The Future Of Aerospace Standardization

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AEROSPACE INDUSTRIES ASSOCIATION

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By the

Future of Aerospace Standardization Working Group
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Examining aerospace standardization systems, processes, and organizations; defining requirements for standards and standards systems to support continued and future growth of the aerospace industry; and setting forth recommendations for ensuring the optimum standards infrastructure for aerospace.

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Preface

The aerospace industry is rapidly transforming into a global industry with worldwide suppliers and prime companies functioning as expanded enterprises in international collaborative partnerships. Standards form the single largest source of technical data used in the global design, build and support of aerospace products. Yet the standards, and the processes used to develop and distribute standards, are not positioned to support a global industry.

The results of an overly complex, often duplicative aerospace standards system are increased costs associated with harmonization of regulatory requirements based on competing standards, increased costs associated with multiple conformity assessments and quality management audits due to multiple standards, and increased costs and inefficiencies associated with redundant and overlapping standards and standards infrastructures.

The Aerospace Industries Association Board of Governors established the Future of Aerospace Standardization Working Group in September of 2003. The Working Group was to examine the current aerospace standardization systems processes and organizations, define requirements for standards and standards systems to support continued and future growth of the aerospace industry, and set forth recommendations for ensuring the optimum standards infrastructure for aerospace. [Note: This report will use the term "standards" to include standards, specifications, and conformity assessment procedures unless otherwise noted.]

The Working Group's Charter was to:

- Identify the key requirements for standards systems that are intended to be used to support the global aerospace industry
- Examine the major standards development models and organizations used today in light of the defined requirements
- Develop a set of recommendations for migrating towards the optimum standards system(s) required for the aerospace industry

From September 2003 through September 2004, the Working Group held four workshop meetings, bi-monthly telecoms, and utilized a dedicated web-site to gather, coordinate, examine and review information regarding the standards and standards systems used to support the aerospace industry. Inputs to the Working Group included documentation governing standards processes and practices; information regarding aerospace standards development, participation and use; details of aerospace Quality System requirements; data regarding impacts of e-business on the ability to integrate, collaborate and migrate technical data throughout the value chain; requirements for the DoD's future combat needs for integrated data; and the FAA's and other national airworthiness authorities' expectations regarding product, process and system standards.

Recommendations in this report are geared towards strengthening the US aerospace standards infrastructure so that the industry is better able to work with the rest of the world for the ultimate goal of supporting and enabling the creation, maintenance and distribution of global aerospace standards which are value-added enablers for the industry. Thus references in this report to the

aerospace industry refer first to the US aerospace industry, but in many cases the extension may be made to include the rest of the world, as the industry is global in nature.

Executive Summary

Aerospace has been at the center of America's technological leadership for the last century. The advances in science, technology, engineering, and manufacturing represented by the civil, military and space sectors are extraordinary. And underpinning all these accomplishments is the vast wealth of technical data housed, maintained, and disseminated through standards. Standards form the single largest source of technical data used in the design, build, and support of aerospace products. And the fact that standards are critical to the production and safe operation of aerospace products and platforms, lead the President's Commission on the Future of the United States Aerospace Industry in their 2002 report to state that *"Global standards and regulations are critical to the efficient operation of the global aviation system and international markets"*.

The Aerospace Industries Association (AIA), at the request of their Board of Governors, established the Future of Aerospace Standardization Working Group in September of 2003 to follow-up on the Commission's report and take an in-depth look at the health of the aerospace standards and to identify actions that industry needs to take to ensure its health in the future. The Working Group examined the current aerospace standardization systems and processes, defined requirements for standards and standards systems which will support continued and future growth of the aerospace industry, and established a set of recommendations for ensuring the optimum standards infrastructure to carry the aerospace industry into the future.

A Call to Action

The findings of the Future of Aerospace Standardization Working Group, and the recommendations made, extend beyond just the membership of the Aerospace Industries Association to include all stakeholders in aerospace. These recommendations are much more far reaching and strategic than can be tackled by the AIA alone. If they are to have any impact, these recommendations must be endorsed and implementation directed by all industry stakeholder leaders including Government policy makers, Industry CEO's and senior management, down to the subject matter experts throughout the aerospace industry.

The impact of not taking prompt action will be the continued erosion of the effectiveness and benefits of this collective body of worldwide aerospace technical information. Without effective leadership in aerospace standardization, an ever increasing percentage of the technical data that supports our industry will be developed in venues controlled outside of aerospace. This means that a greater and greater percentage of our air vehicles will be defined by technical documentation developed in standards committees where the aerospace industry has little influence or the industry is represented by a surrogate on a one nation one vote basis.

It is believed that this report represents the most comprehensive evaluation of aerospace standardization ever undertaken. If the Working Group's conclusions are correct, then inaction is perilous for virtually all stakeholders of aerospace industry – primes, every tier of supplier, customers, both civil and defense, standards developers, and those who rely on the quality, safety, and reliability of the products the aerospace industry produces. It is imperative, therefore, that action be swift, and that it be directed from the very highest levels of industry and government. The actions need to be led from the executive suite and implementation guided by the senior VP level.

Standardization, at its most fundamental level, is tactical, but an industry-wide approach to standardization is clearly strategic. The industry can not afford to neglect the development of the

technical documentation that supports the design, build, operation, and maintenance of aerospace products. With action, however, the US will continue to be a leader in the development of standards essential to our aerospace capability. Leadership can focus resources on critical standardization needs and cease dispersing engineering talent over so many venues that standardization is lost through the diffusion of efforts. With leadership we claim the highroad of standards defined by technical excellence and market relevance, developed through responsive venues involving all stakeholders, and using tools and formats that allow this critical data to seamlessly integrate with all other product data. These recommendations represent a "Call to Action" for the aerospace industry to protect this critical body of technical knowledge and ensure that it will carry the industry successfully into the future.

Chapter 1. Vision: Standards – Enabling the Future of Aerospace

According to an extensive study done in 1987, 39% of all aerospace engineering data and 38% of all manufacturing data is derived from standards. Standards are fundamental to all business aspects of aerospace as the vehicles for interoperability and interconnectivity; the common requirements to ensure reliability, repeatability and quality; the basis for safety and certification; and one of the most powerful mechanisms for propagating change.

But there are major drivers changing the face of the aerospace industry. And the standards systems are in danger of not keeping pace with these changes. Just as the President's Commission on the Future of the United States Aerospace Industry called for the establishment of a national vision to steer the industry, so too does the industry need a vision for its standards. The Working Group adopted the vision of "Standards – Enabling the Future of Aerospace" because this collective body of knowledge is so critical for helping the industry achieve its goals for the future. This vision needs to include all stakeholders functioning in global cooperation to produce and use globally recognized, accepted and utilized standards. The industry must develop a strategic standards strategy to promote standards business models which produce and fund standards so that all industry stakeholders have direct participation, fully support the process, and collectively own the product. The results of this vision must be global standards which are freely and easily integrated into the design/build/support processes, easily used in a collaborative design environment, and easily migrated throughout the supply chain. And finally, standards for the future aerospace industry must facilitate global conformity assessment and certification of aerospace products, platforms, systems, and operating environments.

Conclusions

To achieve our vision for aerospace standards, the Working Group concludes that:

- The nation needs a national aerospace standards vision and strategy which supports the development and use of global aerospace standards.
- There needs to be an aerospace standardization integrator/advocacy body to facilitate the development and implementation of this vision and strategy.
- Government and industry need to recognize the critical role standards play as enablers for aerospace.
- Standards need to be developed through processes which serve, and are used by, the entire aerospace community.

- Standards, and the process used to develop them, need to continuously evolve to incorporate breakthroughs and enhancements in technology to ensure that the standards and the technical data contained therein can be captured, managed, disseminated and integrated into the design, build and support processes used by the aerospace industry and in ways which ensure that standards are an integral part of the e-enabled digital enterprise.

Recommendation #1:
The integral role standards play in the design, manufacture, and support of aerospace products, makes global standards for aviation and space a critical resource for the aerospace industry. It is imperative that the US Aerospace Industry develop a vision and strategy for aerospace standardization that is shared among all stakeholders. Leaders from industry, government and standards developing organizations need to boldly advocate integrated processes and complementary infrastructures that will ensure that standards remain enablers for aerospace.

Chapter 2. Aerospace Standardization – A Huge, Complex System

The aerospace standards development infrastructure is crowded and complex. The industry uses hundreds of thousands of standards including documents from close to 150 different standards developing organizations worldwide. And that number is growing. We send thousands of technical experts to committees to develop standards for parts, materials, testing, quality, electronics, avionics, propulsion systems, fuels, software applications, homeland security, emissions, and a hundred other technology and functional topics. But few aerospace companies, let alone the industry as a whole, have taken the time to look at the entire landscape of standards activities with the intent to pro-actively manage where standards work gets done.

Each standards developer represents an infrastructure that must be maintained and nourished to enable it to continue to function. And each one of these organizations requires time, effort and resources from the various stakeholder groups. The aerospace industry has done little to encourage or promote the rationalization of the various standards developing organizations which support the industry or the harmonization and reduction in the number of standards. There is great potential for large returns on investments in efficiencies and reductions in duplication, not to mention cost savings in the areas of certification and test, through harmonization of standards activities and consolidation in the infrastructures used to develop and maintain these documents.

Conclusions

- The industry needs to take a big picture look at all the standards and infrastructures involved in the creation and maintenance of this critical technical data with the goal of reducing the number of redundant standards, preventing unwarranted proliferation, and consolidating the "standards supply chain".

- The industry needs a single source for visibility of all existing and in-work standards. Emphasis needs to be placed on achieving the goal of identifying a suite of universally accepted standards which contains little to no duplication.

- Pro-active strategic management of aerospace standardization activities is needed to ensure the most efficient and effective use of industry resources and talent. Every effort should be made to develop standards with organizations that offer the broadest inclusion of all stakeholders, the most cost effective processes, and the most easily accessible products.

Recommendation #2:
The aerospace industry needs to reduce the proliferation of standards wherever possible, with the goal of an industry library containing a single suite of globally accepted standards, tests and conformity assessment processes appropriate to the needs of the industry. Additionally, the industry needs to encourage the rationalization and reduction of the number of infrastructures needed to support aerospace standardization, focusing resources on processes and organizations which work to ensure efficient development of standards needed for aerospace.

Chapter 3: Leadership

There is currently no unified aerospace leadership on standardization to function in an integrator/advocacy capacity. Aerospace standardization efforts are currently the work of multiple individual standards development organizations (SDOs). An aerospace standardization integrator/advocacy body is needed to 1) address industry standardization issues, opportunities, and challenges, and work with all stakeholders to prioritize and respond to standards issues critical to aerospace; 2) advocate standards as supporting open and fair international trade and work to ensure a level playing field for development of globally relevant standards (mitigating the efforts of countries to use domestic or regional standards to promote or gain competitive trade advantage); 3) represent a U.S. aerospace position in international forums; 4) promote aerospace standardization in appropriate venues; and 5) provide education, awareness and advocacy for aerospace standards with industry, government, consumers, and trade bodies.

The need for leadership is apparent. The importance of leadership is obvious. The position of leadership is vacant.

Conclusions

- Standards represent a significant investment on the part of the aerospace industry. There needs to be an integration function which can facilitate the prioritization and focusing of industry standardization efforts and the development of industry-wide solutions. The industry needs a forum to come together to focus on ways to rationalize the standards system, help avoid duplicative committee scopes and standards, and to reduce unnecessary proliferation of standards.

- Without effective leadership in aerospace standardization, an ever increasing percentage of the technical data that supports our industry will be developed in venues controlled by foreign aerospace industry. Those standards will, intentionally or by serendipity of familiarity, favor foreign manufacturers. Therefore, they will impact not only the prime system integrators, but will ripple through the entire supply chain that supports the aerospace industry.

- There needs to be a single forum where the stakeholders in the US aerospace industry can come together for energetic, collaborative engagement and effective communication. Without such a forum, the industry will be unable to make the kinds of strategic and business decisions needed to ensure a cost effective and efficient standards system.

Recommendation #3:
The industry needs to have a leadership organization positioned to provide both technical and business integration in standards issues and solutions. The leadership organization must be recognized as an integrator for the industry, respected as objective without conflict of interest, and acknowledged as having the support of both industry and government. The organization must be able and willing to use appropriate means to accomplish aerospace standardization objectives, including application of resources, enlistment of senior management, resolution of overlapping scopes between aerospace standards organizations, lobbying, etc.

Chapter 4: Global Markets – Global Standards

Aerospace is a global industry – our supply chain is all over the world as are our customers. To support the design anywhere, build anywhere, operate anywhere vision of both the defense and commercial industry, we need global standards. Global standards are those that are recognized throughout the world as technically suitable, accepted as meeting the design and certification requirements, and used throughout the industry. The aerospace industry needs to assert the right to choose its standards based on technical merit and suitability for use regardless of whether the document was developed by an organization with the word "International" in its name.

Conclusions

- The aerospace industry needs to work with world governments, regulatory agencies, the US Department of Commerce, the US Trade Representative, and the standards developing community to ensure that global industry standards are chosen based on the merits of meeting technical and market needs, not based on which organization developed them.

- The more universally used a standard is, the better the return on investment. The use of globally recognized and accepted standards means the cost of development and maintenance is spread across a larger portion of the industry, there are usually more suppliers which can lower costs, and expenses involved in certification can be reduced.

- The global nature of the aerospace industry, with its world-wide supply chain and customers, demands global standards. The aerospace industry should strive to develop standards with those organizations that offer all stakeholders the opportunity to participate. The industry should also encourage that access to global standards be easy and efficient for all users.

Recommendation #4:
The Standards of choice for the global aerospace industry must be recognized internationally without bias towards the process for development or for the label of the developing organization. Where applicable, those standards need to be made the basis for national, foreign, regional, and international regulation and law. Global standards should be open for input from all stakeholders in the industry in accordance with standards development principles set forth by the World Trade Organization.

Chapter 5. The Business of Standards – New Models, New Tools

Standards are all too often thought of as just documents containing technical requirements, with little thought given to the "business" of their development and maintenance. But if an aerospace company approached the development of standards with the same mindset as other corporate

activities, then it would apply the same business decision criteria to standards as it does to other business decisions. Criteria would be used to choose where to develop standards; leading to preferred standards developers. Funding levels would recognize the critical importance of standards as part of product data and focus would shift from the small cost to license the standards to the large benefits of standardization.

If the technical data contained in standards is to continue to enable the business of designing, building and supporting aerospace products, then the tools, processes and formats used to author, manage, and distribute this data need to evolve. As the industry moves towards e-enabled processes and integrated product data, standards need to migrate towards a format that will allow them to be assimilated into the product data stream and migrated down through the supply chain. Tools and processes need to take advantage of new technologies to achieve efficiencies in the development and release cycles for standards data.

Conclusions

- The aerospace industry needs to ensure that standards are developed based on market relevance and need. The industry needs to develop processes and tools that will allow stakeholders to identify existing or in-work standards and which will facilitate strategic standardization decisions.

- The aerospace industry needs a robust standards development, coordination, approval, configuration management and promulgation system that ensures that standards data relevant to every step of the design/build/support life-cycle is easily available and user friendly. Such a system would be characterized by features such as (but not limited to):
    - Automated document preparation, coordination, commenting, and balloting that is easily understood, flexible, and engages the global community

    - Readily available and easily accessible standards development committee web sites which meet the needs of the standards developer, the standards acquirer, and the general information seeker

    - Tools which facilitate faster, better, cheaper development and promulgation of standards that are technically accurate, technologically current, market relevant, platform independent, and globally accepted and used

    - Tools which make it easy for the entire aerospace industry world-wide to engage in the development or use of standards at any appropriate point in the process

    - Access not just to the standard as a document, but to the technical information contained in the standards so that users can access the standards data as they need it, in the form they need it, and easily integrate that data into the rest of the product definition data. Standards move to being managed and controlled as a collection of data elements, rather than as a paper paradigm document, so that users (human, machine, and other applications) can construct the appropriate "view" of the standards data that best meets their needs.

- IP issues preventing standards data from being easily integrated with other product data and migrated down the supply chain need to be resolved.

Recommendation #5:
The business models and tools used for the development, distribution, integration and use of aerospace standards need to ensure that:

- standards development is responsive to business drivers and is based on a business case or market need
- the standardization process is adequately funded and supported
- tools and processes used to develop, maintain, and disseminate standards make the best use of technology and the internet to ensure an efficient, effective system involving all the stakeholders
- standards are developed and disseminated in such a way that the data can easily be integrated into product definition data or other life-cycle data streams, and that the tools and the processes are not hampered by data formats or IP issues.

Chapter 6. Standards and Civil Aviation

While conformity assessment and standards are two separate activities, they are closely related. Certification of aerospace products by regulatory agencies (FAA, EASA) is based on the use of and conformance to standards. To the extent that the industry has harmonized standards and standards related data, the certification process is greatly facilitated and the associated costs are reduced. The International Aerospace Quality Group represents one of the best new strategies for global standardization ever created. Established to help the aerospace industry implement the ISO 9000 Quality Management System, the IAQG defined a new strategy for developing an international standard – one that allowed the industry to successfully and rapidly drive globally harmonized quality requirements down through one of the largest and most complex supply chains of any industry.

However the industry is in desperate need of help in clarifying and harmonizing a single industry approach to the development of Qualified Products Lists (QPLs), and their related Qualified Producer or Manufacturer Lists (QMLs) which accompany part and material standards. Established first for use with Mil-Specs, they quickly became part of the data supporting civil aviation as the Mil-Specs became de facto industry standards. The aerospace industry urgently needs to develop a strategy to address when and how a standard should invoke requirements for qualification, guidance for inserting qualification requirements in specifications which takes into account competition in contracting, and plans for addressing legacy QPL management for standards migrated from DoD to industry standards developing organizations.

The International Civil Aviation Organization has long been developing international standards in the areas of aircraft operations, noise, emissions, etc. The role ICAO plays in the development of standards needs to be supported by the industry and recognized by national, regional, and local regulatory authorities. Standards developed by ICAO are consensus based standards developed by national and industry aerospace representatives and as such constitute global aerospace standards. Their primacy over standards developed by other non-aerospace international standards organizations needs to be asserted.

Conclusions

- The aerospace industry needs to better articulate and understand the relationship between standards and conformity assessment.

- The industry needs to harmonize standards which form the basis for regulations and certification and develop globally accepted conformity assessment schemes which are mutually recognized and cost effective.

- The model for global standards development used by the International Aerospace Quality Group has proven to be a successful way for achieving globally harmonized standards. The industry should seriously consider adapting or adopting this model for more standardization efforts.

- The process for the identification of qualified products and producers through the standards system is not functioning in an optimal manner. The industry needs to establish a special task force to deal with QPLs so the processes surrounding their invocation, development, configuration management, distribution, and use are clearly understood and uniformly applied throughout the industry and by all applicable standards developers.

- The International Civil Aviation Organization has been functioning as an international standards developer for the aerospace industry. The industry should work with governments and regulatory agencies to ensure that ICAO standards are recognized as international standards and that the industry maintains the right to utilize ICAO as an international standards developing organization specific to the industry over others such as ISO.

Recommendation #6:

The policies and procedures for assessing conformity of products and processes to standards are key and require urgent improvement as qualification, certification, and conformity assessment are major cost drivers.

The role ICAO plays in international standardization for the aerospace industry needs to be recognized by the US and these venues utilized to provide leadership in advancing US technology and to initiate change where needed.

Chapter 7. Standards for Defense

Military specifications and standards have been fundamental to the aerospace industry for the past 50 years. These documents not only support all the military platforms, but because of the close relationship between civil and military designs they form a large part of the standards used by commercial aviation. Mil-specs are in effect de facto industry standards. Though it was the aerospace industry that called for drastic reform of the Military Standards, the results of the Mil-Spec Reform program begun in 1994 made clear the critical role Mil-specs play in both the military and commercial aviation sectors.

The cancellation of thousands of Mil-Specs and their transfer to industry organizations for maintenance has placed a strain on the industry's standards infrastructures. Industry is facing a bow-wave of converted Mil-Specs in need of maintenance. And the government, if it wants to be able to utilize industry standards, must participate in their development and management. Development and use of global industry standards is critical to the international sale of defense products and their global interoperability. But to ensure the existence of suitable standards for

defense products, there needs to be mutual recognition of the interdependence between industry and governments standards.

Conclusions

- Senior DoD leadership must recognize the critical role government standards play in the commercial aerospace industry and involve those stakeholders in any major standardization initiatives. This will ensure that the key technical data contained in Mil-specs and standards is available to support dual use products and platforms and will ensure a strong supply chain for DoD parts and materials.

- In recognition of the global role Mil-Specs play in the aerospace industry, DoD is urged to establish more effective mechanisms for communicating with industry on standardization issues. This mechanism must provide a forum for discussion of standardization actions which impact both DoD and industry and would involve industry stakeholders in helping to define standardization issues and develop solutions that are mutually beneficial. Such a multi-disciplinary government and industry forum would:

    - Develop recommendations for how standardization can best support logistics reform, interoperability, evolutionary acquisition, technology insertion, and reduction in total ownership costs

    - Address issues such as business strategies that promote civil-military integration for acquisition of defense products and platforms, configuration management policies and practices, technology insertion, logistics supportability, and commercial parts management

- Senior DoD leadership must acknowledge that to ensure that industry standards are suitable for DoD use and that they meet and contain DoD requirements, government subject matter experts must participate on industry committees to develop and maintain these standards. Sufficient funding must be made available; otherwise, the DoD is running the risk of having neither internal nor external standards available for the design, manufacture and support of military products.

Recommendation #7:

Senior DoD and Aerospace industry leadership must recognize the extent to which the commercial aviation and space industries, as well as defense industry, depend upon the library of technical knowledge and discipline of configuration control embodied in the system of military specification and standards. DoD needs to proactively support and participate in the development of industry standards and utilize industry standards to the greatest extent practicable.

Chapter 8. Space – A Growing Role for Standards

As the Space industry moves from military, single product efforts to commercial production products, the role of standards and the use of industry developed documents is increasing. Many aspects of space standardization are common with commercial aviation and electronics. Standard fasteners, materials, electronic performance specifications, etc. are used extensively. However, the

industry is struggling to establish the infrastructures needed to develop standards for the unique aspects of space such as propulsion, vehicle interfaces, payload vehicle interfaces, or ground support equipment. Europe, with the European Space Agency (ESA) and The European Cooperation for Space Standardization (ECSS) has taken the lead in developing standards for space activities including standardization of project management, product assurance and engineering activities for the entire European space community. Without a clear strategy and support from industry and government space agencies, the US is in the process of ceding the development of standards for the commercial space industry to venues outside of our influence.

Conclusions

- As the Commercial Space industry re-energizes, the benefits of industry standardization will be critical to cost, quality and repeatability.

- Industry and government need to work together to ensure that globally relevant standards exist to meet our technical needs in space, and so that the US space industry does not continue to cede strategic standards and associated technical strength to the Europeans or other regional interests.

Recommendation #8:

Industry, NASA, DoD and the FAA, urgently need to work together to ensure the development of globally recognized standards that support both government and commercial space interests. Development and use of industry standards which support US based technology must be a key strategic component of the aerospace industry's standardization strategy.

Chapter 1 –

Vision: Standards –Enabling the Future of Aerospace

Recommendation #1: The integral role standards play in the design, manufacture, and support of aerospace products, makes global standards for aviation and space a critical resource for the aerospace industry. It is imperative that the US Aerospace Industry develop a vision and strategy for aerospace standardization that is shared among all stakeholders. Leaders from industry, government and standards developing organizations need to boldly advocate integrated processes and complementary infrastructures that will ensure that standards remain enablers for aerospace.

A standard is a set of characteristics or quantities that describes features of a product, process, service, interface or material.[1] Standards form the single largest source of technical data used in the design, build, and support of aerospace products. According to an extensive study done in 1987, 39% of all engineering data and 38% of all manufacturing data is derived from standards.[2] It takes thousands of standards to define an aerospace product and to control all the engineering and manufacturing processes used to build and support that product. Standards are what allow the parts used in an airplane to come from suppliers all over the world, meeting the same expectations of reliability, quality and safety. And when a military or commercial plane takes off in one part of the world, and lands in another, global industry standards are what ensure that the landing beacon was understood by the cockpit, the gateway ramp lined up with the airplane, and the mechanics and ground support crew serviced the plane in the same way, with the same parts, no matter where it landed.[3] Given how critical standards are to the production and safe operation of aerospace products and platforms, it's no wonder that the Commission on the Future of the United States Aerospace Industry in their final report stated that "*Global standards and regulations are critical to the efficient operation of the global aviation system and international markets*".[4]

Standards – Fundamental to Product Design and Production

Standards come into play from the very beginning of the design cycle until the end of a product's life and its ultimate disposal. Electronic data interchange standards allow design engineers to work in a collaborative environment and utilize 3-D models. Numerically controlled machines follow standard codes to cut and machine extrusions made from materials meeting specific standards for strength, corrosion resistance, and flexibility. These are installed using fasteners manufactured according to part standards and following standardized processes. Tools used to measure the torque applied to the fasteners are calibrated using standards. Suppliers of parts, materials, and subassemblies such as avionics, must meet performance specifications. Parts and processes are evaluated using non-destructive inspection and test specifications. And all manufacturing and production processes must be done in accordance with safety, quality and

environmental standards. All of these examples illustrate the influence and role different kinds of standards play in the design and manufacture of aerospace products. There isn't a single part, process, tool, or operation that isn't defined or governed in some measure by standards.

Most of the Aerospace Industry takes the role and benefits of standards for granted.

All Stakeholders Important in Aerospace Standardization

Government, industry, academia, and standards developing organizations all play important roles in defining, developing and using aerospace standards. The balance and acceptability of the standards depends on each segment having a part in the standardization process. And all of the stakeholders need to work together to deliver quality aerospace standards to support the future of the industry.

Use of standards not only makes sound economic and business sense from an OEM's perspective, their use is demanded by aerospace customers and regulatory agencies. For design and construction of commercial aircraft, the FAA demands that "the suitability and durability of materials used for parts...must...conform to approved specifications (such as industry or military specifications...). The methods of fabrication used must produce a consistently sound structure. ...the process must be performed under an approved process specification."[5] And the Departments of State, Commerce and Transportation negotiate international aviation agreements and regulations using aerospace standards.

Aerospace Standards Mission

- ***Interoperability & interconnectivity***
- ***Reliability, repeatability, quality***
- ***Safety and certification***
- ***Mechanism for change***

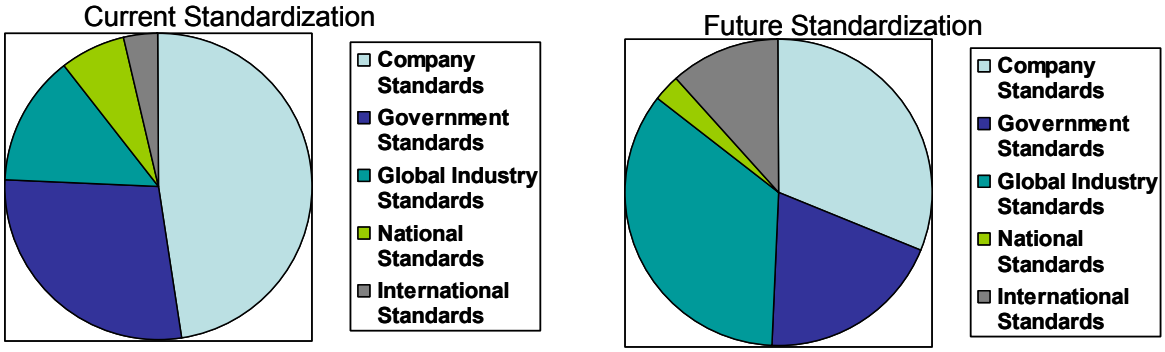
The World is Changing Rapidly

Just as there are many forces driving changes to the aerospace sector, there are changes facing the business of standards. Among these are the rise of consortia and other alternative models to the traditional voluntary consensus standards development process, new electronic tools to e-enable the development and distribution processes, emerging new technologies and the blending of existing technologies requiring new standards committees or alliances between existing bodies, and the rise of horizontal management system standards (such as ISO9000) which impact multiple functions and areas of the product design and operations life cycle.

Where once the majority of standards used in aerospace were company unique standards or Mil-Specs, global partnering and outsourcing, and the government's Mil-Spec Reform initiative which shifted the maintenance of many Mil-Specs to industry, have combined to increase the desire to move to more global industry standards. Additionally, more and more of the standards used are not aerospace unique. For example, Information Technology is taking the industry into

areas that are not the domain of aerospace alone. Where once, a good portion of the technology used to build our products was ours to control, we're now utilizing and incorporating technologies which are used far beyond the aerospace industry, and what's more, were not even originally intended for use by aerospace. Information technologies, and the standards used to define them, are shared by a broad range of industries and products. Company specifications are no longer always an option. Participation in IT standards developing organizations is the fastest growing area of aerospace standards work. Standards must be developed to ensure interoperability and interconnectivity. And moving outside aerospace dominated standards bodies means that aerospace personnel must be able to articulate aerospace unique requirements in such a way that non-aerospace standards developers will not only understand them, but also be willing to accommodate them.

In-flight entertainment systems are an example of an area where the aerospace industry is not leading the technology, but rather is trying to take advantage of all the innovations in personal entertainment equipment. But to do this, the industry has to drive some very special needs into the standards for these products and this technology. Personal DVDs, video games, rapid improvements in liquid crystal displays for small TVs are all happening outside of the aerospace industry, but these are technologies – and standards – which need to be incorporated and managed in the suite of aerospace technical information.



Global partnering and Mil-Spec Reform are changing where aerospace develops standards

Figure 1 – Current versus Future Standardization Trends

Understanding these changes is critical if the United States is to move forward with ensuring that aerospace standards remain vital enablers, helping guarantee the industry remains a strong component of the economic and cultural landscape. And looking ahead, the US aerospace industry's dependence on global standards will only continue to grow as the manufacture and operation of aerospace products becomes more and more a global activity. Military priorities include network centric operations and the blending of coalition forces. Civil priorities include more effective and efficient air traffic management, and global processes for certifying and maintaining new materials and systems. Space is poised for a new burst of expansion with new missions to the moon and Mars and increased commercial launches bringing payloads and launch vehicles from different nations together to place technology in space.

How the aerospace standards community addresses the standards needs of these priorities will significantly impact their cost, and ultimately, their success.

Paradigm Shifts in Standardization

Company Standards	→	**Industry & Partner Standards**
Technically Driven	→	**Business Driven**
Domestic Stakeholders	→	**Global Stakeholders**
Vertical (single issue)	→	**Horizontal (e.g., ISO9000)**
Paper-based	→	**E-business based**
Aerospace – unique	→	**Non-aerospace controlled**

A Domestic Approach is No Longer Enough

US Standards have traditionally dominated the landscape of civil, defense, and space standards because the US dominated the aerospace industry for such a long time. The high degree of circulation US standards enjoyed in the world market was a direct result of the large market share US aerospace products held. These include US Mil-Specs and industry standards developed by US-domiciled standards developing organizations such as AIA, ASTM, ASME, IEEE, SAE, etc. US standards were acknowledged as being particularly attractive for both users and producers because of their recognized technical excellence, and their use kept the overall number of standards down.[6]

But the standards landscape is changing. With the rise of a strong European aerospace industry and a vocal and deliberate standardization strategy on the part of the EU to promote European standards,[7] the leadership role US aerospace standards have enjoyed is shifting. European aerospace manufacturers believe that they have no ability to have their requirements taken into account during the development of what they see as "US aerospace standards" [8], and therefore are actively working to develop and in many cases duplicate already technically acceptable "US" standards.

Around the world, foreign competitors are aggressively implementing standardization policies and developing standards in order to diminish the role of what are perceived as US dominated standards. And both foreign governments and companies are investing significant funds in developing alternative standards and standards infrastructures to the traditional industry standards which have dominated the industry up till now. Fragmenting the standards landscape and duplicating parts and material standards decreases the benefits of having an industry standard and makes more difficult the end goal of having universally accepted and used standards.

A Vision for Aerospace Standards

If standards are to remain enablers for aerospace, what must be done to ensure this? What new standards or standards types need to be created? How will we link standards to the business needs of the industry? Are there new tools needed to allow us to seamlessly integrate standards data into the rest of our design and manufacture data? What's the best business model for the development and distribution of standards? Whatever the future holds for the aerospace industry, at its foundation must be the standards which define the products, processes, and

systems used to capture and convey all the technical data behind these advancements to whomever, wherever, and however they're needed.

The industry has not taken an in-depth strategic look at standards, nor does the industry have a collective vision and strategy for how to continuously improve the standards and standards systems used to support aerospace. The American National Standards Institute, working with all the different private and public sectors involved in US standards setting, has developed a National Standards Strategy [9]. However, the responsibility for tactical initiatives to implement this strategy belongs to each industry or market sector. The aerospace industry has taken no action to support, influence or implement this National Strategy which has been endorsed by such bodies as Congress, the Department of Defense, and the Department of Commerce.

The time is now to shape this vision, not because some outside agency says we should -- but because it represents a strategic investment in our economic and technological strength as an industry. And for this reason, the Future of Aerospace Standardization Working Group offers this vision:

Standards – Enablers for Aerospace's Future

Just as the President's Commission on the Future of the United States Aerospace Industry recommended the vision of "Anyone, Anything, Anywhere, Anytime" to guide the course for US global aerospace leadership, so, too, do we need a vision to ensure the tools will be there to enable this greater vision. If we want to see a bright future for aerospace, then this standards vision will:

- include all stakeholders, functioning in international cooperation to produce and use globally recognized, accepted and utilized standards
- produce and fund standards through business models in which all industry stakeholders have direct participation, fully support the process, and collectively own the product.
- result in global standards which are freely and easily integrated into the design/build/support processes, easily used in a collaborative design environment, and easily migrated throughout the supply chain.
- facilitate global conformity assessment and certification of aerospace products, platforms, systems, and operating environments.

Sustaining our Standards

Sustaining robust, responsive aerospace standards needs to be an industry priority. Today the aerospace industry is responding to many changes and drivers – from dealing with the war on terrorism to strengthening our global economical and technical leadership. Aerospace standards will play a critical role in the ability of our industry to respond to these imperatives.

Now is the time for the aerospace sector – government, industry, regulatory, and supporting standards developing organizations – to come together to address the standards needs required to support the future aerospace industry. Now is the time to collectively support and implement a standards vision and strategy. This vision will help prioritize and determine the standardization requirements and will help focus resources and energies. Successful leadership in aerospace will not be possible without the tools required to design, build, operate, maintain, and certify our products – and those tools are standards.

Conclusions

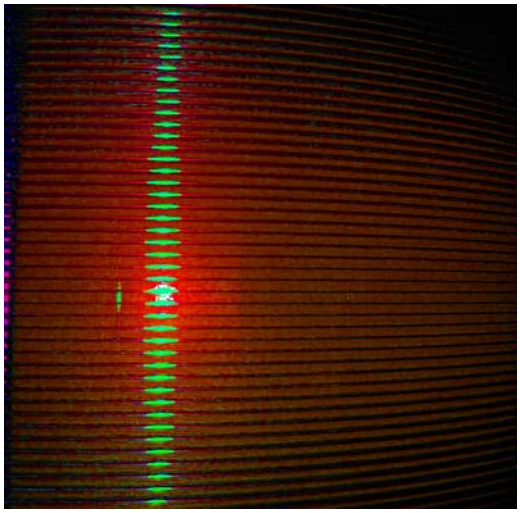
To achieve our vision for aerospace standards, the Working Group concludes that:

- The nation needs a national aerospace standards vision and strategy which supports the development and use of global aerospace standards.
- There needs to be an aerospace standardization integrator/advocacy body to facilitate the development and implementation of this vision and strategy.
- Government and industry need to recognize the critical role standards play as enablers for aerospace.
- Standards need to be developed through processes which serve, and are used by, the entire aerospace community.
- Standards, and the process used to develop them, need to continuously evolve to incorporate breakthroughs and enhancements in technology to ensure that the standards and the technical data contained therein can be captured, managed, disseminated and integrated into the design, build and support processes used by the aerospace industry and in ways which ensure that standards are an integral part of the e-enabled digital enterprise.

Recommendation #1: The integral role standards play in the design, manufacture, and support of aerospace products, makes global standards for aviation and space a critical resource for the aerospace industry. It is imperative that the US Aerospace Industry develop a vision and strategy for aerospace standardization that is shared among all stakeholders. Leaders from industry, government and standards developing organizations need to boldly advocate integrated processes and complementary infrastructures that will ensure that standards remain enablers for aerospace.

Chapter 2 –

Aerospace Standardization -- A Huge, Complex System



Recommendation #2: The aerospace industry needs to reduce the proliferation of standards wherever possible, with the goal of an industry library containing a single suite of globally accepted standards, tests and conformity assessment processes appropriate to the needs of the industry. Additionally, the industry needs to encourage the rationalization and reduction of the number of infrastructures needed to support aerospace standardization, focusing resources on processes and organizations which work to ensure efficient development of standards needed for aerospace.

Many Developers – Many Standards

The United States standards development infrastructure is crowded and complex. There are somewhere around 450 private sector standards developers in the US, with at least 150 more consortia. These organizations produce somewhere in excess of 250,000 standards. Additionally, there are between 50,000 and 100,000 more Federal Government standards produced by standards developers in just about every Cabinet Department or Agency. Many aerospace corporations also have standards departments that rival the largest private sector or government standards developers. Each of these standards developers has infrastructure that must be maintained and supported. Although no complete statistics exist on the total amount of money spent on standards development, an analysis of existing data done by the Working Group shows that the US spends an estimated $1.25B annually on all of these standards and their supporting staff, processes, and procedures. The bulk of this is contributed labor coming from the industry and government participants in standards development activities. Perhaps as many as 200,000 volunteers (~ 25,000 from the aerospace industry) participate in standards development activities – many participating in activities of more than one SDO. This represents a significant commitment of research and engineering resources – resources that most companies and government agencies say are in extremely short supply. ***This expenditure must be made wisely or it ends up being simply an expense instead of an investment.***

It takes a staggering 9 million parts to build the C-17 – and thousands of standards to define those parts.

Are we spending wisely? For the most part, standard development effort is not directed, usually not even influenced, in any sort of a top down strategy – by national need, by industry sector, by user group, by consumers, or by any other broad view. Standards development is largely based on needs asserted by individual participants, on a standard by standard basis, in a committee of an SDO, an office of government, or a corporate standards office. Further, even where a clear need is established, development of a standard to meet that need is dependent on volunteer effort.

Aerospace Industry Dependence on Standards

Of the more than 300,000 standards in the US, the aerospace industry is responsible for producing somewhere around 10%, but, according to Working Group estimates, the industry is responsible for using closer to 35% in the design, develop, build, operate, maintain, and dispose cycle of aerospace products. The aerospace industry, perhaps more than any other, governs its products life-cycles with standards. Nearly 40 % of all engineering and manufacturing data is standards based. Only a few industries can claim to be more tightly regulated by standards than can the aerospace industry. Developing the right standards and ensuring their technical accuracy, currency, and excellence is crucial to the health of the industry.

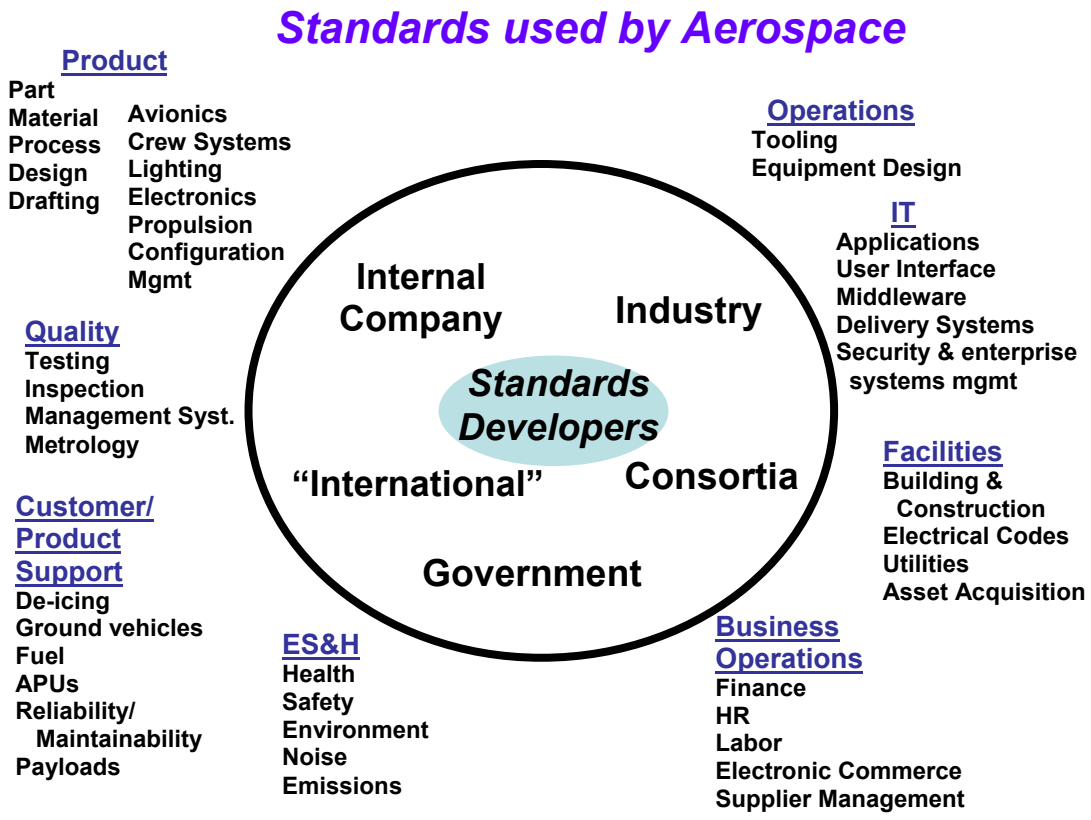


Figure 2 - Examples of the Breadth and Scope of Standards Used In the Aerospace Industry

Multiple Infrastructures and Overlapping Work

Hundreds of standards developing organizations (company, industry, national, regional, and international) are involved in the development of standards used by the aerospace industry. And for the most part, each of these hundreds of standards developers is free to define its scope of activities and the standards it undertakes. The result is a sometimes confusing landscape of overlapping scopes and often duplicative standards. But this is not the fault of the standard developers. In fact, it's to their credit that they remain willing to be responsive to the needs of their constituencies.

The truth is that few aerospace companies, let alone the industry as a whole, have taken the time to look at the entire landscape of standards activities with the intent to pro-actively manage where standards work gets done. For the most part new standards are begun in a particular venue by subject matter experts already participating in that organization. There is little effort made to determine the "best" place for a particular standard to be developed. Nor is there an easy way to quickly determine all the standards developers who have relevant technical committees, identify any relevant or duplicate existing standards, or even ascertain if there is similar work under development in multiple venues.

Each standards developer represents an infrastructure that must be maintained and nourished to enable it to continue to function. And each one of these organizations requires the time, effort and resources from the various stakeholder groups. An efficiently run company probably would never maintain five organizations to do its payroll. Such duplication of infrastructures doesn't make sense. Yet the same business oversight has yet to be applied to the standards world.

Table 1

Aerospace Standards by Key Standards Developing Societies

Presented at the1st International Aerospace Standardization Workshop, Montreal, Canada, 2003

	AIA	AIAA	ARINC	ASME	ASTM	DoD	EIA/GEIA	IEEE	IPC	ISO/IEC	SAE
						(45)					
Avionics			177			27	10	11			28
Bearings	51				2	97				44	89
Cargo Handling	1			87	2	13				36	61
Chemical	3				27	216					73
Composites	3				4	29					467
Computing Hdwr.						17	25	13			26
Configuration Mgmt					1	5	32	4			-
Couplings, Hoses & Tubing	136			49	13	396					1122
Data Management	2					56	2			13	-
Deicing	4					3				3	32
Drafting	6			28	1	19		2			-
Elastomers	1				6	41					187
Electrical/Electronics	155	1			2	2420	170	32	12	54	533
Environmental		1			2	14				3	81
Fabrics					11					2	-
Fasteners	2513			108	4	935				90	1079
Finishes	9				11	219					210
Fire Safety											-
Fluid Power Sys.	12					122				73	154
Fuels & Fuel Sys.	3			21	59	57					58
Ground Support Equipment	16					6				14	65
Human Factors		1			1	17	4	1			167
Information Mngmt.						22				51	-
Instrumentation	1					121				10	97

Landing Gear	3					12				6	81
Lighting	1					56					44
Lubricants	5				2	85					17
Mechanical Parts (clamps, rings, rods, knobs, etc.)	285					316					-
Metals	59				238	432				18	1351
Network/Web								10			-
Nondestructive Tests	5				27	26				9	30
Non-Metallic Materials					61	490					
Oxygen	1				1	36					65
Packaging	59			7	6	87					28
Printed Wiring Boards						24			56		-
Propulsion Systems		3			1	23				1	244
Quality	5					19		2		12	16
Safety	5					6					40
Sealants					11	71					51
Seats	2					2					7
Software Eng.		4				13	25	17		7	13
Space Vehicles		17			3					27	-
Systems Engineering						41	3	14			-
Testing & Metrology	71	2			525	94		8	18	22	15
Totals:	3,417	29	177	300	1,321	6,685	271	110	86	495	6,571

NOTE: Totals for AIA, AIAA, ARINC and SAE are total aerospace standards developed by the society
Totals for all others (because they are not aerospace unique standards developers) are those identified as being used by The Boeing Company

Functional Types of Standards & Percentage Used in Aerospace

While the distribution of types of standards can vary according to programs, platforms and processes, the average breakdown has been roughly estimated at the following:

Parts / Components	50%
Material & Process	20%
Quality	15%
Environmental, Health & Safety	3%
Test & Certification	7%
Tooling	3%
Business Operations & Facilities	2%

In addition to the thousands of standards used by aerospace, most of these standards reference other standards. A survey of approximately 5,000 company part standards showed an average of 8.7 standards references for military and industry standards. So standards are rarely stand-alone technical documents. Instead each standard is part of a larger web of technical information. Managing and ensuring that all references are still valid and current is a huge but critical task. The greater the number of standards, the larger the web of technical information which must be maintained.

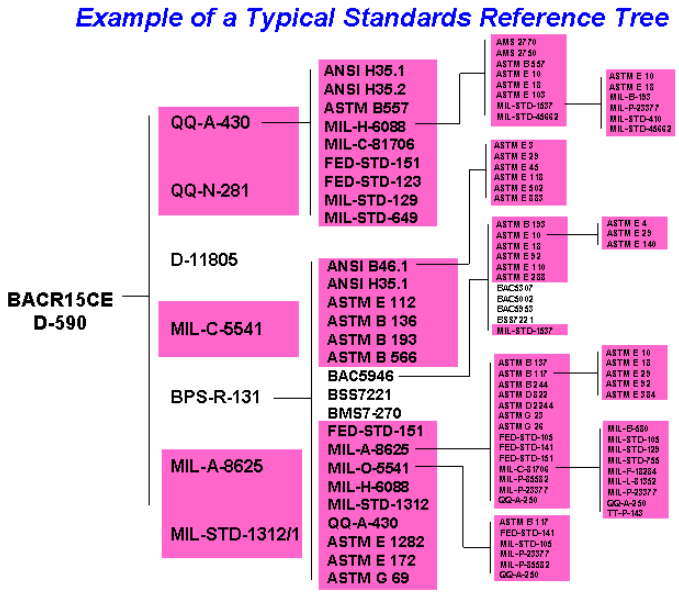


Figure 3 - Example of how a Boeing Part Standard is built on a foundation of industry and military standards

More Standards Not Necessarily Better

More standards do not mean better standardization. In fact numerous studies have been conducted on the value of rationalizing, harmonizing, and reducing the pool of standards available for new design. Over thirty years ago AIA attempted to define the costs associated with the addition of each new part to the pool of standard parts. In 1971 dollars, the estimate came to over $20,000, almost half of which was in the development and maintenance of the part standard.[10] Given inflation, it's almost certain that the cost is much higher. Development and maintenance of Qualified Parts Lists (QPLs) including testing and audits can add up to an additional $7,000 per part standard [11].

There will always be a need for new parts, materials and processes. That's part of innovation and continuous improvement. The real question is how many new standards are created due to inefficiencies in the standards system. How many standards are created when another suitable standard already exists? How many company standards are developed instead of using an existing industry standard?

Many aerospace companies have had internal programs to reduce the number of standards used to define their products. Airbus achieved a 38% reduction in the number of different standards used to define the A330 and A340 from the number used to define the A300 and A310 [12]. And Airbus has noted that the worldwide increase in demand for aircraft which operate globally calls for worldwide availability of low-priced spares. As a result, the share of standard parts and their repeated use in aircraft must be increased (and the number of unique parts reduced). To do this the subject of standardization and the control of the proliferation of standards must be given greater attention. And with the reduction in standards goes a reduction in the cost factors involved in the development and maintenance of these standards.

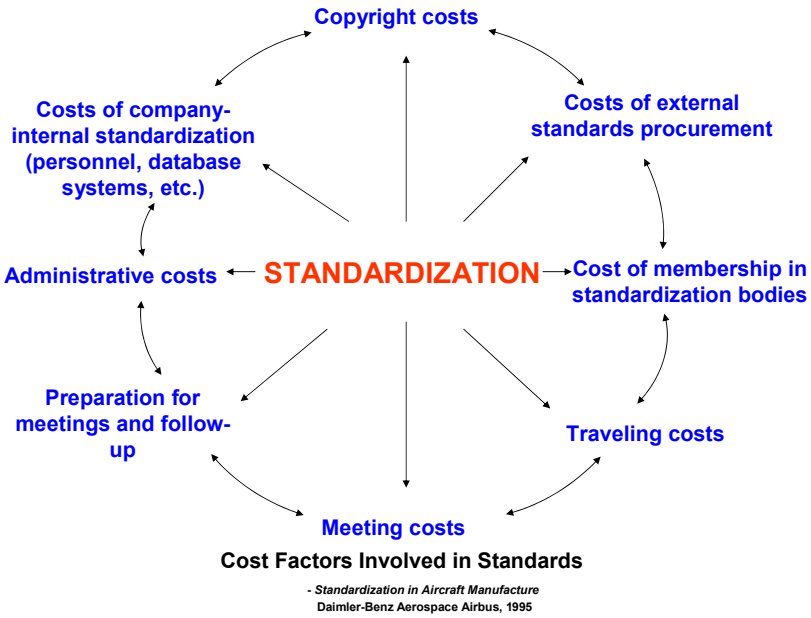


Figure 4 – Cost Factors Involved in Standards

The aerospace industry, as a whole, has done little to encourage or promote the harmonization and reduction in the number of standards. Part of the problems lies in the fact that it is very difficult to have full visibility of all the standards used by the industry either active or in work. The Future of Aerospace Standardization Working Group urges the industry to look for ways to provide users with a single source of standards information on what standards exist and what is under development to help avoid duplicative standards. Efforts should be made to avoid regional duplication and a push made to develop or harmonize around a single global standard. This greatly simplifies and reduces the time and cost involved in certification by multiple regulatory agencies.

The industry should also work closely with their key standards developing organizations to encourage clarification of the scopes and programs of work and to help concentrate similar types of standards within the fewest number of organizations to make the most of the resources and efforts involved in donating subject matter experts to the development activities. It is recommended that the industry first concentrate on those standards developing organizations that are solely devoted to aerospace standards, as we have the most influence there. Efforts to reduce standards proliferation can then extend to those organizations that have aerospace committees and then finally to organizations which develop standards used by multiple industries.

Aerospace Unique Standards program exclusively Aerospace	**AIA, AIAA, ARINC, ICAO, IATA, SAE Aerospace, FAA**
Aerospace Component Standards program has some subject committees devoted to aerospace content	**ASTM, IEEE, Mil-Specs**
Cross Industry Standards program produces content used by many industries	**ASME, AWS, ASHRAE**

Table 2 - Examples of Types of Standards Developing Organizations and Aerospace Influence

An Industry is Only as Good as it's Tools

The aerospace industry has spent vast resources over the last few years working to overhaul its manufacturing processes, introduce concepts such as lean manufacturing and engineering, and in trying to restructure management of its supply chains. Given that billions of dollars worth of parts, materials, sub-assemblies, processes, and tests are defined and governed by standards, it's surprising that little attention has been given to the strategic management of these critical documents or the processes and infrastructures used to develop and distribute them. As an industry we do a fairly good job of managing standards as individual technical documents, but not at taking a big picture view that looks across all standards types and all standards developers. There is great potential for large returns on investments in efficiencies and reductions in duplication, not to mention the cost savings in the areas of certification and test, through harmonization of standards and consolidation in the infrastructures used to develop and maintain these documents.

Conclusions

- The industry needs to take a big picture look at all the standards and infrastructures involved in the creation and maintenance of this critical technical data with the goal of reducing the number of redundant standards, preventing unwarranted proliferation, and consolidating the "standards supply chain".

- The industry needs a single source for visibility of all existing and in-work standards. Emphasis needs to be placed on achieving the goal of identifying a suite of universally accepted standards which contains little to no duplication.

- Pro-active strategic management of aerospace standardization activities is needed to ensure the most efficient and effective use of industry resources and talent. Every effort should be made to develop standards with organizations that offer the broadest inclusion of all stakeholders, the most cost effective processes, and the most easily accessible products.

Recommendation #2: The aerospace industry needs to reduce the proliferation of standards wherever possible, with the goal of an industry library containing a single suite of globally accepted standards, tests and conformity assessment processes appropriate to the needs of the industry. Additionally, the industry needs to encourage the rationalization and reduction of the number of infrastructures needed to support aerospace standardization, focusing resources on processes and organizations which work to ensure efficient development of standards needed for aerospace.

Chapter 3 –
Leadership

Recommendation #3: The industry needs to have a leadership organization positioned to provide both technical and business integration in standards issues and solutions. The leadership organization must be recognized as an integrator for the industry, respected as objective without conflict of interest, and acknowledged as having the support of both industry and government. The organization must be able and willing to use appropriate means to accomplish aerospace standardization objectives, including application of resources, enlistment of senior management, resolution of overlapping scopes between aerospace standards organizations, lobbying, etc.

Leadership?

If *management* is doing things right, and *leadership* is doing the right things, then we seem to have ample management, but little leadership in the area of aerospace standardization. There is plenty of management throughout the SDOs, the government standards developers and regulators, and the corporate standardization programs. The standards and their development are managed fairly well. Where there are instant shortfalls, they are known and are, for the most part, being addressed. What is lacking is industry-wide leadership for standardization.

Few top executives pay attention to the opportunities for market influence through standards. If they did, they would be insisting on a strategic approach to analysis of standards opportunities and needs, and a reasoned, strategic deployment of their standardization resources to influence those standards with the greatest opportunity to advance their company's or their nation's advantage. Such an approach would offer opportunities for improving the efficiency of many engineering activities in the design, build, operate, maintain, dispose cycle as well as providing a potential competitive edge in product development and marketing.

With hundreds of standards developing organizations, thousands of standards, millions of dollars spent on development and acquisition of these standards, and billions of dollars of impact, there is no one at the helm. Standardization priorities are established ad hoc based on what someone needs at the moment, or worse, based on the available technical skill in a standards committee rather than on industry need. Standardization decisions that may affect safety, corporate profitability, and US trade are often made by mid-level engineers and technicians with a wonderful appreciation of the "trees," but little or no appreciation for the "jungle."

No Unified Standardization Leadership

There is currently no unified aerospace leadership on standardization to function in an integrator/advocacy capacity. Aerospace standardization efforts are currently the work of multiple individual standards development organizations (SDOs). An aerospace standardization integrator/advocacy body is needed to 1) address industry standardization issues, opportunities, and challenges, and work with all stakeholders to prioritize and respond to standards issues critical to aerospace; 2) advocate standards as supporting open and fair international trade and work to ensure a level playing field for development of globally relevant standards (mitigating the efforts of countries to use domestic or regional standards to promote or gain competitive trade advantage); 3) represent a U.S. aerospace position in international forums; 4) promote aerospace standardization in appropriate venues; and 5) provide education, awareness and advocacy for aerospace standards with industry, government, consumers, and trade bodies.

The need for leadership is apparent. The importance of leadership is obvious. The position of leadership is vacant.

It takes Leadership to create and sustain the kind of strong partnership between all stakeholders (industry, government, standards developers, and academia) needed to enhance the development, delivery, management, and utilization of aerospace standards

Leadership for Standardization - The aerospace industry needs a forum where all the stakeholders can come together to address standardization issues. That doesn't mean that this forum will work or solve all issues, nor would it be a standards developing body. This would be a place where the industry could come together, articulate an issue, and determine the best plan for addressing the issue along with the best venues in which to undertake any standardization work. This would also be a place where industry could prioritize those standards issues critical to aerospace to ensure the proper focus and attention by senior leaders. This would be the body to facilitate the creation of a US Aerospace Standardization Strategy and to ensure that this strategy supports the National Standards Strategy developed by the ANSI federation and integrates with other national and international standards strategies.

Leadership for Global Standards - There is currently no single aerospace organization actively promoting the development of globally relevant standards in a manner that recognizes first and foremost the technical suitability and market relevance of a standard. The aerospace industry needs a body to be the lead advocate for standards as tools supporting open and fair international trade and which works to ensure a level playing field for the development of globally relevant standards (mitigating the efforts of countries to use domestic or regional standards to promote or gain competitive trade advantage). This leadership body would support and advocate the World Trade Organization's definition of the criteria for developers of international (global) standards and ensure that aerospace standards developed by US domiciled international standards developers (e.g., SAE International, ASTM International, IEEE), and global aerospace organizations such as the International Aerospace Quality Group (IAQG) and the International Civil Aviations Organization (ICAO), are not disadvantaged by any claims that only ISO, IEC, and ITU standards are "international" standards.

Leadership for the US – The aerospace industry needs a single body which can involve all stakeholders to pull together a US position and take that position into international fora. This body would provide a unified voice for the US industry when dealing with standards issues involving regional bodies such as the EU.

Leadership for an Optimized Standards System – The aerospace industry needs a forum where the industry stakeholders come together to set requirements for improvements and enhancements to aerospace standards and the standardization processes. This would provide the industry a single voice back to the standards developing organizations rather than leaving individual and single companies to define requirements which carry little weight without the rest of the industry behind them. This forum would also be a place where the industry could come together to help rationalize the standards system, help avoid duplicative committee scopes and standards, and to reduce unnecessary proliferation of standards. There needs to be a single focal point to provide visibility on all the organizations, committees, and standards supporting aerospace. An aerospace standardization body is needed to assemble the complete index of active and in-work standards to help prevent new standardization efforts being started for subjects where current standards are already in place or being developed elsewhere.

Leadership for Education, Awareness and Advocacy – There needs to be an aerospace standardization body which helps to articulate and promote the value and benefits of standards to the industry. This body would collect case studies and develop educational materials which would communicate the impacts of standards to senior leadership and which would provide skills and knowledge necessary for those participating in the development, maintenance, distribution and use of standards. This body would utilize a wide variety of venues and media to advocate standards, raise the awareness of the benefits of standardization, and advocate policies necessary to ensure the appropriate level of industry support for standards.

"It has been said that learning to be a standards engineer is akin to repairing the exterior of an airplane wing while in flight. Both activities are exciting and well above the crowd. "

--Alan Batik
The Engineering Standard – A Most Useful Tool

Conclusions

- Standards represent a significant investment on the part of the aerospace industry. There needs to be an integration function which can facilitate the prioritization and focusing of industry standardization efforts and the development of industry-wide solutions. The industry needs a forum to come together to focus on ways to rationalize the standards system, help avoid duplicative committee scopes and standards, and to reduce unnecessary proliferation of standards.

- Without effective leadership in aerospace standardization, an ever increasing percentage of the technical data that supports our industry will be developed in venues controlled by foreign aerospace industry. Those standards will, intentionally or by serendipity of familiarity, favor foreign manufacturers. Therefore, they will impact not only the prime system integrators, but will ripple through the entire supply chain that supports the aerospace industry.

- There needs to be a single forum where the stakeholders in the US aerospace industry can come together for energetic, collaborative engagement and effective communication. Without such a forum, the industry will be unable to make the kinds of strategic and business decisions needed to ensure a cost effective and efficient standards system.

Recommendation #3: The industry needs to have a leadership organization positioned to provide both technical and business integration in standards issues and solutions. The leadership organization must be recognized as an integrator for the industry, respected as objective without conflict of interest, and acknowledged as having the support of both industry and government. The organization must be able and willing to use appropriate means to accomplish aerospace standardization objectives, including application of resources, enlistment of senior management, resolution of overlapping scopes between aerospace standards organizations, lobbying, etc.

Chapter 4
Global Markets – Global Standards

Recommendation #4: The Standards of choice for the global aerospace industry must be recognized internationally without bias towards the process for development or for the label of the developing organization. Where applicable, those standards need to be made the basis for national, foreign, regional, and international regulation and law. Global standards should be open for input from all stakeholders in the industry in accordance with standards development principles set forth by the World Trade Organization.

> **"Strong and effective U.S. leadership and participation in international standards organizations are key to the long-term competitiveness of U.S. products in global markets."**
>
> ***--U.S. Congress***
> ***National Competitiveness Act of 1993***

Standards Support Global Trade and Global Partnering

Over 80% of all trade is directly impacted by standards.[13] The majority of commercial jetliners built are sold to customers outside of the country where they were manufactured and aerospace products orbit the earth and fly across the skies 24 hours a day. Aerospace customers, design partners, and suppliers come from all over the world. The industry's focus today is global rather than just local, regional, or national. So, more than ever, standards are vital to facilitating global trade. Standards can open new markets, reduce trade barriers, and assure aerospace customers consistent quality, interchangeability and maintainability.

Global standards form a common language that allows us to integrate our products and services more effectively into international markets. They are the common technical language that ensures that the requirements necessary for the design, build, and support of aerospace products is done in a consistent, quality manner where ever it happens in the world. They help define new emerging technologies, establish widely accepted requirements, set criteria for international quality assessment systems, and meet a fundamental need as the international language of trade. Development of global standards in forums such as the International Civil Aviation Organization

(ICAO), ARINC, and standards organizations such as the Society of Automotive Engineers International (SAE), ASTM International, and the Institute of Electrical and Electronic Engineers (IEEE), are critical to providing a competitive advantage for US aerospace companies.[14] And the more widely a standard is used, the more valuable it becomes to the aerospace industry. Communication, compatibility, economies of scale, and other benefits of standards all increase as those standards become globally recognized, accepted and used.

The European Union has acknowledged that a strong standardization system is key to the functioning of the EU market, the protection of health and safety, the competitiveness of industry, and the promotion of international trade.[15] And while standards can support global trade, the EU also recognizes that standards can enhance domestic competitiveness and has set forth an aggressive standardization policy. The International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) are two of the most widely recognized standards developing organizations which seek to develop standards for international use. Because they are organized around the "one nation, one vote" policy, Europe is actively promoting these organizations as the only developers of "true" international standards. However, the aerospace industry is unique from other industry sectors in that we have the long-standing precedence of using ICAO, ARINC, the International Air Transport Association (IATA), and other standards organizations such as SAE, IEEE, and ASTM, to develop global or "international" standards. Most of these bodies provide the aerospace participants with the more level playing field of direct industry participation. The aerospace industry needs to protect their ability to develop global industry standards in those forums which best serve industry's needs.

Global Standards Best for Key Areas

Global standards on safety are necessary to support the free trade of aerospace products. The aerospace industry needs to advocate for global standards for safety certification as a way to prevent the use of safety certification by some governments to enhance their domestic competitiveness.[16] And global standards are essential to the creation and operation of systems-of-systems solutions to such aerospace challenges at satellite navigation, a modernized Air Traffic Management system, and network centric warfare.

Environmental considerations are becoming increasingly important and will play a growing role in certification, trade, and regulatory policy. The EU has pointed out that standards have a high potential to support sustainable development, comprising economic, social and environmental aspects. The EU Commission has listed standards as one of the tools for establishing the framework for the continuous environmental improvement of products throughout their whole life-cycle. The US is now in a position of playing catch-up as Europe has taken a strong position in the **Commission's Communication on the "Integration of Environmental Aspects into Standardization"** urging stakeholders to integrate environmental protection into standardization.[17]

Aerospace Standards Serve a Global Customer Base

The aerospace industry's customer base and supply chain spans the globe. Standards are what communicate the technical requirements needed to define the design, manufacture and support of aerospace products and they enable the interoperability of systems throughout the world. Yet, there is no single national or international body that provides a common focal point for

government, industry, and academia to address aerospace standardization issues (as opposed to just the development of technical documents) and ensure that there exists a robust set of global standards. An aerospace vision is needed to direct aerospace standards efforts in support of global trade. Speaking for the US aerospace industry, the President's Commission on the Future of the US Aerospace Industry concluded in their 2002 report that while the nation's defense industrial base is strong today, the nation is at risk in the future if the United States continues to proceed without a policy that supports essential aerospace capabilities.[18] Aerospace standards are an integral element of not only national, but global aerospace capabilities and must also be defined as a priority in supporting a strong industry. Leadership in aerospace technology and products will require corresponding leadership in aerospace standards.

The World Trade Organization and Standards

The World Trade Organization has long recognized the role standards play in facilitating the global economy. And in fact, the WTO has developed a set of criteria for what constitutes an "international standards developing organization". These are based on ensuring that due process is followed with regards to issues such as:

- Openness – all stakeholders have the opportunity to participate
- Transparency – all work is visible to and accessible by stakeholders
- Impartiality and Consensus – All Comments are attempted to be reconciled and all processes conducted with impartiality towards the participants

The aerospace industry needs to work with the global community to help dispel the misconception that international standards are only those coming from ISO, IEC, and ITU. The aerospace industry has its own "international" organizations such as ICAO and IATA. Additionally, we rely heavily on industry standards developed by such organizations as SAE International, IEEE, and ASTM International. Such industry organizations as these, while domiciled in the US, meet all the criteria established by the WTO for a developer of international standards. The industry needs to confront the obstacles of culture, distance, regionalism and historic perception of industry standards developers based on where they are domiciled. The focus should be placed on working with all stakeholders to develop the most technically accurate and relevant standards, wherever it best makes sense, as long as the developer meets the WTO criteria.

"Global Standards" not just "International Standards"

The aerospace industry needs to rise above the arguments of what constitutes an "international" standard, and focus instead on the idea of Global Standards. A global standard is one that is:

- Globally recognized – all stakeholders around the world acknowledge its technical accuracy and relevance
- Globally accepted – regulatory agencies and customers around the world recognize the standard as meeting the applicable requirements
- Globally used – all stakeholders use the standard

The aerospace industry needs to ensure that it maintains the right to determine which standards meet the global needs of the industry in the face of strong EU and other regional standards politics which would push CEN, CENELEC, or ISO over a standard developed by a US domiciled global standards developer. The Aerospace Industries Association, in conjunction

with key aerospace standards developers such as SAE, ASTM, ASME, IEEE, etc., needs to work with ANSI, the US Dept. of Commerce and the US Trade Representative to ensure that foreign legislature does not unfairly state a preference or order of precedence for standards which would result in a barrier to trade.

A global aerospace industry needs to have standards that are not dominated by the US, Europe, Japan, or any other regional or political entity. The industry needs to have standards that are dominated by technical excellence and market relevance. In greater proportion than ever before, the standards used in aerospace are not unique to aerospace. Technically excellent, market relevant standards come from many developers, many nations, and many market and technology sectors. These standards are, and must continue to be the technical documentation of first choice for our engineers, designers, maintainers and operators.

Conclusions

- The aerospace industry needs to work with world governments, regulatory agencies, the US Department of Commerce, the US Trade Representative, and the standards developing community to ensure that global industry standards are chosen based on the merits of meeting technical and market needs, not based on which organization developed them.

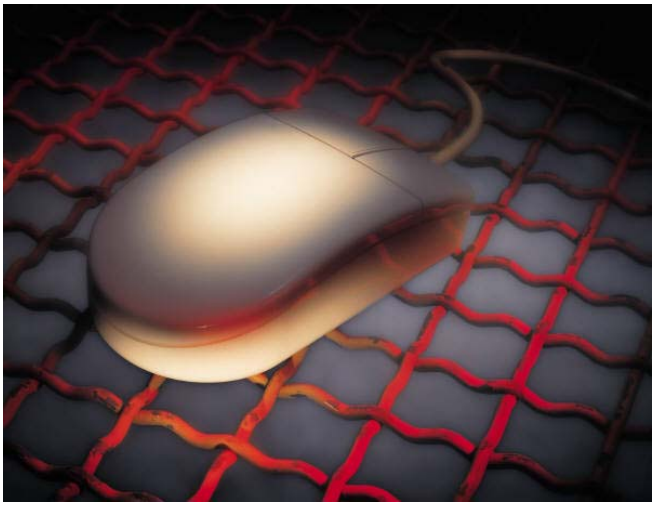
- The more universally used a standard is, the better the return on investment. The use of globally recognized and accepted standards means the cost of development and maintenance is spread across a larger portion of the industry, there are usually more suppliers which can lower costs, and expenses involved in certification can be reduced.

- The global nature of the aerospace industry, with its world-wide supply chain and customers, demands global standards. The aerospace industry should strive to develop standards with those organizations that offer all stakeholders the opportunity to participate. The industry should also encourage that access to global standards be easy and efficient for all users.

Recommendation #4: The Standards of choice for the global aerospace industry must be recognized internationally without bias towards the process for development or for the label of the developing organization. Where applicable, those standards need to be made the basis for national, foreign, regional, and international regulation and law. Global standards should be open for input from all stakeholders in the industry in accordance with standards development principles set forth by the World Trade Organization.

Chapter 5

The Business of Standards -- New Models, New tools



Recommendation #5: The business models and tools used for the development, distribution, integration and use of aerospace standards need to ensure that:

- **standards development is responsive to business drivers and is based on a business case or market need**
- **the standardization process is adequately funded and supported**
- **tools and processes used to develop, maintain, and disseminate standards make the best use of technology and the internet to ensure an efficient, effective system involving all the stakeholders**
- **standards are developed and disseminated in such a way that the data can easily be integrated into product definition data or other life-cycle data streams, and that the tools and the processes are not hampered by data formats or IP issues**

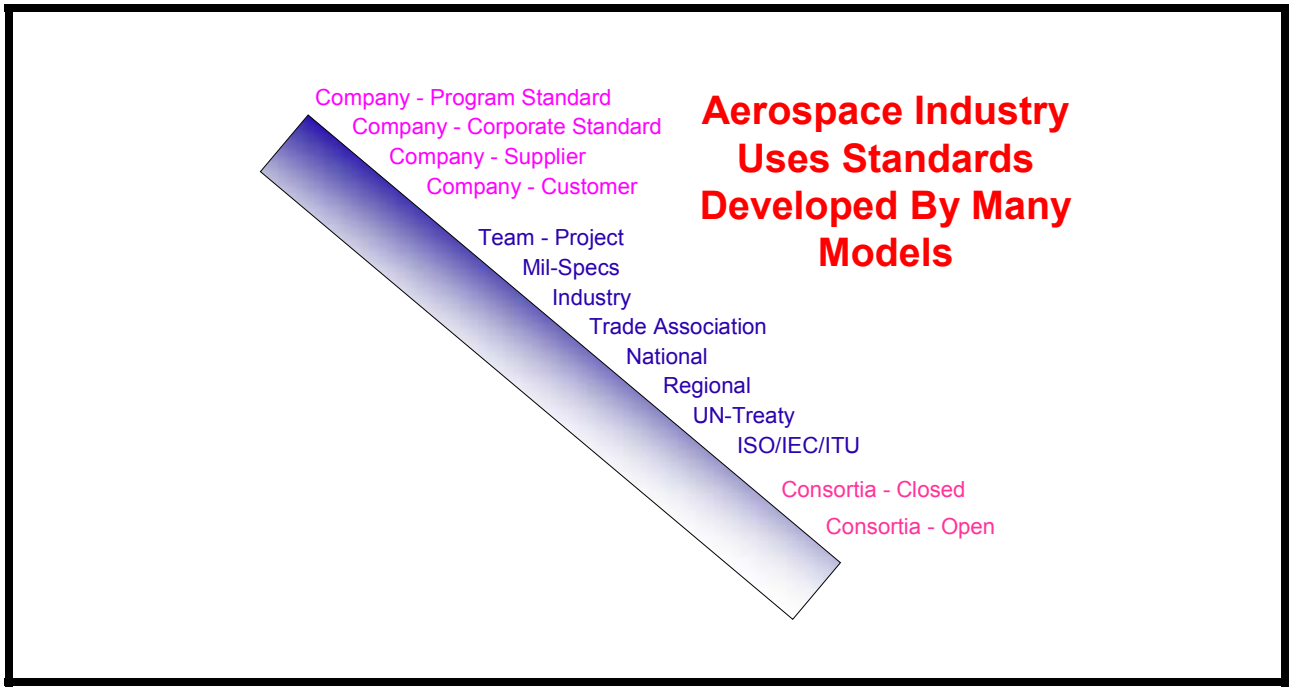


Figure 5 – Aerospace Standards Development Models

Different Models – Same Key Criteria

The aerospace industry uses standards developed in a wide variety of venues utilizing many different business models. Business model refers to the elements of membership (who can participate), consensus building (who can vote and how balloting takes place), funding (how the standardization process is paid for), product (the final format of the resulting standard), distribution (how the standards are distributed or accessed), and ownership of IP (who retains the copyright for the resulting standard).

But regardless of which business model is used by aerospace, the critical components are that the standards are:

- Technically accurate
- Current
- Suitable for their intended use
- Configuration managed
- Accepted by Regulatory Agencies and Customers

Making Business Decisions Regarding Standards Development

Standards are all too often thought of as just documents containing technical requirements, with little thought given to the "business" of their development and maintenance. But as was discussed in Chapter 2, there are many different standards developing organizations and different models for standardization. If an aerospace company approached the development of standards with the same mindset as other corporate activities, then it would apply the same business decision criteria to standards as it does to other business decisions:

- Cost (participation, travel, purchase)
- Control (ability to influence)
- Flow Time (development time)
- Time to Market (time to publish)
- Market Relevance (clear business case for standardization)
- Market acceptance (global relevance)
- Dynamic nature of the subject (evolving vs. basic & stable)
- Maintainability (processes allow for rapid updates in a configuration managed way)
- Ease of Use (process used to create standards are easy and accessible to all stakeholders and resulting standards are easily accessible and in a value-added format)
- Global (involves the global stakeholders and contains global requirements, supporting global platforms and global customers)
- Access to customers, suppliers, competitors
- E-enabled (supports e-business -- the ability to integrate, migrate & collaborate using the technical data from the standard)
- ROI (benefits of using an industry standard vs. costs to develop and/or acquire the industry standard or vs. the cost to develop the standard internally)

If an aerospace company, or the industry as a whole, applied the above criteria to the decision of which organization to engage for the development of a new standard, a set of "preferred

standards suppliers" would emerge. The industry would naturally tend to prefer organizations with minimal participation fees, a strong aerospace focus and ability for direct industry input, and which provided the resulting standards in such a way that they were easily integrated into the rest of the engineering product data.

Applying Business Drivers to Standards Development Means…

- New standards work will be placed in the venue which can deliver a standard which meets the core requirements and best addresses the business drivers
- Pressure will increase for all standards venues to examine their processes and make changes to be responsive to the business drivers impacting their constituencies
- Venues which allow participation from all global stakeholders will be preferred
- Standards themselves will be in a form and format that allows users to access the technical data within in a manner that best facilitates the integration of standards data with other design and manufacture data
- Standards will not be developed without a clear understanding of the business drivers and market relevance for the standardization activity

Funding the Aerospace Standards Infrastructure

Standards are not free. No matter where, how, or by whom they are developed, resources are consumed in the development, coordination, approval, publication, maintenance, indexing, interpretation, appeals, administration, and management. Each organization responsible for each element of the standards life cycle supports the operation in some way. The business models are many and varied. For company standards, the individual company bears all the costs of standards development, maintenance and distribution. In the case of Mil-Specs, it's your tax dollars at work. And for standards developed by private sector or industry standards developers, three broad mechanisms are used to pay for the infrastructure: document sales; participation fees; and membership fees. Most organizations use a combination of these mechanisms to form a business model that allows them to pay for all of the processes and infrastructure costs for the standardization life cycle.

The standards developed by an SDO are typically copyrighted and sold to users. The sales take place in many different ways, from the straight retail sale of a single paper document to an individual user, to corporate-wide access to on-line libraries of standards from multiple developers through a third party provider. Though the business arrangements for these are very different, the model is still the same – cash for access to copyright protected intellectual property. Various organizations depend to dramatically different degrees on the sale of documents. They range from close to 90% of revenue coming from document sales, to a low of zero. The bottom line is not the fact that standards cost – all elements of the infrastructure needed to design, build and support aerospace products cost money. The real issue is whether or not the standards developer and the model used is the most efficient, and cost effective for the price.

Expense to Acquire Standards vs Investment to Use

Standards are tools that must be paid for in order to reap the benefits of their use. Because the standards infrastructure is mostly paid for by the sale of standards, this tends to draw a lot of focus on the "acquisition costs". However this focus ignores the benefits reaped by using

industry standards. These benefits can mean reductions in procurement, manufacturing, certification and conformity assessment costs, which can so far outweigh the cost of the standards themselves as to make their price negligible. And focus on the costs to acquire industry standards also tends to ignore what it would cost to develop the same standard in-house and the impact that would have on procurement, manufacturing, certification, etc. If standardization is not paid for by buying the product, then it must be paid for by buying the process.

The companies that support standards development really serve as technical consultants, and in doing so, donate intellectual property to the resulting standard. In fact, most standards developing organizations execute some form of release form for committee participants. This transfer of intellectual property is a key enabler of the aerospace standardization process, and a main reason why the aerospace standardization system represents a very large knowledge and experience base containing the essence of the aerospace industry intellectual capital accumulated over the last 70 years. And this donation of intellectual content is how a company can ensure that their technical requirements are contained in a standard and vetted through the process of industry-wide review. If the business case for donating technical content is not there, then the company should seek other ways of documenting these requirements in company data systems. Otherwise, the cost recouped by the standards developing organization for managing the standardization process is far outweighed by the standardization benefits to the industry and those participants in the process.

Tools for Standards – Development and Delivery Tools Must Support Current and Emerging Industry Trends

Any consideration of tools and applications depends on an overview of the landscape and environment in which the tools are used. Aerospace, and in fact all industrial sectors, is in the middle of an information handling revolution probably as significant to the culture as that caused by the advent of movable type back in the 1400's. This has contributed to traumatic changes in the way the industry functions, and even what it looks like. The aerospace industry's use of emerging information management and e-business tools for the development, distribution, and integration of standards is caught in the process of playing catch-up to other parts of the business which have more rapidly embraced evolving technologies (e.g., 3D CAD CAM, on-line parts buying, network centric design environments, etc.).

Aerospace OEM's are moving more towards being large-scale integrators with significant portions of the design and production processes being pushed out into the manufacturing supply chain – partners, contracting firms, or long-term suppliers. There is an increasing emphasis towards customer driven design and delivery, with much more design flexibility, speed, and agility and a convergence of sectors such as information technology, telecommunications, and aerospace. The industry is under severe demand for cost, quality and speed. And coupled with the decentralization of functions, collapsing design cycle times and inter-company manufacturing costs, the need for greater collaboration within and between companies is clear. The future demands that companies be able to exchange all types of information with all their suppliers, partners and customers instantaneously – data integration at all levels.

Standards are a part of this information exchange. The significance of standards information flow and integration of into business processes is clear. OEMs routinely need to share standards

information as a part of product designs and order schedules with suppliers, and they expect reciprocal information as well. As more and more external linkages with customers, suppliers, and partners evolve, these linkages become more complex. But the absolute requirement for reliable standards data exchange remains. Standards facilitate these linkages by conveying information needed on a product's functional compliance, safety and suitability. Standards facilitate understanding between buyers and sellers, or between suppliers and customers, and make possible mutually beneficial commercial transactions.

Given the changes impacting the aerospace industry (global outsourcing and partnering, the use of intranets and the internet to e-enable business, simulation and 3D modeling, and integrated product data streams), how the industry develops, distributes and integrates standards data is becoming increasingly critical. With standards forming the single largest source of technical data, not having optimized products and processes for conveying that data will fast become a restriction on the design and manufacture of aerospace products. Having discussed some of the changes of recent years, it can be seen that any standardization tool suite of the future will be operating in an environment characterized by:

- Geographically and politically distributed industry players
- Emerging OEM role of integrator – developing, distributing product interface requirements
- E-business processes prevalent– collaborative standards development, collaborative authoring/editing/distribution, standards information used as digital data
- The industry focused and aligned to manage standardization priorities using, among other tools, a tracking "database" to inventory emerging standardization actions and trends in the industry
- Collaborative management of the aerospace standardization and knowledge base by industry players

Development Demands

The current environment for developing and using standards is one that seeks shorter cycle times for each step of the development and approval process. The push is toward a shorter time to market (i.e., to the end user) from validation of the need for a document until the approved standard is available for use. The current system has many built-in safeguards that tend to be a drag on rapid response to industry needs. Part of the explanation for this is that the aerospace standards systems tend to be either paper based, or at best, automation of paper based systems. As standards developers have moved into electronic development, establishment of consensus, and publication, they have generally not re-engineered the processes, but have rather tweaked existing processes to make them suitable for automation. There is increasing demand for:

- ✓ Development of standards in formats that are electronically user friendly (platform independent, capable of common editing and "comment" tasks, built-in formatting tools);
- ✓ visibility of and access to standards projects throughout the development cycle (from identification of a new project through final balloting, approval and release);

- ✓ conduct of meetings with at least the capability for electronic (as opposed to "warm-body") participation and in ways that will facilitate global participation;
- ✓ coordination of drafts and establishment of consensus in a real-time, on-line, world-wide electronic way;
- ✓ publication in rapidly available, easy to use, non-restrictive forms; and
- ✓ configuration management of standards and standards data so that all released data is always available throughout the life-cycle of a product (50+ years)

A snapshot of major OEM's, Government entities and SDO's paints a picture of the level of tool integration within standardization functions in the Aerospace Industry today.

Table 3 - A summary of generic tools of Standardization today

	Creates internal standards	**Top Source SDO's**	**Authoring Tools for Company Standards**	**Config Mgmt Tools for Company Standards**	**Internal Distribution / Delivery Tools**	**External Distribution Tools (suppliers/ partners)**	**Use of Data**	**Remark**
OEM 1	Matl's, Processes, Parts	SAE, AIA, DoD, ASTM, ASME	Word processing	Manual update Digital workflow, Web workflow	Web	Web/Manual	Manual	
OEM 2	Matl's, Processes	SAE, AIA, DoD, ASTM, ASME	Word processing Web interactive	Manual update Web Workflow	Web	Web/Manual	Manual	
OEM 3	Parts, Material, Process, Design, Drafting, Tooling, Manufacturing, Testing, Quality, Computing, etc.	SAE, AIA, DoD, ASTM, IEEE, ASME, EIA, ARINC, IPC,	Interleaf and Word for text, AutoCAD for graphics	RDM Interleaf tool Manual update, web workflow	Web	Web/LAN/ Manual	Manual/ Pilot program for digital standards data	
OEM 4	Matl's, Processes Parts	DOD, SAE, AIA, ASTM, ASME	Word processing Web interactive	Manual update and Web workflow	Web	Web 95% Manual 5%	Manual	
Govt Agency	Mat'ls, parts, processes, qual, software, IT, human factors, etc	SAE, ASTM, AIA, IEEE, ASME	Word processing w/email coord	Between a & b – we have an online project system, but input is manual	Web	Web	Some combo of all the ways noted, but mostly manual	Web access is free, includes auto alert for new stuff, includes scopes and historical family
SDO 1	Matl's, Processes, Parts	ASTM DOD	Word processing	Manual update Web workflow	Web	Web / Manual	CD Manual	
SDO 2	Parts	DOD	Word processing	Manual update web workflow	Web	Web/Manual	Manual	

Authoring Tools

The predominant methodology currently used in the industry to create standards is "document format based" word processing. Reflecting the onset of high levels of enterprise integration, the industry needs to move forward to fully interactive Web-enabled authoring so that technical content owners can, without advanced software skills, edit and ballot a standard in near real time. Authoring tools should take advantage of web formatting (html or xml) and web sharing, avoiding the "markup-circulate-review-update" document-based paradigm. Such tools should be platform independent and should easily accommodate the global community.

For example, across the industry, strategic identification of standardization needs is fragmented. Some SDO's have a documented, robust process for managing the strategic direction of standardization, including approval and review systems based on business cases, and cataloguing and capture of proposed and actual standardization work items with visibility to the organization management level. Other SDO's clearly do not have a process for this strategic standardization management. Work items are proposed and initiated within these SDO's at the committee level, and progressed as a result of discussion at the technical committee level – leaving little or no opportunity for review and comparison with objectives of the organization. In progress work items are only informally tracked, if at all, and visibility at the SDO management level only appears at the draft standard review and approval event. Practices across the industry appear to be widely distributed between these extremes. Often an integrated industry position on standardization policy, or a set of standardization actions, is sorely missed. Sharing of best practices across the industry would potentially benefit all.

Configuration Management Tools

Configuration management of technical data is critical to the aerospace industry. For standards it means strictly managing the different versions of a document (electronic or paper) so that no data is ever lost and an unbroken data trail exists between the first and the most recent version. The industry needs to convey to its major standards developing organizations the need to ensure that once released as an approved voluntary consensus standard, that any subsequent changes to that document result in a change to the revision indicators. No standard should change their numerical indicator (part of the title) without a clear reference back to the original standard number.

The aerospace industry needs to work with standards developing organizations and standards distributors to develop a common understanding and use of terms related to active and inactive standards. Having different definitions for "cancelled", "obsolete", "inactive", "inactive for new design", etc., is not only confusing, but can cause costly errors through misapplication of the standard. And because aerospace products can have a life-cycle of over 50 years, no standard used by the industry should ever disappear from the inventory or indexes of standards developers or third party vendors.

Delivery/Distribution Tools

Again, it is not surprising to see universal alignment in the industry around the World Wide Web as a distribution tool internally or externally. The predominant mode to flow information to suppliers and partners is a combination of manual delivery of documents, combined with internal Intranet distribution, and for external suppliers some version of a supplier "portal" web site availability. However, the delivery tools of today are primarily geared to delivering documents to an engineering desk-top environment. This ignores the fact that a whole host of new forms of electronic media are being used in aerospace, especially in the manufacturing, maintenance and operational environments. Delivery mechanisms need to take into account all forms of electronic media: hand-helds, PDAs, wireless devices, tablets, laptops, CAD-CAM systems, as well as the engineering desktop design environment.

Standards as Data

The most dramatic finding regarding standards today concerns how the data is used in the industry. The fact that the overwhelming predominance of standards data is still interpreted in document form seems to substantiate the fact that great strides have been made in exchanging and communicating bits and bytes between customers, suppliers and partners. But little progress has been made in using those bits in bytes in a way that can be integrated with other functionally related data, regardless of source, without some form of human interaction in capturing and recreating the data in a series of intermediate steps.

Data integration requires interactive data. Standards data needs to be stored, managed, and delivered as data sets instead of "documents". Users create the view they need from a common data stream. Customized portals provide secure access to critical data. And standards stored as data elements can feed other computer applications such as NC controlled machines, design tools, simulations, etc., as well as human users.

To establish this collaborative infrastructure, we will need to "standardize" our digital data exchange schema, in a way that is independent of infrastructure, or we will have to have compatible infrastructures. Without that, no progress can be made. A package of digital standards information from any SDO must be in a consistent format so that users can acquire and use it via a single consistent infrastructure in their enterprise.

The industry must develop an agreed schema for the digital exchange of standards data – enumerating what the data elements of the various standards type are, and then the formats for each, content for each, etc. This schema must be platform independent

Standards Data Integration and Migration Down the Supply Chain

The increased use of computers in engineering and manufacturing offers opportunities for great advances in cost, quality and speed of the design, development, and production processes. As large scale enterprise integration and convergence occurs in our industry, the capability of our IT systems to integrate all product data will be strategic. The integration facility of the IT tools will become a key enabler. To fully realize these benefits, however, the development and enforced use of another class of standardization is required. This new standardization will deal with the form, structure, and substantive content of the data that must be passed between computing processes during the product design-build cycle. Such standardization will allow the use of

common data for manufacturing planning, purchasing, tooling, inspections, configuration control, and inventory control. It will also allow the development of numerical control data for machine tools and robotic equipment independent of where the data were generated. If one company offloads the manufacture of a part to another, the receiving organization will be able to use the data without tedious conversion.

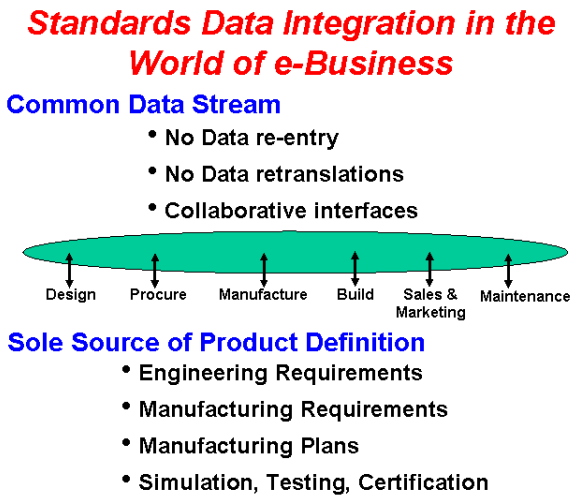


Figure 6 – Standards Data Integration in the World of e-Business

So as aerospace OEM's have turned to extremely complex, costly and critical data systems, one of the most significant issues for the industry is the overarching goal of seamless data exchange, including standards data. Even at our largest most technically advanced enterprises in the industry, manual data entry and re-packaging for transfer to other data systems is prevalent – with the attendant sacrifices to cost, quality and speed of the process for bringing a product to market and supporting it. Against this backdrop we add the increasing rates of aerospace enterprise integration with its supply chain and partners in the next few years. National Coalition for Advanced Manufacturing (NACFAM) estimates for each $1 of software, there is $1-$5 required to integrate it to the rest of a manufacturer's enterprise. This will be significant as new information process technologies begin to hit the shop floor.

IP Issues Becoming Critical Showstoppers

Standards, to function optimally as enablers for business, need to be integrated with all the other pieces of data used by industry. However, the safeguards and processes put in place by the standards developing organizations make data integration almost impossible. An aerospace company can't integrate the data from an industry standard into its product definition data and then flow those requirements down through the supply chain. While the aerospace industry is not advocating the loss or violation of IP rights and protections, the industry needs to find ways to work with the standards developers to ensure that the resulting standards are able to be used and integrated in ways that support the aerospace industry, not inhibit it. If industry, national, and international standards become too difficult to integrate into the data streams of OEMs, aerospace companies will be forced to write their own standards or turn to standards organizations willing to adopt new business models which allow for data integration. The Future

of Aerospace Standardization Working Group sees this issue as one of the largest challenges facing the future of standards used by the industry.

Goals for Standards Data

Fundamental to the requirement of operating in an environment of politically and geographically diverse players is the idea that the standardization process tools and information flow must be platform independent – that is, authoring, distribution and use processes must be decoupled from the hardware and software, but at the same time exploit best technology. The goal for the aerospace industry standardization tool landscape within the next 5-10 years, is to have the standards information moving around digitally to the various locations where it is used or interpreted digitally without having a person reconstruct it. A myriad of "smart" tools or interfaces would be available to capture and interpret standards data as required by the local application, whether that is an MRP system interface requirements definition system or a CAD system. The digital data itself will have become the "standard" or specification, but with the option of capturing that data in a particular way or "view" so an individual can interpret it or even print it out in the more traditional hard copy format.

Standardization tools of the future can certainly be expected to evolve to exploit and further the strengths of today's standardization systems. And the standardization tool set of the future must evolve to minimize the gaps in the process of today. However ultimately, it will be the "market" which will drive these changes. The market drive for "cost, quality and speed" of any process in product design, development, service, support and disposal has already proven that the best answer will surface and will produce the needed standards changes.

Conclusions

- The aerospace industry needs to ensure that standards are developed based on market relevance and need. The industry needs to develop processes and tools that will allow stakeholders to identify existing or in-work standards and will facilitate strategic standardization decisions.

- The aerospace industry needs a robust standards development, coordination, approval, configuration management and promulgation system that ensures that standards data relevant to every step of the design/build/support life-cycle is easily available and user friendly. Such a system would be characterized by features such as (but not limited to):

    - Automated document preparation, coordination, commenting, and balloting that is easily understood, flexible, and engages the global community

    - Readily available and easily accessible standards development committee web sites which meet the needs of the standards developer, the standards acquirer, and the general information seeker

    - Tools which facilitate faster, better, cheaper development and promulgation of standards that are technically accurate, technologically current, market relevant, platform independent, and globally accepted and used

- Tools which make it easy for the entire aerospace industry world-wide to engage in the development or use of standards at any appropriate point in the process

- Access not just to the standard as a document, but to the technical information contained in the standards so that users can access the standards data as they need it, in the form they need it, and easily integrate that data into the rest of the product definition data. Standards move to being managed and controlled as a collection of data elements, rather than as a paper paradigm document, so that users (human, machine, and other applications) can construct the appropriate "view" of the standards data that best meets their needs.

- IP issues preventing standards data from being easily integrated with other product data and migrated down the supply chain need to be resolved.

Recommendation #5: The business models and tools used for the development, distribution, integration and use of aerospace standards need to ensure that:

- **standards development is responsive to business drivers and is based on a business case or market need**
- **the standardization process is adequately funded and supported**
- **tools and processes used to develop, maintain, and disseminate standards make the best use of technology and the internet to ensure an efficient, effective system involving all the stakeholders**
- **standards are developed and disseminated in such a way that the data can easily be integrated into product definition data or other life-cycle data streams, and that the tools and the processes are not hampered by data formats or IP issues**

Chapter 6 –
Standards and Civil Aviation

Recommendation #6: The policies and procedures for assessing conformity of products and processes to standards are key and require urgent improvement as qualification, certification, and conformity assessment are major cost drivers.

The role ICAO plays in international standardization for the aerospace industry needs to be recognized by the US and these venues utilized to provide leadership in advancing US technology and to initiate change where needed.

Conformity Assessment

Quality measures consist of: grade (or inherent value), fitness for use, and conformance to specifications."
- Managing for World Class Competitiveness

While conformity assessment and standards are two separate activities, they are closely related. And certainly the issues surrounding standards and conformity assessment are equally important to all aspects of aerospace – civil, defense, and space. However, the Future of Aerospace Standardization has chosen to examine some of these issues in light of the commercial side of the business, with the understanding that many of the same issues and conclusions apply to the entire industry.

Conformity assessment is the comprehensive term for measures taken by manufacturers, their customers, regulatory authorities, and independent, third parties to assess conformity to standards.[19] Aerospace products are defined and built according to standards. Conformity assessment for the aerospace industry depends on the existence of unambiguous standards against which customers, regulatory agencies, governments, and military organizations can assess that products, processes and services actually conform to claimed standards. Aerospace regulatory agencies such as the FAA and EASA, and government customers such as the US Dept. of Defense require prior assurance of conformity to relevant standards before a product can be accepted and put into service.

Certification of aerospace products by regulatory agencies (FAA, EASA) is based on the use of and conformance to standards. When the FAA awards a Type Design Certificate for a specific model of commercial aircraft, that's a form of conformity assessment based on the determination

that the design – including the standards which make up the product definition – will meet requirements for a safe, reliable, produce-able, quality aircraft. Type Certificates include the Type Design data which consists of those drawings and specifications necessary to define the configuration and the design features of the product.[20] The FAA's Production Certificate is based on the holder's demonstration of the ability to maintain a high-level Quality System capable of continuously producing aircraft which conform to the Type Design data, including the specifications.[21] A failure to comply with standards or the use of outdated standards will result in corrective action by the regulatory agencies and potential withdrawal of either of these Certificates.

The International Aerospace Quality Group – A Standards Success Story Worthy of Being Repeated

The International Aerospace Quality Group represents one of the best new strategies for global standardization ever created. Established to help the aerospace industry implement the ISO 9000 Quality Management System, the IAQG defined a new strategy for developing an international standard – one that allowed the industry to successfully drive globally harmonized quality requirements down through one of the largest and most complex supply chains of any industry. And while the successes of the IAQG are described here in the Chapter for Civil Aviation, the IAQG is not confined to just the commercial sector; it supports all of the aerospace industry. DoD and NASA are some of the biggest users of the suite of IAQG quality standards.

This challenge meant not only creating standards that met the needs of the aerospace industry, but also creating a new standards system in which to develop, promote and implement these new quality standards. Industry leaders had very specific requirements for the standards system needed to support an internationally accepted aerospace quality system. It needed to be international in scope and membership. Industry wanted direct participation and wanted to include aerospace regulatory agencies and customers. It was critical that the system had a fast, responsive standards development cycle. And, most importantly, that the results were a single globally used and recognized standard.

While the industry was reluctant to create a new standards developing organization, there was no existing venue that met all the above requirements. So the industry went to three of the major aerospace standards developers and requested a special alliance to support a whole new standardization model. The result was the International Aerospace Quality Group (IAQG). The IAQG is a cooperative organization of the global aerospace industry. It is not a legal entity, but rather a dynamic cooperation based on trust between international aerospace companies for the purpose of establishing and maintaining standards and initiatives to make significant improvements in quality performance and reductions in cost throughout the aerospace value stream. To facilitate its work and to take advantage of existing infrastructures, the IAQG is divided into three sectors: Europe, the Americas, and Asia; and is sponsored by three aerospace standards organizations: the European Association of Aerospace Industries (AECMA), the Society of Automotive Engineers (SAE), and the Society of Japanese Aerospace Companies (SJAC) (Figure 7).

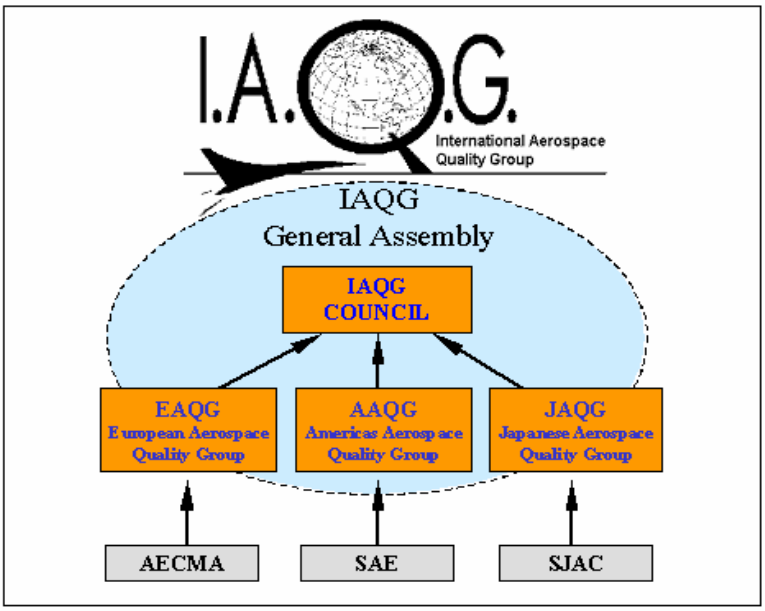


Figure 1

Figure 7 – IAQG Organization Chart

This creative cooperative includes 47 of the largest members of the aerospace industry. The three regional sectors coordinate requirements for quality related standards and the results are then harmonized by the IAQG. The globally harmonized standard is then published simultaneously by each of the three sponsoring organizations. Thus we have AS/prEN/SJAC 9100 which defines the additional requirements for an aerospace quality management system which must be addressed when implementing an ISO 9001:2000-based quality system. And each sector has then authorized translations by other standards developing organizations to provide language specific standards across the international community.

Developing a single aerospace quality system in just over a year, and follow-on quality standards in 9-12 months was quite an achievement. But the real power of the IAQG comes from the commitment of the member companies. There is a signed agreement of intent to implement the resulting IAQG standards by the upper management of all involved companies prior to the development of the standard. Since a standard only has value if it is used, the commitment to implement from the highest levels of the companies involved is the key to success. This is the first time in the aerospace industry that signed commitments from upper management were required prior to participation in the development of international standards. What's more, implementation statistics for each member company are tracked at every IAQG meeting. More than 60 percent of IAQG members have implemented the AS/prEN/SJAC 9100 standard internally and are flowing it down to their suppliers. Most members will require suppliers to comply by December 2003, consistent with the transition from the old ISO 9001 to the new version.

The success of the IAQG as a global industry standards development model is one that should be seriously looked at for other standards types and other standardization initiatives. This is a powerful strategy that brings together an entire community, forges alliances of standards developers, and solicits corporate commitment to implement standards to improve business.

Qualified Products Lists – Significant Room for Improvement

While the IAQG and its suite of quality standards are a standardization success story, the tale of Qualified Products Lists (QPLs), and their related Qualified Producer or Manufacturer Lists (QMLs) is not so bright. Parts and materials used in the design, manufacture, assembly and test of aerospace products are defined by standards. DoD and industry standards then become mandated by the commercial and DoD regulatory agencies as part of the type, design, and production certification process. Parts defined by these standards can make up a significant portion of product Bills of Materials at most aerospace companies.

The concept of qualification and listing of producers and distributors of parts defined by standards was brought to maturity by the DoD and its management of suppliers for DoD procurement. These Qualified Product Lists (QPLs) have been used on Mil-Specs since the 1950's. QPLs have been managed as part of the Mil-Spec system and many aerospace company standards systems have adopted the same practice. The DoD performed or oversaw the qualification testing and inspection and maintained the listing of approved parts and suppliers along with the base standard. The whole aerospace community used these QPLs not only for defense products, but for commercial aircraft.

In the mid-1990's, the DoD cancelled or migrated over 6,000 military specifications and standards to industry standards developing organizations such as SAE International, AIA, and ASTM International. This move was to take advantage of best commercial practices and to allow industry to share in the development and maintenance of these documents, hopefully leading to timelier and more technically current documents. However, migration of DoD standards and associated QPLs to a handful of industry standards developers left no central qualifying agency in place to manage and update qualification requirements for these technical standards. The aerospace industry did not have the infrastructures in place to continue the maintenance of the QPLs. They did not have organizations to conduct the qualification testing and inspections, nor did the standards organizations receiving the cancelled Mil-Specs as part of Mil-Spec Reform have the processes or mechanisms in place to incorporate QPLs into their standards systems.

Some standards developers, responding to industry, have realized the need for third party qualification and have developed affiliated organizations. SAE International works with the Performance Review Institute (PRI) and in Europe AECMA established AECMA-CERT. However, the transition has not been a smooth one. Not all standards developers have set up processes for dealing with qualification requirements. AIA, which received over five hundred Mil-Specs to maintain, still does not have a standards process to allow for QPLs. And even when industry decides to develop a common QPL through an organization such as PRI, there still remain questions regarding maintenance, funding, and liability issues surrounding the QPL.

The transition of thousands of Mil-Specs and accompanying QPLs to industry was further complicated by the DoD's processes which were not always consistent. The rules for how a Mil-

Spec and its accompanying QPL were cancelled upon transfer to an industry organization and how supersession was indicated were not always well understood by the aerospace community, nor consistently applied by the DoD. There are cancelled Mil-Specs still with active DoD QPLs, transferred standards with orphaned QPLs because the industry organization that picked up the base standard did not pick up the QPL, and confusing text regarding supersession directions.

The aerospace industry, working through the AIA's Early Warning Project Group which was established to help with the transition of Mil-Specs to industry organizations, notes that 809 of the 6351 documents used by aerospace have (or had) QPLs. 110 of these were superseded by industry standards:

Doc Status	QPL Status	Number
Active	Active	286
Active	Inactive	2
Active	Canceled	99
Inactive	Active	12
Inactive	Inactive	66
Inactive	Canceled	70
Canceled	Active	4
Canceled	Inactive	1
Canceled	Canceled	269

The Future of Aerospace Standardization Working Group urgently recommends that industry address the costly issues arising from the confusing and inconsistent processes surrounding QPLs. An industry forum should be established to develop a strategy for management of QPLs to make the process transparent to the ultimate end user (e.g., someone on the shop floor). The strategy should address when and how a standard should invoke requirements for qualification, guidance for inserting qualification requirements in specifications which takes into account competition in contracting, and plans for addressing legacy QPL management for standards migrated from DoD to industry standards developing organizations.

ICAO – Setting Standards and Specifications for Worldwide Operations

"Twenty four hours a day, 365 days of the year, an airplane takes off or lands every few seconds somewhere on the face of the earth. Every one of these flights is handled in the same, uniform manner, whether by air traffic control, airport authorities or pilots at the controls of their aircraft. Behind the scenes are millions of employees involved in manufacturing, maintenance and monitoring of the products and services required in the never-ending cycle of flights. In fact, modern aviation is one of the most complex systems of interaction between human beings and machines ever created. Civil aviation is a powerful force for progress in our modern global society. A healthy and growing air transport system creates and supports millions of jobs

worldwide. It forms part of the economic lifeline of many countries. It is a catalyst for travel and tourism, the world's largest industry. Beyond economics, air transport enriches the social and cultural fabric of society and contributes to the attainment of peace and prosperity throughout the world.

This clock-work precision in procedures and systems is made possible by the existence of universally accepted standards. These cover all technical and operational aspects of international civil aviation, such as safety, personnel licensing, operation of aircraft, aerodromes, air traffic services, accident investigation and the environment. Creating and modernizing these standards is the responsibility of the International Civil Aviation Organization, or ICAO, the specialized agency of the United Nations whose mandate is to ensure the safe, efficient and orderly evolution of international civil aviation. ICAO has its headquarters in Montreal, Canada, with seven regional offices throughout the world. From its beginning in 1944 it has grown to an organization with over 180 Contracting States." (from the ICAO Website, queried 5/15/04)

The role described for ICAO above is particularly significant for the worldwide aerospace industry in as much as it represents a prime example of the "four C's" for aerospace – cooperation, consensus, compliance, commitment. The cooperation and consensus aspects are particularly powerful in that member nation and industry representatives voluntarily participate and develop wide ranging standards, by consensus of the technically based stakeholders, for the clear common good. For example, aircraft noise and emissions standards developed and managed by member nation participants, reflect a continued imperative to advance technology and stakeholders have seen commercial benefit by doing so. In effect, these voluntary noise and emission standards represent consensus based conformity assurance standards. Consider the chaos that might result if, for example, noise standards or runway lighting standards were specific to the locality, or even if the language of operations were locally specific. ICAO provides an invaluable forum for harmonization of various standards for operations, and has proven effective worldwide. And industry needs to utilize bodies such as the International Coordinating Council of Aerospace Industries Associations (ICCAIA), an association of industry trade associations, to promote industry requirements into ICAO standards.

ICAO is, however, primarily aviation operations based. Conformity assessment in recent history has fallen to national airworthiness agencies, and as of late, some consolidation across national boundaries has taken place (e.g., JAA). There is still a critical need for additional international harmonization between agencies – for example between the FAA and JAA/EASA considering that with North Atlantic traffic, hundreds of times a day vehicles traverse several national boundaries. There is no question that conformity assessment in aviation is a trans-national issue. Scrutiny of FAA and JAA/EASA conformity assessment regulation reveals general parallelism, but still significant differences at the detail level. Ongoing harmonization efforts must continue.

Within these airworthiness agencies, the value of consensus based international standards development is recognized. Standards provided by ICAO and specific industry organizations like IATA are emerging as a valid path to conformity assessment for aviation – type certification, production certification, airworthiness certification, as opposed to rule making. This is primarily because the airworthiness agencies have begun to recognize that the path to consensus and collaboration is much easier, and already completed by the time the standard is published.

Restated, the role of international participant consensus organizations like ICAO and IATA are organic to future conformity assessment processes, and by that fact, international standardization.

Worldwide Safety Improvement

Governments and industry in the US and Europe have taken significant steps to improve the work of safety regulatory authorities around the world so that all members of the International Civil Aviation Organization (ICAO) are overseeing safety in accordance with international standards. ICAO has conducted audits of all safety regulatory authorities and is in the process of conducting safety assessment of airports and other infrastructures needed to meet international standards and public expectations.

The US and European governments, in strong coordination with ICAO, should take steps to ensure that all activity aimed at promoting adherence to international safety standards is coordinated so that there is a common set of priorities and no duplication of effort. The US aerospace industry should promote the use of ICAO as the venue for the development of both homeland and global security standards.

Conclusions

- The aerospace industry needs to better articulate and understand the relationship between standards and conformity assessment.

- The industry needs to harmonize standards which form the basis for regulations and certification and develop globally accepted conformity assessment schemes which are mutually recognized and cost effective.

- The model for global standards development used by the International Aerospace Quality Group has proven to be a successful way for achieving globally harmonized standards. The industry should seriously consider adapting or adopting this model for more standardization efforts.

- The process for the identification of qualified products and producers through the standards system is not functioning in an optimal manner. The industry needs to establish a special task force to deal with QPLs so the processes surrounding their invocation, development, configuration management, distribution, and use are clearly understood and uniformly applied throughout the industry and by all applicable standards developers.

- The International Civil Aviation Organization has been functioning as an international standards developer for the aerospace industry. The industry should work with governments and regulatory agencies to ensure that ICAO standards are recognized as international standards and that the industry maintains the right to utilize ICAO as an international standards developing organization specific to the industry over others such as ISO.

Recommendation #6: The policies and procedures for assessing conformity of products and processes to standards are key and require urgent improvement as qualification, certification, and conformity assessment are major cost drivers.
The role ICAO plays in international standardization for the aerospace industry needs to be recognized by the US and these venues utilized to provide leadership in advancing US technology and to initiate change where needed.

Chapter 7 –
Standards for Defense

Recommendation #7: Senior DoD and Aerospace industry leadership must recognize the extent to which the commercial aviation and space industries, as well as defense industry, depend upon the library of technical knowledge and discipline of configuration control embodied in the system of military specification and standards. DoD needs to proactively support and participate in the development of industry standards and utilize industry standards to the greatest extent practicable

Mil-Specs – Fundamental to Aerospace

Military specifications and standards have been fundamental to the aerospace industry's design, build, operate, maintain, dispose cycle for the past 50 years. The defense and civil aerospace industries largely grew up together, sharing many technological advancements, the same need for safety and reliability, and in fact sharing the same airspace and pilots as early civil pilots made themselves available to meet military needs and more recently, as retired military pilots have filled the needs for skilled civil aviators. The engineering description of parts, manufacturing processes, quality control procedures, and design were, and still are, described by a suite of specifications and standards produced by the military and by various industry associations including the Aerospace Industries Association, the Society of Automotive Engineers International, ASTM International, the Institute for Electrical and Electronic Engineers, and many others. A symbiotic balance grew up over the years – an undocumented division of labor among the various major standards players, each depending on the other to hold up their end of the bargain, and each undertaking the necessary standards development, upkeep, and publication to ensure that both the civil and the military aerospace industry was technically supported.

Mil-Spec Reform – A DoD Initiative, An Industry Concern

With the end of the cold war in the late 1980s, the United States was eager to reap the promised "peace dividend" from no longer needing to support such a large and robust military establishment. In the early 1990s, as Defense budgets plummeted, the Department of Defense began inevitably to upset the balance of labor for maintaining the nation's, and indeed the world's aerospace standards needs. The Defense Department looked more and more to meet its needs through dual use technologies, dual use products, and dual use standards. At the urging of senior leaders from the aerospace industry, Secretary of Defense William J. Perry, in 1994, announced a policy which would dramatically increase the Department's reliance on standards produced by the private sector. The initiative called Mil-Spec Reform (MSR), also called on the Department to review the roughly 29,000 existing military documents and to eliminate those which they no longer used, inactivate for new design those which were retained only to support legacy systems, and to convert to the private sector those which were still needed, but which described commercial products or practices. In theory, this made perfect sense. In practice, it

had been the policy for years without great success. So Secretary Perry established Integrated Process Teams, an oversight council, a waiver process for Military Standards, and allocated millions of dollars to expedite the reformation. MSR resulted in the inactivation of 8100 Military Specs and Standards, and cancellation of 9600 documents – 3500 of which were replaced by industry standards. It also saw the transformation of thousands of the remaining specifications from detailed prescriptive specifications to performance specifications. While there was much good that came from MSR, many in industry saw some of the reforms as the DoD unilaterally walking away from the balance of labor in development and maintenance of documents needed by the aerospace industry both in the U.S. and internationally. The industry identified conversions to industry specifications that their engineers did not agree with and cancellation of documents that they had designed into air-frames both for Defense and for their civil aviation fleets. The industry asked the Department to slow the process, but the DoD, recognizing that they no longer had the resources to keep up the standards, continued the conversion process at a high rate – literally thousands of documents cancelled or converted within only a few years. The decision made by the executive council in charge, was that it was better to force immediate consideration than to prolong the illusion of maintenance of technical documents when in fact they were already far out of date and technically inadequate.

The aerospace industry found itself caught unprepared to react to the rapid rate of cancellations and conversions and responded with an Early Warning Project Group charged with reviewing the documents being cancelled and converted in order to assess the impact. The EWPG reviewed aerospace companies' use of the documents slated for cancellation or conversion and monitored and ultimately managed much of the conversion process. They established procedures to make identical non-government standards (NGSs) to replace the Military documents and to move custody of the documents to the two principal private sector standards developers, SAE and AIA. It soon became apparent that these SDOs were equally unprepared to handle the deluge of conversions. While they did what they could, standardization needs of the industry were in fact, left unfulfilled. Both AIA and SAE have done much to meet the challenge, but the industry today finds itself with too few resources to adequately meet their standards needs. The DoD and the aerospace industry continue to work in partnership to address standardization issues, but committees find themselves with too few participants due to industry downsizing coincident with the expanded need. This shortcoming continues to be an issue for the industry. This coupled with the other demands placed on aerospace standardization – globalization, lack of clear standardization leadership, unfavorable economic conditions, and increased international competition, demand dramatic measures to meet industry's needs.

A Rethinking of the Role of Mil-Specs is Needed

The aerospace industry, along with many other industries, called for a move away from design or prescriptive standards toward standards that define requirements in terms of desired performance. In some instances, as Mil-Specs were converted to performance specifications, essential requirements were lost or were written in such a way that the contractor's execution of the requirements was unverifiable. The industry also found itself unprepared to take over piece-part qualification of hundreds of parts that had been previously covered by military specifications and qualified by military qualifying activities. Qualification generally applies to products, the use of which may have safety implications, and for which testing for verification takes a long time, is very expensive, or requires special equipment that is not readily available. Qualification is accomplished independent of instant acquisition in order not to hold procurement

for the long testing. The industry has relied on DoD qualification to meet needs for weapon systems at the prime contractor and multi-tier subcontract level. To a lesser but still significant degree, the industry has relied on this qualification for production of civil aircraft as well. The aerospace and defense industry had already begun to develop an industry run and supported independent qualification capability. At the time of MSR, only a comparatively small number of items were being qualified through this capability, and widespread reliance on it had not developed. With the beginning of MSR, as the Department cancelled or converted to NGS specifications that called for qualification, the industry was unprepared to handle the large number and variety of items – neither the documents to support qualification nor the qualification capability was in place.

Aerospace Industry Standards Require DoD Input

"The DoD is committed to increased defense contractor productivity and improved acquisition efficiency. Standardization documents play an important role in this context, and must be selected and properly applied with this objective in mind. They provide the framework by which requirements are defined." [22] These words regarding the importance of standards and contained within the DoD's documentation for the use of standards, commits the government to the use of standards for acquisition.

But if the DoD is committed to the use of industry standards to support the acquisition of new platforms and programs, then they need to ensure that DoD requirements are contained in and met by these standards. The move to use industry standards does not mean that the DoD no longer has to concern itself with the management and maintenance of these documents. This couldn't be farther from the truth.

Key to DoD acquisition policy is the use of commercial best practices and industry standards. The National Technology Transfer and Advancement Act, Public Law 104-113, requires federal agencies and departments to use technical standards that are developed or adopted by voluntary consensus standards bodies as long as those standards meet the government's needs. Government agencies and the Department of Defense recognize the huge cost and time savings through the dual use of technology – technology defined by standards. The Office of Management and Budget (OMB) Circular A-119, "*Federal Participation in the Development and Use of Voluntary Standards*" has resulted in reducing government costs. DoD efforts to replace military specifications with commercial item specifications have saved procurement funds and reduced the need for suppliers to maintain separate military and commercial production capabilities.[23] For aerospace, industry working closely with DoD is key to the creation of standards which will be value-added for both military and commercial use and will allow each to take advantage of best practices developed by the other. And to ensure that DoD requirements are contained in industry standards, DoD subject matter experts need to participate fully in the development and maintenance of industry standards. One of the greatest threats today to the lack of suitable standards for logistics support is the under funding and under-representation of DoD interests in industry standardization activities.

Development and use of global industry standards is critical to the international sale of defense products and their interoperability. Interoperability, facilitated by standards, is vital to any successful joint military effort such as those of the North Atlantic Treaty Organization (NATO) or UN Peacekeeping efforts. Programs such as Future Combat Systems and integrated battle

space management depend on industry standards to define how each platform will integrate and operate in the larger system of systems. Which means that DoD must support these standards activities.

Mil-specs – Created for Defense, Used by Everyone

While the DoD must recognize the value of industry standards to the development, procurement and operations of defense platforms, they must also understand the key role government standards play in commercial aerospace. Commercial aviation has a strong foundation in military products. The first commercially successful jet aircraft (the Boeing 707) combined the aerodynamic and structural features of the B-47 and the B-52 with the cabin capacity of a larger transport as well as sharing much in common with the KC-135 Stratotanker. Mil-Specs, and the parts, materials, and processes they defined, became the core of technical data used for a commercial product. And not just US made aircraft. Aircraft made all over the world incorporate US Mil-specs in their product definition because the parts, materials and processes they define have a high degree of acceptance and are used world-wide. And it's to the DoD's advantage to have commercial aerospace using Mil-Specs. The more widely a standard is used, the more suppliers there are and the lower the price.

Because of the high dependence of commercial aviation on Mil-Specs and Standards, the commercial industry is greatly impacted by any changes to this critical library of technical data. Senior DoD leadership needs to understand and acknowledge the commercial aviation industry's dependence on Mil-specs. Members of the commercial side of the aerospace industry, as well as defense contractors, need to be involved in any changes to the infrastructure of Mil-Specs.

Mil-Spec reform hit the commercial aerospace industry hard, throwing it into a reactive mode to protect the key technical data it had come to depend on, and forcing it to establish the AIA Early Warning Project Group to respond to the cancellations. The amount of confusion caused by these cancellations was quite costly in terms of time, resources, and misunderstandings leading to use of the wrong specifications. Even after the DoD has declared Mil-Spec Reform completed, the aerospace industry is dealing with the aftermath. There is still a need for education and guidance on the use of cancelled specs, the implication of supersession notices, and part marking based on converted mil-specs. To ensure that such costly industry-wide impacts are avoided with any future DoD standardization initiatives, the Future of Aerospace Standardization Working Group urges senior DoD leadership to involve the aerospace industry up front when planning such major standards reforms.

Conclusions

- Senior DoD leadership must recognize the critical role government standards play in the commercial aerospace industry and involve those stakeholders in any major standardization initiatives. This will ensure that the key technical data contained in Mil-specs and standards is available to support dual use products and platforms and will ensure a strong supply chain for DoD parts and materials.

- In recognition of the global role Mil-Specs play in the aerospace industry, DoD is urged to establish more effective mechanisms for communicating with industry on standardization issues. This mechanism must provide a forum for discussion of standardization actions

which impact both DoD and industry and would involve industry stakeholders in helping to define standardization issues and develop solutions that are mutually beneficial. Such a multi-disciplinary government and industry forum would:

- Develop recommendations for how standardization can best support logistics reform, interoperability, evolutionary acquisition, technology insertion, and reduction in total ownership costs

- Address issues such as business strategies that promote civil-military integration for acquisition of defense products and platforms, configuration management policies and practices, technology insertion, logistics supportability, and commercial parts management

- Senior DoD leadership must acknowledge that to ensure that industry standards are suitable for DoD use and that they meet and contain DoD requirements, government subject matter experts must participate on industry committees to develop and maintain these standards. Sufficient funding must be made available; otherwise, the DoD is running the risk of having neither internal nor external standards available for the design, manufacture and support of military products.

Recommendation #7: Senior DoD and Aerospace industry leadership must recognize the extent to which the commercial aviation and space industries, as well as defense industry, depend upon the library of technical knowledge and discipline of configuration control embodied in the system of military specification and standards. DoD needs to proactively support and participate in the development of industry standards and utilize industry standards to the greatest extent practicable.

Chapter 8 –

Space – A Growing Role for Standards

Recommendation #8: Industry, NASA, DoD and the FAA urgently need to work together to ensure the development of globally recognized standards that support both government and commercial space interests. Development and use of industry standards which support US based technology must be a key strategic component of the aerospace industry's standardization strategy.

State of the Space Industry

Looking back at space technology development and deployment over the last half of the 20th century an observer would see the first sub-orbital flights, extended orbital flights, landings on the moon, deployment of satellites enabling worldwide low cost voice and communication, and many more milestones encompassing a record of technological advancement and achievement unmatched in history. This record is significant because of the prima facie achievements, but more so because of the less noticeable achievements in related technologies that were required to enable the space flights. It was these "secondary" achievements however that were and are very significant enablers of success in the Cold War, and of so many other accomplishments and derived technologies, which make our lives what they are today. It is for that reason that we

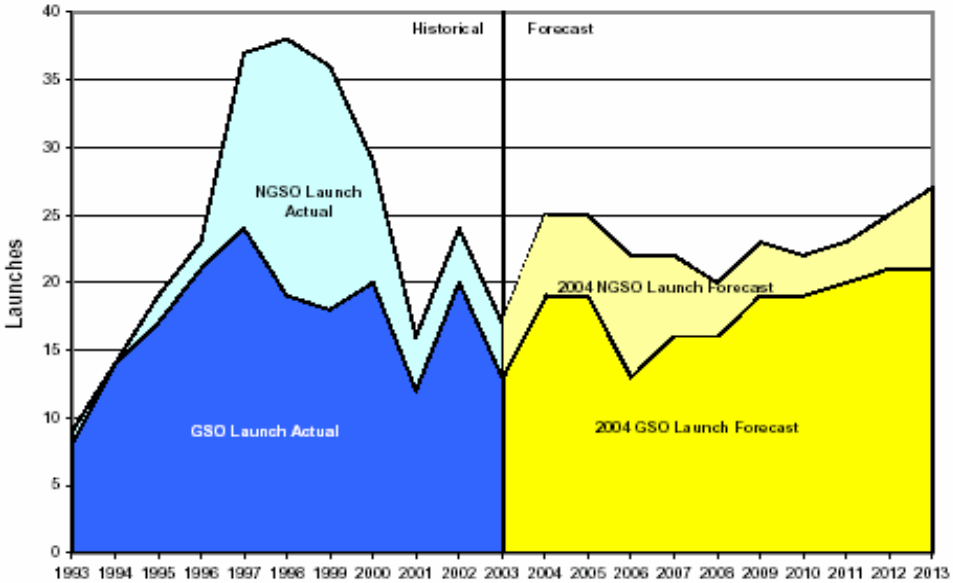


Figure 8 – Combined Launch Forecasts

(*Final Report of the Commission on the Future of the United States Aerospace Industry, 2002*)

need to examine and reevaluate our perspective on Space as an economic and strategic frontier where leadership must be maintained.

The extent of standardization in any industry sector is influenced by the maturity and economic health of the sector, and so it is with space, both commercially and politically. The space industry, whose major components are commercial and government launch services, vehicle, propulsion, and payload manufacture and integration, did not exist, until fairly recently. And a significant portion of the "industry" does not yet operate in a truly commercial market, but rather under close control and specification of the customer (USAF and NASA). Cost of launching, per lb of payload, has not been significantly reduced in recent years from a rough average of $10000/lb [24], and summaries and forecasts of industry growth like that in Figure 7, show that the future for launch business remains relatively flat. Certainly the high cost of launch contributes to this, as well as the fact that there is excessive launch capacity at the moment, driven in some measure by the fact that launch vehicles are developed in response to national security concerns, not solely in response to market demands.

Standardization in the Space Industry – Domestic and Internationally

Historically, and today, there is standardization to a large extent in aspects of the space industry which are common with aviation and electronics. Standard fasteners, materials, electronic performance specifications, etc. are used extensively. This is not surprising in as much as the technology is closely derived from existing specification libraries used currently in those industries. There are, however, very few standards for the unique aspects of space such as propulsion, vehicle interfaces, payload vehicle interfaces, or ground support equipment. The space industry has clearly not yet recognized the benefits of standardization in these areas, possibly because the industry is still young, or because launch operations have been very closely monitored and specified by customers and insurers.[25]

Standardization today is focused primarily on Range safety and launch site safety, with focus on launch corridors, destruct protocols and environmental impact of launches, reentry licensing and

Industry (year of impacts)	Economic Activity ($billion)	Earnings ($billion)	Jobs
Civil Aviation (2000)[9]	$1,000.0	$310.1	10,000,000
Recreational Fishing (2001)[10]	$116.0	$30.1	1,068,000
Commercial Space Transportation and Enabled Industries (2002)	**$95.0**	**$23.5**	**576,000**
Commercial Space Transportation and Enabled Industries (1999)	$61.3	$16.4	497,000
Biotechnology (1999)[11]	$47.0	N/A	437,400
Commercial Shipbuilding (2001)[12]	$11.0	$9.4	147,230
Computer and Video Games (2000)[13]	$10.5	$7.2	219,000

[9] *The Economic Impact of Civil Aviation on the U.S. Economy, Update 2000*, published by Wilbur Smith Associates in April 2003 for the Federal Aviation Administration.
[10] *Sportfishing in America: Values of Our Traditional Pastime*, http://www.asafishing.org/content/statistics/economic/.
[11] *The Economic Contributions of the Biotechnology Industry to the U.S. Economy*, http://www.bio.org/news/ernstyoung.pdf.
[12] *The Economic Contributions of the U.S. Commercial Shipbuilding Industry*, http://www.shipbuilders.org/publications/econcontr_shipbuilding.pdf.
[13] *Economic Impacts of the Demand for Playing Interactive Entertainment Software*, http://www.idsa.com/pressroom.html.

Figure 9 – Comparison of Economic Impact of Commercial Space [26]

so forth. The FAA space operations rules (49 USC subtitle IX) are examples of these. In addition, there is emphasis on insurance driven conformity assessment of vehicles and loads –

this driven primarily by relevant Mil-specs and AGARD (NATO Tech Arm) specifications. The American Society of Mechanical Engineers (ASME) and the American Institute of Aeronautics and Astronautics (AIAA) have begun to engage in the area of systems integration and vehicle interfaces, but overwhelmingly the space related "regulatory" agency is still the government, or agency customer.

Integration standardization -- developing and standardizing common and consistent interfaces between propulsion and vehicle, and payload and vehicle -- is difficult today because of differing flight environments, and access requirements which are primarily instance specific. Because of the flat demand and excess launch capacity in the industry, there is little perceived benefit to these types of standard interfaces, at least today. Domestically, forums such as the annual Space Power Workshop have begun to explore standardization of these mechanical interfaces as well as the information and system interfaces accompanying them.

Some advances, however, have been made in vehicle/systems integration. The DoD's Evolved Expendable Launch Vehicle program (EELV) uses standard specifications for payloads using a common mechanical and electrical interface to the vehicle. In addition, the booster core of the launch vehicle is standardized. These standards are intended to reduce manufacturing, assembly, payload integration and launch operation process costs.

Internationally, however, space standardization appears to be more evolved. In the European Union, the European Space Agency (ESA) and The European Cooperation for Space Standardization (ECSS) develop standards for European space activities including standardization of project management, product assurance and engineering activities for the entire European space community. The ECSS initiative aims to promote the use of existing standards, adopt commonly used international standards, and ensure coordination and liaison with standardization organizations, European governmental agencies, and industry [27] . There is no similar initiative in North America or the rest of the world. In addition, Eurospace, a small space professional organization, is functioning along side of AECMA. Arianespace, the French based private commercial launch consortium dominates the European space landscape, (arguably

Industry	Economic Activity ($000)		Earnings ($000)		Employment (Jobs)	
	1999	2002	1999	2002	1999	2002
Launch vehicle manufacturing and services	$ 3,515,978	$ 791,759	$ 1,071,722	$ 206,328	28,617	4,828
Satellite manufacturing	6,839,132	4,937,867	1,964,415	1,379,491	57,372	31,262
Ground equipment manufacturing	24,030,337	37,934,507	6,893,878	10,134,674	213,076	247,160
Satellite services	25,818,414	49,560,450	6,150,105	11,239,634	186,954	278,287
Remote sensing	235,879	555,282	85,292	192,702	2,820	5,108
Distribution industries	873,971	1,245,881	265,780	374,916	8,506	9,803
Total Impacts	**$61,313,711**	**$95,025,746**	**$16,431,192**	**$23,527,745**	**497,345**	**576,448**

Fig 10 – Impacts on US Economy of Commercial Space Industry 1999-2002 [28]

the commercial space business with over 50% commercial launch market share) [29] and has for instance, just become a member of the Satellite Broadcasting and Communications Association (SBCA) based in Alexandria, Va.

Observations Relative to the Space Standardization Landscape

The landscape of US based space industry standardization can be seen as closely paralleling that of its mother industry – aviation. However, the level of space industry integration does not approach that of the EU. The level of standardization is minimal, owing partially to the flat market demand for commercial services, and partially to the fact that seen against the model of the aerospace industry, where there is significant standardization but little strategic integration, the very thin level of space standardization may be a result of the immaturity of the industry. Until the cost per pound of launch is reduced this may continue. Until "disruptive technology" of propulsion and power take hold in vehicle design, thereby expanding the range of market options in the long term, the demand may stay flat. In this slack economic environment (in space anyway) the immediate benefits of standardization can probably be neglected with little direct impact to the industry.

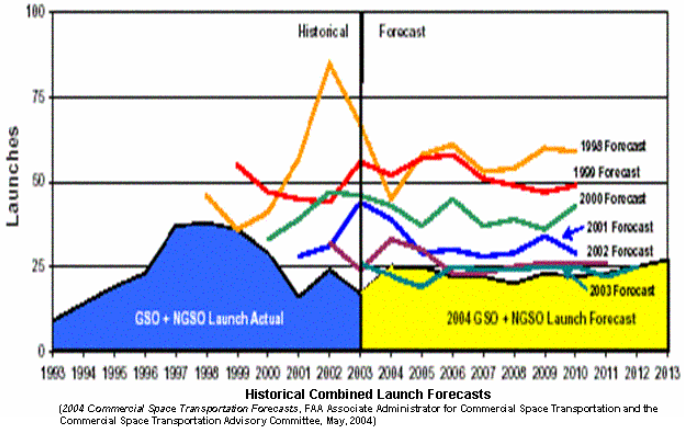


Figure 11 - Historical Combined Launch Forecast

However there are potential implications to competitiveness. Already the ESA, ESCC and Arianespace dominate the commercial space standardization and launch arena. The obvious end state of this is that without a collaborative approach to standardization between the EU and US manufacturers, manufacturers outside the EU will ultimately have to conform to EU standards. Without an integrated approach to US space standardization, it will be difficult for US space commerce interests to present integrated input to any International space standardization activity. At the most, US space industry interests seeking business opportunities outside the US will be forced to conform to standards being developed without active participation, most likely resulting in a competitive disadvantage. Although the EU is not the entire international standardization landscape, they are clearly the most advanced, and may draw the emerging markets, such as China, into a collaborative standardization partnership.

In the US based space industry, there is no collective forum where the major industry drivers, that is NASA and the commercial vehicle and payload producers have come together to develop and integrate approaches to space standardization. There is no significant space standardization

in the industry or jointly with industry and NASA collaborating, although NASA participates in some other international forums, like the Consultative Committee for Space Data Systems (CCSDS), an independent space agency based organization to address space data handling needs.

Conclusions

- As the Commercial Space industry re-energizes, the benefits of industry standardization will be critical to cost, quality and repeatability.

- Industry and government need to work together to ensure that globally relevant standards exist to meet our technical needs in space, and so that the US space industry does not continue to cede strategic standards and associated technical strength to the Europeans or other regional interests.

Recommendation #8: Industry, NASA, DoD and the FAA urgently need to work together to ensure the development of globally recognized standards that support both government and commercial space interests. Development and use of industry standards which support US based technology must be a key strategic component of the aerospace industry's standardization strategy.

Footnotes

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29. *Ibid*