Enterprise Architecture in Lockheed Martin

An Innovative Way to Align IT Spending to deliver an Agile Customer Centric Organization

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Lockheed Martin
Chief Technology Office

1

LM EA Executive Support

ENTERPRISE ARCHITECTURE

Aptitude for whole system thinking. At the heart of all information age transformation is horizontal integration – managing secure, real time knowledge flow across the stove pipes that separate organizations, agencies, enterprises and services. This holistic view of connectivity is key whether your goal is processing a Census form or protecting a seaport. At Lockheed Martin, network centricity is the first principle that we apply to our efforts such as devising enterprise architecture blueprints for civil agency modernization, developing the frameworks to tackle the challenges of homeland security, and creating innovative concepts in joint command and control. Our unique view of what architecture is and how it is leveraged at the outset is what provides unparalleled value to our customers at their defining moments.

Products / Services

We have long discussed the value and power of being able to access critical information wherever and whenever needed in the enterprise. The industrial allegory is lean manufacturing and just-in-time material applications. But how does this translate into the information domain? For the military, the concept of Net-Centric Operations is the framework being used to achieve this vision. In civilian agencies, the Federal Enterprise Architecture is the framework for digital government and information interactions among customers and suppliers. Where are we in achieving the vision of being able to access information across the enterprise, wherever and whenever needed?

Joseph R. Cleveland, Chief Information Officer. Lockheed Martin Corporation; President, Lockheed Martin Enterprise Information Systems

LM Customer Mandate

- **The Clinger Cohen Act and the presidential mandate**
- **The NASCIO commitment**
- **OMB requirement for all government purchases**
- **Starting in 2004, federal agencies must correlate their budget submissions with their Enterprise Architectures**
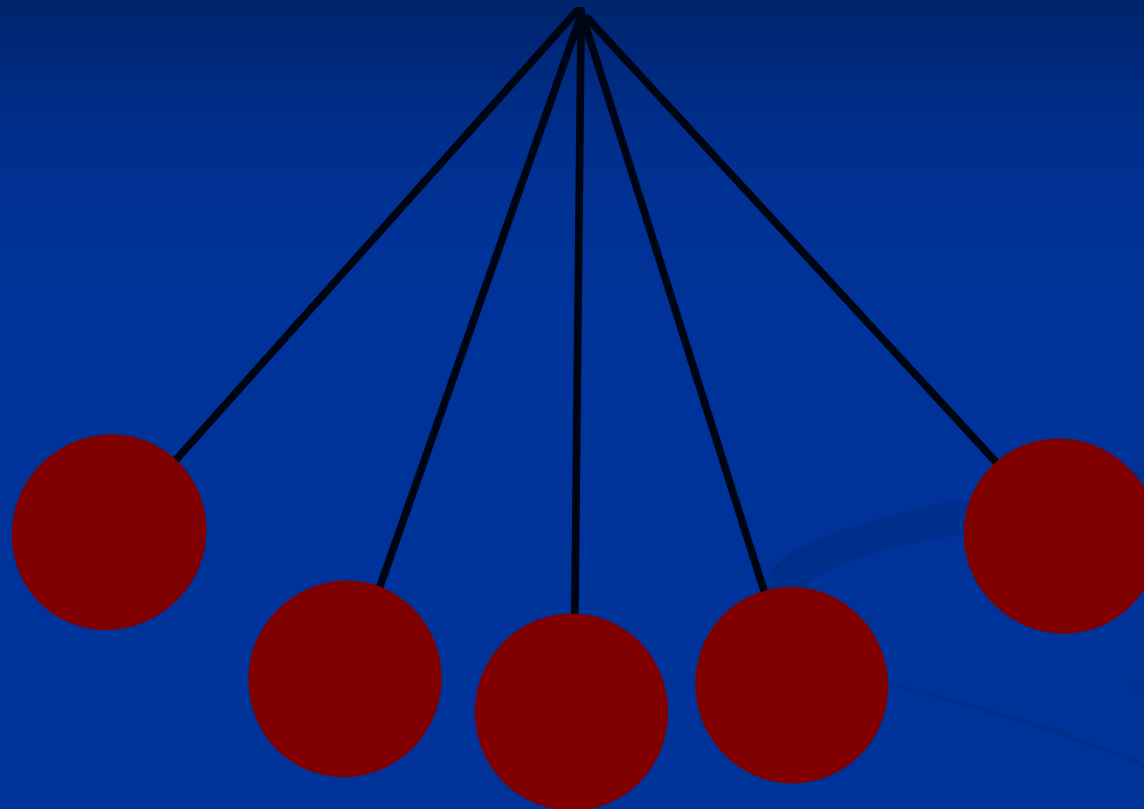- **Sarbanes-Oxley Compliance**
- **UID Initiative- January 2005**

Our Mission in IT

"Magnify the Power of Lockheed Martin through IT"

Business/Technology Pendulum

Business Strategy

Technology Architecture

Information Architecture

Policies and Governance
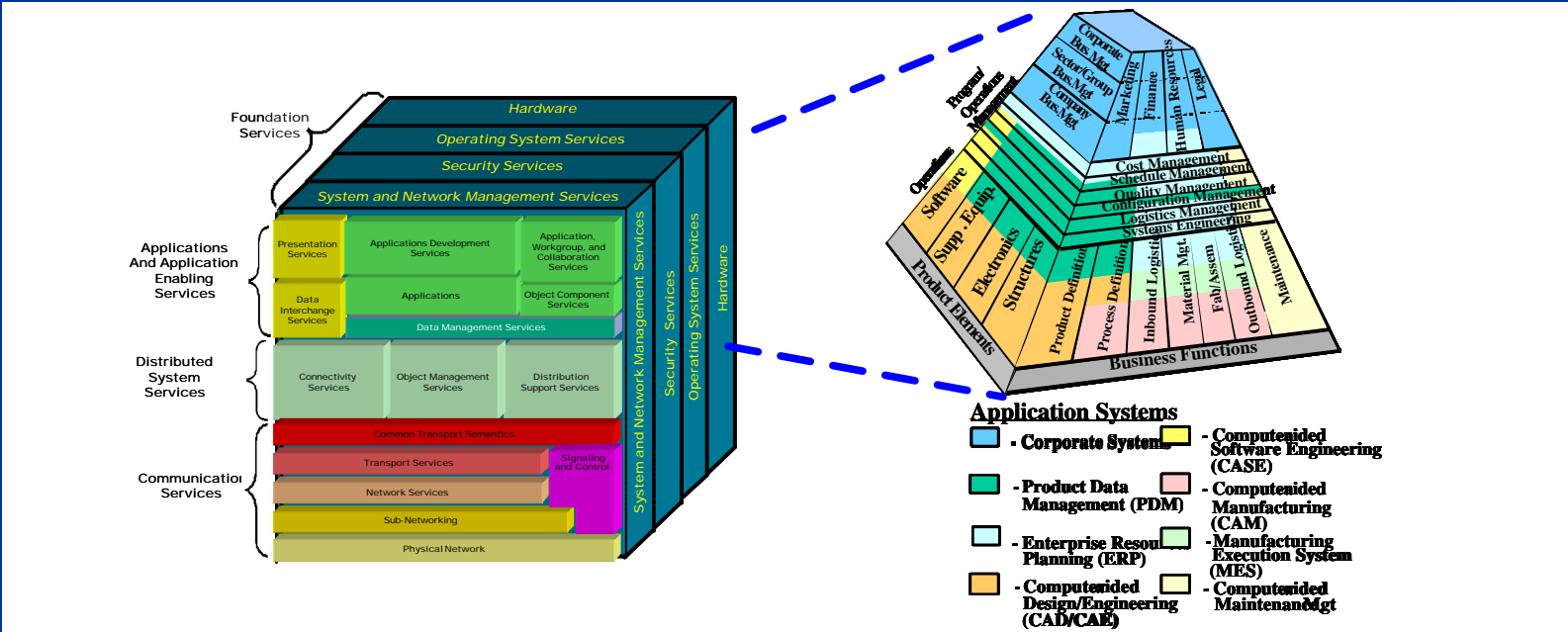
A Brief History

- LM EA is new, but LM 'A' is not !
- ITAF
- BRM, TRM
- We have leveraged EA Evolution

Architectural Frameworks
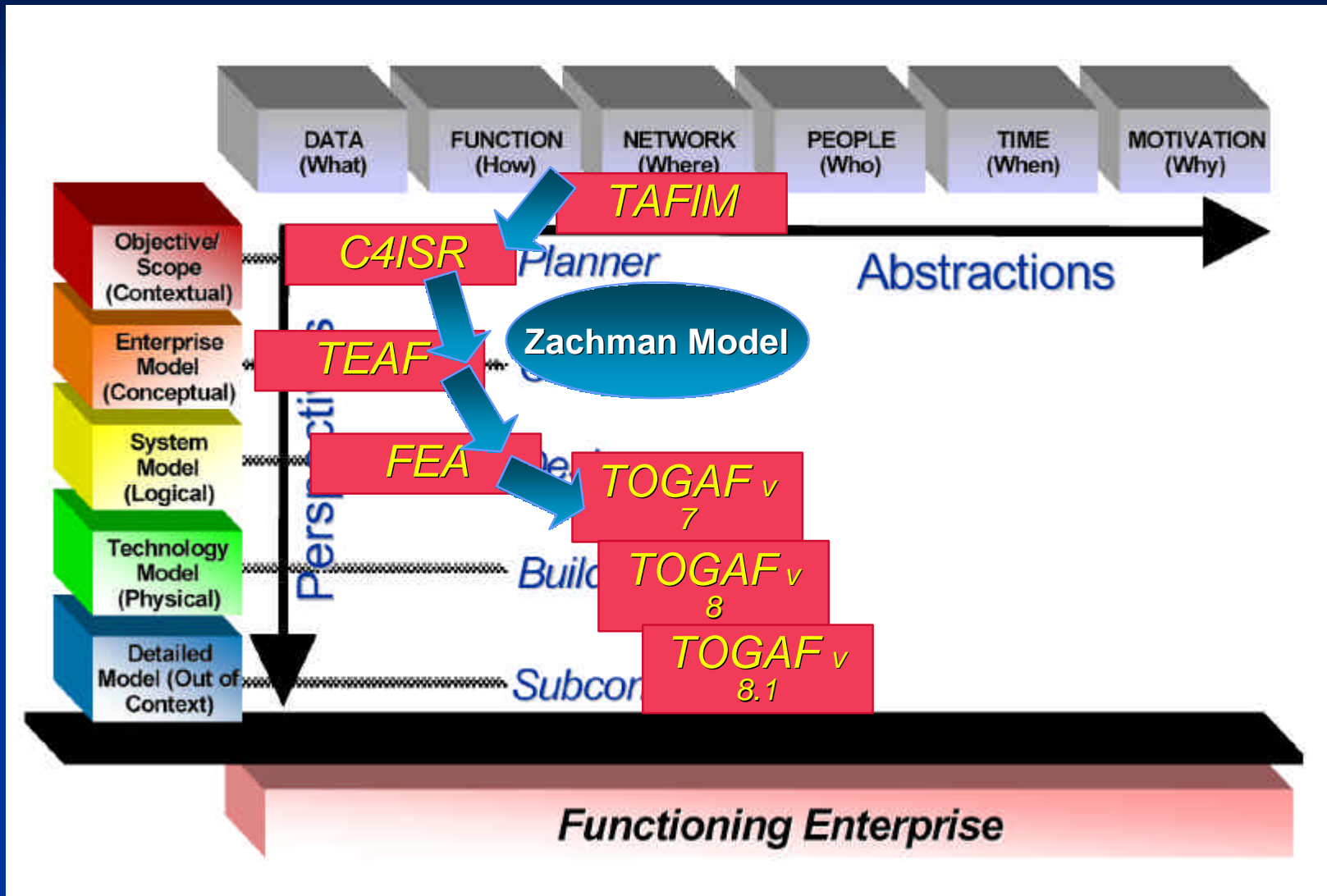
Insertion of New Technology Requires Managed Chaos

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IF YOU WANT TO SUCCEED, DOUBLE YOUR FAILURE RATE.

THOMAS WATSON, FOUNDER IBM

SYSTEM DYNAMICS

CATASTROPHE THEORY   SELF-ORGANIZED CRITICALITY

DYNAMICAL SYSTEMS → NONLINEAR DYNAMICAL SYSTEMS (NDS)

GENERAL SYSTEMS THEORY

FRACTAL GEOMETRY

CHAOS THEORY

SOLID STATE/ CONDENSED MATTER PHYSICS

COMPLEX ADAPTIVE SYSTEMS (CAS)

EVOLUTIONARY BIOLOGY

ARTIFICIAL LIFE
EMERGENT COMPUTATION
BOOLEAN NETWORKS
GENETIC ALGORITHMS

CYBERNETICS

EVOLUTIONARY SYSTEMS AUTOPOIESIS

INFORMATION THEORY

ARTIFICIAL INTELLIGENCE

COMPUTATIONAL THEORY

ALGORITHMIC COMPLEXITY

NEURAL NETS

GAME THEORY   SYNERGETICS

FAR-FROM-EQUILIBRIUM THERMODYNAMICS

EMERGENCE IN SELF-ORGANIZING SYSTEMS

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[from Jeffrey Goldstein]

Some of this is adapted from William Bechtel & Robert Richardson, Discovering Complexity: Decomposition and Localization as Strategies in Scientific Research. Princeton: Princeton University Press, 1993.

What is the Spirit of the Mandate?

- ❑ Complex Organization can't be managed ad-hoc
- ❑ We have to Leverage the Legacy
- ❑ We must deploy new technologies to maintain competitive advantage
- ❑ We need a holistic way to integrate now with the past and still be capable of adapting to the future
- ❑ Agility to deliver the right information at the right time = Knowledge
- ❑ All of this must be done based on Business/Customer demand-agility

Closing the IT Business Chasm

Business needs a new way of strategic thinking

IT needs to align spending with business needs

Business Reconfiguration: A FAST™ Approach

Long Term 5-10 Years — High-level direction

FAST™ Strategy

Medium Term 1-5 Years

Short Term 6-12 months — Rapid prototyping

Effort

Focus

Accelerate

Strengthen

Tie It All Together

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People

CMMI

ITIL

EA

Technology

Process
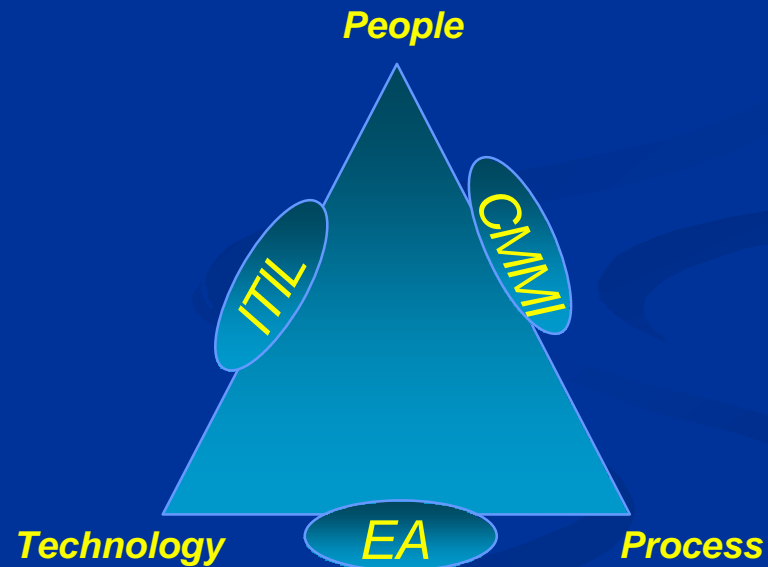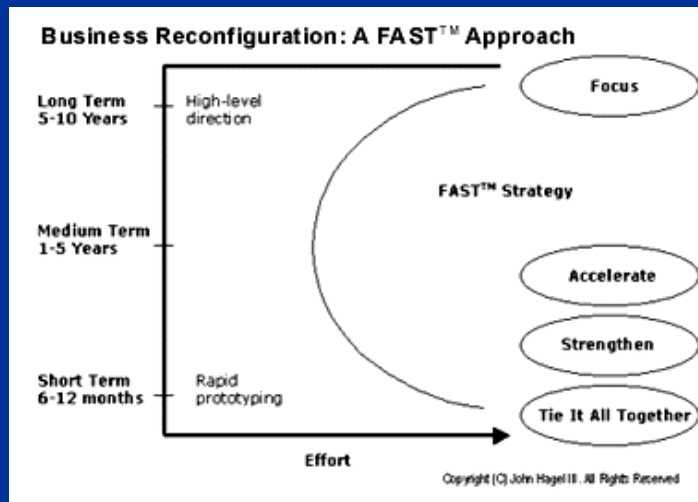
Aligning our IT Strategy with Business Goals

- **Business Goals**
  - Right information to the Right people
  - Collaboration between partners
  - Integrated supply chain (Eng- Mfs- Mkt/Dst-Support)
- **Tech Solutions**
  - Portals
  - Web Services
  - EAI
  - PKI/Directory Services/Systems Management

We created solutions that work part of the time-lacks horizontal integration!

Aligning our IT Strategy with Business Goals

■ The Problem:

  ■ We have built a new layer of silos

  ■ From vertical to internet silos

■ Solutions

  ■ Use Internet Technology

  ■ Loosely Coupled

  ■ Component Based Development

  ■ Service Orientation

  ■ Machine to Machine Interaction Without Human Intervention

Web Services are Beyond SOAP, UDDI, WSDL
It's All about the Service Grid

- **How do we build a loosely coupled federation of components that can be at run time orchestrated**
  - Keep IT "Out of the Process"
  - Keep IT to build Solid Infrastructure for SOA
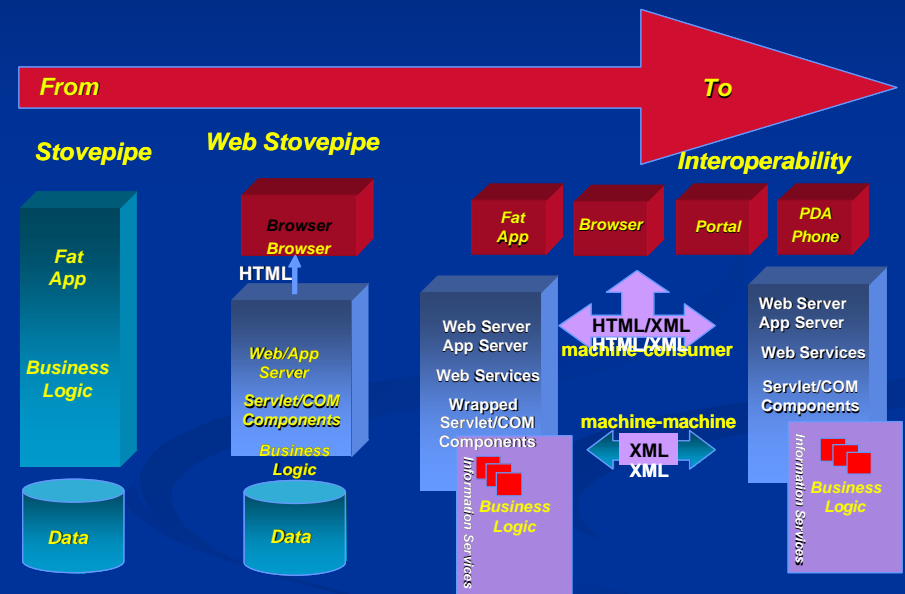
Need a holistic way to look at the complex problem – Enter EA!

The Role of EA

The EA Discipline is required to manage the complexity introduced by the core of WS-The Service Grid.

WEB SERVICES ARCHITECTURE

Application services

Web services

Shared utilities:
- Security
- 3rd party performance auditing/ assessment
- Billing and payment

Service Management:
Provisioning, monitoring, quality of service (QoS), synchronization, conflict resolution

Resource Knowledge Management:
Directories, brokers, registries, data transformation

Transport Management:
Message queuing, filtering, metering, monitoring, routing, resource orchestration

Service grid

Foundation standards
- WSDL – Web Services Description Language
- UDDI – Universal Description, Discovery and Integration
- XML – extensible Markup Language

Foundation protocols
- SOAP – Simple Object Access Protocol
- HTTP – Hypertext Transfer Protocol
- TCP/IP – Transmission Control Protocol/Internet Protocol

Source: Cap Gemini Ernst &Young

Enterprise Architecture

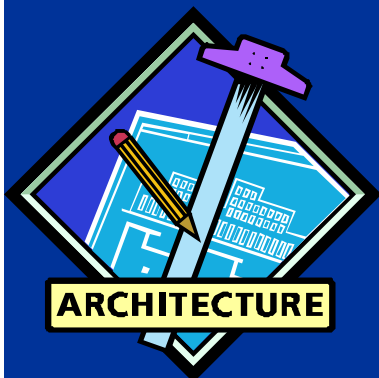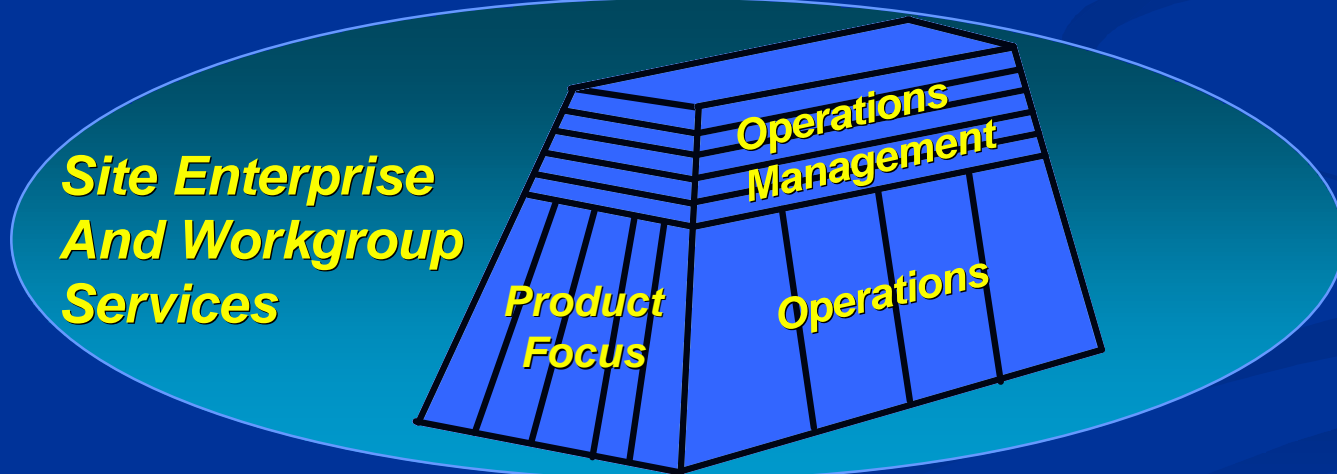A well-designed enterprise architecture is the single biggest technological contributor to business agility. An Enterprise Architecture ensures that essential infrastructure is in place such that LM can successfully harness its assets to foster continuous business innovation and growth. With a focus on business goals, architectural changes need to be implemented in conjunction with business-critical initiatives to ensure valuable changes to the organization.

At its most fundamental level, an enterprise architecture serves as a blueprint for a company's most critical business processes:

>supporting applications and data
>software and hardware infrastructure
>knowledge and expertise

LM Challenge: Aligning IT to the Business

Corporate Enterprise Services

- Lockheed Martin
- Aeronautics
- Info. & Tech. Sys.
- Space Systems
- Electronic Sys.
- ISS

Site Enterprise And Workgroup Services

- Operations Management
- Product Focus
- Operations
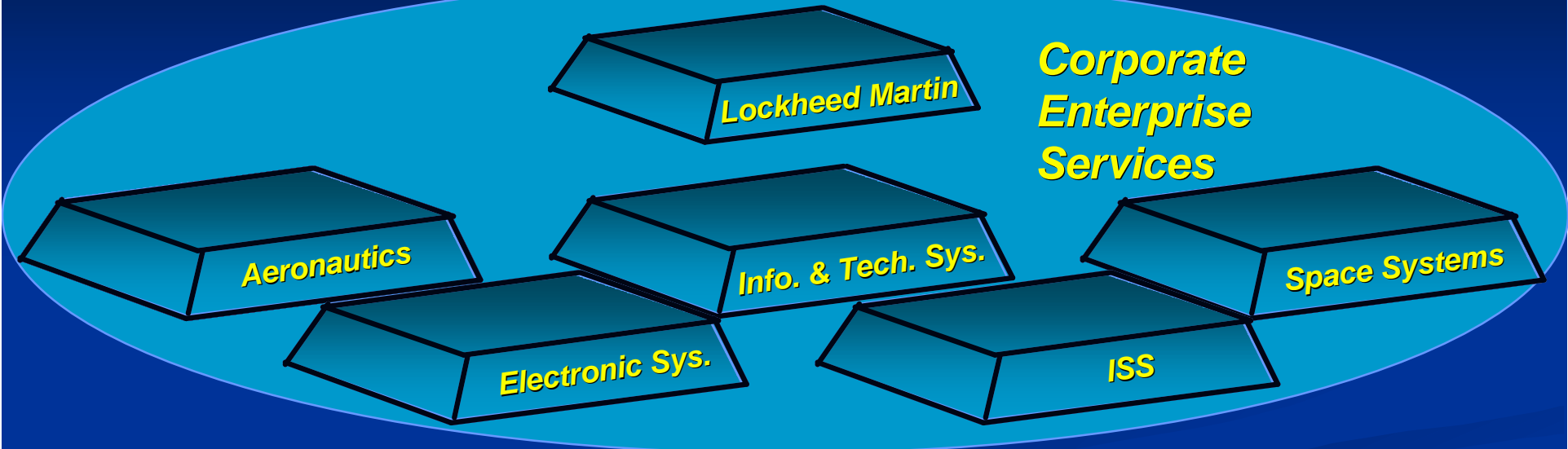
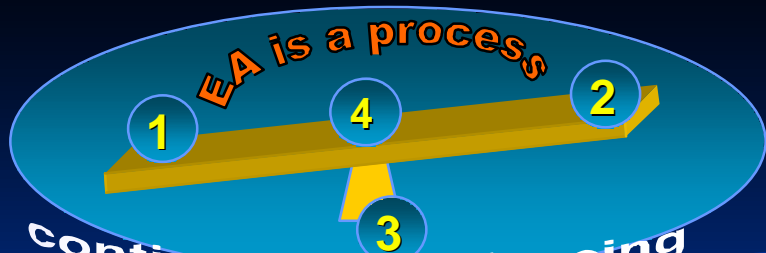**970+ Other Facilities Worldwide**

Small Office Services

30+ Business Units, 60+ Enterprise Sites

What we are doing at LM

- Have Gained Support for CIO/CEO
- Vision clearly articulated
- Customer Support as a major IT provider to the DOD
- EIS internally and leverage of customer contracts
- TOGAF-> ITAF -> EAM ->LM EA Framework

EA is a process — continuously balancing business needs with judicious IT investments

The *Enterprise Architecture Framework* is an overall framework that allows the framing of all of the architecture elements and defines the interrelationships between them in a consistent and organized fashion.

Architecture Blueprint
The Architecture Blueprint is the collection of the actual standards and specifications that define how the Business and IT Portfolios are and will be built.

The Business Architecture Framework includes: The Business Drivers (Enterprise Business Principles, Business Best Practices, and Industry Trends), as well as Business Architecture Processes and Business Architecture Blueprint Templates.

The Technology Architecture Framework documents the Technology Architecture Blueprint including- Technology Drivers (Enterprise IT Principles, IT Best Practices, and Technology Trends), as well as Technology Architecture Processes and Technology Architecture Blueprint Templates.

ARCHITECTURE BLUEPRINT

Influences — Influences — Influences

BUSINESS ARCHITECTURE FRAMEWORK

TECHNOLOGY ARCHITECTURE FRAMEWORK

ARCHITECTURE GOVERNANCE FRAMEWORK

Architecture Governance Framework
The Architecture Governance Framework includes the governance roles, elements, and processes required in maintaining adaptive enterprise architecture.

(1) Business Architecture Framework

- The Business Architecture Framework is recognized as the critical enabler of EA in LM.
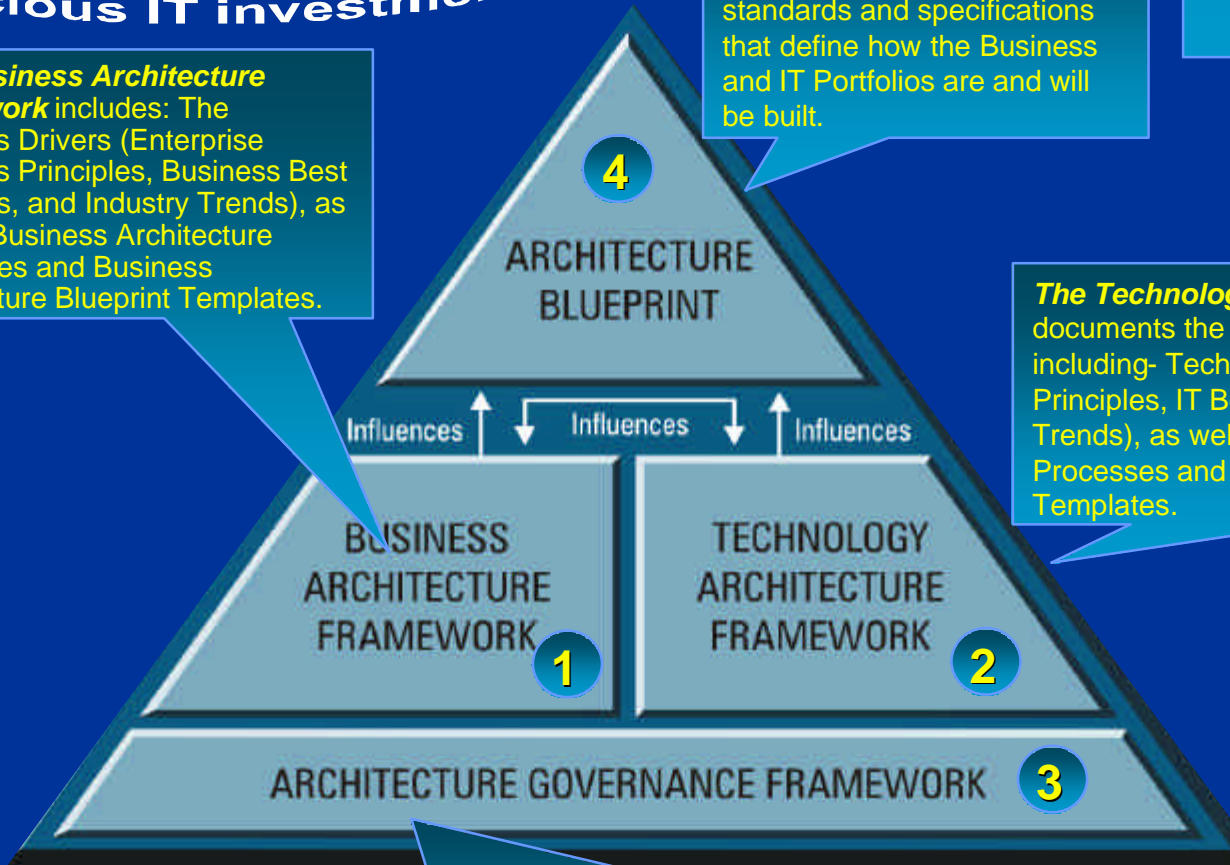
    - *The Business Architecture Framework* includes: The Business Drivers (Enterprise Business Principles, Business Best Practices, and Industry Trends), as well as Business Architecture Processes and Business Architecture Blueprint Templates.

April 21, 2004
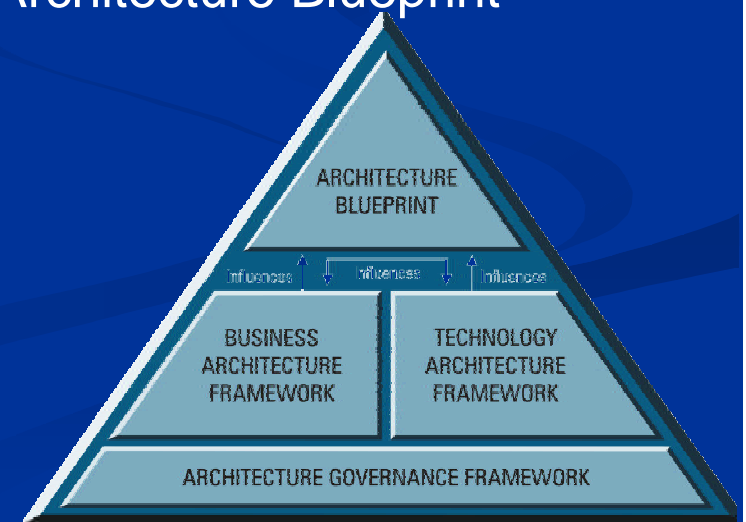
Business Architecture Framework

- LM is a global company and recognizes that the global economy extends the marketplace but also increases the competition
  - European Union (EU)
  - Association of South East Asian Nations (ASEAN)
  - China
  - Russia

- Resulting cost pressures demand improved efficiencies.

- Customers demand improved quality.

- Rapid technological advancement reduces product lifecycles and demands constant renewal of core competencies.

- Systems Integration and Services-oriented businesses emerge as major strategic sources of revenue.

Business Architecture Framework

- Modern business concepts embraced by LM often involve widespread business impact:
  - Six Sigma – find a process that works, do it again, and again, and again….
  - Supply Chain Optimization – get your suppliers to help share the burden
  - Collaboration – leverage the expertise wherever you can find it
  - Design for produce-ability – if we can't build it, is it a good design?

(2) Technology Architecture Framework

- The Technology Architecture Framework is recognized as another critical enabler of EA in LM.
  - *The Technology Architecture Framework* documents the Technology Architecture Blueprint including- Technology Drivers (Enterprise IT Principles, IT Best Practices, and Technology Trends), as well as Technology Architecture Processes and Technology Architecture Blueprint Templates.

April 21, 2004
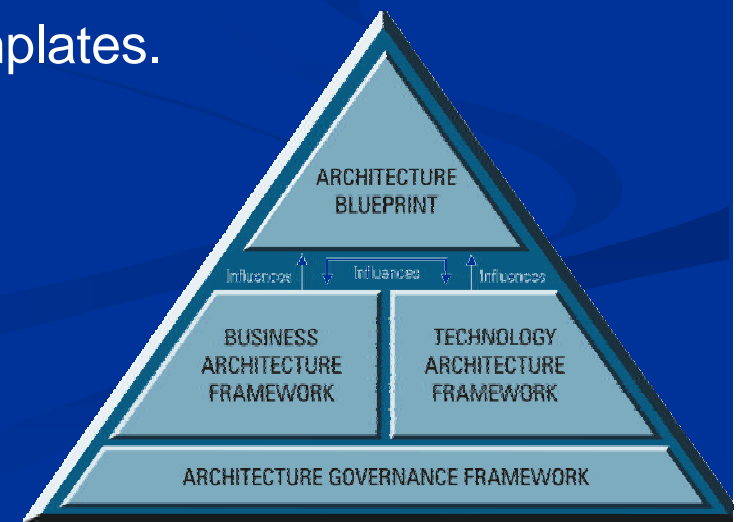
EA Distills the Common Processes

Eliminates Duplication Across the Organization

Business Processes	Business Processes	Business Processes
Manufacturing Process for Aeronautics	**Manufacturing Process for Space Systems**	**Manufacturing Process for Electronic Systems**
Scheduling Procurement Human Resources	Scheduling Procurement Human Resources	Scheduling Procurement Human Resources
Business Logic Manufacturing Logic for Aeronautics	**Business Logic** Manufacturing Logic for Space Systems	**Business Logic** Manufacturing Logic for Electronic Systems
Scheduling Procurement Human Resources	Scheduling Procurement Human Resources	Scheduling Procurement Human Resources
Business Metadata Manufacturing Metadata for Aeronautics	**Business Metadata** Manufacturing Metadata for Space Systems	**Business Metadata** Manufacturing Metadata for Electronic Systems
Scheduling Procurement Human Resources	Scheduling Procurement Human Resources	Scheduling Procurement Human Resources
Middleware	**Middleware**	**Middleware**
Operating Systems	**Operating Systems**	**Operating Systems**
Computer Hardware	**Computer Hardware**	**Computer Hardware**
Networks	**Networks**	**Networks**

Within LM business areas functions such as Manufacturing often find they have many problems in common both in their applications suites and their IT infrastructures. LM business areas may have different manufacturing processes, different manufacturing process support business logic, and different metadata. However the evidence is that there is commonality in the scheduling, procurements, and human resources areas. There is also commonality in the need for information to be shared throughout the entire environment.

(3) Architecture Governance Framework

- The Architecture Governance Framework is recognized as another critical enabler of EA in LM.

  Governing Boards

  Information Architecture Board (IAB)

  Enterprise Architecture Board (EAB)

ARCHITECTURE
BLUEPRINT

Influence   Influences   Influences

BUSINESS
ARCHITECTURE
FRAMEWORK

TECHNOLOGY
ARCHITECTURE
FRAMEWORK

ARCHITECTURE GOVERNANCE FRAMEWORK

April 21, 2004
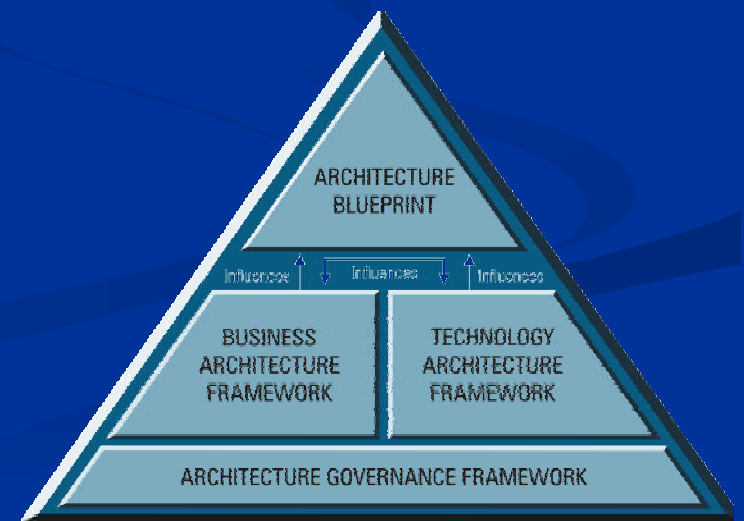
(4) Architecture Blueprint

- The Architecture Blueprint is recognized as another critical enabler of EA in LM.
  - Council of IT Architects
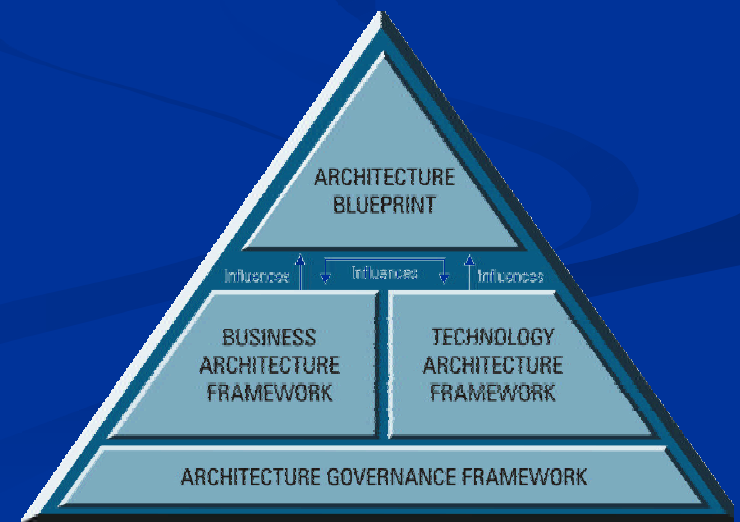
What We have Accomplished at LM

LM Complex IT Systems
The journey to Service Oriented Architecture

From → **To**

Stovepipe

Web Stovepipe

Interoperability

Fat App

Business Logic

Data

Browser

HTML

Web/App Server

Servlet/COM Components

Business Logic

Data

Fat App

Browser

Portal

PDA Phone

Web Server
App Server

Web Services

Wrapped
Servlet/COM
Components

Information Services

Business Logic

HTML/XML machine-consumer

machine-machine

XML

Web Server
App Server

Web Services

Servlet/COM
Components

Information Services

Business Logic

April 21, 2004

28

Where We Were

When project teams work under the assumption that they can do anything that they want, that they can use any technology that they want, chaos typically results. Functionality and information will be duplicated and reuse will occur sporadically if at all. Systems will not integrate well. Systems will conflict with one another and cause each other to fail. Costs will skyrocket because similar products from different vendors, or even simply different versions of the same product, will be purchased and then operated within production. Although each individual project may be very successful, as a portfolio they may have serious challenges.

It doesn't have to be this way!

CITA driving LM towards Enterprise Architecture

"AS-IS"

Business Vision and Mission

LM Aero	
LM Space	
LM TechServices	LM-EIS
LM IS&S	
LM Electronics Systems	
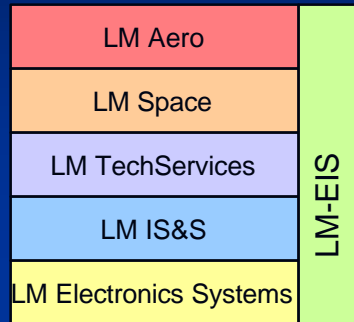
TRANSITION DURING TRANSFORMATION

(3-5 Year Planning Horizon)

- **Prelim** Framework and Principles
- **A** Architecture Vision
- **H** Architecture Change Management
- **B** Business Architecture
- **G** Implementation Governance
- **Requirements**
- **C** Information System Architectures
- **F** Migration Planning
- **E** Opportunities and Solutions
- **D** Technology Architecture

"TO-BE"

Business Target Environment

Business Vision => Technical Vision

Business Mission => Technical Mission

Business Deliverables => Technical Implementation

BUSINESS

Application

Technology

INFORMATION

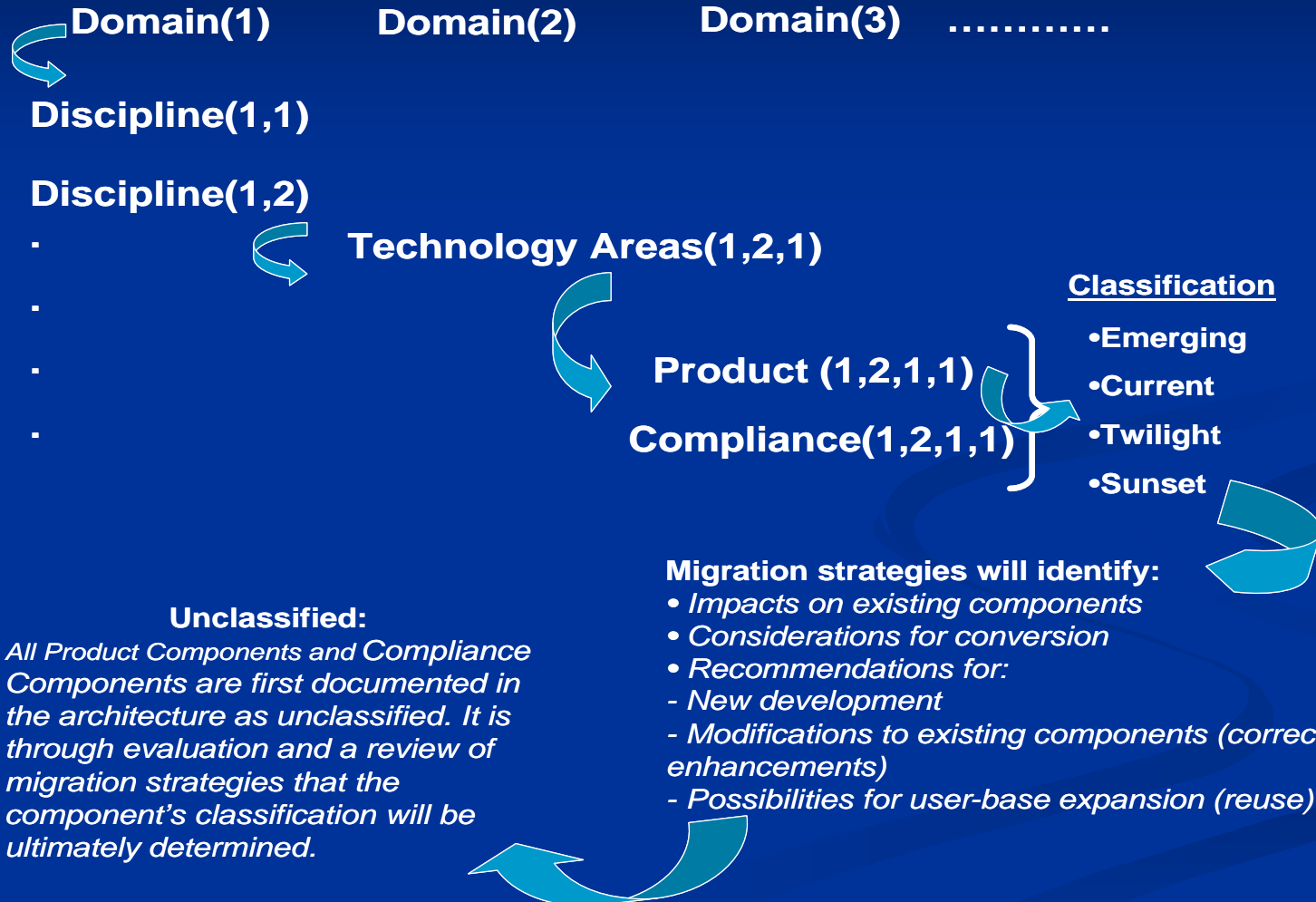# Methodology for Creating the EA from a Framework

Domain(1)   **Domain(2)**   **Domain(3)**   …………

Discipline(1,1)

Discipline(1,2)

·

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·

·

Technology Areas(1,2,1)

Product (1,2,1,1)

Compliance(1,2,1,1)

Classification
- •Emerging
- •Current
- •Twilight
- •Sunset

Unclassified:

All Product Components and Compliance Components are first documented in the architecture as unclassified. It is through evaluation and a review of migration strategies that the component's classification will be ultimately determined.

Migration strategies will identify:
- *Impacts on existing components*
- *Considerations for conversion*
- *Recommendations for:*
- *New development*
- *Modifications to existing components (corrections & enhancements)*
- *Possibilities for user-base expansion (reuse)*

Example

	Information
DOMAIN	
DISCIPLINE	**Data Management**
TECHNOLOGY AREA	*Relational Database* *Flat File Systems* *Desktop Database* *Data Models*
PRODUCT COMPONENT	*Oracle* *Sybase* *DB2* *ERWin* *Designer 2000*
COMPLIANCE COMPONENT	*Data Model Denotations-Crows feet* *Normalization* *Column Naming Standards*

Domain Template

Definition	
Name	
Description	
Rationale	
Benefits	

Boundary	
Boundary Limit Statement	

Current Status	
Provide the status of this discipline	___ Under Review ___ Rejected ___ Accepted

Associated Disciplines	
List Disciplines under this domain	

Related Principles		
Reference #'s, Statements, or Links	Conflict	Relationship

Related Best Practices		
Reference #'s, Statements, or Links	Conflict	Relationship

Related Trends		
Reference #'s, Statements, or Links	Conflict	Relationship

Contracts	
Planned Contracts	
Existing Contracts	

Audit Trail			
Creation Date		Date Accepted/Rejected	
Reason for Rejection			
Last date Updated		Last Date Reviewed	
Reason for Update			
Updated by			

LM EA and Strategic Planning

**Business Inputs &
Capability Gaps**
**(Expressed as need
by business areas)**

Business Vision

- Business Goal
- Business Capability
- Enterprise Requirement
- Bus. Area Interviews

- Trends Conference
- Previous Strategic Plans
- Enterprise State (As-Is)

Synthesis

Application
Infrastructure
Management
Security

- Data Acquisition
- Presentation
- Transformation
- Storage
- Communication

ITSP Strategy Matrix

- Strategy
- Strategy
- Strategy

Operating Plans

Funded Strategic Initiatives

Governance & Guidance

Tactical Initiatives

**Technology Inputs &
Capability Gaps**

Agile Information Model

Common Functional Taxonomy

Applying TOGAF to our Environment

- Step 1 – Assemble our own ADM-like document set (publish as a new set of Command Media)
- Step 2 – Assemble our own Enterprise Continuum
- Step 3 – Assemble our own Resource Base
- Step 4 – Iteratively leverage the results of steps 1-3 to cause continuous improvements and updates to all artifacts
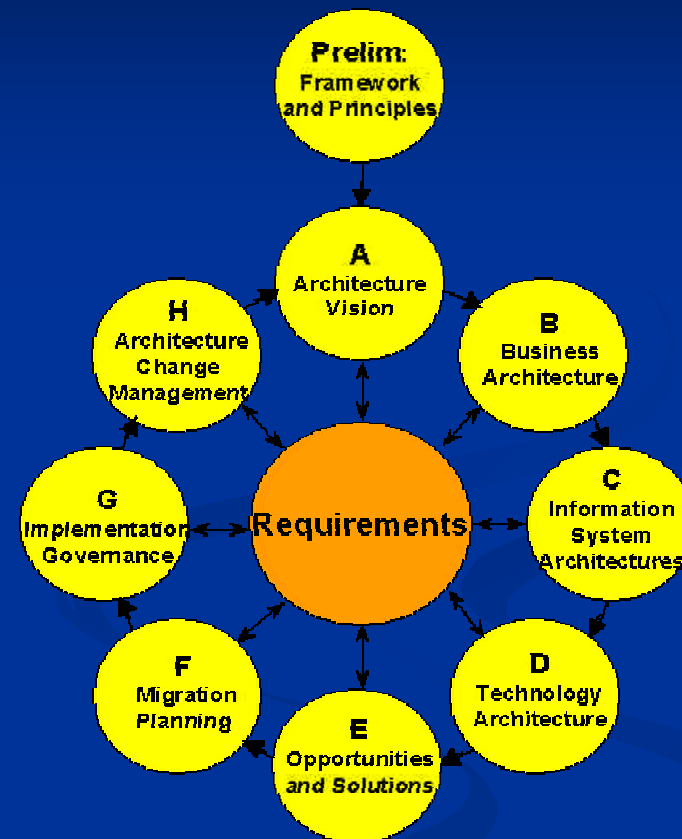
Applying TOGAF to our Environment

- **Step 1 – Develop our own ADM-like document set**
  - Drawing mostly from ITAF Volumes 0, 2, 3 publish a new Command Media series, the Enterprise Architecture Manual (EAM)
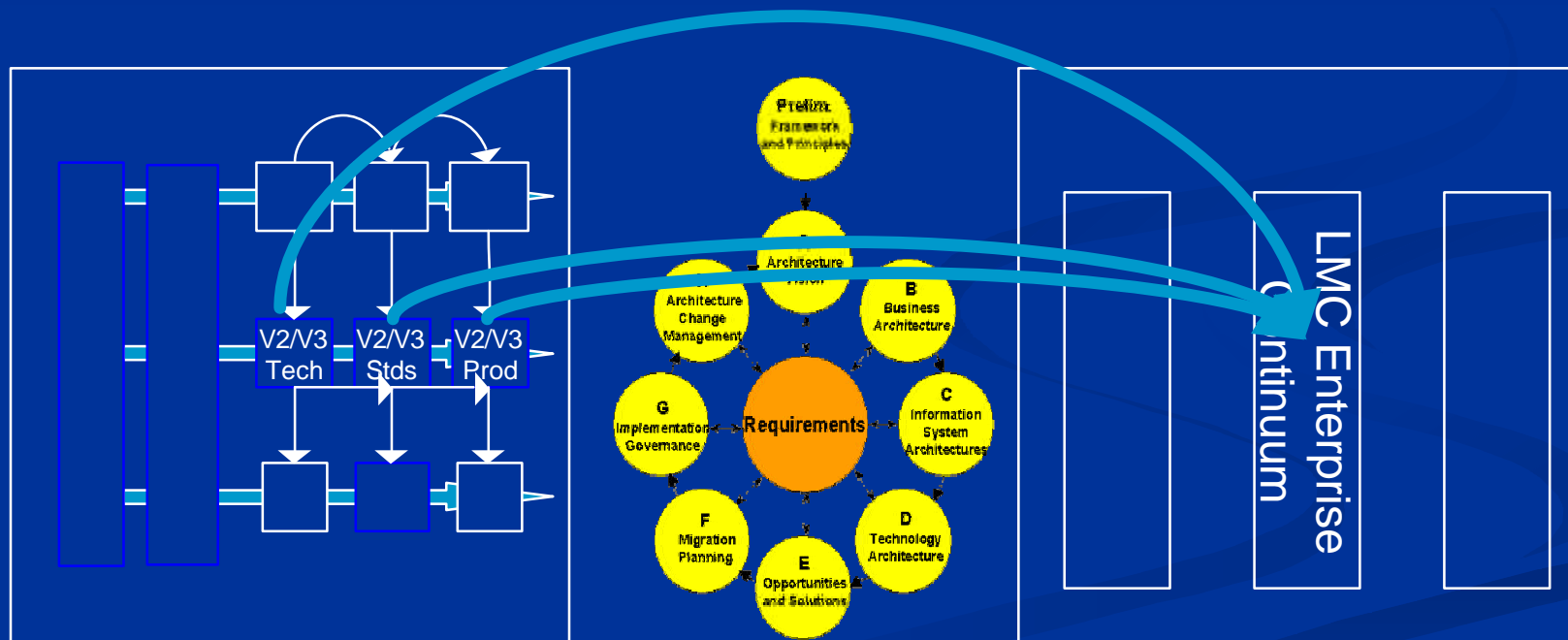 - Also include the ITODs as Command Media
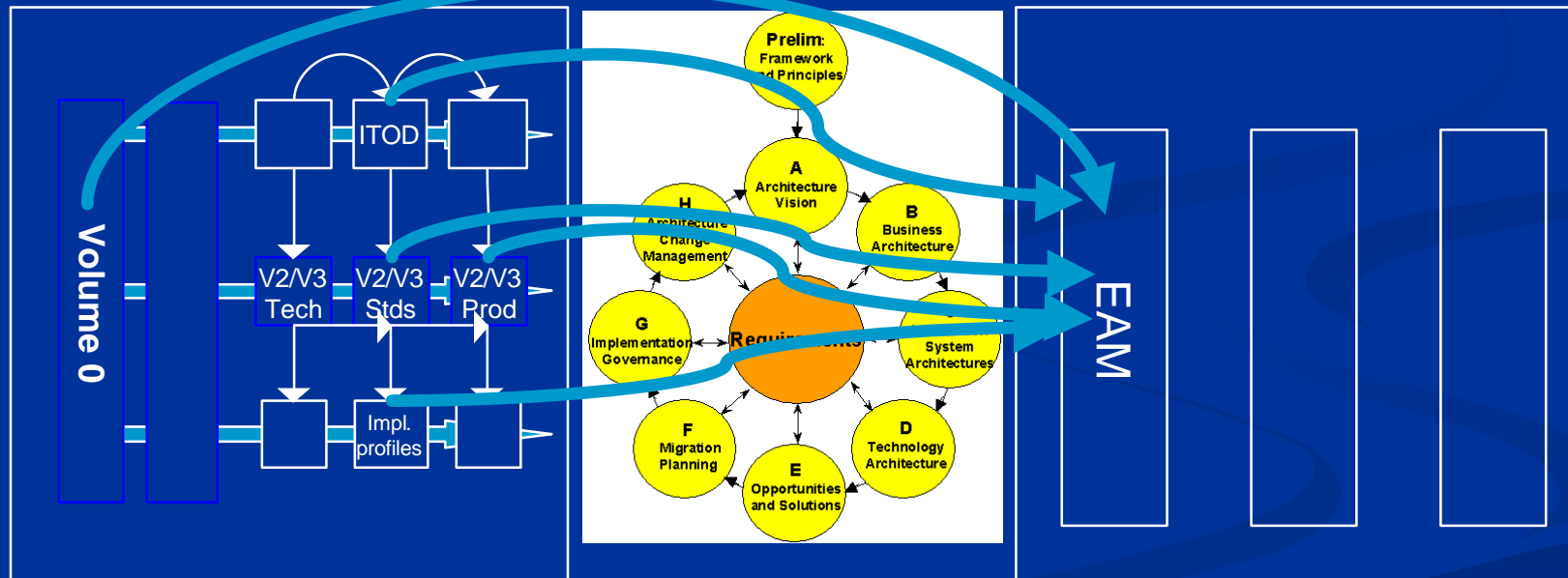
The EAM will include the ITOD's and formalize actionable elements of the ITAF

Applying TOGAF to our Environment (continued)

Step 2 – Assemble our own Enterprise Continuum

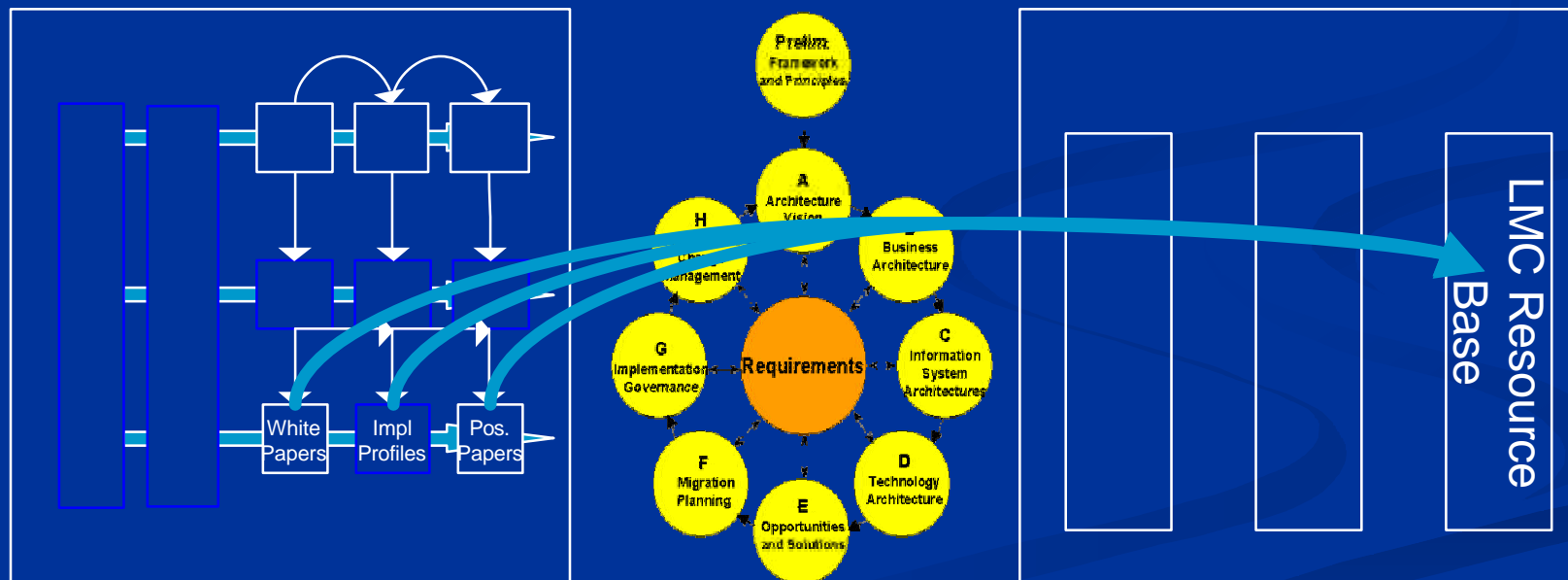- The current ITAF will remain intact as part of the Lockheed Martin Enterprise Continuum

The ITAF and its architectural evolution will make up the Enterprise Continuum

Applying TOGAF to our Environment (continued)

Step 3 – Assemble our own Resource Base

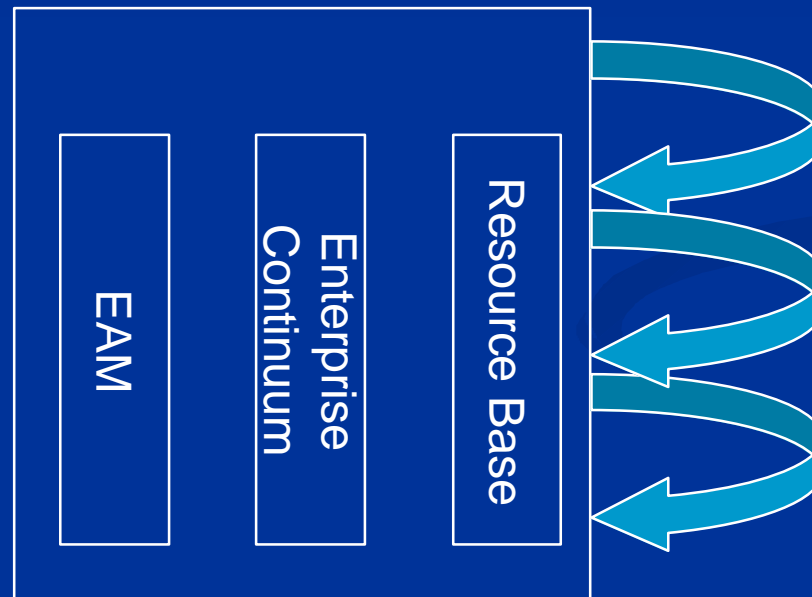- Pull from our extensive base of white papers, position papers, and so on

Leverage our Extensive Architectural Assets
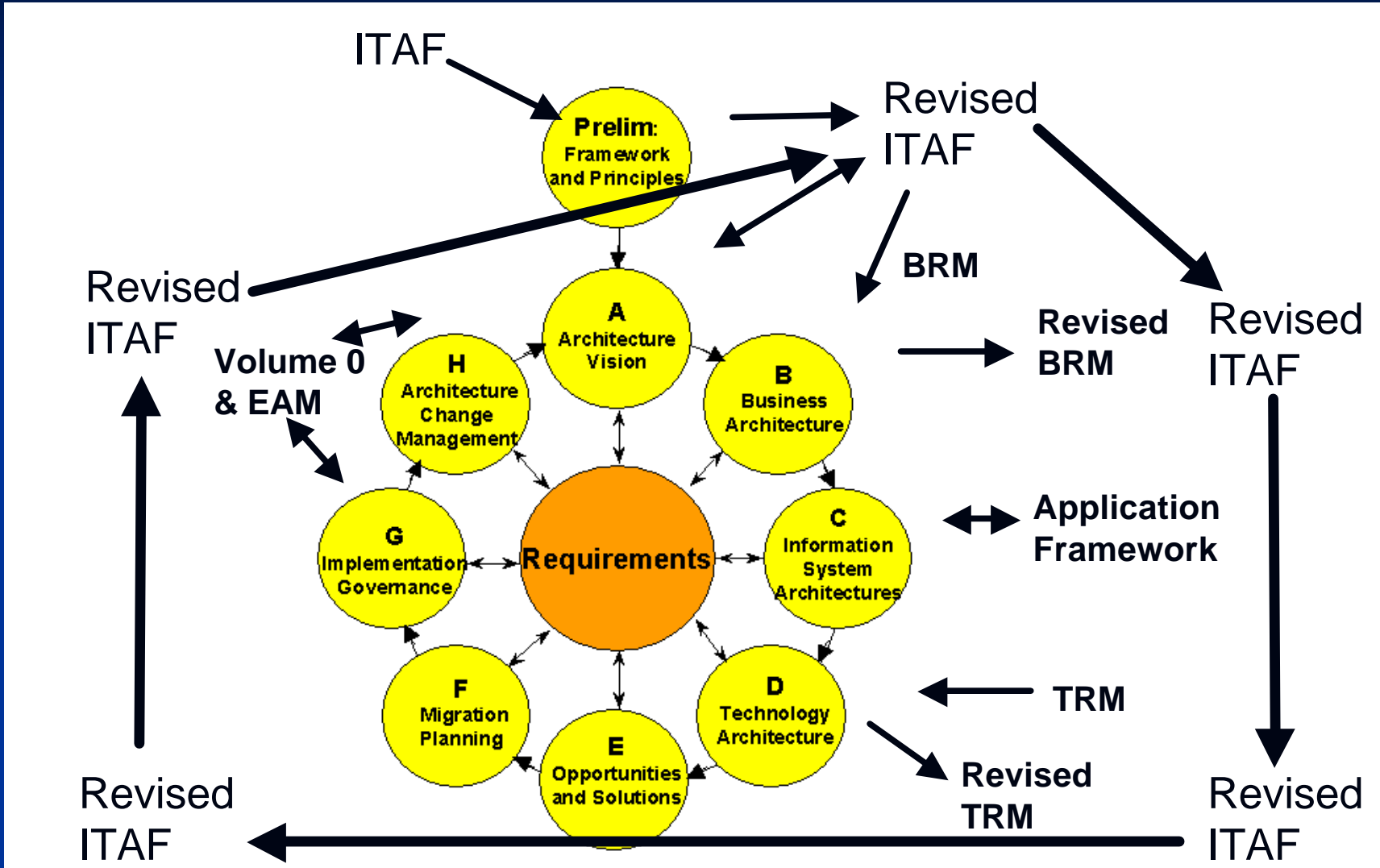
Applying TOGAF to our Environment (continued)

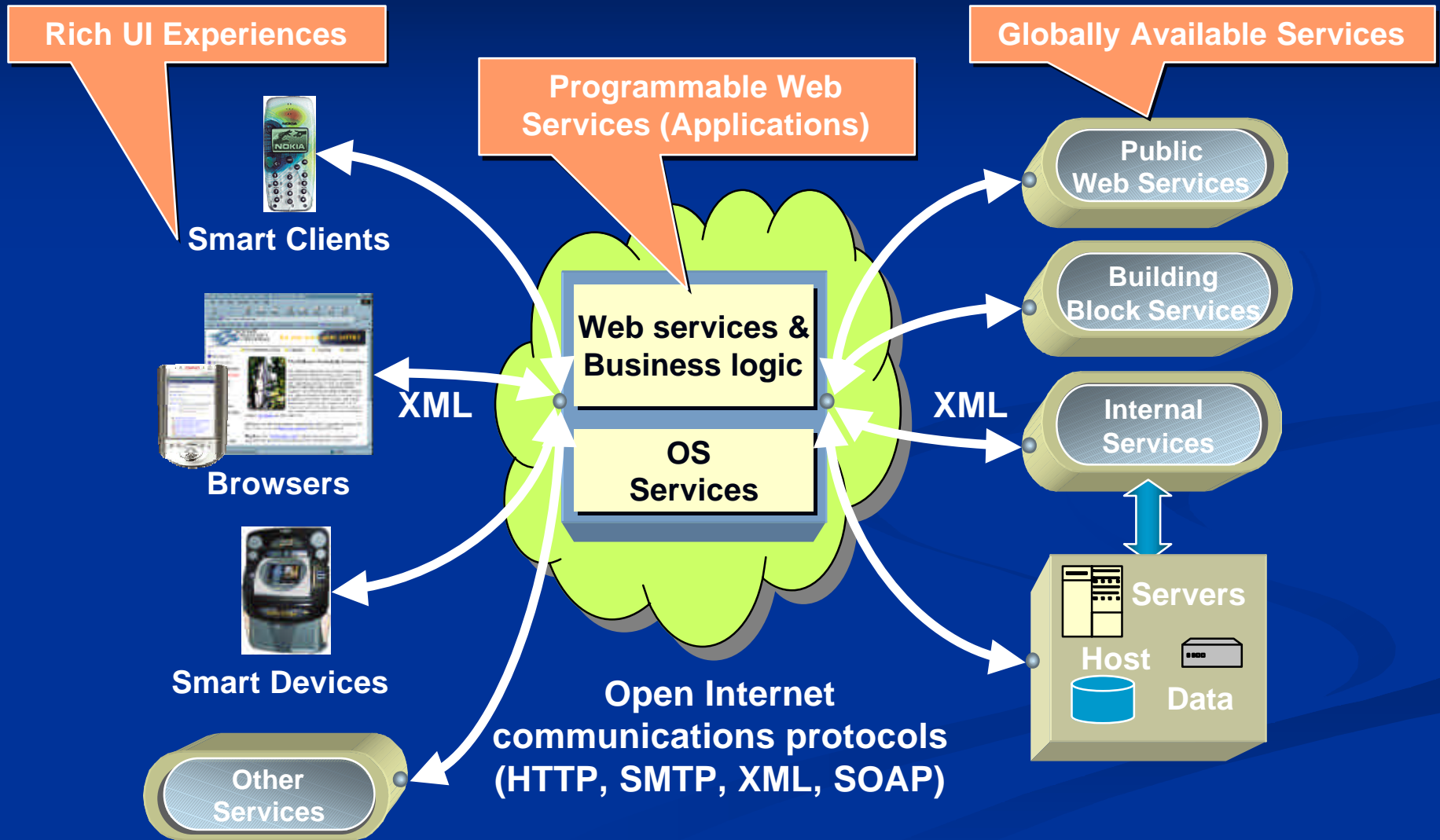Step 4 – Iteratively leverage the EAM to cause continuous improvements and updates to all artifacts

The processes embedded in the EAM ensure continuous feedback

The ITAF maps into and is revised by several stages of the ADM

Target Landscape

Rich UI Experiences

Globally Available Services

Programmable Web Services (Applications)

Smart Clients

Browsers

XML

Web services & Business logic

OS Services

Public Web Services

Building Block Services

Internal Services

XML

Servers

Host

Data

Smart Devices

Other Services

Open Internet communications protocols (HTTP, SMTP, XML, SOAP)

What we have Accomplished

- Initiatives based on near term deliverables
- Integrated EA with ITIL principles
- Use of TOGAF/EA methods in initiatives
  - Next Generation Networks
  - SSO based on PKI/Kerb/AD/SAML
  - Engineering Application Integration including Value Chain (PDM-SAP)

LM EA Best Practices

- Build a sense of urgency

- Build a strong executive sponsorship

- Build a strong dynamic team

- Ensure a strong IT and business skill set representation

- Develop a good understanding of the Business Drivers, and form a vision

- Communicate the vision and the process

- Empower others to act on the vision

- Plan for and create short-term wins

- Establish a framework and a methodology

LM realizes EA Alone is Not Enough!

Enterprise Architecture   +   **Change Management**   +   **Governance**

Each EA is different, reflecting the unique characteristics of the organization and its goals. EA's at the minimum should have three major components: the "As-Is," or baseline, architecture, which captures the organization's current architecture; the "To-Be," or target, architecture, which describes the organization's desired architecture for achieving strategic goals; and a "transition plan", which uses a phased approach to get from "As- Is" to "To-Be." An organization must also have a structured process for managing change to its EA, which needs to change as the organization changes—in a continuous process.

It's a well-known fact that people *don't like change*— they fear the unknown, fear losing control, worry that their jobs may change or go away. Change management—a critical component of any modernization program—involves communication, consensus building, developing new practices, training, working with contractors, and more.

The act of affecting through policy the long-term strategy and direction of an organization. In general, governance comprises the traditions, institutions and processes that determine how power is exercised, how employees are given a voice, and how decisions are made on issues of concern

Commit to ITIL !

Summary

Enterprise Architecture in LM is a business driven initiative where the goal is to manage future IT investments in a holistic sense that continuously aligns our IT investments with business goals.

Successful Enterprise Architecture at LM requires significant coordination, active company-wide participation, and a constant demonstration of value-based results. LM is planning to leverage EA to deliver a consistent view of strategic intent so that as EA evolves and the scope of the architecture is broadened, enabling services are harnessed for greater leverage across the enterprise. The EA is recognized as a foundational component for effectively managing enterprise change.

An Enterprise Architect knows he has achieved the perfect solution not when there is nothing left to add, but when there is, nothing left to take away.

[Saint-Exupery]
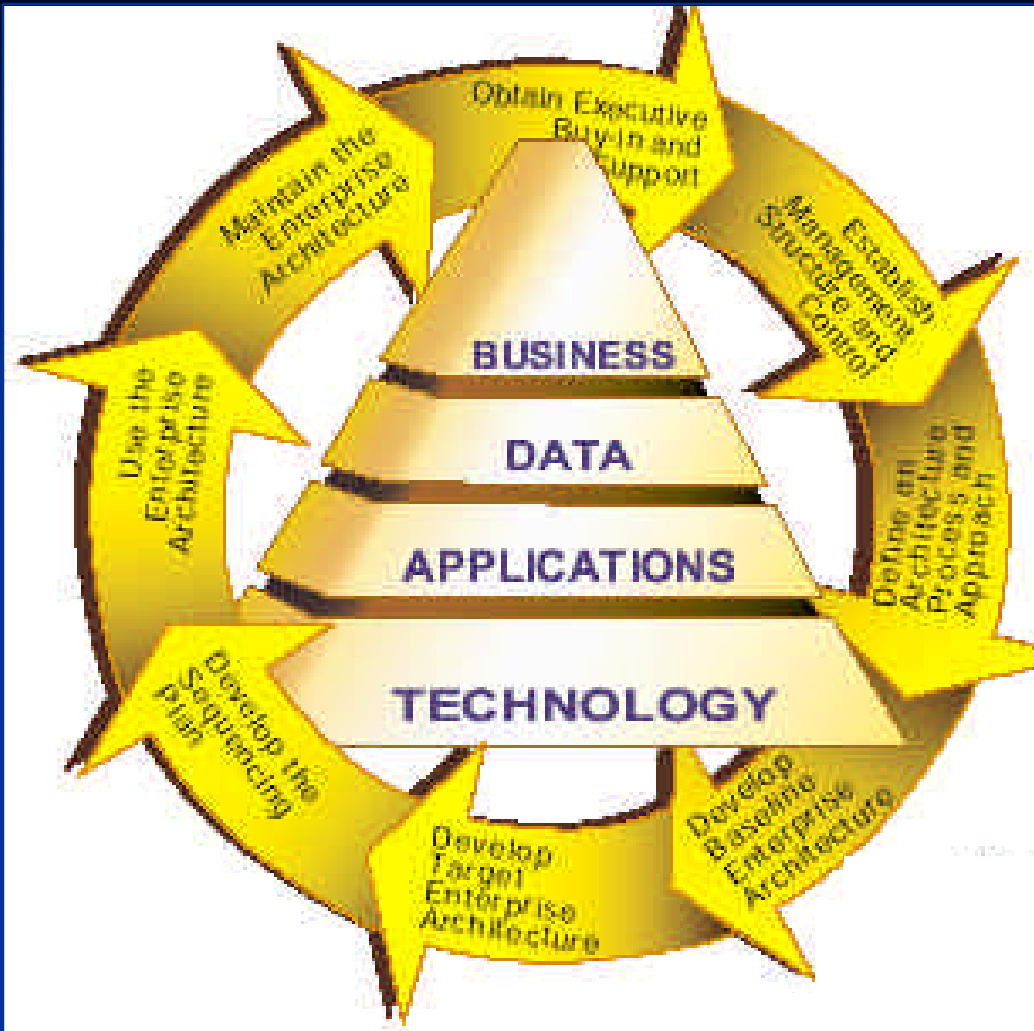
Creating an enterprise architecture requires participation from many areas of the organization and a great deal of communication to plan and implement each stage of the process. The result is a detailed plan or "roadmap" that guides an organization through the modernization process and enables it to achieve its goals.

Enterprise Architecture serves as a blueprint for a company's most critical business processes. It leverages IT as a key catalyst for LM Enterprise Modernization.

Optimizing the Supply Chain

Supplier → **Transportation** → **Dist Centers** → **Customer**

Information Visibility is Key!
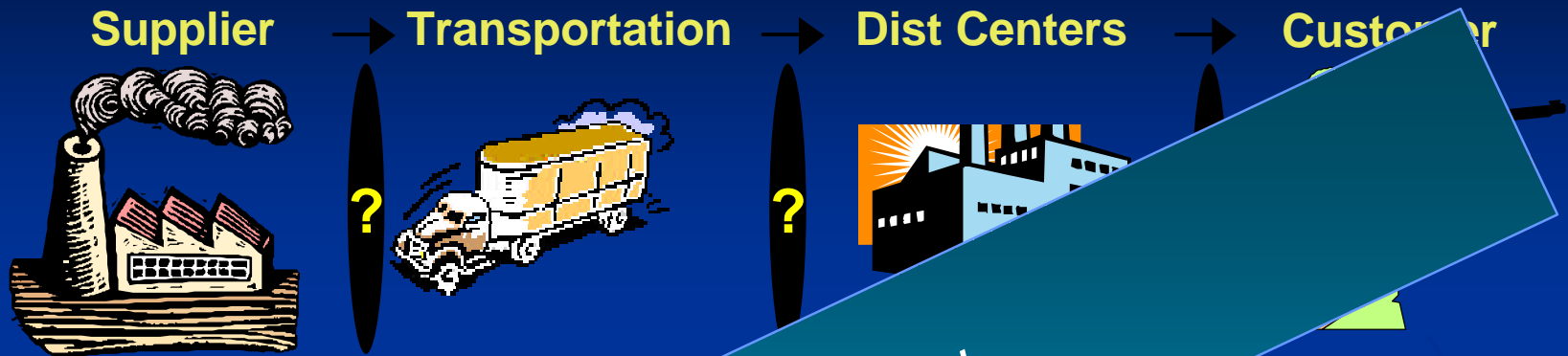
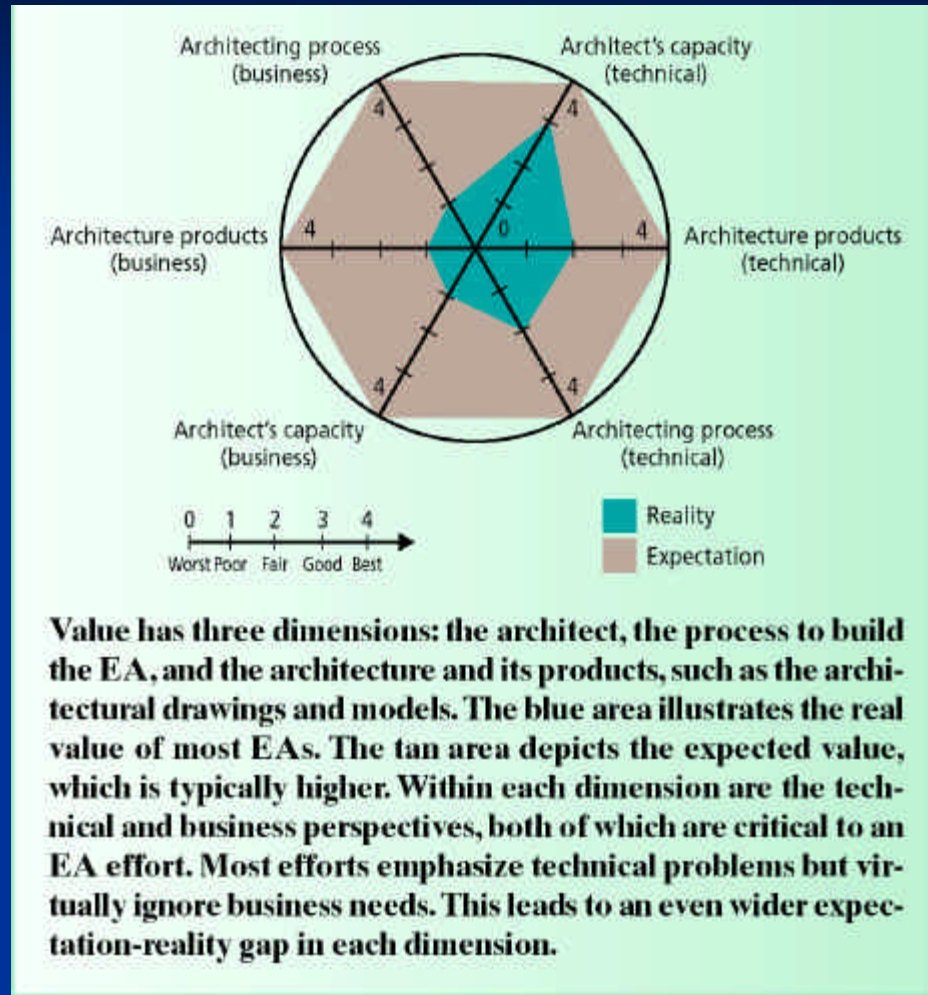|	Supplier	Transportation	Dist Centers	Customer
Current	•Limited information on when shipments/~~leave~~	...receipts ...and costly ...ght claims process		•Limited visibility to customer's support activity
W...	...will track ...ateriel shipments from suppliers	•RFID will track materiel at carrier terminals •RFID will streamline receiving/check-in process		•RFID will track materiel in-transit to customer •RFID will provide visibility at customer's support activity

DOD RFID Policy, Alan Estevez December 2003

How we Measure the Value of EA

WHAT IS VALUE?

We can sum up an EA effort in this broad statement: An architect follows some process and produces some architecture. From this, we see that an EA effort has three value contexts, or dimensions: architect, process, and the final products—the architecture itself and related products, such as the architectural drawings and models.

Value has three dimensions: the architect, the process to build the EA, and the architecture and its products, such as the architectural drawings and models. The blue area illustrates the real value of most EAs. The tan area depicts the expected value, which is typically higher. Within each dimension are the technical and business perspectives, both of which are critical to an EA effort. Most efforts emphasize technical problems but virtually ignore business needs. This leads to an even wider expectation-reality gap in each dimension.

The Business-Technology Partnership venture will assure success!

EA is Blueprint

There are toolsets available to assist but we still have to locate/gather the information

<u>Toolsets Under Consideration</u>
Popkin/EA Tool v8.x
BP Trends/Casewise Modeler 9
Metis/ EA Tool 3.2.3
Troux/v.3.0
Adaptive
Volere

There are several commercial tools that collect information about the enterprise IT environment, and organize them as if creating a blueprint and categorizing the information.

This categorization organizes and classifies all IT components from infrastructure to applications intelligently discovering the relationships and dependencies across all levels of our IT environment. These tools assist users in keeping track of changes and keeping the blueprints up-to-date.