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FEATURE ARTICLE

STANDARDS IN SPACE: AN INDUSTRY AND A PROCESS AT A CROSSROADS [1]

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Abstract: *Today, there are three layers of standard setting activities supporting space applications: a layer comprising a small number of dedicated organizations and ISO subcommittees formed expressly for that purpose; a layer of working groups within other standard setting organizations (SSOs) that have been formed to create standards unique to specific space applications; and a much more numerous layer of working groups in scores of SSOs that create standards that are relevant, but not unique, to space applications. This article will describe the first layer in detail, as well as several examples of the second layer in order to give an overview of standard setting for space applications today, and how this infrastructure is evolving. It also profiles the standards areas and membership of each SSO, and the liaison relationships that they have established in order to help create a nascent standards infrastructure to support space applications. This article closes by reviewing the recommendations of a recent critical report that urges prompt action by government and industry to improve this infrastructure in order to maintain United States leadership in the space industry.*

Introduction: Technical standards are essential tools for all industries, and as each new modern industry has come into being, new standard setting activities have been launched to provide these tools. Usually, one or more new standard setting organization (SSO) is created to serve that purpose, while in other cases, existing organizations add new working groups to meet the need. Often, both types of activity follow to fill the newly created vacuum. Characteristically, as an industry matures, these dedicated and peripheral SSOs evolve a network of liaison relationships among themselves in order to coordinate, develop and maintain the standards that are needed on an ongoing basis to support that industry. However, the more complex an industry is and the more numerous the SSOs that address its needs, the more imperfect such an ad hoc network is likely to be.

With the development of the capability to launch payloads (telecommunications, scientific, exploratory, and so on) into orbit, a broad range of standard setting activities has been commissioned to enable these intensely challenging and technical adventures to occur, although these efforts have still only scratched the surface of the standards that would be required to enable the efficient operation of the space industry. A review of how standard setting for space applications has evolved to date, and the types of activities that have been commissioned, can provide not only a portrait of the state of space standard setting today, but also an example of how new standard setting infrastructures come into being to serve emerging industries as they gain traction in the marketplace.

Not surprisingly, there is a pyramidal hierarchy of SSOs serving the space industry that becomes less numerous as its degree of direct applicability to space applications increases. At the apex of the pyramid is a small group of SSOs that have both a broad scope and a significant dedication to the creation of space-unique standards. Two of those organizations were formed within the existing structure of the International Organization for Standardization (ISO), which functions as the umbrella under which all manner of disparate global standard setting activities are undertaken. The third international organization was formed by and for the national space agencies (although commercial enterprises can participate in its activities as well). In addition, there is a variety of national, and in the case of Europe, regional SSOs that are dedicated in whole or in part to developing standards for space applications.

At the base of the pyramid lies a very broad range of SSOs that create standards that are relevant to space applications. This is hardly surprising, in that spacecraft are complex machines employing almost every kind of mechanical and electronic system, and must be designed, built and launched in earth-based factories and launch facilities, all of which use computers, telecommunications, and materials of all types.

In the middle of the pyramid is a growing number of discrete working groups and committees in disparate SSOs many of which relate to doing productive work in, or from, space. These committees exist to facilitate the use of telecommunications satellites, performing useful work based on global information system technology, and other activities that can be performed using earth-orbit platforms.

This article will attempt to describe the network of dedicated and peripheral SSOs that have evolved to serve the government agencies and private commercial participants in the space industry, detailing the specific types of standards being created by individual SSOs, the types of members that each SSO attracts, and the liaison relationships that are maintained among these participants.

A greater percentage of the SSOs that are in the first "layer" described above will be described below, but this article will also profile representative national standard setting organizations that have significant involvement in standards for space applications, as well as a sampling of those SSOs in more unrelated industry domains that have added activities to address the convergence of their missions with those of the dedicated SSOs. It will close with a review of a recently completed report by the Aerospace Industries Association (AIA) entitled "The Future of Aerospace Standardization," [2] which includes an assessment of the current state of standard setting for space applications, and recommends urgent action in order to properly support future progress in space, and to avoid the erosion of American leadership in that enterprise.

I. "Apex" SSOs We will begin with a review of the organizations (other than space agencies) that exist at the top of the pyramid whose main standards development focus is to enable space applications. [3]

A. International Organization for Standardization (ISO): Since its inception, the International Organization for Standardization (popularly known by its non-acronymic name "ISO") has added new technical domains to its work programs on a regular basis, as new industries have emerged. Within the ISO system, however, new technical committees (TCs) may only be formed if an existing committee could not appropriately address the new technical area. If such a committee does exist, then appropriate subcommittees are created under its authority.

ISO TC 20: Rather than creating a new TC to serve the nascent space industry, the existing ISO TC that had been previously created to serve aviation needs was renamed the "Aircraft and Space Vehicles TC" and its charter broadened to address technical standards relevant or unique to space applications. [4]

The current scope of work of that TC is: " Standardization of materials, components and equipment for construction and operation of aircraft and space vehicles as well as equipment used in the servicing and maintenance of these vehicles." As of this writing, there are nine active Subcommittees (SCs) and three Working Groups under ISO TC 20. Two of these Subcommittees are directly germane to this article, although specific standards of other subcommittees may also be useful in space applications.

ISO is in many respects a virtual organization that credentials standards efforts, but does not itself operate them. TCs and SCs are therefore organized, staffed and administered by other standards organizations that volunteer to serve as Secretariats for this purpose. Often, the Secretariat role is highly desirable, as the work of a new TC or SC can complement and leverage the mission of the SSOs that volunteer, and the successful applicant may find that its standing in the international standards community may be increased as a result of its new responsibilities. The Secretariat for ISO TC 20 is the American National Standards Institute (ANSI), but the functional role is provided by the Aerospace Industries Association (AIA) , which was accredited to this purpose by ANSI.

Participation in all ISO committees and subcommittees is through the national member body recognized by ISO (in the United States, this role is fulfilled by ANSI). Member bodies may enroll in committees, and send guest representatives to meetings if they have not formally enrolled.

With this as prelude, we may turn to the two SCs within ISO TC 20 that were formed for the specific purpose of developing standards for space applications.

ISO TC 20/SC 13: Space Data and Information Transfer Systems: The Secretariat of the subcommittee is ANSI, but the functional role is provided by the Aerospace Industries Association (AIA) , an ANSI accredited SSO that was appointed to this purpose by ANSI. As of this writing, the subcommittee comprises 11 participating and 4 observer members, and has issued 31 standards.

In addition to liaison relationships internal to ISO, the subcommittee maintains formal liaison relationships with seven international organizations that address a variety of domains that are relevant to, or in part dependent on, its standards, including the Committee on Earth Observation Satellites (CEOS), the Consultative Committee on Space Data Systems (CCSDS, described below), the Committee on Space Research (COSPAR), and the International Society for Photogrammetry and Remote Sensing (ISPRS). 5

The Charter and Scope of the subcommittee are as follows:

ISO TC 20/SC 13:

1. Is an international forum that addresses the standardization needs of organizations and personnel involved with data and information transfer and exchange for civil space applications.

2. Promotes international cooperation and progress in civil space applications by encouraging, supporting, and proposing national and international missions; and seeking and initiating new concepts for international cooperative projects and missions. This includes spacecraft missions, ground based radio science, and space and ground tracking networks.

3. Promotes opportunities for partnership in space applications, including space and ground tracking networks and data sharing, between industrialized countries and the developing countries.

4. Acts as an international information exchange mechanism for data, programs and plans pertaining to space applications and space/ground tracking networks.

5. Develops both the technical and the institutional framework for international interoperability to facilitate appropriate cross-support opportunities of space data systems.

6. Recognizes that technical documents appropriate for international data systems standardization purposes have been developed by other organizations and will utilize these existing documents if they have demonstrated their suitability by wide international acceptance. SC 13 will avoid developing new international standards when adequate standards exist. 6

The 31 standards completed to date by the subcommittee encompass a broad variety of topics, including Telemetry and Telecommand, Data Management, Space Communications, and Orbital Systems. 7

United States participation on the subcommittee is through the United States Technical Advisory Group (TAG), which has been accredited to that purpose by ANSI. The US TAG is administered by another ANSI accredited SSO, the American Institute of Aeronautics and Astronautics (AIAA – not to be confused with the AIA, which supports both ISO TC20 and ISO TC20/SC-13). The stated mission of the US TAG is:

a) To represent the U.S. aerospace community in all matters pertaining to the U.S. technical advisory group to ISO/TC20/SC13.

b) To fulfill the functions and responsibilities of a TAG as set forth in its ANSI approved Operating Procedures.

c) To provide a U.S. forum to exchange ideas and viewpoints regarding international space standardization and to establish U.S. consensus on international issues.8

More specifically, the US TAG is chartered with the authority to appoint U.S. experts to serve on subcommittee working groups, determine and represent U.S. positions on draft standards, and make proposals on behalf of U.S.interests 9

ISO TC 20/SC 14: Space Systems and Operations: The Secretariat of this subcommittee is once again ANSI, and the functional role is provided by the AIAA as secretary, which was accredited to this purpose by ANSI. As of this writing, the subcommittee comprises 11 participating and 6 observer members, and has issued 74 standards.

The subcommittee maintains formal liaison relationships with each of the organizations with which ISO TC 20/SC 13 maintains such ties, and, in addition, with several additional European aerospace organizations, the International Academy of Astronautics (IAA-astronautics) and the (impressively named and improbably acronymed) United Nations Office for Outer Space Affairs (UN-OOSA) 10

The Scope of the subcommittee is defined as: " Standardization for manned and unmanned space vehicles, their design, production, maintenance, operation, and disposal, and the environment in which they operate." The subcommittee was founded in 1992, in recognition of the fact that:

The international demand for telecommunication capability, weather prediction, and navigation, in both the developed and developing nations has fostered an expanding commercial space marketplace that is highly competitive at both the system and component levels. International standards for expressing requirements as well as capabilities and the means of verifying performance are; therefore, essential to facilitate fair and equitable trade that will result in reliable commercial space systems. In addition, due to their ever-increasing costs, international collaboration on major civil space programs has become necessary and the norm. International Standards are therefore essential to ensure such programs can be reliably integrated in a cost-effective manner. 11

The subcommittee currently has 80 projects in process, operating under five working groups: Interfaces, Integration and Test; Operations and Ground Support; Space Environment (natural and artificial); Programme Management; and Materials and Processes.

The 74 standards completed to date by the subcommittee address subjects as diverse as Launch Site Operations; various safety standards; Fluid Characteristics, Sampling and Testing of multiple propellants; Surface Cleanliness; and Man-Systems Integration. 12

United States participation on the subcommittee is through a United States TAG administered by the AIAA under accreditation by ANSI. Its mission is similar to that of the ISO TC20/SC-13 TAG. 13

B. Agency Organizations: A limited number of organizations have been formed for the express purpose of providing coordination among, and standard setting by, the space agencies on a global or regional basis (participation by corporate members is also typically permitted). An example of the latter is the European Space European Cooperation for Space Standardization (ECSS) organization, the mission of which is " to develop a coherent, single set of user-friendly standards for use in all European space activities" and the AIAA and AIA in the United States. The CCSDS (described next) is an example of the former.

Consultative Committee for Space Data Systems: The CCSDS was formed in 1982 by the then-most advanced national space agencies for the purpose of developing standards in the area of space communications, and as an outgrowth of a joint NASA-European Space Agency working group that had been formed to facilitate "cross support" among space agencies (e.g., to permit leveraging the data handling services of all agencies in support of each others' missions, as when an orbiting spacecraft is "handed off" like a cell phone call from one nation's communications system to the next).

Currently, 28 nations participate in CCSDS activities, ten of which are full members, and eighteen of which participate as observer members. While over 100 commercial entities also participate as "industrial associates," the agency focus of CCSDS is indicated by the scope of its standard setting efforts: "a) to reduce the cost to the various agencies of performing common data functions by eliminating unjustified project-unique design and development, and b) promote interoperability and cross support among cooperating space agencies to reduce operations costs by sharing facilities. 14

In 2003, the technical organization of CCSDS was revised, using the Internet Engineering Task Force (IETF) as a model, in order to divide its activities into six "Areas:" Space Link Services; Space Internetworking Services; Spacecraft Onboard Interface Services; Cross Support Services; Mission Operations and Information Management Services; and System Engineering Services. Currently, there are 31 active working groups 15

As of this writing, the CCSDS has published 82 standards ("Recommendations"), reports, tutorials, and papers. 16 Through a cooperative agreement with ISO, CCSDS Recommendations are submitted to ISO through ISO TC20/SC-13 for consideration and adoption as ISO standards.

C. "National" Organizations: A number of SSOs that focus predominantly (e.g., the AIAA) or partially (e.g., the IEEE) on standards for space applications are nationally accredited SSOs. However, as is the case in many other technical domains, those described in this article each accept members from other nations as well. Coordination among these organizations occurs through a variety of means such as liaison relationships (e.g., between the ECSS and TC 20/SC-14) and through SSOs acting as the secretary of ISO committees and subcommittees (as is the case with the AIA and the AIAA) in order to keep standards in as close alignment as possible, and to avoid duplicative efforts. 17

American Institute of Aeronautics and Astronautics: The AIAA is an ANSI accredited SSO that accepts members from many nations. Besides operating as the US TAG for ISO TC/SC 13 and 14 and as the secretary for ISO TC/SC 14, the AIAA engages in extensive standard setting activities for space applications in its own right. Unlike a number of other SSOs that are predominantly involved in aviation standards and later branched into standards for space applications, the AIAA focuses predominately on space related needs, and addresses aviation issues only to the extent that its membership base believes that it can make unique contributions .

Unlike many SSOs that admit only public or private sector entities as members, the AIAA is a professional society with admits individual as its members, and performs a number of roles for its constituency besides standard setting. Consistent with that status, it relies on the expertise of individual members to develop the technical content of its offerings. Of course, those individuals most involved are usually serving at the direction of their employers, which include U.S. agencies (e.g., NASA, FAA and DoD) and foreign space agencies, such as the British National Space Center (BNSC), Indian Space Research Organization (ISRO) and Japan Aerospace Exploration Agency (JAXA). Large numbers of professors and students from many countries are also members.

AIAA maintains liaison relationships with a variety of other SSOs and space agencies, both in its own right, as well as in its formal roles within ISO subcommittees.

AIAA currently has twelve active committees distributed within five groups (Aerospace Sciences, Information and Logistics, Propulsion, Space Systems, and Structures, Design and Test). To date, its active and now inactive groups have published 29 standards ("Guides"), reports and other documents. 18

One of AIAA's most recent standards is one of the first to be completed with the input of the "next generation" of space participants. That standard is intended for use by the emerging reusable launch vehicle industry, 19 and was developed by a committee including representatives of not only large aerospace corporations such as Boeing, Lockheed Martin and Northrop Grumman, but also representatives of a number of the new entrepreneurial space companies that have sprung up in part in response to the X Prize competition (e.g., XCOR Aerospace, Kistler, TGV Rockets, and Andrews Space). Regulatory perspective was provided through the participation of representatives of the FAA's Office of Commercial Space Transportation (FAA/AST).

II. Non-space SSOs with Space-Unique Activities

As telecommunications capabilities became more robust, orbiting platforms became more attractive as the foundation for commercial as well as scientific and military purposes. More recently, with the advent of the Internet and other technologies, additional commercial opportunities have arisen that have attracted various information technology SSOs to charter working groups to create new standards, or adapt existing standards or architectures to space-based use. Two examples of this type of activity follow.

Open Geospatial Consortium (OGC): Since 1994, the OGC (an international open standards consortium) has been creating geographic information system standards and conducting testbeds and other activities intended to accelerate the development and utilization of GIS technology. Today, it has 284 commercial, government and university members. As of this writing, OGC has published sixteen specifications, and a variety of other published work product. [20]Approximately 125 government, university, military, defense and technology vendor members have participated in space-relevant OGC activities. A core group of approximately 35 members represent the most consistent participants and contributors. [21]

GIS data is increasingly gathered via satellite, and is crucial to a myriad of government as well as commercial uses. The importance of developing proper GIS standards is underscored by the fact that NASA provided pivotal funding to OGC in its early years, as well as credibility. NASA remains a "Strategic Member" of OGC today, meaning that it provides significant unique funding and support to OGC activities that it believes to be particularly significant.

Participation by other types of agencies is also broad, including NASA, NOAA, and USGS from the United Sates, as well as the European Space Agency, German Aerospace Center, European Commission and the Food and Agriculture Organization of the United Nations (FAO) from abroad. National defense departments also figure prominently in the OGC membership, including (from the United States), the Defense Information Systems Agency (DISA), Defense Modeling & Simulation Office (DMSO), Naval Research Laboratory, among others, and the European Union Satellite Centre and the Australian Department of Defense.

A NASA Cooperative Agreement Notice (CAN) provided initial funding to OGC beginning in December 1994. NASA¹s support was vital during the period when OGC was building critical mass in the industry. The NASA CAN program helped fund the creation of an effective OGC Specification Program process. Subsequently, NASA sponsored several OGC Interoperability Program activities, including the Web Mapping Testbed and several phases of the OGC Web Services (OWS) initiative.

OGC maintains formal liaison relationships with a number of other SSOs, including ISO TC211 for Geographic Information, the IEEE Geoscience and Remote Sensing Society, International Society for Photogrammetry and Remote Sensing (ISPRS) and the NATO-affiliated Digital Geographic Information Working Group (DGIWG). OGC and other SSOs have also engaged in a variety of joint projects. An example is the OGC Earth Imagery Reference Model, which is also designated as ISO Project Team 19101-2, operating under ISO TC211. Less formal relationships are maintained with numerous other organizations and working groups.

The OGC Specification Program and Implementation Program conduct a number of activities relevant to space standards, including the following:

- Earth Observation (EO) Working Group: chartered to gather requirements for EO specification developments.
- The Image Exploitation Systems Working Group: several specifications pertaining to accessing and processing remotely sensed data; Earth Imagery Reference Model.
- Sensor Web Enablement Working Group: addressing the use of all types of sensors, including space based sensors, as web accessible resources.
- The OGC Web Mapping Testbed developed the OpenGIS® Web Coverage Service (WCS) which provides access to numerous types of space-based imagery in multiple data formats.
- The OGC Web Services, Phase 2 (OWS-2): demonstrating improved ease of access to space based observations using NASA and Spot Image data.

Perhaps most intriguingly, an OGC Planetary Working Group has been approved to apply OGC technologies to mapping and investigating planets other than Earth.

Object Management Group (OMG) Space Domain Task Force: [22]

OMG is an international open standards consortium founded to create technical standards (which it refers to as specifications) to enable interoperability among enterprise application software. Members with broad architectural interests may join "horizontally" and participate in all activities, or "vertically" as "Domain Members" in the industry area that is of particular interest to them. OMG has c. 500 commercial, government and university members. The large number of members (for this type of SSO) is in part due to the availability of the Domain Membership option, which facilitates cost-effective participation by end-user entities as well as vendors. Currently, OMG supports 21 Domain subgroups, representing members in areas such as healthcare, telecommunications, robotics and finance (under its Domain Technical Committee) and 35 subgroups under its Platform Technology Committee. An Architecture Board ensures ongoing coherence among the output of these many subgroups [23]

OMG maintains formal and informal liaison relationships with a number of organizations, including ISO/IEC (which have accepted three OMG specifications as standards through the Publicly Available Specification (PAS)) process, the World Wide Web Consortium (W3C), and ANSI.

OMG has a very large catalog of specifications, profiles and other work product . [24]

Its "flagship" specifications and platforms include the Model Driven Architecture (MDA) and the CORBA middleware platform. Its Domain Task Forces standardize "Domain Facilities" for their particular industries.

The OMG Space Domain Task Force (DTF) was established in late 1999. Its current goals include clarifying space, satellite and ground system requirements; encouraging the development and use of CORBA [a core OMG specification] based space, satellite and ground system domain software components; and encouraging the use of UML [an OMG specification] to describe the architectures of distributed space systems in a standard way.

A broad range of vendors and government agencies (both military and space) have been involved in the Space DTF from an early date. Both NASA and the European Space Operations Centre (ESOC) are members of OMG and the Space DTF, and NASA is represented on the OMG Board of Directors.

Recently, the Space DTF announced the formal formation of a close liaison relationship with CCSDS, bringing closer alignment between the standards-based activities of space agencies and vendors. Under this relationship, the CCSDS will collocate most of its twice-yearly standards meetings with OMG Technical Meetings, which are held five times each year, and both organizations will work together on standards-setting projects. The first joint meeting was held in Athens, Greece, in March 2005.

The Space DTF's output includes the recently adopted XML Telemetry and Telecommand Data specification, which is widely used and required in the industry. The current energies of the Space DTF are directed towards creating a "metamodel" for Space command languages, allowing standard tools to convert scripts from one language to another. The Space DTF cooperates internally with other OMG groups working in areas such as Software-defined Radio and security.

III. Space-relevant SSOs

The number of SSOs that produce standards that are relevant to the design, manufacture and operation of space systems are too numerous to mention. NASA, for example, actively tracks the standards of 50 SSOs, and participates in 30. Due to the multitude and breadth of SSOs in this category, a single example must suffice for purposes of this article.

ASTM International (ASTM): ASTM was formally known as the American Society for Testing and Materials, from which its current name derives. The shift in name acknowledges the fact that while ASTM is an ANSI-accredited SSO, it is one of the largest SSOs in the world, and draws its more than 30,000 individual members from more than 100 countries. It has been in existence for over a century, and has developed and maintains thousands of standards.

A large number of ASTM's standards are relevant to the manufacture and testing of space vehicles and supporting infrastructure, and ASTM is therefore representative of the many traditional standards organizations that space agencies and vendors of aerospace materiel either participate in actively, or rely on passively for standards that they implement.

Recently, ASTM began moving into the aerospace area, when it chartered a new initiative called Committee F38 on Unmanned Aircraft Systems. 25 Its work includes development of standards for design and performance, manufacturing quality assurance, flight operations, and development and verification of vehicle software. Over 180 companies, agencies and universities are participating in this committee, with manufacturers and suppliers representing the largest group (38%), closely followed by government agencies, including NASA (34%). Representatives of universities, consultants and trade associations comprise the balance. 26

ASTM maintains liaison relationships with many organizations, with the specific ties relating to the subject matter in question. In the case of its aerospace activities, Committee F38 has established liaison relationships with the AIAA and the Radio Technical Commission for Aeronautics (RTCA).

IV The Future

A. Challenges: While the aerospace industry is in some ways a mature industry technologically, the standards infrastructure that supports it is still not as complete and coordinated as many experts would prefer. Significant progress has been made in some respects (e.g., in developing the type of information and communications technology standards needed to enable the type of cross support between space agencies that CCSDS was formed to achieve), but coherence is still lacking in others.

The European response: Due to the process of European unification, Europe took actions that preemptively addressed this issue more than a decade before it became critical in the space industry generally. The process of unification in Europe brought the realization that real progress on economic and industrial coordination would be dependent in part on breaking down the trade barriers that had been deliberately or inadvertently created by European nations in order to benefit their domestic industries. In clearing away these barriers a much more unified process of standard setting, and many new organizations for that purpose, were created.

One such organization is the European Cooperation for Space Standardization, which commenced joint creation of European space standards in 1993. Its mission is to:

[D]evelop a coherent, single set of user-friendly standards for the European space community, which means ESA, its member states and their space industry….By abolishing the multiplicity of project requirements of the various partners in ECSS, and concentrating on a single set of standards - from which all generic requirements of future space projects would be derived - this initiative should drive an increase in industrial efficiency. This policy will generate more recurring products or services, at reduced cost with consistently high quality. 27

Concurrently, the aerospace industry (both aviation as well as commercial launch) was also identified as an area for aggressive international competition by European industries through new collaborations such as Airbus and Arianespace. As a result, further incentives existed to maximize the efficient, multi-national use within Europe of the standards needed to cooperate and succeed in this endeavor.

The result of the formation of the ECSS and related initiatives, as well as the generally more centralized approach being taken in Europe in the aerospace industry, has been that Europe achieved a valuable head start over the United States on creating the type of centralized, coordinated environment in which necessary standards for space applications could be identified, developed and adopted.

The American response: Historically, the United States standard system has been far more distributed than that which existed in any individual European nation. Consequently, while Europe was centralizing its space standards efforts, efforts in the U.S. were more disjointed and overlapping, and lacked any central management other than which existed as an indirect result of government (and particularly Department of Defense) procurement. Even at NASA, each of the eleven NASA Centers independently selected and utilized the standards that it chose to implement until less than ten years ago.

The increasing need for the United States to pursue a more coherent and effective aerospace standards policy has been well articulated in an extensive report issued in January of 2005, which is clearly mindful of the advantages being enjoyed by Europe as a result of a decade of increasingly unified activity. The report, titled “The Future of Aerospace Standardization," 28 was prepared under the auspices of the AIA for the Technical Operations Council and the Board of Governors of the AIAA by the eleven members of the Future of Aerospace Standardization Working Group, chaired by Laura Hitchcock of The Boeing Company. The authors included nine representatives of major aerospace vendors, plus a representative of the U.S. Defense Standardization Program Office, and one from the AIA.

The report examines aerospace standardization systems, processes and organizations in order to define the standards and standard systems the authors deem to be necessary to support the continued and future growth of the aerospace industry. Each of its eight chapters (some of which address broad topics, such as “vision” and some of which cover specific industry sectors, such as defense) includes a specific recommendation for needed action. The final chapter is entitled “Space – a Growing Role for Standards.”

The scope of the report is broad, and its tone is urgent. As stated in the Executive Summary:

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 *[sic]* 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

Echoing some of the concerns that the ECSS was formed to address, the report notes that the aerospace industry (aviation and space) utilizes hundreds of thousands of standards created by almost 150 different SSOs worldwide. In consequence, the report concludes that very significant benefits could be gained by rationalizing and consolidating this vast system, and “identifying a suite of universally accepted standards which contains little to no duplication." 30 Echoing a desire heard more and more frequently in diverse standards sectors, the report also calls for a central registry of relevant standards.

Similarly, the report notes that unless a “leadership organization” capable of providing a central forum and point of integration within which U.S. based efforts can be coordinated and integrated, “an ever increasing percentage of the technical data that supports our industry will be developed in venues controlled by foreign aerospace industry." 31 At the same time, the report also calls for global implementation of the most appropriate standards, and a more effective global conformity assessment system. 32

The tone of the report turns almost bleak when it turns to standards for the U.S. space industry, calling the level of standardization “minimal,” and repeatedly citing Europe favorably for its success in addressing most of the problems that the report highlights for U.S. curative action.

While the report notes that the reusable, non-military vehicles are expected to begin to be developed at some point in the future, it also stresses that commercial launches using existing systems have been essentially flat for four years, and little significant improvement is forecast before 2013 for this industry segment. 33 In the face of this lack of increasing market opportunity, the report finds both lack of initiative on the part of U.S. industry, and also increasing risk of loss of what business is available to Europe, which already dominates the commercial launch marketplace.

The report finds that most existing consensus based standards relate to safety issues, while most other parameters are still defined by military specifications or other customer-unique requirements. As noted above, the report notes that while a broad base of standards is in use that are either repurposed, or adapted from, aviation standards, there are still far too few space-unique standards in areas such as propulsion, vehicles interfaces, payload vehicle interfaces, and ground support equipment (some of which, the report notes, Europe has already developed). As a result, the report concludes that “The space industry has clearly not yet recognized the benefits of standardization in these areas,..." 34

As a result of waning U.S. commercial power, the report suggests:

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.* *35 [emphasis added]*

The situation could become further exacerbated if China elects to draw closer to Europe, rather than the U.S., as it pursues its own aggressive space program and becomes more involved in space standards development.

The authors of the report show particular concern over the lead taken by Europe over the United States as a result of its centralized standard-setting infrastructure, concluding:

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 for 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 36

In its concise recommendation relating to the space industry, the report therefore concludes that NASA, the DoD and the Federal Aviation Administration (FAA):

[U]rgently 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 that support US based technology must be a key strategic component of the aerospace industry's standardization strategy. 37

B. Opportunities: One of the major shifts to be anticipated in the future will be the proliferation of companies that are not dependent upon government, or government supported, launch systems. While this industry is in its infancy, commencement of suborbital adventure travel is imminent, albeit on a limited and wildly expensive basis. As these efforts, as well as commercial ventures directed at lowering the per-pound cost of placing payloads into orbit, become more serious, new entrants into standard setting, as well as the need for new types of standards (e.g., for high-strength composite materials) can be expected to increase.

New satellite-based applications and increased use of satellite based data and services may also be expected to proliferate. When invited to identify some of the most interesting opportunities for space standardization in this area, George Percivall, Executive Director, Interoperability Architecture for OGC, offered the following as examples:

Three challenges in dealing with space-based data are access, encoding formats, and value-added processing. Standards reduce these challenges.

Access to space-based data has been difficult as imagery typically has been in off-line archives in unique formats. Further, remote sensed data has not been traditionally represented as geographic information, making it difficult to integrate space-based data with other sources. Recent advances in geospatial standards…[will enable] moving space imagery to on-line servers [which] will enable ready access of terabytes of earth imagery to large numbers of users.

The ready accessibility of earth imagery data is welcome progress, but it is also necessary that users will be able to extract the information relevant to their interest. Space-based remote sensed imagery is huge in data size but may provide little information to the user until it is processed by complex algorithms. OGC has demonstrated scripting of this processing that can be set up by a subject matter expert in remote sensing and then executed by analysts and decision makers with less experience with remote sensed data...38

V. Conclusions

Fifty years following the advent of the space industry, and 26 years after man first walked on the moon, the state of standardization for space applications is at something of a crossroads, and particularly so for U.S. industry.

In some respects, global standards are adequate, but this is true only where the need has been most urgent (as with space agency mission cross support) or where an existing base of aviation standards existed that could be used or adapted to space industry usage. In most space-unique areas, however, standards exist largely in the form of military specifications and (increasingly) European-origin form.

At the same time, the space industry is largely stagnant, due in large part to the perpetually high cost of putting payloads into orbit (c. US $10,000 per pound). Development of a common and comprehensive suite of standards is one of the few non-revolutionary methods that can be utilized to significantly reduce this cost, thereby offering the hope for wider commercial opportunities.

In another example of a crossroads, the United States, which had gained undisputed leadership in the space industry by the culmination of the Apollo program, is in danger of being supplanted in that role (at least in the ongoing commercial marketplace) by Europe. Leadership in setting the global standards urgently needed by the industry may therefore go by default to Europe unless the warnings of the Future of Aerospace Standardization report are heeded and acted upon by U.S. stakeholders.

The status of space standardization as described in this article, then, is one of both potential and concern. In the plus column, there are hundreds of organizations around the world that are capable of creating the standards needed, provided that they are motivated by their members to do so. And in the negative column could be placed the same statement. Much good work has been done, and many useful liaison relationships formed, but there are too many organizations doing too little work, with too much redundancy, and too little attention in some of the most critical areas.

Clearly, if the current administration in the United States is serious about its commitment to reinvigorate the U.S. space program, it would do well to heed the advice of The Future of Aerospace Standardization. If the actions recommended in that report were put into practice, it would represent one of the lowest cost, highest reward strategies that could be employed to achieve the new goals assigned to NASA within available budgets, and maintain the historic leadership that America has provided in the past in the pursuit of discovery and commercial activity in space.

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Endnotes

1. The author is indebted to the following individuals, each of whom was interviewed in connection with this article: Paul Gill, Technical Standards Manager, NASA; Craig Day, Program Manager, American Institute of Aeronautics and Astronautics; George Percivall, Executive Director, Interoperability Architecture, Open Geospatial Consortium; Jon Seigel, Vice President, Technology Transfer, Object Management Group; and Pat Picariello, Director, Developmental Operations, ASTM International.

2. The report may be found here

4. ISO TC 20 summary information page. The current business plan for this committee, which contains a useful overview of the aerospace industry and a segmentation of that industry, may be found here.

5. ISO information page for ISO TC/SC 13

6. American Institute of Aeronautics and Astronautics ISO TC 20/SC 13 U.S. TAG information page

7. The full list of standards may be found here

8. AIAA

9. The full charter may be found in the Operating Procedures for the TAG, here

10. ISO information page for ISO TC/SC 14

11. ISO TC20/SC-14 Business Plan Executive Summary, page 1 (October 14, 2004)

12. The full list of standards may be found here.

13. See AIAA ISO 20/SC-14 US TAG page

14. A concise and helpful history of CCSDS may be found at: http://public.ccsds.org/about/history.aspx

15. A diagram showing all working groups by Area may be found at http://public.ccsds.org/sites/cwe/default.aspx

16. The complete list of published material may be viewed at: http://public.ccsds.org/publications/AllPubs.aspx The interrelation of CCSDS standards is graphically represented at: http://public.ccsds.org/publications/default.aspx

17. Other SSOs in this category with significant activities supporting space applications include the Society of Automotive Engineers (SAE) and the American Society of Mechanical Engineers (ASME).

18. For a complete list, see http://www.aiaa.org/content.cfm?pageid=313

19. Guide to the Identification of Safety-Critical Hardware Items for Reusable Launch Vehicle Developers

20. Published specifications may be found at: http://www.opengeospatial.org/specs/?page=specs

21. Interview with George Percivall, Executive Director, OGC Interoperability Architecture.

22. The home page of the Task Force may be found at: http://space.omg.org/

23. The full OMG committee and subgroup structure may be viewed at: http://www.omg.org/homepages/index.htm

24. The full catalog of OMG published specifications may be accessed at: http://www.omg.org/technology/documents/spec_catalog.htm

25. The committee's home page may be found at: http://www.astm.org/COMMIT/COMMITTEE/F38.htm

26. Interview with Pat Picariello, Director, Developmental Operations, ASTM International.

27. Kriedte, K., A New Approach to European Space Standards, ESA Bulletin Nr. 81 (February 1005), at: http://www.esa.int/esapub/bulletin/bullet81/krie81.htm

28. Hitchcock, Laura et al., The Future of Aerospace Standardization, AIA (January 2005).

29. Ibid., page vi.

30. Ibid., page viii.

31. Ibid., page ix .

32.Other recommendations less relevant to this article include the need for better infrastructural tools for standard setting, and more assistance from the U.S. Department of Defense in moving military specifications into the voluntary consensus standards system for development of industry-wide standards. See report, pp. xiii and xiv.

33. Ibid., page 46

34. Ibid., page 47

35. Ibid., page 49

36. Ibid., page xv.

37. Ibid.

38. Interview with George Percivall