

AADL Overview and Perspectives

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Safety Critical Embedded Software System Challenge

SAE AADL Standard and Virtual System Integration to the Rescue

Embedded Software System Qualification and Assurance

The Safety Critical Embedded Software System Challenge

Problem:

Software increasingly dominates safety and mission critical system development cost.

80% of issues discovered post unit test.

Solution: Early discovery of system level issues through virtual Integration and incremental analytical assurance.

Approach:

International standard based technology matured into practice through pilot projects and industry initiatives.

Open source research prototyping platform continually enhances analysis, verification, and generation capabilities.

Reduced Defect Leakage through Early Analytical Assurance is Critical



We Rely on Software for Safe System Operation

Quantas Airbus A330-300 Forced to make Emergency Landing - 36 Injured

Written by htbw on Oct-7-08 1:48pm

From: soyawannaknow.blogspot.com



Thirty-six passengers and crew were injured in a mid-air drama that forced a Qantas Airbus A330-300 to make an emergency landing, the Australian carrier said Tuesday.

The terrifying incident saw the Airbus A330-300 make a mayday call when it suddenly changed course from Singapore to Perth, Qantas said.

from Singapore to Perth, Qantas said.

Australian Transport Safety Bureau said yesterday. The plane fell 650 feet within seconds, slamming passengers and crew against the ceiling, before the pilots regained control.

"This appears to be a unique event," the bureau said, adding that the Toulouse, France-based Airbus, the world's largest maker of aircraft, issued a telex late yesterday to airlines that fly A330-300s and A350-900s fitted with the same air-data computer. The advisory is "aimed at minimizing the risk in the unlikely event of a similar occurrence."

Two Crashes In Five Months

What's Wrong with Boeing's 737 Max 8?

Boeing's new airplane has only been around for two years and already two 737 Max 8s have crashed, killing 346 people. The disasters may be attributable to a design flaw that emerged when engineers began cutting corners.

Boeing's Max 8 is short, limiting ground clearance under the wings. The engine simply doesn't fit.

FAA says software problem with Boeing 787s could be catastrophic

By **Dan Catchpole**

[@dcatchpole](https://twitter.com/dcatchpole)

The Federal Aviation Administration says a software problem with Boeing 787 Dreamliners could lead to one of the advanced jetliners losing electrical power in flight, which could lead to loss of control.

The Buzz: Hipster's dilemma

Boeing & aerospace news

Aerospace blog

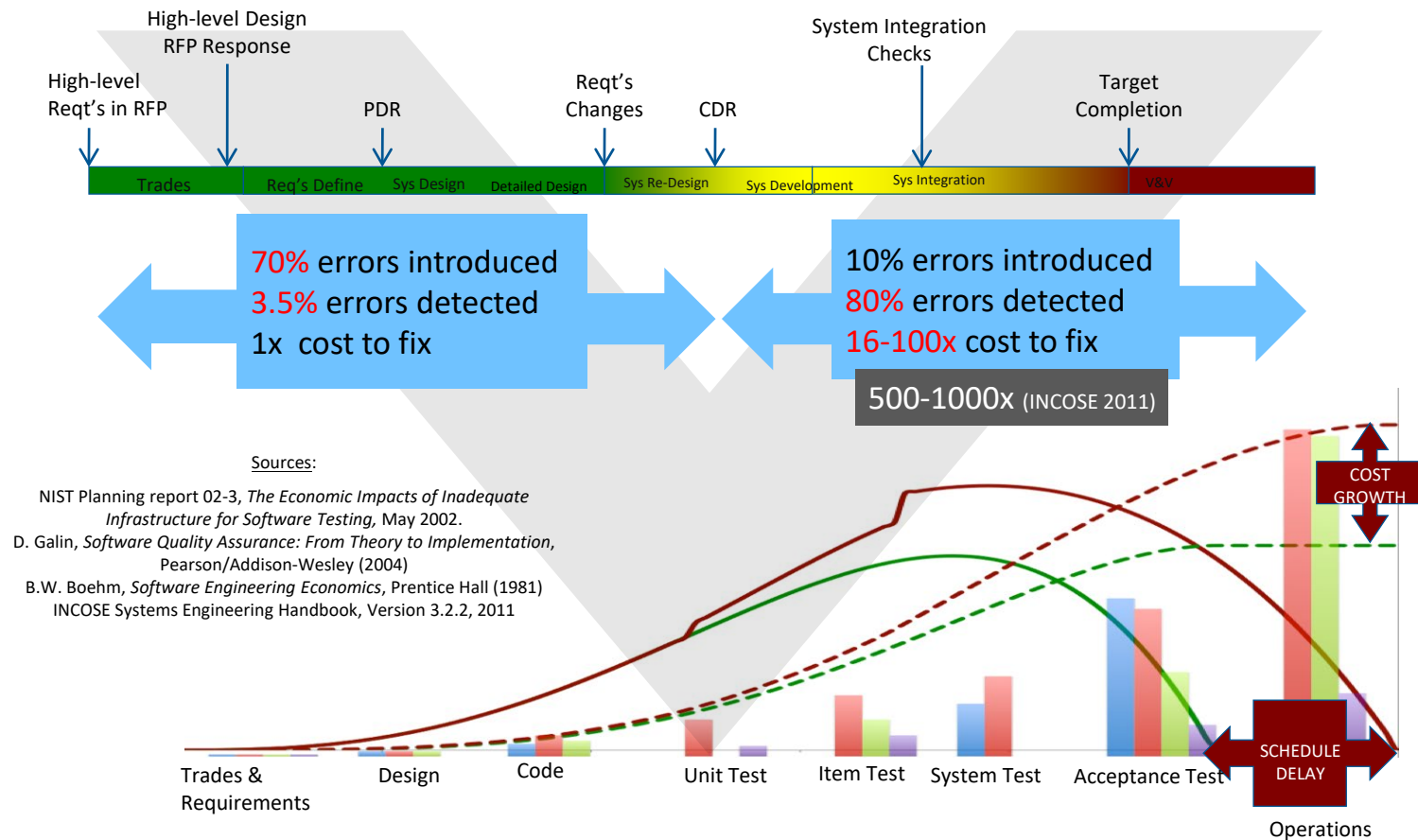
The FAA notified operators of the airplane Friday that if a 787 is powered continuously for 248 days, the plane will automatically shut down its alternating current (AC) electrical power.

Embedded software systems introduce a new class of problems not addressed by traditional system safety analysis

Breakdown in human intensive safety assessment process



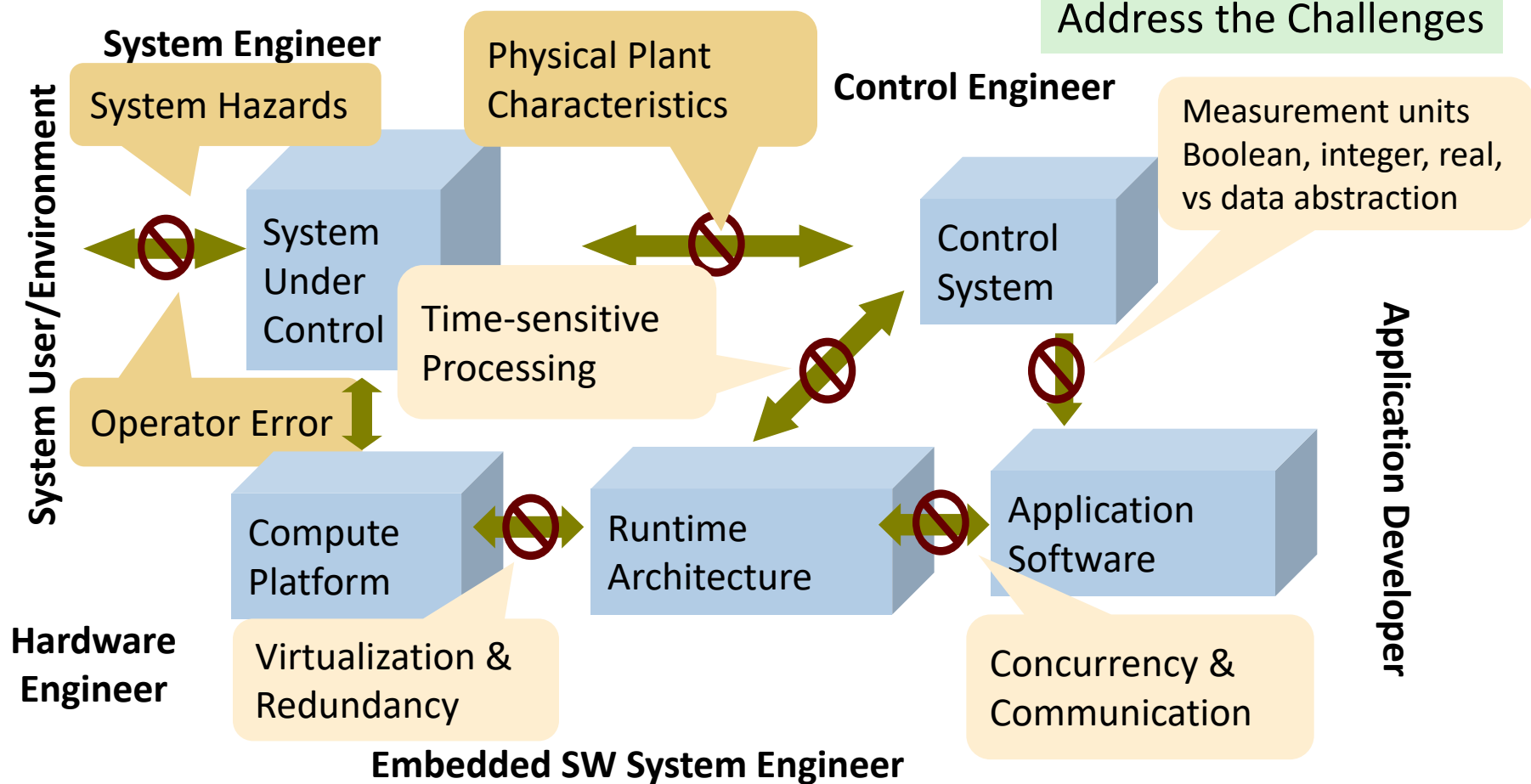
Current Practice: Impact on Cost and Schedule



Software as % of total system development cost
1997: 45% → 2010: 66% → 2024: 88%

Post unit test software rework currently
~50% of total system development cost

Technical Challenges in Safety-Critical Embedded Software Systems



Why do system level failures still occur despite best safety practices?

*Embedded software systems have become a major **safety** and **cyber security** risk*

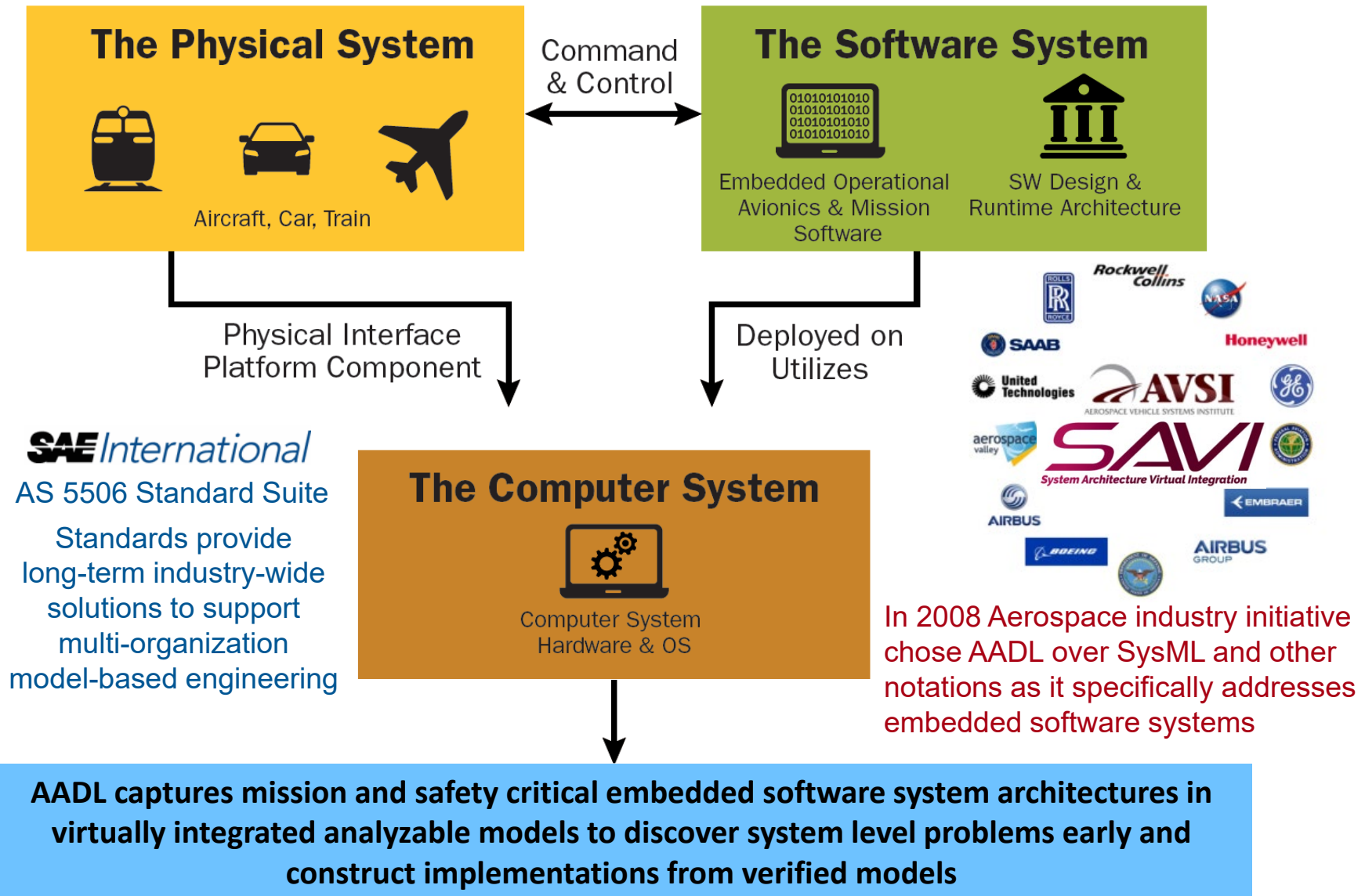
Safety Critical Embedded Software System Challenge

**SAE AADL Standard and Virtual System
Integration to the Rescue**

**Embedded Software System Qualification
and Assurance**



Architecture Analysis & Design Language (AADL) Standard Targets Embedded Software Systems



SAE *International* AADL Standard Suite (AS-5506 series)

Core AADL language standard [V1 2004, V2 2012, V2.2 2017]

- Focused on embedded software system modeling, analysis, and generation
- Strongly typed language with well-defined semantics for execution of threads, processes on partitions and processor, sampled/queued communication, modes, end to end flows
- Textual and graphical notation
- Revision V3 in progress: interface composition, system configuration, binding, type system unification

Standardized AADL Annex Extensions

- Error Model language for safety, reliability, security analysis [2006, 2015]
- ARINC653 extension for partitioned architectures [2011, 2015]
- Behavior Specification Language for modes and interaction behavior [2011, 2017]
- Data Modeling extension for interfacing with data models (UML, ASN.1, ...) [2011]
- AADL Runtime System & Code Generation [2006, 2015]

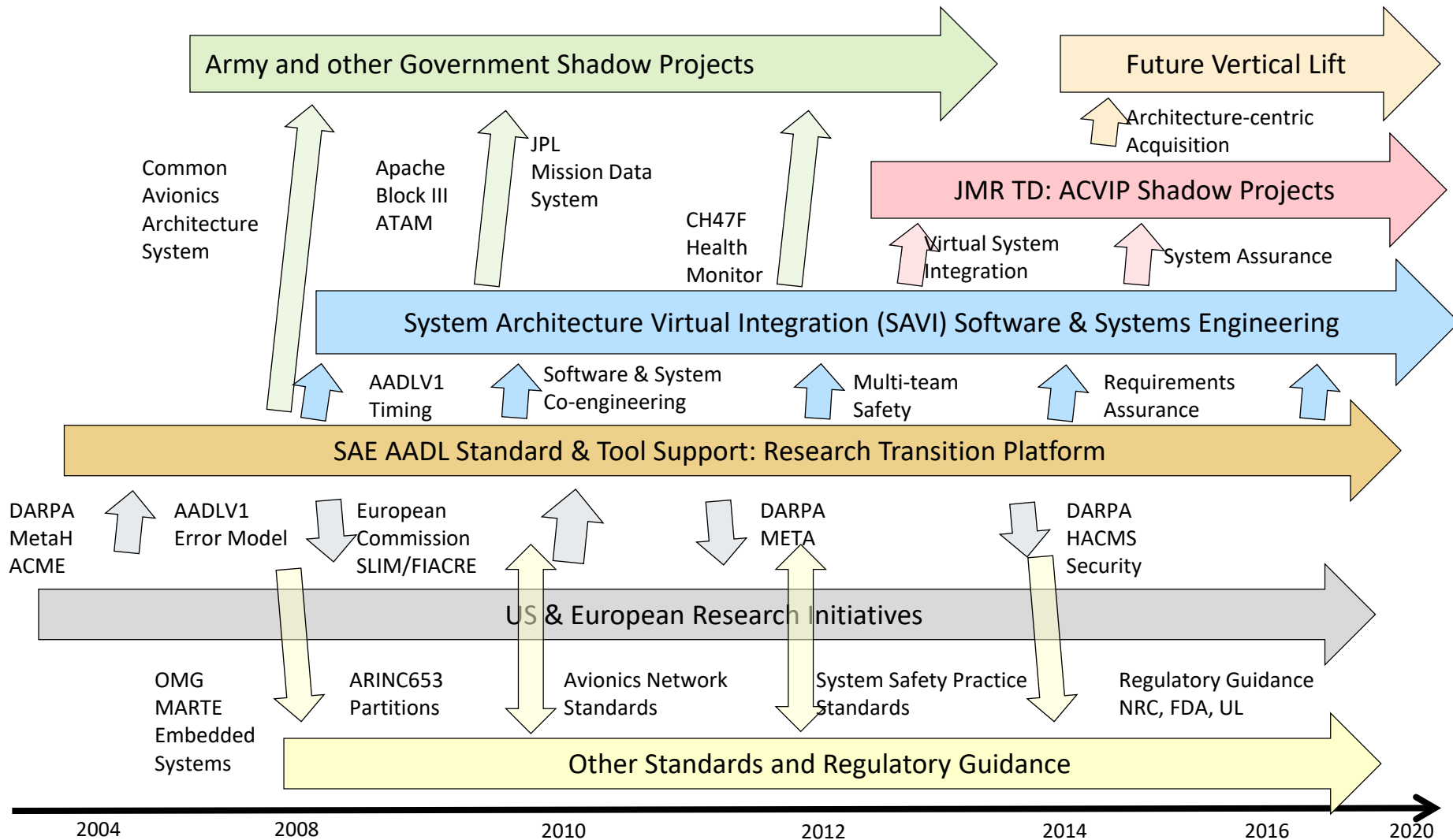
AADL Annexes in Progress

- Network Specification Annex
- Cyber Security Annex
- FACE Annex
- Requirements Definition and Assurance Annex
- Synchronous System Specification Annex

SAE AADL & Architecture-centric Virtual Integration

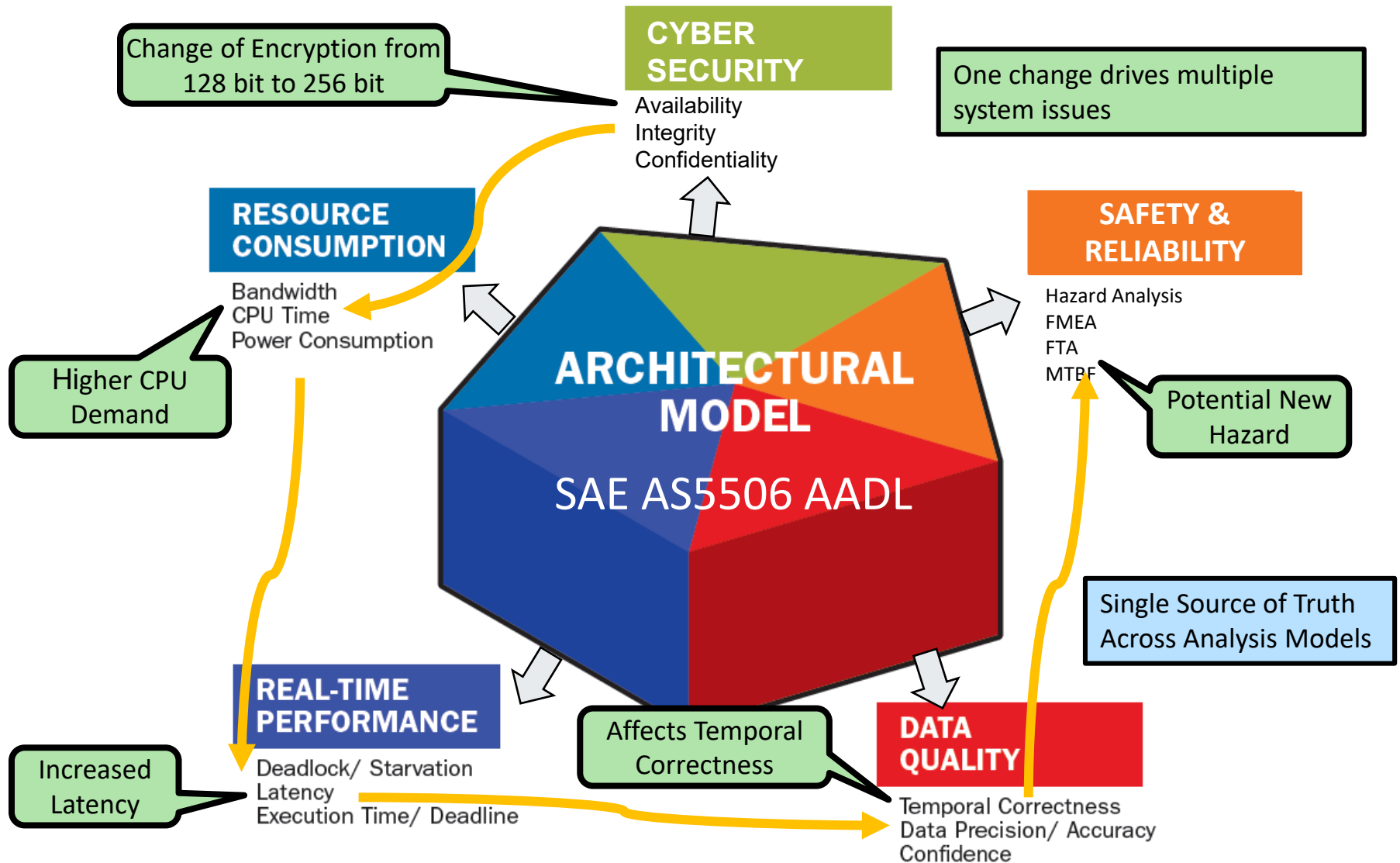
Evolution, Maturation and Transition

AMRDEC has funded AADL standards development since 1999



Analysis of System Properties via Architecture Model

A Contribution to Single Source of Truth



Latency and Jitter Contributors

Control System Engineering View

Processing latency

Sampling latency

Physical signal latency

Software System Latency Contributors

Execution time variation: algorithm, use of cache

Processor speed

Resource contention

Preemption

Legacy & shared variable communication

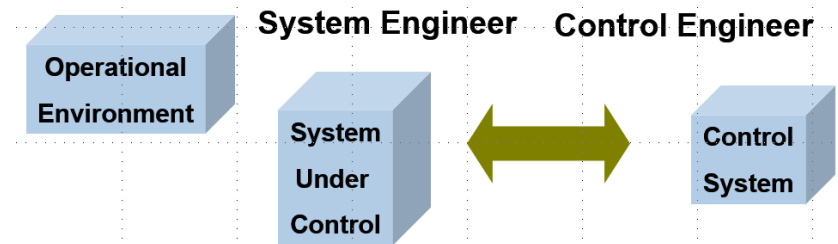
Rate group optimization

Protocol specific communication delay

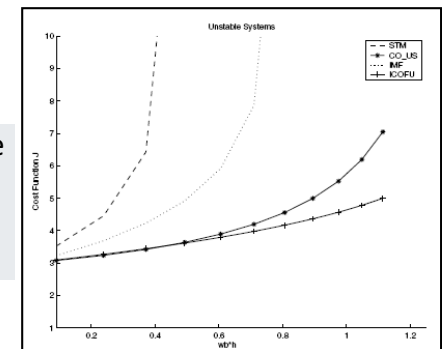
Partitioned architecture

Migration of functionality

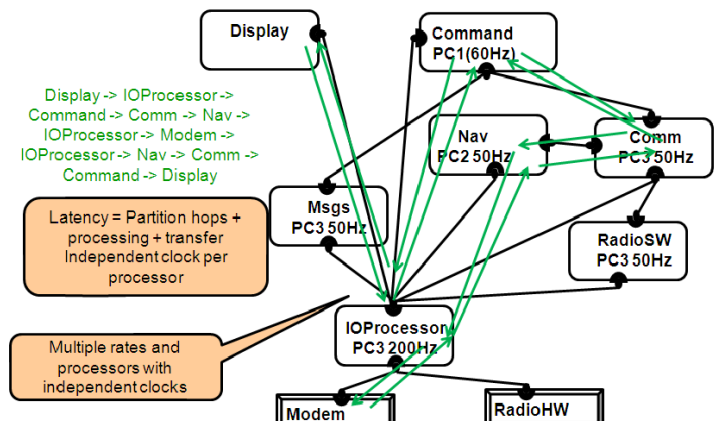
Fault tolerance mechanisms



Impact of Scheduler Choice
on Controller Stability
A. Cervin, Lund U.
CCACSD 2006



Flow Use Scenario through Subsystem Architecture



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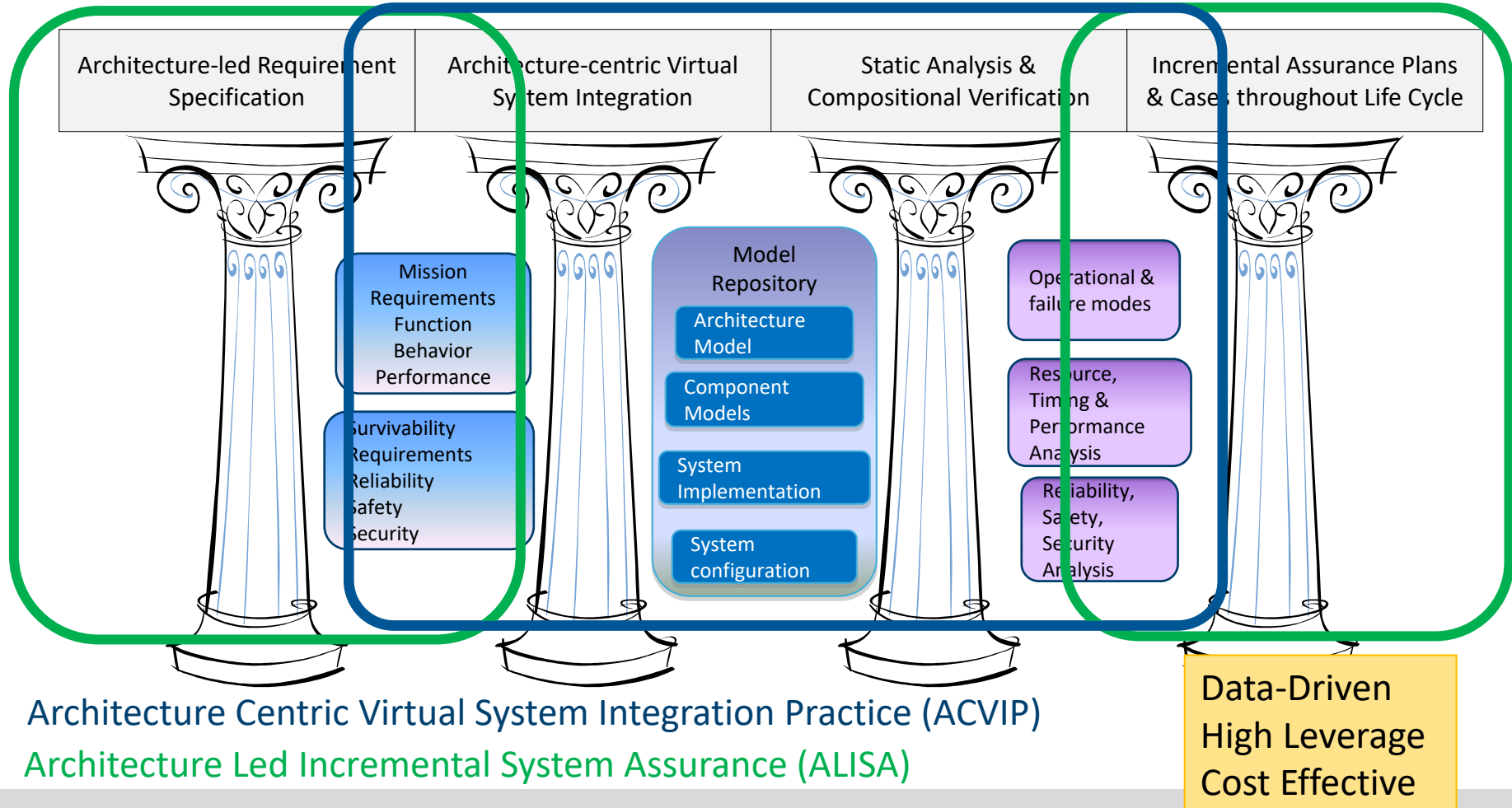


Assurance & Qualification Improvement Strategy



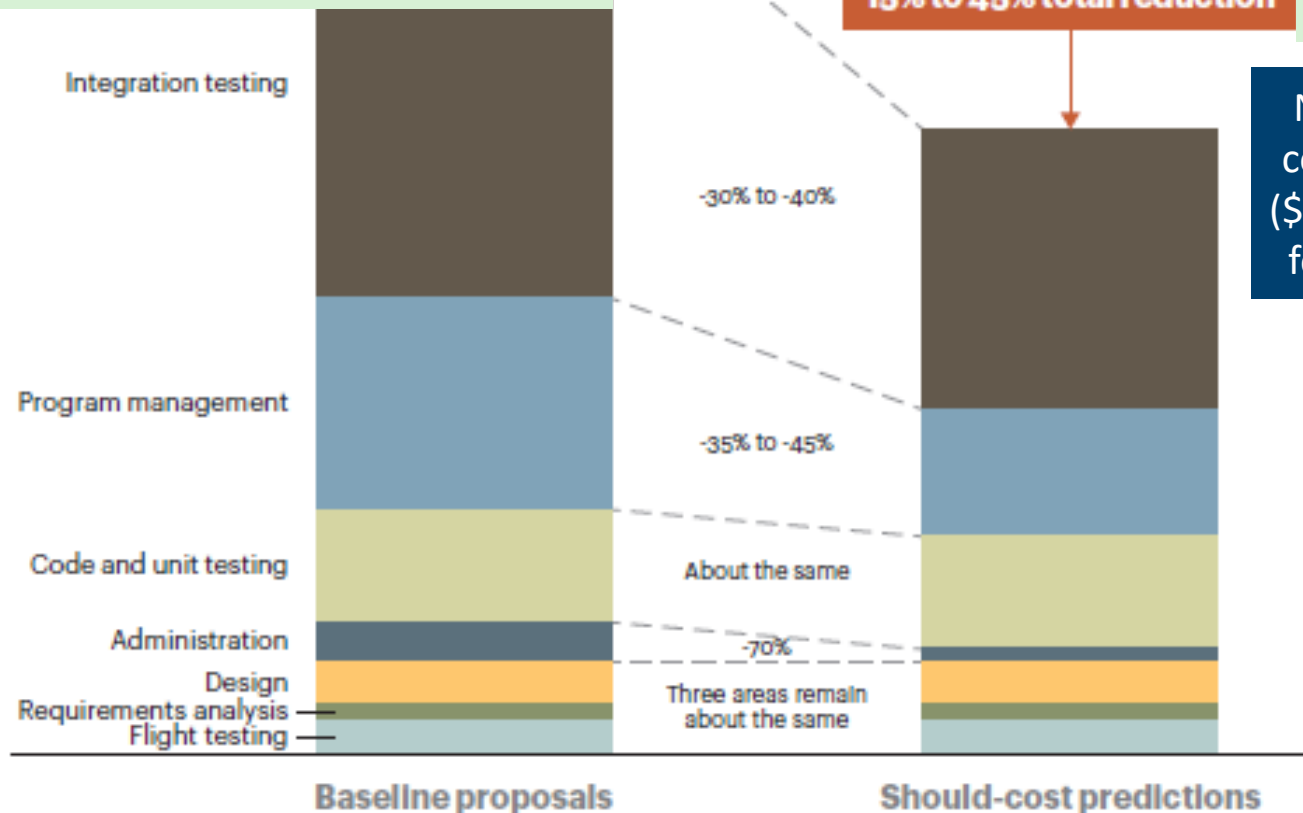
Assurance: Sufficient evidence that a system implementation meets system requirements

2010 SEI Study for AMRDEC
Aviation Engineering Directorate



Cost Reduction Potential through Virtual Integration of Embedded Software Systems

Reduction through Focus on Verification of Architecture



ROI on AADL Pilot

Nominal development cost reduction of 26.1% (\$2.391B out of \$9.186B) for a 27 MSLOC system

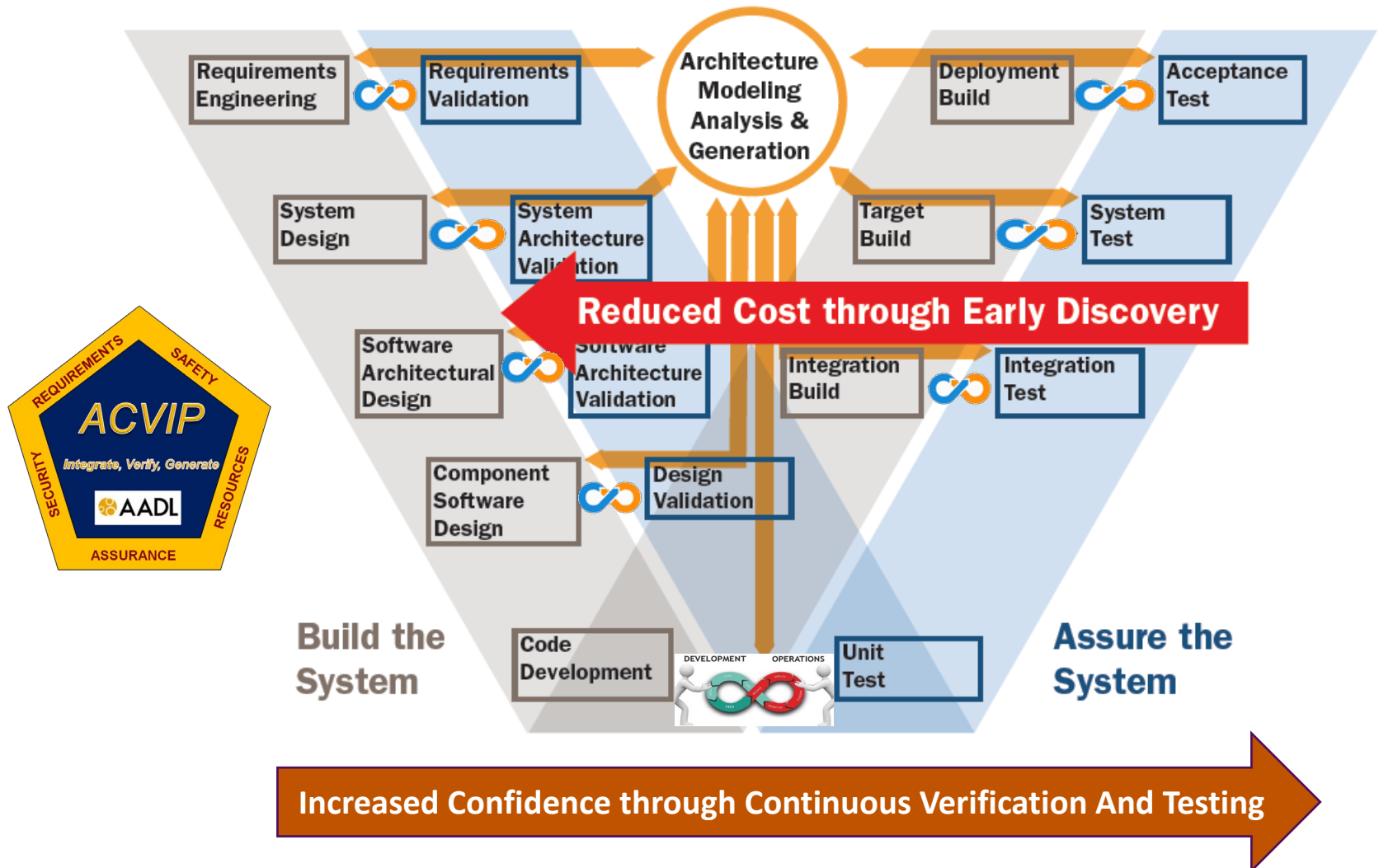
Source: *ROI Analysis of the System Architecture Virtual Integration Initiative*
CMU/SEI-2018-TR-002



AT Kearney "Software: The Brains Behind U.S. Defense Systems"



Benefits of Virtual System Integration & Continuous Lifecycle Assurance



Summary

Safety Critical Embedded Software Systems are facing exponential growth in software development cost exceeding 70% of total system development cost.

AADL is basis for a set of technologies and practices that specifically have been designed to provide early detection and continuous verification throughout the life cycle.

A number of case studies and pilot projects by different organizations have demonstrated the benefit of virtual system integration with AADL.