Agency Level Software Standards Development at NASA

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Abstract: NASA is moving to establish agencywide standards as a result of a number of external and internal influences. This paper addresses the challenges and mechanisms used to establish agencywide NASA software standards. The author examines the standards development, approval, and implementation process from the perspective of NASA's Software Management and Assurance Program (SMAP). The paper concludes with a status of the software policy and standards under development through the sponsorship of the software assurance organization.

1 Software Assurance Perspective on Standards

The Office of Safety and Mission Quality (OSMQ) has the agencywide responsibility for establishing and independently assuring a NASA wide program in safety and mission quality. The author manages the NASA Headquarters software assurance program within the Reliability, Maintainability and Quality Assurance Division of OSMQ.

Assuring software quality is dependent upon the existence of a framework to evaluate quality. Software standards are an important element of the framework. The NASA Software Assurance Guidebook [1] defines software quality assurance as "... a planned and systematic approach to the evaluation of the quality of and adherence to software product standards, processes, and procedures". Currently, NASA has software standards at the program and project level, but not at the agencywide level.

For overall technical direction and agency-level guidance, NASA uses NASA Management Instructions (NMIs), which are policies, and NASA Handbook (NHBs) which provide more detailed technical guidance, like a standard. Although the NMI and NHB series are primarily a management directives series, they are currently the only agencywide directives series.

Over time, they have been used to provide technical guidance and carry the authority of agency level official direction. There is an initiative to establish a technical publication program to manage the engineering standards and the development process. The draft NMI that establishes this is discussed in section 8. In response to internal and external factors, NASA is now establishing the framework for software assurance at the agency level.

Figure 1 depicts the proposed hierarchy of agencywide software policy and standards currently being considered by NASA. The specific documents that are now being drafted are discussed in section 8. Standards that are in planning are indicated by "TBD" (To Be Determined).

NASA's projects continue to increase in size, complexity, and duration. The duration and sophistication of the missions are driving NASA to implement more of the functionality of each mission in software. The flexibility that software provides makes it ideal for long duration missions, because it allows for adaptations throughout the mission; however, this flexibility has a price. Increased flexibility normally results in a much more complex system design, increasing risk and lowering reliability. Better standards and software engineering practices hold the promise of improving the engineering of the larger complex software.

2 Motivations for Agency Standards Development within NASA

Several factors, both external and internal to NASA, have called for NASA to provide stronger central management especially of assurance. For example, Challenger investigations and reports indicated that stronger management oversight from NASA headquarters is needed. Specifically, a more visible
program was recommended in safety, reliability, maintainability and quality assurance. In a draft report evaluating NASA's Information Resources Management program, the General Services Administration (GSA) observed that 'NASA does not yet have a software life cycle management standard'. GSA recommended that the existing draft policy and standards, which had been in review for some time, be implemented [2]. The review and approval process for NASA standards is described in section 6.

Recent internal assessments from several sources have also stressed the need for agencywide standards. An internal review was conducted for the NASA Information Resources Management Council to assess the agency's readiness for supporting Ada technology and to assess the current posture of NASA's software management structure [3]. One finding of particular relevance was that 'NASA does not have an adequate set of agency-level standards and internal organizations to provide direction in software engineering and to support the evolution to new software technologies such as Ada.'

Other factors support the development of NASA agencywide standards. There is a strong grassroots movement within NASA to implement software policy and software engineering standards. However, strong grassroots support does not always translate into support by senior managers. Factors other than technical concerns influence the development of agencywide standards.

NASA remains a very project-driven organization. Projects such as Space Shuttle, Space Station, and the Hubble Space Telescope are prime examples. A project manager for each project allocates scarce resources among the competing elements of the project. A primary means used by the project manager to secure resources within a project is to identify an NMI or NHB that requires certain actions to be performed. Thus, the software standards, i.e., the NHBs, are needed to provide the mechanism for the software developers and assurers to support their requests for resources.

Development of agencywide standards could be advantageous to NASA. Such standards could be used to provide guidance to NASA civil servants for software to be developed in-house. In cases where contractors are developing software for NASA, agencywide standards could be used as benchmarks to evaluate the adequacy of contractors' proposed standards. Agencywide standards could be tailored and contractors required to follow them as is the case with MIL-STD 2167A for example.

Agencywide or multi-field center projects also would benefit from common standards. Use of contractor-specific standards creates a significant extra workload for NASA when performing system level reviews and assurance functions. Adoption of agencywide standards would promote consistency throughout the individual
elements of an agencywide project. The Space Station Program has adopted an early version of NASA's current draft agencywide Information System Life Cycle and Documentation Standards to promote uniform documentation across the major contractors.

Standards provide a mechanism for capturing the corporate knowledge of a workforce. Within NASA, there are many senior engineers and managers who are eligible for retirement. A significant and unexpected change in the civil servant retirement system could foster a significant loss of experienced leadership and technical expertise. NASA is particularly vulnerable to a loss of corporate knowledge. Standards provide a means of capturing and instituting knowledge.

3 NASA Standard Publication Series

As already stated, NASA provides technical guidance through NASA Handbooks. These were not intended to provide the level of technical guidance normal to software engineering standards. The lack of agencywide software standards presents a significant challenge to an organization attempting to generate technical guidance. NASA has recently established a separate division within the Office of Safety and Mission Quality, the Technical Standards Division, to manage standards at the agency level. An initial task of this division will be to establish a NASA-wide document series for technical publications.

4 Mechanism for Developing Agencywide Directives

There is no single approved method for drafting NMIs or NHBs. The process usually begins with an organization identifying a perceived agencywide need. A headquarters level office sponsors the draft through the approval process discussed in section 6. Programs and field centers have always had the prerogative to develop or adapt standards to meet local requirements and local standards as well as other sources are considered when developing agency level guidance.

The headquarters sponsoring organization usually has responsibility or is the lead organization in the area and decides that a policy or standard is necessary to accomplish its mission. For example, the NASA Headquarters Software Management and Assurance Program (SMAP) has taken the lead for software standards. The SMAP is sponsored by the OSMQ which is responsible for software assurance and needs the software standards to accomplish its Agencywide assurance mission.

NASA has no separate headquarters office for software engineering. The Office of Safety and Mission Quality evolved from the NASA Chief Engineer's Office and has the mission to ensure NASA has an institutional, that is to say agencywide, program in software assurance. OSMQ is one of the few Headquarters offices to have a responsibility that spans the agency and therefore is a natural choice to sponsor agencywide software standards.

5 The Software Management and Assurance Program Experience with Developing Agencywide Standards

The software standards discussed in section 8 are examples of policy and standards generated through the sponsorship of SMAP. The following section discusses the development mechanism as an example of how NASA is producing software standards.

The SMAP has a Steering Committee with representatives from all NASA program offices and field centers. Steering Committee members are software management, assurance, and engineering professionals who provide their guidance and expertise. The SMAP uses knowledge and experience of the Steering Committee members to identify issues that should be addressed at the Agency level. In turn, members have a forum for addressing issues of interest and potential solutions to agencywide software concerns.

The SMAP Steering Committee has become a key player in development of software policy and standards. Working groups within the Steering Committee are informal associations of software professionals interested in improving a particular aspect of the software development process at NASA. Current areas of interest have resulted in draft Information System Life Cycle and Documentation Standards and Software Assurance Standards (refer to section 8).

The standards development process for software has worked in the following manner. A working group drafts a document with the help of support contractors. The draft is reviewed informally by the working group until consensus is reached that a wider review would be beneficial. The initial wider review includes the complete SMAP Steering Committee roster made up of NASA civil servants and NASA support contractors. This review process is informal and may result in several iterations between the working group and the broader Steering Committee. Issues are resolved informally within the working group. This process
results in a widely supported draft document which is then offered as a proposed NMI or NHB. The Office of Safety and Mission Quality is the sponsor that formally submits the paperwork necessary to establish an NMI or NHB.

6 Standards Approval Process

This step begins the formal approval portion of the process. The draft document becomes official NASA direction after concurrence is reached by the program offices and field centers that will be affected. The concurrence process is separate from the development process. The approval process is formal but loosely structured and is conducted by the Office of Management, the office at headquarters responsible for managing the directives system.

It is still the responsibility of the organization sponsoring the new standard to resolve any nonconcurrences on the draft document. The approval process does not specify a formal structure for the resolving nonconcurrences. Ideally, a compromise is reached among the sponsor and the reviewing organizations and the revised draft is forwarded to the appropriate level for signature.

Since there is no formal linkage between the development process and the concurrence process, those who generated the standard may not be the ones involved in the review and concurrence process. This sometimes leads to delays, bottlenecks, or even stalemates as the standard continues to be modified and reissued for review.

The current process is therefore time-consuming and does not guarantee resolution, especially in a situation where equally viable, yet incompatible, technical approaches cause a deadlock. Based on this experience, the OSMQ is now experimenting with a Software Policy and Standards Disposition Board. The Board is a more structured and effective way of resolving issues. Its first test has proven successful at resolving issues that could not be resolved using the previously mentioned process. The significant difference between the Board approach and the current open-ended concurrence process is in the power delegated to the representatives.

Each board member has been selected by the field center's director or headquarters program office to speak for their organization. The Board's charter requires that the member's have negotiating rights and are empowered to vote on their organization's behalf.

The identification of a Board will make it possible for an organization drafting a software standard to ensure linkage between the developers and the approvers. Involving the reviewers in the development process should streamline the approval process. Efforts are currently under way to reestablish an engineering council within NASA to provide focus for all engineering standards. It is envisioned that the Software Disposition Board will become a subpanel to this broader engineering group.

7 Implementing Standards

There are several methods of implementing new standards. Just the fact that the document has been made an NMI or NHB does have some impact in getting it implemented. Each field center has a process in place that ensures all relevant NMIs and NHBs are referenced on new contracts. Once referenced on a contract it becomes a requirement that NASA will enforce through contract administration activities, such as reviews and audits. The management oversight responsibility of program offices includes ensuring that their projects adhere to the NMIs and NHBs and enforcing this through project reviews.

The Safety, Reliability, Maintainability, and Quality Assurance organizations provide an independent mechanism to assure compliance in several ways. The Headquarters OSMQ organization does bi-annual institutional reviews of the field centers assurance organization. The field center level assurance organizations take part in the center wide review of the requirements to be placed on a contract. They have a continuing obligation to survey and audit the projects and contractors to assure implementation of these requirements. The key vehicle to ensure implementation remains enforcement of the contract since the vast majority of NASA software is developed under contract.

8 Status of Agency Software Policy and Standards

NMI 2410.6 NASA Software Management Requirements for Flight Projects

NASA is currently in the process of establishing an agency framework of software policy and standards. The current NASA-wide software guidance document (NMI 2410.6) was produced in 1979 as a software management instruction for flight projects. NMI 2410.6, "NASA Software Management Requirements for Flight Projects," requires the development of a
software management plan to be reviewed by a committee of peers. The NMI is limited to flight project software and identifies specific topics that must be addressed in the management plan. It is more of a management plan standard than a policy.

**NMI 2410.XX NASA Software Management, Assurance, and Engineering Policy (Draft)**

This draft software policy establishes policy for managing, assuring and engineering all software acquired or developed by NASA. It mandates the establishment of classes of software based on risk and the consequences of failure of that software upon the mission. Within each software class a minimum standard of management, assurance, and engineering requirements and activities will be established. This policy provides the impetus for establishing a set of software standards at the agency level. The draft is currently being evaluated by the Software Policy and Standards Disposition Board.


The purpose of the standards are to provide a standard, tailorable life cycle process, and define the structure and formats for documenting products of that process. The data item descriptions (DIDs) are derived from MIL-STD 2167. The NASA standard differs in its prescribed hierarchical organization of documents. The hierarchy suggested within the standards defines a relationship among the DIDs. The standard also differs by establishing a minimum set of four documents and encouraging tailoring of the documentation requirements.

The standard has been in use for 2 years on a trial basis. The Space Station documentation requirements are based on an earlier release, Release 3.0. The standard has also been applied to a number of other small flight projects at NASA research centers. Based on this experience and with the additional leverage due to development of an automated documentation support system and a 2-day training course, we are in a position to formalize a NASA documentation standard. The draft is now in review by the Software Policy and Standards Disposition Board.

**NHB 2410.XX Software Assurance Standard (Draft)**

The draft Software Assurance Standard establishes the software assurance requirements for all NASA software projects and acquisitions. The standard is intended to provide an integrated set of requirements for a comprehensive software assurance program. The standard is based on the NASA Software Assurance Guidebook, SMAP-GB-A201, published in September 1989. The guidebook describes the best software assurance practices now employed at NASA field installations. The guidebook has had wide distribution within NASA and has fostered the generation of other more detailed guidebooks on specific assurance practices like audits [4] and formal inspections [5].

Short-term plans are to formalize the draft into a NASA standard on software assurance. The final form the assurance standard takes will in part depend on Information System Life Cycle and Documentation Standards and feedback from the use of the above mentioned assurance guidebooks.

The efforts of the SMAP and the OSMQ to develop software standards will be influenced by initiatives of the previously mentioned Technical Standards Division and the re-establishing of the NASA-wide engineering council. The engineering council will be the agency forum to address all engineering topics in hardware as well as software. The SMAP will probably continue to be the source of draft software standards, OSMQ will provide the necessary sponsorship, and the emerging engineering council and Technical Standards Division will provide the mechanism to achieve agencywide review and approval. The following policy is being proposed by the Technical Standards Division and the engineering council and will have an impact on future hardware and software standard development within NASA.

**NMI 8070.XX Engineering Standards and Practices Program (Draft)**

The purpose of NMI 8070.XX is to establish NASA policy and organizational responsibilities for the development, management and utilization of engineering standards and practices on NASA programs. The policy provides a basis for achieving the following objectives: a) Providing institutional focus for
the management of NASA standardization activities, b) Improving the technical and cost effectiveness of standards and practices developed for NASA programs, and c) Ensuring the most effective use of standards on NASA programs.

9 Conclusion

Many challenges face NASA, especially in software development. NASA is working aggressively to address the need for more and better software standards as a means of achieving its goal of quality software. The process of developing and implementing software standards has only begun but is making progress. It is a continuing process that will help NASA prepare for the challenges of the future.

10 References:

1. Software Assurance Guidebook, SMAP-GB-A201, September 1989
5. Software Formal Inspections Guidebook, SMAP draft, December 1990