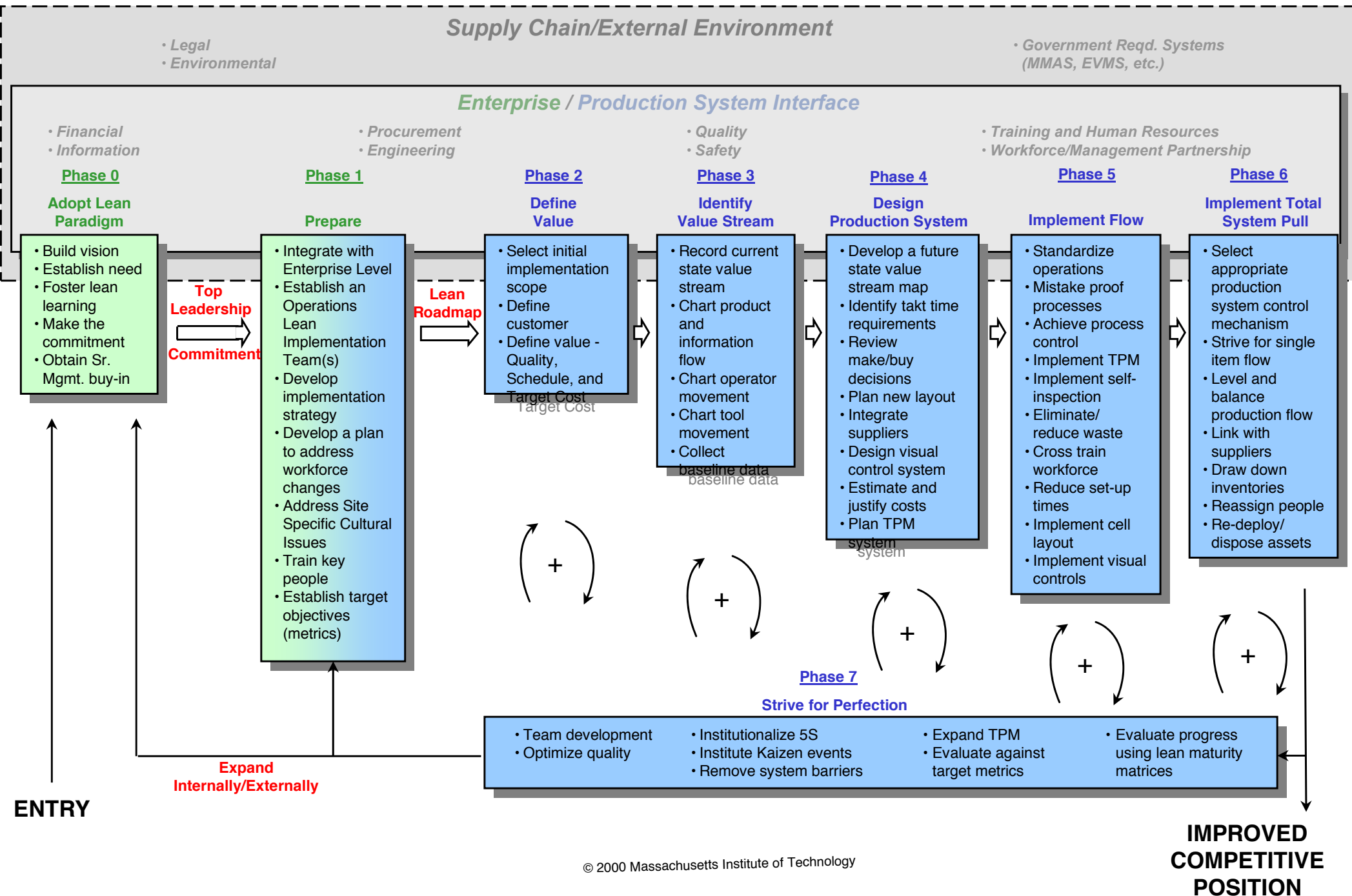
Source: J. Miltonburg, Manufacturing Strategy ©1995, p31.



Content

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Production Operations Transition-To-Lean Roadmap





Content

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Background

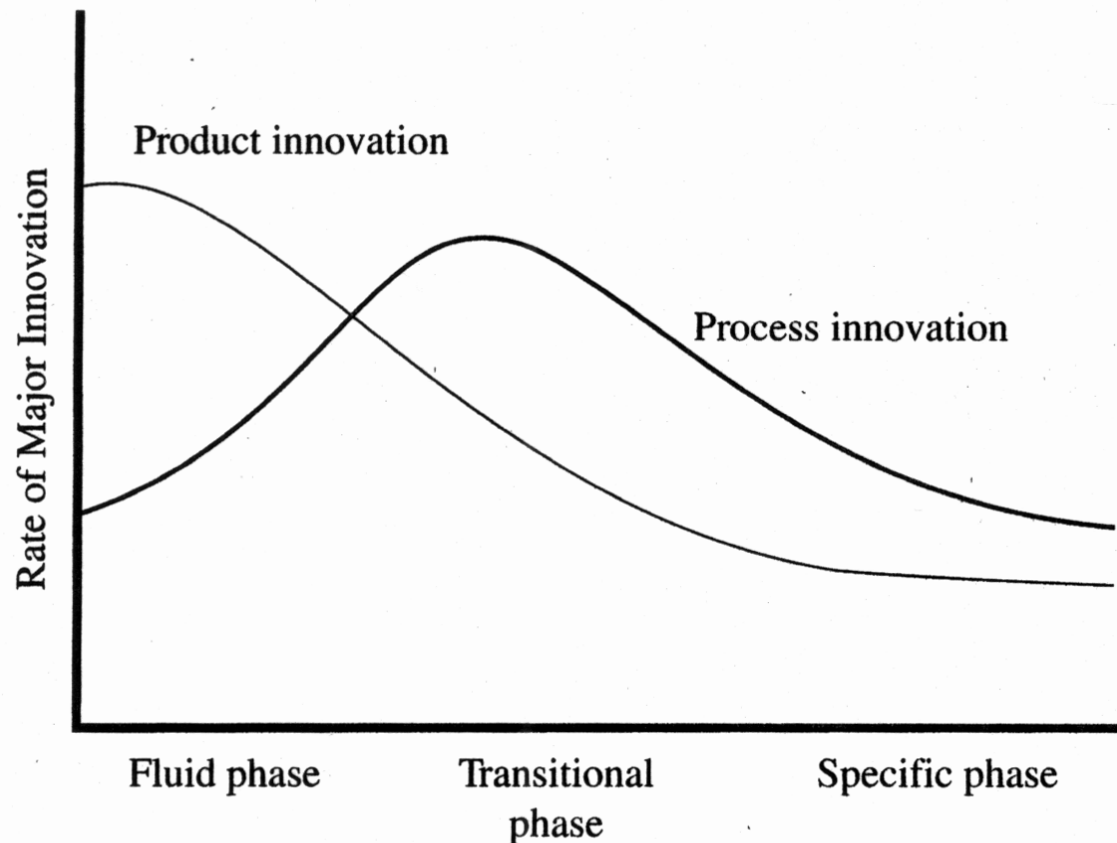
- **Matured aerospace industry**
- **Industrial innovation theory**
- **Implications on the aerospace industry**



Matured Aerospace Industry

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

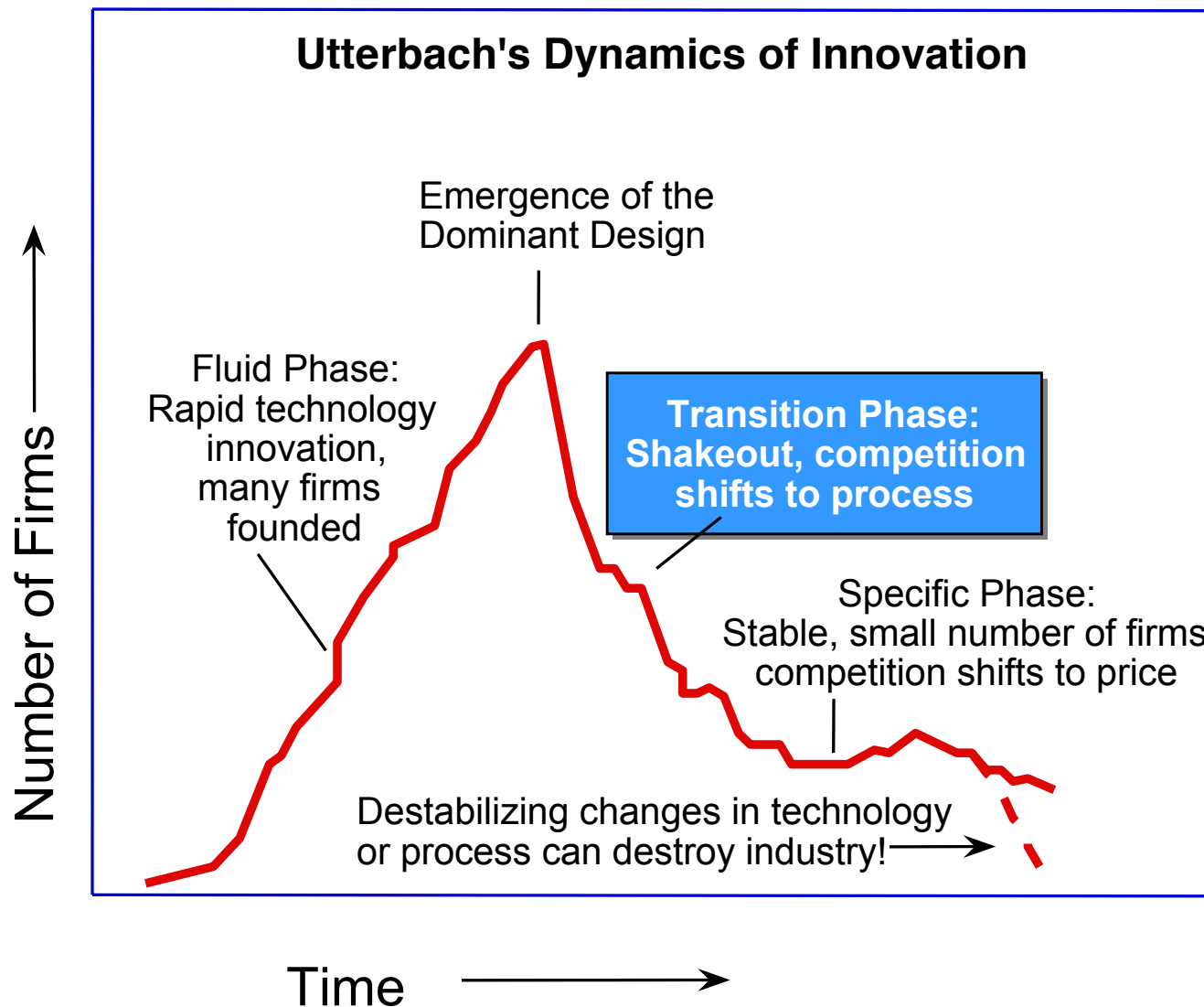
Utterback's Dynamics of Innovation Model



- 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

Source: William Abernathy & James Utterback, 1978

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 Utterbach, *Dynamics of Innovation*, 1994

Dominant Design?



1958



1995

Dominant Design?



1953



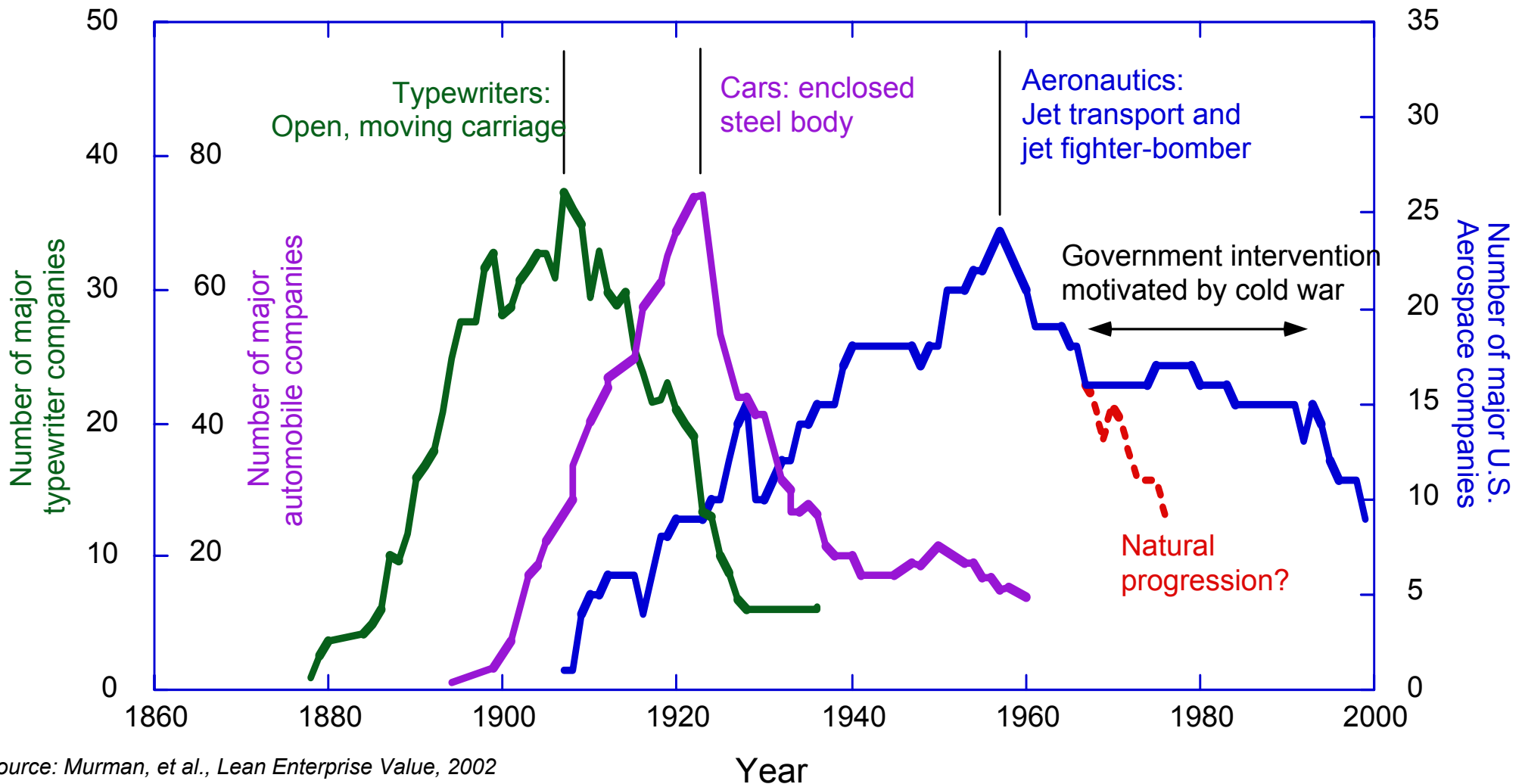
1972

2002



Extension of Theory to the Aerospace Industry

Industrial evolution and the emergence of the dominant design



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



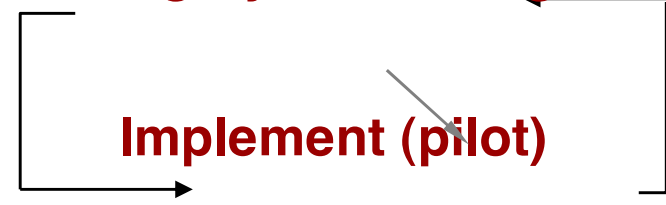
Corporate Level (Corporate Strategy)
[Seek approval]

[Interpret]
Business Unit (Business Strategy)



Requirements/Considerations/Constraints

Manufacturing System Design/Selection *Opti/Size*



Modifications



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)**