The Challenge...

Going Beyond Systems Engineering

SI 4000 Systems Engineering Seminar

Tom Williams
Sector Vice President, Program Integration
Integrated Systems Sector
What’s Wanted - “Major Concerns”

- On Time Delivery
- Within Budget
- High Reliability (Missions Success)
- Meet War Fighters’ Needs
- Agile, Credible, Spiral Capable Development

*Deliver What Is Promised, When Promised!*
Recent USAF ACAT-1C/D Program Experience

Actual Cost/Schedule vs Negotiated Contract

- 36% Cost Over-Runs
- 2 Year Schedule Increase
- 2% Cost Over-Run When Compared to the Cost Assessment Improvement Group (CAIG) Estimate

Source: Space Systems Development Cost Growth Analysis Conducted by Booz-Allen-Hamilton (83 Surveys of 67 Organizations)
Enhancing Program Performance

- Program Manager SE Training
- SE/SI Training (Internal / External/Univ. Affiliations)
- Architects / Integrators as Recognized Disciplines
- Accelerate Domain Knowledge Acquisition
- Strengthening Material / Procurement PM Talent Pool
- Corporate (Cross-Business Area) SE Councils – SEAG
- SE Community of Practice & User Groups
- People-to-People Contact Tools
- Embedding Processes/Knowledge in “Closed Loop” Workflows
- Integrate Intermediate SE Work Products into End-to-End Business Systems (ERP Systems)
- Willoughby-Like Program / Product / Process Templates
- Integrated Analysis and Synthesis Tools (Early Simulation)
- Program Health Visibility Systems
- Enhanced Risk Mgmt Tools
- Extend Unified Modeling Language Tools to SE
- Cross-Program Peer Reviews Using Domain Experts
- SE Products Precede Downstream Design
- CMMI (SW/SE/IPPD/SS)
- Lean / 6σ
- Non-Advocate Reviews (NAR) / Independent Cost Evaluations (ICE) Prior to Proposal Submittals
Capability Maturity Model “Integration” - CMMI®

- Process Improvement
  - Causal Analysis and Resolution
  - Organizational Innovation and Deployment

- Quantitative Management
  - Quantitative Project Management
  - Organizational Process Performance

- Standardized Processes
  - Organizational Environment for Integration
  - Integrated Teaming
  - Organizational Process Focus
  - Organizational Process Definition
  - Organizational Training
  - Integrated Project Management
  - Risk Management

- Level 5
  - Requirements Management
  - Project Planning
  - Project Monitoring and Control
  - Supplier Agreement Management
  - Measurement and Analysis
  - Process and Product Quality Assurance
  - Configuration Management

- Level 4
  - Decision Analysis and Resolution
  - Requirements Development
  - Technical Solution
  - Product Integration
  - Verification
  - Validation

- Level 3
  - Software
  - Systems Engineering / Hardware
  - Integrated Program Management
  - Product Development
  - Supplier Sourcing

- Level 2
  - Four Discipline Models Address Different Parts of the Business

- Level 1
  - Provides Architecture for Linking/Integrating of Processes
  - Provides a Measurement/Assessment Approach
  - Does NOT Assess “Goodness” of the Processes Being Used or Number of Processes Under Control
Expanding Our Focus

Executable Programs

Program (Structure / Infrastructure) Integration

Product Integration

Process Integration

System Engineering...

...Involves Structured Requirements Analysis Allocation and Design Synthesis (Hierarchical Product Decomposition) DRM Associates
Going Beyond the “Product”

The Reason for the Program’s Existence: The Product Baseline Evolves from “Back of the Envelope” to “10,000 Parts flying at 50,000 Ft”

Performance Baseline

Product Baseline

Project Baseline

Enterprise Baseline

Manage and Integrate ALL Baselines

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One Approach...

- Executability Templates
  - "Expert System" Tailored to:
    - Program Life Cycle
    - Program Size and Complexity
  - Similar in Format to Willoughby Templates
    - Leverages Past Company/Industry Experience and Best Practices
How Do You Measure Good Systems Engineering?

The Number of Successful Programs
What Is System Engineering?

IEEE 1220:
An Interdisciplinary Collaborative Approach to Derive, Evolve, and Verify a Life Cycle Balanced System Solution that Satisfies Customer Expectations and Meets Public Acceptability

Mil-Std 499B:
An Interdisciplinary Approach Encompassing the Entire Technical Effort to Evolve and Verify an Integrated and Life-cycle Balanced set of system People, Product and Process Solutions that Satisfy Customer Needs

EIA/632 EIA 620 ISO/IEC 15288
System Engineering Process

Process Inputs

- Requirements Analysis
  - Requirements Baseline
  - Requirements trade studies and assessments
  - Requirement and constraint conflicts
  - Requirement trade-off's and impacts
  - Decomposition and allocation alternatives

- Functional Analysis
  - Functional Architecture
  - Decomposition / allocation trade-off’s and impacts

- Functional Verification
  - Verified Functional Architecture
  - Design solution requirements and alternatives
  - Design solution trade-off’s and impacts

- Synthesis
  - Physical Architecture
  - Design trade

- Design Verification
  - Verified Physical Architecture

Process Outputs

- System Analysis
  - Functional trade
  - Design trade

Control

Source: IEEE 1220-1998. © IEEE 1998. All rights reserved.
Is SE Training Enough?

**Domain Expertise + Systems Engineering/Integration Expertise**
System(s) Complexity

- Net Ready
- Interoperable
- Spiral Capable
System(s) Complexity

• Net Ready
• Interoperable
• Spiral Capable

• Program Dependencies on Other GFP/GFE
System(s) Complexity

- Acquisition Approaches Which Drive Increased Concurrence and Number of Contract Elements
- Program Dependencies on Other GFP/GFE
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- Dominant Portion of Development Content and Occurs at the Suppliers
System(s) Complexity

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Impact on the Cost of Integration?
(Mil Handbook 881)
Why Do Programs Get into Trouble?

- Lack of Breadth of Knowledge, Experience, Tools and/or Capability
- Negotiate Contract, Can be Unknowingly Changed
- Sell / Propose
- Contract Go-Ahead
- Budget to CAIG Should Cost Levels
- SE Weighting in Source Selection Process
- “Best Value” Selection
- DAU Training
- SEPs
- Back Loaded Award Fee Structures
- Execute Program

- Requirements
- Unknowns
- Baselines

Competition Desire to Win Can Drive Cost at the Expense of Program Executability

Cost and SOW Risk Balance Can be Unknowingly Changed

Lack of Breadth of Knowledge, Experience, Tools and/or Capability

“Built Broke” — “Negotiated Broke” — “Execution Problems”
The Goal and the Trap

5000 Acquisition Model:

- Milestone A: Concept Refinement
- Milestone B: Technology Development
- Milestone C: System Development & Demonstration (SDD)

System Development & Demonstration (SDD):
- LRIP

Full-Rate Production & Deployment:
- FRP Decision Review

Initial Operational Capability (IOC):
- Design Readiness Review

Operation & Support (O&S):
- Sustainment

Full Operational Capability (FOC):
- Disposal

Systems Acquisition:
- Sustainment

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The Goal and the Trap

- System Development & Demonstration (SDD)
- Production & Deployment
- Operations & Support (O&S)
- Sustainment & Disposal

Measures of Effectiveness
Measures of Supportability

IBR / SRR → TEMP - IOT&E
(Test Eval Mgmt Plan)

Milestone
IOC (Initial Operational Capability)
FOC (Full Operational Capability)

Concept Decision
Concept Refinement
Technology Development
System Integration
System Demo
Design Readiness Review
System Development & Demonstration (SDD)

FRP Decision Review
Full-Rate Production & Deployment
Production & Deployment

LRIP
Sustainment
Disposal
Operations & Support (O&S)

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The Goal and the Trap

Programs are Inherently Unstable...
Allow Room to Re-balance

What’s left for Uncertainty? (Unknown-Unknowns)

KPPs + Schedule + Cost
KPPs + Schedule

KPPs
(Key Performance Parameters) / Requirements

Programs are Inherently Unstable... Allow Room to Re-balance
Leverage Intermediate SE Work Products

- JCIDS
- Spec Released
- Trade Study Reports
- Published vs Plan
- Design Decision Memos
- ICDs, IDDs Released
- Procurement Spec
- Open TBDs

Clear / Biddable Req’ts

- ID Req’ts Issues
- Interpret Req’ts
- Contractor

Government

- Compliance to Technical Plans
- Req’ts Decomposition & Functional Allocation
- Specs Released
- Interim System Integration Test Results
- TPMs
- Initial H/W TPMs
- Manufacturing & Design Issues
- Parts Availability

OT&E

- System Test Results
- TPMs

Track Release and Quality of Intermediate Work Products

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Shift More Focus on Requirements-Technology Capability vs Design Pre-SDD
Requirements Interpretation

Is the Traditional SRR Approach Sufficient in a Performance Based Specs World?
Requirements Interpretation

Is the Traditional SRR Approach Sufficient in a Performance Based Specs World?

- Establishment of a *System Requirements Interpretation Document (SRID)* or *Requirements Data Base* which clearly interprets all requirements in *Simple English* and captures the intent of the parties.

- Joint War Fighter (Require), SPO (Acquire) & Contractor (Developer) participation required in this interpretation process.

- Drive discovery of key “Derived” requirements… Early.
Closing Thoughts

- If you’re **only** integrating in the product domain, beware… Program (Infrastructure), Process, Cost, GFE/GFP and Schedule are domains that you must integrate as part of the Systems Engineering Process.

- Don’t paint yourself into a corner… Leave room for unknown-unknowns when setting requirement(s) thresholds.

- Don’t let interpretation of requirements be a variable… Do it jointly, early and allow time for “serial” decomposition and flow-down of requirements.
“HOPE”... Isn’t a System Engineering Process???
HOPE… Isn’t a System Engineering Process???