Lean Aerospace Initiative

Product Realization in the Defense Aerospace Industry

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web.mit.edu/lean

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  - General lean concepts in factory design
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  - Manufacturing System Design Framework
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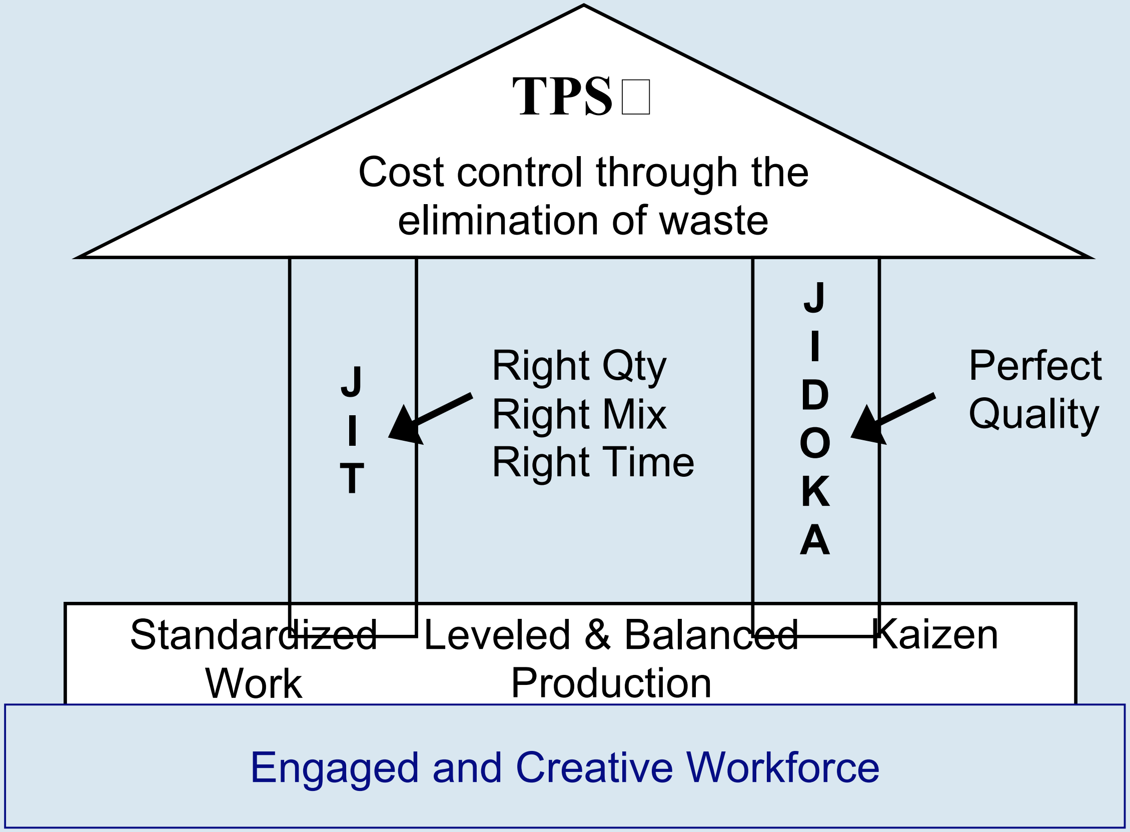
Lean from the Toyota Production System Shows How It All Relates



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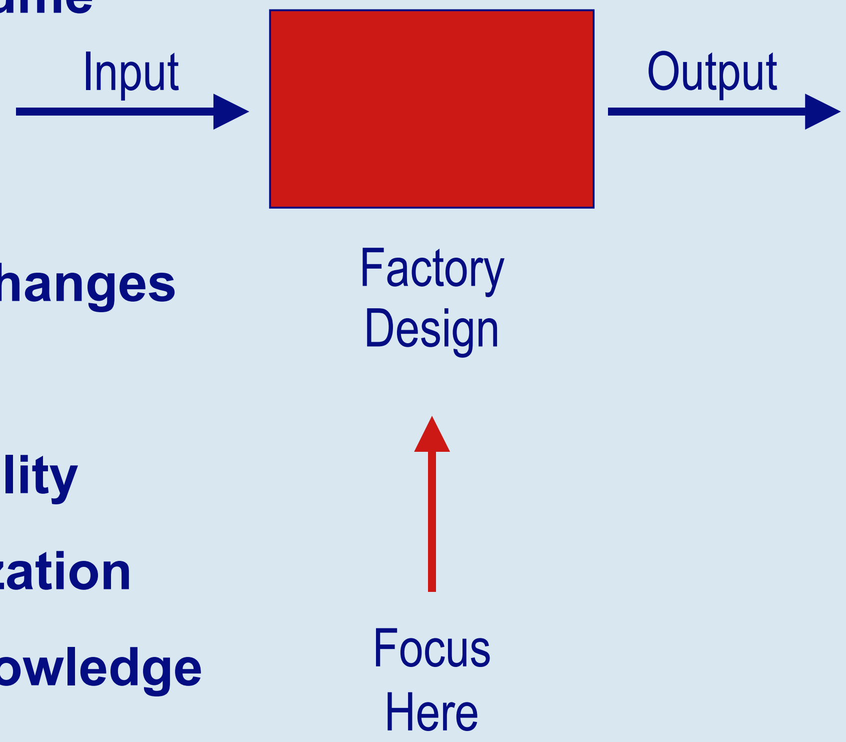
Aerospace Factory Designs Have Many Things to Consider

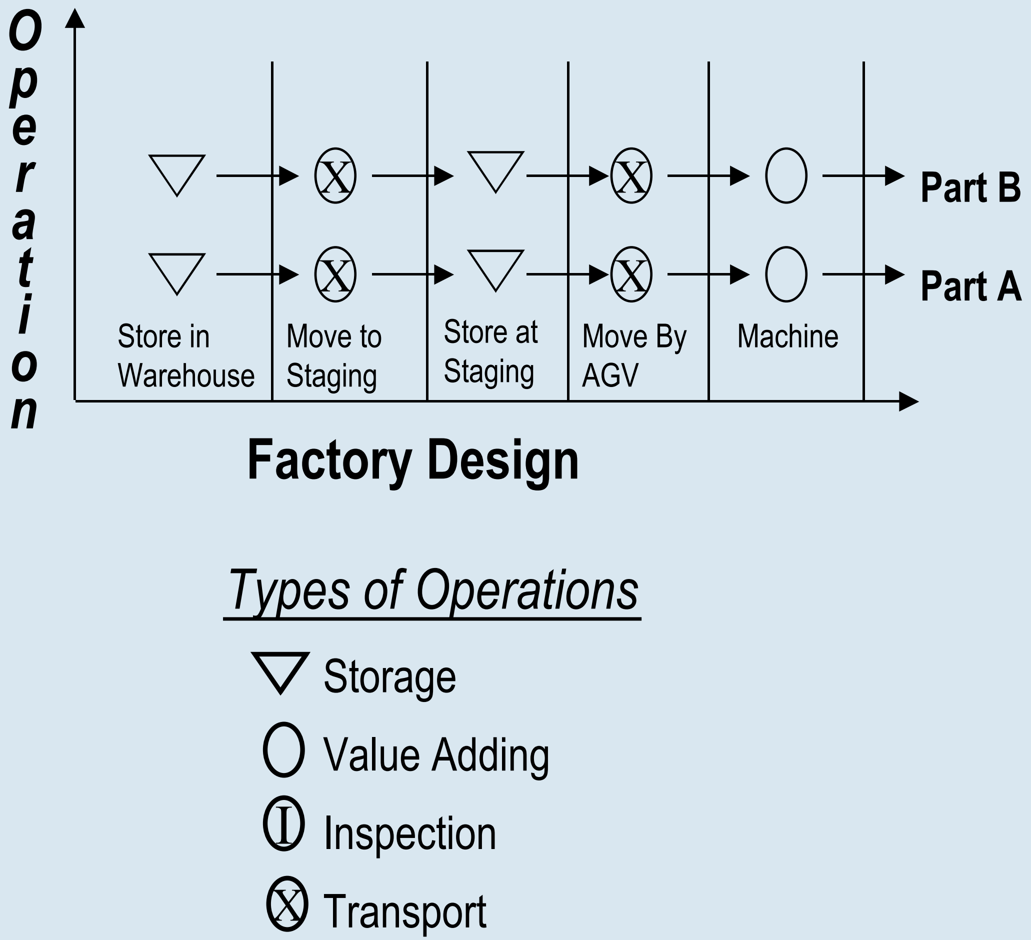
- Production volume
- Product mix
- Product design
- Frequency of changes
- Complexity
- Process capability
- Type of organization
- Worker skill/knowledge



- 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



Only Understood Processes Can Be Improved

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- 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

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Definite Boundaries Exist Between Flow and Pull

Flow

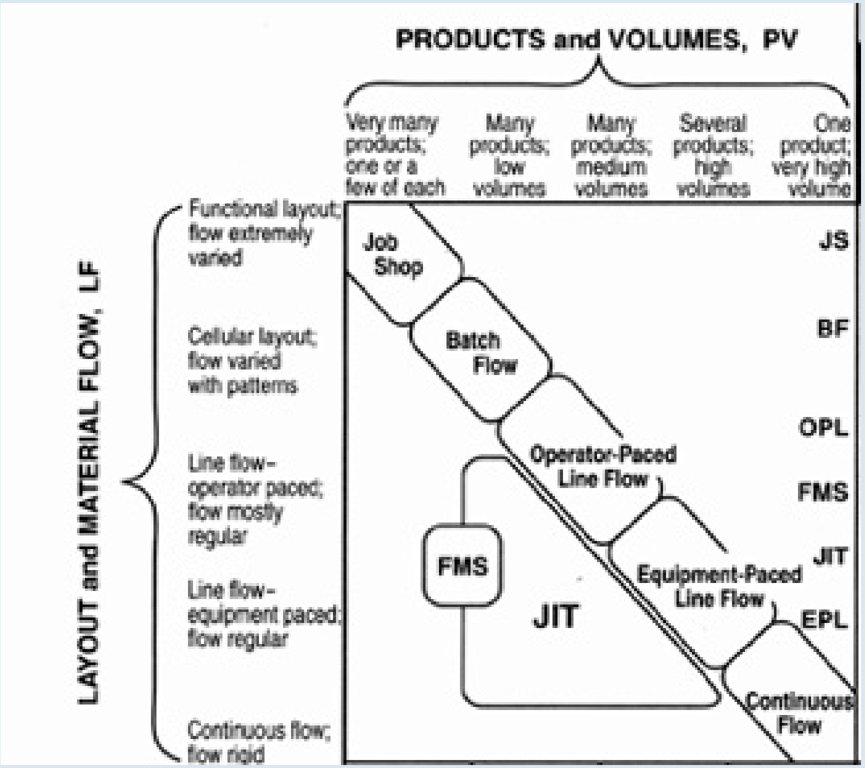
- MRP used for planning and control
- Group technology
- Reduce the number of flow paths
- Batch or single items
- Inventory to buffer flow
- Process control
- Minimize space & distance traveled with contiguous processing established

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.

Part II

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Introduction

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

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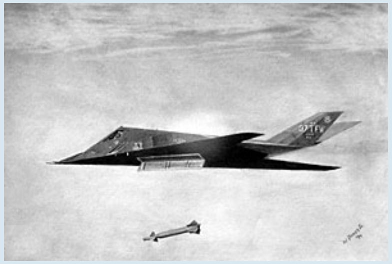
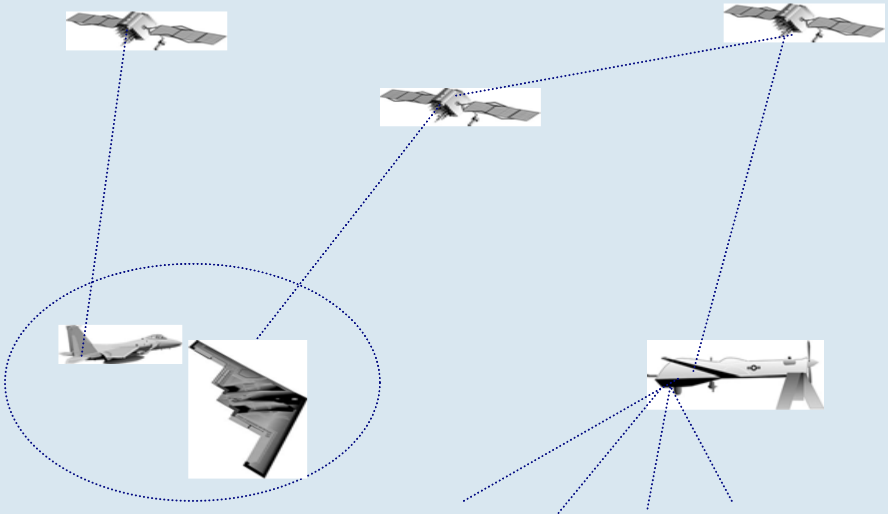
Matured Aerospace Industry

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





Pictures taken from the Air Force Website (http://www.af.mil/)

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

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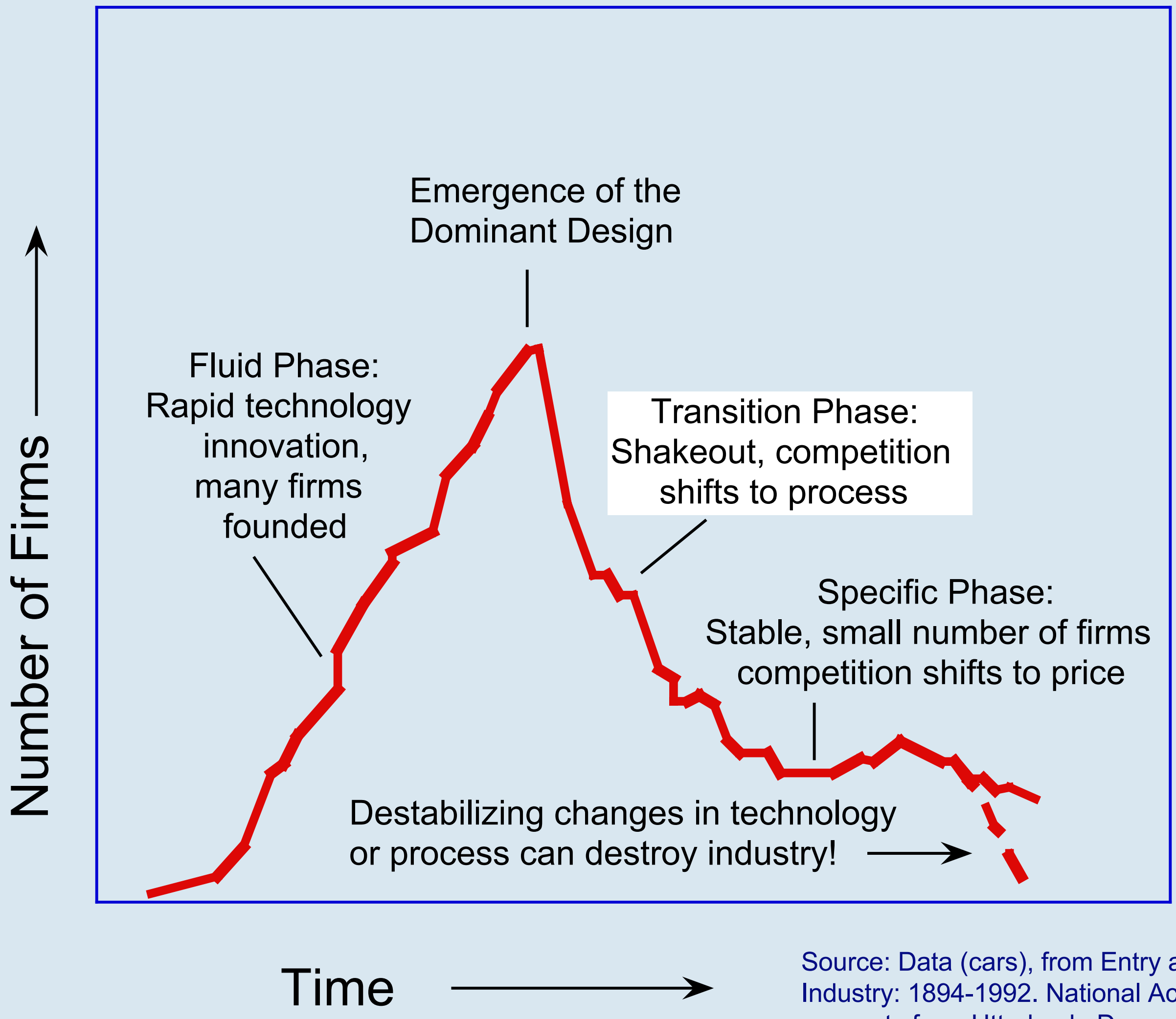
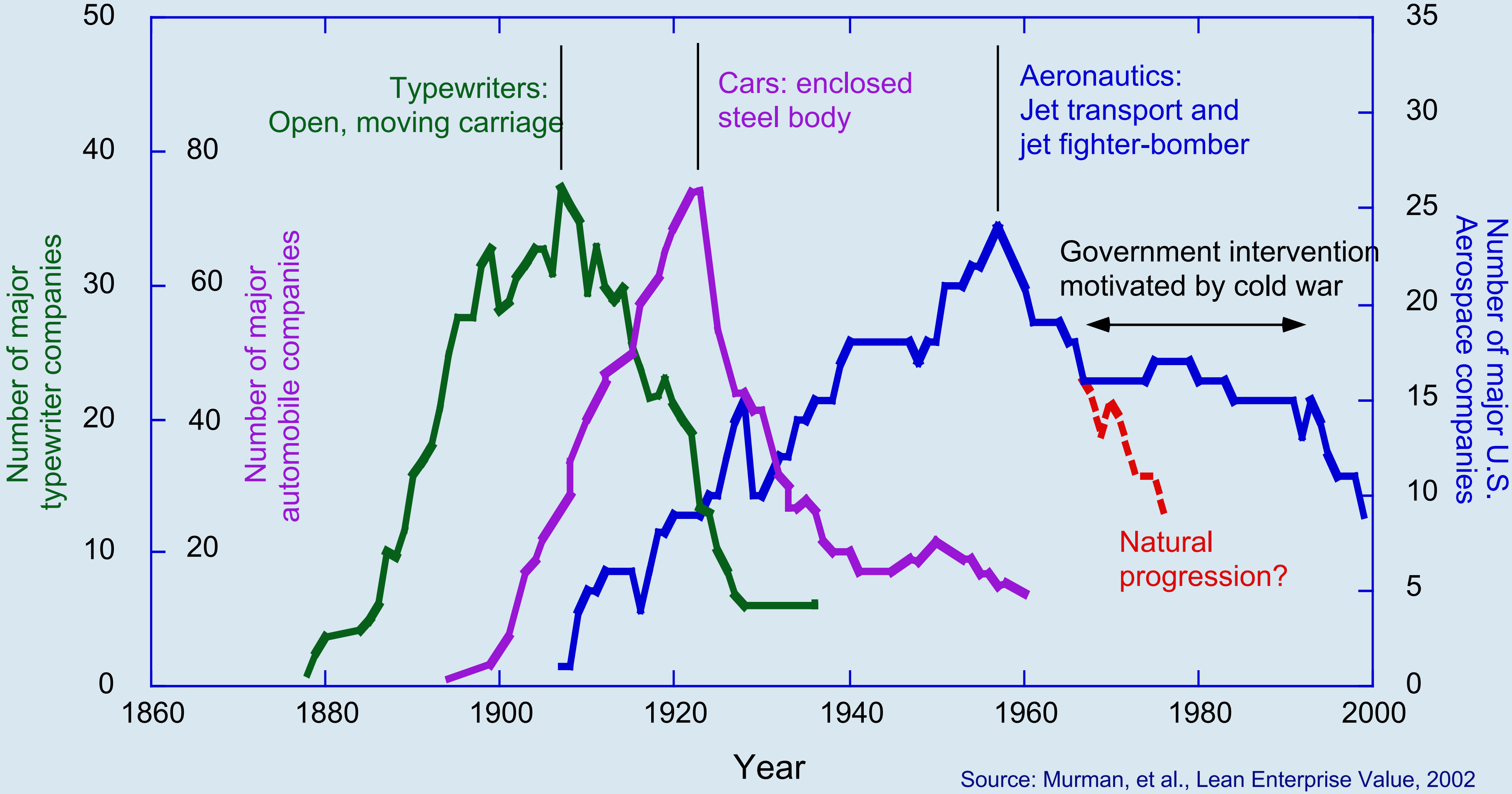
Theory in Application



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

Extension of Theory to the Aerospace Industry

Industrial evolution and the emergence of the dominant design



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

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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

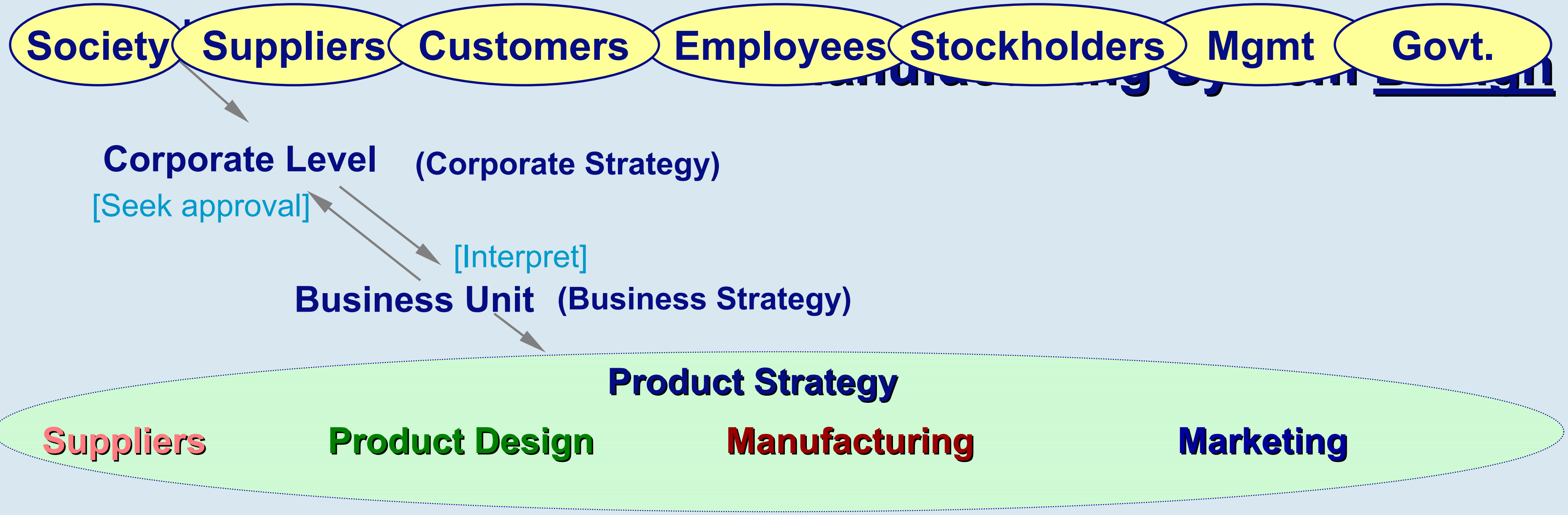
A holistic manufacturing system design framework to ensure process considerations are integral to the product development process

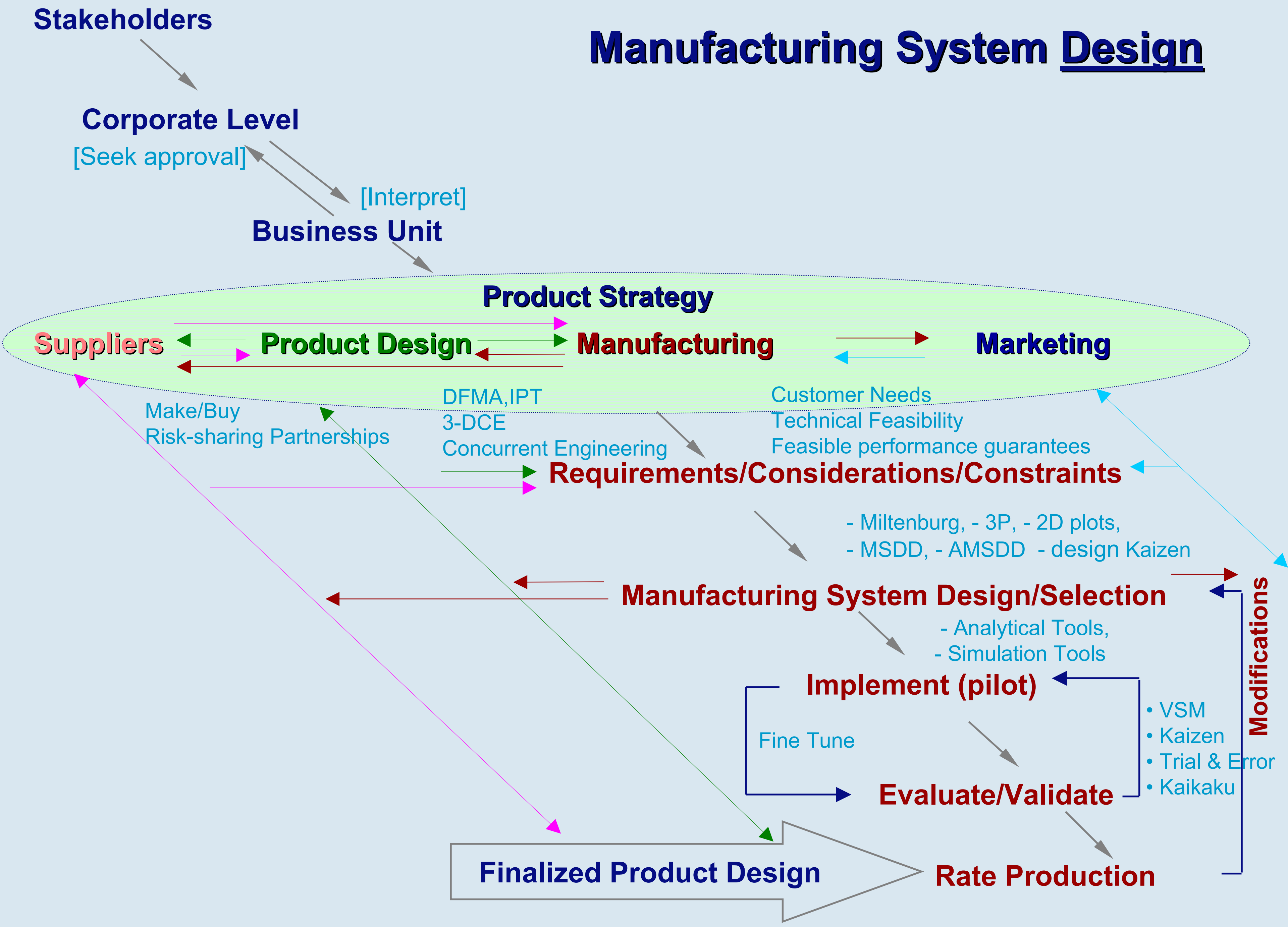
Characteristics

- 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

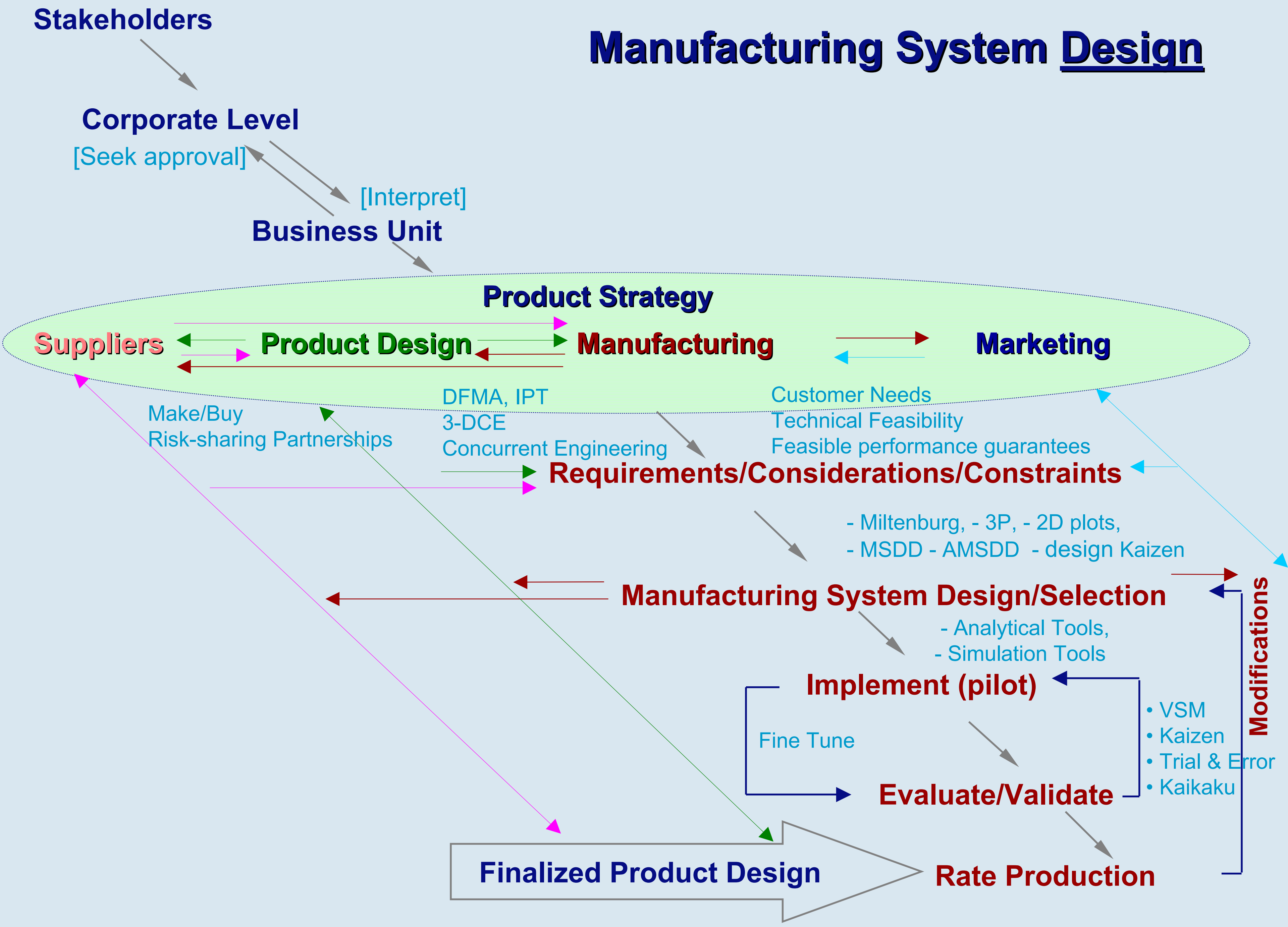
Manufacturing System Design

- 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 Unit
(Business Strategy)
Product Strategy
Suppliers
Product Design
Manufacturing
Marketing


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

Manufacturing System Design



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Insights from the Framework

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

Hypothesis: following the framework process will result in the development of effective manufacturing system that meets the goals of the corporation

Framework Validation

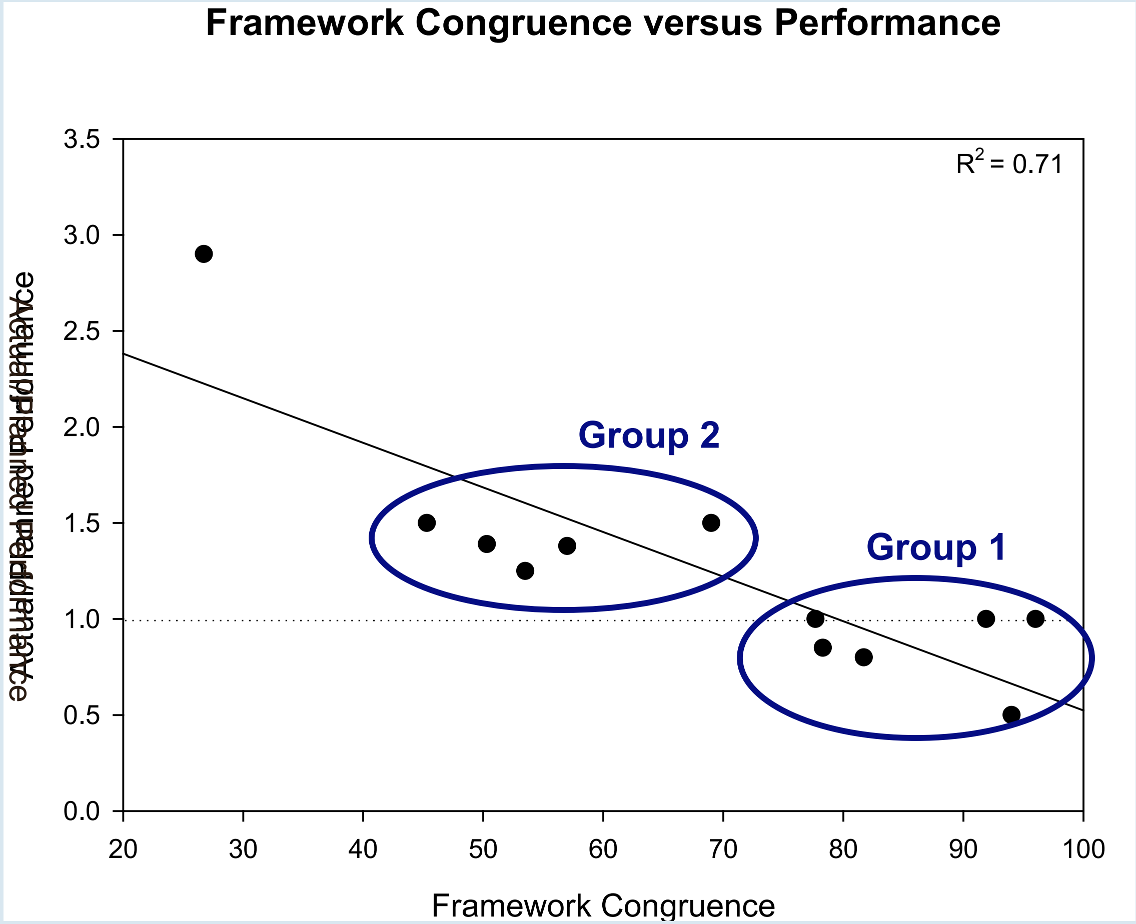
Research Design

- Case study - 14 assembly sites (6 aerostructures, 2 electronics, 2 launch vehicles & 4 space)
  - Real time “fly on the wall”
  - Retrospective

Method

- Structured interview to assess framework congruence
  - Strategy linkage
  - Phase presence, timing and breadth
- Performance metric (actual/planned)

Framework Validation Results



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Scoring Breakdown

Framework Congruence	Phase Presence	Timing	Breadth	
96	25.90	30.71	39.38	Group 1
94	25.90	30.00	38.05	
91.9	22.48	29.00	40.38	
81.7	18.57	26.62	36.62	
78.3	23.24	24.19	30.86	
77.67	20.90	25.90	30.86	Group 2
69	21.24	26.62	21.19	
57	17.24	19.76	20.14	
53.5	13.33	15.90	24.29	
50.3	12.33	17.90	20.14	
45.3	15.00	18.76	12.29	
26.73	7.33	11.76	7.67	

How important are the different aspects?

- Which of Phase Presence, Timing or Breadth impacted the ability of the system to meet its planned performance?

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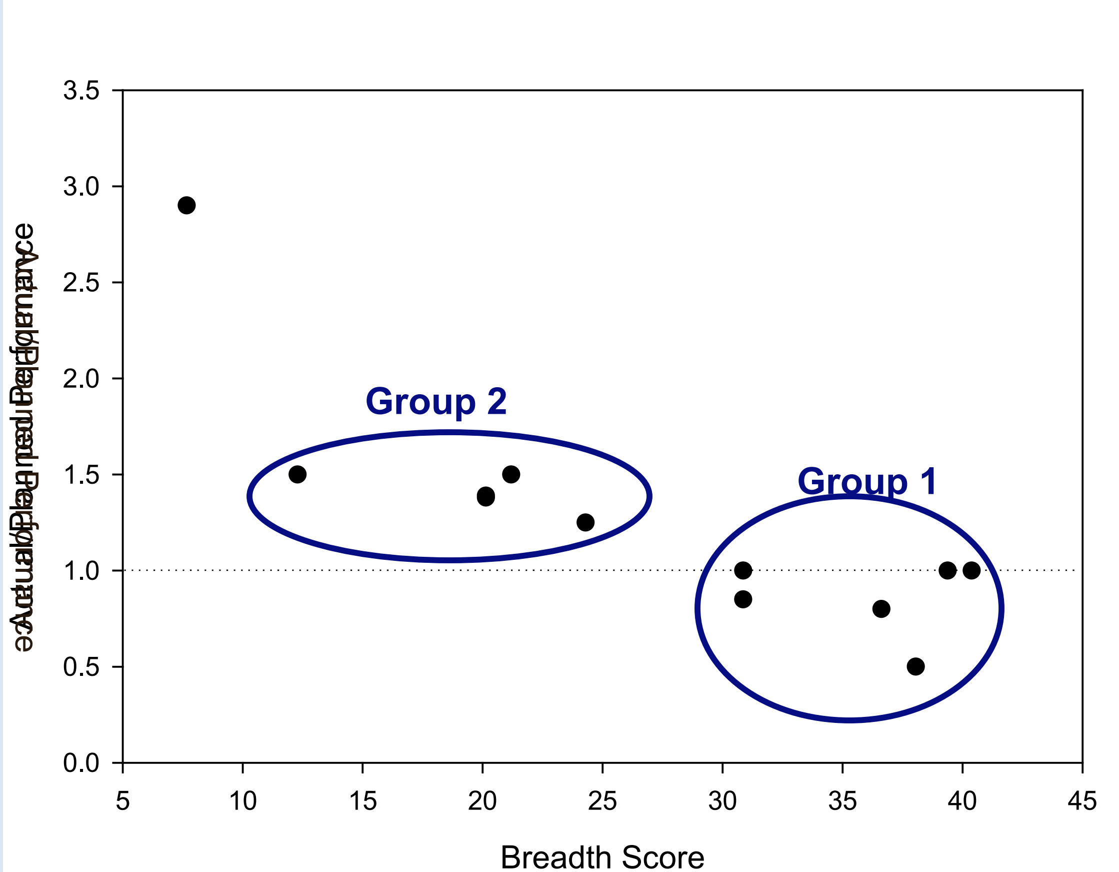
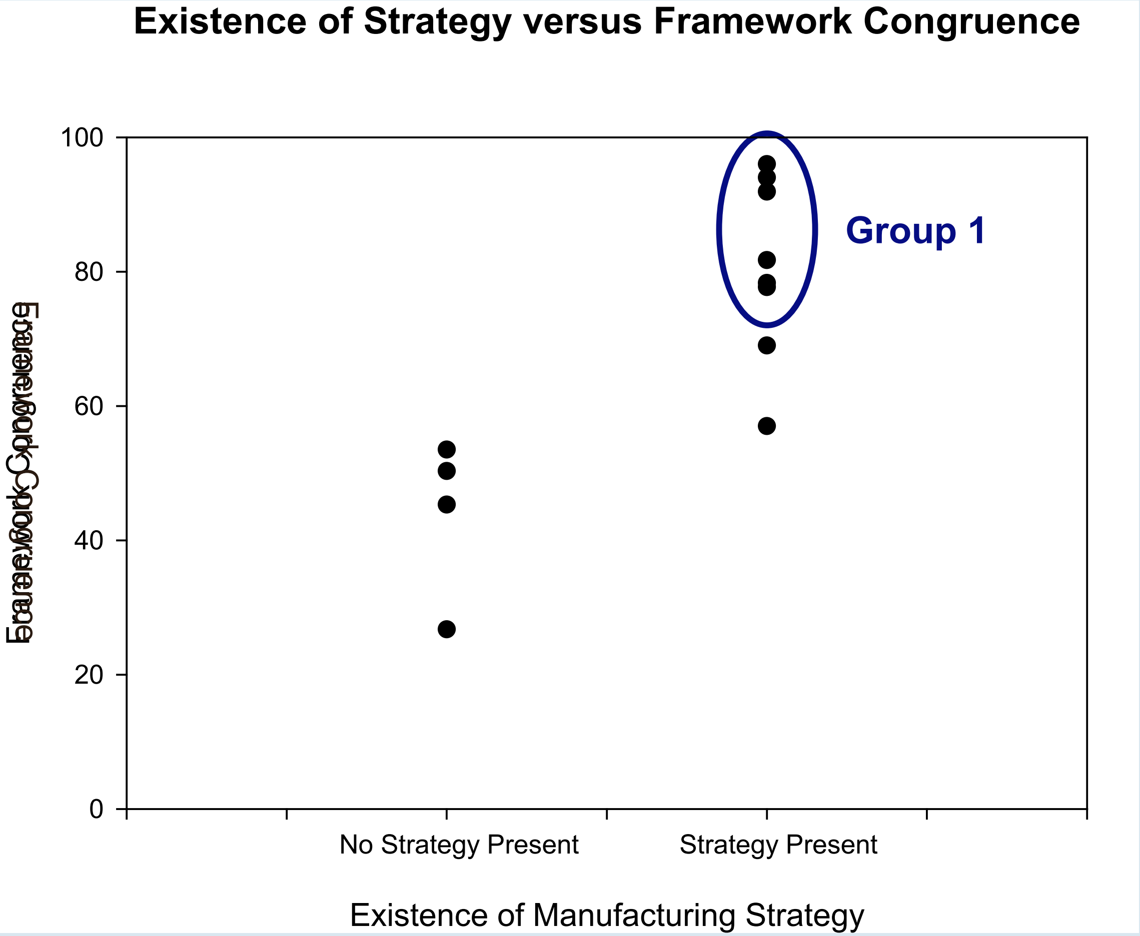
Determinants of Performance

Breadth Score versus Performance



Strategy Presence Results



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)

