Suitable Metrics for Measuring the Effectiveness of the Systems Engineering Process

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and

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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.

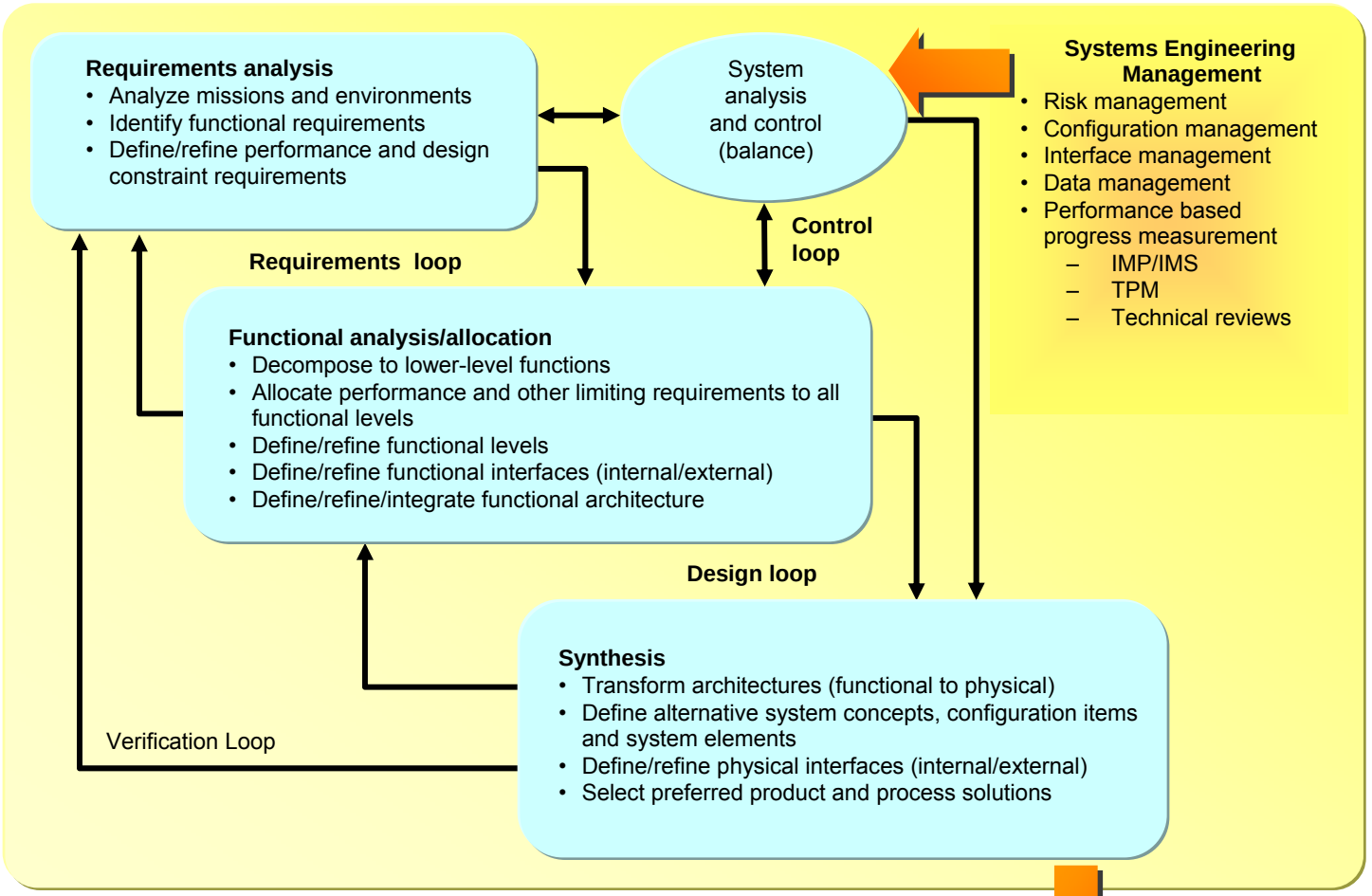
- Further, these program-level metrics are also flags that help forecast positive or negative events. Each predictive metric has a high or low correlation counterpart(s), its reactive metric(s). As we determine the relationship between predictive and reactive metrics, they can be mapped to different 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



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

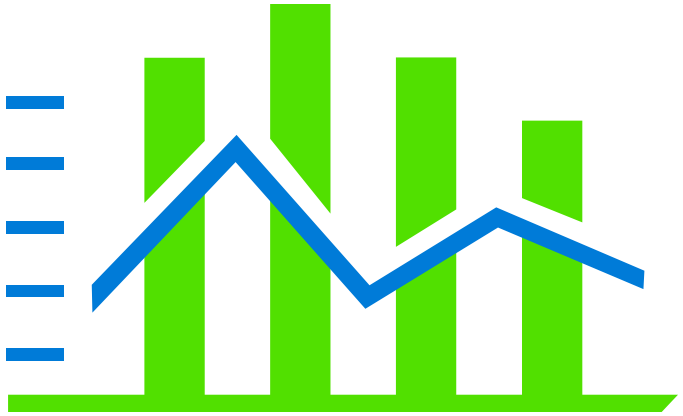
- Definition of Effectiveness
  - Adequate to accomplish a purpose; producing the intended result or expected result
  - Descriptions: Influence, Efficiency, Capability

- 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)?

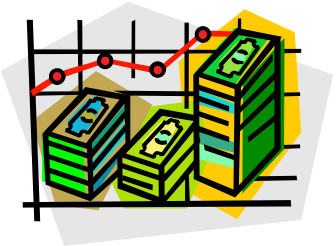


Thinking About Performance

- Common Types of Measures of Performance (MOP)

Quality

Cost

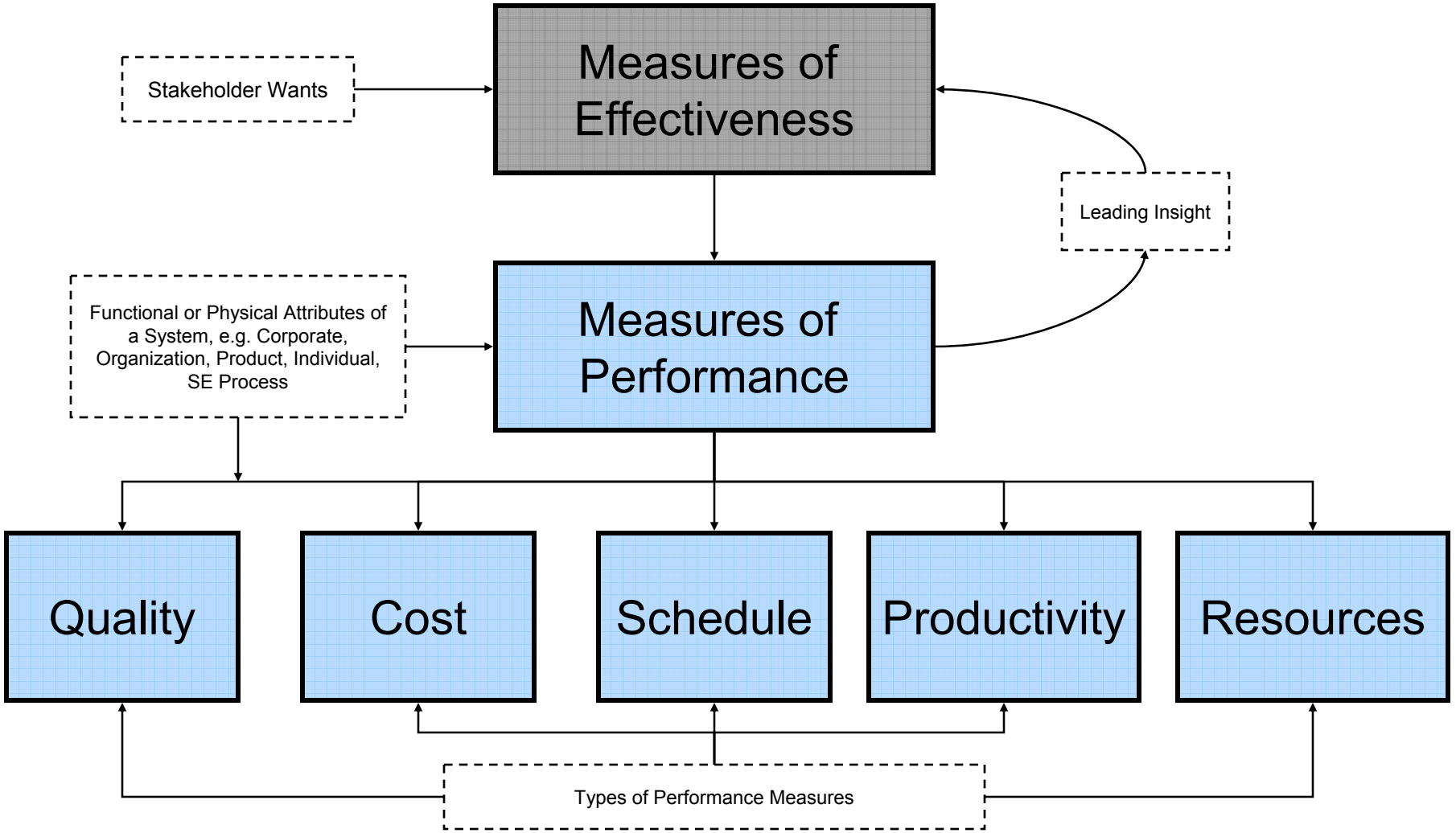


Schedule

Productivity

Resources

Measures of Effectiveness & Performance



Measures of Effectiveness & Performance for the SE Process

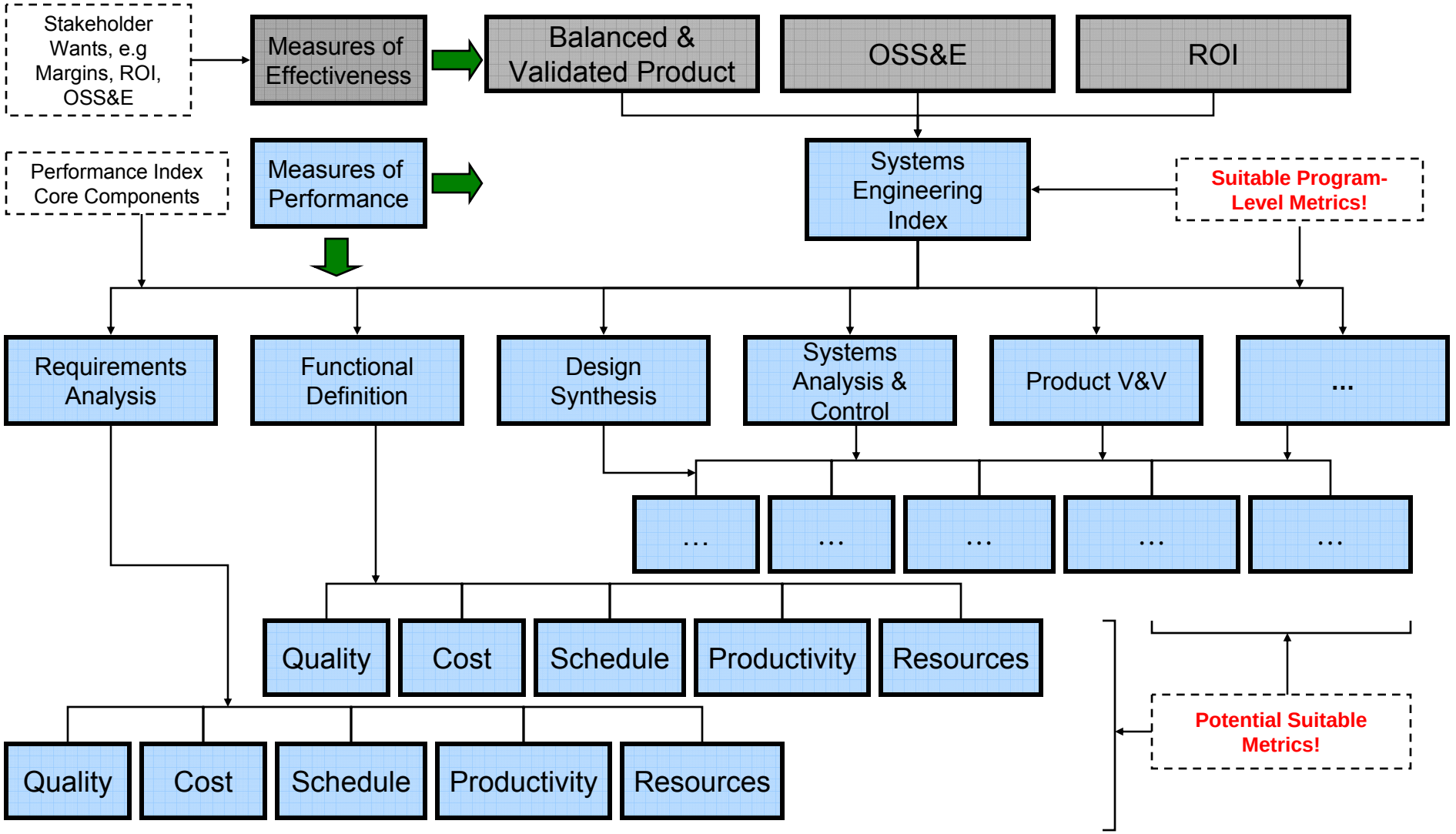
- Now, put your Engineering Cap back on

- 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

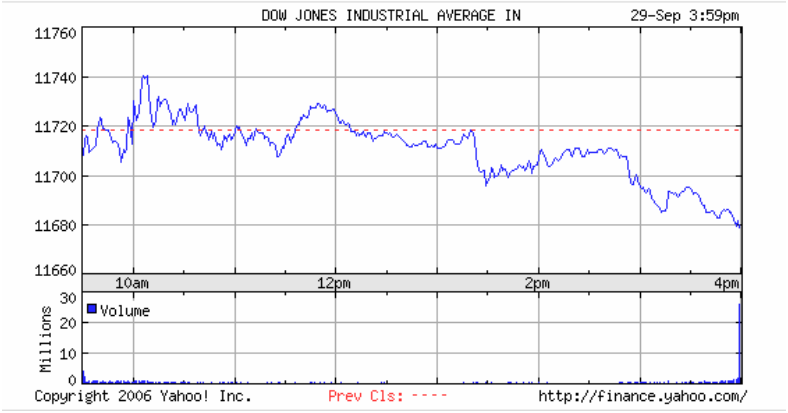
  - Other SE Elements
    - Suppliers & Supplier Management
    - Production
    - Operations Support
    - Sustainment

Suitable Measures of Effectiveness & Performance for SE Process



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



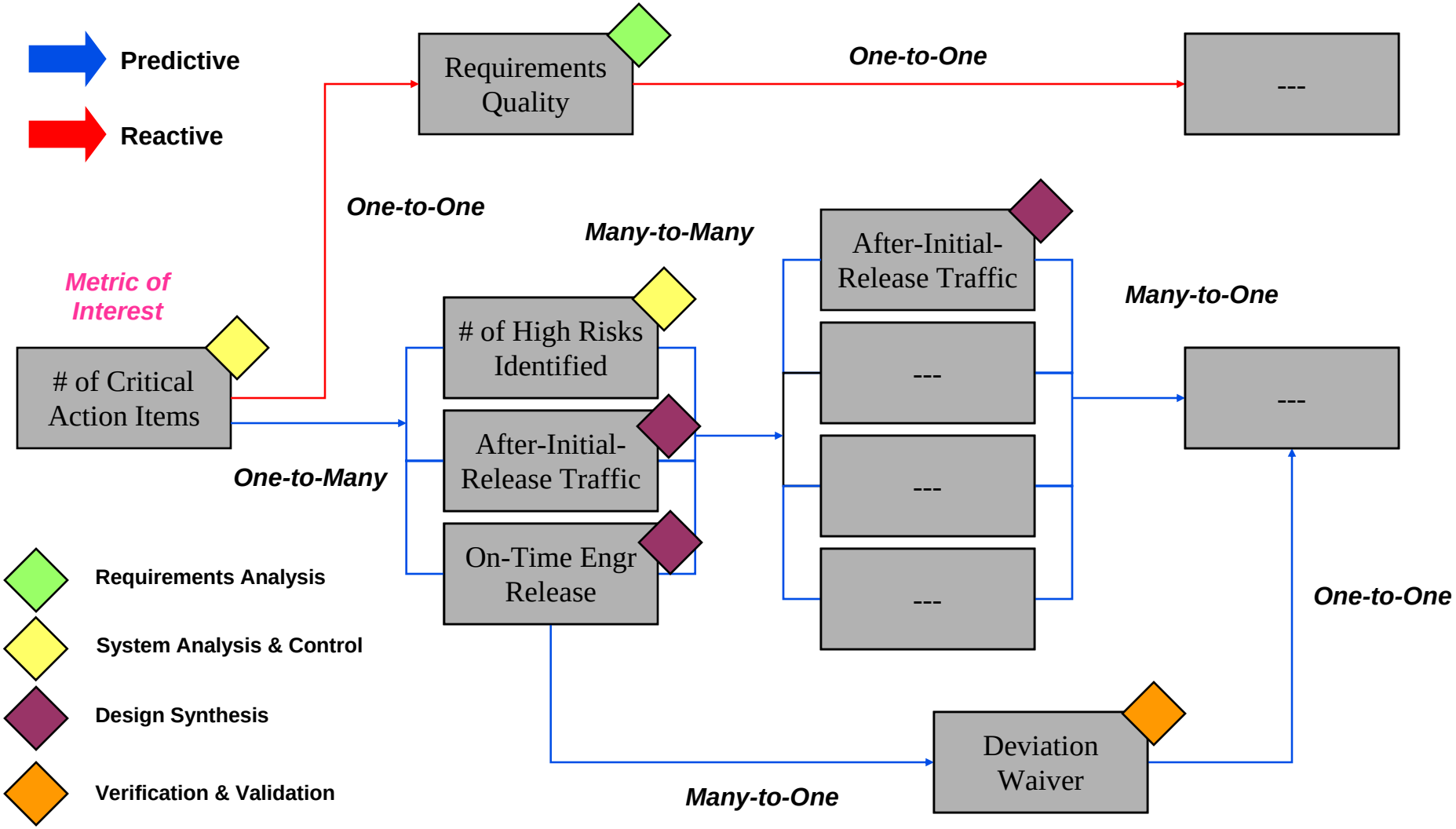
Predictive & Reactive: Examples of Suitable Metrics

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

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)



Corporate / Program Performance

- Higher-Level MOEs
  - Profit Margins → **Financial Performance**.
  - Cost Reduction → **Financial Performance**.
  - Return on Investment → **Financial Performance**.
  - Customer Satisfaction → **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

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Thank you!