Developing Performance-Based Software Requirements for Open Architecture Design

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The Software Challenge

- Complex System-of-Systems and Net-Centric Warfare Platforms are Software Dependent
- Evolutionary Acquisition Development Methodologies Make Software Size and Effort Estimation Very Difficult
- Software Life-Cycle Costs Linked with Size and Complexity
- Software Engineering Environment is Immature

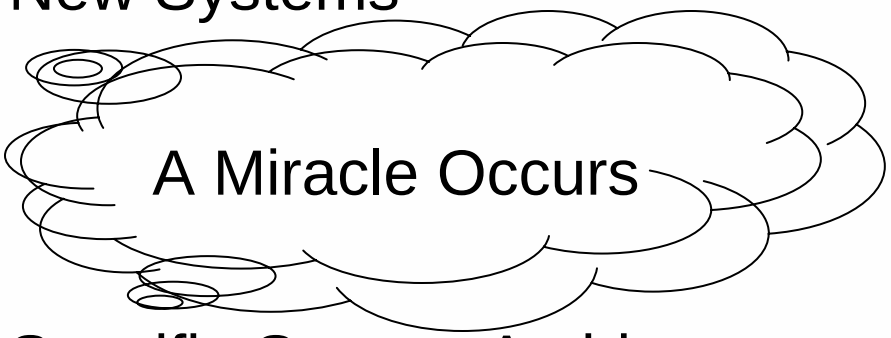
Software Engineering Immaturity

- Software Engineering Environment is Significantly Unbounded
- Very Few Industry-Wide Standards, Tools, Methodologies and Protocols
- No Apparent ‘Dominant’ Language, Coding Process, or Software Development Tools
- Commercial Market Develops Relatively Short-Lived Products – Long-Term Sustainability Rarely Considered

SEI S/W Quality Attribute Workshop

Traditional System Development

Operational Descriptions
High-Level Functional Requirements
Legacy Systems
New Systems



Quality Attributes Often Missing from Req Docs, or Vaguely Understood & Weakly Articulated

Specific-System Architecture
Software Architecture
Detailed Design
Implementation

Getting to OA Software Design

- Need OA Design Supporting S/W Supportability Performance as the Ability to Upgrade, Modify and Maintain the S/W is Paramount
- Requirements Communicated via the Performance Specification Drive the OA Design
- High-Level, Vaguely Stated Requirements Will Not Drive the S/W Developer to Produce an Architecture that Supports Long-Term Supportability Performance in a Dynamic, Net-Centric Environment

The MUIRS Analytic Methodology

- The Only S/W Performance You Get is What You Specify in the Requirements – Compensate for the Immature S/W Engineering Environment
- The WBS Must be Developed to a Level Where the S/W Developer can Understand the Design Requirements Critical To the Warfighter
- The Performance Spec Must Convey Gov't Needs for Maintainability, Upgradability, Interoperability, Reliability, & Safety/Security (MUIRS), Which Drives the OA S/W Architecture

MUIRS Analysis

- As the WBS and Performance Specification are Developed…
- Does the S/W Developer have Sufficient Guidance to Design an OA Architecture that Supports Warfighter Needs for:
  - Maintainability (PDSS Concept, Rehosting, etc.)
  - Upgradability (Known, Planned & Potential Systems)
  - Interoperability (Legacy, Current, & Planned)
  - Reliability (Fault Tolerance, Degraded Ops, etc.)
  - Safety/Security (Attack Hardened, Recovery, etc.)

Evolutionary Acquisition Impact

- Initial Requirements and Performance Specification are Very High Level
- Requirements are Refined through an Iterative Spiral Process during Systems Development
- Initial Software Development and Sustainment Estimates are Conducted Without Detailed Knowledge of Actual Effort Needed
- Significant Portion of Software Effort is Revealed Only *After* Requirements are more Fully Developed

Software Size Estimation Problems

- DoD Routinely Underestimates S/W Size (therefore, Complexity) by Over 100%
- An Example:
  - C-17 Single Complex System 9 Mil SLOC
  - JSF Family of Systems 17 Mil SLOC
  - FCS 18+1+1* (Estimated) 34 Mil SLOC

    *(18 Federated Systems + Network + Soldier)
- S/W Development Effort Cannot be Accurately Estimated when Requirements are "Vaguely Understood and Weakly Articulated" (SEI QAW)

Software Life-Cycle Costs

- DoD Spent about $41 Billion for S/W Development and Sustainment in FY04
- Obvious Connection Between S/W Size, Complexity and Development Cost & Sched
- PDSS Represents 70% to 90% of S/W TOC
- S/W 'Maintenance' Driven by Many Factors, is Needed Immediately on Fielding, and Occurs Frequently Throughout its Life-Cycle
- S/W 'Maintainers' are S/W Engineers, Usually Contracted

Software Supportability Estimation

- Linked to S/W Size and Complexity
- A Basic Model (Lientz & Swanson UCLA)
  - S/W Professional Maintains an Average of 16,500 SLOC per Year
  - FCS's 34 Mil SLOC would Require 2,060 S/W Maintainers per year at @ $175,000 each
  - ROM for FCS Annual S/W Maintenance Budget is $175k X 2,060 = $360.5 Mil
  - If Off by 100% = $721 Mil, 200% = $1.0815 Billion
- DoD Must Reduce Supportability Costs by Driving OA S/W Architectural Designs

Summary

- With S/W Development, You Get the Performance You Specify… Not Much More
- S/W Engineering Immaturity Must be Compensated for by More Thorough Requirements & Performance Spec Development
- "A Miracle Occurs" is Not a Strategy for Driving S/W OA Design and Performance
- Cannot Continue to Develop S/W Intensive Systems That are Difficult and Costly to Support
- S/W Supportability ***is*** S/W Performance!