Causal Factors of Software Intensive System Issues

Tri Service Assessment Initiative

Practical Software and Systems Measurement
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Some Questions …

Why do we always seem to be trying to solve the same problems in our software intensive programs?

Are we focusing on the symptoms or the causes of our software issues?

How do we define program success?
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Presentation Objectives

• Convey what we have learned through a systemic “Cross Program” analysis of multiple software intensive DOD programs

• Identify some of the recurring factors that materially impact software intensive acquisition and development efforts

• Provide some ideas on how we can improve based on the results from real program experiences
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Presentation Outline

• TAI Initiative Overview
• Top-Level Analysis Results
• Systemic Analysis Approach
• Software Intensive Program Issues – Causes and Effects
• Next Steps
Independent Expert Program Reviews

- **IEPR Policy**
  - ACAT ID/IC programs shall conduct an IEPR after Milestone B and before CDR
  - IEPRs shall be considered for ACAT IA, II, and III programs
  - IEPR Implementation Plan provides guidance for implementing policy and will be staffed after DoD 5000 release

- **Tri-Service Assessment Initiative**
  - Primary implementation for conducting IEPRs
  - Sponsored by OSD - Software Intensive Systems Office
  - Three year history
  - Structured multiple-level assessment architecture
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**TAI Systemic Analysis Objectives**

- **Identify systemic issues that impact program success**
- **Understand their cause and effect relationships**
- **Develop recommendations to improve SIS acquisition:**
  - Policy and guidance
  - Education and training
  - Tactical and strategic decision making
- **Provide DoD users with a source of objective - actionable - defensible information**
  - Enterprise (OSD, Services, PEOs)
  - Program (PMs, staffs)
  - Technical Interface (DAU, SEI, IEPR WG, etc.)
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Systemic Analysis Bottom Line

Use *real program assessment data* to:

- Identify
- Characterize
- Explain
- Correct

The problems that systematically impact Software Intensive Program success
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**TAI Systemic Analysis Team**

- **Kristen Baldwin, SIS**
- **Bob Charette, ITABHI**
- **Laura Dwinnell, Northrop Grumman**
- **Ken Smith, SEI**
- **Dave Zubrow, SEI**
Top-Level Analysis Results
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Top-Level Conclusions

• Assessment results show **repeating trends**:
  - across assessed programs
  - regardless of program characteristics
  - over a long time period

• Program failure is related to a combination of **unrealistic enterprise constraints and expectations**, and **poor program execution**:
  - can be poor program execution alone
  - can be a mismatch between expectations and program execution capability
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Top-Level Conclusions (cont.)

• Causative issues produce different performance symptoms in different programs
  - single issue can cause many symptoms
  - many unique issue combinations
  - relatively complex interactions

• Past DoD corrective actions and associated policy have largely focused on the symptoms and not the causative issues
  - usually on a symptom by symptom basis
  - symptoms are perceived as causes of failure
The sum of Enterprise constraints and expectations and poor Program execution limits the trade space on our programs - this reduces the opportunity to make changes to improve program performance.
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Systemic Analysis Model

ENTERPRISE LEVEL

- Acquisition “Drivers”
  - Process
  - Policy
  - Politics
  - Strategy
  - Assumptions
  - Multiple Stakeholders
  - Scope of Project Portfolio - Product Line

- Expectations
  - Objectives
  - Functional Capability

- Constraints
  - Required Practices
  - Resources
  - Funding
  - Time

PROGRAM LEVEL

- Program Start
- Program Milestone
- Program Restructure

- Plans, Trade-Space, and Resource Allocation Impacts
- Processes - Product - Quality - Capability
- Organizational Impacts
- Performance Impacts

ACQUISITION ENVIRONMENT
(Economy, Technology, Threats)
And In Addition …

- The number of enterprise mandated requirements is significantly large
- These requirements may be uncoordinated, unvalidated, and unfunded
- What we do is different from what we teach
- “Best Practices” require “Best Execution” to influence success
- Program success factors are not always the opposite of program failure factors
- Successful programs are more pro-active - they aggressively “manage the trade space”
Systemic Analysis Approach
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**TAI Assessment Architecture**

**Assessment Process Model**
- Identify and prioritize program issues
- Develop value-added recommendations
- Generates consistent information sets

**Assessment Information Model**
- Generic Program issue structure
- Defines assessment “scope”
- Flexible typology

Both Components are Required for Individual Program Assessment and Systemic Cross-Program Analysis
Assessment Process Model

- **Enterprise Technical and Management Actions**
  - Enterprise Analysis Information Requirements And Results
  - Program Feedback Assessment Results
  - Program Characteristics Program Issue Profile

Core Program Assessment Activities

- **Establish and Improve Assessment Capability**
  - Improvement Actions

- **Initiate and Plan Assessment**
  - Evaluate Process Systemic Analysis

- **Perform Assessment**
  - Integrate and Report Assessment Results

- **Integrate and Report Assessment Results**
  - Assessment Profile
Assessment Information Model

- User / Customer
- Schedule
- Technical Product
- Technical Process
- Management
- Resources
- Financial
- Mission Requirements
- Environment
- Project Specific
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**Systemic Analysis Process**

**TAI Program & Other Data Sources**

- Analyze Assessment Findings
  - Typology Allocations
  - Frequency of Occurrence
  - Symptom Identification
  - Initial Issue Relationships

- Identify Causes and Effects
  - Issue Pattern Definitions
  - Issue Type - Characterization
  - Issue Interactions
  - Enterprise - Program Allocations

- Integrate Results
  - Root Cause Identifications
  - Number of Instances
  - What If and Trend Analysis
  - Executive Level Conclusions

Recommendations
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**Findings Mapped To Information Model**

- **User/Customer**
- **Schedule**
- **Technical Product**
- **Technical Process**
- **Management**
- **Resources**
- **Financial**
- **Mission Requirements**
- **Environment**

Mapping represents findings from 21 Program Assessments

**Number of Occurrences**

0  50  100  150  200  250  300  350
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Leading Second Level Issue Areas

• Program - Organizational Management
• Development Progress
• Product Quality
• Product Requirements
• Technical Process Capability
• Personnel Resources
• Acquisition Strategy
• Project Planning

All issue areas had both Enterprise and Program Level Allocations
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Recurring Program Symptoms

• Over Budget
• Late
• Poor Product Quality
• Poor Communication
• Inadequate / Late Decisions
• Costly Technology Refresh
• Poor Morale
• No Product Line Architecture
• Poor Interoperability
• Rework
Software Intensive Program Issues
Causes and Effects
Initial Findings Analysis Indicated:

- That identified issues were connected in recurring patterns or sequences

- That issue sequences were of different types:
  - Triggering Sequences
  - Failure Sequences
  - Success Sequences
  - Symptoms / Impacts

- That the issue interdependencies - the causes and effects - were extremely complex
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1.3, 5.1, 5.2, 6.1, 6.2, 7.1, 7.2, 7.3
Desire to provide acquisition managers with alternate sources for components

1.3, 3.1, 4.2, 5.1
Desire to reduce costs through streamlined processes and leveraging

2.1, 5.1, 6.1, 6.2, 7.1, 7.2
Desire to facilitate rapid technology insertion

1.3, 3.1, 5.1, 6.2
The procurement climate/desire for commonality is driving system partitioning

5.3, 5.5, Collateral Impacts

5.1, 5.3, 6.2, 7.1, 7.2, 7.3
Business strategies outweigh technical considerations in selection of system architecture

2.1, 4.2, 4.4, 5, 6, 7.1, 7.2
Partitioning the system adds to the complexity

6.1, 6.2
Using APB for new tech development vs. rapid tech delivery

1.3, 2.1, 5.1, 6.1, 6.2, 9.1
Requirements process is perceived to be broken

6.1, 7.1, 7.2, 7.3
No interface requirements specification

6.1, 7.1, 7.2
Interface design is challenging, esp. in allocating perf. Reqmts

1.2, 1.3, 5.1, 5.3
Operational upgrade strategy

2.1, 5.1, 6.2
True requirement for upgrading the system is questionable

1.3, 5.1, 5.3, 6.1
No one in charge of CCS system

1.3, 5.1, 5.3, 6.2, 9.1
Different groups have competing visions

4.4, 4.5, 5.4, 7.3
Intellectual property rights of middleware producers

4.4, 4.5, 5.4, 7.3
No App developer willing to sign license agreement for middleware products

6.2, 7.2, 7.3
Mismatch between test needed and test required for end-state architecture

6.1, 6.2, 7.2, 7.3
APB process does not provide for system level test and certification needed for end-state architecture

1.2, 1.3, 5.1, 5.3
Program office roles overlap and conflict

4.2, 6.2, 7.2, 7.3
New simulation, stimulation capabilities will have to be developed for tactical control and weapons control

1.3, 2.1, 5.3, 6.1, 6.2, 9.1
Requirements process is perceived to be broken

6.1, 7.1, 7.2, 7.3
New simulation, stimulation capabilities will have to be developed for tactical control and weapons control

2.1, 5.1, 6.2
Congressional plus-ups perturb systems engineering veracity

2.1, 3.2, 4.2, 4.4, 5.1, 5.2, 7.1, 7.2
Network-centric vision has no substantive description

1.3, 5.1, 5.5, 6.2
Desire to change [domain area] acquisition culture

1.3, 5.1, 5.5, 6.2
Desire to provide acquisition managers with alternate sources for components

1.3, 3.1, 5.1, 5.2
Congressional plus-ups perturb systems engineering veracity

1.3, 3.1, 4.2, 5.1
Desire to reduce costs through streamlined processes and leveraging

1.3, 2.1, 5.3, 6.2, 7.1, 7.2, 7.3
Desire to facilitate rapid technology insertion

1.1, 2.1, 5.1, 5.2, 5.3, 5.4, 6.2, 7.1, 7.2, 7.3
Several uncoordinated paths for tech insertion

6.1, 6.2
Using APB for new tech development vs. rapid tech delivery

1.3, 2.1, 5.3, 6.1, 6.2, 9.1
Requirements process is perceived to be broken

6.1, 7.1, 7.2, 7.3
No interface requirements specification

6.1, 7.1, 7.2
Interface design is challenging, esp. in allocating perf. Reqmts
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Phased Approach to Causal Analysis

- Identify End-to-End Issue Sequences (Top-Down)
- Quantify Recurring Issue Patterns
- Define Terminology
- Identify and Count Issue Sequence Components (Bottom-Up)
- Quantify and Characterize
- Integrate Sequences into Causal Threads
- Numerical and Scenario Analysis
- Assessment Process Feedback
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Recurring Issue Patterns

• Unintended Policy Impacts
• Impacts of Congressional Mandates
• Inadequate Family of Systems Management
• Interoperability Clashes
• Premature System Deployment
• Poor Technology Refresh Management
• Ineffective Systems Engineering
• Compliant but Inadequate Process Capability
• Overly Aggressive Program Concurrency
Recurring Issue Patterns (cont.)

- Inadequate / Inappropriate Development Approach Chosen or Mandated
- Intellectual Property Rights and Proprietary Issues
- Production Capability Inadequately Addressed
- Incomplete Risk Management / Measurement
- Inadequate Resource Infrastructure
- Inadequate Change Management
- Disconnected Education & Training
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Unintended Policy Impacts

COTS vs. Supportability

1.1 Maximize COTS

7.2, 7.3 Difficult & Complex System & Subsystem Requirements

7.1 Highly Constrained, Costly, & Risky Designs

6.2 Underestimated Testing

Symptoms Seen..

- Over budget
- Late
- Poor Product Quality
- Costly Technology Refresh
- Rework

1.1 Minimize Maintenance

Maximize Reliability & Performance
Premature Systems Deployment

Symptoms Seen:
- Over budget
- Late
- Poor Product Quality
- Miscommunication
- Costly Technology Refresh
- Poor Morale
- No Product Line Architecture
- Poor Interoperability
- Rework

1.3 Unplanned Move from Prototype to Operational System
3.1 Insufficient Funding
7.2 Incomplete Requirements
6.2 Incomplete Testing
7.1 No robust Design
4.1 High Turnover Rate
7. Poor Technical Decisions
4.1 Inadequate Staff
4.1 Staff Burnout

Inadequate Resource Infrastructure

Symptoms Seen:
- Over budget
- Late
- Poor Product Quality
- Poor/late Decisions
- Costly Technology Refresh
- Poor Morale
- Poor Interoperability
- Rework

1.3 Competing Industry Pulls
2.1, 7.1, 7.2, 4.1 Complex Technical & Domain Knowledge Required
4.1 Inadequate Staff Level Expertise
7.2 High Risk Solutions
Surviving Programs

1.3 Downsized Industry
1.3 Lack of Demand
1.1 Security Levels Required
1.3, 5.1 Govt Strategic Decision Not to Invest In Technology
The Way Forward - Recommendations

• Improve and integrate IEPR results - Refine Systemic Analysis Techniques

• Identify and Quantify both Issue and Success related Causal Patterns

• View Enterprise and Program Level Corrective Actions as Part of an Integrated Solution

• Recognize and Address Issue and Performance Interdependencies

• Use a “Corrective Action Team” Approach to Address Prioritized Causative Issues
Summary

• Systemic analysis based on real program assessment results provides a unique opportunity to use actual data to make a difference

• The causes of program performance shortfalls are extremely complex - improvement strategies and associated action plans must address this complexity
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