Enterprise Value: The New Lean Horizon

Product Realization in the Defense Aerospace Industry
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Background

- 21st century aerospace challenge
- Industry maturity perspectives
- Implications on the aerospace industry
Aerospace has four core missions:

- Enabling the global movement of people and goods
- Enabling the global acquisition and dissemination of information and data
- Advancing national security interests
- Providing a source of inspiration by pushing the boundaries of exploration and innovation

These missions will never be routine and require the best technology and the best organizations.

“The core challenge for industry in the 21st century involves identifying and delivering value to every stakeholder. Meeting that challenge requires lean capability at the enterprise level.”
The Needs of Aerospace Customers are Changing

From a focus on single vehicles to platforms...

To networks of platforms and...

More flexible challenges in their employment

Innovation in the industry is thus shifting from single vehicles to networks of capability
Cost of Tactical Aircraft
Source: Augustine’s Laws

Then-Year Dollars

Year of Initial Operation

Gross National Product
Defense Budget
Aircraft Unit Cost

1900 1950 2000 2050 2100 2150

One Thousand
One Million
One Billion
One Trillion
One Quadrillion
One Quintillion

$
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.

Utterback’s Dynamics of Innovation Model

Fluid Phase:
Rapid technology innovation, many firms founded

Transition Phase:
Shakeout, competition shifts to process

Emergence of the Dominant Design

Specific Phase:
Stable, small number of firms, competition shifts to price

Destabilizing changes in technology or process can destroy industry!

Dominant Design?

1958

1995
Aerospace Industry

Industrial evolution and the emergence of the dominant design

- Typewriters: Open, moving carriage
- Cars: enclosed steel body
- Aeronautics: Jet transport and jet fighter-bomber

Government intervention motivated by cold war

Natural progression?

Number of major U.S. Aerospace companies

Year

1860 1880 1900 1920 1940 1960 1980 2000

Number of major typewriter companies

1860 1880 1900 1920 1940 1960 1980 2000

Number of major automobile companies
Implications of Post Dominant Design

- Little product differentiation
- Incremental product innovation
- Acquisition cost becomes focus
- Operating costs more of a concern
- Mergers, acquisitions & exits
- Process innovation dominates
- Organizations become more rigid & hierarchical
- Less risk taking

= AEROSPACE INDUSTRY?
Fine’s 3-D Concurrent Engineering Model

PRODUCT
- Performance Specifications

PROCESS
- Technology And process Planning

SUPPLY CHAIN
- Details, strategy
- Manufacturing System, Make/buy
- Time, Space, and Availability

Recipe, Unit Process
- Product Architecture, and Make/buy

Fine’s Model and the Aerospace Industry in the Transition Phase

In a post dominant design environment two relationships predominate

- Product interactions become more interlinked with process and the supply chain
- Supply chain integration and process improvements have a predominant impact on cost

Design must be much more interactive with mfg & suppliers

Source: Shields, LAI Joint Workshop “Integration-Framing”, Jan 30, 2002
Conclusions

- Aerospace industry innovation shifting to systems of systems
- In a maturing single product environment
  - Product and life cycle cost predominate
  - Best addressed by process & supply chain improvements
- Enterprise strategy should change in recognition of this new competitive landscape

Lean beyond the factory floor means shifting the enterprise focus from *product design* to *product realization*
Research Overview

- Research objectives
- Manufacturing System Design Framework
- Research Design
- Introduction of the case studies
- Results - with Bonus material!
- Conclusions
Research Objectives

○ Goals guiding the research effort:
○ Study and improve available tools in use
○ Understand the processes used in industry to design manufacturing systems
○ Propose a model for industry to use
○ Test this model in industry
○ Establish key characteristics of this design process
○ Create analytical models to predict manufacturing system performance
Elements for a Manufacturing System Design Framework

- A holistic view of manufacturing system design environment
- 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
- Not prescriptive
- Can lead to innovative & new manufacturing system designs
- Shows the unending design cycle -- Continuous Improvement
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
Stakeholders

Corporate Level
[Seek approval]

Business Unit  (Business Strategy)

[Interpret]

Product Strategy

Suppliers  Product Design  Manufacturing  Marketing

Society  Suppliers  Customers  Employees  Stockholders  Mgmt  Govt.
Manufacturing System Design

Stakeholders
- Corporate Level
  - [Seek approval]
- Business Unit
  - [Interpret]

Product Strategy
- Suppliers
- Product Design
- Manufacturing
- Marketing

Requirements/Considerations/Constraints
- DFMA, IPT
- 3-DCE
- Concurrent Engineering
- Customer Needs
  - Technical Feasibility
  - Feasible performance guarantees

Manufacturing System Design/Selection
- Miltenburg, 3P, 2D plots,
- MSDD, AMSDD, design Kaizen
- Analytical Tools,
- Simulation Tools

Implement (pilot)
- VSM
- Kaizen
- Trial & Error
- Kaikaku

Fine Tune

Evaluate/Validate

Finalized Product Design

Rate Production
Research Design

- Assembly operations
- Site selection criteria
- Framework Evaluation Tool
- Performance Metric
Data Collection

- 30+ site visits since June 2000
- Over 240 interviews ranging from vice presidents to shop floor workers
- Real time “fly on the wall” or retrospective observations
Case Studies - Air

- **Major Aerostructures (6):**
  - 737NG, F-18 E/F EFF, F-16, F-22 (wing/aft, mid), X-35

- **Electronics (2):**
  - Wedgetail, TDR-94
Case Studies - Space

- Launch Vehicles (2):
  - EELV: Atlas V, Delta IV

- Space (4):
  - A2100, AEHF, Iridium, HVSP
Framework Validation Results

Framework Congruence versus Performance

R² = 0.71

Group 1

Group 2
### Scoring Breakdown

<table>
<thead>
<tr>
<th>Framework Congruence</th>
<th>Phase Presence</th>
<th>Timing</th>
<th>Breadth</th>
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<tr>
<td>96</td>
<td>25.90</td>
<td>30.71</td>
<td>39.38</td>
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<tr>
<td>94</td>
<td>25.90</td>
<td>30.00</td>
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<td>22.48</td>
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<tr>
<td>26.73</td>
<td>7.33</td>
<td>11.76</td>
<td>7.67</td>
</tr>
</tbody>
</table>

- How important are the different aspects?
- Which of Phase Presence, Timing or Breadth impacted the ability of the system to meet its planned performance?
Determinants of Performance

**Phase Presence versus Performance**

- **Phase Presence Score**
- **Actual/Planned Performance**
- **Group 1**
- **Group 2**

**Phase Timing versus Performance**

- **Phase Timing Score**
- **Actual/Planned Performance**
- **Group 1**
- **Group 2**

**Breadth Score versus Performance**

- **Breadth Score**
- **Actual/Planned Performance**
- **Group 1**
- **Group 2**
Framework Validation Results

Framework Congruence versus Performance

R² = 0.71

Group 1

Group 2
Strategy Presence Results

Existence of Strategy versus Framework Congruence

- Group 1

- Existence of Manufacturing Strategy

Axis:
- Framework Congruence
- No Strategy Present
- Strategy Present
Scope of Results

Framework Congruence versus Performance

R² = 0.71

Example 1
Stakeholders

Corporate Level

Corporate Goals
Manufacturing System Design

Business Unit

Example 1

Manufacturing System Design/Selection
- Review Requirements
- Picked Cells

Evaluate/Validate
- VSM
- Kaizen
- Trial & Error
- 5S

Implement (pilot)

Fine Tune Simulations

Finalized Product Design

Rate Production
Scope of Results

Framework Congruence versus Performance

Example 2

R² = 0.71

Actual/Planned Performance

Framework Congruence

20 30 40 50 60 70 80 90 100
Manufacturing System Design
Example 2

Stakeholders

Corporate Level
[Seek approval]

Business Unit

[Interpret]

Product Strategy

Suppliers

Product Design

Manufacturing

Marketing

Requirements/Considerations/Constraints

Outside Intervention

Customer Needs
Technical Feasibility
Feasible performance guarantees

Manufacturing System Design/Selection
Simulation Tools

Implement (pilot)

Fine Tune

Evaluate/Validate

Finalized Product Design

Rate Production

• VSM
• Kaizen

Modifications

3P
Scope of Results

Framework Congruence versus Performance

R² = 0.71

Example 3
Stakeholders

Corporate Level
[Seek approval]

[Interpret]

Business Unit

Product Strategy (all products)

Suppliers

Make/Buy
Risk-sharing Partnerships

DFMA, IPT
Concurrent Engineering

Customer Needs
Technical Feasibility
Feasible performance guarantees

Requirements/Considerations/Constraints

Manufacturing System Design/Selection

Pre-Design Kaizen
Simulation Tools

Implement (pilot)

Fine Tune

Evaluate/Validate

Finalized Product Design

Rate Production

Examples: 3

Modifications

• VSM
• Kaizen
• Trial & Error

Manufacturing System Design

Example 3
Scope of Results

Framework Congruence versus Performance

R² = 0.71

Example 4
Conclusions

❍ The role of manufacturing as a source for competitive advantage

❍ Framework Validation
  ○ Framework congruence and system performance

❍ Key Characteristics
  ○ Breadth
  ○ Strategy
  ○ Status