# NDIA 10th Annual Systems Engineering Conference

*Reducing Acquisition Costs Through Incremental Migration to SOA*
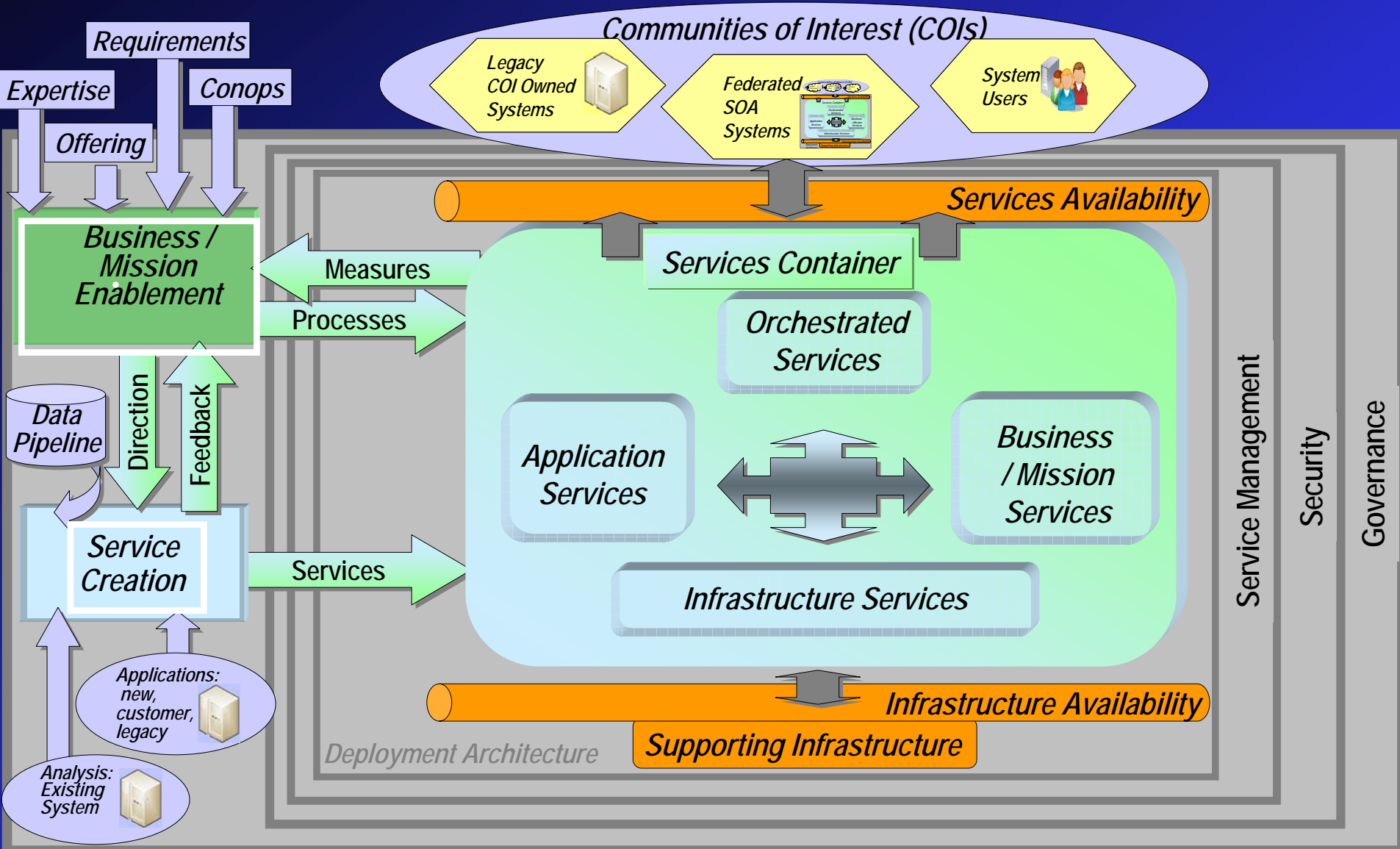
**Presented by
Tim Greer
Lockheed Martin Corporation
25 October 2007**

**LOCKHEED MARTIN**

- Overview of Service Oriented Architecture (SOA)

    – Common Reference Architecture

- Methods of migrating from System of Systems PORs to SOA

- Program acquisition costs for migration of POR's to SOA

- Mitigation of acquisition costs

- Program Examples

    – Global Combat Support System – Air Force (GCSS-AF)
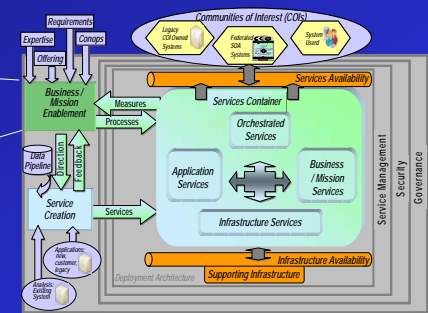
    – An Army Program

# Common Reference Architecture

**Communities of Interest (COIs)**

Legacy COI Owned Systems

Federated SOA Systems

System Users

Requirements

Expertise

Conops

Offering

Services Availability

Business / Mission Enablement

Measures

Processes

Services Container

Orchestrated Services

Data Pipeline

Direction

Feedback

Application Services

Business / Mission Services

Service Creation

Services

Infrastructure Services

Applications: new, customer, legacy

Analysis: Existing System

Deployment Architecture

Infrastructure Availability

Supporting Infrastructure

Service Management

Security

Governance

# Business / Mission Enablement



Business / Mission Enablement

- Business or Mission Enablement Element – Supports the definition, modeling, and analysis of services and service-oriented architectures that meet the business / mission needs

- This element of the architecture will be updated as the SOA is in use to optimize the performance of the services for accomplishment of a desired mission

- As new services come online the system will continuously be redesigned to take advantage of the latest technologies being employed.

Service Creation
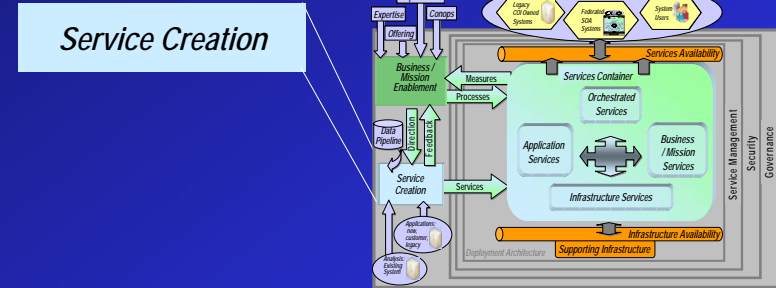
- Service Creation Element - Service creation encompasses the engineering tasks required to develop a new service, incorporate an existing service, or to convert a legacy application into a service

# Services Container

- Services Container Element - Assembly of services based on business / mission enablement processes and supported by an infrastructure framework. Various combinations of services, business logic, and workflow are combined to provide service availability to the COIs



*Services Container*

# Infrastructure Services
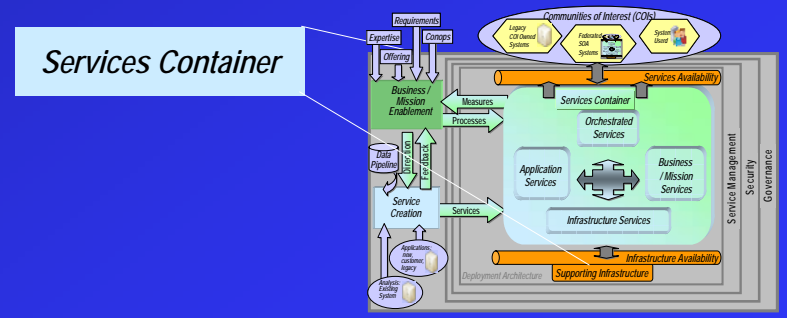
*Infrastructure Services*
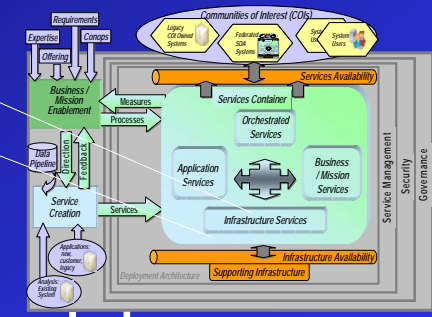
- Infrastructure Services - The basic, underlying services that enable the accessibility, interactions, communications, and runtime operations of a SOA
  - Security
  - Mediation
  - Service Management
  - Information Delivery
  - Discovery
  - Data Management

# Supporting Infrastructure

- Supporting Infrastructure - Products and technologies used in the storing, transmitting and utilizing of information that supports the runtime operations of a SOA
  - Service Bus
  - Registry
  - Repository
  - System Management
  - BPEL Engine
  - Collaboration
  - Application Services
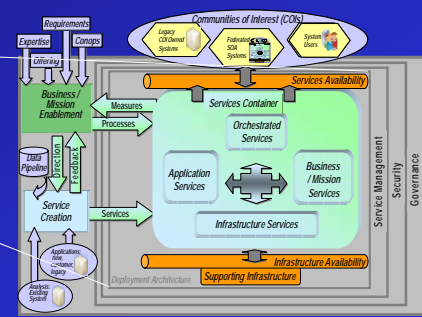  - Web Support
  - Transport
  - Storage



*Supporting Infrastructure*
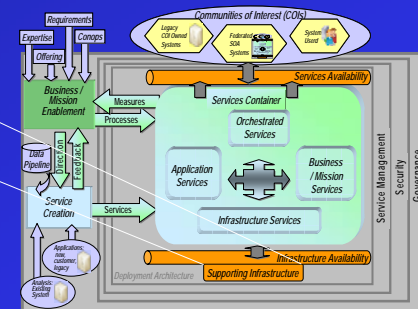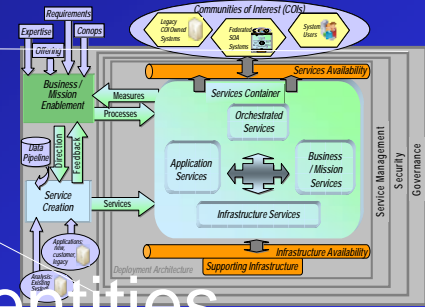
# Service Management



Service Management

- ## Service Management - Configuring, monitoring, maintaining and managing of services and the service infrastructure

  – Business Activity & Event Monitoring

  – Fault Management

  – Configuration Management

  – Service Level Agreement Management

  – Performance Management

# Security



- Security – Mechanisms which protect entities within the SOA environment, including consumer, provider, services and  information; and, additionally provide interface between security services from different enterprises

  – Policy Management

  – Assured Information Sharing

  – Availability

  – Network Defense

# Governance

- Governance - Collection and enforcement of policies which the enterprise, services, and data owners must abide by to guarantee success at all tiers of the SOA

  – Design and development practices

  – Technology selection

  – Policy management

  – Contract management

  – Configuration management

  – Release management

  – Runtime management

  – Problem management
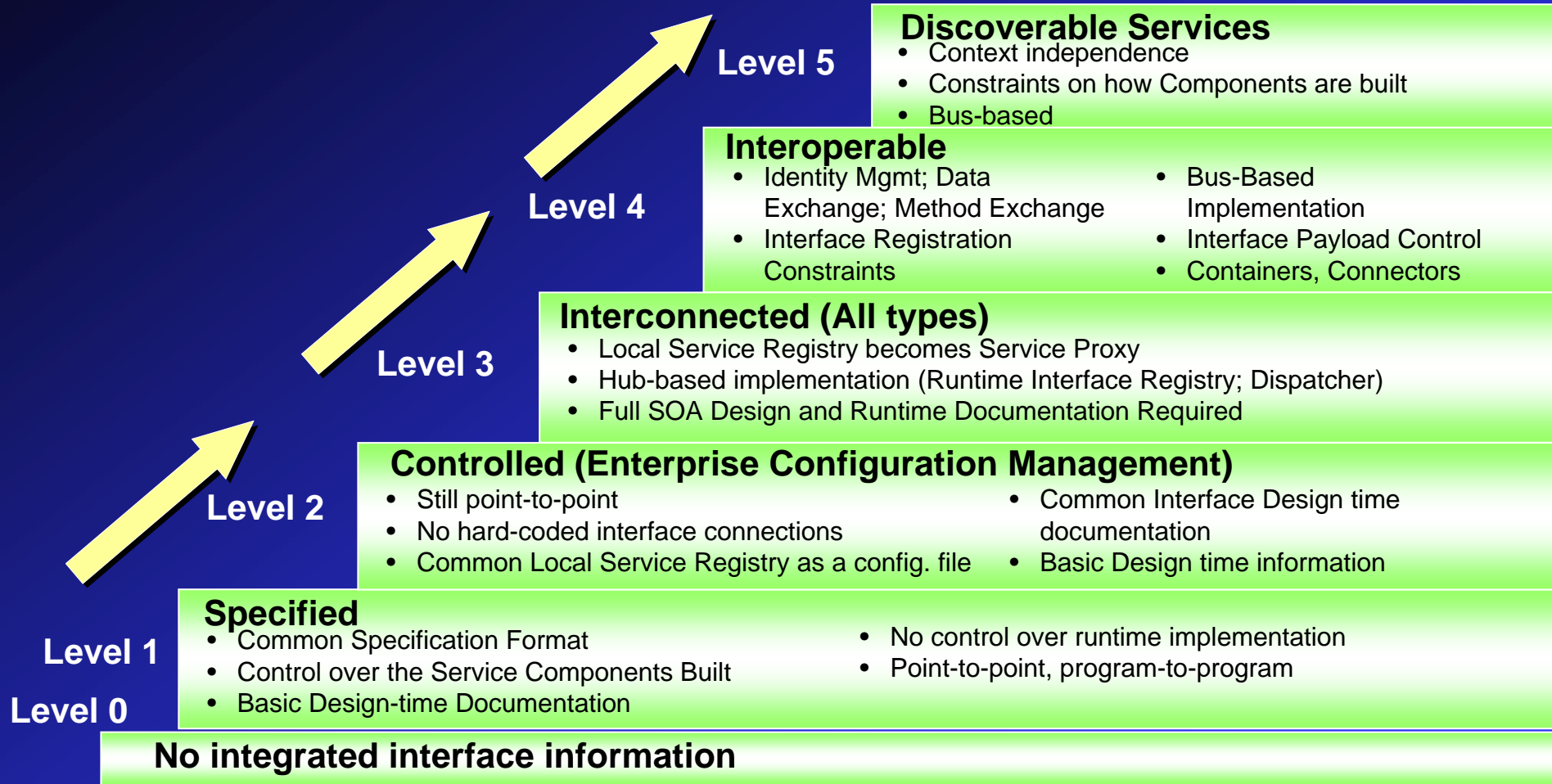
  – Change management

# Migration Methods
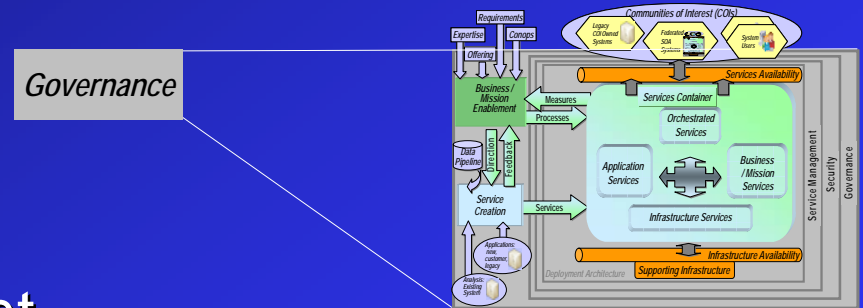
- Build Infrastructure – Leave POR in Place

- Build some infrastructure for new services – wrappers on non-SOA components

- Build services for certain components – add infrastructure later

- Wait until infrastructure is in place – build services that work

LOCKHEED MARTIN

**Level 5**

**Discoverable Services**
- Context independence
- Constraints on how Components are built
- Bus-based

**Level 4**

**Interoperable**
- Identity Mgmt; Data Exchange; Method Exchange
- Interface Registration Constraints
- Bus-Based Implementation
- Interface Payload Control
- Containers, Connectors

**Level 3**

**Interconnected (All types)**
- Local Service Registry becomes Service Proxy
- Hub-based implementation (Runtime Interface Registry; Dispatcher)
- Full SOA Design and Runtime Documentation Required

**Level 2**

**Controlled (Enterprise Configuration Management)**
- Still point-to-point
- No hard-coded interface connections
- Common Local Service Registry as a config. file
- Common Interface Design time documentation
- Basic Design time information

**Level 1**

**Specified**
- Common Specification Format
- Control over the Service Components Built
- Basic Design-time Documentation
- No control over runtime implementation
- Point-to-point, program-to-program
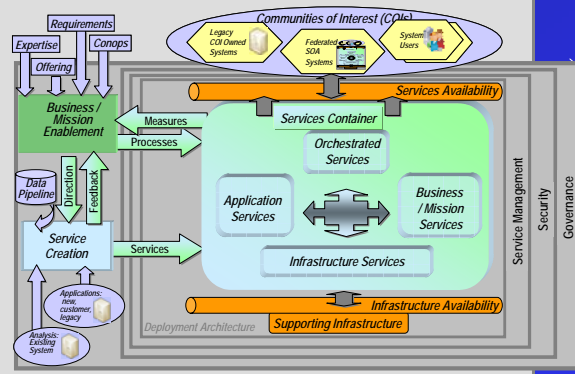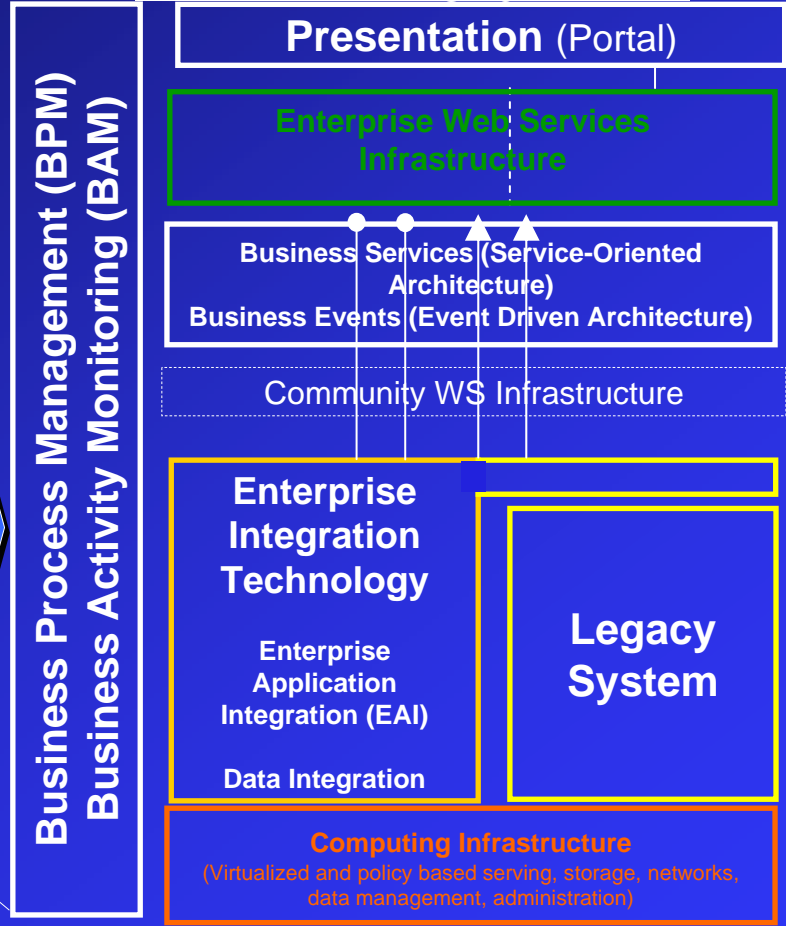
**Level 0**

**No integrated interface information**

- *Integration is a set of enterprise characteristics*
- *These characteristics are additive: Level 5 integration contains Level 4; Level 4 contains Level 3; …*

# Transformation Use Case: Legacy System Enterprise Application Integration

- How does one integrate legacy applications and data?
  - For purposes of this use case assume the following:
    - *Current Enterprise State that is at Level 2 or below on the LLI Continuum*
    - *Program centric Domain expertise & huge legacy portfolio (S/W development)*
    - *Multiple SOA systems; not stovepipe -> reuse opportunity, maturity models, guidelines*
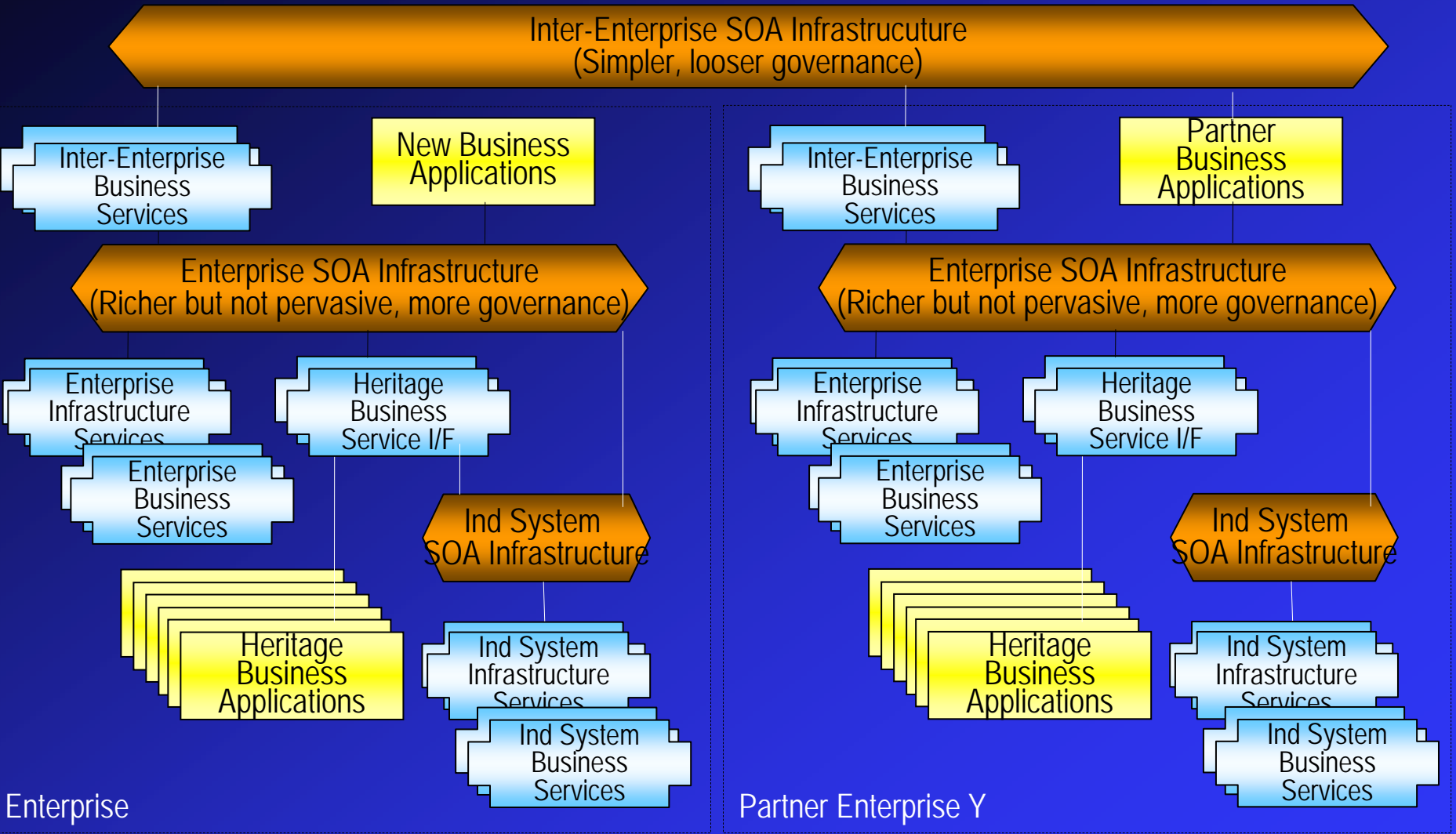  - Apply integration strategies to system components that meet the criteria

## SOA End State *(Legacy-Focused)*

**Business Process Management (BPM)**
**Business Activity Monitoring (BAM)**

**Presentation** (Portal)

**Enterprise Web Services Infrastructure**

**Business Services (Service-Oriented Architecture)**
**Business Events (Event Driven Architecture)**

Community WS Infrastructure

**Enterprise Integration Technology**

**Enterprise Application Integration (EAI)**

**Data Integration**

**Legacy System**

**Computing Infrastructure**
(Virtualized and policy based serving, storage, networks, data management, administration)

# SOA implemented at multiple tiers

**Inter-Enterprise SOA Infrastructure**
(Simpler, looser governance)

## Enterprise

**Inter-Enterprise Business Services**

**New Business Applications**

**Enterprise SOA Infrastructure**
(Richer but not pervasive, more governance)

**Enterprise Infrastructure Services**

**Enterprise Business Services**

**Heritage Business Service I/F**

**Ind System SOA Infrastructure**

**Heritage Business Applications**

**Ind System Infrastructure Services**

**Ind System Business Services**

## Partner Enterprise Y

**Inter-Enterprise Business Services**

**Partner Business Applications**

**Enterprise SOA Infrastructure**
(Richer but not pervasive, more governance)

**Enterprise Infrastructure Services**

**Enterprise Business Services**

**Heritage Business Service I/F**

**Ind System SOA Infrastructure**

**Heritage Business Applications**

**Ind System Infrastructure Services**

**Ind System Business Services**

## *Multiple Tiers allow incremental SOA advancement*

# Software Cost Drivers for Legacy System Migration

- Operating Systems – upgrades, licensing fees

- COTS Products – licensing fees, maintenance contracts

- DBMS – licensing fees, maintenance contracts

- GOTS Products – upgrade schedule – POM Cycle

- New Development – POM Cycle, JCIDS

- SOA Infrastructure Development

# Mitigation of Software Costs

- **Operating Systems – Upgrades, Licensing Fees**
    - Consolidation on fewer OS's
- **COTS Products – Licensing Fees, Maintenance Contracts**
    - Enterprise licensing
- **DBMS – Licensing Fees, Maintenance Contracts**
    - Data Access Service => Reduce DBMS's
- **GOTS Products – Upgrade Schedule – POM Cycle**
    - Wrappers Standardize Interfaces
- **New Development – New Requirements, JCIDS Process**
    - New WS reduce deployment cycle time – Portal may address reqmnts
- **SOA Infrastructure Development**
    - Tiered architecture reduces initial investment

# Program Examples

- The following examples show the degree to which the principles discussed thus far have been implemented and how effective these efforts have been to date

  – Global Combat Support System – Air Force (GCSS-AF) – SOA migration project was initiated in 2003

  – An Army Program – Migrating to SOA and scheduled to deploy to Iraq in 2009.

# GCSS-AF

**https://www.gcss-af.com/cfs/outreach/index.cfm**

# GCSS-AF SOA Journey

| Stage Name | Business Silos | Standardized Technology | Optimized Core | Business Modularity |
|---|---|---|---|---|
| IT Capability | Local IT Applications | Shared Technical Platforms | Enterprise-wide Hardwired Processes and Data | Plug and Play Business Process Modules |
| Business Objectives | ROI of Local Business Objectives | Reduced IT Costs | Cost and Quality of Business Operations | Speed to Market and Strategic Agility |
| Funding | Individual Applications | Shared Infrastructure Services | Enterprise Applications and Data Stores | Reusable Business Process Components |
| Key Management Capability | Technology-Enabled Change Management | Design and Update of Standards; Funding Shared Services | Core Enterprise Process Definition and Measurement | Management of Reusable Business Processes |
| Who Defines Applications | Local Business Leaders | IT and Business Unit Leaders | Senior Management and Process Leaders | IT, Business and Industry Leaders |
| Key IT Governance Issues | Measure and Communicate Value | Global Responsibilities | Align Project Priorities with Architecture Objectives | Define, Source and Fund Business Modules |

Source: Architecture as Strategy by Ross, Weill, Robertson, HBS Press, June 2006

**https://www.gcss-af.com/noosphere/space/SOA+Journey**

Web Page by John Wunder, Lockheed Martin Corporation Copyright 2007

- ROI is sub-optimized to within program, unit, lifecycle boundaries. Interfaces optimized to specific method needs reducing by bytes size of message while proliferating protocols leading to hundreds of different interfaces on dozens of protocols burdening source systems interface code that is over 70% of their function, causing exceedingly high operations cost and setting up a closely coupled brittle structure that is exceeding expensive to move forward. Each phase of the lifecycle optimizes for itself. Shorter delivery schedules or cheaper product costs are not considered in relation downstream impacts

# Reduced IT Costs:

- Commoditization of IT Infrastructure Enterprise licenses for software and hardware. Reduced O&S cost through common infrastructure. Reduced assembly cost through eliminating '*botique engineering*'

# Cost & Quality of Business Operations:

- BEA (DoD Business Enterprise Architecture) eLog21 and other like minded functional initiatives focused on mission processes, people and information and measured success not in lines of code, deliveries or response time but rather in mission effectivenes and asset status, particularly aircraft.

# Strategic Agility:

- Velocity, Velocity, Velocity was our mantra. It allowed us to make and correct mistakes faster and with the built in feedback we had we consistently moved forward. Have not reached the Chief's vision of changing information flows in hours and days but it is on the horizon.

# Individual Applications:

- We were going to modernize all applications and every modernization was a separate program. 'Silver bullet' approaches program by program. Specific examples were:

    - 1. GOLD for IMDS and SBSS

    - 2. Teradata for FIRST

    - 3. AF Portal for OLVIMS

    - 4. J2EE for CAS

    - 5. Homegrown Portal

# Shared Infrastructure Services:

- Key here is consistency and communication. Industry and the customer will evolve toward a common definition of the services you provide. You need to have a communication plan that is adaptive enough to adjust but managed enough that there is agreement as to context, content and use of the services you provide. Agreement is way more important than having the right definition. It is way too easy to fall into '*analysis paralysis*' trying to define the essential services. It is way better to evolve a service oriented organization that is always providing better services.

# Enterprise Applications & Data Stores:

- Major portfolios aligned and individual initiatives were terminated. Whole communities like A4/7 (Old Installations and Logistics) went on bare bones sustainment of legacy systems to free funds for Expeditionary Combat Support Systems. Rigorous funding tied to effect producing capabilities is managed through a hierarchical portfolio process culminating in the Senior Working Group (SWG) which meets once a month with the SecAF and reports status.

# Another DoD Program Migrating to SOA

# SOA Goals

- **Integrated Portal**
  - Create an integrated Portal available to both internal and external users
  - Portal presents both domain-specific and multi-domain JSR 168 compliant portlets
    - JSR 168 promotes capability of using portlets in different Portal frameworks
- **Integrated Data Access**
  - Develop single multi-domain search interface compliant with NCES Content Discovery and DDMS
    - Establishes architecture for integration of NCES compliant data sources and integration of DCGS-A nodes into larger enterprise searches
- **Introduction of SOA Infrastructure Toolset**
  - Commercial Enterprise Service Bus (ESB) used to realize Multi-INT objectives though content-based routing and orchestration of domain services using BPEL 1.1 compliant workflow
    - BPEL compliance promotes capability of porting workflow to different workflow engines
  - Use of UDDI compliant service repository
    - UDDI Repository wrapped in NCES defined services to abstract complexities of UDDI and promote portability to different repository implementations
- **Establishment of SOA Governance Procedures**
  - Government and industry jointly own process for specification and validation of service interface standards
- **Implementation of a Layered DIB Compliant Architecture**
  - User Facing Layer – Portal and Desktop Visualization Framework (MFWS/VIPER)
  - Processing Layer – Service Orchestration
  - Data Layer – Publication of Metadata to DIB MDC for inter-service DCGS interoperability
  - Core Layer – SOA security model based on NCES Security Services

# Multi-Tier Architecture

## USER FACING

PORTAL FRAMEWORT

CLIENT FRAMEWORK

STAND ALONE CLIENTS

## DOMAIN COMPONENTS

DOMAIN ORCHESTRATION

DOMAIN WEB SERVICES

LEGACY APPS

## CROSS DOMAIN COMPONENTS

CROSS DOMAIN ORCHESTRATION

CROSS DOMAIN WEB SERVICES

## DATA ACCESS COMPONENTS

METADATA FRAMEWORK

DATA ACCESS WEB SERVICES

LEGACY DATA ACCESS COMPONENTS
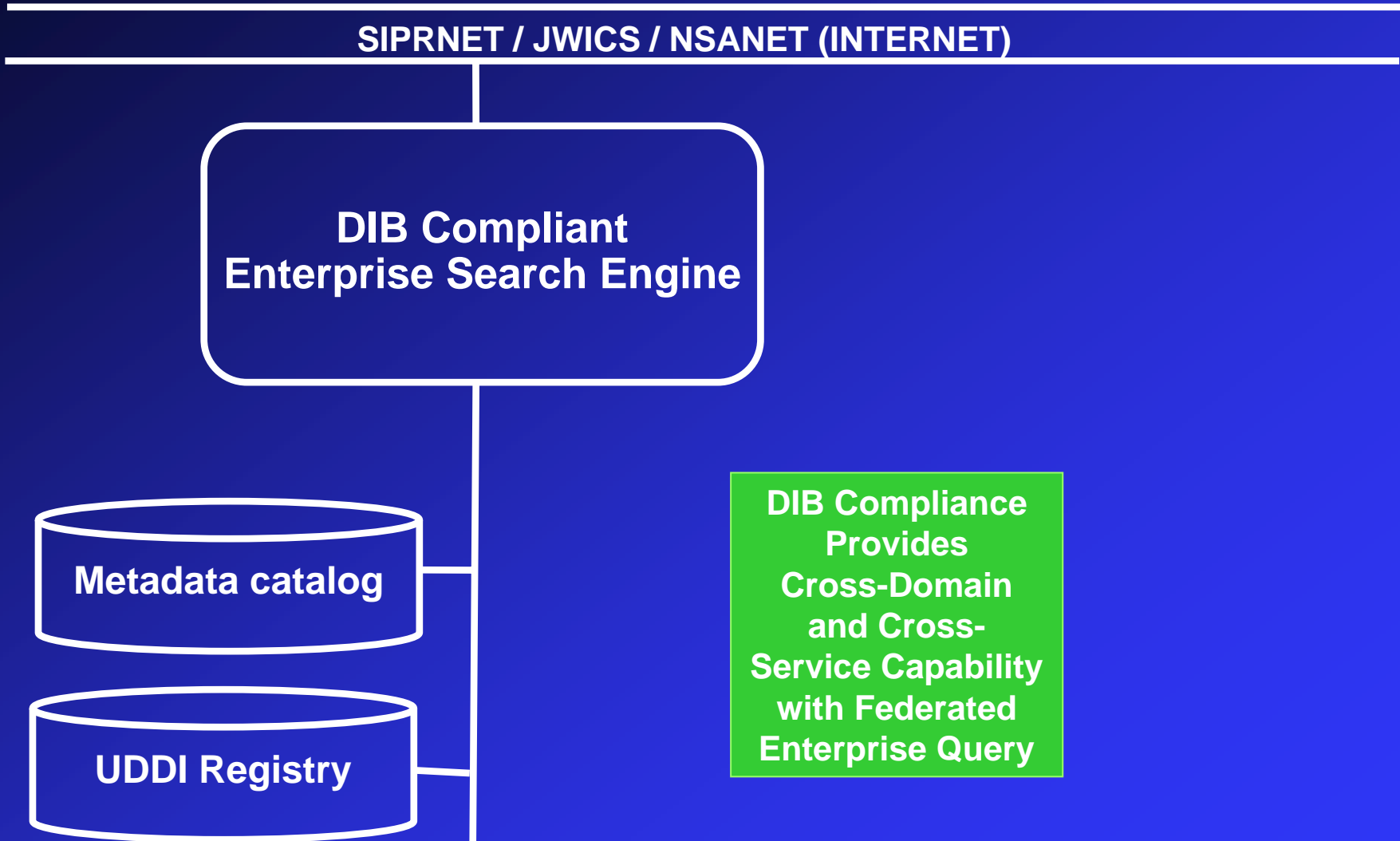
## DATA BASES & INFRASTRUCTURE SERVICES

SECURITY

DATA MANAGEMENT & INFO EXCHANGE

SERVICE AND SYSTEM MANAGEMENT

**EXTERNAL USERS**

**EXTERNAL SOURCES**

**EXTERNAL SYSTEMS**

**ENTERPRISE SERVICE BUS**

30

# Enterprise Search Capability

**SIPRNET / JWICS / NSANET (INTERNET)**

**DIB Compliant
Enterprise Search Engine**

**Metadata catalog**

**UDDI Registry**

**DIB Compliance Provides Cross-Domain and Cross-Service Capability with Federated Enterprise Query**

31

# Consolidated Infrastructure

## New Software Components Utilize Common Infrastructure

- **Visualization**
  - Overlay Manager
  - Symbol Manager
  - NRT Viz Stream
  - Intel Folders

- **Information Exchange**
  - Information Gateway
  - Report Manager
  - Message Logger
  - Message Pub/Sub
  - Address Book
  - Message Transform

- **Data Management**
  - Metadata Pub/Sub
  - Metadata Discovery
  - User Alert Management
  - Alert Services
  - ISR Data Services

- **Service Management**
  - Service Publish
  - Service Inquiry

## SECURITY

## ESB

# Portal Framework

- Portal Provides Standard Visualization for Each Domain
- Customizable to the User Profile
- Accessible from Any Workstation on the Network (Including Laptops)
- No Need to Deploy Client Applications
  - New Capabilities Added Quickly
- Maintains Version Control
- Can Realize Some Level of Data Fusion at the Visualization Layer

# Portal Pages

# ESB Use

- ESB used to implement common service orchestration patterns
  - Content-Based Routing
  - Composite Application
- Service Orchestrations implemented to maximize portability
  - BPEL 1.1 used to specify orchestrations (business processes)
  - Use of vendor extensions strictly controlled and documented
  - Transformations into Program Specific Data Model done at Gateway and Data Manager components to minimize dependencies on transformation engines unique to COTS ESB variant
- Caching of UDDI service binding information used to improve performance
  - Implement using Web Service caching technology
  - IBM "*dynacache*" used to cache NCES UDDI Abstraction Services
    - *Redundant UDDI queries returned from cache as opposed to hitting the registry for every query*

> Actions taken to alleviate SOA performance and portability concerns include pushing transformations down into services and implementing web service caching of UDDI interfaces
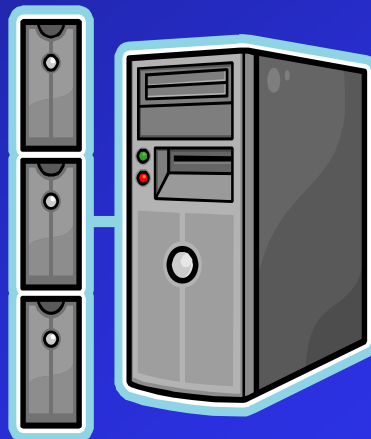
# Virtual Machine Ware Reduces HW

- **WebLogic Portal Server**
  - •84 Portlets
  - •Log4J
  - •Windows 2003
  - •2 Cores
  - •8 GB

- **WebLogic Application Server**
  - •Six Web Apps
  - •24+ Web Services
  - •Log4J
  - •Windows 2003
  - •2 Cores
  - •8 GB

- **JBOSS App Server**
  - •23 Web Apps
  - •Sensor Platform Model
  - •Sensor Platform Model UI
  - •Logger
  - •Saba
  - •AAR
  - •Windows 2003

# More Capability – Fewer Vehicles
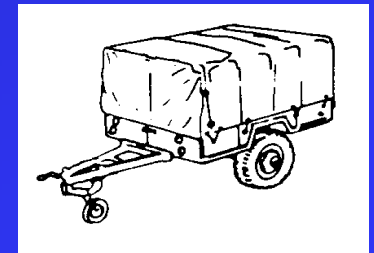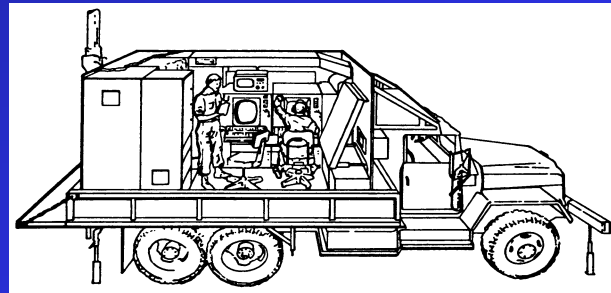
## Mobile Unit Transport Requirements

**CURRENT**

- **14 Vehicles**
- **12 Pull Behinds**
  - **4 Trailers**
  - **7 Power Generators**
  - **1 Comms Unit**

**TOTAL = 26 UNITS**

**MIGRATED CAPABILITY**

- **7 Vehicles**
- **8 Pull Behinds**
  - **2 Trailers**
  - **5 Power Generators**
  - **1 Comms Unit**

**TOTAL = 15 UNITS**

# Integration and Test Improvements

- **Standards Compliance reduces integration time**

  - Automated Test Tools Used to evaluate Web Services for OASIS Standards Compliance

  - Automated Test Tools Used to evaluate Portlets for JSR 168 Compliance

- **Web Services reduces integration time by encapsulating the changes to allow late introduction of a capability or removing of a planned capability without incurring compile time errors.**

- **Reduced regression testing when updates are made to services that do not affect other services**

- **The focus of the evaluation for accreditation is data centric instead of system centric.**

*LOCKHEED MARTIN*

- The initial investment in SOA infrastructure can be reduced through a combination of mitigation techniques

- Migration to SOA can increase capabilities without increasing the overall system footprint

- Initial investment in infrastructure may realize immediate operational benefits

- The anticipated long term beneficial effects of SOA migration are proving to be realized in programs that have made the investment

- Multi-Tier SOA architecture can limit the initial investment and position a program for long term combinatory explosion of capabilities as other programs come online