Value of Systems Engineering

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BLUF

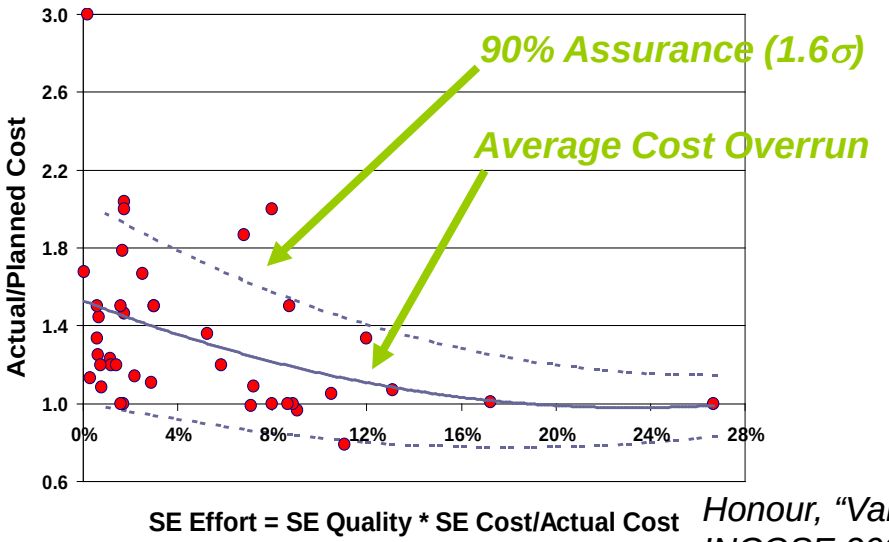
- "…there is a strong case to be made for a quantitative relationship between systems engineering investment and the quality of program performance." – Eric Honour, Value of Systems Engineering

How can we capture the value of Systems Engineering?

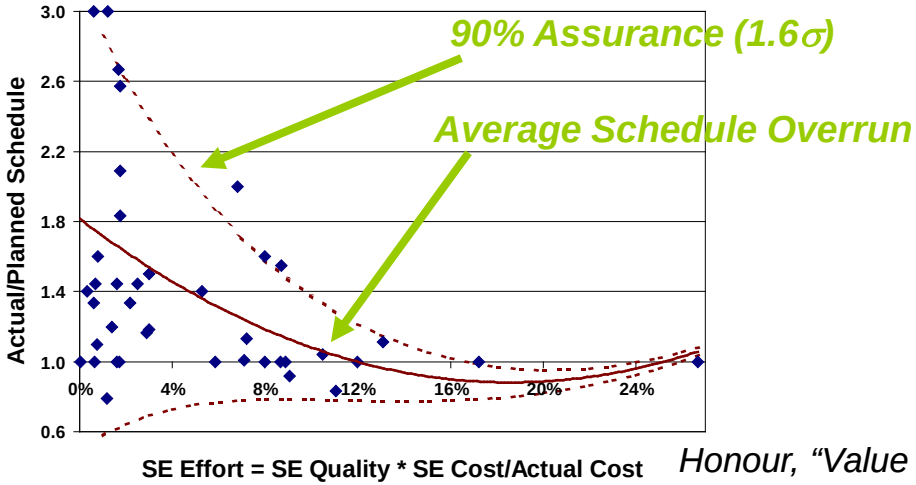
Goals & Strategy

Goal	Strategy
What information is available about the value of SE?	Research •INCOSE Value of SE & SE ROI •Qualitative findings •Quantitative findings
Determine Value of Systems Engineering on a given program at ARDEC	Use the Voice of the Customer/Interviews •Determine how much SE was done •How has SE benefited the program? •Where was there room for SE-related improvement?
Capture SE lessons learned to foster improvement	

Outside Findings- INCOSE



Honour, "Value of SE"
INCOSE 2004



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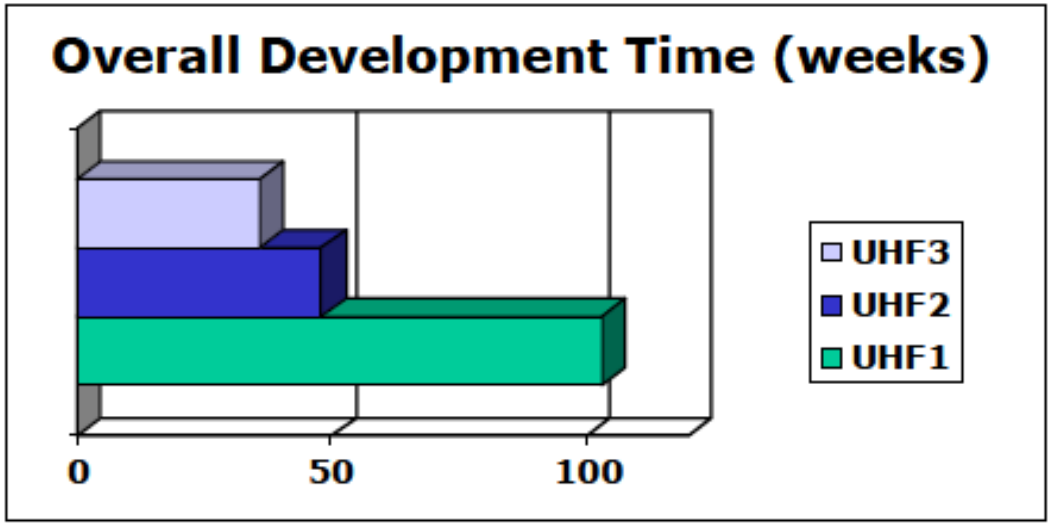
Malcolm Baldrige National Quality Award 2007 Award Recipient

Outside Findings- INCOSE



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- Boeing study- Parallel development of 3 Universal Holding Fixture (UHF)
- UHF 3 was the most complex system
- More rigorous SE resulted in shorter durations between:
  - Requirements to subcontract RFP
  - Design to production
  - Overall development time
- Also superior quality of work (subjective)

* Honour, Eric C. Understanding the Value of Systems Engineering. Pg. 8. Honourcode, Inc.

Outside Findings- INCOSE

- Systems Engineering Return on Investment (ROI)
  - Follow up on Value of SE and SE Effectiveness research
- Interview a set of programs from participating organizations
- Formal, consistent interview format
- Gather data in regard to:
  - Funding method
  - Total program cost
  - Cost compliance (% over or under planned cost)
  - Schedule compliance (% over or under planned schedule)
  - Percentage of program cost used in SE effort
  - Subjective assessment of SE quality (scale of 1- poor to 10- world class)

Outside Findings- INCOSE

- Correlation between project success and ratio of effort on each area of SE to total SE effort
  - Verification/Validation
  - Technical Management/Leadership
  - Technical Analysis
  - System Implementation (integration)
  - System Architecting
  - Requirements Engineering
  - Scope Management
  - Mission/Purpose Definition
- Successful projects experienced cost overrun < 3%
  - ranging from 38% underrun to 1% overrun
- Unsuccessful projects ranged from 3% to 200% overrun

Outside Findings- INCOSE

- Unsuccessful projects, in comparison to successful projects, expended:
  - 50% less effort in mission definition
  - 33% less effort in requirements engineering
  - 33% less effort in scope management
  - 40% more effort in systems architecting
  - 60% more effort in implementation/integration
  - 25% more effort in verification/validation

Successful Projects Spent More Up Front

Outside Findings- INCOSE

- "These findings are consistent with the long-held anecdotal knowledge… that programs expending more front-end effort can expect to reduce overall cost and schedule"*

•Honour, Eric C. "Demographics in Measuring Systems Engineering Return on Investment (SE-ROI)". INCOSE, 2009.

How does ARDEC measure up?

- Metrics
- Project Exit Interviews
- Lessons Learned

Metrics Overview

- Gather metrics on select projects during execution to monitor:
    1. Requirements Stability
    2. Quality of Requirements
    3. Requirements Traceability
    4. Procedure Compliance
    5. Customer Satisfaction
    6. Process Tailoring
    7. Technical Performance Measures(TPMs)
    8. Project Deliverables
    9. Execution Per Plan
    10. Technical Reviews

Overview of Exercise

- Interview SE and ARDEC Project Officer after project close-out
  - Gather feedback on all areas of our Organizational Standard Process (OSP)
  - Establish an informal dialogue to encourage anecdotal feedback as well

* Included personnel from both System Engineering and Project Management to ensure unbiased responses

Findings- Communication

- SE role in communication is huge
  - Synthesize information from all silos
  - Dialogue with customer/user to get the right requirements
    - Combination of the right information and the right tools
    - Ex: Tracing requirements is only useful when the right requirements are being traced!
  - Also a huge role in contractor management

Findings- Technical Planning

- Laying out the project plan from a SE perspective enables success
  - Metrics & measures communicate program status
  - Provide context to frame where a project is in its lifecycle

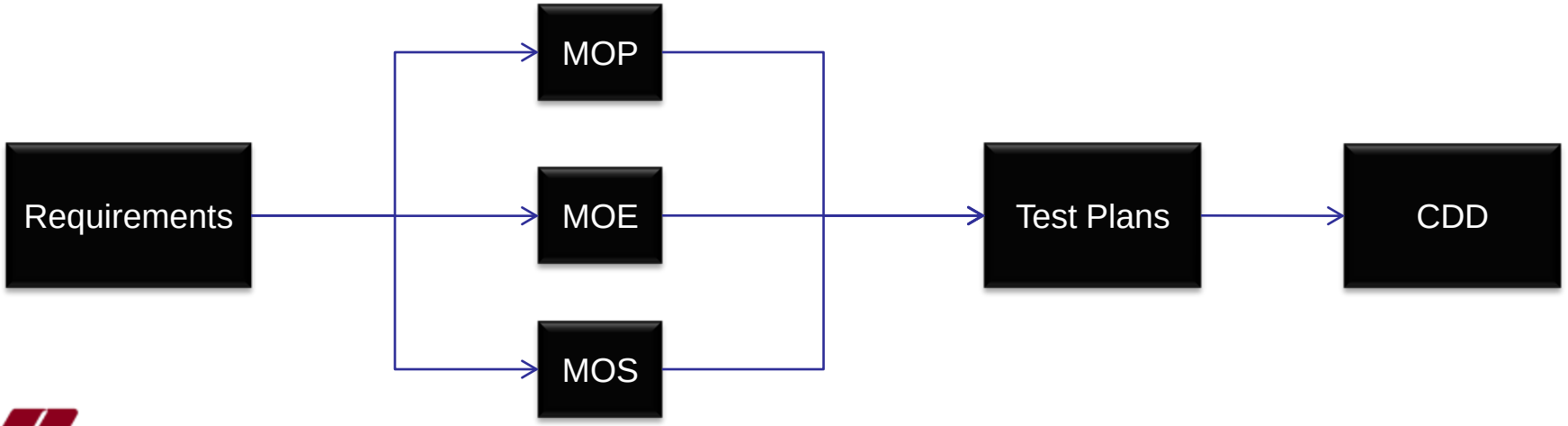
Findings- Requirements

- "Application of a tool for requirements management is critical"

- Use of DOORS as an SE tool
  - Limitations
    - Licenses- one SEL was the only IPT member with DOORS access
  - Benefits
    - Able to leverage DOORS database for numerous products and activities
      - Requirements Traceability
      - Verification plan

Findings- QFD

- Use of Quality Function Deployment (QFD) as a requirements tool
  - One program successfully implemented a QFD
    - Resulted in stable requirements through the program
    - Simplified writing the requirements document (i.e. Concept Development Document)



Findings- QFD

- Speaking to the SE and ARDEC Project Officer allowed for further discussion on successful QFD implementation
  - Gathered insight on:
    - Contracting the exercise
    - Roles and required participation
    - Leveraging the QFD to enable transition & communicate “readiness” to our acquisition partners

Findings- Risk Management

- SE's role in regard to Risk Management is pivotal
  - Communicate risk to management
  - Organize & understand variables affecting risk
    - Traditional cascading risk charts, risk matrix, risk register
    - Also implement quantitative risk analysis
      - Assess current design state

Findings- SE & Decision Making

- SE products aid in decision making
  - Removes emotion
  - Enables fact-based decisions & acquisition
  - Decision Analysis- builds consensus, defines alternatives, assigns priority
  - Example:
    - Feasibility study on one project showed that one alternative was feasible in a 10 year time frame, while another was not

Findings

- SE is commonly misunderstood
  - If tools are properly implemented, they provide a bridge to communicate with our Acquisition Partners
  - SE Products noted by projects to be especially helpful:
    - Feasibility study
    - QFD
    - Interface Control Documents (ICDs)
    - Risk matrix, associated products
    - Technology Readiness Level (TRL) tool

Findings- SE OSP

- Procedures and templates provide a useful framework for a SE
  - ARDEC SE OSP had not been established when one project began
  - SE had to research procedures and best practices on his own in order to implement the SE Process

Lessons Learned

- Stakeholder buy-in is key
  - Define acceptance criteria
  - Example:
    - Problems occurred on one project during testing as a result of undefined:
      - MOEs, MOPs, MOSs

Lessons Learned

- Establishing knowledge of and adherence to SE best practices is essential from the start of a project
  - Example:
    - Configuration Management: SE had little understanding of the process & the level of implementation appropriate for Technology Development
    - Not implementing from inception made it difficult to instantiate later on within the IPT
      - Resulted in rework during project close-out
- Inexperience is a big barrier to successful SE
  - Strong training base, weak in amount of experienced personnel

Takeaway- Value of SE

- Benefits within ARDEC
  - Open dialogue about the strengths and weaknesses of our organization and OSP after close-out allows for greater insight
    - Employees do not feel threatened
    - Project success is not threatened
    - Allow for greater understanding/documentation of lessons learned
  - Promotes SE within the organization
    - Justification for continued funding of SE Infrastructure
    - Greater understanding of what a SE can provide to a program

Takeaway- Value of SE

- Direction of Value of SE at ARDEC efforts
  - Enable robust analysis of the Value of SE by capturing more qualitative AND quantitative data
    - Continue to gather feedback from projects
      - Capture lessons learned
      - Improve ARDEC's SE OSP
      - Incorporate findings into Internal SE Training
    - Leverage cost, schedule & performance data collected by Project Management to correlate the SE Metrics we collect to project performance
      - Allow for more robust analysis of internal ROI

Conclusion

- "If you have a good systems engineer [on a program], the program goes great."
  - ARDEC Project Officer

- ARDEC projects implement SE and find utility in our SE OSP
  - Strive for Continuous Process Improvement (CPI)

Systems Engineering is beneficial in regard to project cost, schedule and performance