

SAE AEROSPACE SYSTEMS AND TECHNOLOGY CONFERENCE

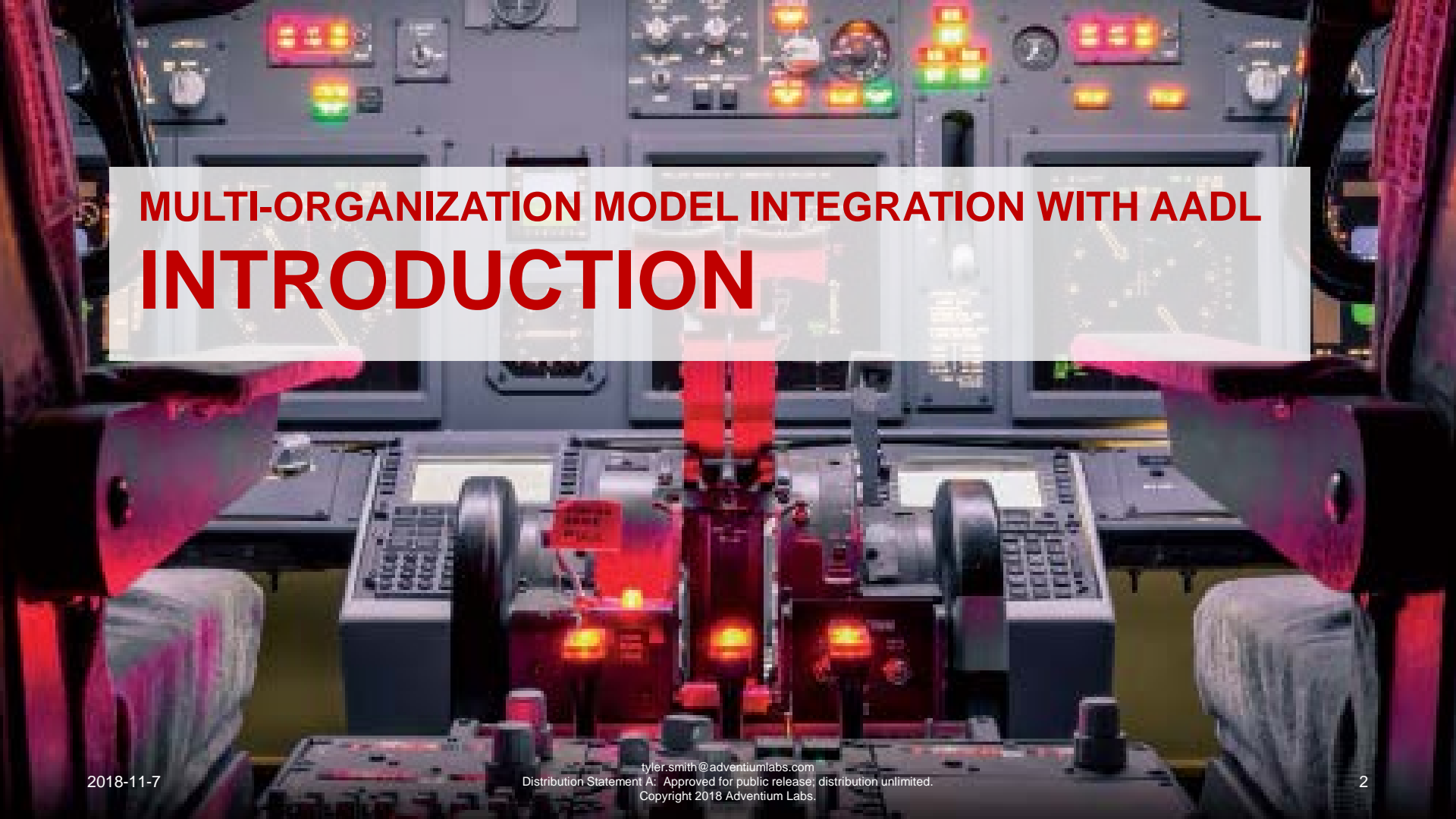
MULTI-ORGANIZATION MODEL INTEGRATION WITH AADL

Tyler D. Smith

Co-Authors: Dr. Rob Edman, Rand Whillock, Bruce Lewis, Dr. Steve Vestal
Adventium Labs

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MULTI-ORGANIZATION MODEL INTEGRATION WITH AADL INTRODUCTION

OUTLINE

- Key Takeaways
- About Adventium Labs
- Research Question
- Approach
- Architecture
- Methodology
- Results
- Lessons Learned
- Summary

KEY TAKEAWAYS

Software engineering practices like test driven development add value to multi-organization model integration.

Continuous Virtual Integration (CVI) used as part of the procurement and project management processes allows managers to monitor the progress of the project and understand tradeoffs and work status.

Model Based Systems Engineering (MBSE) allows preservation of Intellectual Property.

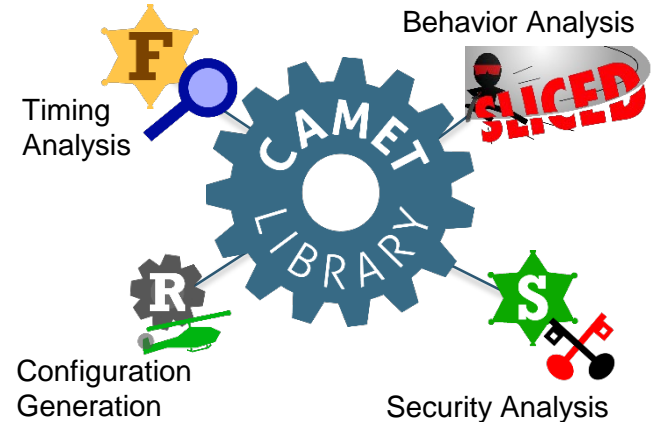
ABOUT ADVENTIUM LABS

Adventium Labs

- Adventium has extensive experience in cyber security, systems engineering, and automated reasoning.
- Adventium's Bruce Lewis is the chair of the AADL Standards Committee.
- Authors of the AADL Annex for the FACE Technical Standard.

U.S. Army AMRDEC

- Work done in conjunction with U.S. Army AMRDEC Joint Multi-Role Mission System Architecture Demonstration (JMR MSAD).



ARCHITECTURE CENTRIC VIRTUAL INTEGRATION PROCESS

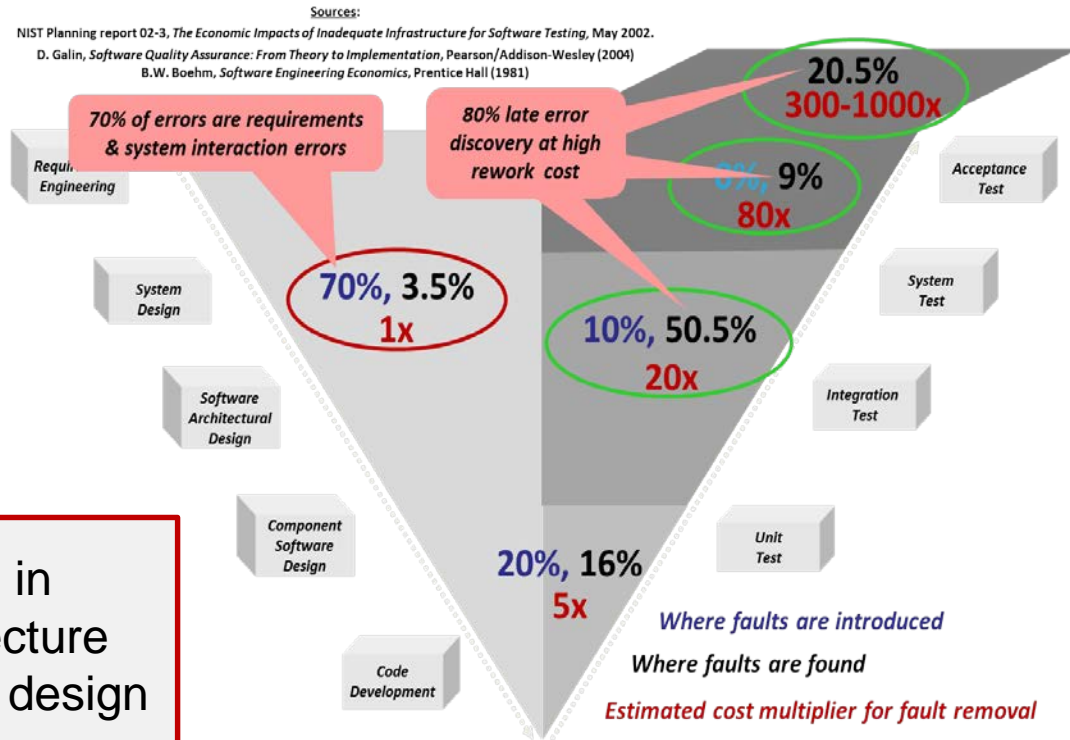
Costly defects are


- Introduced early.
- Detected late.
- Expensive to repair.

Often “repaired” by

- Reducing capabilities.
- Increasing ownership cost.

Expensive defects are in requirements and architecture specifications, not detailed design or code

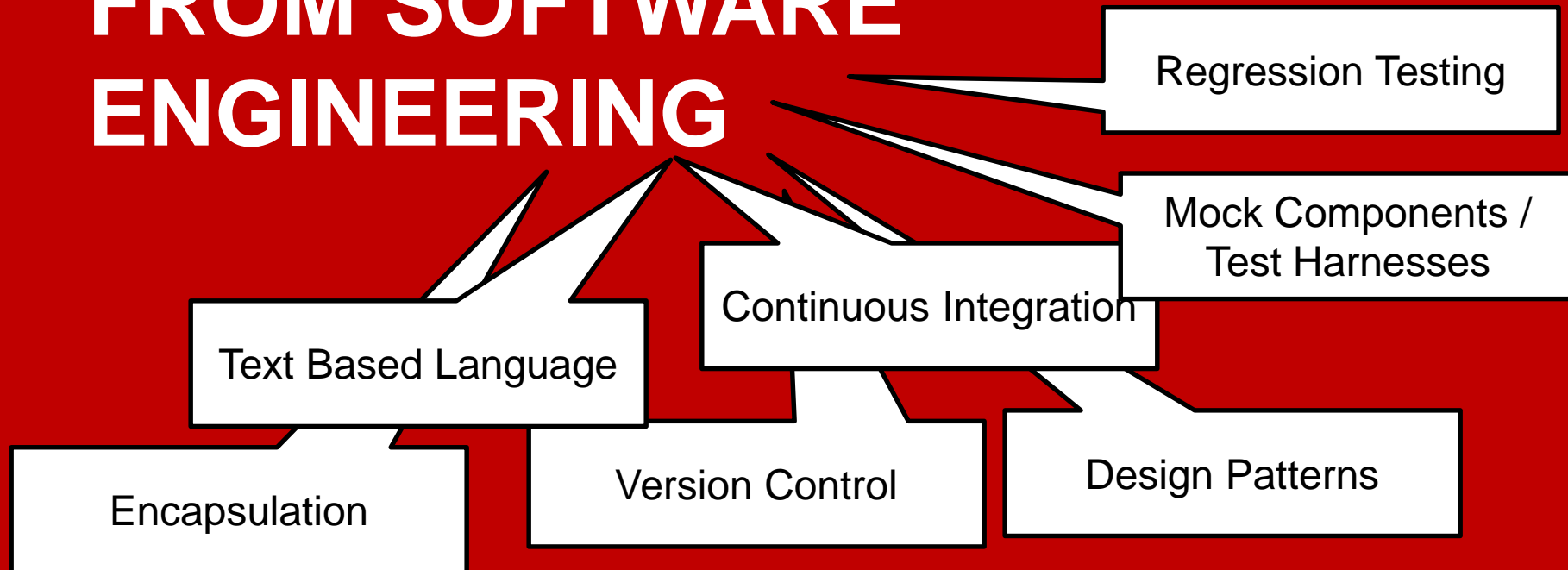




MULTI-ORGANIZATION MODEL INTEGRATION WITH AADL RESEARCH QUESTION

WILL PRACTICES ADOPTED FROM SOFTWARE ENGINEERING ADD VALUE TO INTER-ORGANIZATION MODEL-BASED SYSTEMS ENGINEERING?

WILL PRACTICES ADOPTED FROM SOFTWARE ENGINEERING



Intellectual Property
Protection

Requirements
Communication

Trade Analysis

INTER-ORGANIZATION MODEL-BASED SYSTEMS ENGINEERING?

Cost

Maintainability

ADD VALUE

Schedule

Model Reuse

PROJECT OBJECTIVES

Demonstrate application of software engineering practices to multi-organization model integration, e.g.

- Version controlled repositories
- Test driven development
- Continuous integration
- Automated analysis and reporting

Document modeling patterns for IP protection.

Determine the effect of IP protection modeling patterns on analysis.

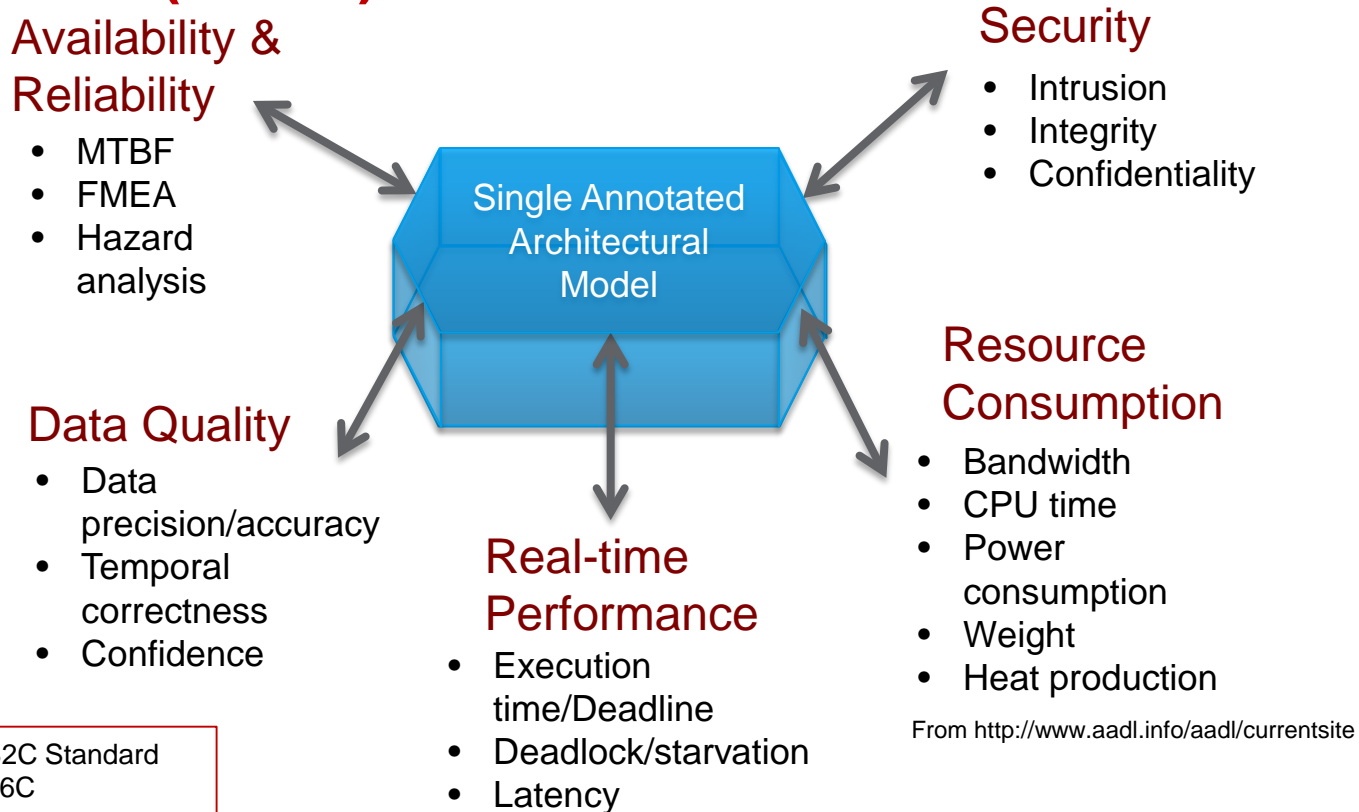
Exercise and validate tools for Architecture Centric Virtual Integration Process (ACVIP).

- Continuous Virtual Integration Toolkit (CVIT)
- Open Source AADL Tool Environment (OSATE)



MULTI-ORGANIZATION MODEL INTEGRATION WITH AADL APPROACH

SAE STD. ARCHITECTURE ANALYSIS & DESIGN LANGUAGE (AADL)



SCENARIO

The MSI is charged with updating an existing airborne mission system. As the system integrator, the MSI has existing models of the system that are proprietary. The customer is funding the integration process and determines the schedule and design artifacts that must be generated by the MSI. The customer funds the ASoT provider to manage system models for the MSI, supplier, and Customer.

Customer

Sets schedule and review requirements.

Authoritative Source of Truth (ASoT) Provider

Manages model repositories and continuous integration.

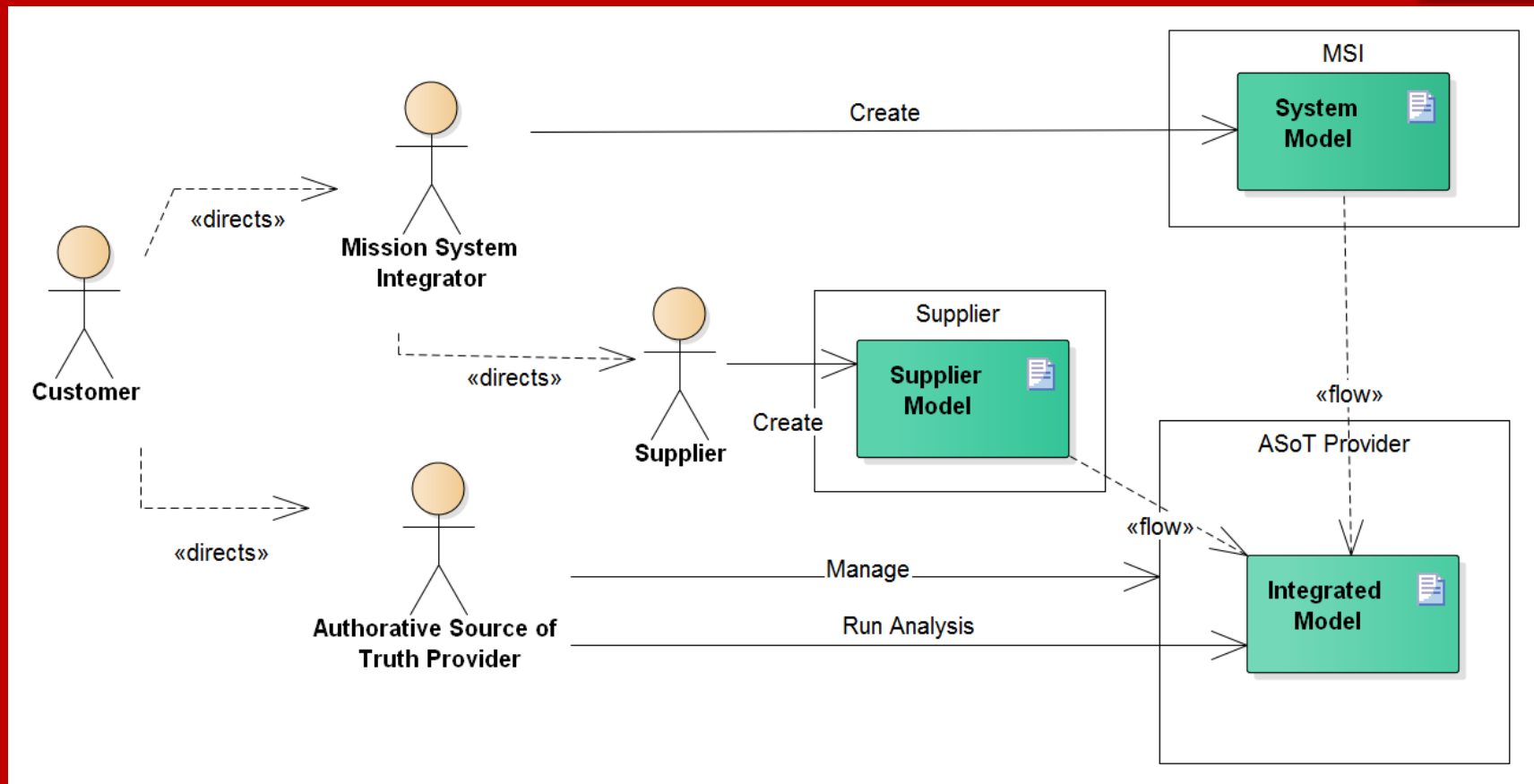
Mission System Integrator (MSI)

Creates an MSI system model.

Supplier

Provides a GPS component model to integrate.

MODEL EXCHANGE



STAKEHOLDER CONCERNS

Mission System Integrator (MSI)

- Deliver working system.
- Protect intellectual property.
- Minimize duplicate engineering effort.

Supplier

- Meet MSI hardware and software requirements.

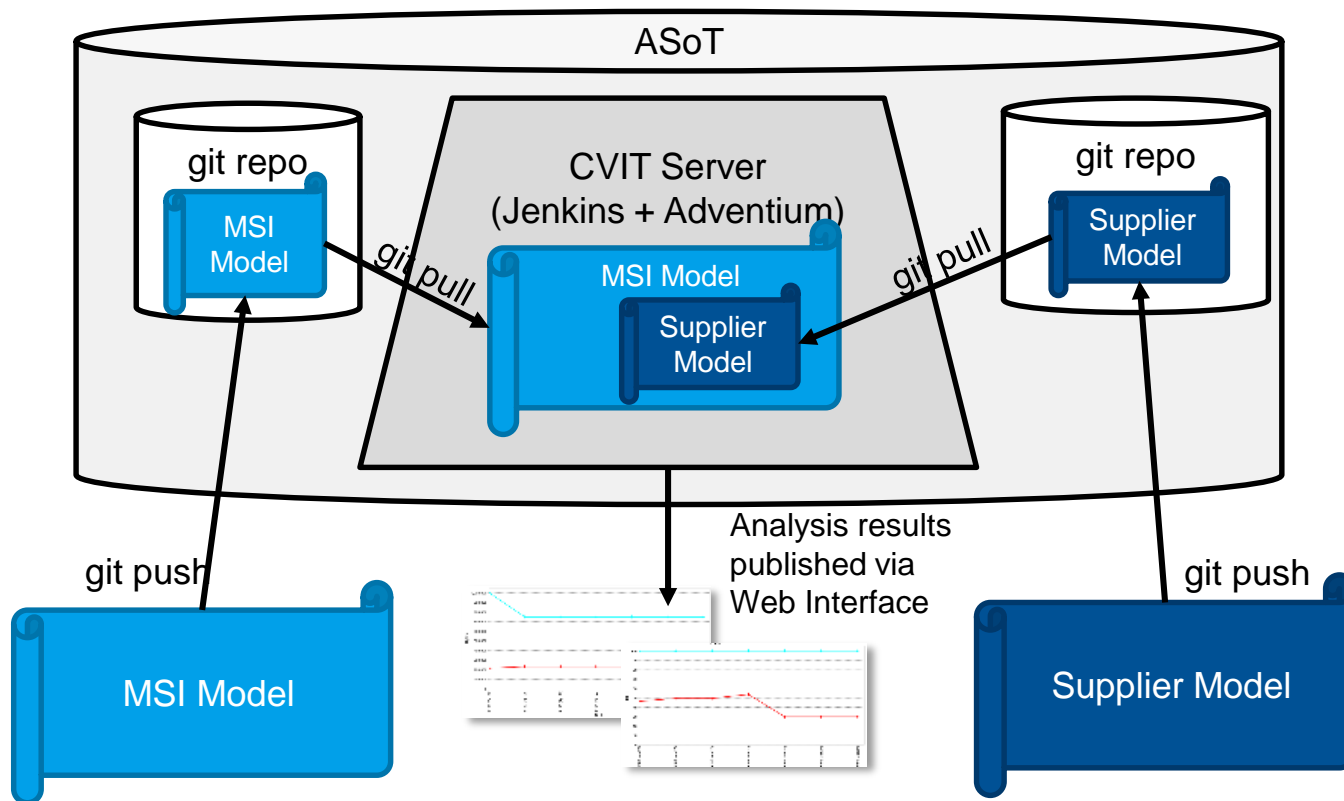
MSI's Customer

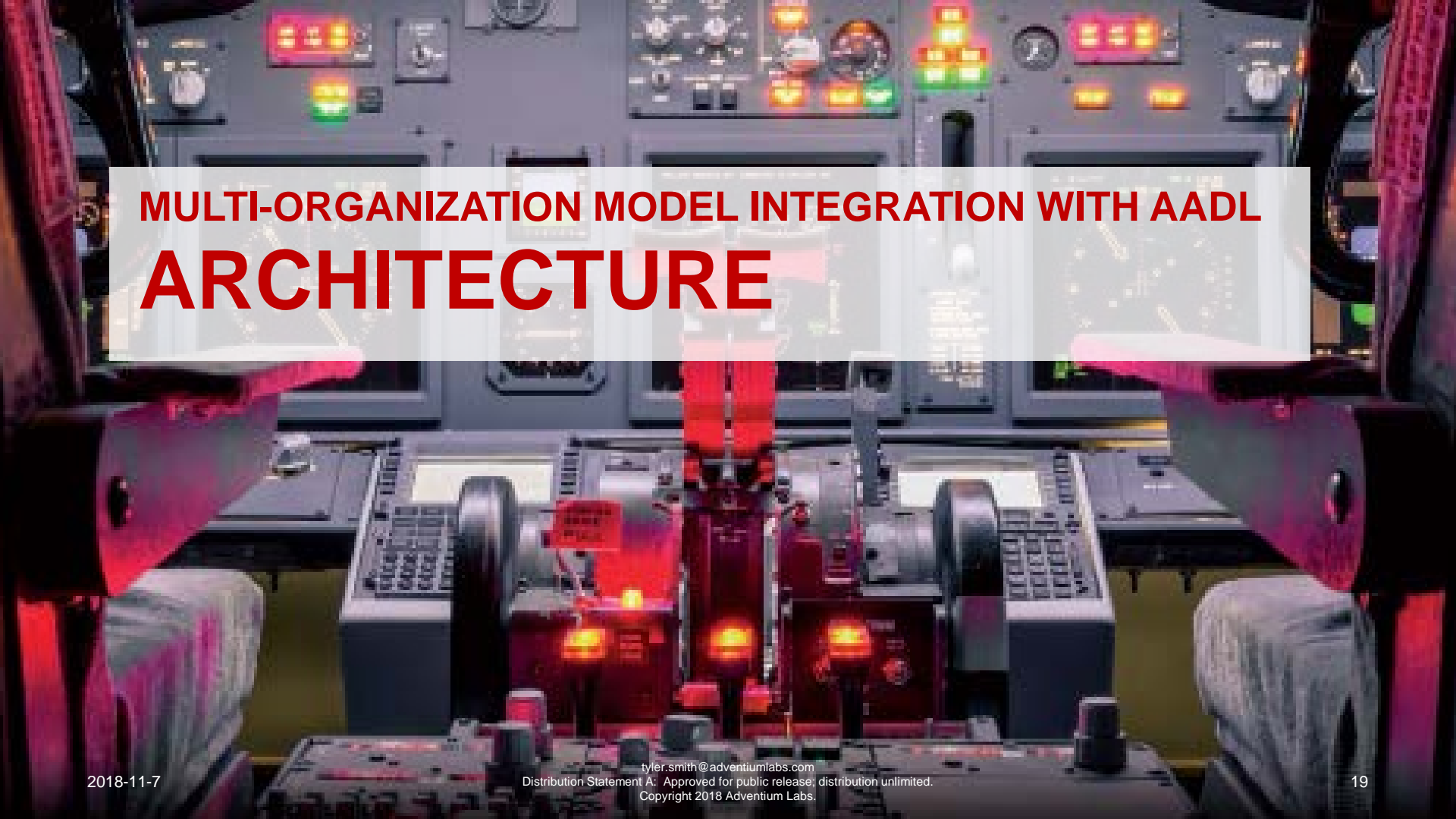
- Meet schedule and cost goals.
- Completed system meets functional and non-functional requirements.

ASoT Provider

- Provide necessary data access to all parties.
- Limit unnecessary data access.

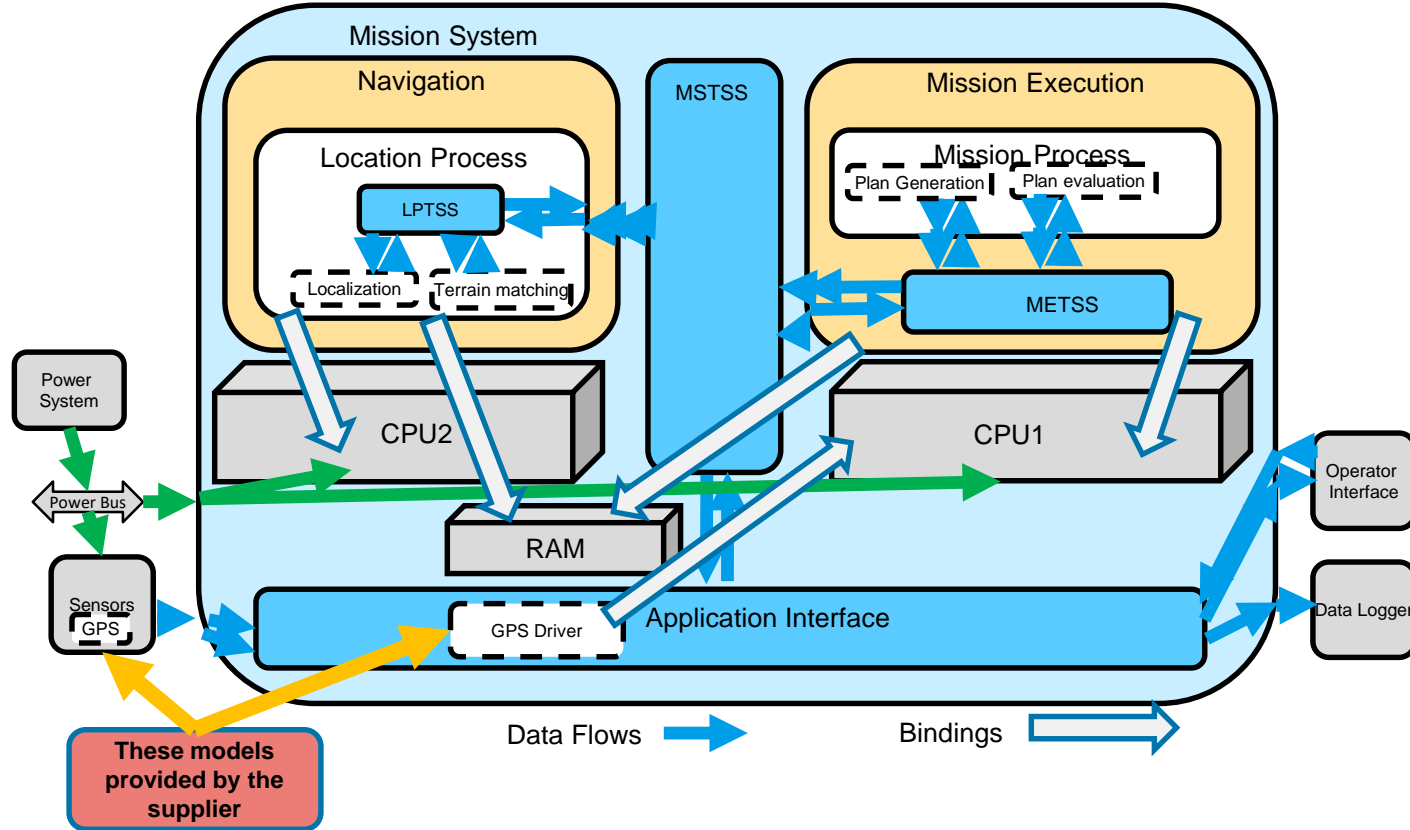
CONTINUOUS VIRTUAL INTEGRATION





MULTI-ORGANIZATION MODEL INTEGRATION WITH AADL ARCHITECTURE

MSI SYSTEM MODEL



SUPPLIER PROVIDES

The supplier shall provide a blackbox integration model of the IMU/GPS and its software describing:

- Mass
- Power Requirements
- Data Connections
- Software properties
 - CPU requirements
 - RAM requirements
 - Timing requirements

MSI PROVIDES

Generic Template of desired device model

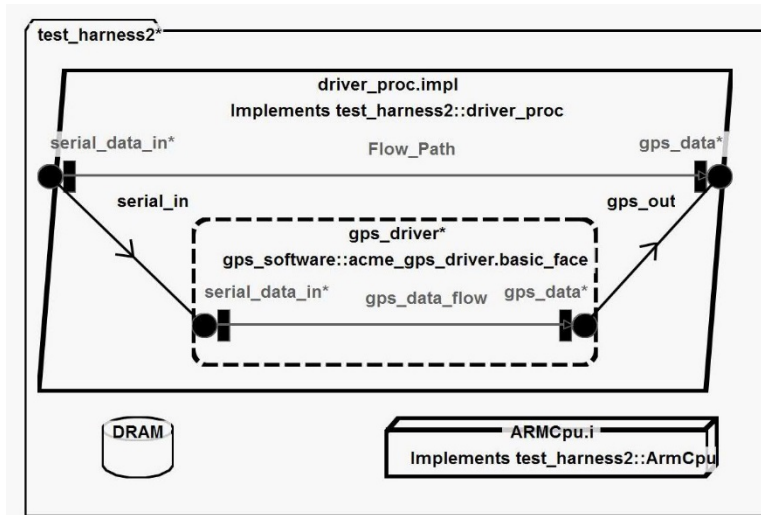
- Defines input and output ports

Test harness

- Data Path Names
- Error Types
- Error Path Names
- Budget requirements
- Weight, power usage, latency, CPU usage, RAM usage

Additional Model Elements

- Additional models elements required for context
- Definition of power bus





MULTI-ORGANIZATION MODEL INTEGRATION WITH AADL METHODOLOGY

MODEL-BASED ANALYSES

System Requirements Review (SRR)

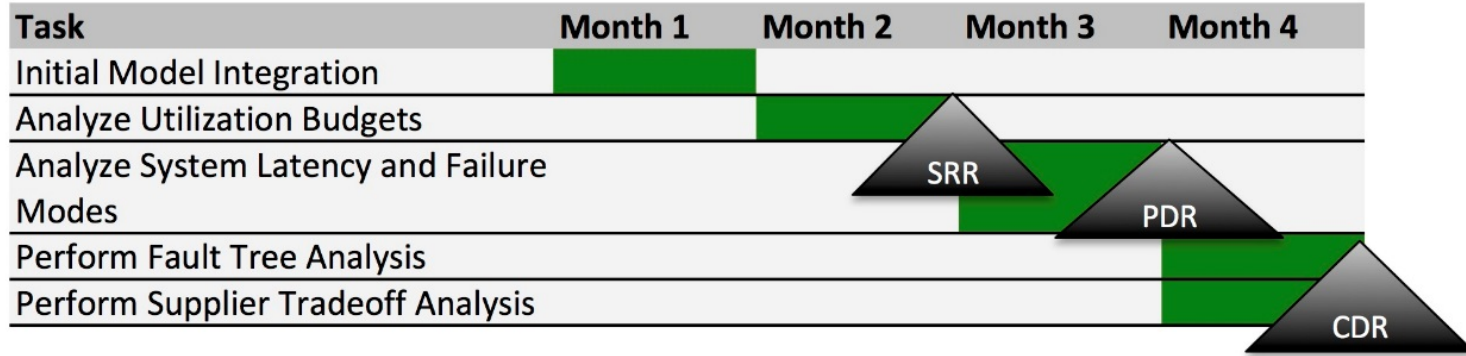
- Utilization
- Power
- Mass
- Blackbox latency

Preliminary Design Review (PDR)

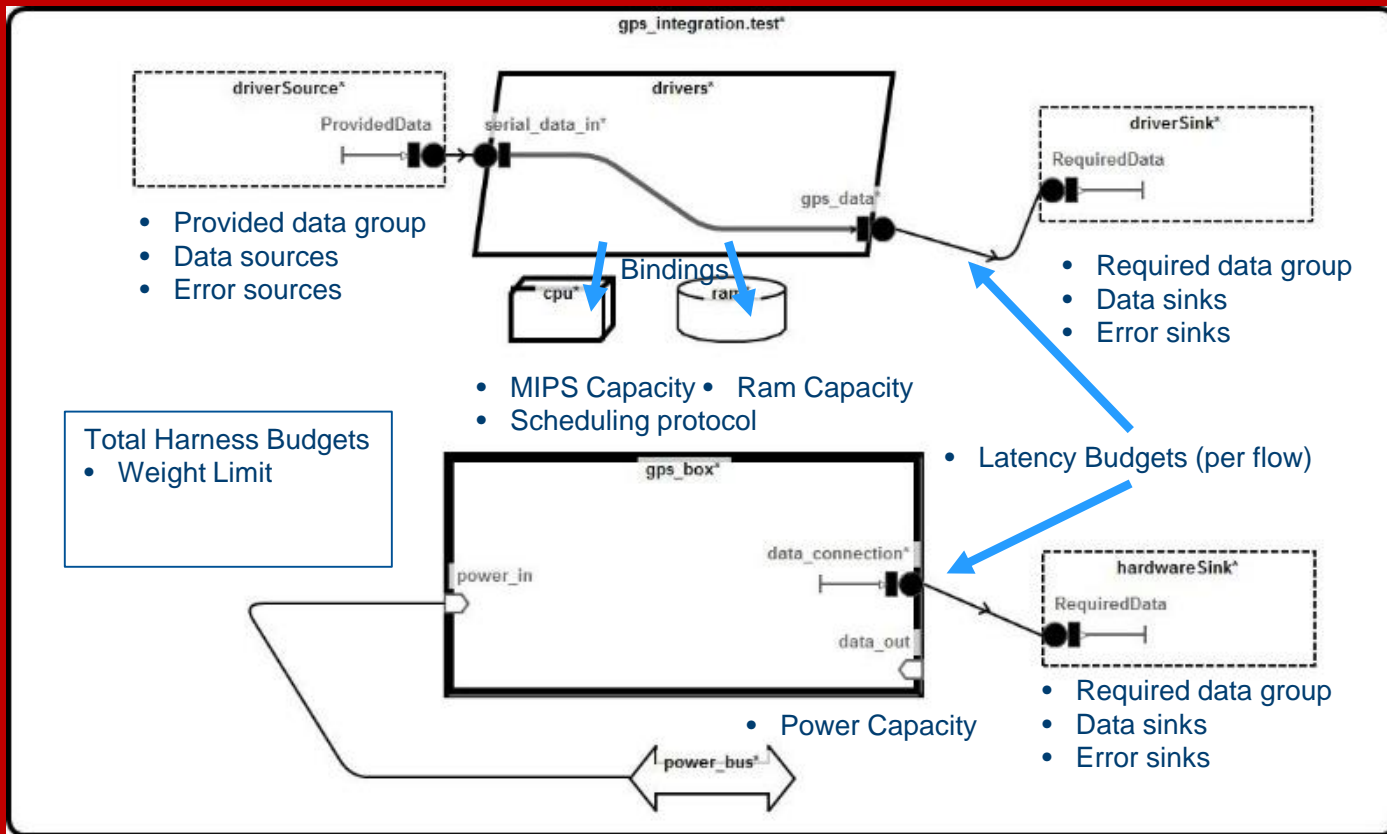
- Failure modes
- White box latency
- Schedulability

Critical Design Review (CDR)

- Fault tree
- Design trade



REQUIREMENTS CONTAINED IN TEST HARNESS

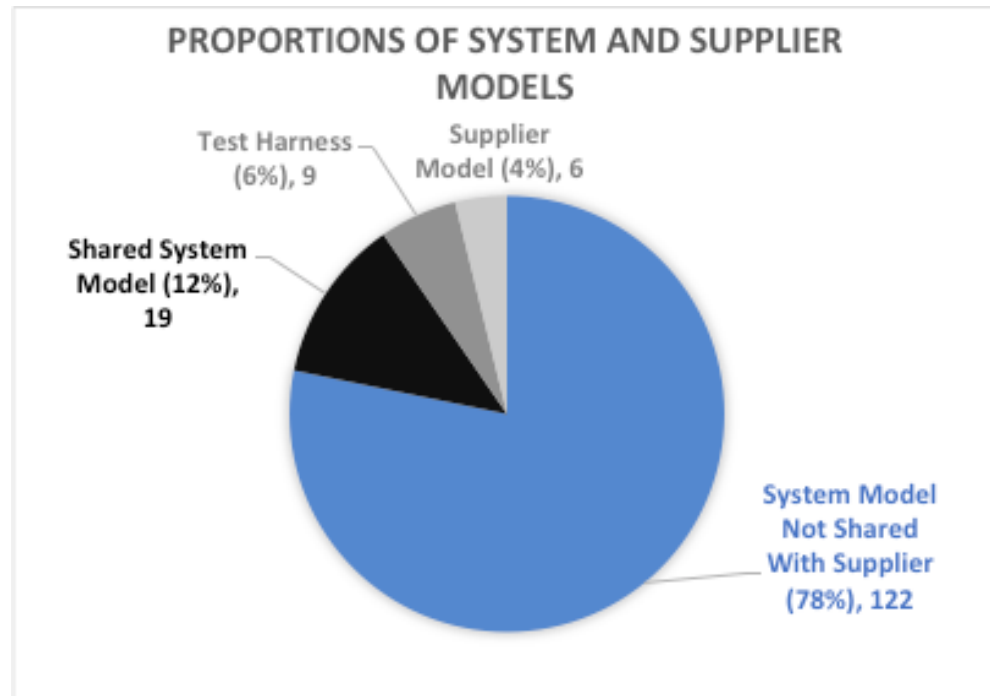




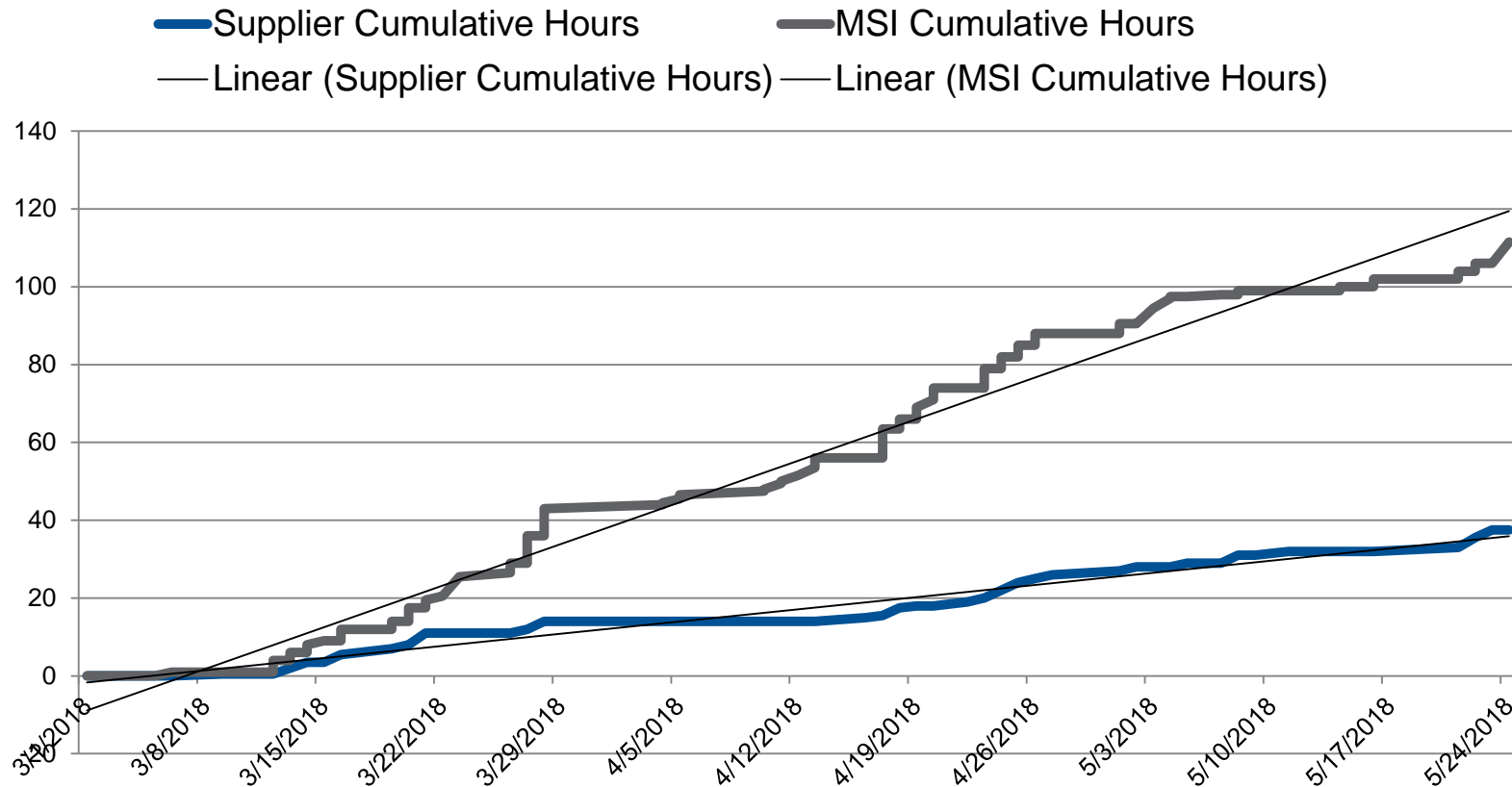
MULTI-ORGANIZATION MODEL INTEGRATION WITH AADL RESULTS

DATA ACCESS

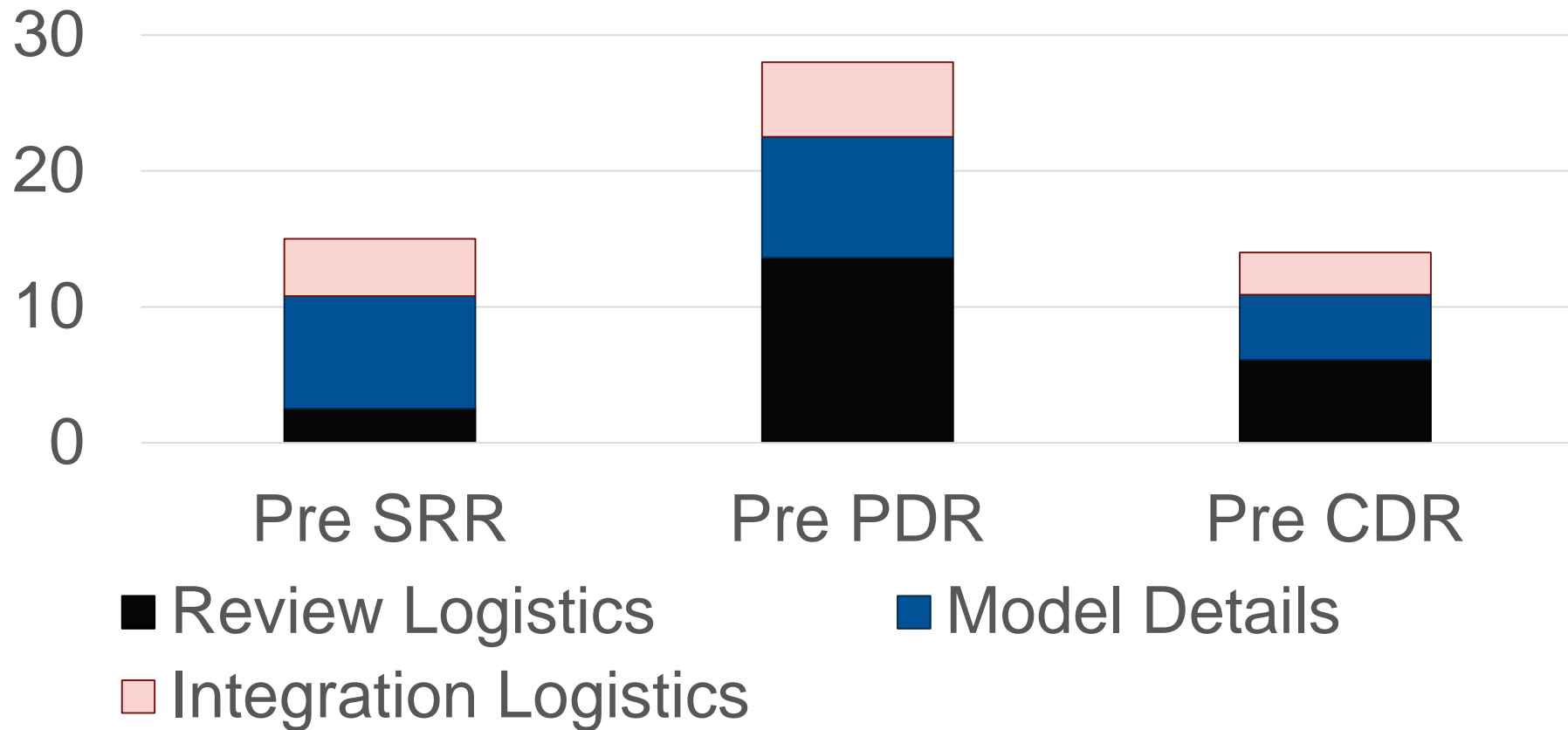
- Supplier had read access to *parts* of MSI model
- MSI had read/write access to MSI model
- Supplier had read/write access to supplier model
- MSI had read access to supplier model
- ASoT and customer had read access to both models



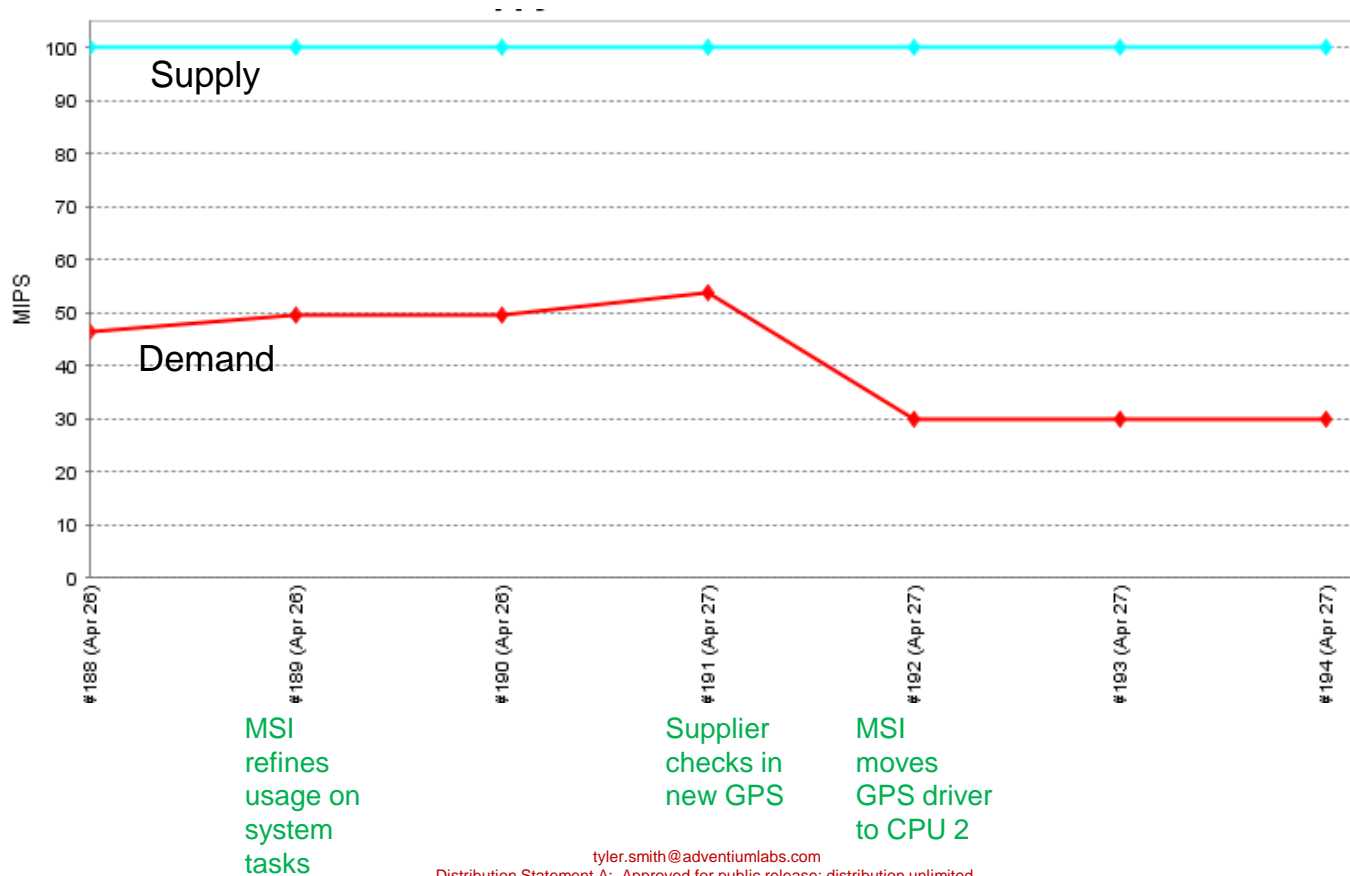
LEVEL OF EFFORT



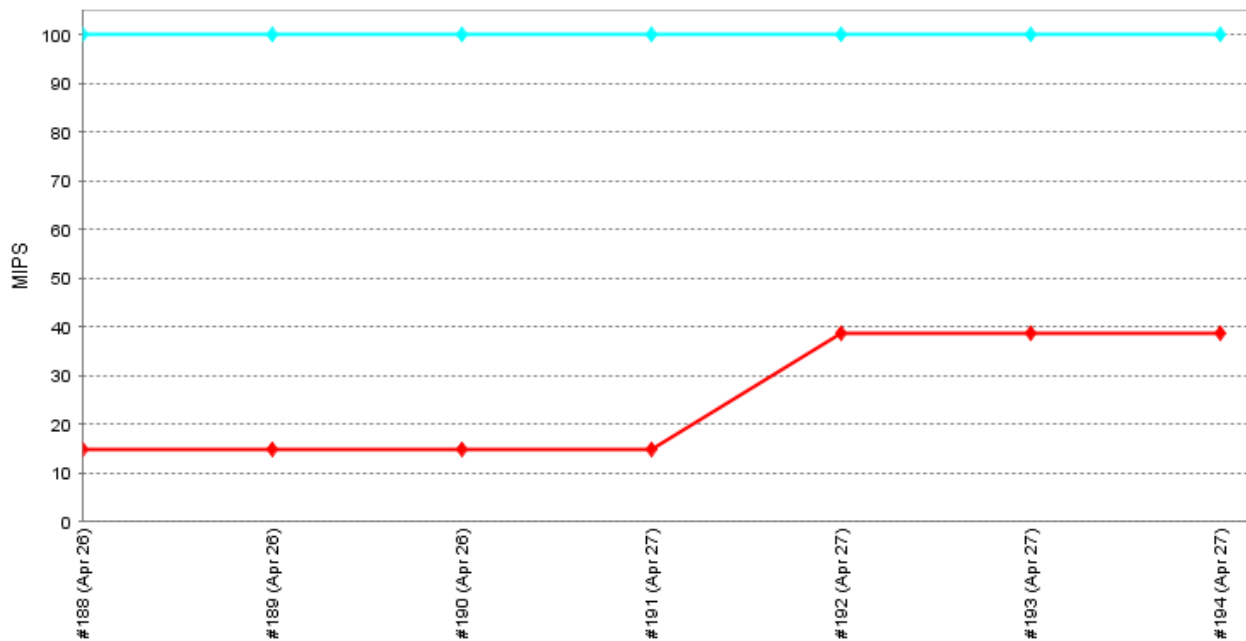
EMAIL COMMUNICATIONS BY TOPIC AND REVIEW



CPU 1 SUPPLY AND DEMAND



CPU 2 SUPPLY AND DEMAND



MSI
moves
GPS driver
to CPU 2



MULTI-ORGANIZATION MODEL INTEGRATION WITH AADL LESSONS LEARNED

LESSONS LEARNED - SUPPLIER

Clear communication of required properties and desired analysis from MSI is key.

A test harness provides a useful check to assure the supplied model integrates into the MSI model.

A test harness lets the supplier run the analysis on their device models against their individual budget requirements.

Provide a generic GPS box template as a placeholder in the system model and use it to communicate requirements to the Supplier.

Need to provide the supplier enough elements from the system model to support their own local testing.

- Not a separate model that the MSI has to build, but a logical subset of the overall MSI model to limit the added overhead.
- Keep the model subset size to a minimum to maintain IP control.
- Design the MSI model for this type of partitioning.

LESSONS LEARNED – CUSTOMER

Specify the desired analysis up front

- Analysis requires planning, e.g., what properties to track and specify.

Specify requirements in analyzable formats

- Requirements in AADL reduces need for translation between representations.

Require increasing levels of model detail in addition to specific analyses.

- Could run all analyses at *every* review gate, adding detail in each review.



MULTI-ORGANIZATION MODEL INTEGRATION WITH AADL SUMMARY

SUMMARY

Test harness provides a means for communicating requirements and details (names of ports, paths, error types) to Suppliers (our ICD is the model template and test harness)

Consider IP protection when structuring projects

CVIT isolates Supplier from full system model IP, while supporting analysis against local requirements

**CONTINUOUS INTEGRATION +
MODEL TEMPLATE + TEST HARNESS
→
MINIMAL MODEL INTEGRATION EFFORT**

TO LEARN MORE

ADVENTIUMLABS.COM/CAMET/FACE

- Review the AADL Annex for the FACE Technical Standard
- Review the Introduction to AADL Analysis and Modeling with FACE Units of Conformance
- CVIT and analysis tools are available on Adventium's Curated Access to Model-based Engineering Tools (CAMET) library:
 - www.adventiumlabs.com/our-work/products-services/model-based-engineering-mbe-tools

OSATE.ORG

- Download OSATE
- Install the FACE Data Model to AADL Translator

END



LESSONS LEARNED – ASoT PROVIDER

The MSI did not need to edit supplier models.

CVIT Server handles changes to either model:

- Incorporates changes
- Executes the MSI model
- Runs analysis tools
- Publishes reports

The Supplier did not need access to the full MSI model.

LESSONS LEARNED – TOOL PROVIDER

Provide headless tools analysis tools.

- Automated execution of tests saves time.

Many analyses are inter-dependent.

- Schedule generation → Configuration generation
- Utilization analysis → Report generation

Incorporate Universally Unique Identifiers (UUIDs) into the core language.

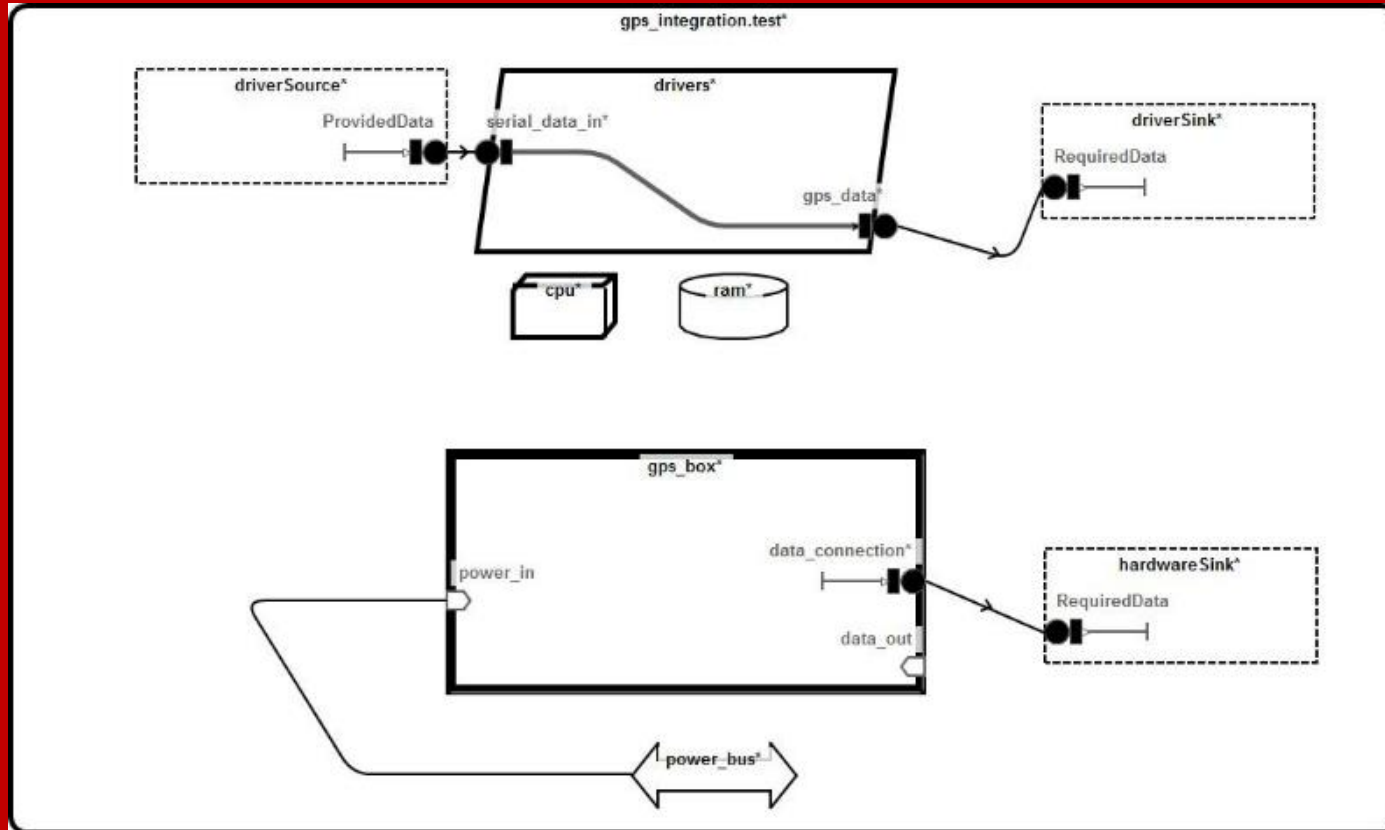
- UUIDs are platform agnostic.
- UUIDs can be automatically generated.
- UUIDs facilitate traceability across tools and models.
- UUIDs have no association to the identified object or element.

Allow multiple inheritance.

Improve semantics for bus access.

Allow cross-package extension.

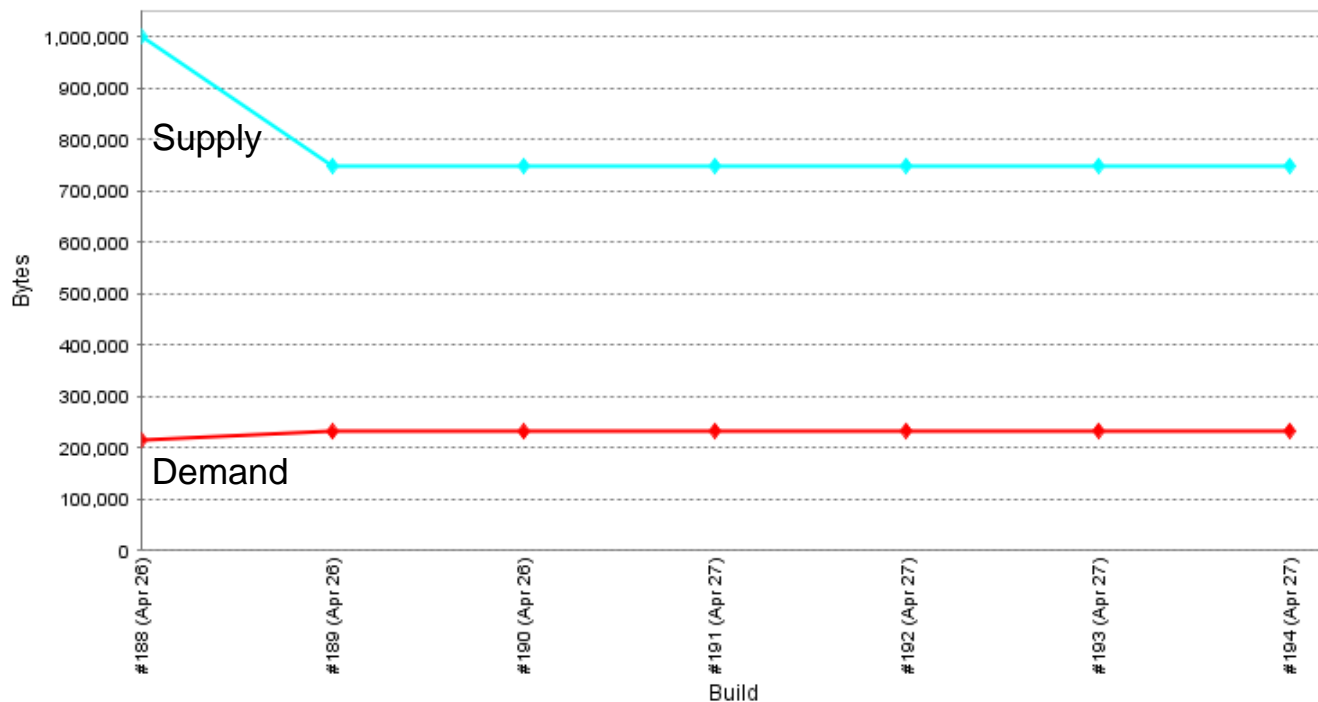
TEST HARNESS



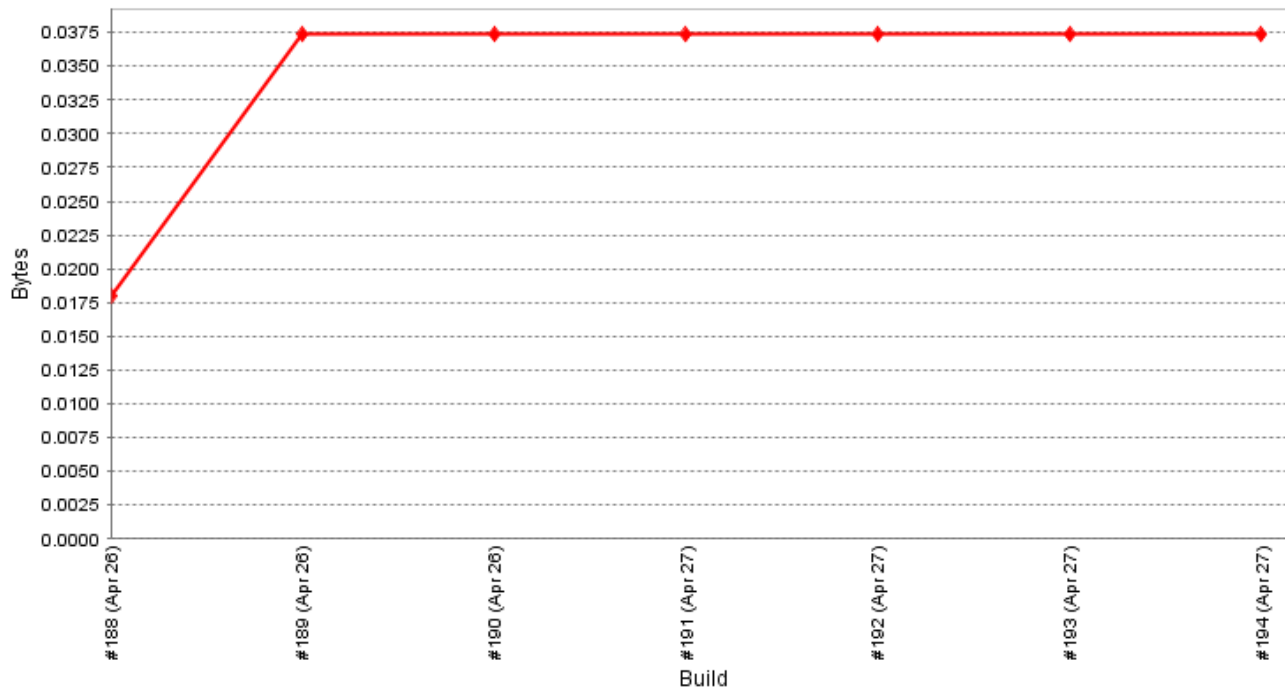
	Review Logistics	Model Details	Integration Logistics
All Email	39%	39%	22%
Pre SRR Emails	17%	55%	28%
Pre PDR Emails	49%	32%	20%
Pre CDR Emails	44%	34%	22%

Percent of Emails by Topic and Review

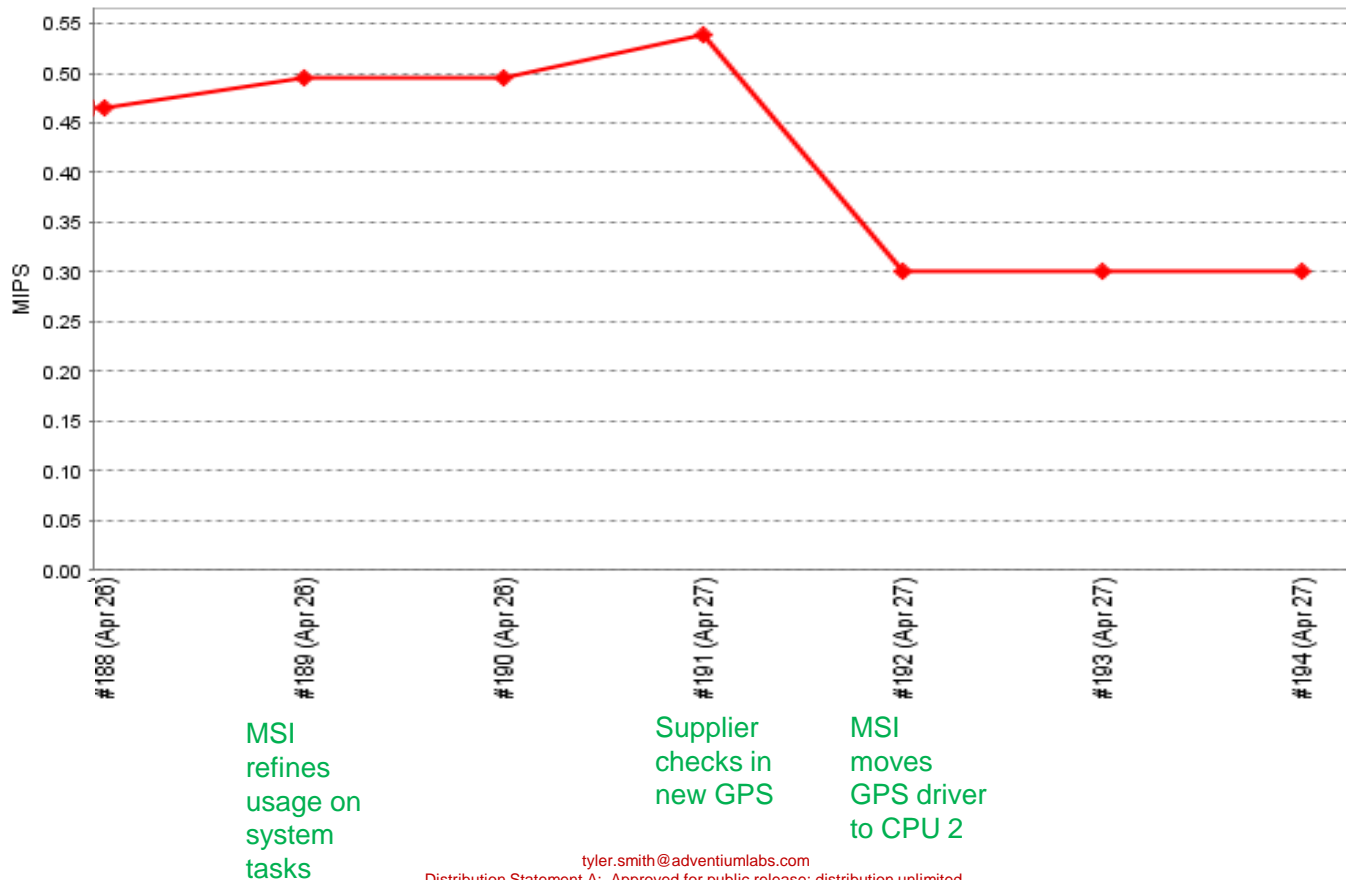
RAM SUPPLY AND DEMAND



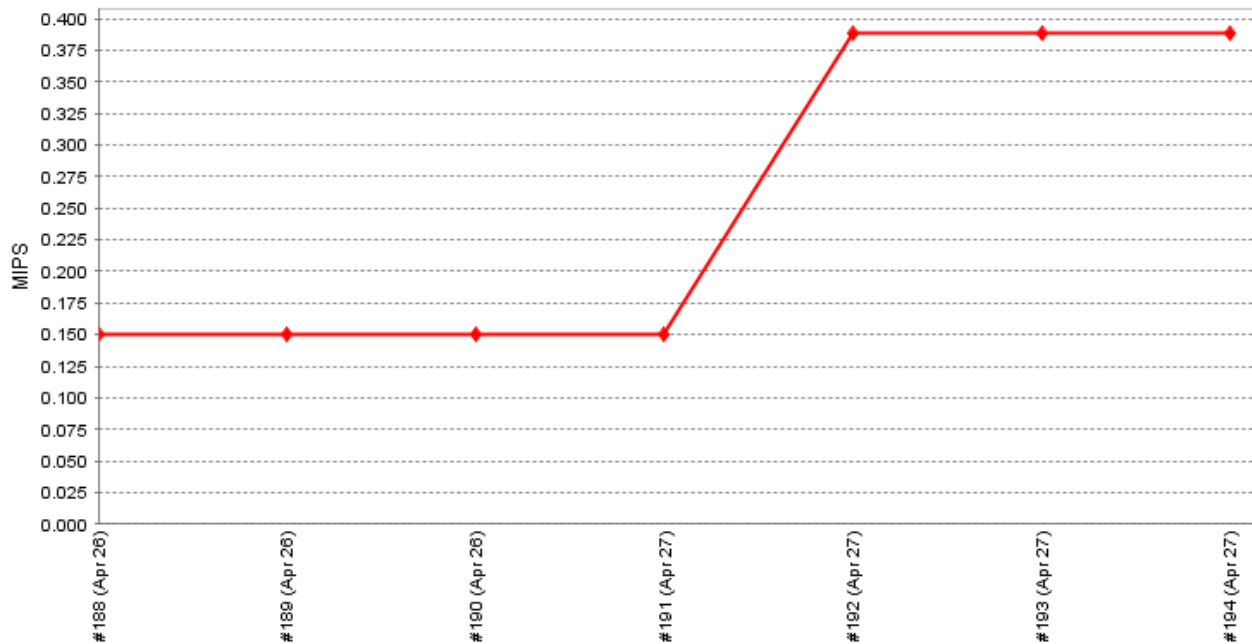
RAM UTILIZATION



CPU 1 UTILIZATION



CPU 2 Utilization



MSI
moves
GPS driver
to CPU 2

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SINGLE LINE SPACING**

Body Arial Regular 18 pt with single line spacing

- Bullet one using “Increase List Level” button, Arial 18pt with single line spacing