Integration Strategies across Enterprise Networks:

Applications to Enterprise Architecting with examples drawn from the F-35 Joint Strike Fighter Enterprise Network

Chris Glazner

Lean Aerospace Initiative

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Motivation for Enterprise Network Integration Research

- No single company is in command of all of the technologies necessary to produce a modern aerospace system--it is too costly to maintain multiple world-class competencies in today's competitive environment.
- Increasingly, companies are collaborating as partners on joint complex projects and are forced to collaborate throughout many aspects of the project, and the cost of collaboration can be high. Those who best integrate their enterprises with others in their network will have an advantage in such an industry structure.
- IT/IS alone cannot -- and will not -- solve all enterprise network integration issues, but has the potential to significantly impact integration efforts.

MOVING FROM THE PAST
(vertically integrated) enterprises

TOWARDS THE FUTURE
(networked) enterprises

Why form an Enterprise Network?

- Enterprise Networks are formed to address business opportunities that require competencies that no single firm has or can deliver as cheaply as a network can.
- They allow firms to focus on core competencies, leaving other tasks to partners in the network.

But When?

- As the costs of collaboration are decreased, ENs will become a more common business architecture (Coase, 1937, Williamson, 1985, Axelrod, 1984)
  - Currently, the costs of cooperation remain relatively high (especially in complex, information intensive industries), but are being reduced through integration efforts.

Concept - Enterprise *Integration*

- **Enterprise Integration is a term that has been used differently by both the ICT and Enterprise Architecting communities**
  - **The ICT community has used it to refer to the integration of disparate ICT systems to provide a single, coherent ICT solution to the enterprise**
    - "enterprise integration, also referred to as a 'customer-oriented manufacturing management system' and 'enterprise resource planning' has evolved from a number of proceeding information systems including MRP, MRPII and CIM."(Noori and Mavaddat, 1995).
  - **The organizational community uses the term in reference to integrating the organization's strategy, processes, and knowledge to streamline the performance of the enterprise**
    - "the definition, analysis, redesign and integration of business processes, process data and knowledge, software applications and information systems within an enterprise…"(Huat Lim et. al., 1997)

Enterprise *Network* Integration: My Definition

"*Enterprise Network Integration is the definition, analysis, redesign and integration of business processes, strategy, organizations, process data and knowledge, software applications and information systems within an enterprise network such that there is a high degree of coupling between constituents of the enterprise network while retaining autonomy.*"

-Glazner, elaborating on Huat Lim, et al.

My Views of the Enterprise:

Strategy Process Organization Technology

The F-35 Joint Strike Fighter

- Must meet the needs of many diverse customers
- Must have STOVL capabilities.
- Must fly supersonic
- Must be highly adaptable and evolvable.
- Must be stealthy
- Must have advanced avionics
- Must have very low lifecycle costs

No one company or has ever delivered such a fighter -- it requires complementary competencies from many companies.

JSF's Evolution of Integration and Architecture

- Early on in the conceptual design phase, LM partnered with BAE, NG for specific domain expertise
- Later, the JSF program under Burbage acquired more international participation
- LM IS&T then designed a collaborative infrastructure to tie everything together
  - Given a large, open space to work
  - Very LM-centric
  - Implementation was initially bumpy, but is steadily improving

Why create such large enterprise network for the JSF?

- The required competencies do not exist in one or even a few companies;
- **Increased political robustness--more partners bring in more political, financial support.**

Major Barriers to Integration

- ITAR--imposed by the customer
- Disparate information systems for both data exchange and design software
- Highly networked industry, with partners working for competitors, and competitors forced to work together and share information
- Different working cultures, with different PD processes in place

Many of the most vexing problems come at the boundaries of the enterprise "views"

Intra-view Integration: Strategy and Organization

- **Strategy**
  - Shared fate, shared goal of a long-lived, low(er)-cost, successful aircraft
  - International ties create entangling alliances, making program cuts by the US Govt more difficult.
  - Bring suppliers closer into the program than previously done.
- **Organization**
  - IPTs comprised of personnel from many companies; key IPTs led by a non LM employee.
  - Co-location of some international partners, suppliers to Ft. Worth.

Intra-view Integration: Process and Technology

- **Process**
  - LM pushed for standardized design, materials and manufacturing interfaces, documents throughout the JSF Program.
  - Enabling processes, such as HR, R&D, and finance, remained separated

- **Technology**
  - LM IS&T developed and fielded the entire application package and ICT infrastructure
    - Integrated PDM and design application suite tailored to the program
    - Integrated management of meta-data: JSF Data Library
    - Integrated management framework
    - Development of data standards for work on the program
  - Most explicit integration effort was focused on technology

Inter-view Integration

- Technical-organizational:
  - Data ownership issues arising from integration of design apps with stakeholder disenchantment
  - Mismatches between technical system performance and user expectations
- Technical-process
  - Developed processes not always clearly reflected in captured process in the IT system
- Strategic-organizational-process-technical:
  - International participants blocked from most documents; new processes devised to allow them greater access data they need while remaining in compliance with ITAR and working within the IT system
- Strategy-organization:
  - Politics plays a large role in contract awards, especially at the international level, clashing with supply chain management

JSF's Solutions to EN-specific Governance Concerns for Integration

- **Secure, trust-based collaboration**
  - Handled largely through IT systems. Extensive protocols for ensuring secure communications, ITAR compliance, user authentication.
  - Trust and contracts are used to ensure participants won't use JSF (or other member's) proprietary IP on other projects. There are few actual controls, but few violations

- **Central Control**
  - While there is unprecedented collaboration, ultimately, LM and the JPO have central control and budget authority.

Present work

- Many vexing and unanticipated problems occurred at the boundaries of the traditional "views"
  - Can we learn more about the nature of cross-view interactions? What are the most important interactions to consider? What is too far down in the weeds?
  - Can we predict trouble areas before they arise by studying these interactions?
  - Are there better enterprise architectures for addressing these interactions that can either mitigate or take advantage of them?

Questions?

Backup Slides

Enterprise Dynamics:
Understanding and Modeling Interaction Effects in Complex Engineering Enterprises

Background

- The many interactions across the highest-levels of an enterprise can give rise to behavioral complexity
- The enterprise can be viewed in several domains, or views: *strategy*, *information*, *organization*, and *process* are common domains used in enterprise architecting and modeling
- Many of the most vexing problems an enterprise faces occur at the boundary of these domains:
  - •The IT architecture may not reflect organizational realities
  - •Strategic concerns could drive partnering arrangements that affect the design process which is then encumbered by security constraints
- An enterprise-level view is needed to understand and design the enterprises that will produce complex engineering systems.

Key Questions

- What are the cross-domain interactions of interest in complex engineering enterprises? How can we characterize them?
- Can existing organizational science theories be extended to take into account these interactions?
- Can an integrated model of a complex engineering enterprise be built that can be used as a tool in designing the future state of the enterprise and to test hypotheses?

Knowledge Domain

What does this research accomplish?

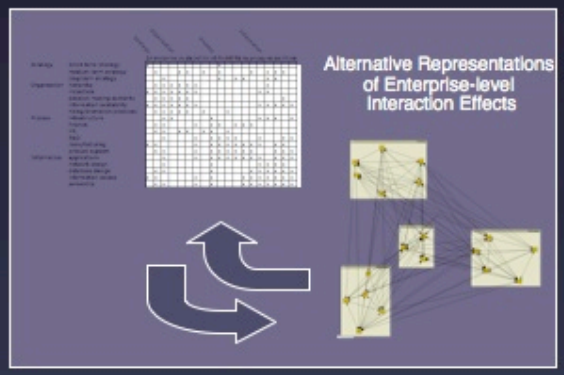
This research will present a deeper understanding of typical dynamic, cross-domain interactions in complex enterprises. This work will extend current organizational design theory with regard to high-level interaction effects, and develop an integrative enterprise model that can be used for decision-making, theory-development and testing.

Who should use it?

This research should be used by those involved in enterprise architecting and high level enterprise decision-making to better understand enterprise structure and alignment and possible effects of decisions across the enterprise.

What are the benefits?

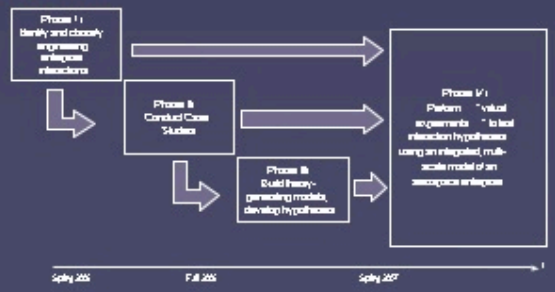
LAI consortium members will be able to gain insight into behaviorally complex problems at the enterprise-level, and be able to better structure themselves to mitigate or take advantage of these effects. Additionally, a "flight simulator" model of interaction effects will be produced, allowing LAI members to customize it and perform their own "what if" analyses.



Research Methodology

- Phase I:
  - Literature review of enterprise architecting and modeling literature and of computational organizational design literature
- Phase II:
  - Case study analyses of a sample of enterprises
- Phase III:
  - Extend extant theory using "toy" models to make them more applicable to realistic enterprises
  - Develop hypotheses that can predict performance characteristics
- Phase IV:
  - Develop an integrated "prototype" model of an enterprise that captures cross-domain interaction effects

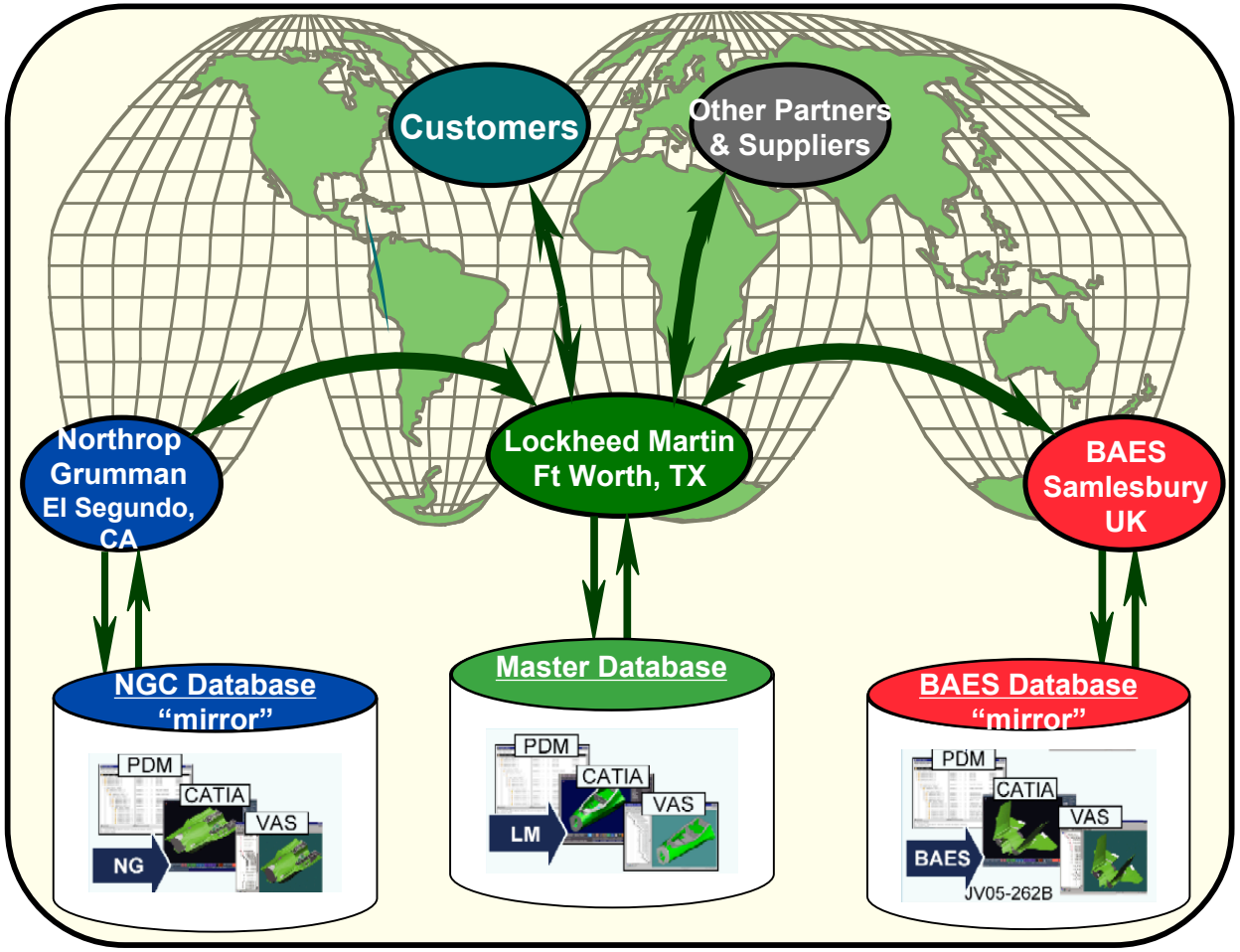
Timeline



Contact: Chris Glazner
glazner@mit.edu

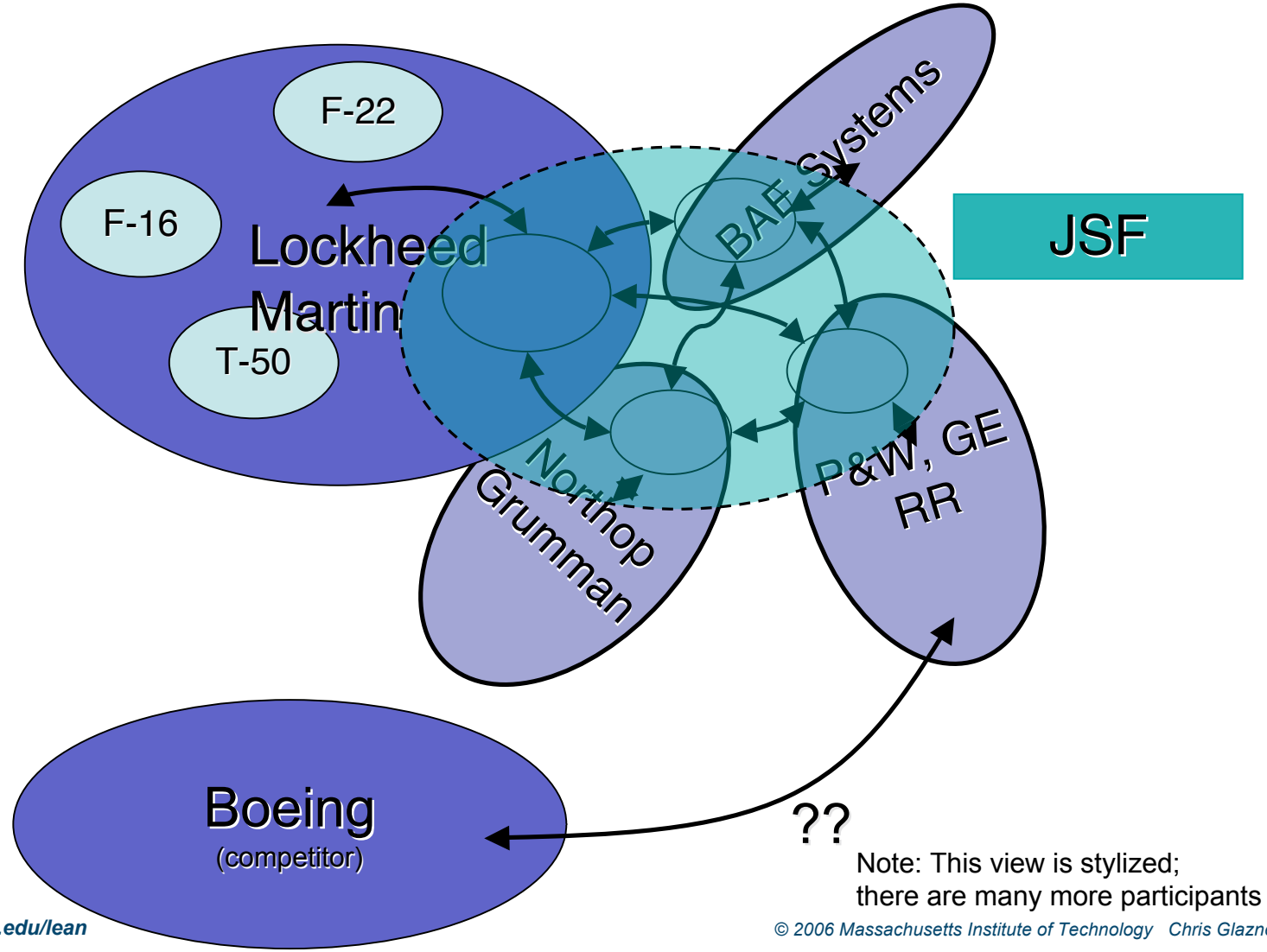
Integrating Disparate ICT Systems

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



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

A high-level conceptual view of the JSF EN



Note: This view is stylized;
there are many more participants and divisions

The JSF EN seen in the EN Taxonomy

- **Duration -** Long-term alliance
- **Structure -** fixed, contract-based structure
- **Governance -** centralized control through Lockheed Martin and to some extent, JPO
- **Participation -** Open networks in the sense members are free to join other networks
- **Visibility -** Wide visibility from suppliers to integrators(multi-level); limited visibility between suppliers(intra level), good visibility between top level partners.
- **Coupling -** Highly coupled core group of team members, with coupling becoming looser away from this core group