Suitable Metrics for Measuring the Effectiveness of the Systems Engineering Process

Benjamin Q. Luong
and
Lauren L. Nguyen

Copyright © Boeing 2006
Abstract

• As we strive to develop resilient large-scale integrated products and enterprise systems that are entirely inventive and/or significantly better than their predecessors, the Systems Engineering discipline leads us to improve product definition, product development, and overall performance of businesses, particularly commercial and defense programs.

• In recent years, Boeing has made significant leaps in improvement to the application of the Systems Engineering Process, especially in the areas of requirements management, risk management, trade studies, and verification and validation. During our continuous improvement journey, there is a need for a way to measure the effectiveness of Systems Engineering on program performance. This presentation describes a set of Systems Engineering ‘program-level’ predictive and reactive metrics that give clear visibility into the benefit of Systems Engineering on program performance.

• Further, these program-level metrics are also flags that help forecast positive or negative events. Each predictive metric has a high or low correlation counterpart(s), its reactive metric(s). As we determine the relationship between predictive and reactive metrics, they can be mapped to different pinpoints in the Systems Engineering Process. Also, a reactive metric within the process may be predictive, which may map to another reactive metric. By understanding and evaluating the results of these metrics, we can continuously improve the application of Systems Engineering and ultimately, program performance.
Topics of Discussion

- Systems Engineering Process Fundamentals
- Thinking about Effectiveness
- Thinking about Performance
- Measures of Effectiveness & Performance
- Suitable Measures of Effectiveness & Performance for Systems Engineering Process
- Suitable Systems Engineering Index
- Predictive and Reactive Metrics: Examples
- Predictive and Reactive Relationships
- Corporate / Program Performance
- Conclusion
Systems Engineering Process Fundamentals

- **Process input**
  - Customer needs/objectives/requirements
    - Missions
    - **Measures of Effectiveness**
    - Environments
    - Constraints
  - Technology base
  - Outputs from prior phase
  - Program decision requirements
  - Requirements applied through specifications and standards

- **Requirements analysis**
  - Analyze missions and environments
  - Identify functional requirements
  - Define/refine performance and design constraint requirements

- **Functional analysis/allocation**
  - Decompose to lower-level functions
  - Allocate performance and other limiting requirements to all functional levels
  - Define/refine functional levels
  - Define/refine functional interfaces (internal/external)
  - Define/refine/integrate functional architecture

- **Synthesis**
  - Transform architectures (functional to physical)
  - Define alternative system concepts, configuration items and system elements
  - Define/refine physical interfaces (internal/external)
  - Select preferred product and process solutions

- **Verification Loop**
  - Requirements loop
  - System analysis and control (balance)

- **Control loop**
  - Design loop
  - Systems Engineering Management
    - Risk management
    - Configuration management
    - Interface management
    - Data management
    - Performance based progress measurement
      - IMP/IMS
      - TPM
      - Technical reviews

- **Process output**
  - Balanced Product
  - Phase dependent
    - Decision support data
    - System architecture
    - Specifications and baselines
Thinking About Effectiveness

• Take off your Engineering Cap

• Put on your Business Cap

• Ask the Fundamental Business Questions:
  – What does effectiveness really mean?
  – What are everyday examples or types of effectiveness?
  – How do we measure effectiveness?
Thinking About Effectiveness

• Definition of Effectiveness
  – Adequate to accomplish a purpose; producing the intended result or expected result
  – Descriptions: Influence, Efficiency, Capability

• Various Types of Effectiveness
  – Corporate Effectiveness
  – Organizational Effectiveness
  – Product Effectiveness
  – Individual Effectiveness
Thinking About Effectiveness

• Measures of Effectiveness (MOE)
  – Corporate Effectiveness → Performance!
  – Organizational Effectiveness → Performance!
  – Product Effectiveness → Performance!
  – Individual Effectiveness → Performance!
  – SE Process Effectiveness → Performance!

• What are the common Measures of Performance (MOP)?
Thinking About Performance

- Common Types of Measures of Performance (MOP)

Quality

Cost

Schedule

Productivity

Resources
Measures of Effectiveness & Performance

- Stakeholder Wants
- Functional or Physical Attributes of a System, e.g. Corporate, Organization, Product, Individual, SE Process

Leading Insight

Types of Performance Measures

- Quality
- Cost
- Schedule
- Productivity
- Resources
Measures of Effectiveness & Performance for the SE Process

Now, put your Engineering Cap back on

Measures of Effectiveness ‘for’ the SE Process
1. Balanced & Validated Product
2. Product Operational Safety, Suitability & Effectiveness
2. Return on Investment (ROI)

Measures of Performance ‘from’ SE Process
- Apply the business fundamentals to each core SE Process Element
  - Requirements Analysis
  - Functional Definition
  - Design Synthesis
  - System Analysis & Control
  - Product Verification & Validation

- Other SE Elements
  - Suppliers & Supplier Management
  - Production
  - Operations Support
  - Sustainment
Suitable Measures of Effectiveness & Performance for SE Process

- Stakeholder Wants, e.g. Margins, ROI, OSS&E
- Measures of Effectiveness
- Balanced & Validated Product
- OSS&E
- ROI
- Systems Engineering Index
- Performance Index
- Core Components
- Measures of Performance
- Suitable Program-Level Metrics!

- Requirements Analysis
- Functional Definition
- Design Synthesis
- Systems Analysis & Control
- Product V&V
- ...

- Quality
- Cost
- Schedule
- Productivity
- Resources
- Potential Suitable Metrics!

10/26/2006
Suitable Systems Engineering Index

• Comprised of Several, Weighted Components with Trend Curves
  – Requirements Analysis Performance
  – Functional Definition Performance
  – Design Synthesis Performance
  – System Analysis & Control Performance
  – Product Verification & Validation Performance
  – Suppliers & Supplier Management Performance
  – Production Performance
  – Operations Support Performance
  – Sustainment Performance
Predictive & Reactive: Examples of Suitable Metrics

- Requirements
  - Requirements Quality
  - Design Synthesis
    - On-Time Engineering Release
    - After-Initial-Release (AIR) Traffic
  - System Analysis & Control
    - Design Reviews: Number of Critical Action Items
    - Risk Management: Number of Risks Identified, Mitigated, Retired, Realized & Elevated
  - Product Verification & Validation
    - Requirements Compliance
  - Production
    - LRU Tag Trend
    - Deviations & Waivers

- Predictive
- Reactive – Predictive
Predictive and Reactive Metrics – Industry Examples

• Reactive Indicators of Economic Growth (Common Examples)
  – Gross Domestic Product (GDP)
  – Stock Market Indices:
    • Dow Jones
    • NASDAQ
    • S&P 500
    • Nikkei 225
  – These can be predictive in a different context when they provide leading insight into any specific economic segment

• Predictive Indicators of Economic Growth (Common Examples)
  – Inflation
  – Manufacturing & Housing Index
  – Interest Rates
  – Employment Rate
  – Oil Prices
  – Corporate
Typical Predictive and Reactive Relationships (snapshot)

- **Requirements Quality**
  - Predictive
  - Reactive
  - Metric of Interest
  - # of Critical Action Items
  - # of High Risks Identified
  - After-Initial-Release Traffic
  - On-Time Engr Release
  - Deviation Waiver

- **System Analysis & Control**
  - After-Initial-Release Traffic

- **Design Synthesis**
  - On-Time Engr Release

- **Verification & Validation**
  - Deviation Waiver

- **Requirements Analysis**
  - Predictive
  - Reactive

- **One-to-One**
  - Many-to-Many
  - Many-to-One

10/26/2006
Corporate / Program Performance

• Higher-Level MOEs
  – Profit Margins → Financial Performance.
  – Cost Reduction → Financial Performance.
  – Customer Confidence → Financial Performance.
  – Program Mgmt Indicators → Financial Performance.

• Higher-Level MOPs
  – Quality → Malcolm Baldridge, ISO, CMMI Level 5
  – Cost → Lean, Six Sigma, Savings, Rework
  – Schedule → Timely Product Delivery
  – Productivity → Employee Satisfaction
  – Resources → People, Processes & Tools
Conclusion

• Systems Engineering effectiveness can be gauged through performance of Systems Engineering elements

• Typical performance indicators may include Quality, Cost, Schedule, Productivity, and Resources

• Suitable metrics can be derived from performance indicators

• Metrics can be Predictive, Reactive or both

• Relationship between Predictive and Reactive metrics can be correlated to specific elements/phase of the Systems Engineering Process

• Continuous evaluation of these metrics increases Systems Engineering effectiveness and overall Program performance
Contact Information

• Benjamin Q. Luong, Systems Engineer
  – Phone: (562) 593-4668
  – Email: benjamin.q.luong@boeing.com

• Lauren L. Nguyen, Systems Engineer
  – Phone: (562) 593-4489
  – Email: lauren.l.nguyen@boeing.com

Thank you!

Questions? We might have answers…