Aerospace Vehicle Systems Institute

SAVI: Aerospace Platform Development and Certification Using Modeling & Simulation to "Integrate, then Build"

NDIA Systems Engineering Conference

October 2009

Outline

❑Who and What is AVSI SAVI?

❑Why SAVI?

❑How does SAVI approach modeling?

❑When is SAVI used?

❑Where is SAVI going?

Who and What is AVSI SAVI?

Aerospace Vehicle Systems Institute

AVSI **is a global cooperative of aerospace companies, government organizations, and academic institutions**

Aerospace systems and research
- Reliability
- Certification
- Virtual Integration

System Architecture Virtual Integration

SAVI: a program addressing virtual systems integration
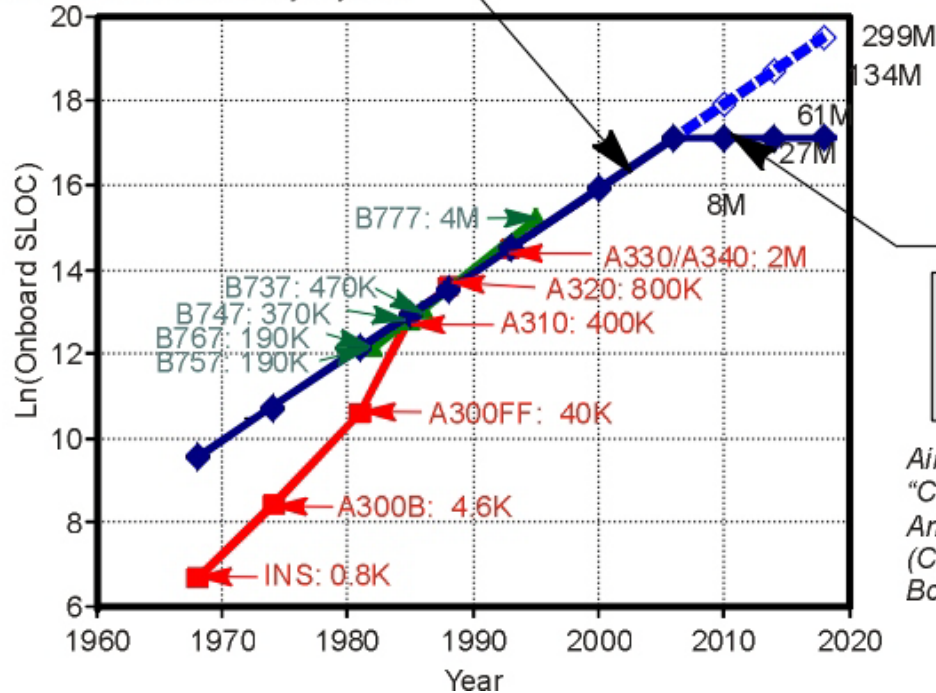
Why SAVI?

The Need for Predictable Systems

Integration

System Complexity

Estimated Onboard SLOC Growth

Slope: 0.1778 Intercept: -338.5
Curve Implies SLOC doubles about every 4 years

299M
134M
61M
27M
8M

This line fit is pegged at 27.5 M SLOC because the SLOC sizes for 2010 - 2020 are not affordable. The COCOMO II estimated costs to develop that much software is in excess of $10B

B777: 4M
A330/A340: 2M
B737: 470K
A320: 800K
B747: 370K
B767: 190K
A310: 400K
B757: 190K
A300FF: 40K
A300B: 4.6K
INS: 0.8K

Legend:
- Straight line curve fit
- Boeing aircraft
- Airbus aircraft
- Not affordable extrapolation

Airbus data source: J. P. Potocki De Montalk, "Computer Software in Civil Aircraft," Sixth Annual Conference on Software Assurance (Compass '91), Gaithersburg, MD, June 24-27, 1991
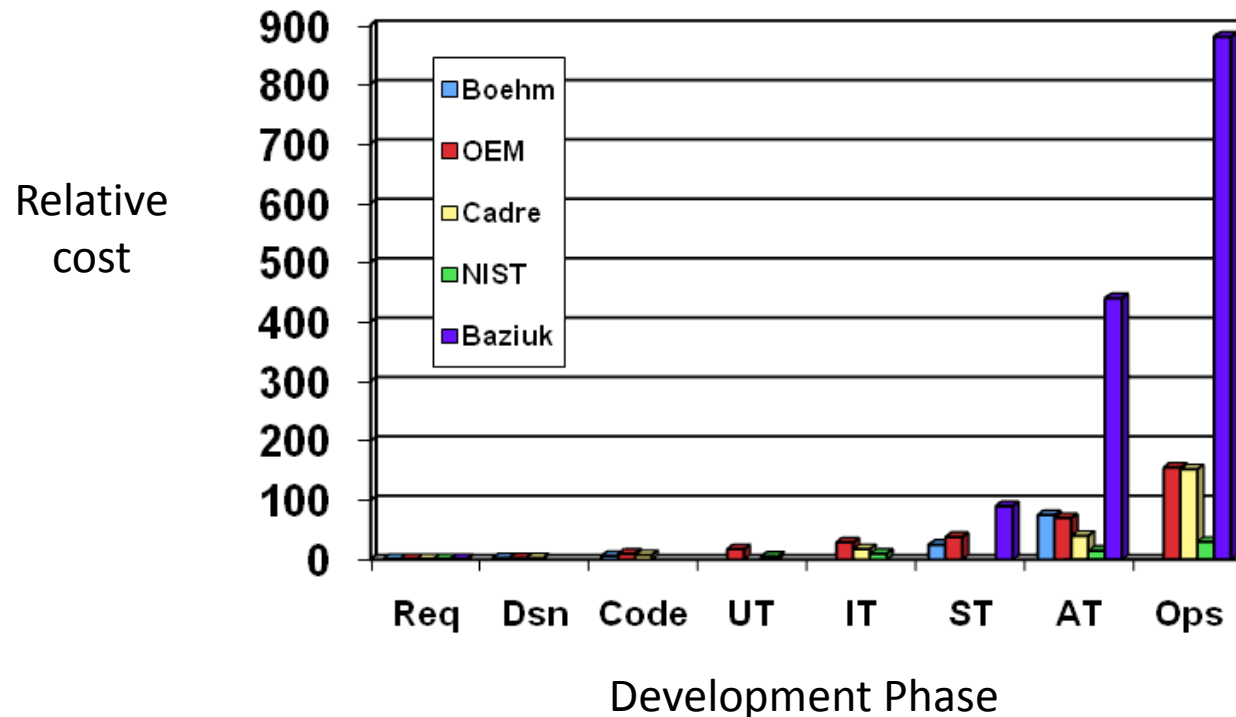Boeing data source: J. J. Chilenski, 2009

Acronyms:
SLOC: source lines of code
COCOMO II: COnstructive COst MOdel *II*

Development Cost Growth

Errors discovered late in the product lifecycle

Relative cost to fix an error by development phase

Relative cost

Development Phase

Reaching Limits of Traditional Methods

❑ Integration complexity will continue to increase

❑ Individual companies cannot solve it alone

❑ Industry cannot afford to solve it multiple times

❑ We can't afford not to solve it

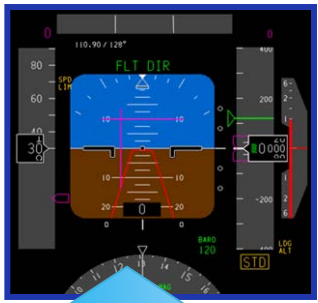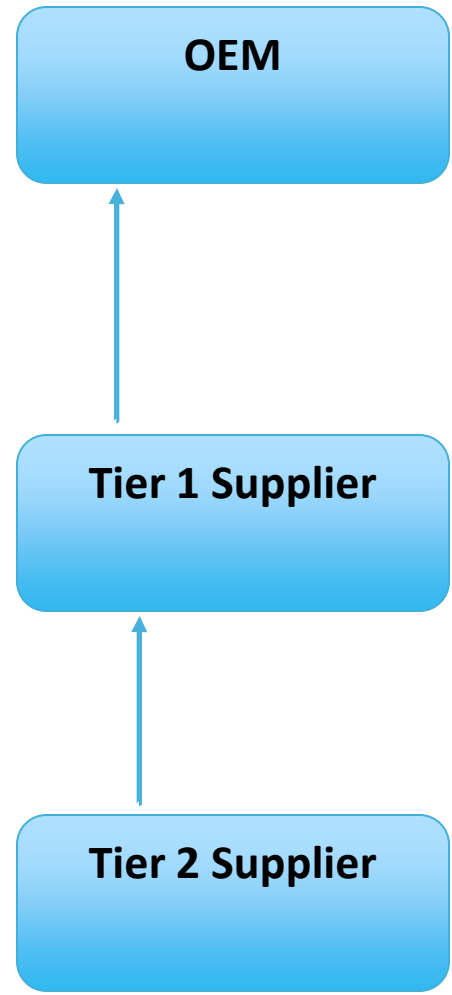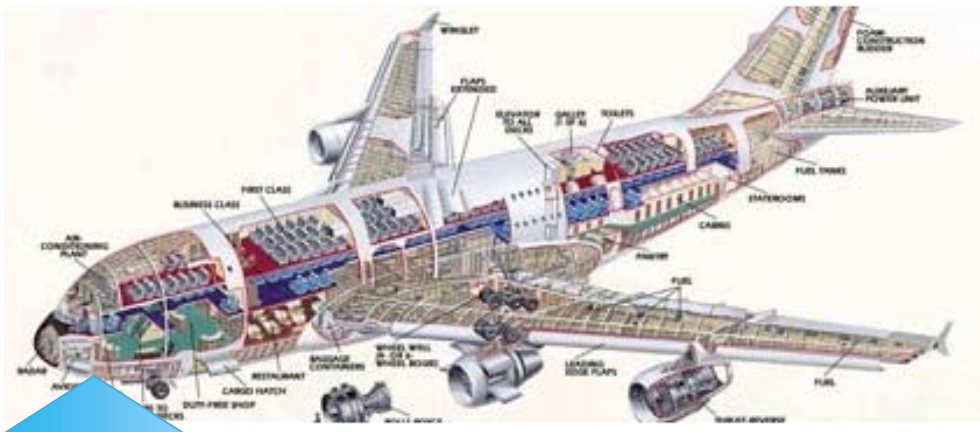A coordinated, industry-wide effort is needed to solve this issue.

How Do We to Address This Issue?

Modeling

(But what exactly does that mean?)

How Does SAVI Approach Modeling？

The Systems and the Supply Chain Are Both Hierarchical

OEM

Tier 1 Supplier

Tier 2 Supplier

We should expect similar structure in the tools and in the processes employed in their development.
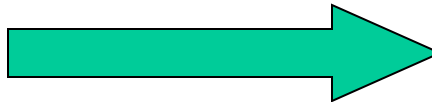
Potential Model-Based Engineering Pitfalls
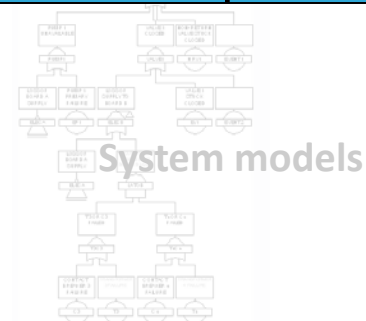
The Issues
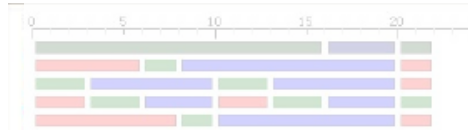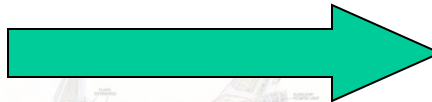
Potential Solution

Inconsistency between independently developed analytical models

Architecture-centric model repository

System models

Confidence that model reflects implementation

Generation from validated models
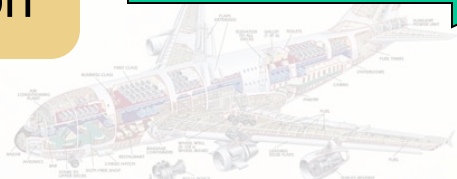
System implementation

Architecture-Centric (but Data-Friendly) Engineering Approach

Virtual Integration & Validation of System Architecture

Annotated Architecture Model

Auto-generated analytical models
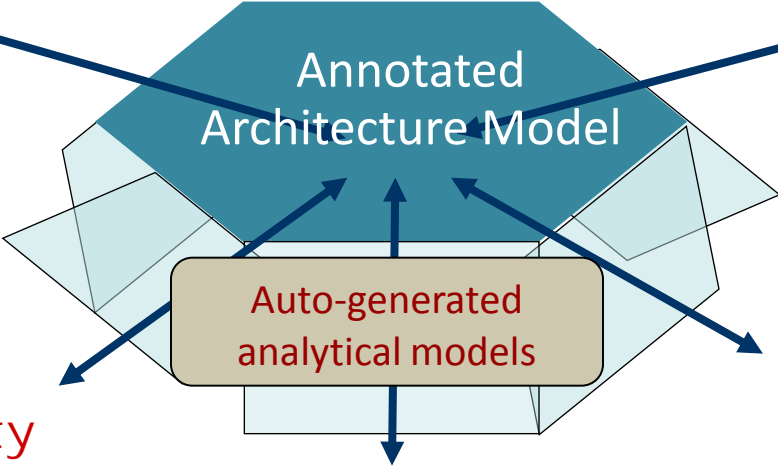
Availability and Reliability

MTBF

FMEA

Hazard analysis

Cyber Security

Availability

Authentication

Integrity

Confidentiality

No repudiation

Data Quality

Data precision/accuracy

Temporal correctness

Confidence

Real-time Performance

Execution time/Deadline

Deadlock/starvation

Latency

Resource Consumption

Bandwidth

CPU time

Power consumption

How Will SAVI Work?

Requirements   *Verification/Validation*

Design & Build   *Integration/Deployment*

How Will SAVI Work?

Requirements   *Verification/Validation*

Define the data structure needed for information storage & analysis (Model Repository)

Model Repository

Design & Build   *Integration/Deployment*

How Will SAVI Work?

Requirements   *Verification/Validation*

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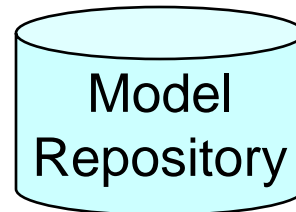
Design & Build   *Integration/Deployment*

How Will SAVI Work?

Requirements

Verification/Validation

Define the data structure needed for information storage & analysis (Model Repository)

Define the data transforms needed for information interchange (Model Bus)

Design & Build

Integration/Deployment

How Will SAVI Work?

Requirements

Verification/Validation

Design & Build

Integration/Deployment

Users

Model Bus

Model Repository

Define the data structure needed for information storage & analysis (Model Repository)

Define the data transforms needed for information interchange (Model Bus)

How Will SAVI Work?

Requirements

Verification/Validation

Airframer

Suppliers

Regulators

Model Bus

Model Repository

Model Repository

Model Repository

Model Repository

Model Repository

Define the data structure needed for information storage & analysis (Model Repository)

Define the data transforms needed for information interchange (Model Bus)

Design & Build

Integration/Deployment

How Will SAVI Work?

Requirements

Verification/Validation

Users

Model Bus

Model Repository

Model Repository

Model Repository

Model Repository

Model Repository

Information – Virtual
Integration Data

Design & Build

Integration/Deployment

Define the data structure needed for information storage & analysis (Model Repository)

Define the data transforms needed for information interchange (Model Bus)

How Will SAVI Work?

Requirements

Verification/Validation

Users

Model Bus

Descriptions

Models

Data

Analysis Results

Other info

Design & Build

Integration/Deployment

Model Repository

Define the data structure needed for information storage & analysis (Model Repository)

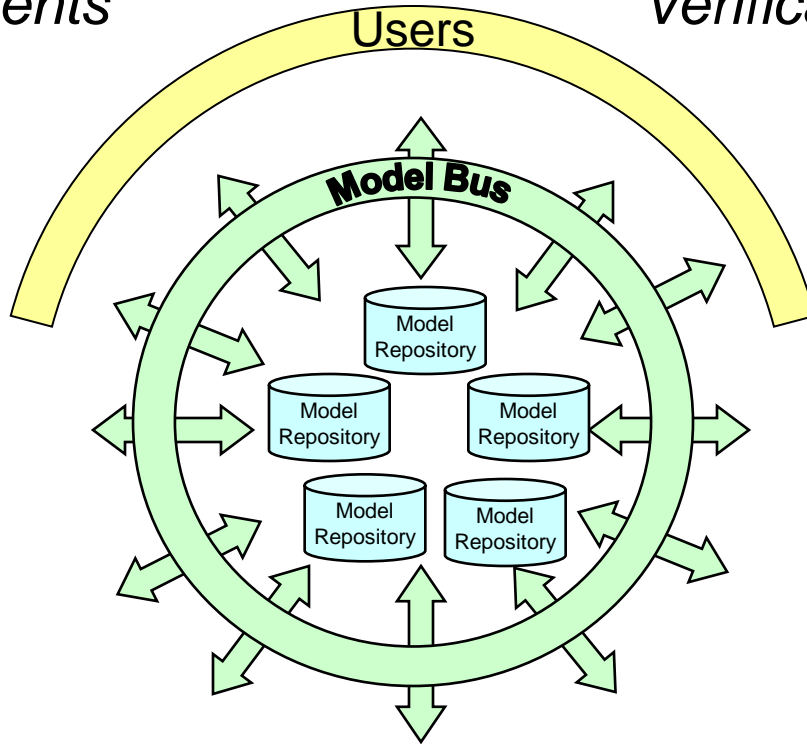Define the data transforms needed for information interchange (Model Bus)

How Will SAVI Work?
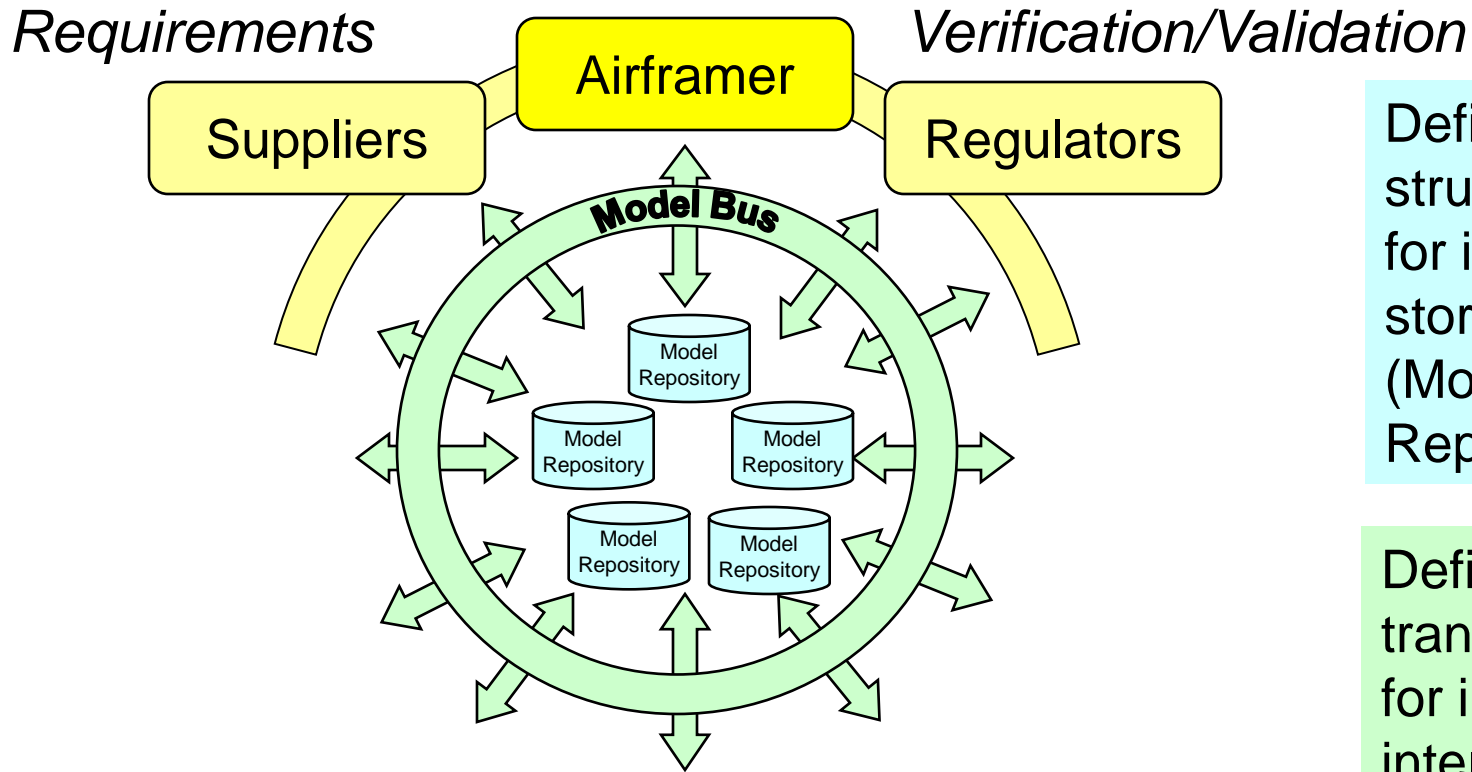

Requirements

Verification/Validation

Define the data structure needed for information storage & analysis (Model Repository)

Define the data transforms needed for information interchange (Model Bus)

Design & Build

Integration/Deployment

How Will SAVI Work?

Requirements

Verification/Validation

Users

Model Bus

Model Repository

Model Repository

Model Repository

Model Repository

Model Repository

Information: Virtual Integration Data

Require/Specify Tools

Design/Build Tools

Integrate/V&V Tools

Other tools

Define the data structure needed for information storage & analysis (Model Repository)

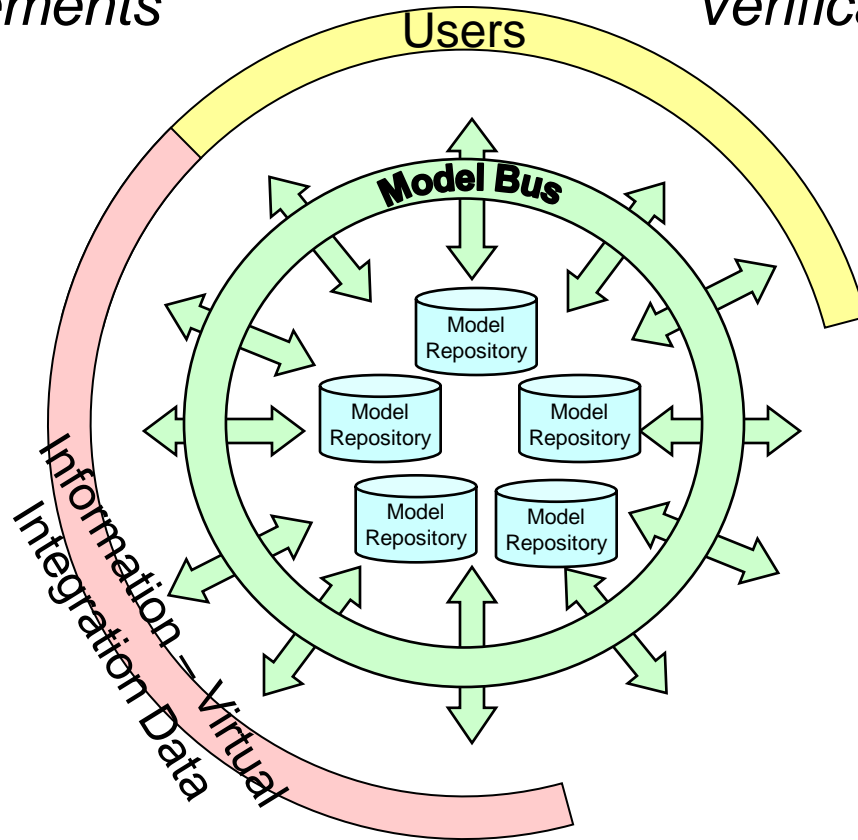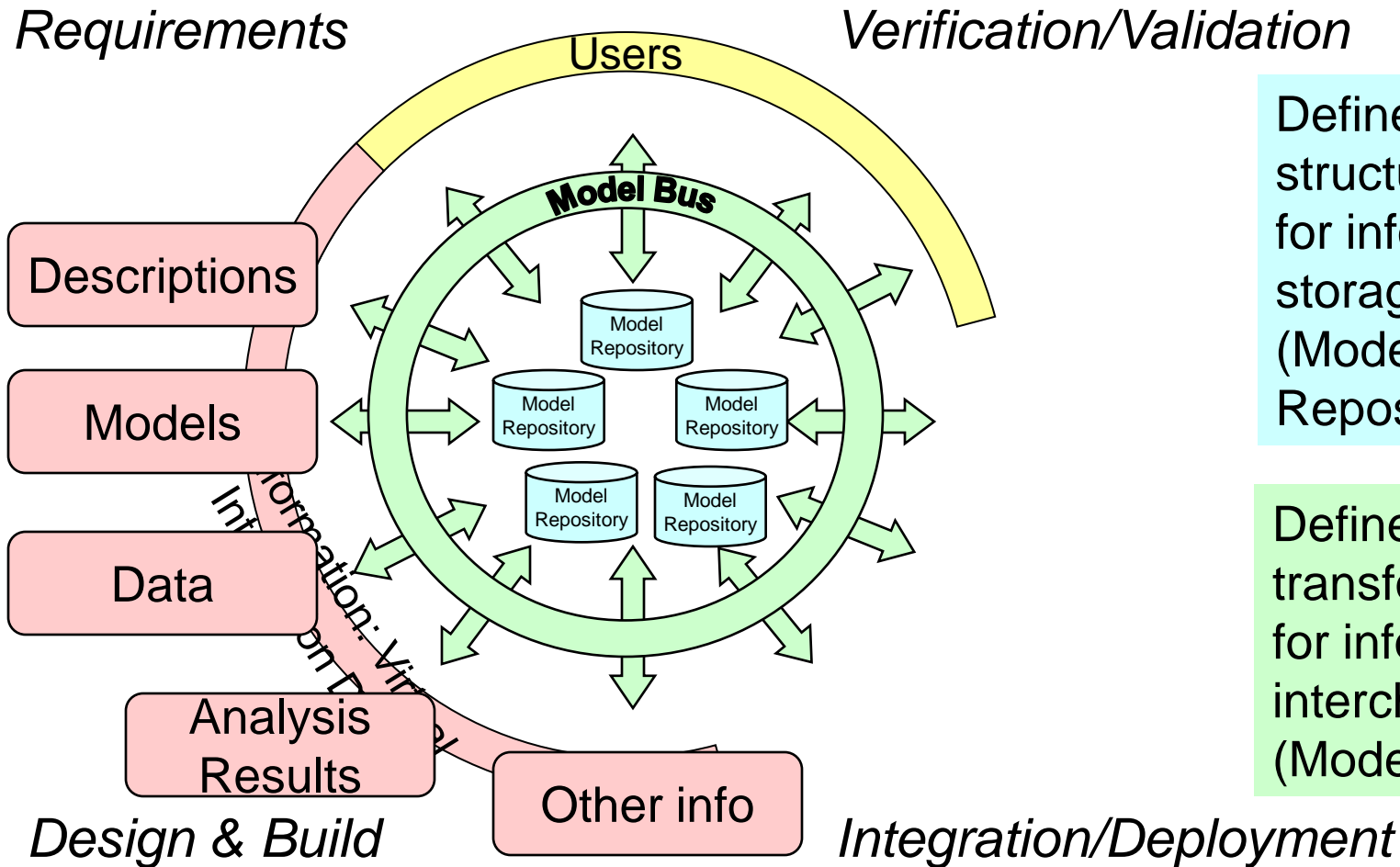Define the data transforms needed for information interchange (Model Bus)

Design & Build

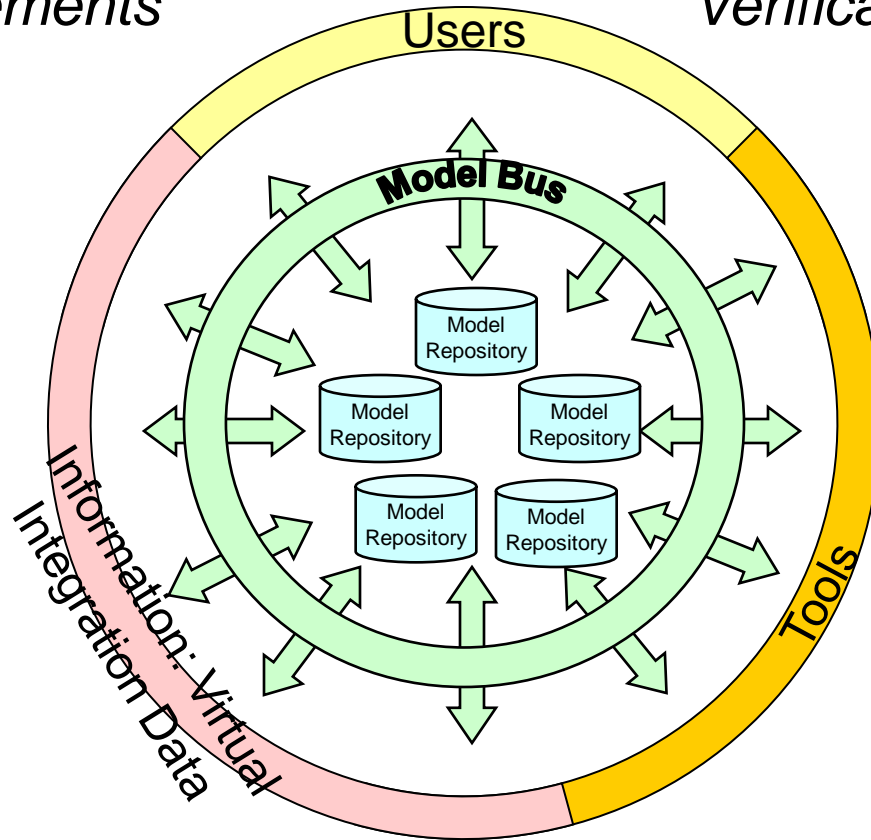Integration/Deployment

How Will SAVI Work?

How Will SAVI Work?

Requirements

Verification/Validation

Airframers

Suppliers

Regulators

Users

Descriptions

Model Bus

Require/Specify Tools

Models

Information: Virtual Integration Data

Model Repository

Design/Build Tools

Data

Tools

Integrate/V&V Tools

Analysis Results

?
Other Tools

?
Other Info

Define the data structure needed for information storage and analysis (Model Repository)

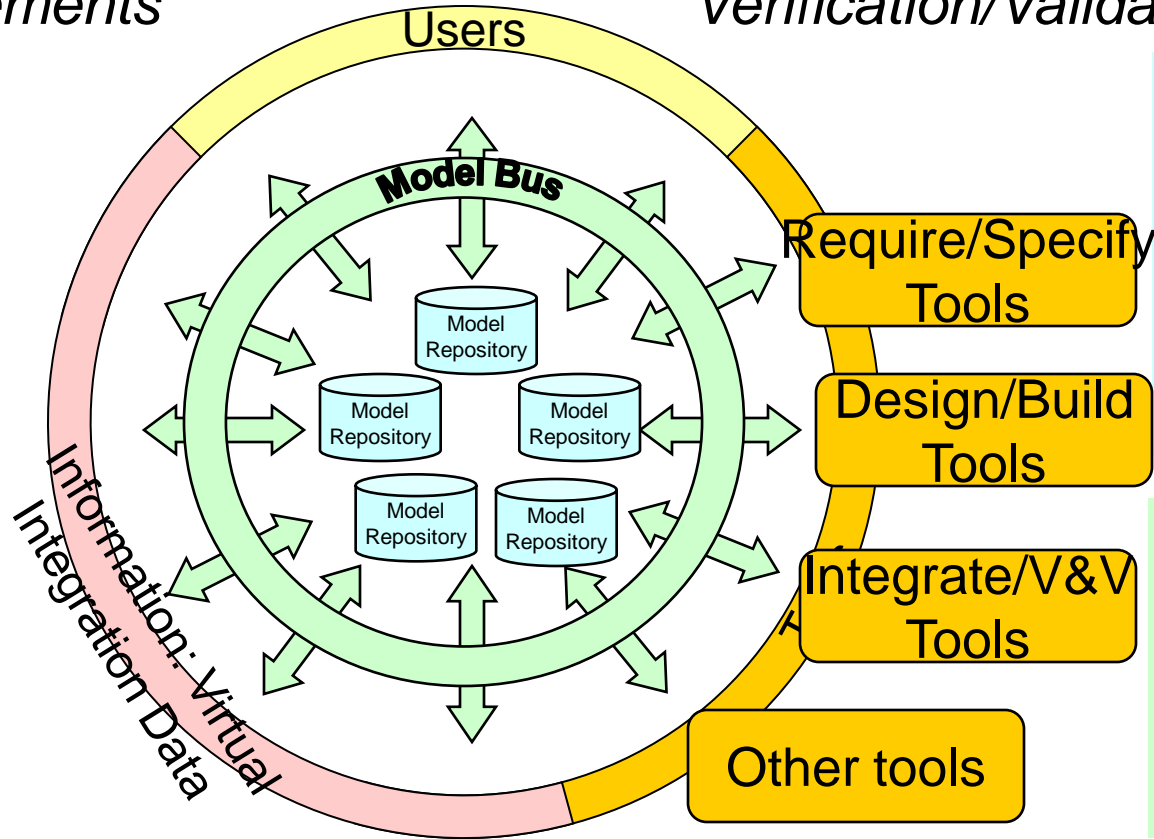Define the data transforms needed for information interchange (Model Bus)

Design and Build

Integration/Deployment

When is SAVI used?

SAVI Scope, SAVI Impact
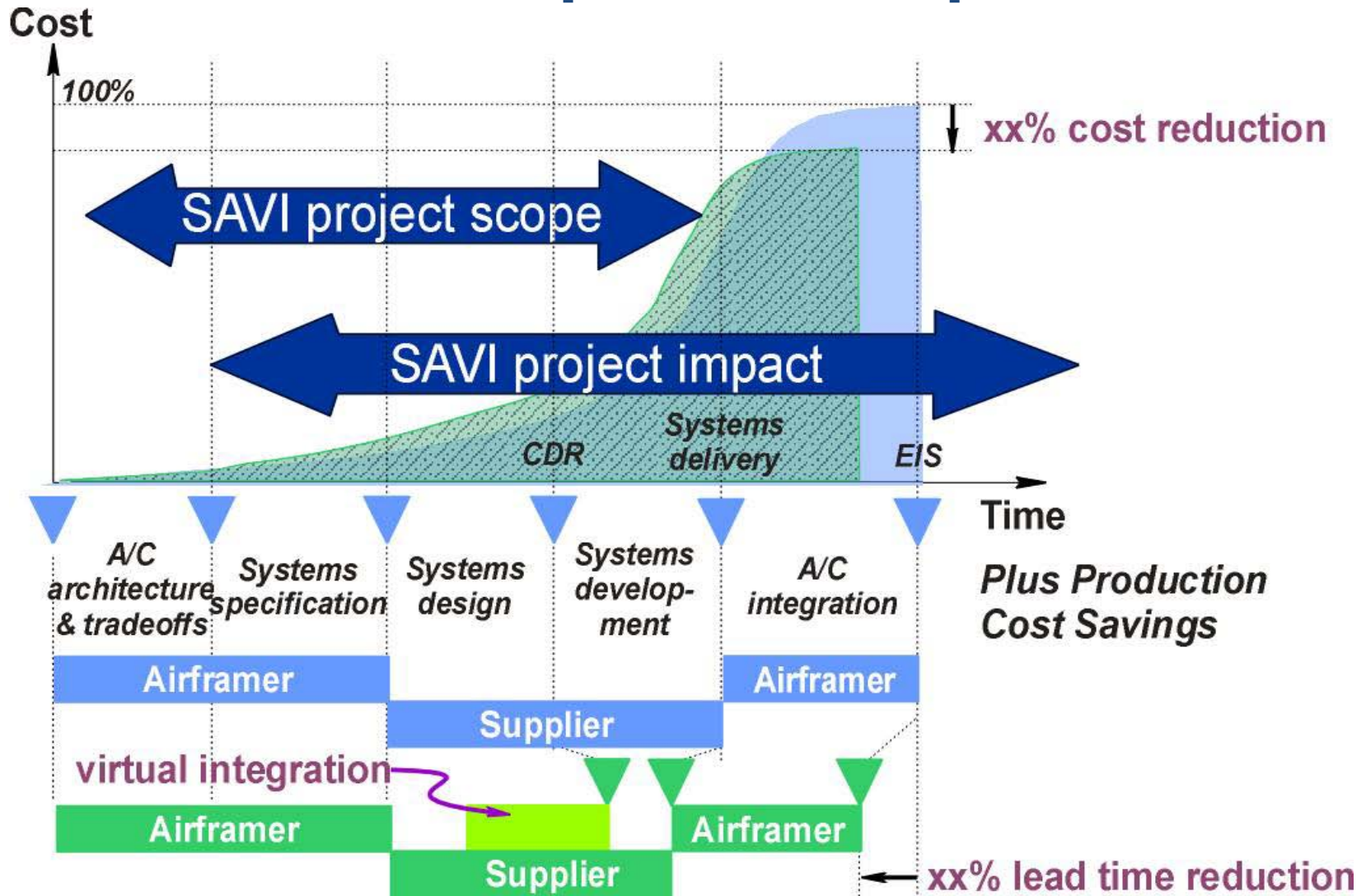
Virtual Systems Integration
Uncovers Errors Earlier in Development
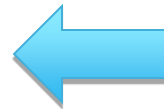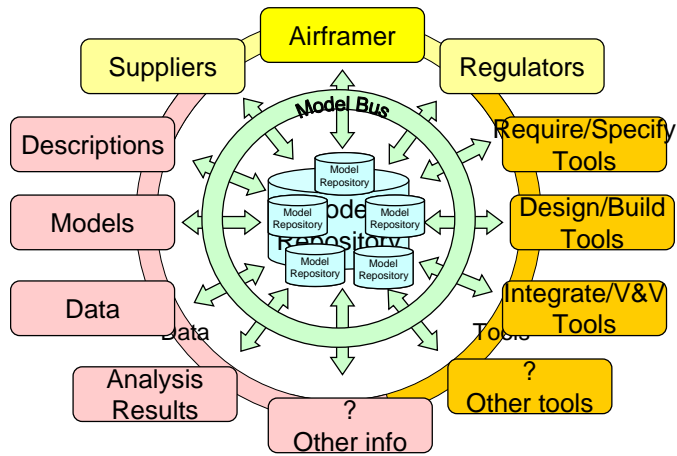
The Model Bus and

Model Repository are SAVI constructs that

enable…

Model Based Acquisition Environment

… early validation of system

behavior to

reduce integration errors.
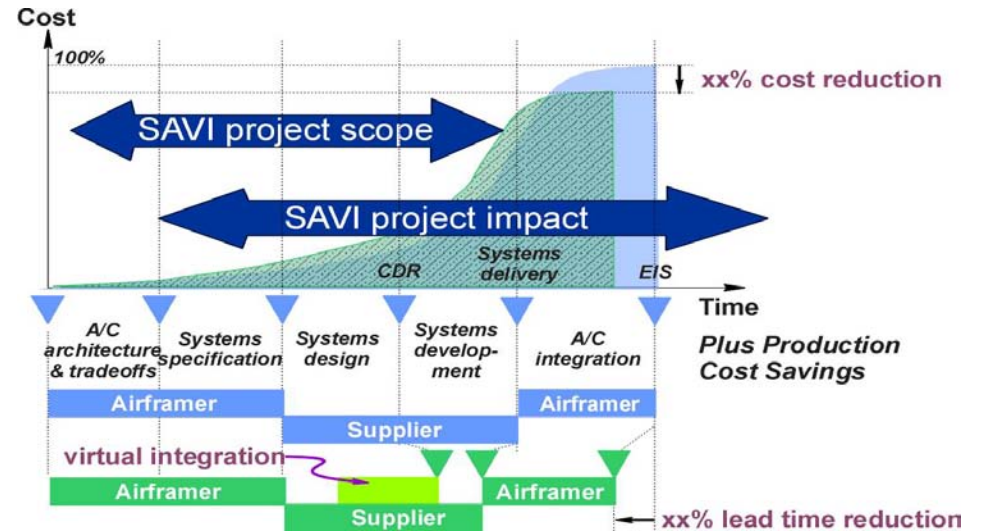
SAVI Approach: Integrate, Then Build

❑ **SAVI is**

- ❖ **A changed acquisition paradigm to facilitate systems integration**
- ❖ **A research effort to define the standards and technologies needed to effect virtual integration**
- ❖ **Built on the three-legged stool of**
  - ✓ *Model-Based*
  - ✓ *Proof-Based*
  - ✓ *Component-Based*
- ❖ **Structured/transformable data interfaces**
- ❖ **A global collaboration**

❑ **SAVI is not**

- ❖ **A software tool or a design tool**
- ❖ **A continuation of current system development practices**

Proof-of-Concept (PoC) Objectives

❑ Produce a credible ROI estimate

❑ Define a roadmap for development of SAVI

❑ Develop a Proof-of-Concept Modeling environment:
  - ❖ Establish a prototype Model Bus
  - ❖ Establish a prototype Model Repository
  - ❖ Define a sample model that captures targeted systems properties
  - ❖ Perform system analyses across multiple levels of abstraction

Boeing

Rockwell Collins

BAE Systems

SEI

Distributed PoC Model Development

Airbus

Lockheed-Martin

Subversion Model Repository at AVSI
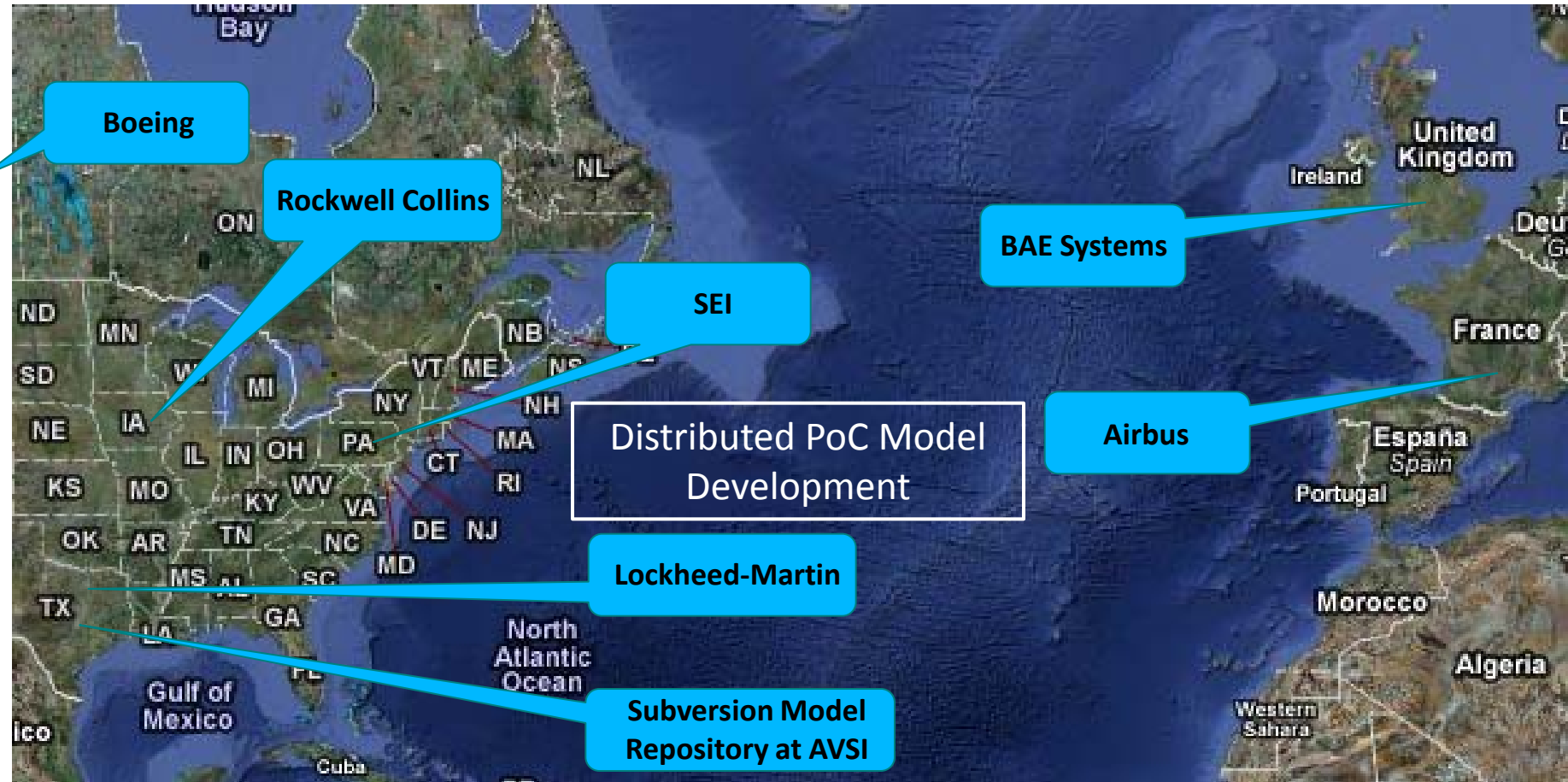
Global Team

Proof-of-Concept Demonstration - (2/3)

- ❏ **Three Models （Tiers 1, 2, and 3） Analyzed**
  - ❖ **Tier 1 (Aircraft level)**
  - ❖ **Tier 2 (Aircraft system level)**
  - ❖ **Tier 3 (Sub-system/LRU level)**

- ❏ **Analysis and Demonstration**
  - ❖ **Propagated requirements and constraints from higher-level model down to suppliers' lower-level models**
  - ❖ **Verified lower-level models satisfy higher-level requirements and constraints**

- ❏ **Evaluation Based on Quality Factors**
  - ❖ **Started with 19 (Criticality, Frequency, Difficulty, Cost,...)**
  - ❖ **Video demonstrations available**

Proof-of-Concept Demonstration - (3/3)

❑ Did this PoC Demonstration show that SAVI methodology is technically feasible?

UNANIMOUS -- YES!

❑ Core concepts were demonstrated on three different models, BUT…

➢ **Scalability was not fully explored**

➢ **Open issues with Architecture Description Language (ADL) that was used for the PoC (AADL in this case)**

  • *Meets needs of all Use Cases?*

  • *Full compatibility with DoDAF version 2?*

Accomplishments

First Feasibility Demonstration Completed

- ❑ Documented As-Is, To-Be Acquisition Models

- ❑ Proof-of-concept demonstrates SAVI technical feasibility

- ❑ Created Road Map for this new paradigm

- ❑ Analysis shows favorable Return on Investment （ROI）

Spiral Development Planned

❑ **Technical Readiness Level （TRL）9**

	SAVI Program
Concept Loop	
Proof of Concept Loop	**AFE#58**
Technology Demonstration Loops SAVI v1.0 SAVI v2.0	**AFEs#60-67**
Development "Productionization" Loop SAVI v3.0	
Sustainment Loop(s)	
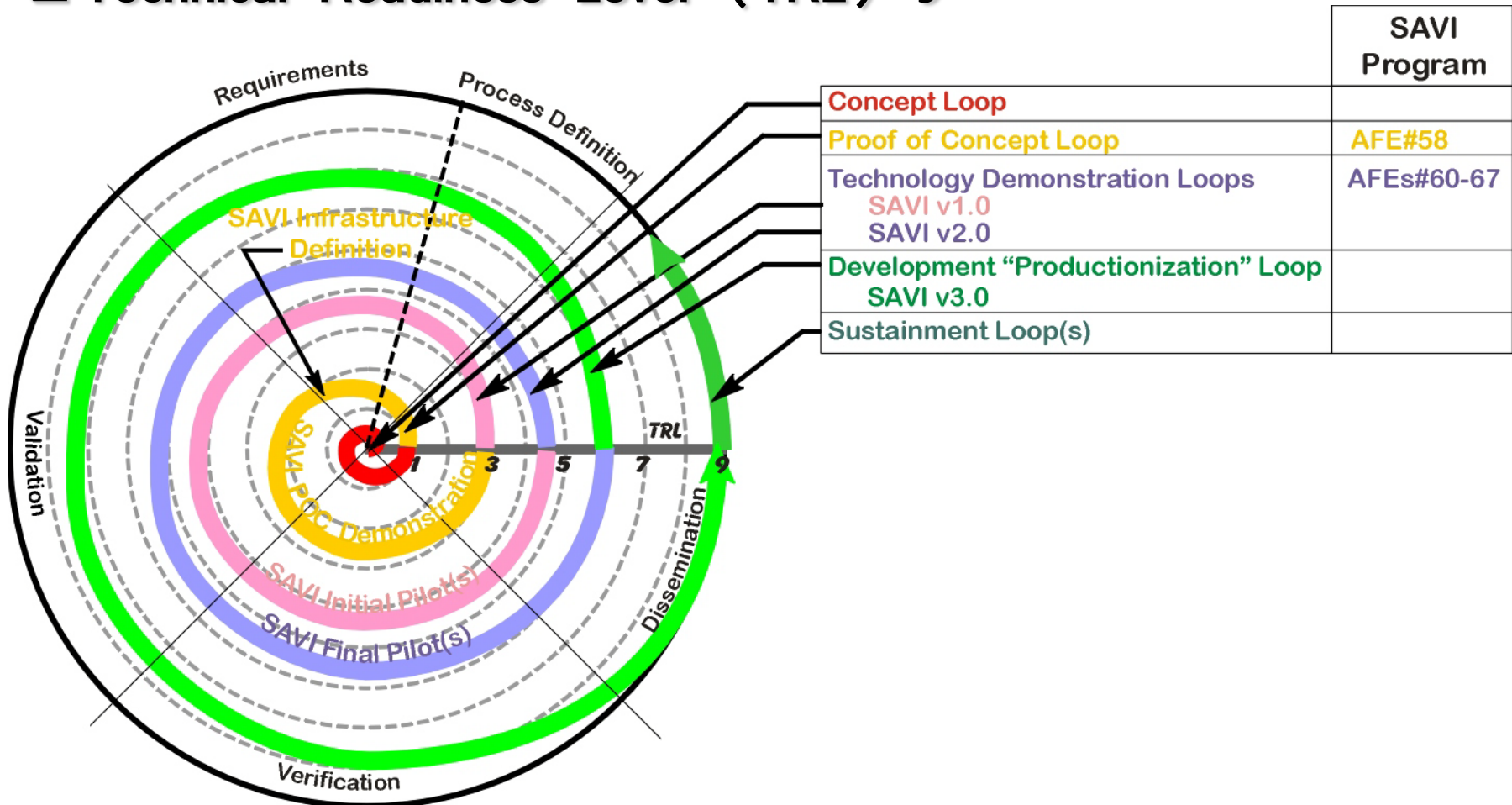
SAVI Development Roadmap

2009	2010	2011	2012	2013	2014	2015	2016

SAVI PROJECT

SAVI Process description v1.0

Model Bus & Model Repository Specs

ADL Selected

SAVI Process description v1.1

Model Bus & Model Repository Specs v2.0

AFE 58   AFE 59

SAVI DEPLOYMENT

SAVI Tools pre-implementation

SAVI Tools & Process

Models	Encapsulation	ADL based & Multi-level	Full SAVI systems scope
Interfaces	Functional	Functional & types	Aircraft signals
Requirements	Functional at model level	Func. at ADL component	
Architectural model	Interfaces & existing models	Full data	
Configuration mgt.	Version mgt	Full services	
Documentation prod.	Basic production	Full internal prod.	Full external prod.
Repository MMI	ADL visualization	Analysis & Simul. Integ.	
I/O services	ADL & models exchanges	IP / security / IS integ.	
Analysis tools	Safety, functions, weight	Performances analyses	Full analyses
Simulation tools	Simulation app. gen.	Full simulation capabilities	

SAVI v1.0   SAVI v2.0   SAVI v3.0

COMMUNICATION

Partial Supply Chain integration (SAVI partners)   Full supply chain integration

Tools Vendors (partners)   Tools Vendors Integration

AIRCRAFT APPLICATIONS

Airframer Suppliers

Architecture design   Prelim. system design   Aircraft program

SAVI partners   All suppliers

Questions?

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Dr. Don Ward   （254）842-5021,（903）818-3381

SAVIPM@dishmail.net