# Enterprise Integration for Value Creation


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# Lean Enterprise Transformation Issues

- Why do many lean transformation activities fail?
- What are the key success factors in implementing lean enterprise wide?
- How can we better assure that lean will impact bottom line results?
- Are there certain activities that are ideally performed before others?
- How do we assess an organization's "readiness to change"?

# Key Questions Regarding Enterprises

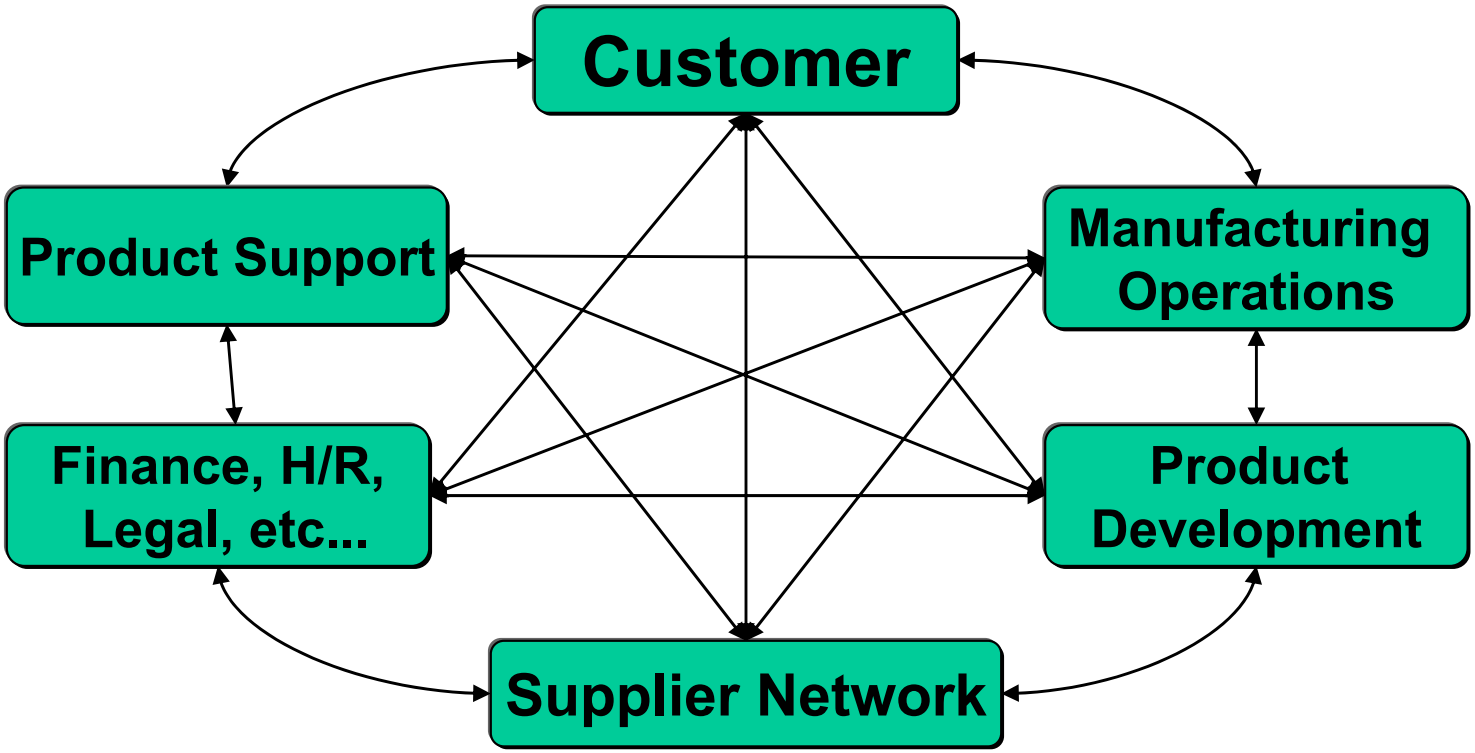
- What are the key elements and interrelationships that comprise the "enterprise system"?
- What are the key attributes of the successful enterprise?
- How do you organize to deliver best value to the full set of enterprise stakeholders in context of a given business model?
- What measures and incentives are most effective in context of enterprise structural and behavioral factors?
- Are enterprises are more effective if processes are standardized and managed at the enterprise level rather than localized level?
- How can knowledge be integrated across an extended enterprise that crosses individual single enterprise (e.g., company) boundaries?
- How do you architect an enterprise that can most effectively produce a desired 'product system'?


# Define Enterprise in a Lean Context

***"A lean enterprise is an integrated entity that efficiently creates value for its multiple stakeholders by employing lean principles and practices."***

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

# Integrated Enterprise



# Lean Enterprise System

- A Lean Enterprise Requires the Integration of
  - Processes
  - People / Organization
  - Information
  - Technology
  - Products
- Holistic View
- Enterprise as a System

# What Does It Mean to Integrate?

- Why Integrate?
- Where in the enterprise should integration take place?
- How much integration?
- Who needs to be involved in the integration process?

# Enterprise System Issues

- Standardization
  - Across products, processes, technology and information management
- Integration
  - Within and across enterprise boundaries
- Leadership
  - Required for complex transformation
- “Enterprise Engineering”
  - New expanded tool set required

# Leadership Issues

- Optimization across multiple stakeholder objectives
- Global communication and seamless information flow
- Change management and enterprise transformation
- Enterprise “value metrics”
- Organizational effectiveness

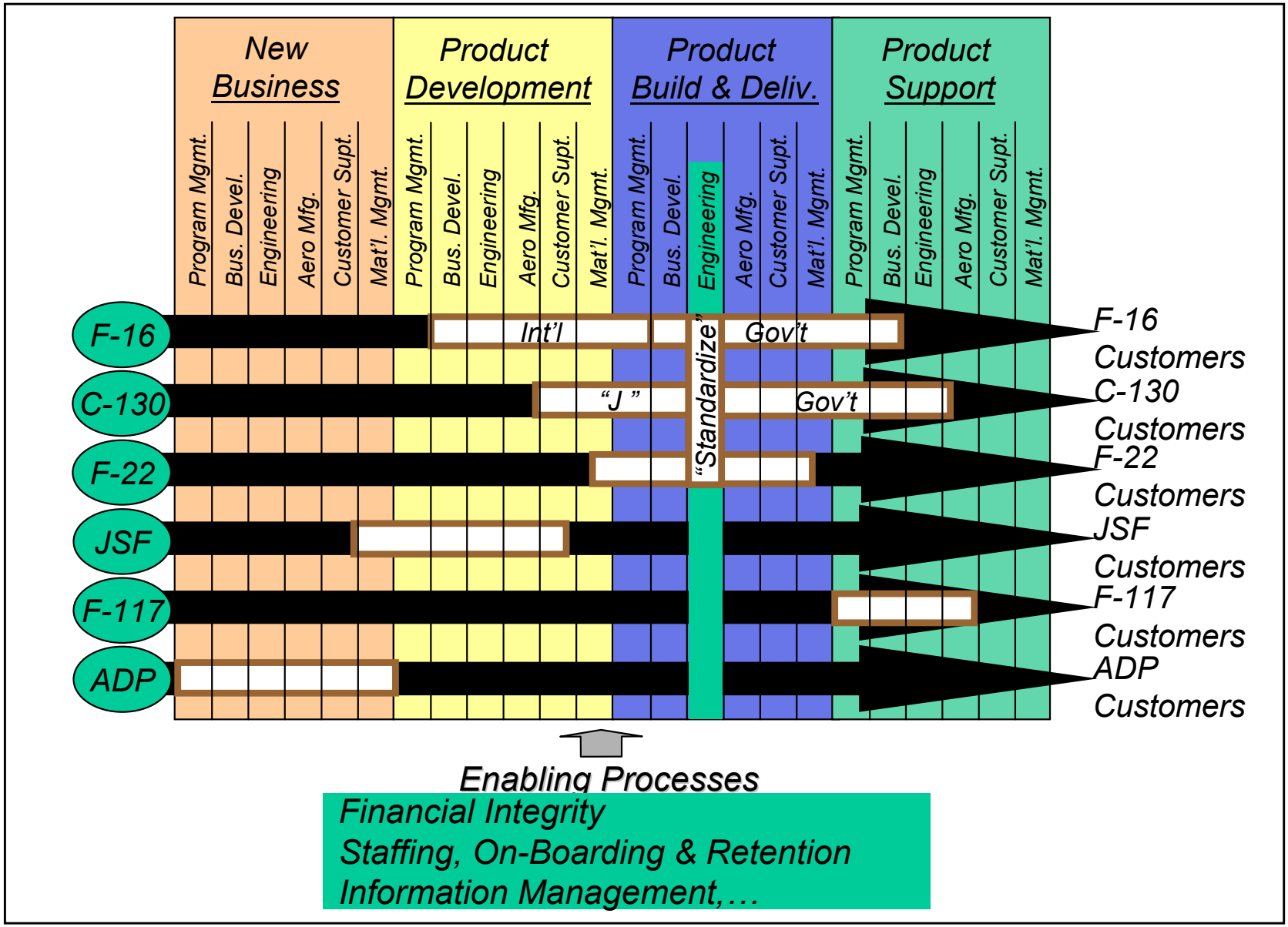

# Multi-program Enterprises add Value beyond that Created by Programs in Isolation

- Multi-program enterprises can:
  - **Increase scope** of possible value creation activities by allowing specialization and integration of expertise
  - **Enhance productivity** through coordination and creation of enabling infrastructures
  - **Manage knowledge creation** and reuse to achieve economies beyond those found in markets


# A Key Issue in Multi-Program Enterprise Design is Balancing Demands of Local Performance with Enterprise Integration/Capability

- Program enterprises typically generate revenue streams
- Multi-program enterprise typically provides enabling infrastructure as a service
- Overhead policy provides support for enterprise infrastructure
  - Dilemma: how to prioritize allocation of enterprise resources between “direct” and “indirect” functions
- Important multi-program enterprise value creating activity is integrating knowledge and processes across multiple enterprise boundaries

# Example of One Challenge……
# Value Streams, Processes & Program Phases



# 3 Approaches to Enterprise Integration

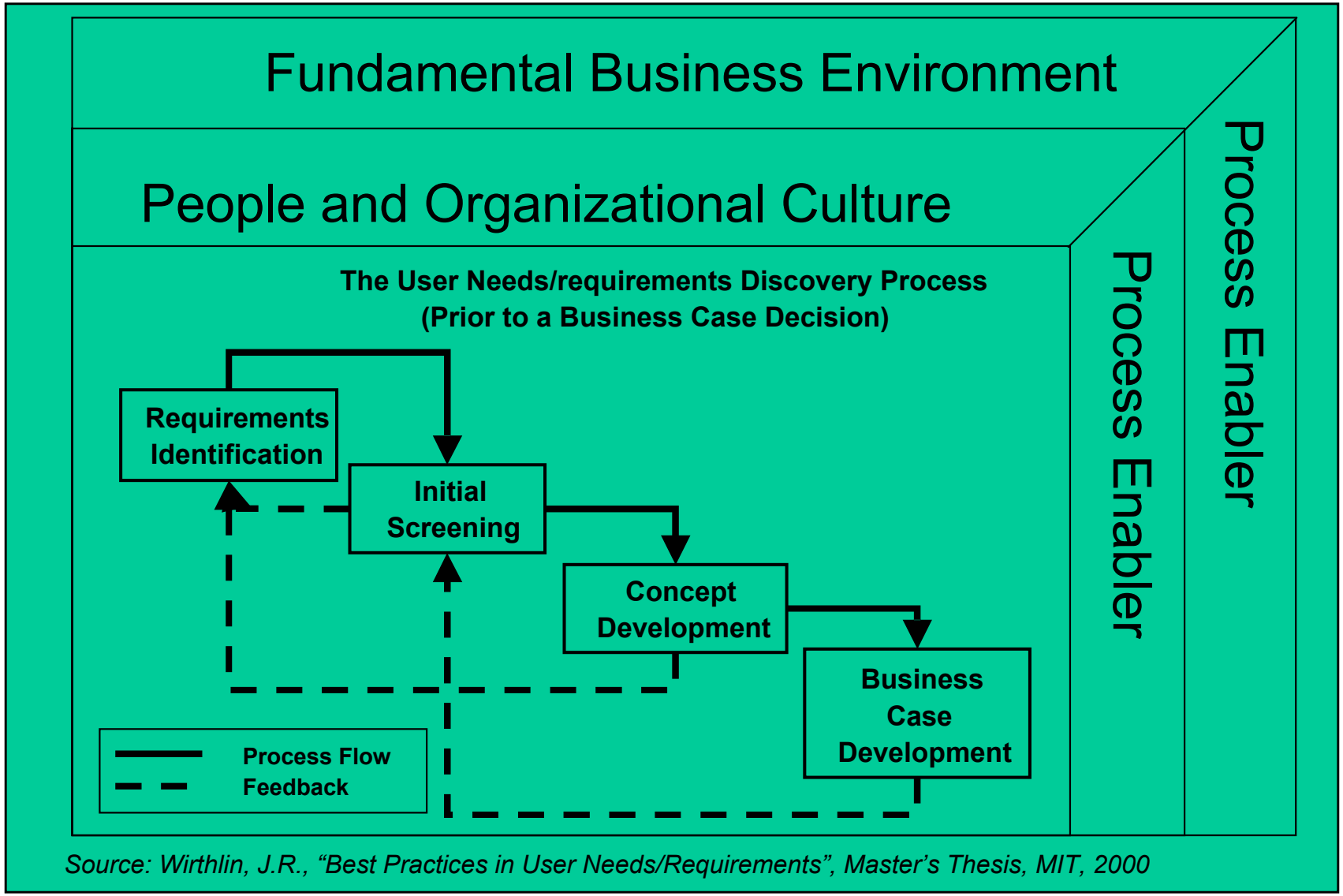
- **Directive control**: prescribe enterprise behavior by policies, rules, and resources
- **Managing the architecture**: direct enterprise behavior when a few but not all stakeholders are under direct control
- **Collaboration**: influence key stakeholders' behavior when they are outside direct control

*Source: "Lean Enterprise Value", Murman et al., Palgrave, 2002*

# Directive Control is Used when Key Enterprise Stakeholders are Under a Single Management Structure

- Have direct control over organizational and aspects of enterprise and technology architecture
- Classic hierarchy structure
- Top-down definition of roles, responsibilities, policies and procedures, and incentives
- Examples from product development starting with the front end and running through design

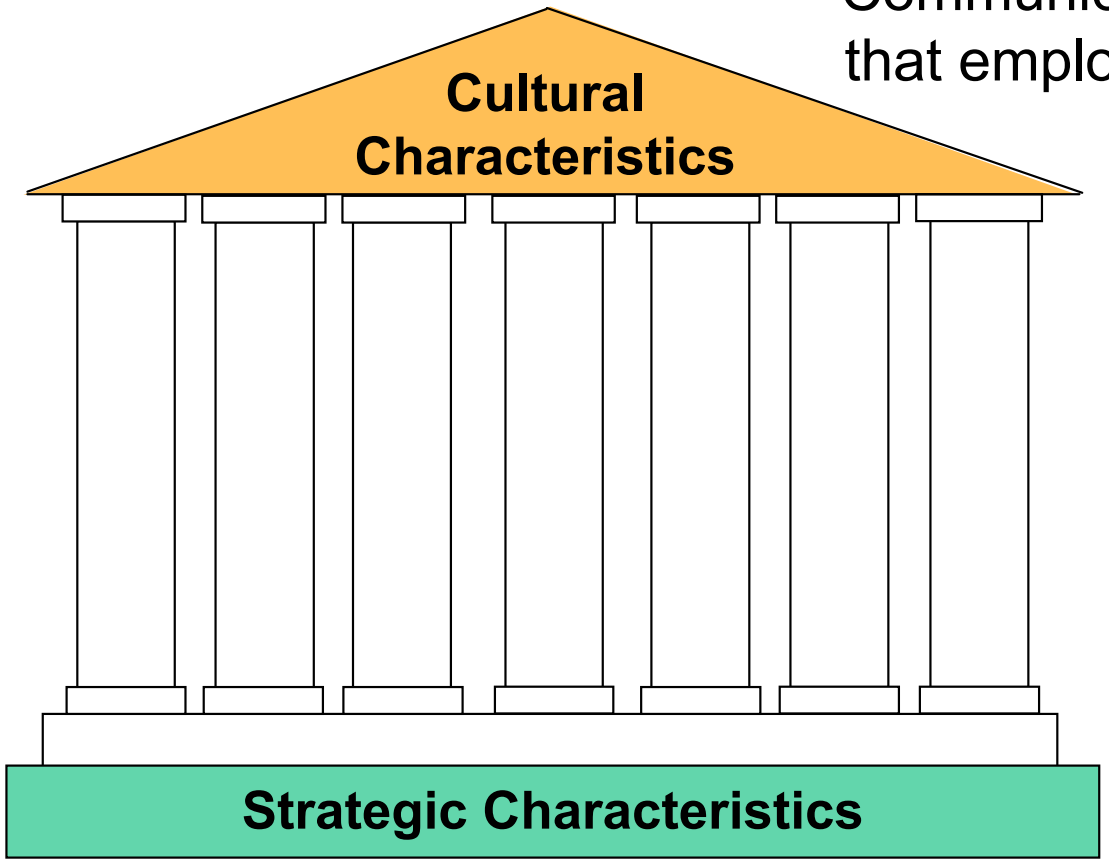
# A High-Performing PD Front End Relies on Deliberate Analysis Embedded in Organizational Capabilities




*Source: Wirthlin, J.R., "Best Practices in User Needs/Requirements", Master's Thesis, MIT, 2000*

# Building Product Line Engineering (PLE) Capability in Enterprises

Communication and training ensure that employees can execute to PLE objectives




**Political Characteristics**

Enterprise leadership plays a key role in defining responsibilities and incentives; consistency and follow-through on PLE strategy execution

PLE goals and metrics focus behavior; resource and technology sharing designed into organization and product architecture

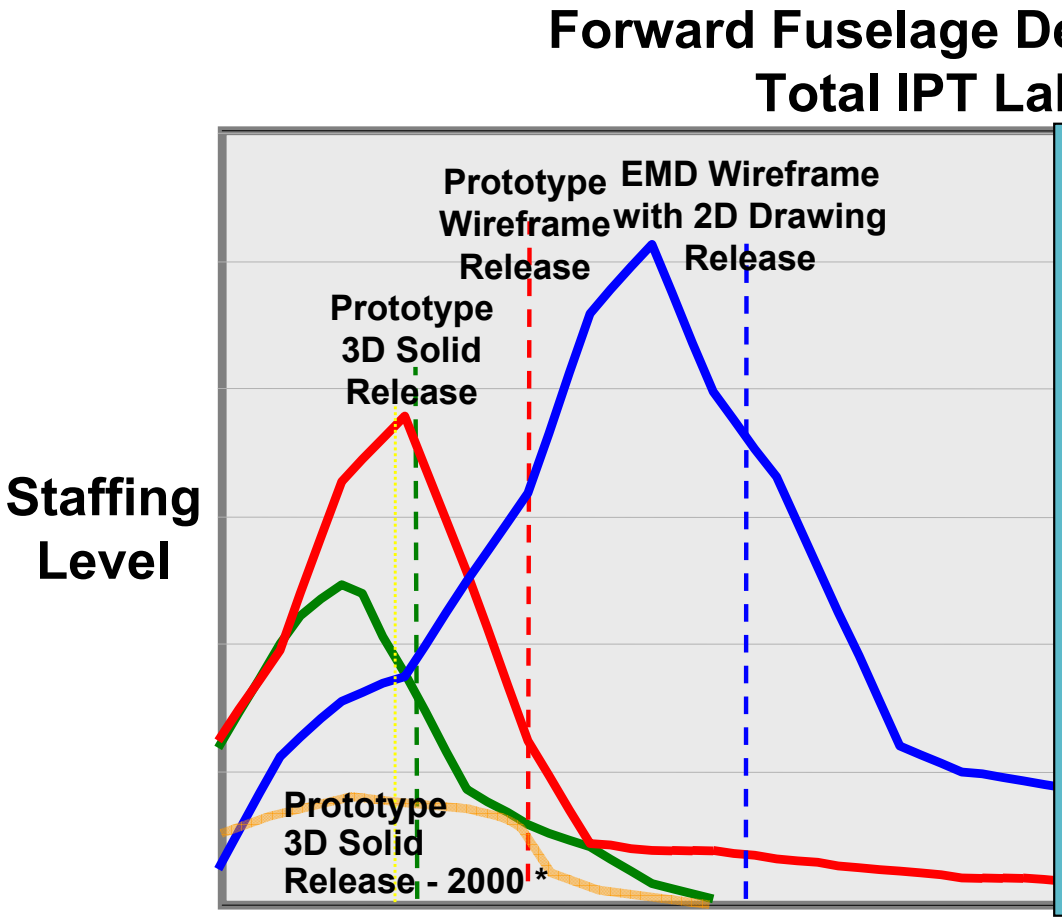
*Source: Beckart, Michelle, "Organizational Characteristics for Successful Product Line Engineering", Master's Thesis, MIT, 2000*

# Co-Location Improves Integration

- Scope: *Class II , ECP Supplemental, Production Improvements, and Make-It-Work Changes Initiated by Production Requests*
- Value stream simplified, made sequential/concurrent.
- Single-piece flow implemented in co-located “Engineering cell”
- Priority access to resources

| Category | % Reduction |
|---|---|
| Cycle-Time | 75% |
| Process Steps | 40% |
| Number of Handoffs | 75% |
| Travel Distance | 90% |

# Modern Tools Improve Cycle Time




- Modern Programs Feature DMAPS Processes/Tools
  - 3D Solid Model Master Definition - No Drawings
  - Detail Available Much Earlier to Support Full, Data-Driven IPT Decisions
  - Daily VR Reviews
  - Virtual Manufacturing
- Improved Supplier Coordination and Concurrent Procurement

* Indicates results from vehicle of approximate size and work content of forward fuselage

# Implementation of Shared Services

- Map the HR&A Value Stream
- Identify & Eliminate Redundant Processes, Procedures and Shadow Organizations
- Standardize HR&A Processes Across the Sector
- Establish Pull by Providing Those Services on Demand
- Level-Load Processes
- Lower Costs

*Source: Ellis, R. Northrop Grumman, "Lean Enabled HR&A" Presentation at LAI Executive Rountable, Dec 13, 2001.*

# Observations on Directive Control Approaches to Enterprise Integration

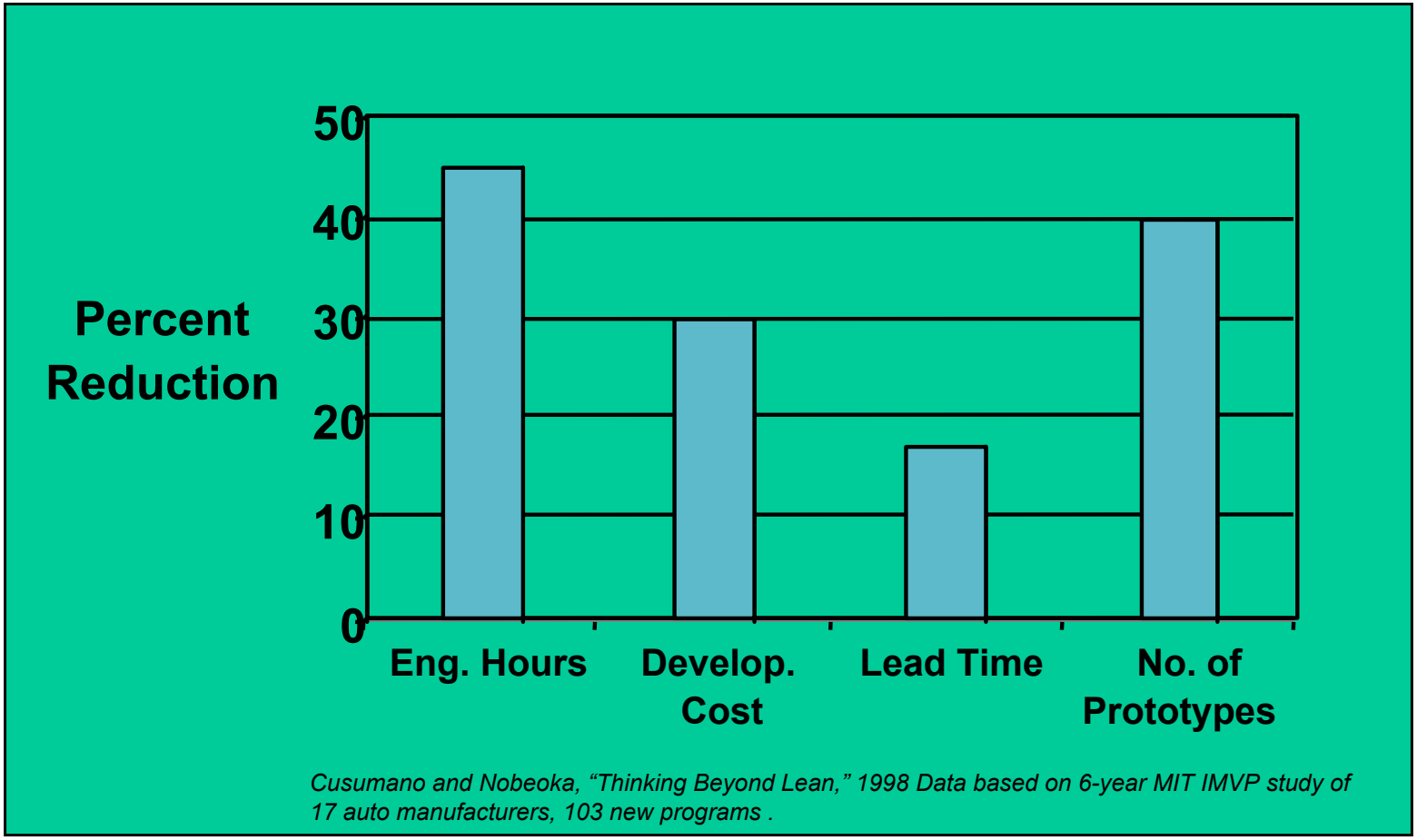
- Senior management buy-in to phase gate or PLE process essential
- Continuous review of how projects line up against enterprise strategy
- Discipline required to ensure new products fit within strategic plan
- Formal product development processes defined
- Formal portfolio management processes in place
- High performance using directive control involves deliberate organizational and product design

*Source: Beckart, op. cit.*


# Manage the Architecture when Key Enterprise Stakeholders are outside Hierarchical Influence

- Key stakeholders (product line managers, risk-sharing partners, etc.) fall outside the domain of control of enterprise leaders
- Limited control over organizational dynamics compensated by emphasis on control over product architecture
- E.g.: Toyota product centers
- Focus is to re-use knowledge, verified designs, existing infrastructure, and enterprise relationships
- Tradeoff is efficiency (enabled through reuse) with performance (in meeting a specific customer's demands)

# Concurrent Technology Transfer in the Auto Industry Demonstrates NRE Savings



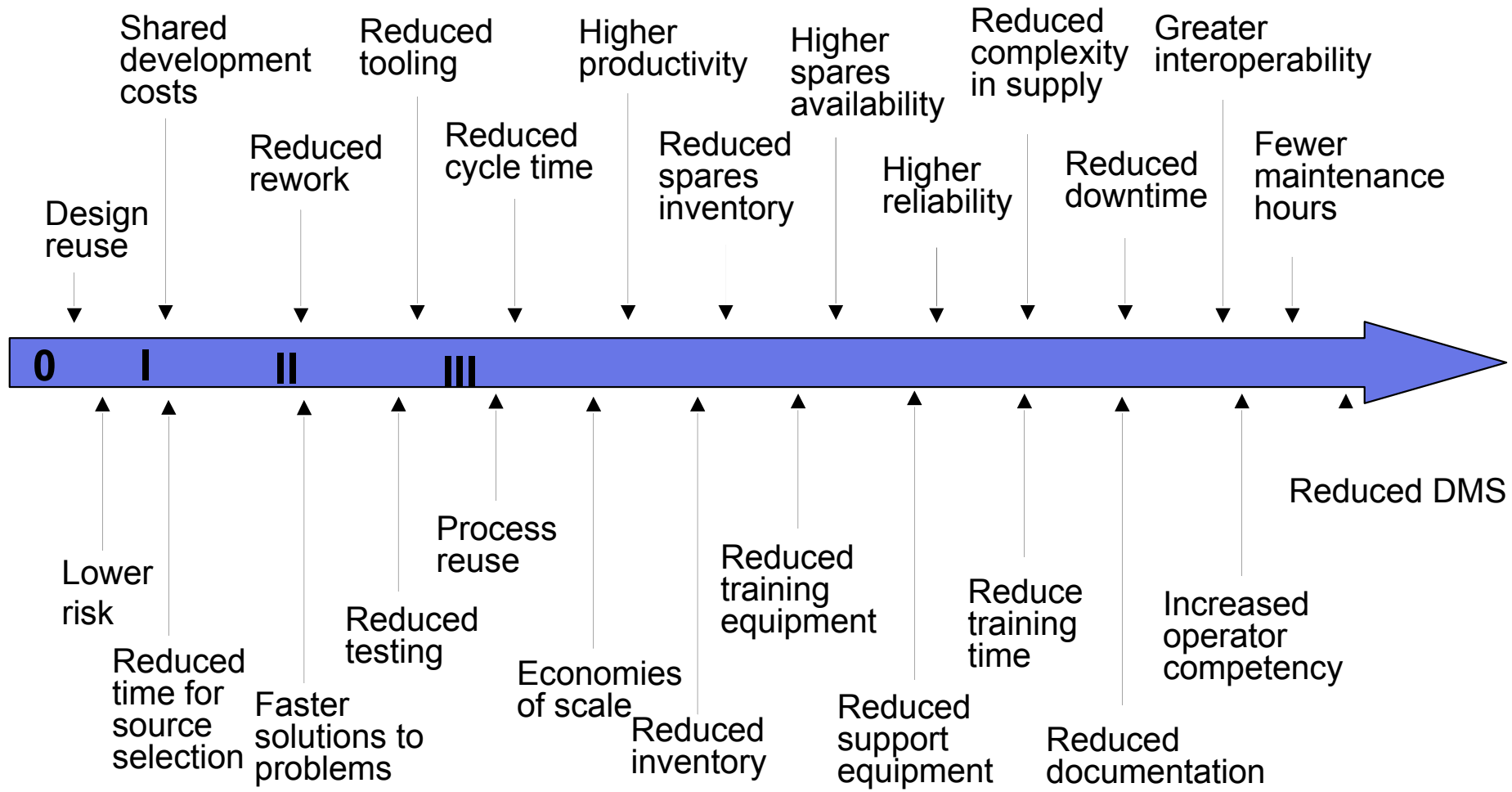

*Cusumano and Nobeoka, "Thinking Beyond Lean," 1998 Data based on 6-year MIT IMVP study of 17 auto manufacturers, 103 new programs .*

## Improvements a result of concurrent technology transfer and multi-project management

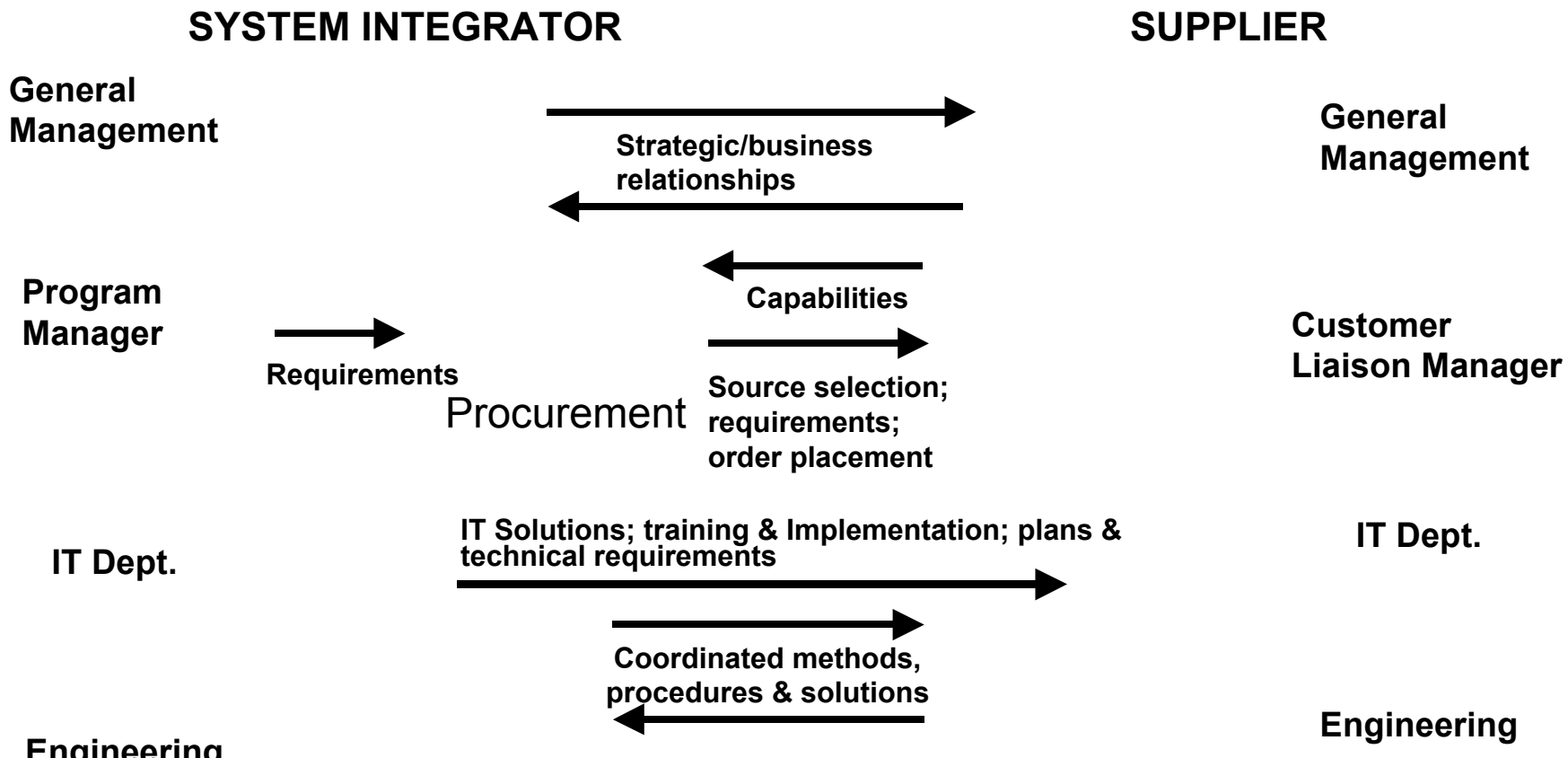
# Examples of Commonality in Lifecycle Operations

- Commercial Airline:
  - Main engine starter is common across 747-400, 767, and 767-300ER
  - 26 airports service these aircraft (11 common)
  - Airline only has to stock 14 spares, as opposed to 25 if they were not common
- PMA-276
  - UH-1Y and AH-1Z deploy together on the same MEU, relying on the same mobility, maintenance, training, and sustainment infrastructure
  - 85% commonality between UH-1Y (utility) and AH-1Z (attack) reduces the detachment maintenance personnel requirement from between 4 and 14 people (3 to 12%)
  - Nearly $1.5 billion in savings from commonality over 20 year lifecycle of program

# Timeline of Commonality Benefits Illustrates Linkage to Multi-Stakeholder Enterprises

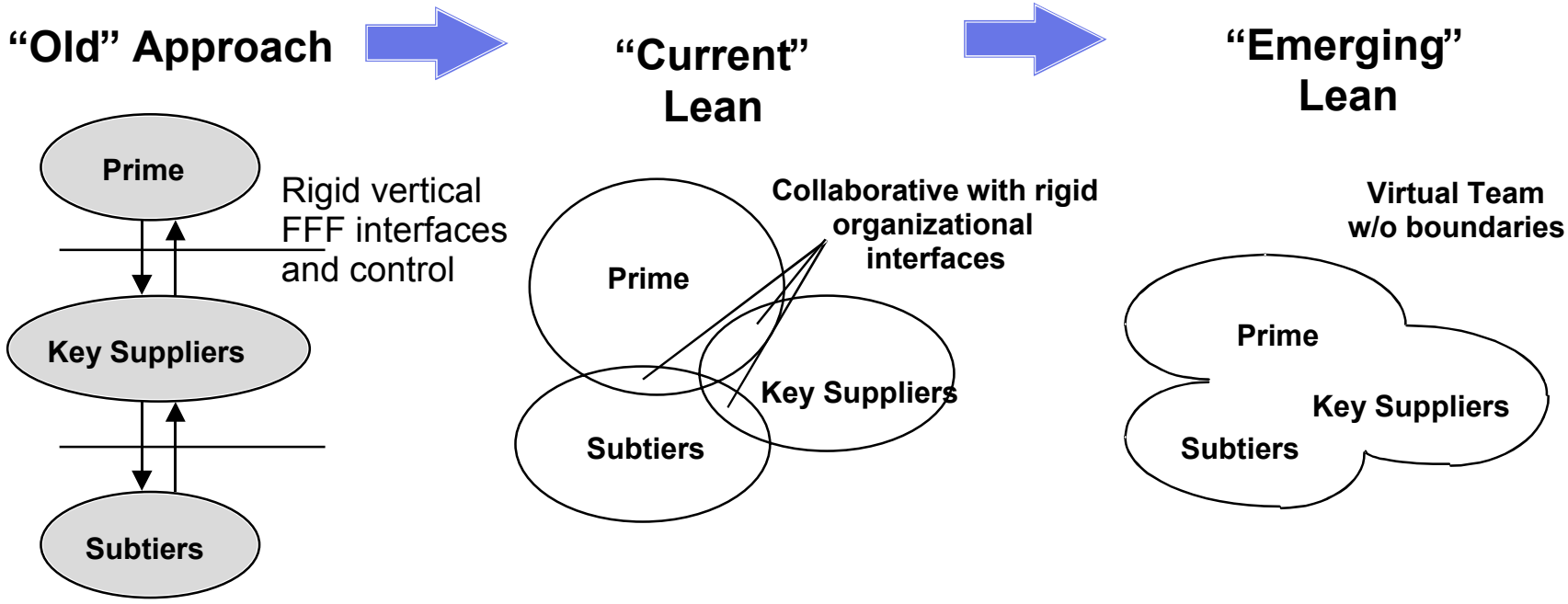


# System Integrator-Supplier Communications Involve Interactions at Different Levels




Source: Adapted from William R. Neill, "Design Chain Engineering: Implementing Integrated Supply Chain Product Development ," Presentation at an MIT Workshop (06/24/1999)

# Early Supplier Integration Results in Significant Benefits through Architectural Innovation




Arm's length; interfaces totally defined and controlled

Collaborative; but constrained by prior workshare arrangements

Collaborative and seamlessly I integrated; architectural innovation

**ARCHITECTURAL INNOVATION:** Major modification of how components in a system/product are linked together

- Significant improvement in system/product architecture through changes in form/structure, functional interfaces or system configuration
- Knowledge integration over the supplier network (value stream perspective ; prime-key suppliers- subtiers; tapping supplier technology base)

# Observations on Architectural Integration Approaches

- Senior leadership plays a pivotal role by enabling lifecycle analysis and integration of multiple enterprise perspectives
- Much of the challenge may be organizational rather than technical
- Portfolio strategies and processes are necessary to obtain full benefits
- Metrics and incentives that measure and reward lifecycle value creation a key enabler
- Customer enterprise structure and demand determine applicability of this approach

# Influence Standards when Key Stakeholders Lie outside Direct Hierarchical Control

- Standards allow decentralize collective action across enterprise boundaries
- With limited control over stakeholders and product design, emphasis shifts to “control points” in product architecture
- Standards foster innovation in the supply base by enabling modular decoupled designs
- Standards are often a strategic battleground—high-stakes winner-take-all contests encourage some enterprises to push proprietary standards at the expense of a broader spectrum of stakeholders
- Several models of collaborative forums exist that successfully develop open standards

# Common Large Area Display Illustrates the Value Delivered through the Creation and Use of Standards

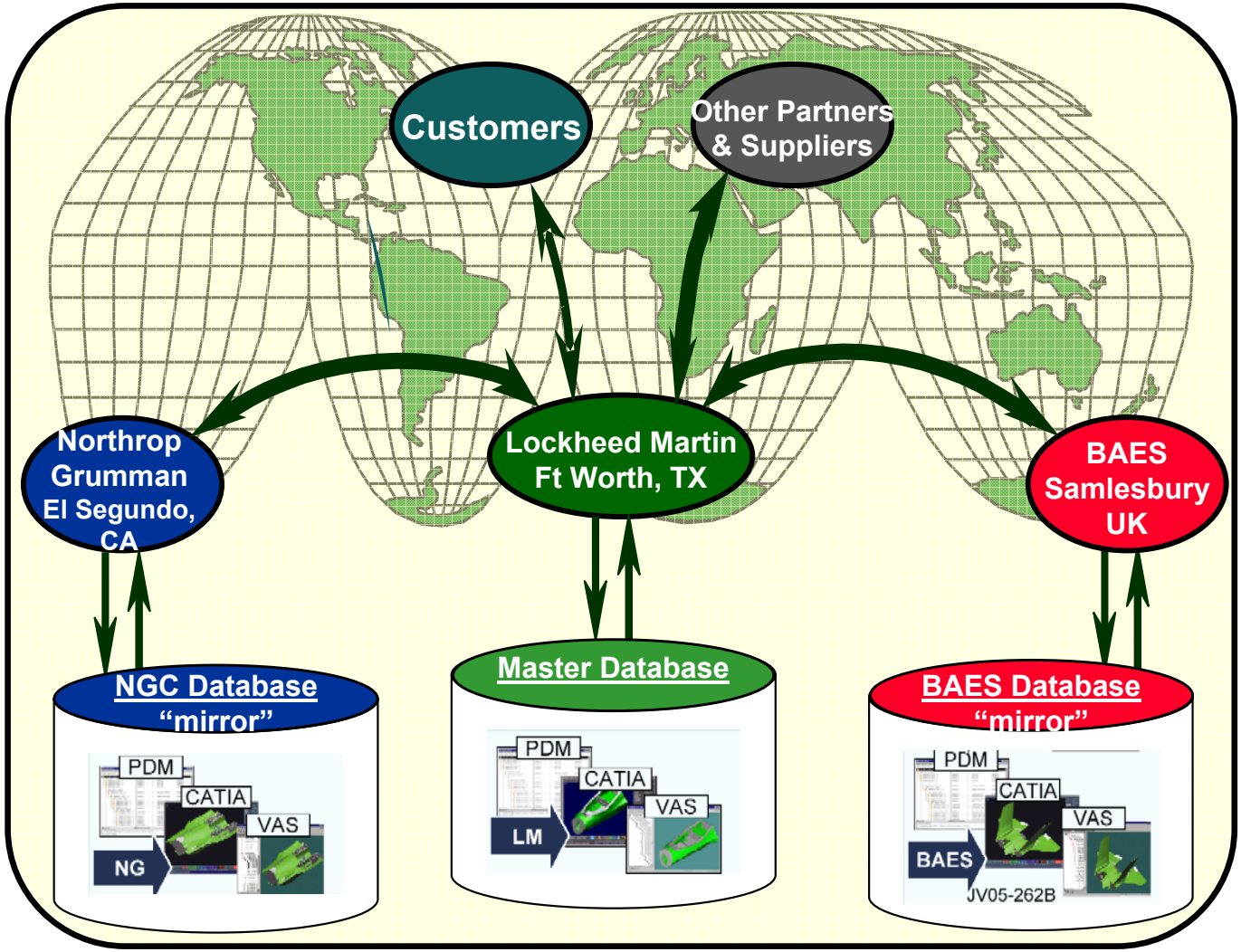
- 500 displays for AWACs
  - But 15,000 displays for DoD
- Standardized on commercial display for all of DoD
  - 60% less weight
  - 90% less maintenance cost
  - 11 fold increase in MTBF
  - 30% power reduction
  - Better resolution
- Up to $100M in DoD savings

# Observations on Using Standards to Achieve Enterprise Integration

- Important to establish neutral forum or broker to define standards that prevent bias towards one solution
- Use open architecture where possible
- Consider technology clockspeed; look to industries or sectors that more closely match that of the system in question
- Establish a common syntax to facilitate knowledge sharing

# Information Technology is Vital to Enterprise Integration Lean

- Virtual Enterprise System (VES) provides the backbone for the digital design and manufacturing environment
- All product data available real-time worldwide
- Enables collaborative development



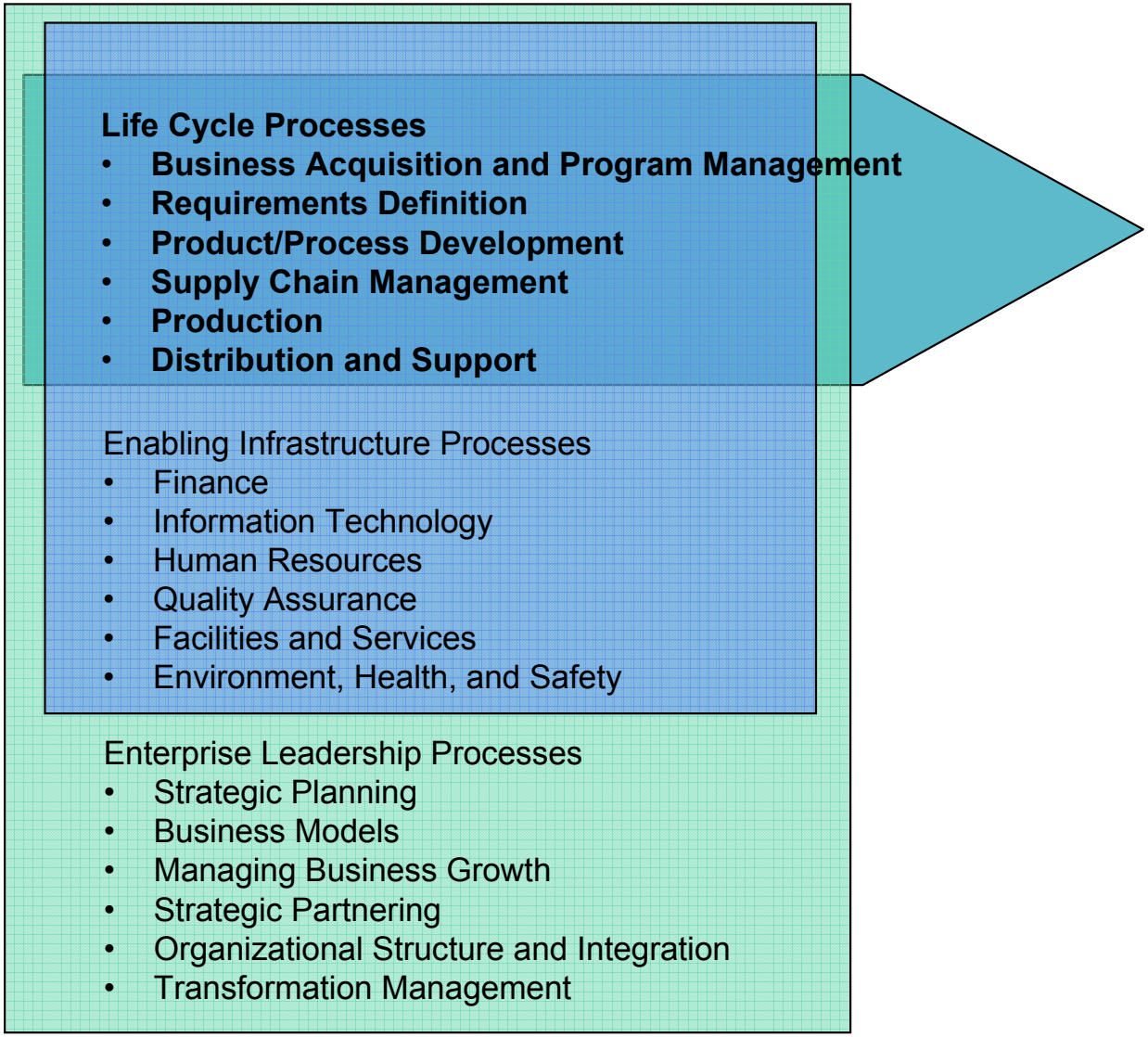

*Adapted from Burbage, T. Lockheed Martin, "JSF - A Winning Environment" Presentation at MIT, March 6, 2002.*

# Enterprise Process Architecture

**Process standardization**

**is a**

**key enterprise strategy**



# Integrated Systems Operating Concept

| Market-Focused IPTs | Shared Services | Common Systems | Lean: Shop Floor & Above | Optimized Assets & Technology Deployment | Leadership Culture |
|---|---|---|---|---|---|
| Airborne Ground Surveil. & Battle Mgmt. Systems | Human Resources & Admin. | Human Resources | Define Value | Rationalized Assets | Shareholder Value Education |
| Airborne Early Warning & Elect. Warfare Systems | Materiel | Procurement | Map Value Stream | Shared Centers of Excellence | Incentivized Mgmt. Perf. |
| Air Combat Systems | Transaction Accounting | Payroll | Establish Flow | Distributed Product-Specific Capabilities | Weighted Financial Goals |
| | Information Services | Finance | Implement Pull | Joint Synergy Programs | Measuring Underpining S/T & L/T Actions |
| | Sector HQ Staff Functions | | Strive for Perfection | | |

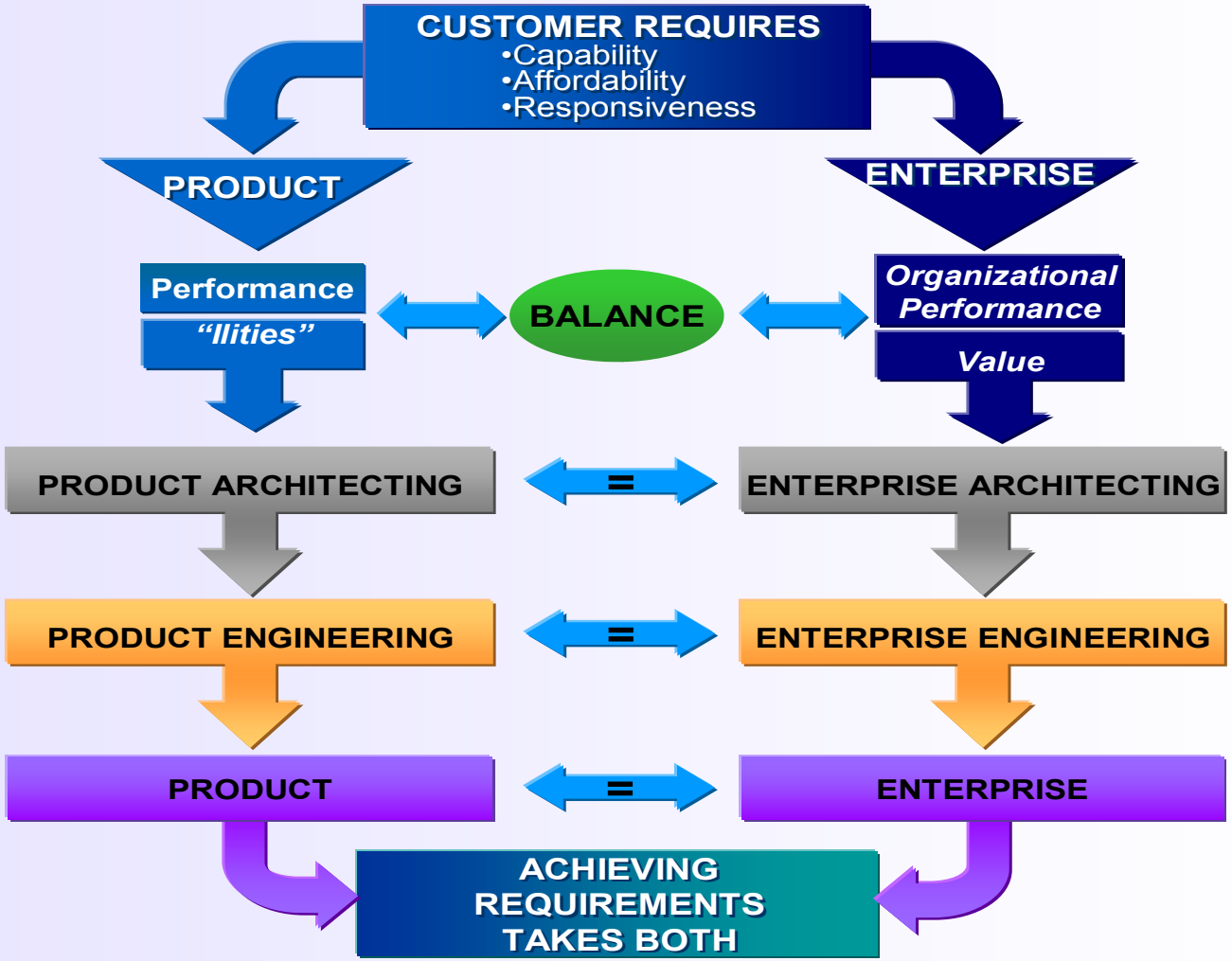
**A Fully Integrated Enterprise With a Shared Infrastructure Providing Distinct Competitive Advantages**

Source: Cool, C. Northrop Grumman, "Journey to a Lean Enterprise" Presentation at MIT, Oct 31, 2001.

# Simple Financial Metrics can Misrepresent the Value of Enterprise "Infrastructure" Investments

- Research found that a military customer valued systems engineering analyses enough to pay for them in a military program but corporate would not in a comparable commercial program
- Spacecraft testing research also showed commercial programs more likely to have infrastructure-related failures
- Financial results-based decisions may inhibit capabilities development that pays dividends in the long-term

# Parallels in Creating Products and Enterprises



# Architecting As An Art And Science Applicable To Enterprises

- Complexity of 21st century systems is driving systems architecting as an important activity within systems engineering to the extent that it is sometimes now considered to be independent of systems engineering

- Similarly, complexity of 21st century enterprises is driving the need for enterprise systems architecting as a unique activity that is distinct from enterprise engineering

**PAST**
(hierarchical) Enterprise

**FUTURE**
(networked) Enterprise

# Current Field Of Enterprise Architecting

- Applying architecting to enterprises is not a new idea – we have seen it evolve over the past decade
- Enterprise Architecting has grown into a well-recognized field, moving beyond the early business process re-engineering focus to take a more comprehensive view of the structure and purpose of an enterprise
- One of the shortfalls of the current field of enterprise architecting is that it currently takes an information technology centric perspective
  - Driven by the large capital investments made in the last decade to insert enabling technologies into the enterprise organization in support of business practices and processes


# Transitioning from Enterprise Architecting to Enterprise Systems Architecting

## Enterprises have long been studied by management scientists and social scientists … largely through taking one single view (organizational or IT)

- In early work in this field, Rechtin (2000) proposes the principles of systems architecting as extensible to architecting organizations.
- Additional works (e.g., Bernus, 2003) describe information enterprise architecting with some extension to organizational factors
- Others describe a process-based view

## *Enterprise Architecting* practice is well established today but tends to be information technology centric

- Works well for the simpler enterprises trying to align processes and technology with organizational structure.
- As enterprises move from simple organizations to a complex networked organizations (extended enterprise), an enriched view is needed
- Needs to be more highly integrated with strategy and culture, and we require some new lens with which to view the enterprise

# Enterprise Systems Architecting

- With the growing complexity of systems, there is a corresponding increase in the complexity of the enterprises that develop, operate, and sustain such systems in an increasingly global environment
- Enterprises are complex, highly integrated systems comprised of processes, organizations, information and technologies, with multifaceted interdependencies and interrelationships
- There are many aspects of an enterprise that must be considered: political, cultural, legal, economic, environmental, technological, sociological, psychological, geographical, and temporal
- Current practice of Enterprise Architecting has been a significant contribution to creating and sustaining modern enterprises; however, we feel the current field is not a sufficient approach to the enterprises of this new century
- Enterprise Systems Architecting is a new strategic approach which takes a systems perspective, viewing the entire enterprise as a holistic system encompassing multiple views such as organization view, process view, knowledge view, and enabling technology view in an integrated framework

# Enterprise Systems Architecting As An Emerging Art And Science

- Enterprises of this century are truly systems in themselves and as such the properties for complex systems also relate to complex enterprises
  - System properties: sustainability, scalability, flexibility, agility, stability, adaptability, robustness, and others
  - "Soft properties (emergent values): extend from the human dimension inherent in the enterprise system
- We are beginning to research how the various properties and behaviors of systems relate to enterprises
  - What enterprise architecture could maximize the long term stability of the enterprise?
  - What architecture would maximize the flexibility of the enterprise in regard to its ability to design innovative new products?
  - Can a single enterprise model be 'optimized' for both such properties, or do we need to select for one over another?
- A far-reaching goal would be to develop the knowledge that is needed to be able to model enterprises in such as way that we can predict enterprise behaviors and outcomes to optimize around various properties, and provide the flexibility that will enable ease of change to the enterprise system in the future.

# Enterprise Systems Architecting As An Emerging Art And Science

To differentiate our approach from the current enterprise architecting theory and practice, we use the term *Enterprise Systems Architecting*

- Architecting looks not just at transition from an 'as is' to the 'to be' state, but also at the underlying decision analysis related to various alternative 'could be' states
- Architecting enriches the thinking about the enterprise through a deeper exploration of each enterprise view, and at the interconnections and interrelationships between these views
- Decisions are made about the alternatives in context of the business model, technology strategy, culture, purpose, and other factors
- Architecting is both art and science, and the current state of systems architecting is probably more of the former
  - The 'art' uses qualitative and heuristic techniques including lessons learned, value judgments, and soft measures
  - Increasingly, architecting is a science using quantitative analytic techniques - math, modeling, measurement

# Research Questions

*Our research has a goal of predictability of enterprises in context of the large scale engineering system*

- What are the basic principles for architecting enterprises?
  - Rechtin (2000) proposes heuristics for architecting organizations that may evolve to enterprise architecting principles
- Can we architect enterprises to optimize around selected properties?
- What emergent behaviors do we see in complex enterprises?
- How can enterprises be effectively modeled?
- What positive qualities will emerge in a well-architected enterprise?
- What makes an enterprise behave as a holistic system?
- How does uncertainty management relate to enterprise architecting?
- Can enterprise systems be predictably architected for selected properties?


# Summary

- Enterprises, much like products, must be architected as complex integrated systems
- In the past decade, we've seen the evolution of *enterprise architecting* which has led to development of architecture frameworks, standards, modeling languages and tools
- We see the current field as too limited, and that a more holistic systems approach to architecting enterprises is needed
- Complex enterprises exhibit systems properties, as well as unique emergent qualities/values rooted in the human dimension
- There is significant research ongoing at MIT and other leading universities to evolve this art and science, and more is needed to address challenging research questions
- Further work is beginning on how to educate the future systems leaders who will architect, build, and transform complex enterprise systems