Improving Program Affordability through the Application of Data Analytics

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Overview

Improving Program Affordability through the Application of Data Analytics

- Background
- Objective
- Cost Growth and Schedule Delays
- Statistical Analysis of Schedule Delays
- Key Schedule Drivers
- Quantitative Analysis of Issues Identified by Gate-Based Reviews
- Causal Linkages of Gate-Based Review Issues and Schedule Drivers
- Improving cost/schedule efficiencies
- Conclusions

Background

DoD Affordability Initiatives

- Dr. Ashton Carter, DoD AT&L, memo on "Implementation Directive for Better Buying Power: Guidance for Obtaining Greater Efficiency and Productivity in Defense Spending" – 3 Nov 2010
  - Affordability is now a mandated parameter at milestone decision points for all Acquisition Category (ACAT I) programs
  - 23 principal actions organized in 5 major areas:
    - Target Affordability and Control Cost Growth – Mandate Affordability – Drive Productivity Growth through Will Cost/Should Cost Management
    - Incentivize Productivity and Innovation in Industry
    - Promote Real Competition
    - Improve Tradecraft in Services Acquisition
    - Reduce Non-Productive Processes and Bureaucracy

Focus of this Presentation

Affordability and Control Cost Growth

- "Should Cost" and "Will Cost" from Dr. Ashton Carter Nov 2010 memo
  - Will Cost: What a system would cost based on business as usual.
    - This is the ICE or independent cost estimate
    - This is also what contractors typically used in their cost proposals
  - Should Cost: "Should Cost targets will be developed using sound estimating techniques that are based on bottom-up assessments of what programs should cost, if reasonable efficiency and productivity enhancing efforts are undertaken. These costs will be used as a basis for contract negotiations and contract incentives and to track contractor and program executive officer/project manager performance."

Identifying cost efficiencies that could (should) be applied requires an understanding of the root causes of key drivers for cost growth

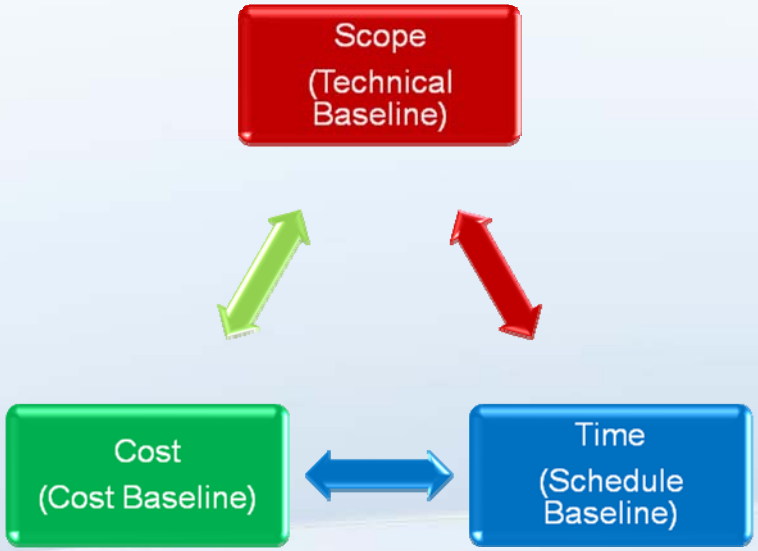
Objective

Improving Program Affordability thru Application of Data Analytics

- Understand cost growth and schedule delays
- Investigate how schedule performance data and statistics can be used to identify key schedule drivers
- Investigate how issues identified during Gate-Based Design Reviews can be used to identify root causes for schedule delays
- Identify potential areas for improving cost/schedule efficiencies to improve Program Affordability

Understand Cost Growth and Schedule Delays

- Numerous studies conducted by GAO, SMC, NASA, and MDA showed that the average DoD programs have encountered significant schedule delays and cost growth
  - Schedule Risk Analysis and Cost Risk Analysis have consistently underestimated the extent of schedule delays and cost growth
  - High correlation between schedule delays and cost growth



- Program Cost Baseline is based on technical and schedule baselines
- Controlling Cost Growth requires mitigating schedule delays

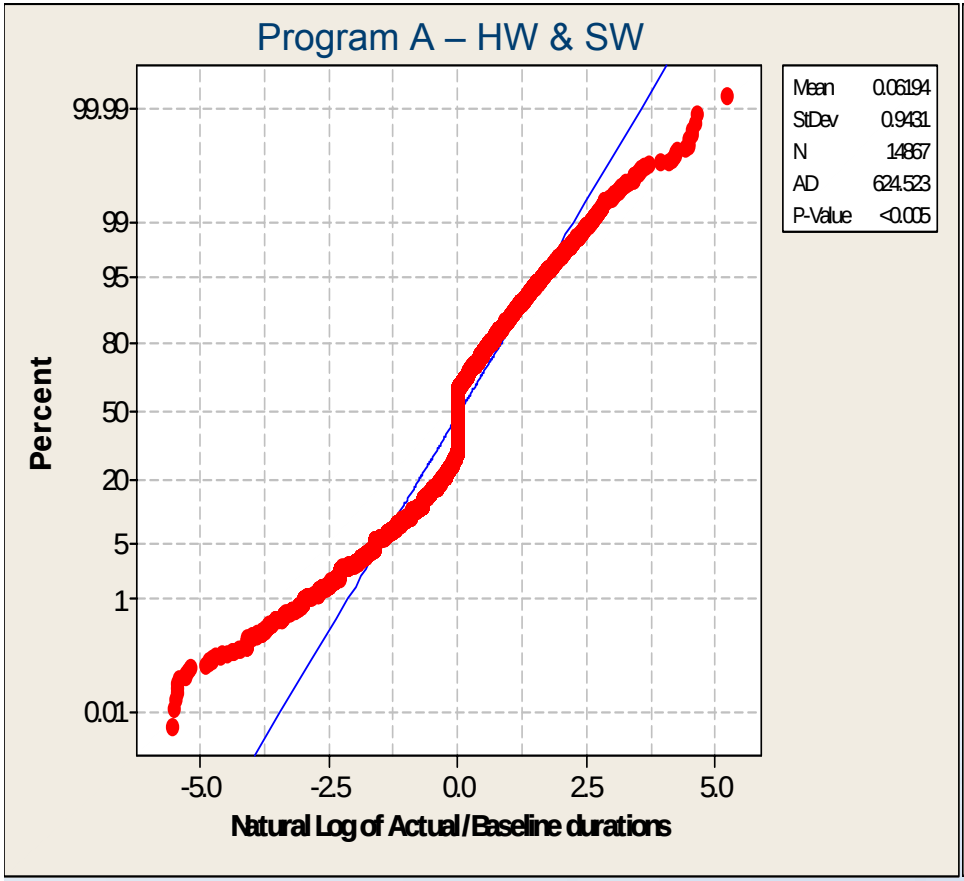
Prior Statistical Analysis Results on Cost Growth and Schedule Delays

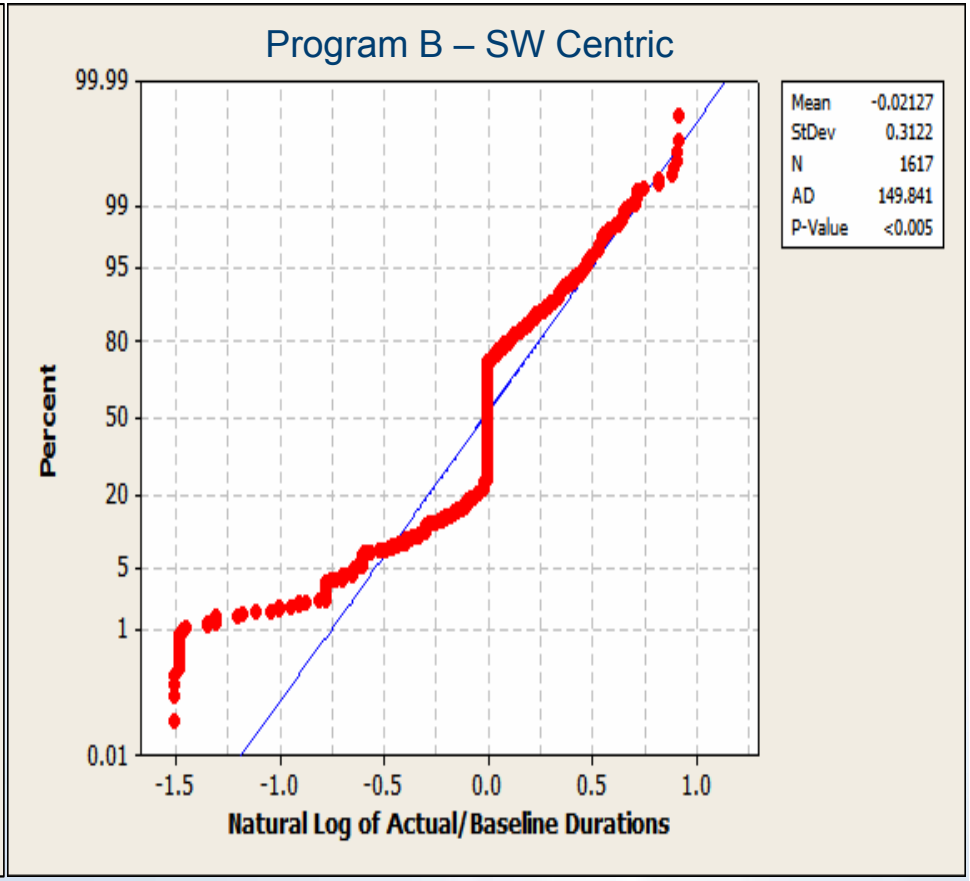
- Missile Defense Agency Cost Estimating and Analysis (Smart 2011)
  - Smart used the cost growth data (from 289 NASA and DoD programs) to fit to a variety of standard probability distributions
    - Resulting S-curve using Log Normal distribution to represent cost risks was shown to produce a more representative prediction of program cost growth
- Recent statistical analysis results on schedule delays (Wang 2012)
  - Detailed statistical analysis on schedule performance data from multiple SMC Space Programs
    - "Fat Tail" Distribution behavior for schedule delays also manifested at individual programs
    - Our results at the individual program level are consistent with the tail end statistical analyses reported in (Smart 2011) at the portfolio level with data from 289 programs

Statistical Analysis of Schedule Performance Data

- Multiple ACAT-1 program schedule performance data have been analyzed
- Summary results present the analysis of two representative ACAT-1 programs
  - Program 1: HW & SW Development Program
  - Program 2: SW Centric Development Program

Anderson-Darling Log Normal Test





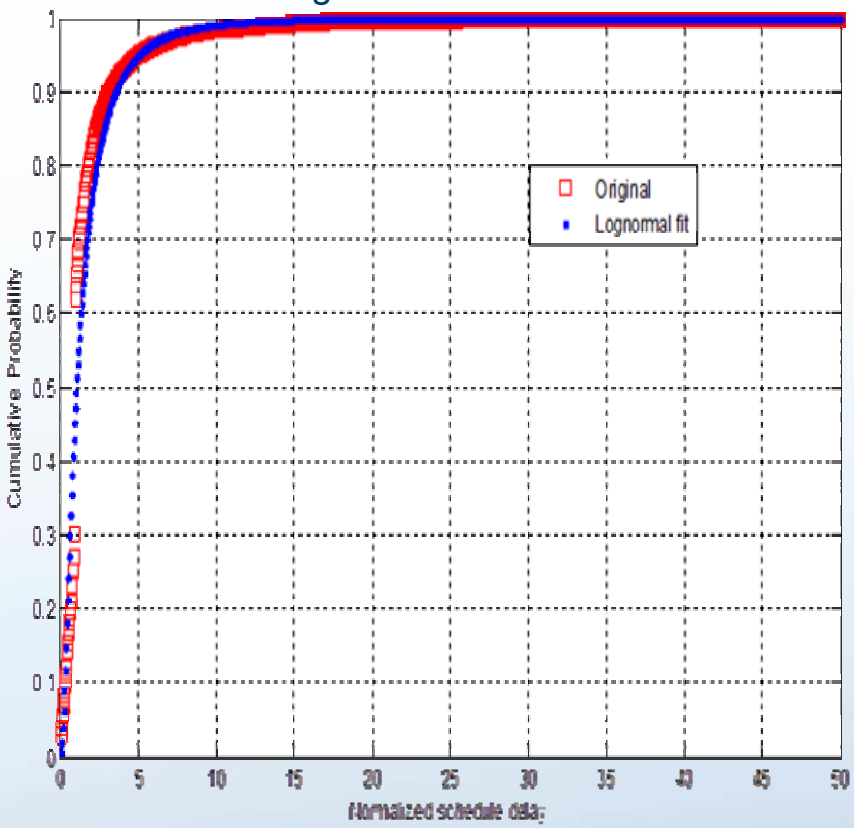
Δ = actual task duration / baseline task duration;

Δ does not fit Log Normal per Anderson-Darling Test due to: (1) Spike at Δ = 1; and (2) Thicker distribution at extreme left

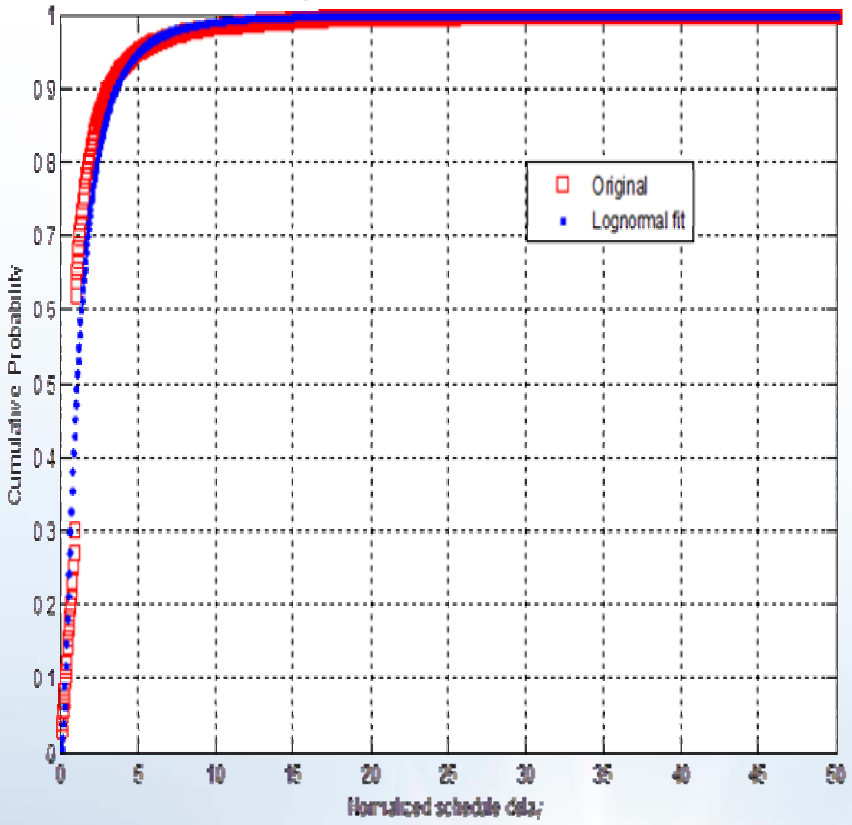
However, the right tail fits the Log Normal extremely well (see next slide)

Cumulative Probability Distribution of Schedule Delay (Δ)

Program A – HW & SW



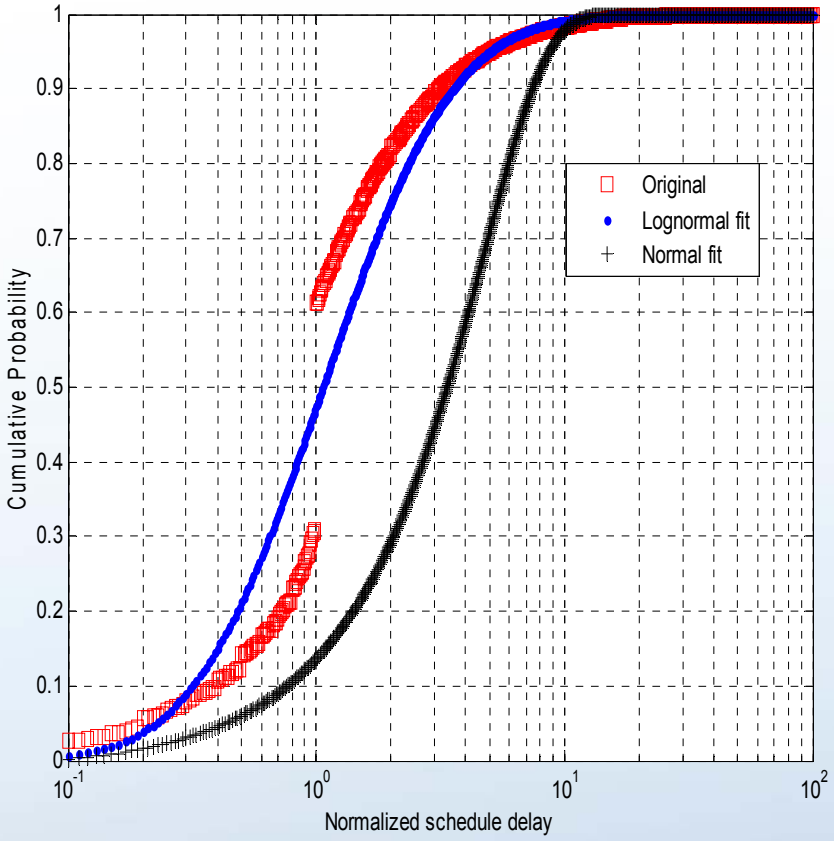
Program B – SW Centric



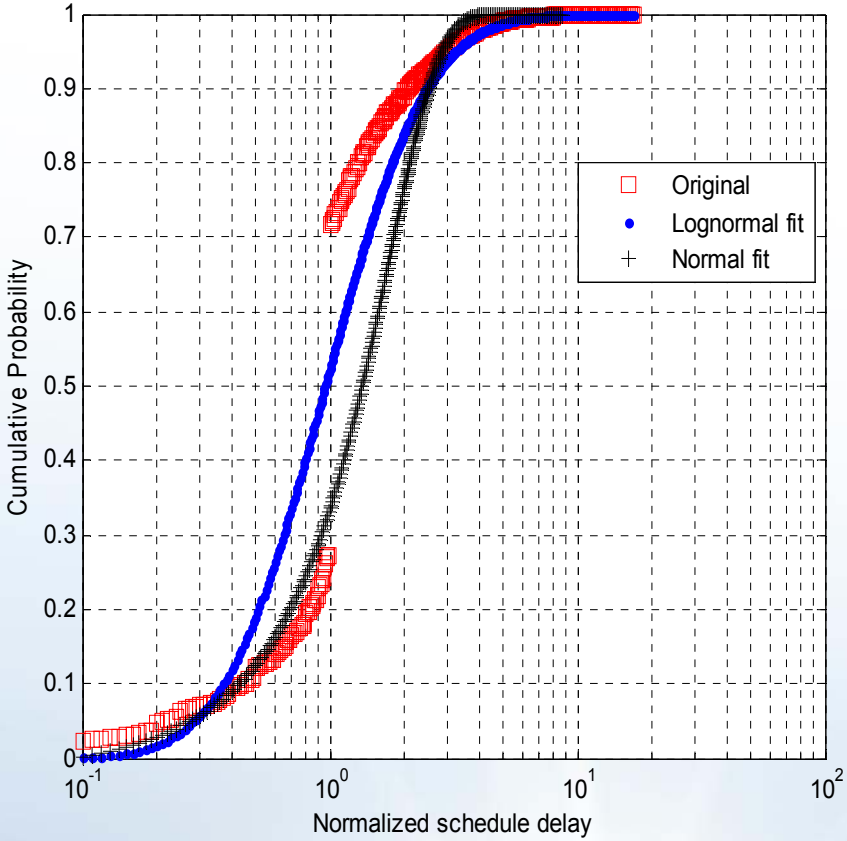
Δ exhibits "thick-tail" behavior similar to Log Normal

Cumulative Distribution Function (CDF) of Δ

Program A – HW & SW



Program B – SW Centric



CDF (Δ) behaves more like a Log Normal distribution instead of Normal distribution at the right tail end

Understanding Schedule Performance Drivers (1)

Schedule under runs: 0 < Δ < 0.4 (Non-Critical Path Activities)

Program A – HW & SW

- 609 Tasks with 0 < Δ <= 0.1
  - Types of Activity: CDRL preparation, review meetings, Action Item (AI) resolution, non-labor material purchase
- 452 Tasks with 0.1 < Δ <= 0.2
  - Types of Activity: track meeting AI, presentation preparation, subcontract tasks, review meeting planning & preparation, reviews, test fixtures checkout, specialty engineering reviews and testing, ERB meetings, AI tracking, review board approval, documentation, CDRL preparation and submittal, materials procurement/receiving/testing
- 359 Tasks with 0.2 < Δ <= 0.3
  - Types of Activity: preliminary design, test fixtures integration and test, materials procurement and test, CDRL preparation, reviews, data package preparation, analysis and report generation, board level assembly and test, specifications, engineering analysis
- 411 Tasks with 0.3 < Δ <= 0.4
  - EDU drawing & checkout, drawing check, CDR preparation, interface design, tool training, harness assemblies, test fixtures design, low level module assemblies and test, reliability analysis, review, AI tracking and resolution, engineering analysis, board level design and test

Program B – SW Centric

- 335 Tasks with 0 < Δ <= 0.1
  - Types of Activity: CDRL preparation, review meetings, Action Item (AI) resolution, non-labor material purchase, Peer reviews, design documents/requirements/SW build plan updates, design reviews preparation
- 167 Tasks with 0.1 < Δ <= 0.2
  - Types of Activity: CDRL preparation, review meetings, Action Item (AI) resolution, track meeting AI, presentation preparation, review meeting planning & preparation, analysis support for technical reviews, test procedures development and test cases development, algorithm definition, design documentation
- 146 Tasks with 0.2 < Δ <= 0.3
  - Types of Activity: preliminary design, CDRL preparation, PDR and CDR reviews preparation, analysis and report generation, design documentation, test plan development, test cases development
- 162 Tasks with 0.3 < Δ <= 0.4
  - Types of Activity: preliminary design, CDRL preparation, PDR and CDR reviews preparation, analysis and report generation, design documentation, test plan development, test cases development, peer reviews, action item resolution and tracking

Understanding Schedule Performance Drivers (2)

On Schedule: Δ ~ 1.0

Program A – HW & SW

- Approximately 33% of all program tasks were completed exactly on-time
- Approximately 40% of all program tasks were completed within the range: 0.9 <= Δ <= 1.1

Program B – SW Centric

- Approximately 29% of all program tasks were completed exactly on-time
- Approximately 52% of all program tasks were completed within the range: 0.9 <= Δ <= 1.1

Understanding Schedule Performance Drivers (3)

Significant delays: Δ > 4 (1036 Tasks – Critical Path activities)

Program A – HW & SW

- 1036 Tasks with Δ > 4

  Types of Activity: Thermal Vac, critical path HW integration and test, critical path SW unit test and integration, develop work around for parts that failed to meet requirements/specs, test plan development for critical path HW and SW, etc.

Program B – SW Centric

- 159 Tasks with Δ > 4
  - Types of Activity: Update CI architectural analysis, update/generate SW requirement specs., update SW Master Build plan, update Use Cases in software design, update test plan and test procedures, integration and test, network configuration, SW applications configuration, update drawings, update verification plan, address design issues, etc. **CDF (Δ) behaves more like a Log Normal distribution instead of Normal distribution at the right tail end**

Activities related to critical path HW and/or SW items are key drivers for Schedule Performance

Root Cause Analysis for Schedule Performance Drivers

Observations

- Schedule Performance Drivers that tend to be late:
  - Inadequate Architectural design
  - Inadequate / Incomplete Requirement spec, traceability
  - Integration and Test for critical HW & SW
  - Inadequate / Incomplete Test plans and Test Procedures for critical HW & SW
- Schedule activities that tend to be finished earlier than planned:
  - Engineering analysis, and design
  - Design documentation / requirements update
  - Test plans and test cases development
  - PDR preparation, CDR preparation

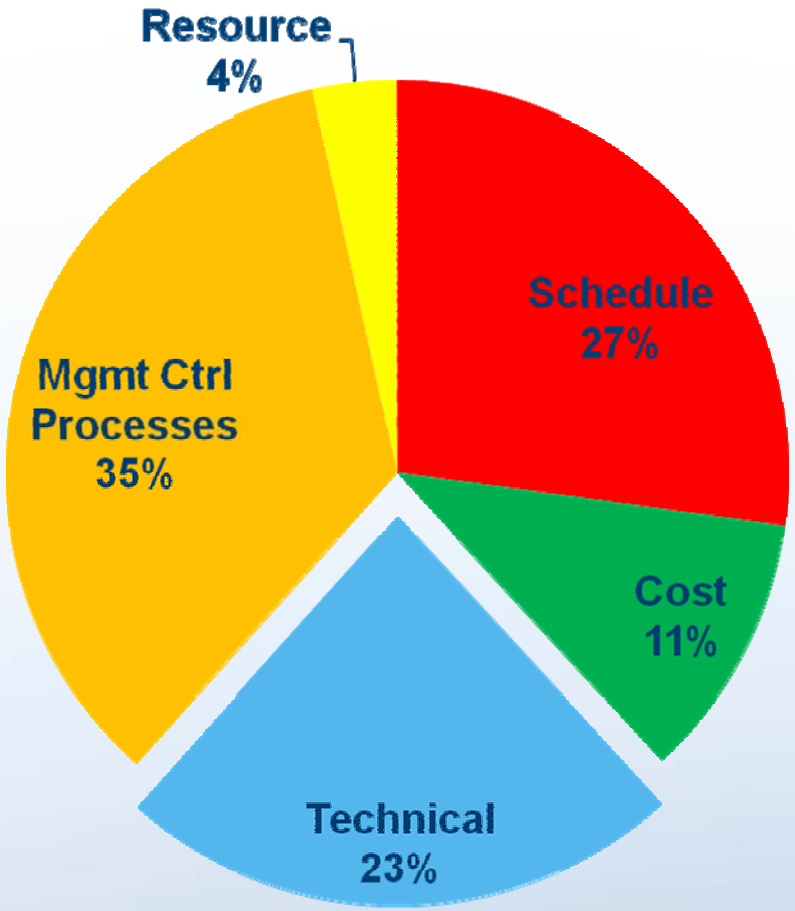
Root Cause Analysis methodology

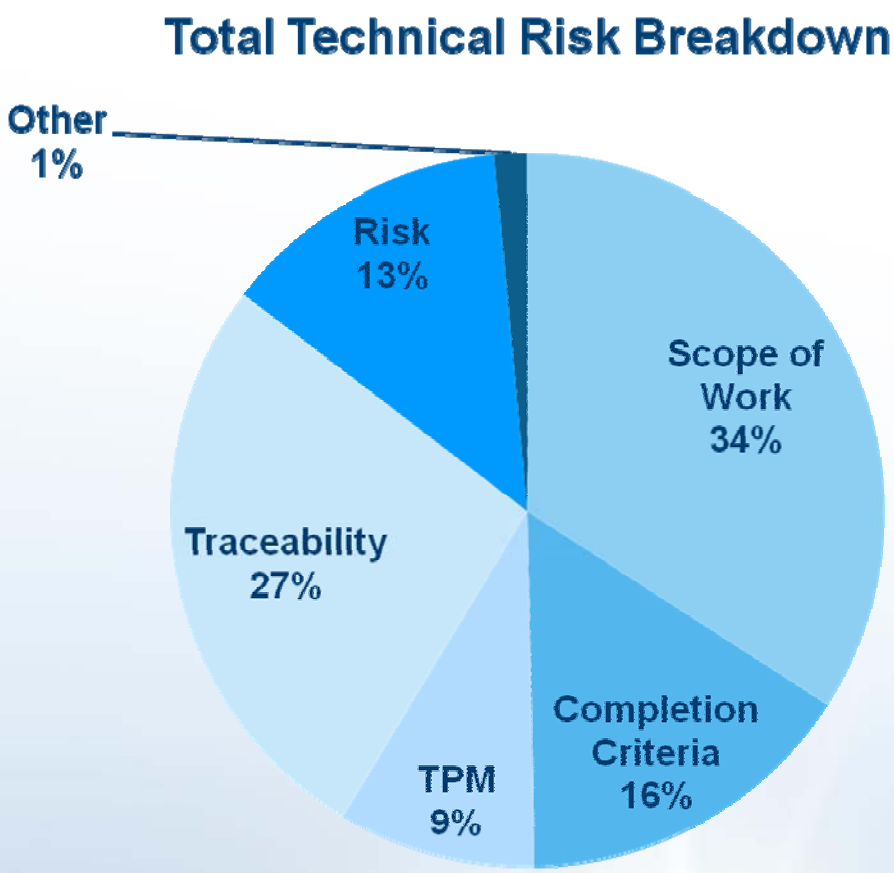
- Perform quantitative analysis of findings and issues identified by various gate-based reviews (e.g. Integrated Baseline Review (IBR), Preliminary Design Review (PDR), and Critical Design Review (CDR))
- Identify causal linkages between quantitative analysis of gate-based review findings and key schedule performance drivers

Quantitative Analysis of Gate-Based Review Findings

- Based on previously published quantitative analysis for multiple Gate-Based Reviews for SMC ACAT-1 programs over the past 5+ years (Wang, 2011)
  - IBR Technical Baseline Reviews
  - PDRs
  - CDRs

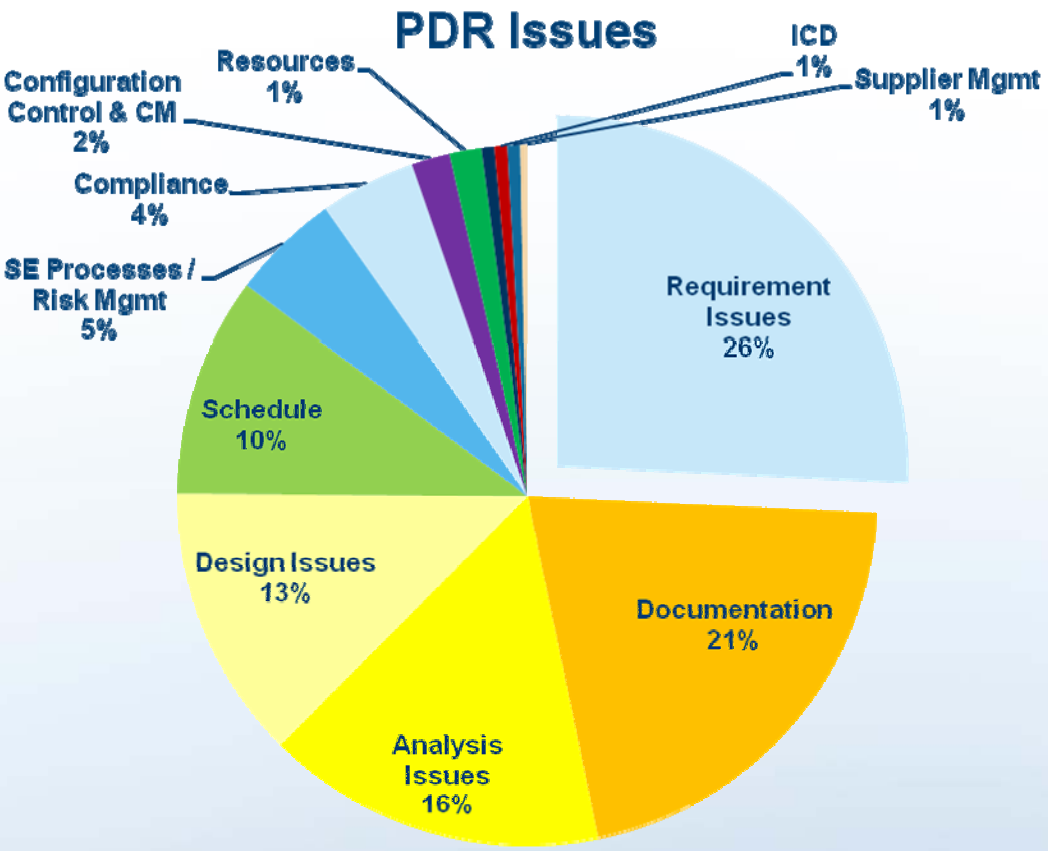
IBR Technical Baseline Review Findings

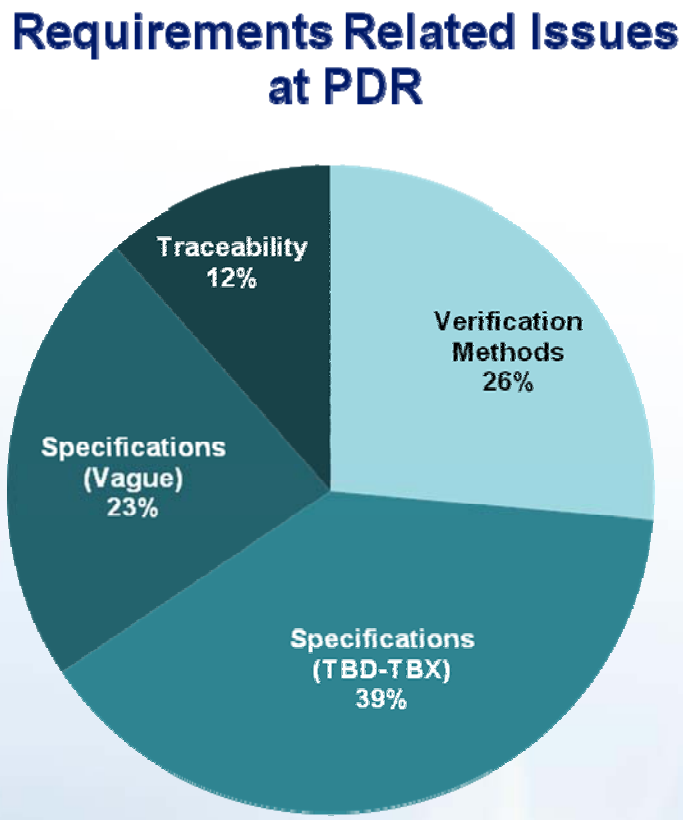




84% of Technical Issues have significant impacts on schedule and cost

PDR Findings

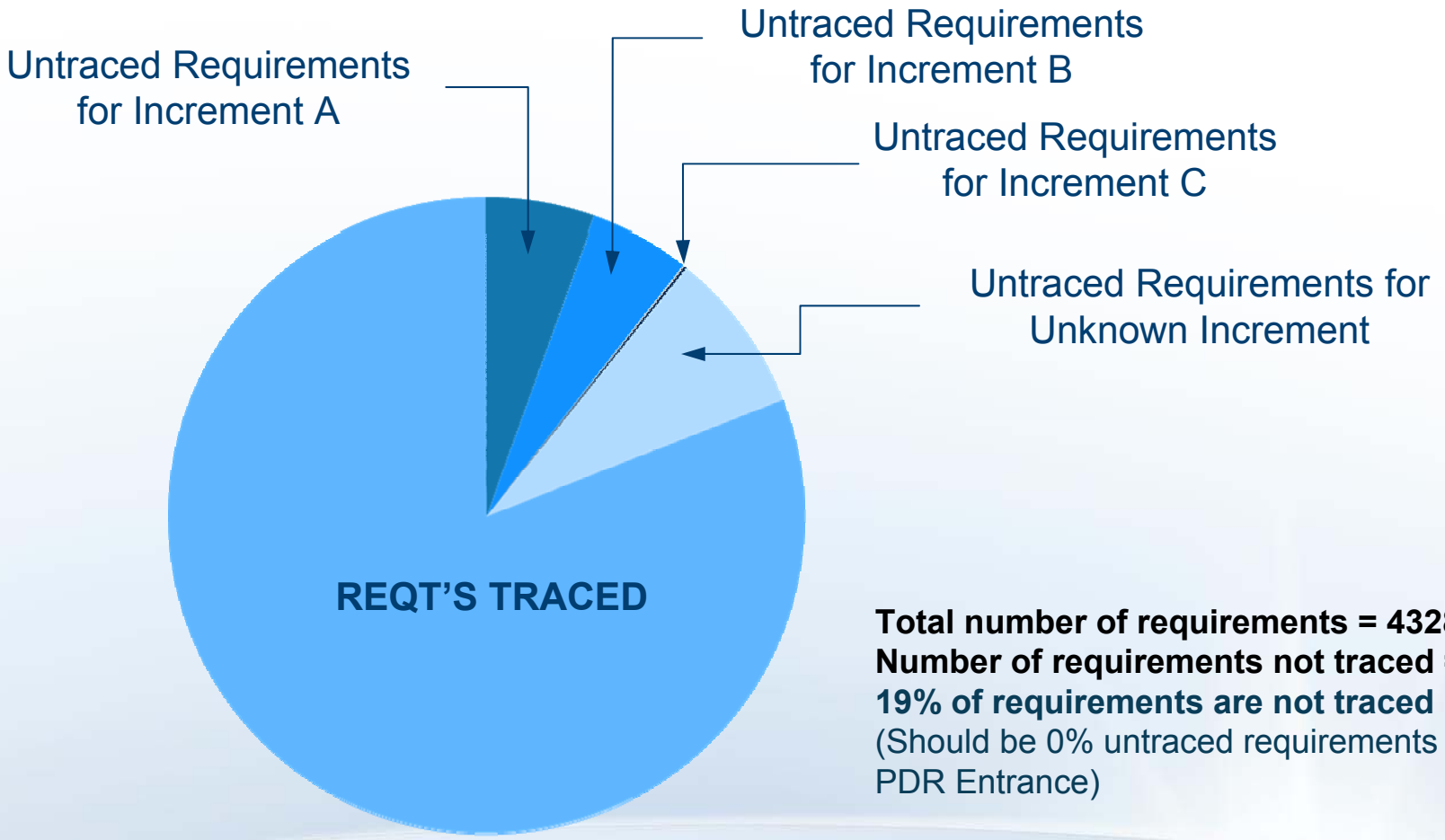




(Based on SMC ACAT-1 Programs)

Lack of objectivity & specificity in SRR, SDR, PDR Entrance & Exit Criteria Compliance evaluation

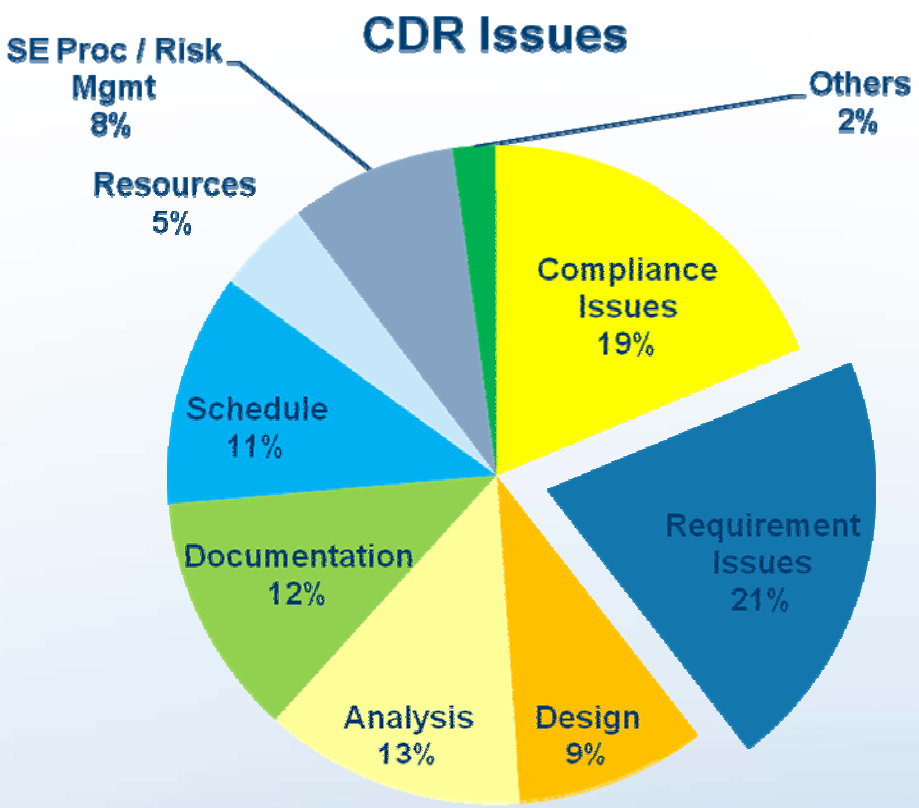
Functional Requirement Traceability Issue at PDR – Program X

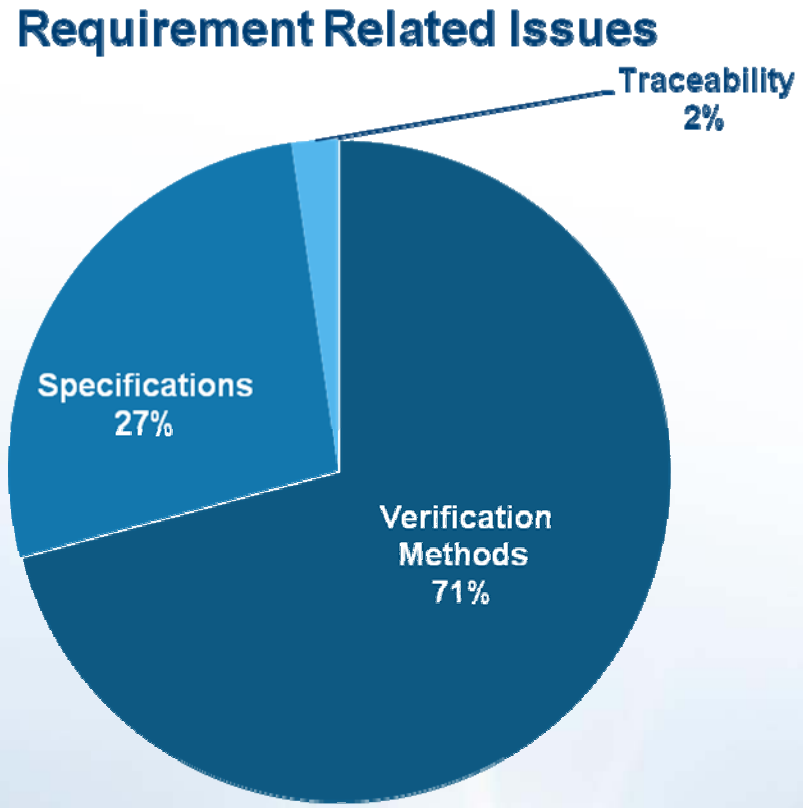


Total number of requirements = 4328.
Number of requirements not traced = 824.
19% of requirements are not traced
(Should be 0% untraced requirements at PDR Entrance)

Inadequate functional requirements traceability resulted in incomplete design
Root Cause: Non-Compliance with PDR Entrance Criteria

CDR Findings



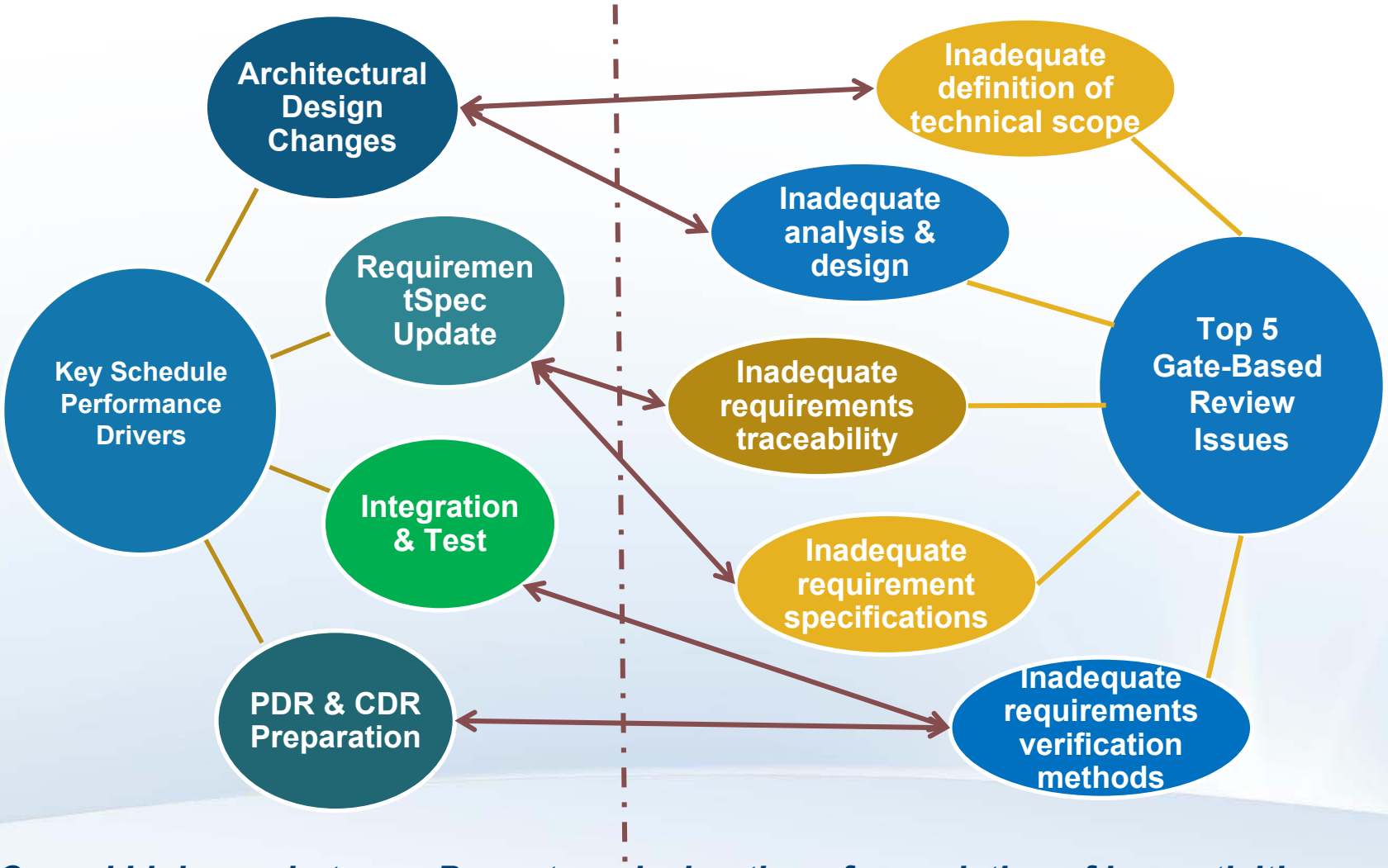


Need objective assessment of Exit Criteria compliance to focus immediate attention on high risk issues

Summary of Key Findings from Quantitative Analysis

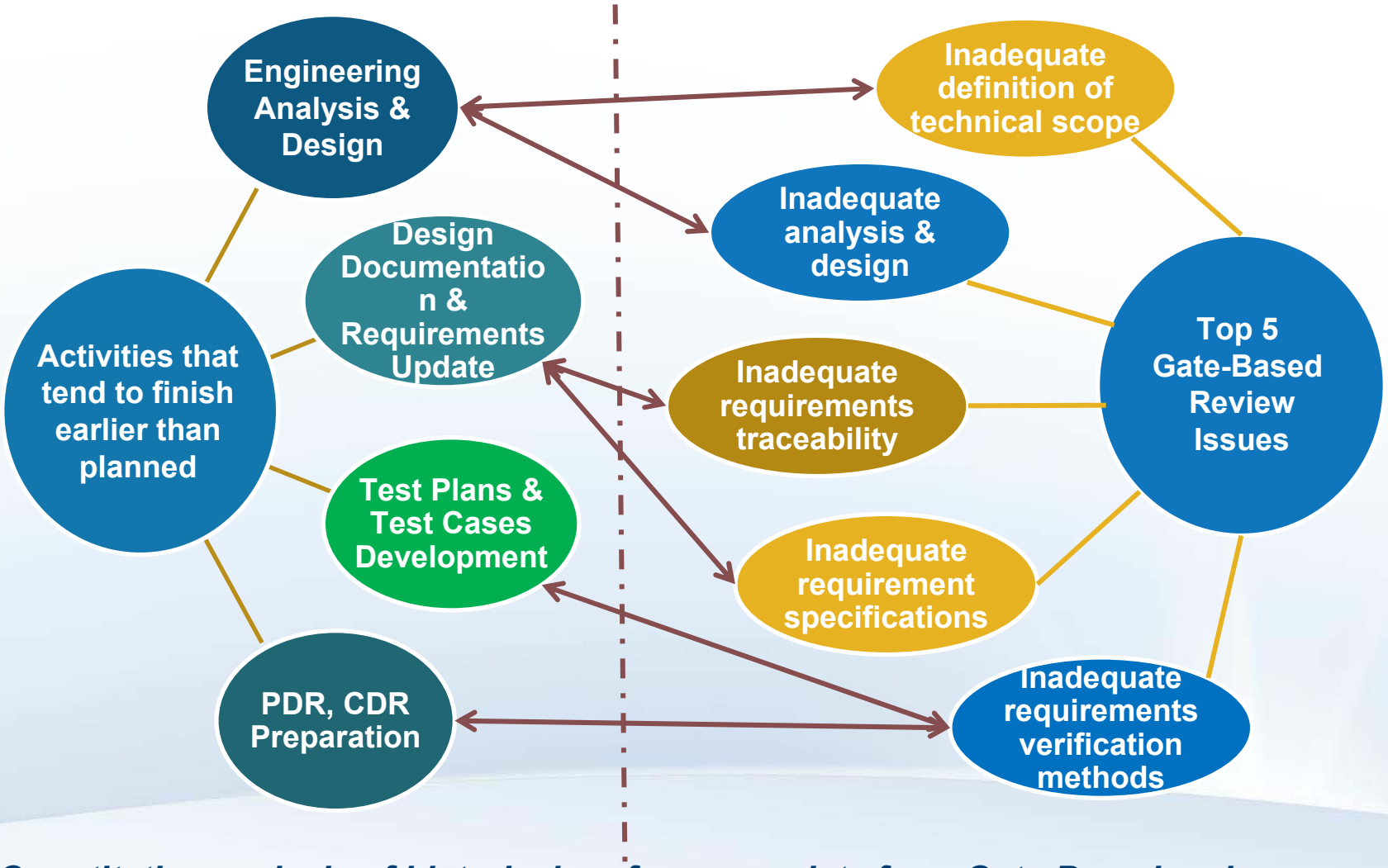
- Top 5 issues from Gate-Based Reviews:
  - Inadequate definition of technical scope of work
  - Inadequate requirements traceability
  - Inadequate requirements specification
  - Inadequate requirements verification method
  - Inadequate analysis / design

Causal Linkages between Gate-Based Review Issues and Key Schedule Performance Drivers



Causal Linkages between Premature declaration of completion of key activities results and Top 5 Gate-Based Review Issues

Causal Linkages between Gate-Based Review Issues and Schedule Activities that Tend to Finish Ahead of Schedule

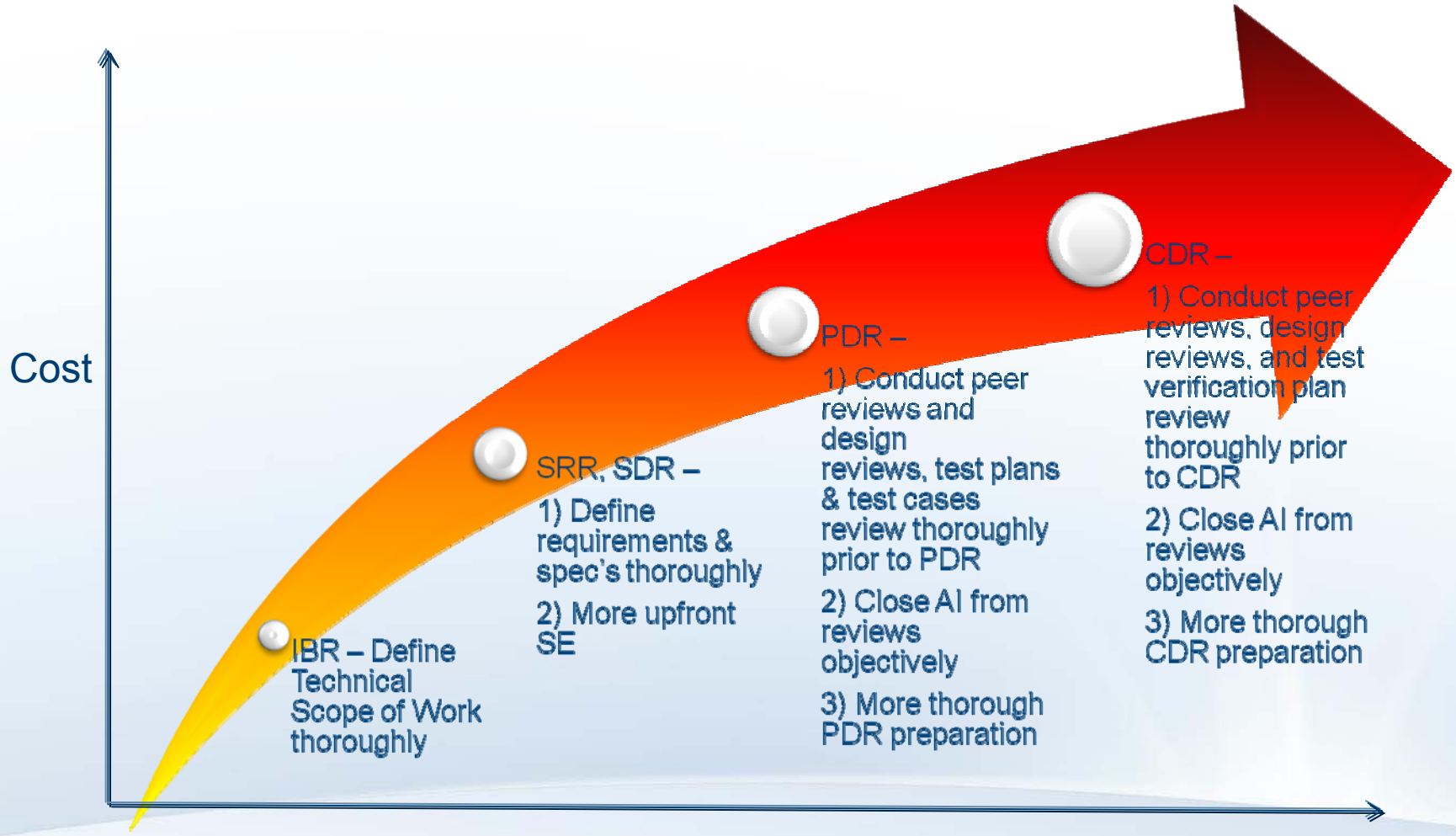


Quantitative analysis of historical performance data from Gate-Based reviews shows definitive causal linkages to schedule performance

Summary of Root Cause Analysis

- Our quantitative and statistical analysis shows that the major root causes of schedule delays (and therefore cost growth) are:
  - Inadequate definition of technical scope of work
  - Inadequate requirements traceability
  - Inadequate requirements specification
  - Inadequate requirements verification method
  - Inadequate analysis / design
- These major root causes for schedule delay are caused by:
  - Premature declaration of completion of key activities, e.g.
    - Engineering analysis & design
    - Design documentation and requirements update
    - Test plans and test cases development
    - PDR & CDR preparation

Potential areas for improving cost/schedule efficiencies to improve Program Affordability



Impacts of not addressing review issues early resulted in more schedule delays and cost growth

Conclusions

- Statistical analysis of cost growth behaviors from a portfolio of 289 DoD programs suggested that cost growth behaves like “fat-tail” distribution
- Statistical analysis of schedule delay behaviors from individual programs suggested schedule delays also behaves like “fat-tail” distributions
  - Key schedule performance drivers for “fat-tail” behaviors were identified
- Quantitative analysis of Gate-Based Review issues showed that
  - Top 5 Gate-Based Review Issues have causal linkages with key schedule performance drivers
  - Additional analysis showed the Top 5 issues have causal linkages with activities that consistently finished earlier than planned
- Actionable recommendations were presented to mitigate and address the Top 5 Gate-Based Review issues
- Significant improvement in program affordability can be realized by implementing the recommendations

References

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Backup Slides