SE1
Integrating Systems Engineering (SE) and Program Performance Management (PPM) to Increase the Probability of Delivering Needed Capabilities for Project/Program Success

Glen B. Alleman
Tuesday 20 August 2019
1:10PM – 1:50PM

Sobering Thoughts About Managing Complex Systems

NEW SYSTEMS MEAN NEW PROBLEMS

Unconstrained System – a collection of component systems, simple or complex, managed, operated, developed, funded, maintained, and sustained independently of its overarching principal system that creates a new capability.

Complex System – a collection of large, multifaceted, and interrelated component systems that are dependent on the entirety of the principal system for management, operations, development, funding, maintenance, and sustainment. Complex systems are non-deterministic, adaptive, holistic, and with nonlinear interfaces between attributes.

In Complex Systems, Malfunction and Even Total Non-Function May Not Be Detectable for Long Periods, If Ever
Systems Engineering and Project Performance Management Both Needed For Success

Connecting the dots between Systems Engineering and Project Performance Management starts with Shared Data and Processes

Increasing Probability of Program Success

Measures of Effectiveness
- Delivering Needed Capabilities for Program Success
- Measures of Performance
- Key Performance Parameters

Risk Management

Arrive at Needed Time for Needed Cost for Program Success

Technical Performance Measures
- Schedule Performance Measures
- Cost Performance Measures

Program Performance Management

Seeing the Three Phases of Project as a Whole is the Foundation of Systems Thinking

Systems Thinking is a discipline for seeing wholes. It is a framework for seeing interrelationships rather than things, for seeing patterns rather than static ‘snapshots.’ Systems Thinking is a discipline for seeing the ‘structures’ that underlie complex situations. [182]
For each Idea on Integrating Systems Engineering and Project Management, We Need to Assess the Idea with Measures of Effectiveness and Measures of Performance, to see How These Increases the Probability of Project Success

We need both Efficiency (Cost, Schedule, Requirements) and Efficacy (Capabilities, Effectiveness, and Performance) of the Project Success
Roles of PPM and SE

Systems Engineer

- Focused on the Business
  - Solutions that deliver
    - Capabilities
    - What are they?
    - How are they assembled?

- Responsible for defining, designing, and delivering this solution that meets:
  - Measures of Effectiveness and Performance (MEE)
  - Measures of Performance Key Performance Parameters
  - Key System Attributes

Project Manager

- Focused on the Business
  - Requirements
  - When are these needed?
  - How much will they cost?

- Responsible for designing and operating the control system that manages the work associated with the solution that meets:
  - Technical Performance Measures (TPM)
  - Quantifiable Backup Data (QBD)

Integrating Systems Engineering and Project Performance Management

Project Performance Manager

- Focused on Business Requirements
- How Much and When
- Responsible for designing and operating the project control system to manage work that produces the system

Systems Engineer

- Focused on Business Requirements
- How Much and When
- Focused on Business Solution
- What and How
- Responsible for Defining, Designing, and Delivering the Solution
Integrating these Two Perspectives

**Project Management**
- ** WHEN **
  - Project Schedule (IMP/IMS)
- ** HOW MUCH **
  - Cost Breakdown Structure (CBS)

**Systems Engineering**
- ** WHY **
  - Vision
  - Business Case
  - Risk Register
- ** WHAT **
  - Product Breakdown Structure (PBS)
  - Work Breakdown Structure (WBS)

The Core Failures Resulting from the Separate but Equal Paradigm

- Cost, Schedule, Performance (CSP) measures needed to manage delivery of Requirements
- Risk Management of C,S, and P
- Physical % Complete
- EAC, ETC, TCPI
- CSP Margin management

Separate Solutions create cultural barriers to Increasing Probability of Success. These barriers isolate data and processes needed for success. Only by removing the barriers through in Integrated Project Performance Management System can the Probability of success be Increased.
A Process-Centric Solution to the Organizational Problem

PM Processes
- Cost
- Schedule
- Technical Performance
- Risk Management

SE Processes
- Mission and Vision
- Effectiveness
- Capabilities
- KPP's / KSA's

Integrated Project Performance Management System (IPPMS)

Integrating two separate process models into a Single Integrated Project Performance Management System (IPPMS) provides the solution to the problem is isolated paradigms. But the Challenge is, How to Perform this Integration.

Overview of the Integration

Formal Model of Integration in sysML
Assessment of Integration Effectiveness and Performance
Integrate Standards from Both Domains
Assign shared responsibilities for Processes, Data and Outcomes

Increased Probability of Project Success
The World of Engineered Systems

The World of Project Management
Motivation for Integrating SE and PPM starts with 4 Known Root Causes of Project Failure

- **Unrealistic** Performance Expectations, with missing Measures of Effectiveness (MOE) and Measures of Performance (MOP).
- **Unrealistic** Cost and Schedule estimates, based on inadequate risk adjusted growth models.
- **Inadequate** assessment of risk and unmitigated exposure to these risks without proper handling plans.
- **Unanticipated** technical issues without alternative plans and solutions to maintain effectiveness of the product or service.

“Borrowed” with permission from Mr. Gary Bliss, Director Performance Assessment and Root Cause Analyses, Office of Assistant Secretary of Defense for Acquisition, Technology, and Logistics.

System Engineering Connects the Dots Between all the Project Information

- Stakeholder Needs
- Use Cases
- Operational Scenarios
- Stakeholder Requirements
- System Requirement
- Interfaces
- System Architectures
- Verification Objectives
- Test Cases
The Composite Elements of Systems Engineering

Work Breakdown Structure defines deliverables

Needed Capabilities
- Requirements Derived from Capabilities
- Work Breakdown Structure defines deliverables
- Work Packages to produce deliverables in the WBS terminal nodes

All programmatic data under change control
- Risk mitigation or retirement shown in the schedule
- Formal risk management in RM Tool
- Credible Work Packages sequences to produce delivered value needed by the business

"Understanding alone isn't enough get people moving." — Shigeo Shingo
### Systems Engineering is a Closed Loop Control System

- **Requirements Analysis**
  - Analyze mission and environment
  - Identify MOP's and MOIP's
  - Identify KPP's and Constraints
  - Perform Analysis of Alternatives

- **Functional Analysis**
  - Decompose functions
  - Allocate KPP's and TPM's to functional levels
  - Define functional architecture

- **Synthesis**
  - Transform functional architecture to physical architecture
  - Define alternative system concepts
  - Select preferred alternatives
  - Define Physical Interfaces

- **System Analysis & Control**
  - Effectiveness
  - Risk
  - Interfaces
  - Data
  - Configuration

- **Project Control Loop**

- **Trade Studies**
  - Effectiveness
  - Risk
  - Interfaces
  - Data
  - Configuration

- **System Design Loop**

- **System Verification Loop**

### Summary of These Concepts

<table>
<thead>
<tr>
<th>Requirements Analysis Loop</th>
<th>System Analysis and Control Loop</th>
<th>Verification Loop</th>
<th>Synthesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mission and Environment Analysis</td>
<td>Progress Measurements</td>
<td>Lower Level Decomposition</td>
<td>Transform Architecture from Functional to Physical</td>
</tr>
<tr>
<td>Functional Requirements Identification</td>
<td>Control and Manage</td>
<td>Allocate Requirements to all Functional Levels</td>
<td>Define Alternate System Concepts, CI's, System Elements</td>
</tr>
<tr>
<td></td>
<td>Select Preferred Alternatives</td>
<td>Define, Refine Internal and External Interfaces</td>
<td>Define, Refine Internal and External Interfaces</td>
</tr>
</tbody>
</table>

---

PGCS 2019 Master Workshop, 21–22 August, Canberra Australia

SMC Systems Engineering Handbook, Version 3, Figure 13
The objective of Systems Engineering is to assure the system is designed, built, and operated to accomplishes its purpose in the most cost-effective way possible, considering performance, cost, schedule and risk.

A system is a collection of different elements that together produce results not obtainable by the elements alone.

Systems Engineering is the art and science of developing an operable system capable of meeting requirements within imposed constraints.

All Successful Projects Require Credible Answers To These 5 Immutable Principles [59] …

1. What Does DONE Look Like?
2. How Do We Get to DONE?
3. Is There Enough Time, Money, and Resources, To Get to DONE?
4. What Impediments Will Be Encountered Along The Way to DONE?
5. What Units of Measure are used to confirm Progress To Plan Toward DONE?
16 Elements of Program Management Used to Implement the Five Immutable Principles

Program Process Capabilities
1. Program Management Involvement in Proposal
2. Program Planning
3. Performance Management
4. Sub-Contract Management
5. Follow-On Business Development
6. Earned Value Management
7. Requirements Management
8. Schedule Management
10. Risk Management

Program Enablers
11. Organization/IPD
12. Customer Partnership
13. Program Review Process
14. Configuration/Data Management
15. PPM Process Management
16. PPM Development and Succession

Business Enablers

The 4 + 1 Elements Needed To Increase Project’s Probability of Success

1. What Capabilities are needed to fulfill the Concept of Operations, the Mission and Vision, or the Business System Requirements?
2. What technical and operational requirements are needed to deliver these capabilities?
3. What is the cost and schedule that delivers product or services that meet the requirements?
4. What are the periodic measures of physical percent complete?
5. What will be impediments are there to success and what are the mitigations?

† A Concept of Operations (ConOps) describes the characteristics of a proposed system from the viewpoint of an Individual who will use that system. It is used to communicate the quantitative and qualitative system characteristics to all stakeholders.
The Notional Project

- We work for an Unmanned Aerial Vehicle (UAV) firm entering the ranching and farming marketplace.
- We know how to build complex equipment, including flying machines, electronics, and training systems for government agencies.
- We now want to do the same for farmers and ranchers.