Proven Standards

A Product of Technical Excellence

by William Vaughan and Paul Gill

Technical excellence drives the development of uniformity of practices that results in standards that can be applied throughout an organization, reducing costs and mitigating risk. Initiatives that address the enhancement of an organization's technical excellence are key to the organization's maintaining a high level of performance on current programs and projects, as well as to its preparing for new programs and projects. This article addresses the interrelationship of standards and technical excellence, and it discusses some related National Aeronautics and Space Administration (NASA) initiatives, of which good standards are an important part.

Technical Excellence

Technical excellence is the goal of all organizations and individuals, whether in government or industry, national or international. What do we mean by technical excellence? Most people have their own ideas and interpretation as to what constitutes technical excellence. Entering "technical excellence" into the search page of Google produces a significant number of results, evidence that technical excellence is important to a large number of organizations and people, whether in the engineering discipline or other disciplines.

According to "Mr. Webster," excellence is defined as the state, quality, or condition of excelling; superiority. To excel is to be better than, or to surpass, others. We believe most, if not all, people would be comfortable with this definition. However, because the intent of this paper is to demonstrate the importance of technical excellence relative to proven standards, it may be appropriate to explore some statements that have been made concerning technical excellence.

One author defined technical excellence as an effort to ensure that well-considered and sufficient technical thoroughness and rigor are applied to programs and projects under an uncompromising commitment to safety and mission success.[1]

Another author identified four guiding principles to achieving technical excellence:[2]

- Clearly documented proven policies and procedures
- Effective training and development
- Engineering excellence
- Continuous communications.

The same author also stated that two fundamental attributes must be considered when pursuing technical excellence: (1) personal accountability, whereby each individual must understand and believe that he or she is responsible for the success of the organization's mission, and (2) organizational responsibility, whereby the organization provides the proper training, tools, and environment.[3]

It has also been noted that, due to the rapidly expanding technology and science, engineers and technologists in the 21st century must have a strong technical background in their fields and understand technology at the interface between traditional fields.[4] They must be creative, skilled problem solvers who can think critically using sound principles and concepts. Technical excellence and good standards are products of these principles.

Louis Armstrong is understood to have remarked that if you have to ask what jazz is, you will never know. (His exact words are not known, but it is accepted that he said something to this effect.) This remark could also apply to technical excellence. This becomes clear when one tries to quantify the meaning of technical excellence by producing metrics to establish whether a particular objective or goal has been achieved. For example, what provides a measure of the technical excellence achieved by an organization: number of patents received? number of professional journal publications? number of individuals with advanced degrees? number of engineers versus nonengineers at work? positive versus negative feedback on products? equipment or system successes versus failures? profit a company makes? number of standards it uses?

In the aerospace arena, one can certainly equate organizational technical excellence—and thus proven engineering and use of technically proven standards—to mission success. In the final analysis, technical excellence is one of the most important goals of any organization. How one achieves and maintains it is another question for which there is no simple answer. Unquestionably, an organization with recognized technical leaders who have vision, superior technical competence, and the desire to excel will achieve technical excellence. Development of proven standards is certainly a product of this goal. Thus, technical leadership is key for an organization's success and the ability of the managers assigned to carry out the organization's mission.

Technical excellence is also related to the strategic management of an organization's human capital. The technical excellence of its workforce is an organization's most critical asset in accomplishing its mission. Therefore, ensuring the continued development of scientific and technical expertise is necessary to preserve an organization's, and the nation's, role as a leader in technology. It is also significant to producing good standards and, accordingly, their application.

In an attempt to identify a few outstanding characteristics of managers and management approaches that would ensure a program's success, NASA, after completing the very successful Saturn-Apollo program, undertook a research study in 1974 on management philosophies as applied to major NASA programs.[5] The study identified three "tall poles" important to program management:

- "Pay attention to detail." (George M. Low)
- "Leave no stone unturned." (Wernher von Braun)
- "Be aggressive—not passive." (Lee B. James)

These philosophies create policies and management methods that are highly conducive to program success or, in other words, technical excellence. Proven standards are a product of these efforts.

Some Examples of Technical Excellence Initiatives

In 2007, NASA undertook a technical excellence initiative to identify and resolve engineering challenges.[6] The initiative was designed to provide quality solutions and work that will translate into an agency investment strategy for application to present and future missions. Among the attributes of this initiative are the improvement of overall technical capability; development of analysis and testing beneficial to multiple missions, programs, and projects; advancement to tool/technique capability; and proven standards.

In 2006, the aerospace industry released a position paper that argues for standards based on technical excellence of content rather than the source of a standard.[7] Experts from the Aerospace Industries Association's Strategic Standardization Forum for Aerospace (SSFA) prepared a position paper on the use of standards in response to growing concern that certain policies and legislation may be putting the industry—and consumers—at risk. The SSFA emphasizes that the aerospace industry must select standards based on safety, quality, and technical merit, rather than based on which organization developed them.[8] Thus, the authors of the paper recognized technical excellence relative to ensuring that proven standards are produced and applied in order for good engineering to be achieved.

> Along with cost and schedule, mass control of space systems is a primary measure of the health of a space system's development. This can be seen by often quoted price per pound delivered to space, based on cost schedules of available launch service providers. When payloads exceed their requirements, additional costs for launch vehicle upgrades and altered launch planning can have a catastrophic effect on a payload's programmatic success. While development of mass control standards has traditionally focused on the mass of the payload, little attention has been given to the mass and performance of the launch vehicle itself. Individually, stages of launch vehicles are subjected to traditional mass control; however the relationship between the

> mass of the stage and the corresponding performance of the launch vehicle is an important contribution to technical excellence and the resulting standards. These relationships are to be addressed in upcoming revisions to both national [and] international mass control standards for space systems, and will have a meaningful effect on the development of new commercial and government launch systems.[9]

The philosophy relative to enhancing technical excellence through the interplay of standards and their use is reflected in the following by Michael Griffin, who was the NASA Administrator from 2005 to 2009:

> One aspect of this discussion is the need to set certain engineering technical standards to ensure compatibility and interoperability in our exploration architecture. Analogous to my previous comments about spoken languages for future space explorers, it is important that the engineering standard for NASA's architecture be specified with the international metric, or SI, standards as the base unit of measure, with English units only by exception when it makes sense for NASA to do so. Thus, we hope for a high degree of compatibility of interfaces and standards, as space-faring nations explore the Moon, Mars, and near-Earth asteroids together.[10]

Thus, technical excellence is crucial to ensuring the compatibility and interoperability of a system's architecture. Proven standards, also referred to as good standards, are important to achieving this goal.

Good Standards

Perhaps it is best to again consult the dictionary for what is meant by the term "standard." It means, among other things, "a degree or level of requirement, excellence, or attainment." It is this meaning that we associate with good standards and their role in achieving the success of a program or project.

The motivations for good standards and the associated enhancement of technical excellence vary considerably. One most often sees economic issues as the principal motivation. Applications to regulatory matters are another strong motivation. Among the principal motivations for good standards are international competitiveness; commodity confidence; safeguards for health, safety, and environment; risk reduction; facilitation of commercial communications; and technology transfer. However, enhancing organizational capabilities and technical excellence, although readily recognized as a key motivation, is not often seen in the list of motivations for the development and promotion of good standards. For example, in its overview of the U.S. standardization system, the American National Standards Institute noted the following:

> Within the U.S. standardization system, stakeholders—companies, government agencies, public interest organizations, and individuals—follow the method of standards

development and the conformity assessment scheme most appropriate for their particular needs. Rapidly evolving fields have requirements that are far different from those of traditional manufacturers or highly regulated technologies.[11]

In 2012, the *World Standards Cooperation Newsletter* emphasized that

> good standards are technology-independent. A good standard helps companies build products that work and communicate with each other and within existing systems safely, anywhere in the world. A good standard focuses on criteria that help industry stakeholders to consistently test and verify the safety, performance and quality of different technologies in the same space. This builds trust and is the only way how markets can grow and expand.[12]

Many strong domestic and global standards developers are serving, for example, the aerospace industry. The U.S. aerospace industry has a stated policy of choosing standards based on technical merit and suitability for use rather than based on the developing organization. This practice is important to ensure the use of proven standards.

Standards are an integral part of all organizational product development efforts. Designers and development engineers should be among the most aggressive supporters of technical standards. Standardization activities establish engineering and technical applications for processes and practices and, in doing so, enhance all organizational capabilities and further promote technical excellence. Thus, they enable an organization to not dissipate its energies on the costly exercise of "reinventing the wheel."

The integration of good standards is one step toward the goal of significantly enhancing an organization's technical capabilities and products. Technical excellence is the key to the nation's future in the rapidly growing globalization of industry. For the United States to remain competitive and maintain its technical leadership in the world, enhancing the nation's capabilities is critical. These capabilities can be acquired only by achieving technical excellence, which is a requirement for good systems engineering.[13] Good standards provide a major opportunity to achieve the goal of enhancing organizational capabilities and providing a means whereby technical excellence can be infused into the development and manufacturing process.[14]

In many cases, the existing standards, or the requirements within them, are so well established that—without good examples highlighting a deficiency or weakness in the standard—it is hard to substantiate the need for a change on the basis of technical excellence.

Such was the situation facing the NASA Engineering and Safety Center's threaded fastening systems standard development team, which, over a period of about 4 years, developed and released NASA-STD-5020, "Requirements for Threaded Fastening Systems in Spaceflight Hardware." The team, comprising subject matter experts from NASA, aerospace contractors, and academia, decided in its initial meetings that it would, to the extent possible with available resources, use test data to substantiate changes to traditional requirements. One example of this was the development of a structural failure criterion for a bolt loaded in both axial tension and transverse shear (tension/shear interaction), particularly for the case of a single lap shear joint. Equations for tension/shear interaction in fasteners have been extensively published in aircraft structures manuals or text books for decades. However, the applicability of those equations to a single lap shear joint was frequently questioned, especially for the common design situation of a preloaded bolt installed into a threaded insert. Using a custom-designed fixture, a NASA program sponsored the testing of several aerospace-quality bolts at varying ratios of tension load and shear load and plotted a failure envelope to fit the data. This test program indicated that the traditional interaction equations were potentially not conservative. Therefore, the modified criterion was incorporated into a new NASA standard. Thus, as a result of technical excellence, a new and better standard was produced.

Enhancing an organization's capabilities and products is an important product of standards, especially when coupled with allied information such as lessons learned and experiences with the use of a standard. Such must be the thrust of any viable organization. This is reinforced and expanded based on feedback from an organization's staff, its contractors, and users of its products in order to improve the content of standards. Feedback, in turn, helps industry meet demands for timely, productive, and reliable systems and contributes to improvements in efficiency and costs.

Another area in which technical excellence drives the use of proven standards is model-based engineering (MBE). A National Defense Industry Association (NDIA) report[15] defines MBE as an approach to engineering in which models

- are an integral part of the technical baseline;

- evolve throughout the acquisition life cycle;
- are integrated across all program disciplines (systems engineering, operations analysis, software engineering, hardware engineering, manufacturing, logistics, etc.); and
- can be shared and/or reused across acquisition programs, including between government and industry stakeholders.

The creation, management, and usage of product-related data across a cradle-to-grave life cycle are daily events at NASA. The integration and sharing of electronic product data between NASA centers, across programs and projects, and with prime contractors and subcontractors have become mission critical. The agency-wide challenge is to provide a product development capability level that is seen in many of NASA's prime contractors.

Multidisciplinary teams (such as systems engineering, product engineering, manufacturing, purchasing, operations, maintenance, and sustainment), as well as remote participants (local or globally dispersed suppliers, subcontractors, and so on), need quick access not only to the product data they are working on but also to associated information that better defines product performance, functionality, form, and fit to enable building of their products and services related to the product data.

To meet the demands of an MBE environment, the transition can be successful only if it is approached in a collaborative manner with the involvement of the government, industry, tool vendors, and academia. The NDIA report[16] recognizes the need for

- developing an MBE standards road map,
- initiating a research program to close high-priority technical gaps,
- developing the standards identified in the standards road map,
- providing seed funding for the development of reference implementations of select MBE standards, and
- developing an MBE program.

Many organizations have realized that they must put proven standards in place before they can successfully evolve into an MBE environment. One such organization is PDES, Inc., which was formed in the 1980s and comprises members from industry, U.S. government agencies, universities, and software vendors. PDES supports the digital enterprise through the development and implementation of information standards to support MBE, model-based manufacturing, and model-based sustainment. Implementation testing and data exchange using the ISO 10303 standard are an integral part of PDES.

Other organizations, such as the International Council on Systems Engineering, Object Management Group, Inc., and National Institute of Standards and Technology, are collaborating in the development of rigorous, proven standards that facilitate data exchange among disparate product life-cycle management systems.

Concluding Remarks

We have endeavored to focus on the importance of standards and to provide readers with some information and motivations that will enhance their quest for technical excellence. The need for technical excellence is a significant matter for all organizations. Proven standards are an important product of technical excellence. Proven standards play an important role in the transfer of technical experiences, lessons learned, best practices, and infusion of new technology for the further enhancement of technical excellence within all organizations. Thus, not only do good standards support the achievement of technical excellence, they also enable technical excellence to be passed on to others. Although technical excellence is not easy to quantify, there is no doubt it is readily recognized, both by those involved in standards use and development activities and by those who are the "customers," be they public, government, or industry.

[1]Teresa Vanhooser, "MSFC Technical Excellence/Technical Authority," NASA Marshall Space Flight Center, Huntsville, AL, May 2007.

[2]Chris Scolese, "Four Guiding Principles of Technical Excellence," *ASK OCE*, Vol. 1, Issue 4, NASA Headquarters, Washington, DC, February 8, 2006.

[3]Chris Scolese, "Technical Excellence: Roles and Responsibilities," *ASK OCE*, Vol. 1, Issue 5, NASA Headquarters, Washington, DC, February 24, 2006.

[4]"Engineering and Technology for the 21st Century: Technical Excellence," Brigham Young University, Provo, UT, March 16, 2007.

[5]Konrad K. Dannenberg, *Management Philosophies as Applied to Major NASA Programs*, NASA-CR-141258, 1974.

[6]See Note 4.

[7]American National Standards Institute, "Aerospace Industry Argues for Standards Based on Technical Excellence Rather Than Source," March 7, 2006.

[8]Strategic Standardization Forum for Aerospace, Aerospace Industries Association, "Safety of Aerospace Products Demands Freedom to Select Most Appropriate Standards," http://www.ssf-aerospace.org/, March 2006.

[9]See Note 1.

[10]Michael D. Griffin, "Partnership in Space Activities" (remarks, 56th International Astronautical Congress, October 20, 2006).

[11]American National Standards Institute, *Overview of the U.S. Standardization System: Voluntary Consensus Standards and Conformity Assessment Activities*, Third Edition, 2010.

[12]"Standards Grow Business," *World Standards Cooperation (WSC) Newsletter*, No. 5, newsletter@worldstandardscooperation.org, August 2012.

[13]William Vaughan, "Technical Excellence: A Requirement for Good Systems Engineering," *Defense Standardization Program Journal*, July/December 2010.

[14]William W. Vaughan and Paul S. Gill, "Engineering Excellence and the Role of Technical Standards" (paper AIAA-2006-0573, 44th AIAA Aerospace Sciences Meeting, 2006).

[15]NDIA, *Final Report of the Model Based Engineering (MBE) Subcommittee*, Final Draft, February 10, 2011.

[16]See Note 15.

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