Using Performance-Based Earned Value® for Measuring Systems Engineering Effectiveness

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Outline

- Performance-Based Earned Value®
- SE Effectiveness
- SE Metrics Architecture
- Example Metrics for Requirements

The Scope of Earned Value is Limited

- *ANSI/EIA-748B, 3.8
  - "Earned value is a direct measurement of the quantity of work accomplished. The *quality* and *technical content* of work performed is controlled by other processes." [emphasis added]
- Need another method to assess ***quality*** of work accomplished

* "Standard for Earned Value Management Systems"

Easy PBEV℠ Example

- Task: wash windows
- Desired outcome: clean windows
- Quality measure: cannot see anything on window surface (no distortion or obscuration of reflections)
- Earned Value: Window was washed
  - "I washed the window"
- PBEV℠: Window is clean
  - "But it's not clean" – PBEV℠ less than EV
- Difference (PBEV℠ – EV) = "Unearned value" = Quality criteria for the product delivered by the activity, or the *cost of rework*

What is Quality?

- **"Quality is conformance to requirements" (Crosby, "Quality is Free", 1979)**
- **Therefore, "quality" of work accomplished is composed of**
  - Inherent quality of work product **(conformance to work product standards, e.g., specs, drawings, plans, reports)**
  - Conformance of work product to technical requirements **associated with the system (e.g., design satisfies requirements)**

SE Quality Example - Specifications

- A major SE work product is a specification containing all requirements for a system
- Requirements Specification Quality – 2 parts
  - Specification structure and syntax
    - Conforms to template standards (quality of specification)
      - Completeness, outline, format
    - Requirements are well-stated (quality of requirements)
      - Clarity, verifiability, etc.
  - Specification content
    - System described satisfies user needs and/or contract requirements, e.g., weight, speed, availability, etc.

SE Effectiveness

- "Effectiveness" is an ability to produce the needed result using the committed resources
  - Resource commitments based on planning
  - EV measures execution vs. plan
  - Resource utilization: money, people, facilities, time
- What are the "needed results" or products of SE?
  - Specific SE work products
  - Program outcomes
    - Cost – Budgeted cost
    - Schedule – Committed schedule
    - Technical Performance – Systems satisfying requirements and needs
  - ➢ Leads to PBEV[SM*]

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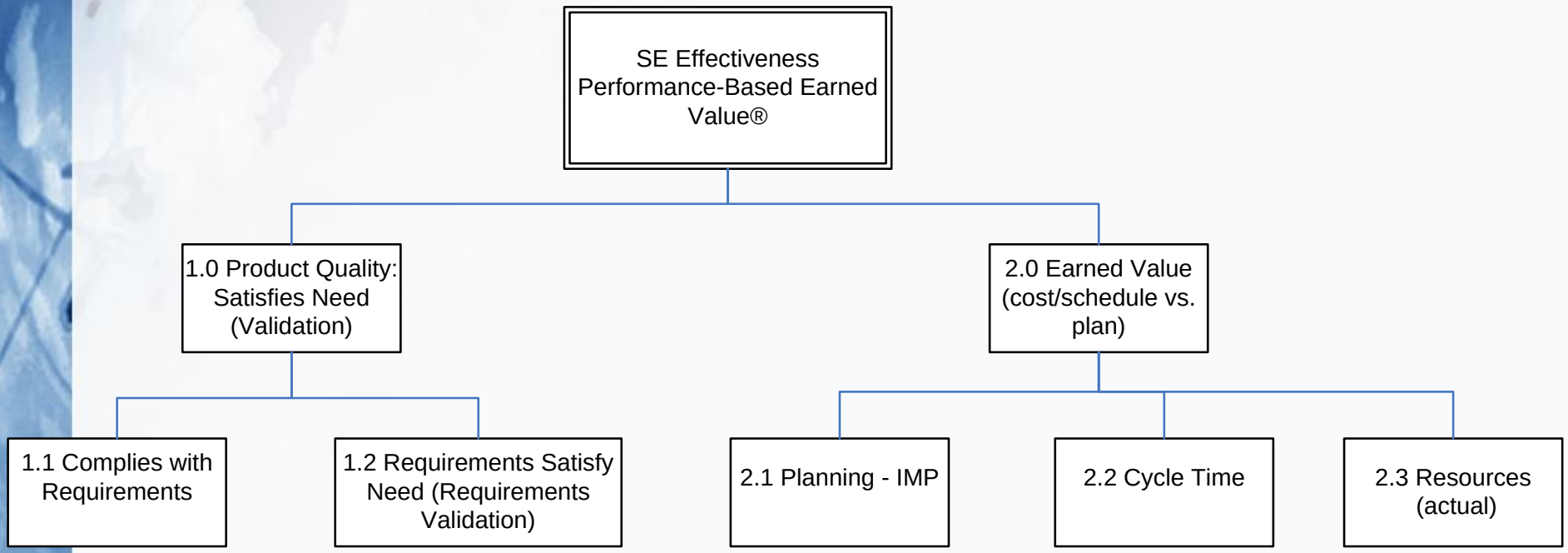
SE Effectiveness Decomposition

- **Define contributors to SE Effectiveness**
  - **Leads to SE Metrics Architecture**
- **Three contributing streams**
  - **Product Quality – Satisfying needs and requirements**
  - **Cost and**
  - **Schedule** } Collectively measured by Earned Value
    - **Planning (basis for product definition and EV)**
- **Essential elements**
  - **Work product quality and completeness – fitness for use by downstream "customer"**
  - **Timeliness – available when needed**
    - **Defined by coordinated schedule; measured by EV**

SE Measures Architecture

- **Top level of measures architecture shows decomposition of SE Effectiveness and PBEV^{SM}**

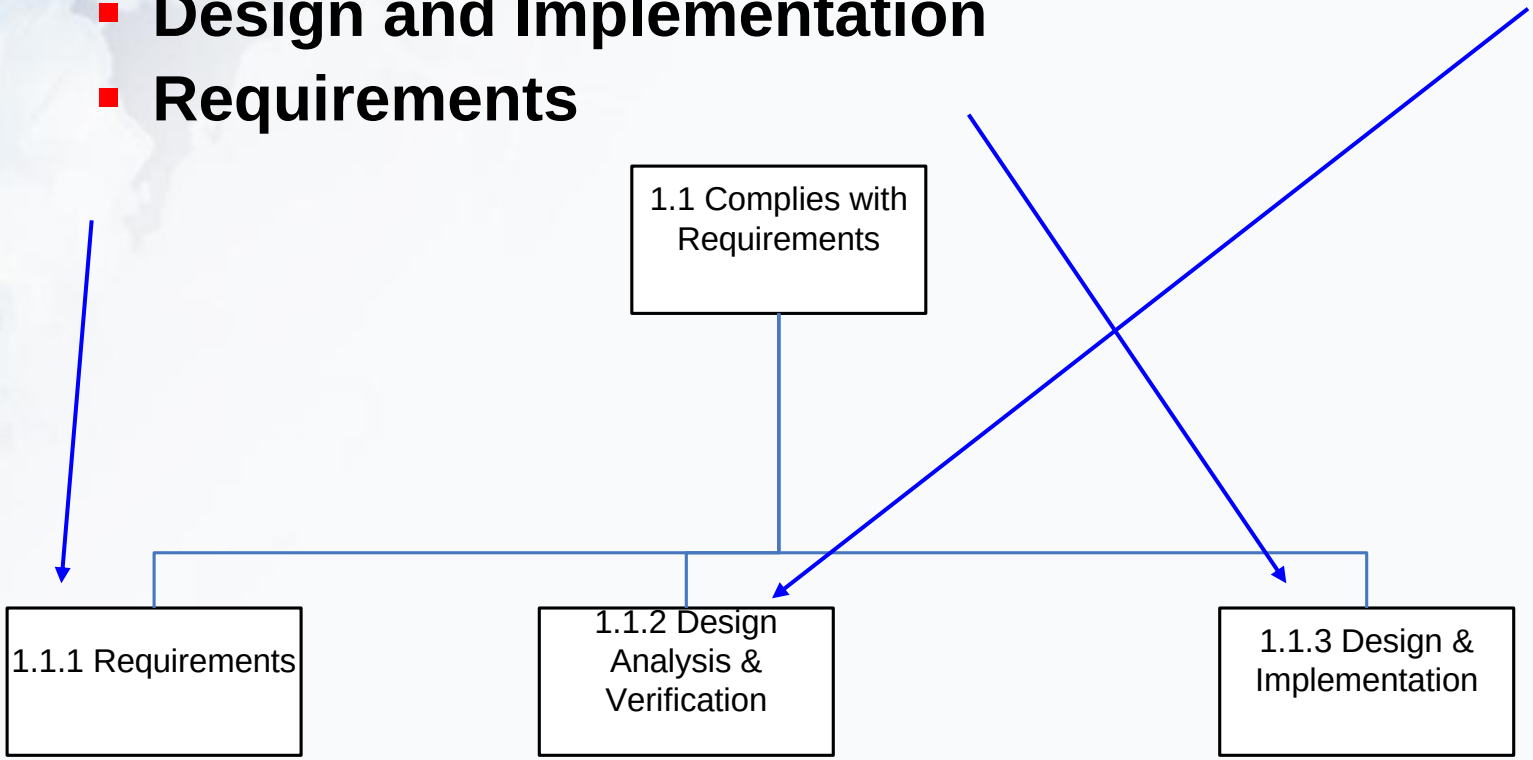


Using PBEV℠ for SE Effectiveness

- **Work definition – IMP/IMS**
  - Define work products for every scheduled activity (evidence of completion)
    - Plans, requirements, design, interfaces, verification
  - Define objective quality standards for work products
  - Define technical content requirements for work products
- **Progress assessment**
  - Value is earned (EV) based on
    - Satisfying work product quality standard
    - Satisfying technical requirements associated with work product
  - Technical maturity per plan – % of planned TPM achieved (Solomon)
- **"Unearned value" is cost of rework: the work not-yet-accomplished**

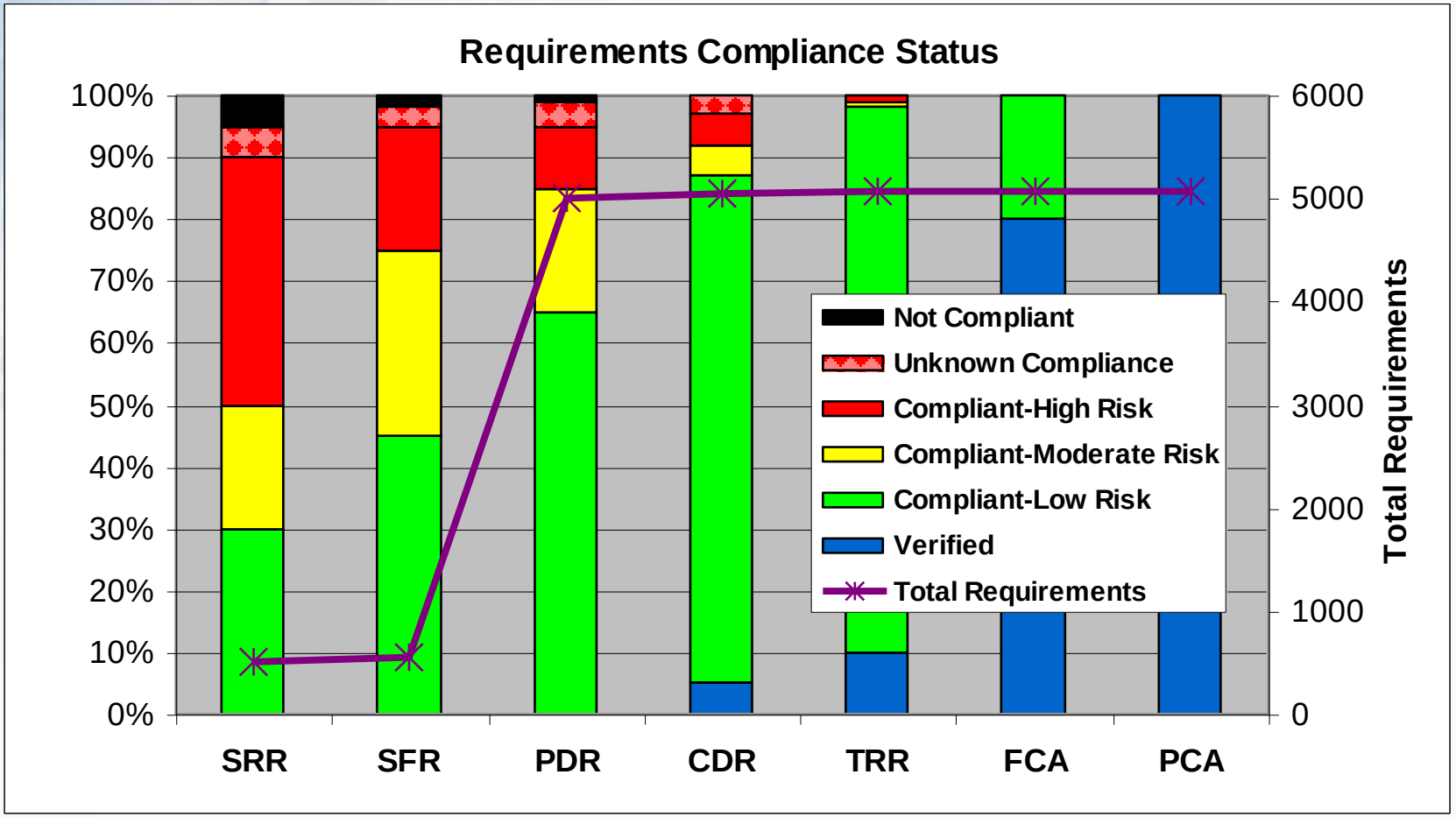
Decomposition of Compliance of Design with Requirements

- **Measure Quality and Completeness of**
  - **Design Analysis and Verification (Compliance)**
  - **Design and Implementation**
  - **Requirements**



Technical Compliance Metric

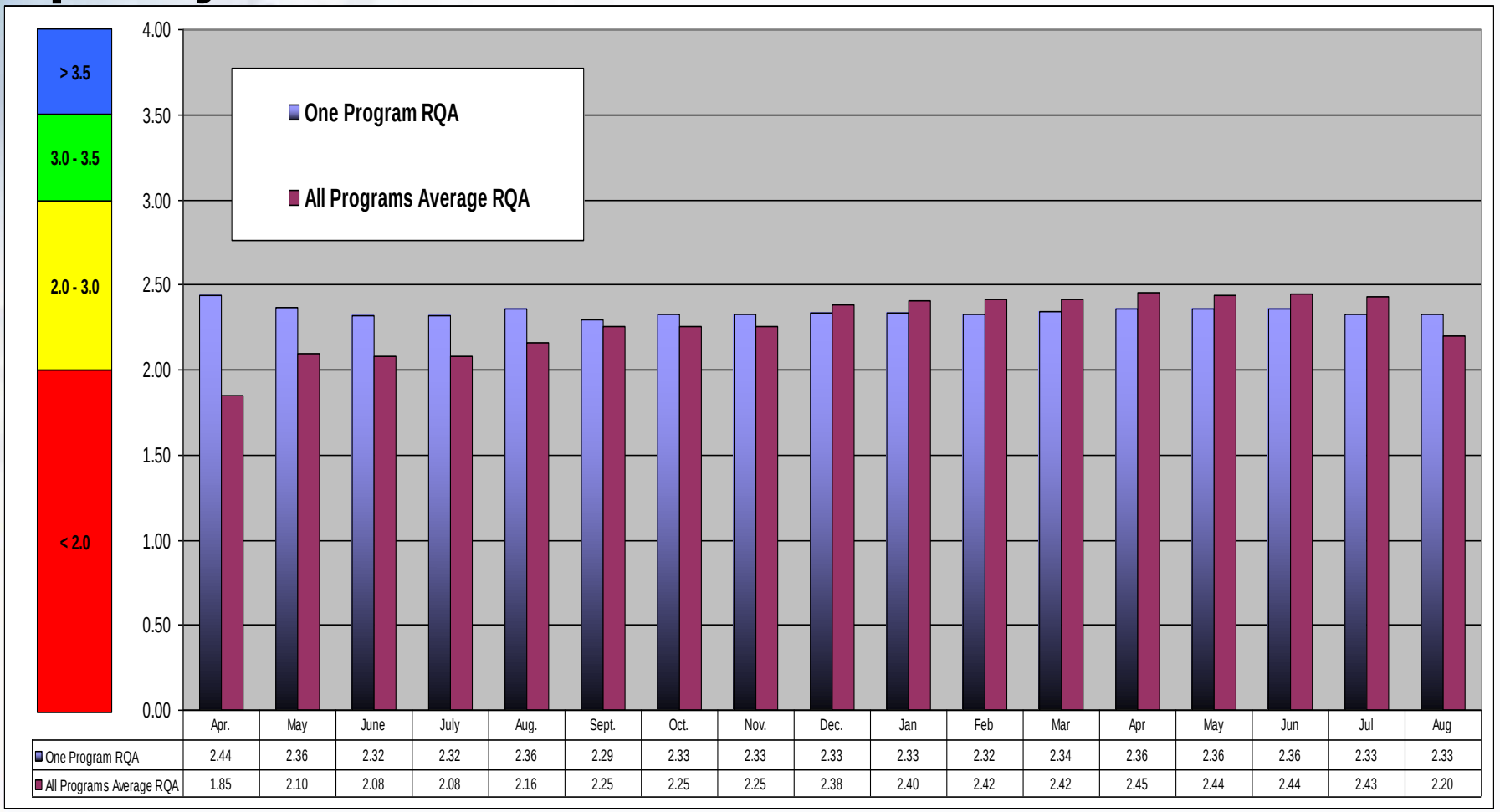
- **At each major review, assess % requirements for which design is compliant, with associated risk level of non-compliance***



*Notional data

Requirements Quality Assessments (RQA)

- **Assess quality of requirements vs. objective quality standard**



	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
One Program RQA	2.44	2.36	2.32	2.32	2.36	2.29	2.33	2.33	2.33	2.33	2.32	2.34	2.36	2.36	2.36	2.33	2.33
All Programs Average RQA	1.85	2.10	2.08	2.08	2.16	2.25	2.25	2.25	2.38	2.40	2.42	2.42	2.45	2.44	2.44	2.43	2.20

Summary

- EV alone is inadequate to assess technical progress
- Program goals include satisfying cost, schedule, technical requirements
- PBEV[SM] offers a method to integrate these
- Architecture of SE measures enables decomposition and allocation of PBEV[SM] contributors to measurements of common SE work products