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IV&V Workshop

IV&V Technical Rigor

Jeff Northey jeffrey.r.northey@nasa.gov

Shirley Savarino shirley.savarino@ivv.nasa.gov

Agenda

- Overview, Context
- Technical Rigor – planning, technical, management
- How Technical Rigor is utilized at NASA IV&V
- Summary and closing thoughts

Technical Rigor – Overview and Context

- Technical Scope: ‘where’ IV&V will be applied (a CSCI, a behavior/capability, a domain, an interface, etc.)
- Technical Rigor: ‘what’ IV&V will be done and ‘how’ IV&V will be performed. Includes:
 1. What technical objectives (or tasks) we choose
 2. What methods/approaches/techniques we choose
 1. Includes more/less formal techniques and recording procedures (IEEE 1012 “rigor”)
 3. How we apply those methods
 1. Includes broader/narrower analysis across all normal and abnormal system operating conditions (IEEE 1012 “intensity”)
- All three aspects can be modified to ‘increase’ or ‘decrease’ technical rigor (modifications based on mission characteristics, risk, etc.)
- Recognizing the options that exist within the realm of Technical Rigor, appropriately considering and selecting will result in a higher quality IV&V product.

Technical Rigor – Mission Understanding

Attributes of Complexity, which feed into technical rigor

Mission type: high pointing requirements, autonomy, human

Software complexity: SLOC count, levels of integration, documentation

Software development methods – e.g. autocoding, MBSE

Programmatics: developer experience, schedule

Higher complexity of the deployed software demands more IV&V technical rigor

- Mission understanding is key to understanding how to apply technical rigor ← the IV&V objectives of a are the same across a software development lifecycle, but how the work performed is driven by the mission understanding
- Mission type, for example, immediately identifies potential areas of concern
 - Better understanding of mission and development adds fidelity to where to focus



Astrophysics = Pointing accuracy and knowledge



Interplanetary = autonomy and Fault Protection



Manned = Human Safety



Operational = data quality, dependability, delivery

Technical Rigor – planning and management

- IV&V planning can be based on a standard set of attributes (based on the WBS), but modulated based on mission understanding.
- **Intensity:** Intensity is where it might be appropriate to apply *additional* tasking. Intensity can be based on project complexity, or project risks associated with meeting a specific capability
- **Rigor:** There are cases where a standard set of IV&V work instructions won't apply to different development methods. In these cases, IV&V does the same thing but needs to do it a *different* way
- **Project Risks** can affect both intensity and rigor
 - For example, a risk associated with project documentation methods could affect rigor
 - A risk associated with a complex maneuver or pushes the boundaries of engineering could affect intensity

Step 1: Identify Potential drivers

Criticality Assessment

Project Development Methods

Project Risks

Step 2: Evaluate Sufficiency of Processes

For critical areas, application of standard work instructions may not meet the demands of the capabilities that are being implemented

Step 3: Establish objectives and potential benefits of any additional or different tasking needed

This enables a clear understanding of “why” and also knowing when “mission accomplished”

Step 4: Develop and execute new tasks

Communication even more important for these tasks because of their importance and novelty

Mild iterations might be appropriate between Steps 3 and 4

Communicate successes and lessons learned

Technical Rigor – Suggestions on optimally Developing and Implementing methods

From prior chart...

Step 3: Establish objectives and potential benefits of any additional or different tasking needed

This enables a clear understanding of “why” and also knowing when “mission accomplished”

Step 4: Develop and execute new tasks

Communication even more important for these tasks because of their importance and novelty

- Identify and staff skill sets that can address the challenge (based on step 3)
- Use a team approach – the analysis team should understand the objectives/benefits and be part of the development of new tasks.
- Internal interchange through formal and ad-hoc meetings. The more the team works together, the higher the quality of the output
- Since new techniques are utilized, an environment where successes are celebrated is important. Problems are identified by individuals but addressed by the team
- Peer review adds to team understanding and consistency of products
- Use metrics to quantify progress and benefits
- Good technical leadership is important to balance creativity and chaos

Technical Rigor – Interactions with Developers

- Application of technical rigor can “streamline” project interface
 - Particularly when technical rigor is applied to highly critical capabilities and risky areas of development
 - Challenge areas in software development are hard to IV&V, but even harder to develop. So technical rigor is a bridge between mutual objectives
- Interactions between IV&V and the development project often include: ongoing IV&V tasks, including how analysis is performed and intended benefits to the project (what types of issues are anticipated)
- If the IV&V technical rigor is aligned with project
 - IV&V efforts help provide assurance in an area they are worried
 - IV&V spans development teams (e.g. system teams and software teams) to provide cross-phase value in a targeted area
 - Attributes of success in interactions (often realized as part of Step 3)
 - IV&V POCs and/or project development teams applaud new process
 - Artifacts are readily provided to support IV&V analysis
 - Development project is interested in full analysis results, not just the resulting issues
 - Development project is anxious for the IV&V results

Technical Rigor – Examples

Need:

Intensity:
Fault Protection
(driven by both criticality and risk)

Understanding that Fatal EVRs cause computer resets
Ensure there aren't unintended FataIs

Technical Rigor:

At final build, IV&V performed an evaluation across requirements, design and code to establish accountability for all the Fatal EVRs that were present in the code

Benefits:

Identified deleted req'ts where FataIs still existed in code, and also req'ts where FataIs had been removed after original analysis
Accountability and assurance that all FataIs in code were intended

Rigor:
Simulink GNC
(driven by development methods)

Project implementing GNC algorithms using Simulink and RTW autocoder

IV&V added rigor to design methods working within the Simulink models provided by the project. Additional task reviewed autocoder.

The detailed design analysis and autocoder check simplified the code analysis and provided mission assurance appropriate to a Simulink development

Intensity:
Processor Boot
(driven by criticality)

Project expressed concern regarding Boot. This capability scored high on criticality assessments

Two identical processors on the spacecraft implemented by two contractors. IV&V created an idealized boot model to evaluate req'ts

40% of the instrument boot requirements were a result of this IV&V analysis

Rigor:
Regression Analysis
(driven by risk)

Development did not use an integrated environment. Requirements tracked in four different repositories

IV&V developed tools to perform the software regression analysis across the repositories as system evolved

IV&V metrics and results on the consistency of req'ts across activities now being used as a "wedge" within project for fixes

How Technical Rigor is used at NASA IV&V

- Technical objectives are defined in the IV&V WBS or “Technical Framework”
 - ‘What’ we want to accomplish
 - Organized by content type (e.g. objectives for V&V of requirements)
- Methods are documented and organized according to technical objective and maintained in the IV&V Catalog of Methods
 - ‘How’ will we meet our objectives?
- Mission characteristics, IV&V Project characteristics, etc. drive identification of objectives, selection of methods, and application of methods.
- Technical Rigor: ‘what’ and ‘how’ IV&V will be performed. Includes:
 1. Technical objectives (or tasks)
 2. Methods/approaches/techniques we choose
 3. How/approaches/techniques methods are applied
- All three aspects can be modified to ‘increase’ or ‘decrease’ technical rigor (modifications based on mission characteristics, risk, etc.)
- When new/evolved methods are proven, they are fed back into the IV&V Catalog of Methods

Summary, Closing Thoughts

- Recognize the options (be open to all possibilities), appropriately consider and select IV&V approaches, including application of Technical Rigor
- Benefits
 - Yields a higher quality IV&V product.
 - Clarifies specific objectives of and provides focus to the IV&V effort.
 - Leads to more effective and efficient use of time.