Acquisition Research Program:
Creating Synergy for Informed Change

Software is Consuming DoD Total Ownership Costs

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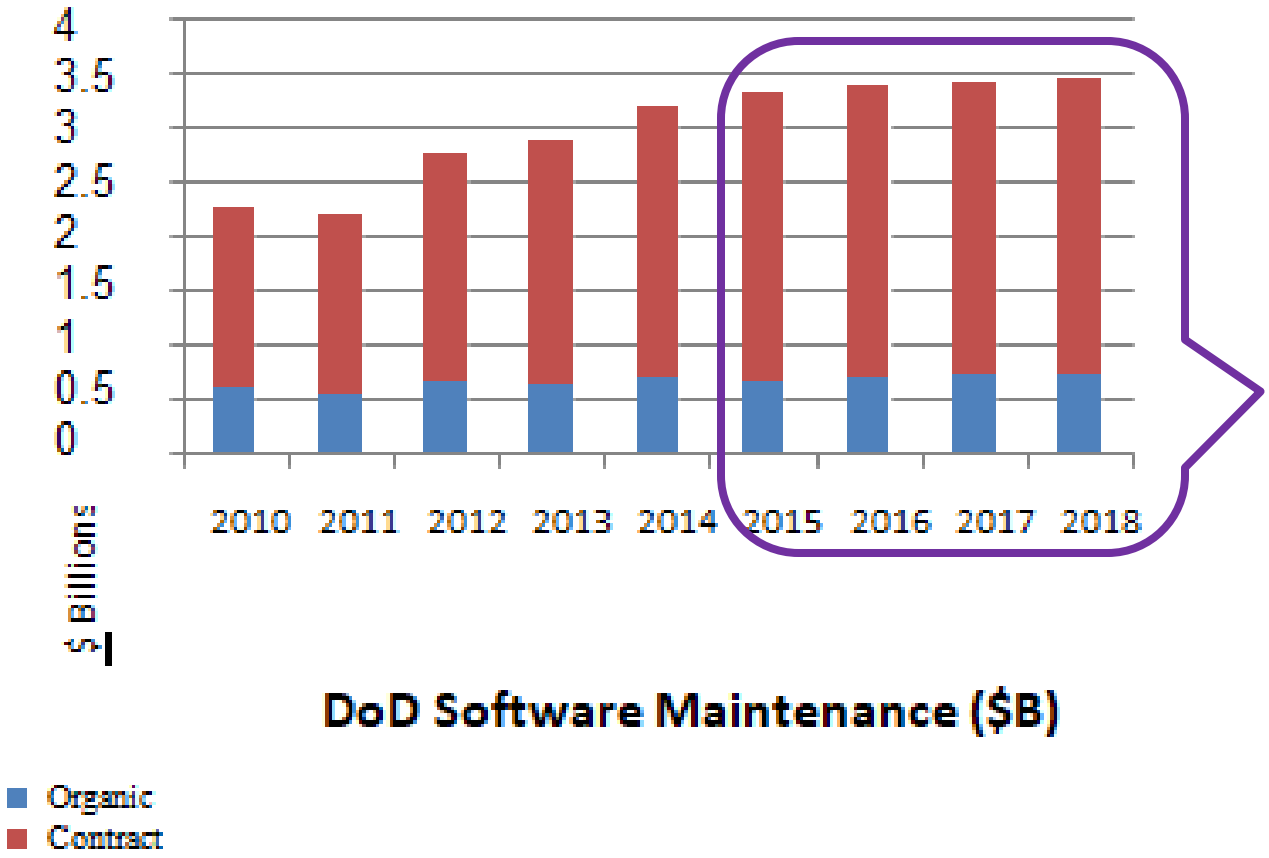
The Problem

- Software sustainment cost growth rate means DoD will not be able to afford all of the software-intensive systems it desires

The Symptoms

- Accelerating software sustainment costs
- Software size routinely underestimated
  - FCS initial SW estimate; 34 mil SLOC. LRE at cancellation; 960 mil SLOC
- Software sustainment costs more than expected
  - B1 bomber annual SW sustainment cost: $100 mil

DoD Software Maintenance Costs



Estimated, but why reduced growth rate?

Source: POM 2014 PB-45 SNaP Data

Software Sustainment Drivers

- Size – Source Lines of Code (SLOC)
- Complexity – Interfaces, Algorithms, Structure
- Architecture – Designed for Maintainability?

- Software Maintainers
  - Same skill sets as developers: Engineers
  - Overwhelmingly contractors
  - Must contract for Software Engineers!

The Underlying Causes

- The DoD Requirements Generation System
  - Requires interpretation between Capabilities-Based terms (JCIDS) and Performance-Based terms (Performance Spec), and again to Detailed Specification
  - ***Purposely vague to garner maximum innovation***
  - ***Dependent on the developer to correctly interpret and propose innovative solutions***
  - ***Typically does not specify sustainability performance in detail***
  - Accustom to Hardware Engineering environments, which ***do*** compensate for missing or vague supportability requirements

Causes continued

- Immature Software Engineering Environment
  - No industry-wide standards, protocols, formats, architectures, tools, or languages
  - ***No sustainability standards or architectures***
  - No ability to compensate for missing or vague sustainability requirements
  - ***Totally dependent on clear, unambiguous, and complete requirements***
  - Requirements creep and late definition disastrous to the ***architectural design, complexity, and size***
  - ***All*** of the above contribute to software supportability burden and system TOC

Causes Continued

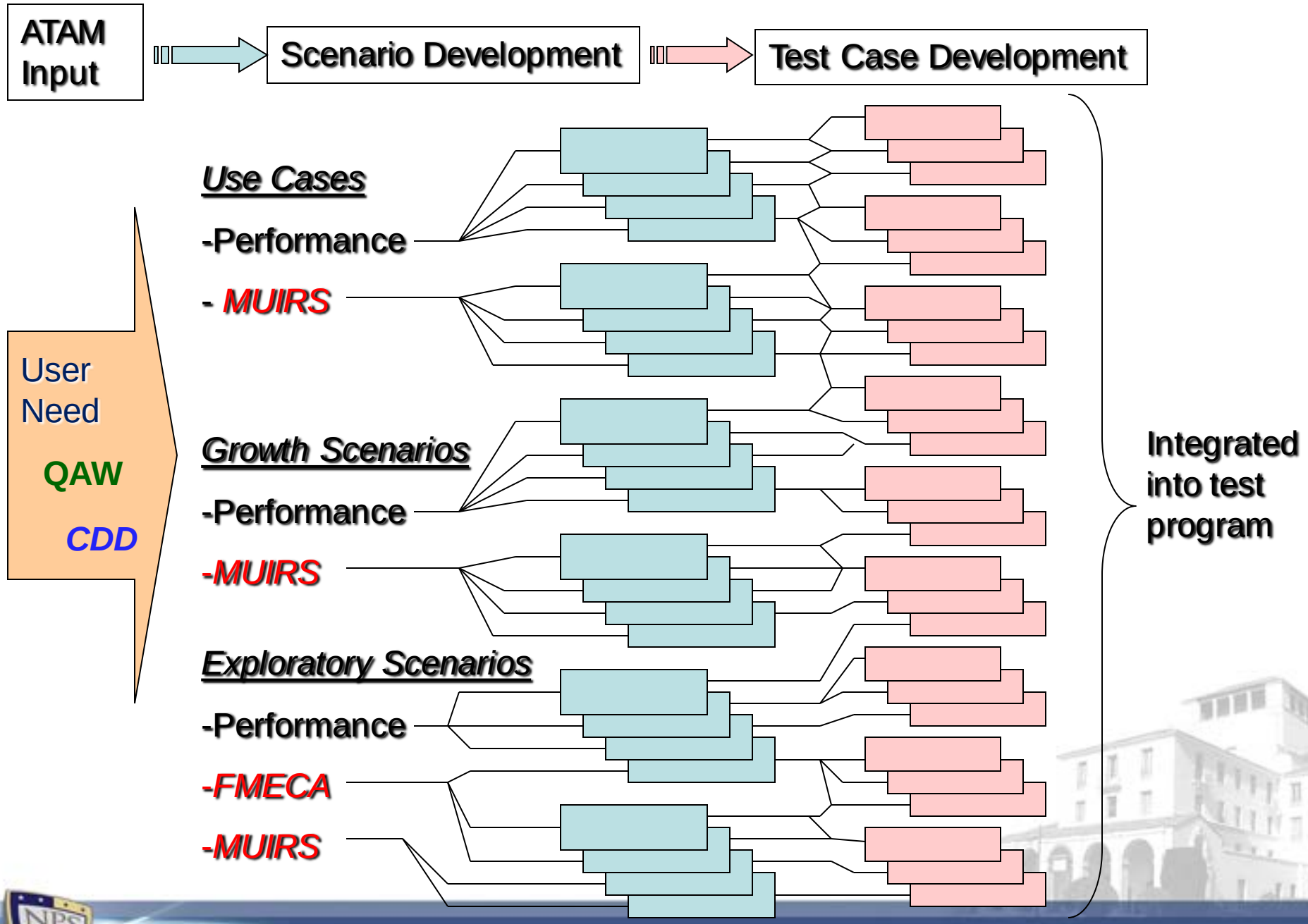
- Estimating Software Size
  - Extraordinarily difficult to do, especially with unprecedented software functionality (weapon systems)
  - Inaccurate estimating methodologies: "COCOMO demonstrated an accuracy of 20% of actuals 46% of the time" – USC experience with in-house development
  - Analogy method inaccurate: F-22 - 6 mil SLOC, F-35 – 24 mil SLOC (and counting!)
  - Reused or COTS software typically add so much complexity to the design, that the known SLOC count is negated and sustainment cost remains high

Attacking the Causes

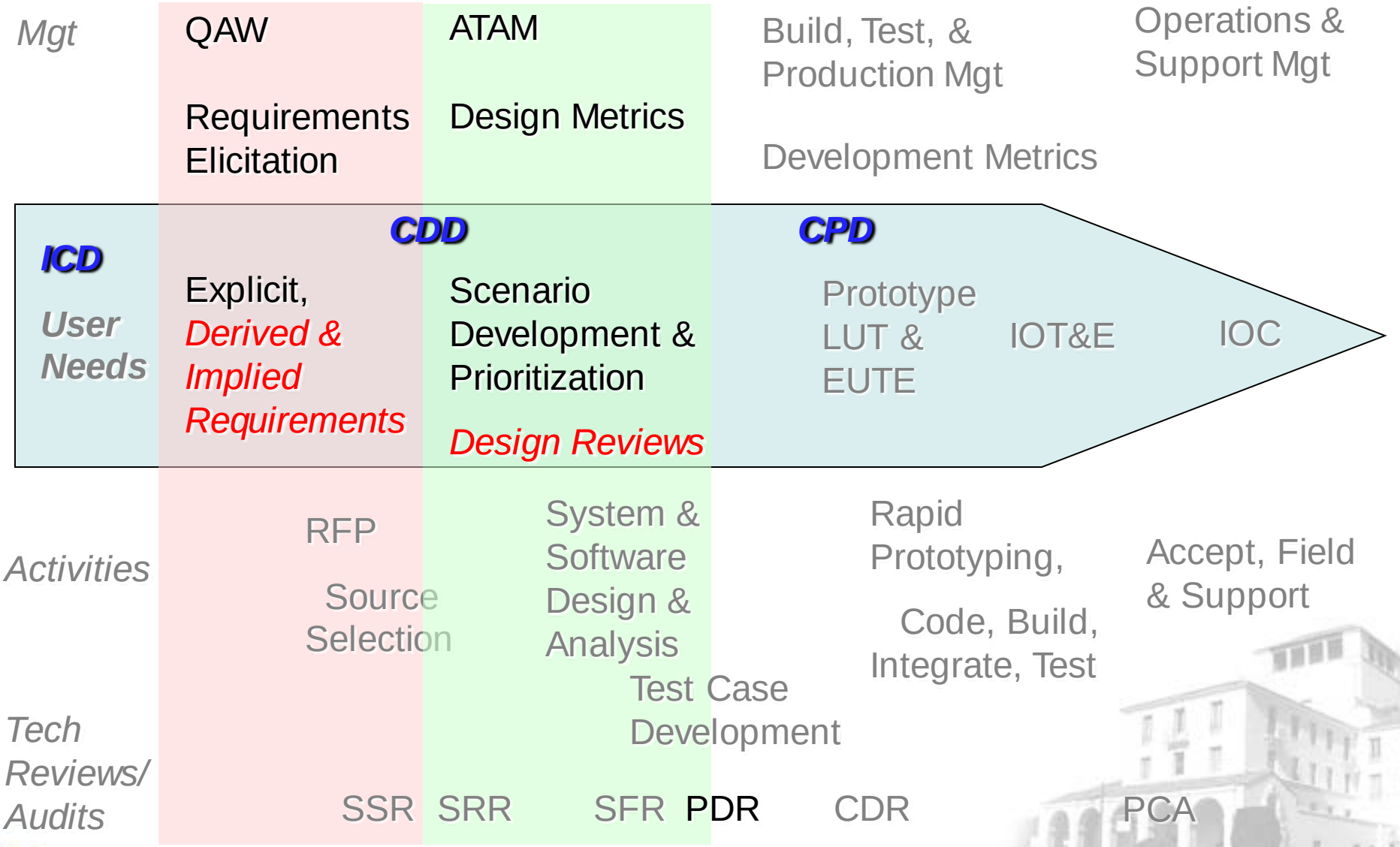
- Implementation of analyses, tools, and processes
  - MUIRS Analysis
    - Analyses for sustainability and safety/security needs
  - SEI's Quality Attribute Workshop (QAW)
    - A more complete inventory of requirements
  - SEI's Architectural Trade-off Analysis Methodology sm
    - Clarifies context and drives architectural design
    - Connects user needs to system design to test program
  - FMECA
    - Identifies critical and non-critical system attributes

MUIRS Analysis

- Maintainability
  - Does design support software maintenance? PDSS?
- Upgradeable
  - Can planned and unplanned upgrades be accomplished without reengineering?
- Interoperability
  - What are interface requirements for current and future Net-Centric and interoperable systems?
- Reliability
  - Will Maintenance/Upgrades degrade reliability?
- Safety/Security
  - Does sustainability impact cyber vulnerabilities?


ATAM Input
Scenario Development
Test Case Development
User Need
QAW
CDD
Use Cases
-Performance
- MUIRS
Growth Scenarios
-Performance
-MUIRS
Exploratory Scenarios
-Performance
-FMECA
-MUIRS
Integrated into test program

QAW & ATAM Integration into SW Lifecycle Management



Summary

- The MUIRS and FMECA analyses will help capture missing or vaguely stated sustainability requirements
- The analyses and systems engineering tools help to compensate for the immature software engineering environment, which cannot fill any gaps in the communicated requirements
- Using these analyses within the enhanced Systems Engineering tools will help improve sustainability design and performance