Agenda

- The problem
- Current practice and standards
- What really happens
- Recommendations
Reviews

- Meetings where developers and stakeholders discuss project status, progress, risks, and potential changes

- Purpose: to provide opportunity for stakeholders
  - to determine state of development by
    - assessing progress
    - assessing risks
    - assessing emerging system development approach / design
  - to affirm approach or redirect development effort by
    - re-evaluating priorities
    - mitigating risks
    - revising engineering plan or approach
    - reassessing requirements
  - to authorize continued work by
    - establishing formal baselines
    - identifying any required corrective actions
The problem

- Engineering reviews are often based on legacy processes
  - which were largely based on the Waterfall process model
- Modern development processes are significantly different and improved
- Result is a mismatch between the review approach and the development approach
  - Government reviewers expect one thing, developers present another
- Examples
  - Developer follows an incremental development approach, resulting in some SW builds prior to PDR
    » PDR criteria fails to include test results from early builds
  - Developer follows an iterative development approach, resulting in evolving SW requirements (not all defined up-front)
    » System fails SSR due to incomplete requirements
The challenge

- Suppose a program is following an incremental approach
  - Multiple SW builds/increments over time
- When is best time to hold the reviews?

- But requirements analysis not complete
- But architectural design not complete and already has code and test results
- But detailed design not complete and already have code and test results
Impacts of the mismatch

- Reviews tend to be less useful than they could be
- Government customers become frustrated because they don't hear what they are expecting
- Contractors end up spending effort on non-productive tasks just to satisfy legacy expectations
- Excessive effort is spent on formatted deliverables
  - By the Contractor – in developing them
  - By the Government – in reviewing them
- Government focus is misdirected, frittering away valuable resources
- Important information regarding progress and quality is overlooked
  - Potentially raising risk
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Drivers

- JCIDS
- MIL-STDs 498 and 2167
- Systems Engineering V-chart
- MIL-STD-1521B
- 1521B defines the following reviews:
  - System Requirements Review (SRR)
  - System Design Review (SDR)
  - Software Specification Review (SSR)
  - Preliminary Design Review (PDR)
  - Critical Design Review (CDR)
  - Test Readiness Review (TRR)
  - Functional Configuration Audit (FCA)
  - Physical Configuration Audit (PCA)
  - Formal Qualification Review (FQR)
  - Production Readiness Review (PRR)
Underlying model

- Based on engineering V chart
- Relies on a sequential set of events, progressive in nature

Diagram:

- System performance specifications
- System functional specifications
- System architectural design
- System detailed design
- CI verification
- System integration testing
- System qualification testing
- System operational testing

-flow chart with key:
- SRR
- Sys PDR
- Sys CDR
- SFR
- SysTRR

Requirements baselined
Architecture baselined
Detailed design baselined
Sample MIL-STD life cycle

Notice long span of time between CDR and TRR
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SW in relation to the system

- SW is developed as part of a larger system, each level having its own requirements, architecture, and design.
Levels of design

stimuli → System → responses

stimuli → responses

CIs

SW units

responses
Levels of system design

- Each level has its own design process
  - System requirements → system architecture → system design → system integration → system verification
  - Subsystem requirements → subsystem architecture → subsystem design → subsystem integration → subsystem verification
  - CI requirements → CI architecture → CI design → CI integration → CI verification

- A review of the system architecture (e.g., at a System PDR) is fundamentally different than a review of the architecture for a SW CI PDR
  - The architecture of the system is at a different level than the architecture of a SW CI
SW SCI development activities

- All SW is developed using the activities defined in IEEE/EIA 12207.0 regardless of the process followed
- **When** these are performed is defined by the overall process followed
  - e.g., projects can perform requirements analysis towards end of development, concurrently with integration and test
  - e.g., user interfaces can be defined late in development, after sufficient usability analysis has been performed – still a part of requirements definition
  - e.g., when coding during an early build, activity is still part of code and unit test

<table>
<thead>
<tr>
<th>SW requirements analysis</th>
<th>Architectural design</th>
<th>SW detailed design</th>
<th>SW coding &amp; testing</th>
<th>SW integration</th>
<th>SW qualification testing</th>
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For each SCI
Some alternative development strategies

Waterfall

Incremental – no overlap

Incremental – overlap
SW developed incrementally

- Development programs have multiple levels
  - System level
  - Subsystem level
  - CI level

- CIs developed incrementally feed into incremental integrations for subsystems

- Subsystems developed incrementally feed into incremental integration for the system
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Perspective

- Experience and lessons-learned have resulted in current best practice to place increasing reliance on early builds of system
  - Risk reduction by exploration of requirements and design via early implementation (serving as prototypes)
  - Provides for early deployable systems as off-ramps
  - Provides early and on-going insight into progress and emerging risk
- Important to exploit early increment experience as a key source of information for assessing progress and maturity
  - Using an incremental approach to programmatic and technical reviews
Overall recommendations

- Encourage (via RFP/SOW) risk-aware development processes, including incremental approaches – select those that best suit needs of system to be developed
  - Especially the Incremental Commitment Model
- Plan acquisition to incorporate reviews
  - At the right time
  - Focused on maximizing insight and likelihood of identifying risks before they become problems
- Ensure that nature and general scheduling of reviews is clearly defined in the SOW
  - With specific need dates for system capabilities
  - Require periodic technical reviews to correspond to contractor development events
- Define criteria for content and scheduling of reviews up-front to ensure adequate review coverage is achievable
Incremental commitment model

- Overall concept of risk reduction via incremental development clearly described by the Incremental Commitment Model (ICM)

Two general approaches to iterations

- **Type 1**: Implements a subset of the overall requirements – can be integrated
  
  ![Diagram of Type 1 iteration](image1)
  
  **Recommended**

- **Type 2**: Implements portions of the overall system, but not enough to integrate
  
  ![Diagram of Type 2 iteration](image2)
Risk reduction opportunities

- **Situation 1 of 1,000,000**
  - Uncertain how to design a complex series of functions
  - Solution
    - Start with core set of functions, build with multiple iterations, use lessons-learned to improve each iteration

- **Situation 2 of 1,000,000**
  - Uncertain about real requirements when interacting with “physics”
  - Solution
    - Build initial solution with approximate parameters for first iteration
    - Include data extraction as a part of design
    - Use each iteration to refine knowledge

- **Result – gain benefits of prototyping without throwaway artifacts**
  - and maintain full quality of design and code
Overall recommendations (cont’d)

- With incremental approach, require contractors to describe their planned development approach and the role of reviews, to include:
  - Requirements refinement
  - Architectural and detailed design maturation
  - Code and test results
  - Changes to planned increment content

- Require review content to provide information necessary to assess
  - Actual progress vs planned progress
  - Actual product quality and content
  - Quality based on expectations
  - Risk of proceeding

- Ensure that each level of review is defined to correspond to the information appropriate to that review
  - SW PDR ≠ Sys PDR
Overall recommendations (cont’d)

- At reviews, evaluate
  - Results of previous increments
  - Progress for current increment
  - Plans for next increment

- Select attendees at each review to correspond to the appropriate stakeholders

- Focus on key information at each level
  - CI-level reviews – focus on the CI and how it is being developed in the context of the requirements allocated to it
  - Increment reviews – can be performed at all levels of increments – CIs, subsystems, and system
  - System-level reviews – focus on overall system and how the pieces are coming together
    » Correlate with system-level increments
Suggested scheduling

- Planning review schedule
  - Define reviews at all levels for each increment
    - CI / subsystem / system
  - For SW CIs, hold review after each activity

- For increments, consider holding reviews at beginning, middle, and end of each increment to assess overall design, across all CIs
Sample strategy

- System builds
- System I&T
- Subsystem A I&T
  - SCI 1
  - SCI 2
  - SCI 3
- Subsystem B I&T
  - SCI 4
  - SCI 5

SCI Iteration review

System PDR  System CDR1  System CDR2  System TRR
Summary

- Modern development processes are significantly different than (and much improved over) legacy processes
- They have evolved from traditional Waterfall approach in which each phase of development was sequentially performed
- Important to plan for reviews to exploit the strengths of incremental approaches
End

Any questions?....

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