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An Evidence-Based Systems Engineering (SE) Data Item Description

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Abstract

Evidence-based SE is an extension of model-based SE that emphasizes not only using SysML or other system models as a basis of program decisions, but also the use of other models to produce evidence that the system models describe a feasible system. Such evidence is generally desired, but often is not produced because it is not identified as a project deliverable in a Data Item Description (DID). Going forward with such unproven solutions frequently leads to large program overruns.

Based on experience in developing and using such a DID on a very large project, we summarize the content and form of such a DID, and a rationale for its use. Its basic content is evidence that if a system were produced with the specified Architecture, it would:

- Satisfy the specified Operational Concept and Requirements;
- Be developable within the specified Budget and Schedule;
- Provide a superior return on investment over alternatives in terms of mission effectiveness; and
- Provide satisfactory outcomes for the system's success-critical stakeholders.

One key factor of the DID is that the content of the evidence be risk-balanced between having too little evidence (often the case today) and having too much (analysis paralysis). Thus, it is not a one-size-fits-all DID, but one which has ways to be tailored to a project's most critical evidence needs.

Keywords: Feasibility Evidence Description (FED); Data Item Description (DID); Evidence-Based Decision Making; The Incremental Commitment Spiral Model

1. Motivation and Context

Numerous General Accountability Office (GAO) reports (e.g., [1]) and Standish Reports [2] have shown that a majority of Government and commercial projects are delivered after significant budget and schedule overruns, and

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with deficiencies with respect to their desired functionality and quality. For Government projects, the GAO reports have identified a major cause of system acquisition project overruns to come from proceeding into development with inadequate knowledge that the system could be developed within the project's budget and schedule. However, the provision of such knowledge is rarely required on Government contracts. In general, it is asked for, but relegated to appear in optional appendices of requirements and design deliverables, where it is among the first things to be dropped if the project has insufficient systems engineering budgets to produce the evidence data.

Similar problems also occur in the commercial sector, for similar reasons. In general, the available outsourcing contract exhibits put evidence of feasibility into optional appendices at best, and the project manager or contract manager's path of least resistance is to use these without modification. Having a Data Item Description (DID) for such evidence that could be put on contract as a first-class deliverable would involve customers and developers in ensuring that planning, estimating, budgeting, scheduling, developing, monitoring progress, and reviewing feasibility evidence would be consistently done.

Based on experience in developing and using such a DID on a very large project, we summarize the content and form of such a DID, and a rationale for its use. The generic definition of feasibility evidence is:

Evidence provided by the developer and validated by independent experts that if the system is built to the specified architecture, it will:

- Satisfy the requirements: capabilities, interfaces, levels of service, project constraints, and evolution directions;
- Support the operational concept;
- Be buildable within the budgets and schedules in the plan;
- Generate a viable return on investment;
- Generate satisfactory outcomes for all of the success-critical stakeholders;
- Resolve all major risks by treating shortfalls in evidence as risks and covering them by risk management plans;
- Serve as basis for stakeholders' commitment to proceed.

Such evidence may come from prototypes, models and simulations, benchmarks, safety cases or other forms of analysis, or more simply where possible by pointers to the results from equally or more complex systems that the proposed team has developed.

For complex systems, such evidence is unlikely to be complete. Shortfalls in such evidence are uncertainties or probabilities of loss, which when multiplied by the size of loss, become Risk Exposure. In a milestone decision review, such risks and provided risk mitigation plans can be used to decide whether or not to proceed into the next phase. If the risks are acceptable, as in rapid fielding situations, going forward would be acceptable. If not, as with shortfalls in safety assurance or technology maturity evidence, either deferring commitment to go to the next phase, or going forward with a viable risk mitigation plan may be preferable.

One key factor of the DID is that the content of the evidence be risk-balanced between having too little evidence (often the case today) and having too much (analysis paralysis). Thus, the DID includes a minimum-essential base case of feasibility evidence for simple systems, and a detailed set of evidence for highly complex and critical systems. Intermediate systems, and the simpler parts of complex systems, can use a risk-based approach for tailoring up from the base case by selectively applying appropriate elements of evidence needed for complex and critical projects or elements.

2. Feasibility Evidence Description (FED) Development Process Framework

The most important characteristic of evidence-based system specifications and plans is that *If the evidence does not accompany the specifications and plans, the specifications and plans are incomplete.*

This does not mean that the project needs to spend large amounts of effort in documenting evidence of the feasibility of a simple system. The appropriate level of detail for the contents of the FED is based on the perceived risks and criticality of the system to be developed. It is NOT a "one size fits all" process, but rather a framework to help developers and stakeholders determine the appropriate level of analysis and evaluation. As with reused specifications and plans, evidence can be appropriately reused. If a more complex system than the one being reviewed has been successfully developed by the same team, a pointer to the previous project's evidence and results will be sufficient.

Table 1 outlines a process that can be used for developing feasibility evidence [3]. The process clearly depends on having the appropriate work products for the phase (Step A). As part of the engineering work, high-priority feasibility assurance issues are identified that are critical to the success of the system development program (Step B). These are the issues for which options are explored, and potentially viable options further investigated (Step C). Clearly, these and the later steps are not performed sequentially, but concurrently

Table 1. Steps for Developing a FED

Step	Description	Examples/Detail
A	Develop phase work-products/artifacts	For a Development Commitment Review (DCR), this would include the system's operational concept, prototypes, requirements, architecture, life cycle plans, and associated assumptions
B	Determine most critical feasibility assurance issues	Issues for which lack of feasibility evidence is program-critical
C	Evaluate feasibility assessment options	Cost-effectiveness; necessary tool, data, scenario availability
D	Select options, develop feasibility assessment plans	The list of options at the end of Section C.1 (prototypes, benchmarks, exercises, etc) is a good starting point
E	Prepare FED assessment plans and earned value milestones	The plans include the enablers in Step G
F	Begin monitoring progress with respect to plans	*Also monitor changes to the project, technology, and objectives, and adapt plans*
G	Prepare evidence-generation enablers	Assessment criteria Parametric models, parameter values, bases of estimate COTS assessment criteria and plans Benchmarking candidates, test cases Prototypes/simulations, evaluation plans, subjects, and scenarios Instrumentation, data analysis capabilities
H	Perform pilot assessments; evaluate and iterate plans and enablers	Short bottom-line summaries and pointers to evidence files are generally sufficient
I	Assess readiness for Commitment Review	Shortfalls identified as risks and covered by risk mitigation plans Proceed to Commitment Review if ready
J	Hold Commitment Review when ready; adjust plans based on review outcomes	See Commitment Review process overview below.

NOTE: "Steps" are denoted by letters rather than numbers to indicate that many are done concurrently.

Since the preliminary design and plans are incomplete without the FED, it becomes a first-class project deliverable. This implies that it needs a plan for its development, and that each task in the plan needs to be assigned an appropriate earned value. If possible, the earned value should be based on the potential risk exposure costs, not the perceived available budget. Besides monitoring progress on developing the system, the project needs to monitor progress on developing the feasibility evidence. This implies applying corrective action if progress falls behind the plans, and adapting the feasibility evidence development plans to changes in the project objectives and plans. If evidence generation is going to be complex, it is generally a good idea to perform pilot assessments. The preparations for the commitment review are discussed next.

3. Commitment Review Process Overview

Figure 1 [3] highlights the activities that need to be performed in preparation for the review, the actual review, as well as the post-review activities and follow-up. The entry criteria include ensuring that the feasibility evidence preparation has been successfully tracking its earned value milestones. The inputs include preparing domain extensions to the core review questions, identifying committed expert reviewers for each of the review questions, and familiarizing them with the review process.

The review meeting will include not only the developer SEs and the expert reviewers, but also the stakeholder upper-management decisionmakers, who will need some context-setting before the developer responses to reviewer issues are discussed. The review exit criteria and tasks include key stakeholder concurrence on the way forward and commitment to support the next phase, as well as action plans and risk mitigation plans for the issues identified.

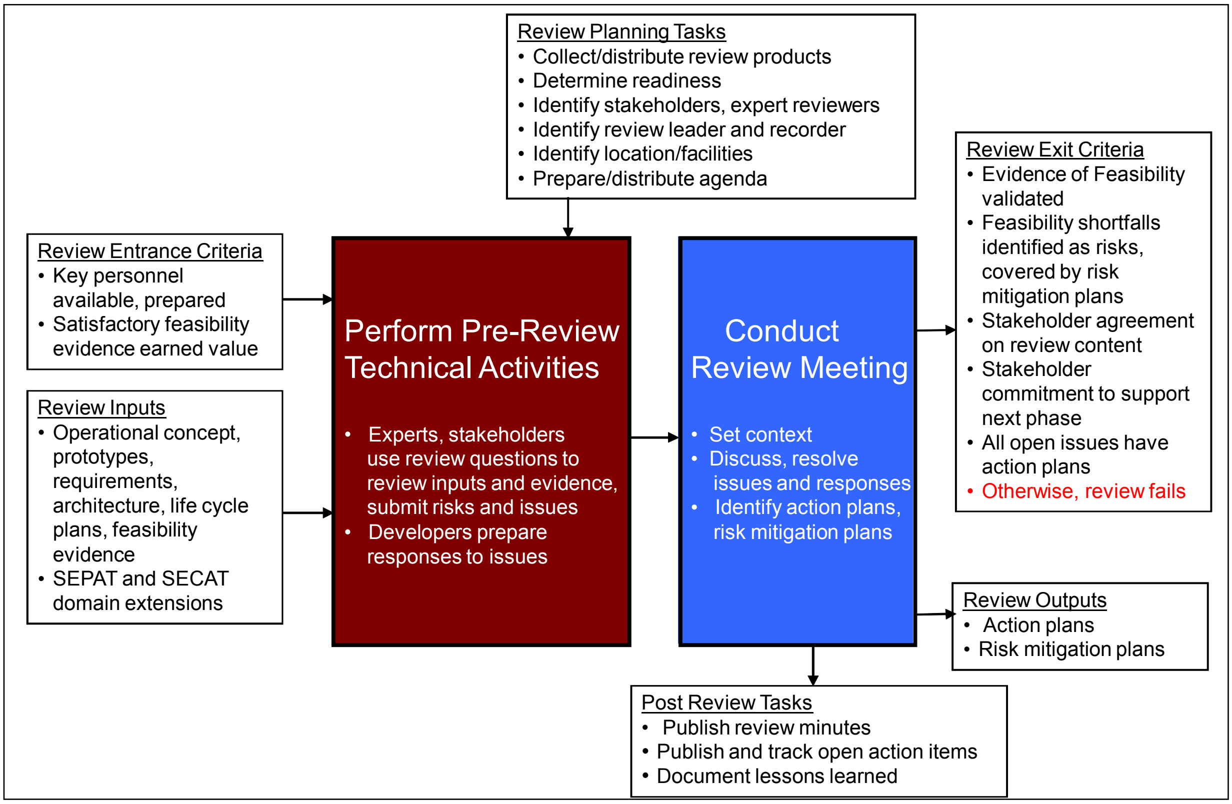

Fig.1. Overview of Commitment Review Process

The paper continues to summarize the content of the FED DID; to present the FED DID; to summarize experience in using successive versions of it; and to provide conclusions on its content and usage.

4. Content of the FED DID

The FED DID content begins with an overview, including guidelines for tailoring the FED up from the most simple version, instead of tailoring it down from the most complex version (Tailoring down from complex versions is the usual practice. It creates a situation in which the project manager's path of least resistance is not to tailor down anything, leading to extensive wasted effort on non-value-adding items).

Next, a table is provided with criteria for determining whether a project is simple, complex, or intermediate (often with simple and/or complex parts). The first section to be completed is a simple set of general project information, which can then be tailored up for more complex projects.

The main section is for the feasibility evidence. It begins with a definition of feasibility evidence: basically, evidence that the project plans and specifications are technically and economically feasible, and that they produce satisfactory outcomes for all the success-critical stakeholders. It then has subsections for a hierarchy of Goals, critical success factors (CSFs), and Questions to be assessed at major project decision points. The hierarchy enables tailoring-up from just Goals for simple projects to critical Questions for Intermediate and Complex projects.

The concluding sections provide an example of use of the framework, conclusions, and references.

The FED Data Item Description
Data Item Description
System and Project Feasibility Evidence Description

Overview

The FED Data Item Description provides guidelines for tailoring the content of the FED to be most cost-effective for its system and project. It is not intended to be tailored down from its most detailed content. Instead, it is tailored up from the minimum-essential content for simple (S) projects, or is tailored up for intermediate (I) and complex (C) projects by selectively applying parts of the Complex content. Guidelines are provided in Table 2 for determining whether a project should use an S baseline, a full-C baseline, or a tailored I version. The level of detail in the FED should be risk-driven. If it's risky to exclude something, put it in. If it's not risky to exclude something, leave it out.

The FED and its review by independent experts is the basis for informed risk-based commitment decision making by the project's success-critical stakeholders. It is organized to apply to all of a project's commitment milestones. But its content will vary from milestone to milestone, again with a risk-driven level of detail.

Table 2. Criteria for Simple, Intermediate, & Complex (parts of) Projects

Criterion	*Size*	*Complexity*	*Criticality*	*Capability*
Criterion Content	Number of personnel	Novelty; Technical Risk; Stakeholder Conflicts; External Constraints	Loss due to defects	Personnel; Organization: relative to complexity & criticality
Simple Level	1 – 10	Low	Comfort; Discretionary funds	High - Very High
Intermediate Level	10 – 100	Mixed	Serious funds; Quality of life factors	Mixed
Complex Level	Over 100	All high to very high	Essential funds; Loss of human life	Low

1. **General Information**

Figure 2 provides a set of minimum-essential data elements that are generally sufficient for simple projects. Intermediate and Complex projects would tailor these up to meet their special needs. Example extensions for less-simple projects are also listed below as candidates for tailoring-up.

For less-simple projects, different parts may have different success-critical stakeholders and schedules. They may require contract information, formatting instructions, version indicators, tables of contents, lists of figures and tables, and pointers to subsidiary information such as applicable policies, formal expert review reports, risk mitigation plans, or other action items.

Project Name: ____

Project Primary Objective: ____

Success-Critical Stakeholders:____________________ ____

____

(Includes Role, Organization, Authorized Representatives and Contact Info for each stakeholder)

Life Cycle Process: ☐ Agile ☐ Architected Agile ☐ IC Spiral ☐ RUP ☐ Vee ☐ Other ____________

Decision Milestone: ____

Key FED Dates:

Review Version Complete ______________

Review Complete ______________

Decision Meeting and Outcome Decided ______________

Fig.2. FED General Information for Simple Projects

2. **Feasibility Evidence**

The generic definition of feasibility evidence was provided in section 1. For a Simple-Level system, the feasibility evidence could be as simple as a statement such as, "the system is simpler than two others successfully developed by the same team, based on the company's in-place Enterprise Resource Planning system," along with pointers to information on the two successful systems. For Intermediate and Complex Level systems, a tailoring framework for selecting and organizing needed categories of feasibility evidence is presented next.

2.1 A DID Tailoring-Up Framework for Intermediate and Complex Systems

The tailoring framework below was developed as part of a U.S. Department of Defense (DoD) Systems Engineering Research Center (SERC) research project to develop an evidence-based systems engineering risk assessment instrument for application to DoD systems [4,5]. It is organized into a hierarchy of Goals, critical success factors (CSFs), and Questions. This helps in tailoring-up, as less-critical aspects can be addressed at the Goal or CSF level, and more-critical aspects can be expanded as appropriate into the Question level.

This hierarchy of review questions enables projects to enter single-click higher or lower Impact levels and Evidence of Feasibility levels for each Question, enabling the assessment of its likely project risk. Thus, unimportant aspects can be dropped by assigning them a Little or No Impact level. The Impact levels are quantitative ranges of likely extra project cost to remedy the aspect's shortfall (0-2%; 2-20%; 20-40%; 40-100%), and the Evidence of Feasibility levels are quantitative levels of probability of occurrence of the aspect deficiency (0-.02; .02-2; .2-.4; .4-1.0). These enable the tool to determine a quantitative project risk exposure level for each aspect.

The framework below contains a few U.S. Department of Defense (DoD)-specific terms, reflecting the sponsorship of the research effort. These can be mapped fairly straightforwardly onto other domain terms. For example, the DoD Milestones A and B correspond fairly closely to the completion of the Exploratory and Concept stages of ISO/IEC 15288 on Systems Engineering Processes[6] and of the concurrent-engineering version of the Vee model [7]. They also correspond to the Life Cycle Objectives and Life Cycle Architecture milestones for the Rational Unified Process [8,9]), the Foundations and Development Commitment Reviews of the Incremental Commitment Spiral Model [10,11], and the Discovery and Architecture milestones of the AT&T Architecture Review Board process [12,13].

The DID Tailoring-Up Framework: Goals, Critical Success Factors, and Questions

Goal 1. Concurrent definition of system requirements and solutions

CSF 1.1 Understanding of stakeholder needs: capabilities, operational concept, key performance parameters, enterprise fit (legacy)

(a) At Milestone A, have the Key Performance Parameters (KPPs) been identified in clear, comprehensive, concise terms that are understandable to the users of the system?
(b) Has a Concept of Operations (CONOPS) been developed showing that the system can be operated to handle both nominal and off-nominal workloads and meet response time requirements?
(c) Has the ability of the system to meet mission effectiveness goals been verified through the use of modeling and simulation?
(d) Have the success-critical stakeholders been identified and their roles and responsibilities negotiated?
(e) Have questions about the fit of the system into the stakeholders' context—acquirers, end users, administrators, interoperators, maintainers, etc.—been adequately explored?

CSF 1.2 Concurrent exploration of solution opportunities; Analysis of Alternatives (AoAs) for cost-effectiveness and risk (measures of effectiveness)

(a) Have at least two alternative approaches been explored and evaluated?
(b) At Milestone B, has the government structured the program plan to ensure that the contractor addresses the allocation of capabilities to hardware, software, and human elements sufficiently early in the development program?
(c) Has the claimed degree of reuse been validated?
(d) Have the claimed quality of service guarantees been validated?
(e) Have proposed Commercial Off-the-Shelf (COTS) and third-party solutions been validated for maturity, compatibility, supportability, suitability, and effectiveness, throughout the expected system lifetime?

CSF 1.3 System scoping & requirements definition (external interfaces; Memoranda of Agreement (MoA))

(a) Have external interface complexities been identified and addressed via MoAs or their equivalent? Is there a plan to mitigate their risks?
(b) At Milestone B, are the major system-level requirements (including all KPPs) defined sufficiently to provide a stable basis for the development through Initial Operational Capability (IOC)?
(c) By Milestone A, is there a plan to have information exchange protocols established for the whole system and its segments by Milestone B?
(d) Have the key stakeholders agreed on the system boundary and assumptions about its environment?

CSF 1.4 Prioritization of requirements & allocation to increments

(a) Can an initial capability be achieved within the time that the key program leaders are expected to remain engaged in their current jobs (normally less than 5 years or so after Milestone B)? If this is not possible for a complex major development program, can critical subsystems, or at least a key subset of them, be demonstrated within that time frame?
(b) At Milestone B, do the requirements and proposed solutions take into account likely future mission growth over the program life cycle?
(c) Have appropriate early evaluation phases, such as competitive prototyping, been considered or executed for high-risk/low-maturity components of the system?
(d) Have stakeholders agreed on prioritization of system features and their allocation to development increments?

Goal 2. System life-cycle organization, planning, and staffing

CSF 2.1 Establishment of stakeholder life-cycle Responsibilities, Authorities, and Accountabilities (RAAs) (for system definition & system development)

(a) Are the stakeholders who have been identified as critical to the success of the project represented by highly qualified personnel -- those who are collaborative, representative, empowered, committed, and knowledgeable?
(b) At Milestone A, are there validated plans, budgets, and schedules defining how the pre-Milestone B activity will be done, and by whom?
(c) Has the government attempted to align the duration of the program manager's assignment with key deliverables and milestones in the program?
(d) Have the key stakeholders agreed to the proposed assignments of system roles, responsibilities, and authorities?

CSF 2.2 Establishment of Integrated Product Team (IPT) RAAs, cross-IPT coordination needs

(a) Does the project make effective use of Integrated Project Teams (IPTs) throughout the supplier hierarchy?
(b) Are the IPTs staffed by highly qualified personnel, as in 2.1 (a)?
(c) For IPTs addressing strongly coupled objectives, are there super-IPTs for resolving conflicts among the objectives?

CSF 2.3 Establishment of necessary plans and resources for meeting objectives

(a) Have decisions about the use of one-shot, incremental, or evolutionary development been validated for appropriateness and feasibility, and accepted by the key stakeholders?
(b) Have system definition, development, test, and evolution plans, budgets, and schedules been validated for appropriateness and feasibility, and accepted by the key stakeholders?
(c) Is there a valid business case for the system, relating the life cycle system benefits to the system total cost of ownership?

CSF 2.4 Establishment of appropriate source selection, contracting, and incentive structures

(a) Has the competitive prototyping option been addressed, and the decision accepted by the key stakeholders?
(b) If doing competitive prototyping, have adequate plans and preparations been made for exercising and evaluating the prototypes, and for sustaining core competitive teams during evaluation and downselecting?
(c) Is the status of the candidate performer's business and team "healthy," both in terms of business indicators, and within the industrial base for the program area? Is the program aligned with the core business of the unit, and staffed adequately and appropriately?
(d) Has the acquiring organization successfully completed projects similar to this one in the past?
(e) Has the candidate performing organization successfully completed projects similar to this one in the past?
(f) Is the program governance process, and in particular the system engineering plan, well articulated and compatible with the goals of the program?

CSF 2.5 Establishment of necessary personnel competencies

(a) Does the government have access over the life of the program to the talent required to manage the program? Does it have a strategy over the life of the program for using the best people available in the government, the Federally Funded Research and Development Centers (FFRDCs), and the professional service industry?

(b) At Milestone B, have sufficiently talented and experienced program and systems engineering managers been identified? Have they been empowered to tailor processes and to enforce development stability from Milestone B through IOC?
(c) Has the government attempted to align the duration of the program manager's assignment with key deliverables and milestones in the program?
(d) Is the quantity of developer systems engineering personnel assigned, their skill and seniority mix, and the time phasing of their application throughout the program lifecycle, appropriate?

Goal 3. Technology Maturing, Architecting

CSF 3.1 COTS/Non-Development Item (NDI)/Services evaluation, selection, validation for maturity & compatibility

(a) Have COTS/NDI/Services opportunities been evaluated prior to baselining requirements?
(b) Have COTS/NDI/Services scalability, compatibility, quality of service, and life cycle support risks been thoroughly addressed?
(c) Has a COTS/NDI/Services life cycle refresh strategy been developed and validated?

CSF 3.2 Life-cycle architecture definition & validation

(a) Has the system been partitioned to define segments that can be independently developed and tested to the greatest degree possible?
(b) By Milestone A, is there a plan to have internal and external information exchange protocols established and validated for the whole system and its segments by Milestone B?
(c) Does the project have adequate processes in place to define the verification, test & validation, and acceptance of systems and system elements at all phases of definition and development?
(d) Is there a clear, consistent, and traceable relationship between system requirements and architectural elements? Have potential off-nominal architecture-breakers been addressed?
(e) Does the architecture adequately reconcile functional hardware part-of hierarchies with layered software served-by hierarchies?
(f) Has a Work Breakdown Structure (WBS) been developed with the active participation of all relevant stakeholders, which accurately reflects both the hardware and the software product structure?

CSF 3.3 Use of prototypes, exercises, models, and simulations to determine technological solution maturity

(a) Will risky new technology mature before Milestone B? Is there a risk mitigation plan?
(b) Have the key non-technical risk drivers been identified and covered by risk mitigation plans?
(c) Is there a sufficient collection of models and appropriate simulation and exercise environments to validate the selected concept and the CONOPS against the KPPs?
(d) Has the claimed degree of reuse been validated?

CSF 3.4 Validated system engineering, development, manufacturing, operations & maintenance budgets and schedules

(a) Are the major known cost and schedule drivers and risks explicitly identified, and is there a plan to track and reduce uncertainty?
(b) Have the cost confidence levels been developed and accepted by the key system stakeholders?
(c) Is there a top-to-bottom plan for how the total system will be integrated and tested? Does it adequately consider integration facilities development and earlier integration testing?
(d) If timeboxing or time-determined development is used to stabilize schedules, have features been prioritized and the system architected for ease of adding or dropping borderline features?
(e) Are there strategies and plans for evolving the architecture while stabilizing development and providing continuity of service?

Goal 4. Evidence-based progress monitoring and commitment reviews

CSF 4.1 Monitoring of system definition, development and test progress vs. plans

(a) Are the levels and formality of plans, metrics, evaluation criteria, and associated mechanisms (IMP, IMS, WBS, EVMS) commensurate with the level of project requirements emergence and stability? (too little is risky for pre-specifiable and stable requirements; too much is risky for emergent and unstable requirements)
(b) Are the project's staffing plans and buildup for progress monitoring adequate with respect to required levels of expertise?
(c) Have most of the planned project personnel billets been filled with staff possessing at least the required qualification level?

(d) Is the project adequately identifying and managing its risks?
(e) Have the processes for conducting reviews been evaluated for feasibility, reasonableness, completeness, and assurance of independence?
(f) Has compliance with legal, policy, regulatory, standards, and security requirements been clearly demonstrated?

CSF 4.2 Monitoring of feasibility evidence development progress vs. plans
(a) Has the project identified the highest risk areas on which to focus feasibility analysis?
(b) Has the project analyzed alternative methods of evaluating feasibility (models, simulations, benchmarks, prototypes, reference checking, past performance, etc.) and prepared the infrastructure for using the most cost-effective choices?
(c) Has the project identified a full set of representative operational scenarios across which to evaluate feasibility?
(d) Has the project prepared milestone plans and earned value targets for measuring progress in developing feasibility evidence?
(e) Is the project successfully monitoring progress and applying corrective action where necessary?

CSF 4.3 Monitoring, assessment, and replanning for changes in needs, opportunities, and resources
(a) Does the project have an effective strategy for performing triage (accept, defer, reject) on proposed changes, that does not destabilize ongoing development?
(b) Does the project have an adequate capability for performing change impact analysis and involving appropriate stakeholders in addressing and prioritizing changes?
(c) Is the project adequately verifying and validating proposed changes for feasibility and cost-effectiveness?

CSF 4.3 Use of milestone reviews to ensure stakeholder commitment to proceed?
(a) Are milestone review dates based on availability of feasibility evidence versus on availability of artifacts or on planned review dates?
(b) Are artifacts and evidence of feasibility evaluated and risky shortfalls identified by key stakeholders and independent experts prior to review events?
(c) Are developer responses to identified risks prepared prior to review events?
(d) Do reviews achieve risk-based concurrence of key stakeholders on whether to proceed into the next phase? (proceed; skip a phase; revisit the current phase; terminate or rescope the project)

5. Example of Use

Quantitative Methods, Inc. (QMI) is a leader in developing Environmental Impact report (EIR) generator packages for use by systems developers and government agencies. QMI has successfully developed EIR generators for the states of California, Colorado, Florida, Maine, Massachusetts, Oregon, Texas, and Washington. QMI has recently been awarded a contract for developing an EIR generation package for the State of Georgia, which has put the use of the FED DID onto the contract. QMI and the State of Georgia personnel are collaboratively tailoring the FED DID to the project.QMI has provided evidence that their EIR generator results for California, Florida, and Texas were more comprehensive than those needed for Georgia, except for Georgia's request to include some recent advanced environmental pollution analysis algorithms for the Atlanta metropolitan area. The parties have agreed that QMI needs only to tailor up the portions of the FRD DID that cover the evidence of successful definition and development of these algorithms. Also, due to the uncertainties in the algorithms' performance against complex operational scenarios, the contract was revised not to identify point-solution goals for the Key Performance Parameters (KPPs) of analysis throughput, response time , and accuracy, but to identify ranges of acceptable and desired KPP values. The resulting tailoring activity enabled the parties not only to identify the evidence needs, but also to the key technical activities and data needs involved in this aspect of the project. For Critical Success factor (CSF) 1.1 of the DID Framework above, the definition of KPP ranges has taken care of Question (a), but Question (c) on verification of feasibility via modeling and simulation is tailored in. For CSF 1.2 on Analysis of Alternatives, QMI will include plans to perform benchmark tests of algorithm performance on several high-performance-computing platforms to provide evidence of achievable throughput, response time, and accuracy vs cost. These will take care of Question 1.2 (a), and the resulting evidence will be reviewed by tailoring in Question 1.2 (d).

These preparations for the assessment and selection of alternative solutions are sufficient to address the questions in CSF 1.3 on system scoping, but an additional concern arises with respect the Question 1.4 (b) on the ability of the solutions to scale up to future growth. A proposed future growth option for the Atlanta metropolitan area is to expand the environmental monitoring systems via a smart sensor network with over 1000 times as many sensors. It is unclear that any of the currently-available solutions could scale up by a factor of 1000, but it is also unclear how rapidly the future sensor network solution technology will scale up to such levels. The issue is addressed by tailoring in Question 1.4 (b), and identifying this issue as a potential risk to be analyzed by an integrated product team (IPT) of relevant experts, and assessed at the project's Preliminary Design Review (PDR) equivalent of a DoD Milestone B.This plan covers Question 2.1 (b) with respect to pre-Milestone B plans and Question 2.2 (a) with respect to the use of IPTs. Questions 2.2 (b) and (c) are tailored in to review evidence that the IPT's are appropriately staffed with experts, and that they do not over-optimize on scalability at the expense of other KPPs.. Question 2.5 (d) could be added, but it is redundant in this case and is not necessary. The remainder of the tailoring-in activities follow up with the plans as prepared. With respect to CSF 3.1 on COTS evaluation and selection, tailoring in a focus on evaluating COTS products for future scalability would be worthwhile. If solution scalability is identified at the PDR as a future risk, Question 4.1 (d) on risk management could be tailored in., and followed up by Question 4.3 (c) on preparation for milestone risk reviews.

6. Conclusions

Having a Data Item Description for feasibility evidence as a first-class citizen provides an alternative to the current situation in which the path of least resistance is to use a set of deliverables in which evidence preparation and review is optional, and often leads to uninformed milestone decisions and subsequent project overruns. Having a DID which is tailored up from a simple version avoids the path of least resistance of accepting the full set of DID items and producing many non-value-adding evidence items. Treating evidence as a first-class deliverable implies that the evidence to be generated needs to be assessed for useful value, planned for, tracked with respect to plans, reviewed by independent experts, and used as a basis for milestone decisions. The case study shows that the process of tailoring the DID not only enables its efficient use, but also enables the project stakeholders to collaborate, better understand, and plan for addressing the key issues involved in achieving project success.

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