Integrated Architecture Development

28 Jan 2004

Brig Gen J. Maluda, USAF
SIAP System Engineer

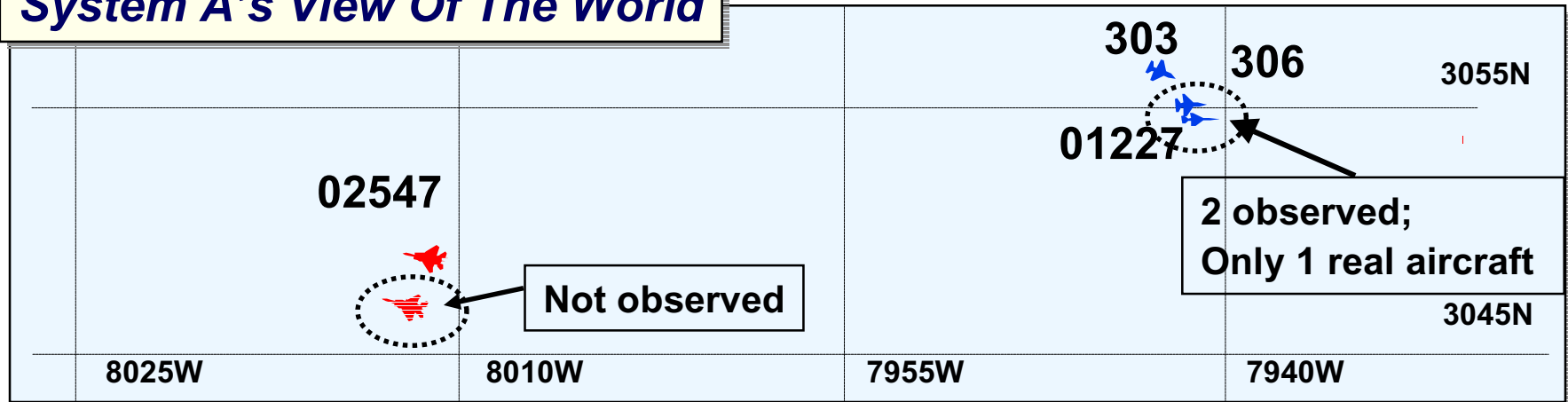**Col H. Dutchyshyn, USAF**
Deputy SIAP SE
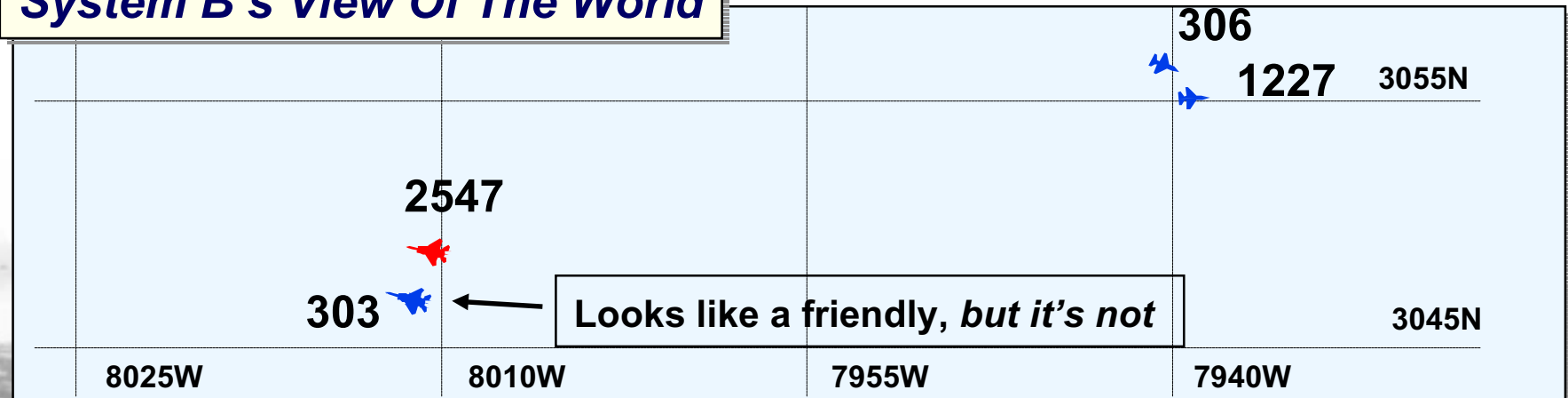
CAPT Jeffery W. Wilson, USN
Technical Director

SIAP system engineering . . .

Getting everyone on the same sheet of music

System A's View Of The World

303
306
3055N
01227
02547

Not observed

2 observed;
Only 1 real aircraft

3045N

8025W   8010W   7955W   7940W

System B's View Of The World

306
1227   3055N

2547

303   **Looks like a friendly, *but it's not***

3045N

8025W   8010W   7955W   7940W

Joint Tactical BMC2 (today)

Displays

Sensors | **Tactical BMC2 Functionality** | **Weapons**

Displays

Sensors | **Tactical BMC2 Functionality** | **Weapons**

Communication network

Displays

Sensors | **Tactical BMC2 Functionality** | **Weapons**

Displays

Sensors | **Tactical BMC2 Functionality** | **Weapons**
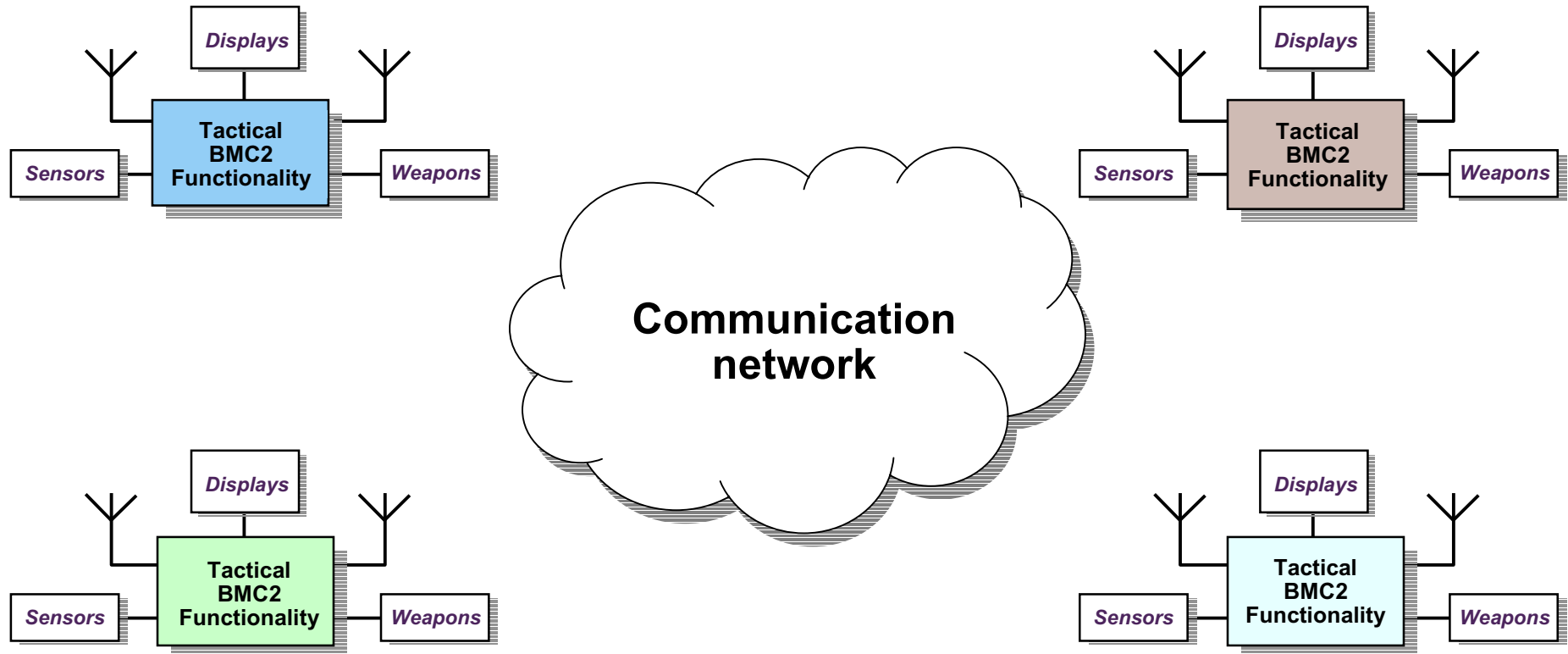
Common functionality, implemented and maintained many ways

Joint Tactical BMC2

Joint Tactical BMC2 domain

Data obtained from sources outside the distributed system

Data exchanged among peers within the distributed system

Displays

Sensors

Joint Tactical BMC2

System–specific Tactical BMC2

Weapons

- **Help is needed in identifying and controlling interface (e.g., system-specific Tactical BMC2, sensors)**

Service Combat and Command and Control System Program Manager's domain

Joint Tactical BMC2 (future)

Displays

Joint Tactical BMC2

System–specific Tactical BMC2

Sensors

Weapons

Displays

Joint Tactical BMC2

System–specific Tactical BMC2

Sensors

Weapons

Communication Network (and Enterprise Services)

Displays

Joint Tactical BMC2

System–specific Tactical BMC2

Sensors

Weapons

Displays

Joint Tactical BMC2

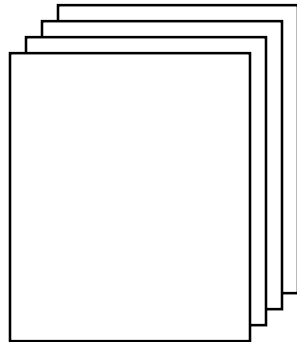**System–specific Tactical BMC2**

Sensors

Weapons

Common functionality, <u>implemented</u> <u>and</u> <u>maintained</u> <u>commonly</u>

Configuration Management

Paper Standard(s) and Specification(s)

Integrated Architecture Behavior Model ("Platform" Independent Model")

IA Repository

- **Gaps, overlaps, and conflicts**
- **Context-free**
- **Static**
- **Syntax**
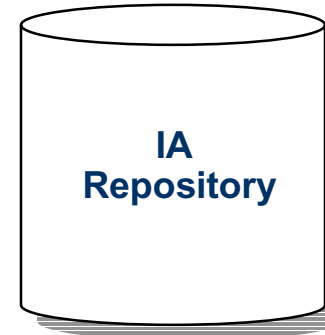
- **Unambiguous**
- **Described in context**
- **Dynamic**
- **Syntax and semantics**
- **Strong typing**

Shift from static, paper artifact to dynamic behavior model

Integrated Architecture Behavior Model

- **Derived from JROC-validated <u>requirements</u>**

- **Unambiguously describes <u>dynamic</u> system behavior in an open source model**

- **Supports selection among alternative solutions**

- **Delivered to program managers with verification/validation data and JDEP technical framework**

> **Idealized model of distributed system performance that shows industry what "good" looks like – automates the standards**

Precepts

Cornerstones

- **Continuous Readiness**
- **Sensor Netting**
- **Battlespace Dominance**
- **Proven Lethality**
- **Coordinated Weapon Employment**
- **Joint Command Support**
- **Information Assurance**

Architecture Quality Attributes

- **Performance (functionality)**
  - Correctness
  - Efficiency
  - Completeness
- **Reliability**
  - Survivability
  - Fault tolerance
  - Openness
- **Scalability**
  - Flexibility
  - Openness
- **Maintainability**
  - Openness
  - Expandability
  - Testability
- **Safety**
- **Security (Info. Assurance)**
  - Survivability
- **Verifiability**
  - Openness
- **Reusability and portability**
  - Equipment and OS independence
  - Openness

**Source: IEEE-Std 1061-
ISO Std 9126
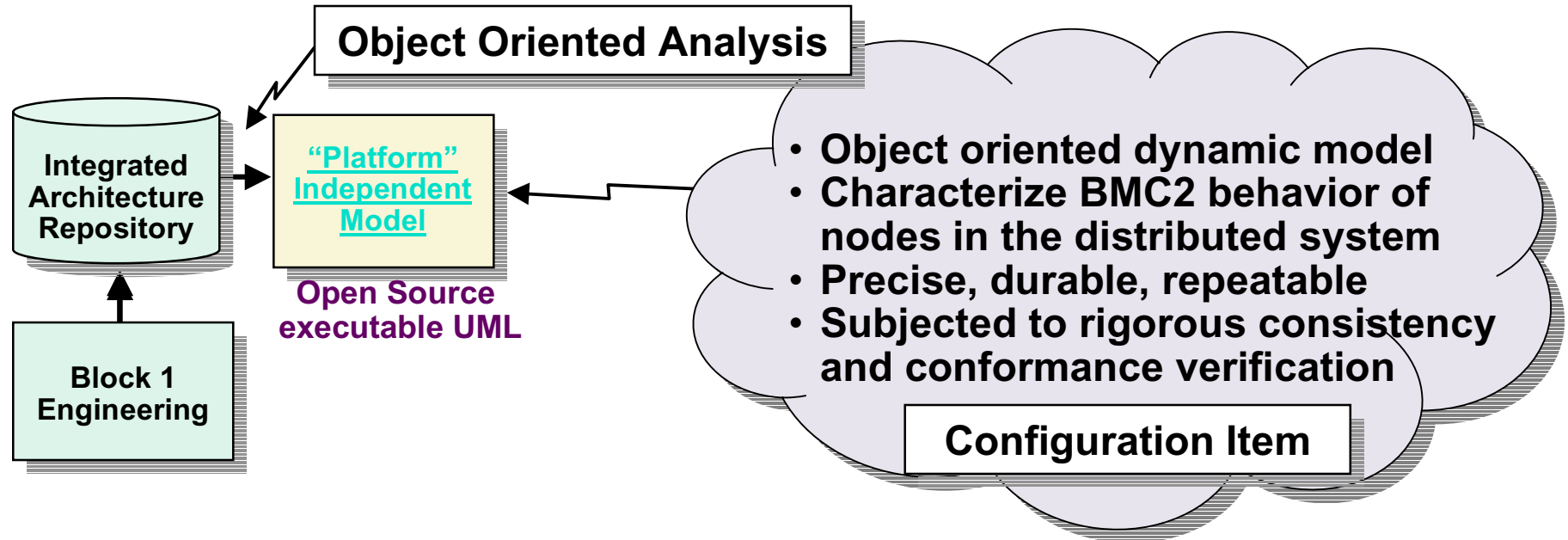MITRE Guide to Total Software
Quality Control**

Outcomes

- **Reduce fratricide**
- **Employ weapons to design range**
- **Counter existing and emerging threats**

- **Increased performance**
- **Lifecycle cost avoidance**
- **Reduced time to field new and modified capability**

Model Driven Architecture

Object Oriented Analysis

Integrated Architecture Repository

"Platform" Independent Model

Open Source executable UML

Block 1 Engineering

- **Object oriented dynamic model**
- **Characterize BMC2 behavior of nodes in the distributed system**
- **Precise, durable, repeatable**
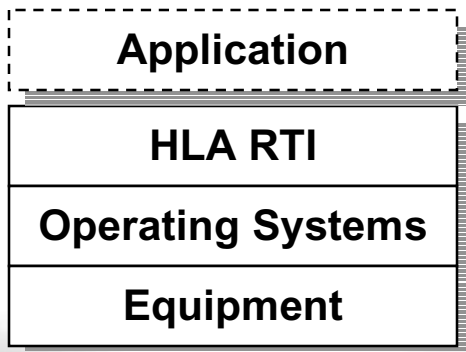- **Subjected to rigorous consistency and conformance verification**

Configuration Item
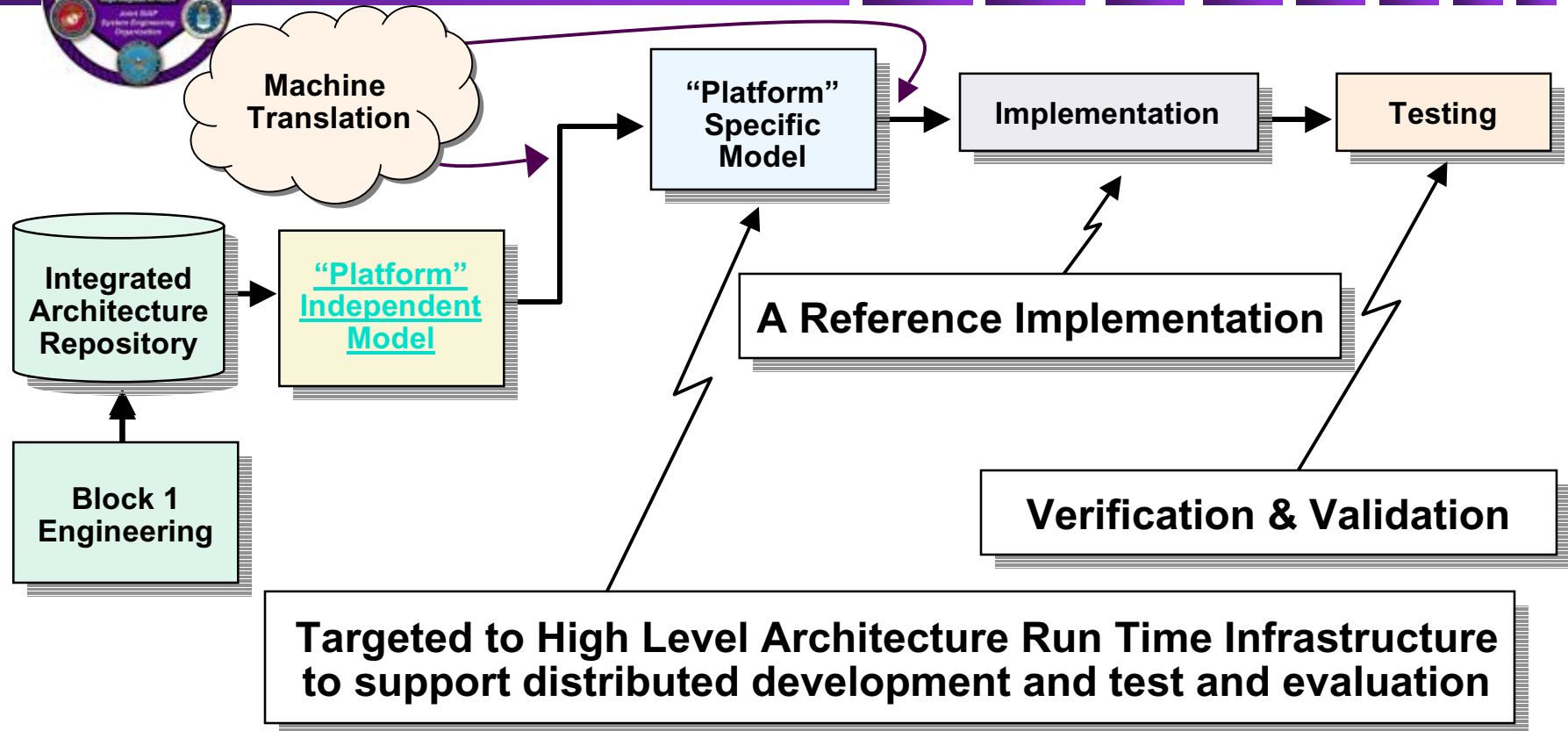
Isolate functionality from specific implementation technologies allows Design for Change

Model Driven Architecture

Machine Translation

"Platform" Specific Model

Implementation

Testing

Integrated Architecture Repository

"Platform" Independent Model

A Reference Implementation

Block 1 Engineering

Verification & Validation

Targeted to High Level Architecture Run Time Infrastructure to support distributed development and test and evaluation

Application

HLA RTI

Operating Systems

Equipment

Model Driven Architecture

```
                                                   ┌──────────────┐      ┌──────────────┐      ┌──────────────┐
                                                   │  "Platform"  │ ──►  │Implementation│ ──►  │   Testing    │
                                                   │   Specific   │      │              │      │              │
                                                   │    Model     │      └──────────────┘      └──────────────┘
                                                   └──────────────┘
┌──────────────┐      ┌──────────────┐        ┌───►
│  Integrated  │      │  "Platform"  │ ──┬────┘    ┌──────────────┐      ┌──────────────┐      ┌──────────────┐
│ Architecture │ ──►  │ Independent  │   └────►    │  "Platform"  │ ──►  │Implementation│ ──►  │   Testing    │ ──►
│  Repository  │      │    Model     │             │   Specific   │      │              │      │              │
└──────────────┘      └──────────────┘             │    Model     │      └──────────────┘      └──────────────┘
        ▲                                          └──────────────┘
        │
┌──────────────┐
│   Block 1    │                                                              ┌─────────────────────────────┐
│ Engineering  │                                                              │  Verification & Validation  │
└──────────────┘                                                              └─────────────────────────────┘

                              ┌───────────────────────────────────────────────────────┐
                              │ Example, targeted to specific industry standards (e.g., │
                              │     TAO, POSIX), based on individual system needs       │
                              └───────────────────────────────────────────────────────┘
```
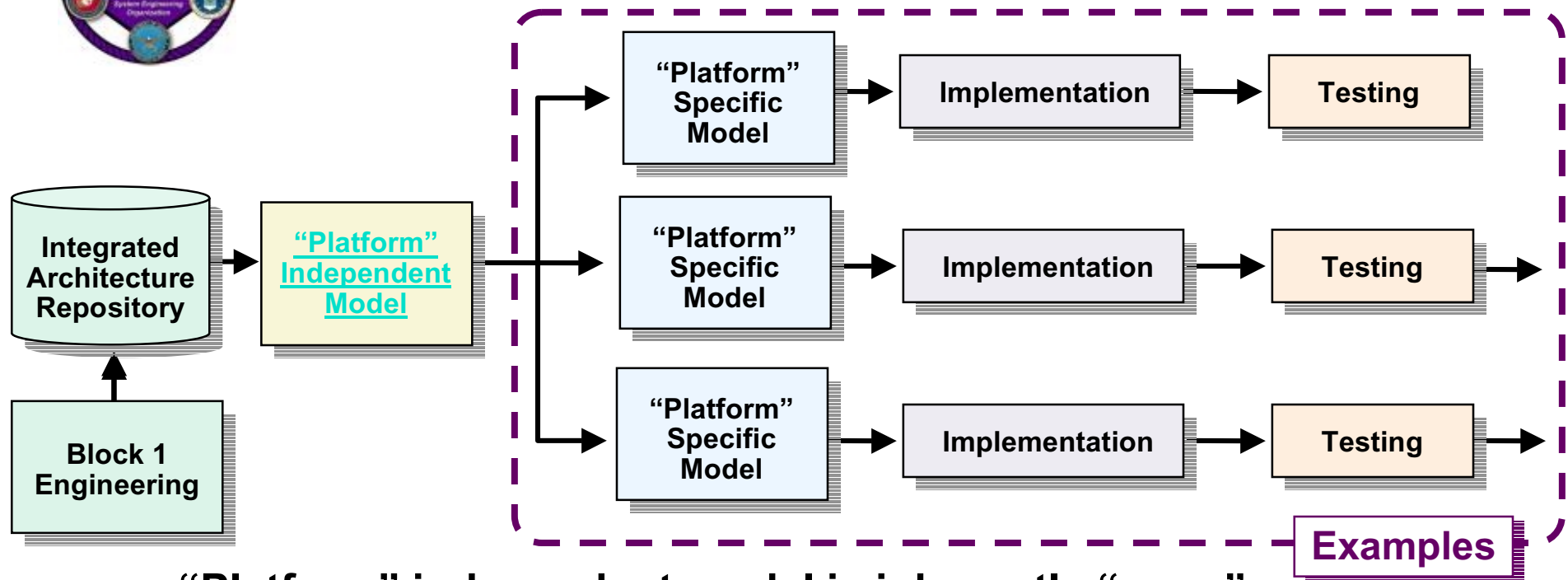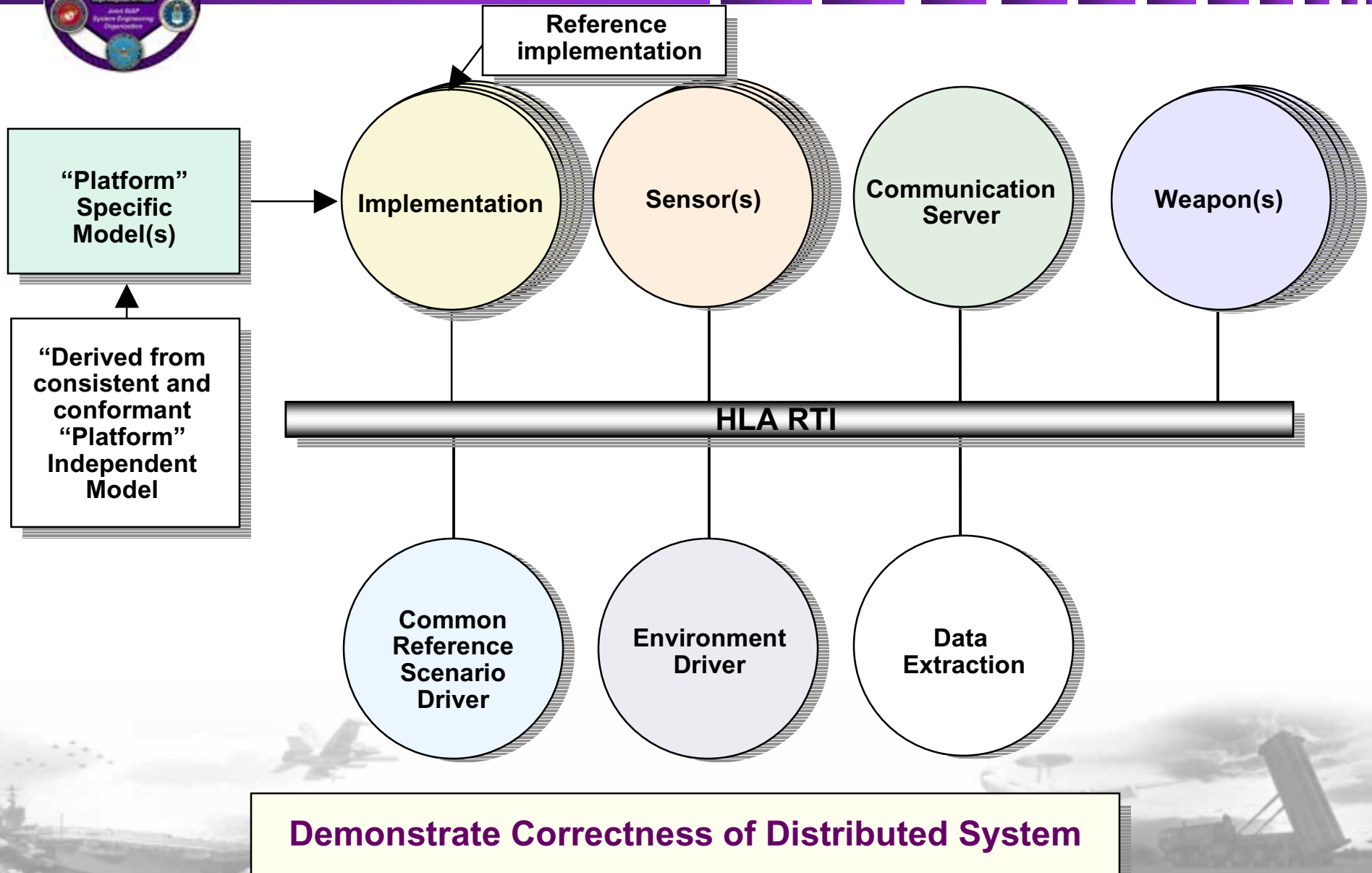
Model Driven Architecture

- "Platform" independent model is inherently "open", provides dynamic model of system behavior, and allows deferral of specific implementation technology decisions

- HLA-compliant model demonstrates distributed system performance

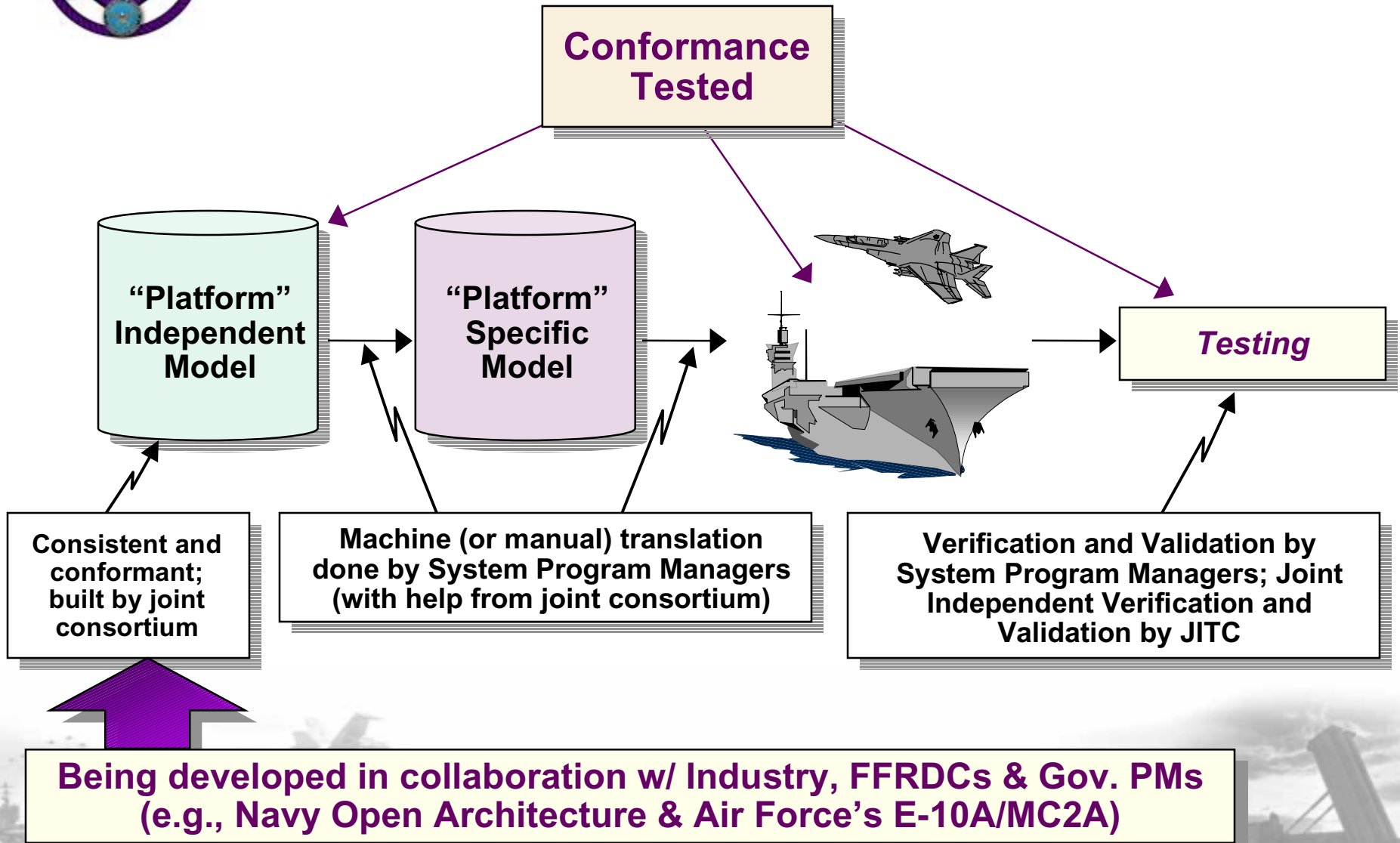- One or more specific model(s) demonstrate distributed system performance in real system(s)

# Verification and Validation

Reference implementation

"Platform" Specific Model(s)

"Derived from consistent and conformant "Platform" Independent Model

Implementation

Sensor(s)

Communication Server

Weapon(s)

HLA RTI

Common Reference Scenario Driver

Environment Driver

Data Extraction

Demonstrate Correctness of Distributed System

Implementation in tactical systems

Conformance Tested

"Platform" Independent Model

"Platform" Specific Model

Testing

Consistent and conformant; built by joint consortium

Machine (or manual) translation done by System Program Managers (with help from joint consortium)

Verification and Validation by System Program Managers; Joint Independent Verification and Validation by JITC

Being developed in collaboration w/ Industry, FFRDCs & Gov. PMs (e.g., Navy Open Architecture & Air Force's E-10A/MC2A)

Deliverables

- **One "Platform" Independent Model**
- **Two or more example "Platform" Specific Model(s)**
  - One HLA RTI-specific
  - At least one targeted to a specific communication environment and operating system
- **Reference Implementation(s) derived from "platform specific model(s)**
- **Unit and integration test scripts and results (verification)**
- **Validation test scripts and results**
- **JDEP kit**

Funding Strategies

- ## Original Service estimates accounted for redundant development

	Design	Code	Int	Test	Pgm Mgt
System A	a · b	c	d	e	f
System B	a · b	c	d	e	f

Common
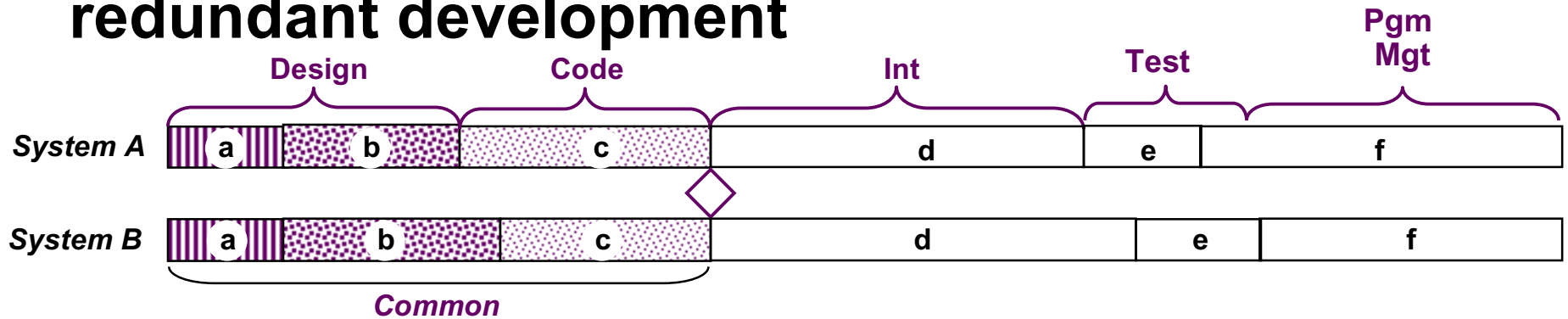
Block 0 & Block 1 → Total $ = System A + System B

- ## A change in business model should reduce total cost and help synchronize development

New Method   Total $ = $a + b + c + A_d + B_d + A_e + B_e + A_f + B_f$

Design	Code	Int	Test	Pgm Mgt	
a · b	c	d	e	f	System A
		d	e	f	System B
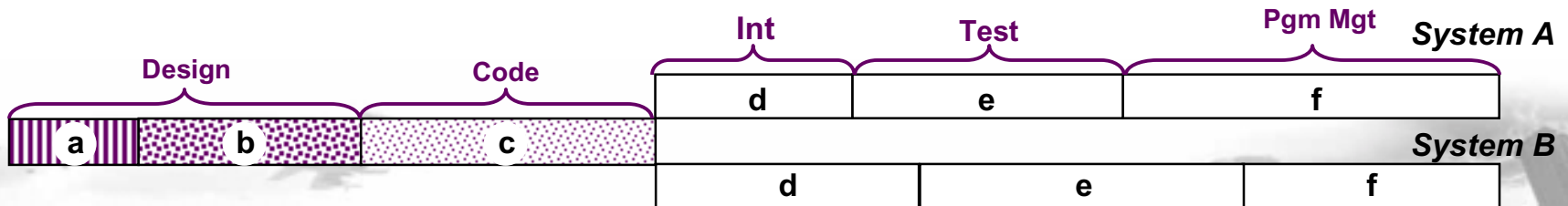
Demands change in business model

The message

- **Integrated Architecture continues to be a key task force product**

- **Integrated Architecture behavior model supports dynamic analysis and improved communication with industry**

- **Approach changes configuration item(s) from paper specifications and standards to dynamic behavior model**

The Integrated Architecture provides the basis for reducing development costs, reducing time required to field new and modified capability, and increasing operational effectiveness

Requirement sources

TAMD, CID, GIG CRDs

MIL-STD-6016B

STANAG 5516

JSLIR-16 (draft)

STANAG 5522

MIL-STD-3011

SIAP SE Technical Reports

Existing Architecture products
- Views
- Threads

Athena/Sea Athena/Common C&D

MSI

SRIG design

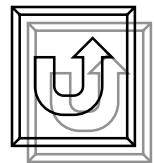Navy OA materials

SGS/AC spec, source code

JDEP kit

SIAP Block 0 DSB

SIAP Block 1 DSB

USAF DLI/LCI/TDLCS

USAF COLE

USMC COLE

Large number of ways to describe expected performance creates gaps, overlaps, and conflicts…Integrated Architecture can force convergence and consistency

"Platform" Independent Model

- ## Who
  - Industry/University/FFRDC/Government Team
- ## What
  - Independent of computer, operating system, and "middleware"
  - Complete and correct model of an arbitrary distributed system peer
    - Syntax and semantics
    - Dynamically verifiable (unambiguous)
  - Tailored for specific implementations (e.g., AWACS, AEGIS) when "Platform" Specific Implementation is built

"Platform" Independent Model *(cont.)*

- ## Why

  - Express the behavior of the distributed system in an industry standard language

  - Allow verification and validation of the integrated architecture

  - Change configuration management artifact from paper standard and source code to behavior model

  - Support verification and validation of end product

"Platform" Independent Model *(cont.)*

- **Where**

  - Collocated team in Arlington, VA

- **When**

  - Block 1 System Engineering FY 02-03

  - Build and test model FY 03-05

  - Integrate and test FY 06-07

  - IOC FY 08

"Platform" Independent Model *(cont.)*

- ## How
  - Product of disciplined, but efficient system engineering process
  - Model developed by partnership of industry, university, FFRDC, government
  - Implemented and integrated by industry

- ## How much
  - Joint Tactical BMC2 functionality; extensible to service–unique functionality

JDEP kit contents

- **Attributes Technical Reports**
- **Common Reference Scenarios**
- **Common Reference Scenario Driver**
- **ARCTIC**
- **PET**
- **Environment services**
- **Communications services**
- **Sensor representations**
- **Weapon representations**