Defense Standardization Program

Journal

JULY/SEPTEMBER 2017

Warfighter Support

Everything You Wanted to Know about ASIC but Were Afraid to Ask

Interoperability and Standards for a SATCOM-Connected World
DISA's Satellite Interoperability and Standards Committee

Satellites and the Emergence of Rendezvous and Proximity Operations

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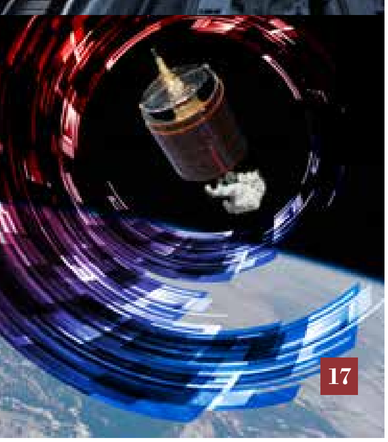
Contents *July/September 2017*

Departments



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Director's Forum

Standardization and Its Role in Supporting the Warfighter

Providing our warfighters the provisions they need for battle is a big job, and standards help to make this job doable. We provide the technical documentation to support procurement, testing, inspection and acceptance, qualification, and other technical support for goods ranging from meals, ready to guns and ammunition; to planes, ships, and tanks; to protective armor worn in combat; and to communications equipment and electronic components used among our coalition partners. Nearly every item in our supply system relies to some extent on the Defense Standardization Program.

Standards play a key role in supporting the warfighter and in ensuring that our efforts on the battlefield are both efficient and effective. Standards allow systems to work together—Cesare Balducci, former deputy director of the NATO Standardization Agency, once said, "There is no capability without interoperability." Interoperability is what allows us to be a lethal fighting force. It allows us to fight alongside our coalition partners, and it affords us the ability to be one step ahead of our adversary.

This issue of the ***DSP Journal*** explores how important standards considerations are when developing systems to support the warfighter. For example, this issue covers how the Air and Space Interoperability Council (ASIC) uses the standards development process to ensure that there are no impediments to effective and efficient coalition air operations. Standards allow ASIC to meet its mission, and by leveraging collective expertise, ASIC is better able to enhance air and space operations and to provide a mechanism to resolve coalition interoperability challenges. Whether through facilitating working groups, creating mutually agreed-upon air standards, or providing a management architecture to orchestrate stakeholder participation and deliver organizational outcomes, the standards process helps raise awareness of joint requirements, maximizes information exchange, and minimizes duplication of effort.

Gregory E. Saunders
Director
Defense Standardization Program Office

You can also read how the Defense Advanced Research Projects Agency (DARPA) along with the National Aeronautics Space Administration (NASA) are working together to create operational safety standards. Few appreciate how much our communication, navigation, and commerce systems rely on orbital assets. In the past, when we lost a satellite, rebuild and relaunch was the only path to recovering the capability. Looking to work with an accredited standards developing organization, DARPA and NASA are hoping to develop on-orbit servicing safety standards that will allow these agencies (as well as commercial space servicing companies) to relocate, repair, and refuel unmanned satellites. These standards will be primarily based upon integration and harmonization of industry and government best practices. DARPA is confident that private-sector collaboration in this development process will yield results beneficial to all parties.

Lastly, Dave Locker discusses the role of standards in parts, materials, and processes engineering (PM&P). Industry and military standards provide the framework to establish common terminology, achieve economies of scale and efficiency, and define level playing fields for competition. The automotive and commercial aviation sectors have identified common performance elements that suppliers must address. To take advantage of these similarities, MIL-STD-11991 ("General Standard for Parts, Materials, and Processes") and its associated Data Item Description, DI-STDZN-81993, provide an efficient mechanism to implement PM&P engineering on a program by including requirements for a PM&P management plan in the contract statement of work. These established business practices provide an excellent opportunity for military systems to leverage existing capabilities in the supply chain to achieve high reliability and lower cost, which in turn benefits the warfighter.

Outfitting, supplying, and provisioning for our men and women in uniform is a big job. When we think of outfitting the warfighter, we tend to think of the large end-use items. But we should not forget how standards early in the development of our systems provide the foundation for those large items in the battle space. As some smart logistician once said, systems don't fail—parts fail. It is part of the role and responsibility of our standardization program to ensure the quality, reliability, and safety of those parts so that systems remain fully available and operational.

Everything You Wanted to Know about ASIC but Were Afraid to Ask

By the ASIC Management Committee

The Air and Space Interoperability Council (ASIC) is a Five-Eyes (FVEYs) interoperability organization comprising the air forces of Australia, Canada, New Zealand, the United Kingdom, and the United States. Originally conceived by the air force chiefs of the United States, Canada, and the United Kingdom in 1947 following World War II, the Air Standardization Coordinating Committee (ASCC) was formally established by the signing of a memorandum in 1948. Being a major air force in its own right, the U.S. Navy formally joined in 1951, and then in a wider coalition embrace, Australia joined in 1964 and New Zealand followed a year later. A review of ASCC in 2006 brought about by collective experiences in the Middle East area of operations changed the focus of the organization from standardization to one of interoperability, and it was rebranded as ASIC to underscore the transformation.

Despite ASIC's significant legacy as a FVEYs information-sharing organization, the work of the council, and indeed its very existence and raison d'être, is generally not widely known within air force, defense, and wider related communities. Reasons for this state of affairs are many, but they fundamentally reside in a historical attitude of "quietly getting on with the task and not blowing one's own trumpet." This article provides an opportunity to change that.

So What Does ASIC Do?

ASIC strives to ensure there are no impediments to effective and efficient FVEYs coalition air operations—that is, the ability to work together in pursuit of common aims through a shared understanding and agreed commonality, where appropriate, in techniques, tactics, and procedures. In a nutshell, it's to enhance interoperability!

How Does ASIC Operate?

Interoperability is a key tenet of respective national defense policies and strategies. Further, enhanced interoperability leads to more effective use of resources and concentration of efforts within a coalition. ASIC provides a mechanism to resolve coalition interoperability challenges facing the five member nations by leveraging collective expertise to enhance air and space operational effectiveness and efficiency.

ASIC VALUES

Shared vision. The greatest strength of ASIC member nations is our common heritage, language, and close strategic relationships.

Trust and understanding. ASIC has built up an extraordinary professional relationship since its inception based on a strong history of coalition participation. The networks established have fostered strong and ongoing connections and mutual respect and understanding. A clear understanding of our respective air forces' doctrines, capabilities, and limitations is essential in conducting effective coalition operations.

Collaboration. Each member nation brings unique experience, knowledge, and ability to the table. These traits are shared through the ASIC forum; the interoperability that derives from the exchange of knowledge results in a synergy of military capabilities and is of significant importance in a fiscally constrained environment. ASIC allows member nations to achieve interoperability, economy of effort, and operational effectiveness.

Commitment. Each ASIC member nation has affirmed within its respective defense statement that it is committed to fostering interoperability. This commitment is further demonstrated by the appropriate allocation of national resources to meet project timelines as well as the obligation to adopt, promulgate, and implement all relevant ASIC agreements. Where a nation has cause to reserve the right to implement, either partially or fully, promulgated ASIC products, such implications from this action will be clearly understood and acknowledged.

Accordingly, particular mechanisms to affect the ways ASIC interacts with targets and stakeholders are both measured and graduated:

- Facilitating working groups to address identified "friction" in FVEYs coalition air operations
- Creating mutually agreed-upon FVEYs air standards applicable to expeditionary air operations
- Sharing information among the ASIC nations on training, tactics, and procedures—predominantly through advisory and information publications
- Loaning equipment between ASIC nations for test and evaluation purposes
- Providing a management architecture to orchestrate stakeholder participation and deliver organizational outcomes.

ASIC MANAGEMENT

ASIC management consists of a three-tier system:

National directors provide the strategic direction and authorize the annual tasking and lines of operation for the council, and they are appointed at the general-officer level from each member nation.

A Washington, DC-based **management committee** oversees day-to-day operations and performs management duties by implementing the strategic direction, chairing the working groups, and acting as the conduit between the council's operational tiers. The committee is typically established at the O-5 level by representatives from each member nation's air force.

Working groups are established along generally agreed-upon doctrinal "war-fighting concepts" and provide an operator-level approach to address ASIC tasking. Their definitions and descriptions are developed and bound in an interoperability context. The functional concepts describe the desired levels of interoperability, so that work can be properly focused. Roles or tasks are listed that might be performed within a particular functional concept. Nations appoint a head of delegation, who represents their interests within the working group, and various subject matter experts (SMEs) to tackle the specific issues germane to the task at hand. The working group predominantly interacts at a distance (virtually) but gathers once per calendar year to determine and finalize output and outcomes.

ASIC WORKING GROUPS

Aerospace Medicine

Consisting of the surgeon general (or equivalent) for each member air force, the Aerospace Medicine Working Group encompasses all aspects of aviation medicine such as the following:

- Hypoxia effects and mitigation
- Aviation medical standards
- Safety, survival, and aeromedical equipment.

Aeromedical evacuation in C-17 aircraft.

Agile Combat Support

The Agile Combat Support Working Group embraces the gamut of two main trade groups—engineering and logistics. The predominant activity is focused on expeditionary operations, and it addresses issues involving the following:

- Airfield operations and support equipment
- Aircraft engineering and airworthiness
- Logistics supply and integration.

Air Mobility

The Air Mobility Working Group's emphasis is interoperability across the range of air transport roles, and it encompasses air movements, airlift, air-to-air refueling, and airborne operations. Typical focus areas include the following:

- Air terminal operations
- Carriage of dangerous goods
- Airdrop of equipment and personnel.

Intelligence, Surveillance, and Reconnaissance

The Intelligence, Surveillance, and Reconnaissance (ISR) Working Group focuses on the seamless integration of all the elements inherent in the field of ISR. Particular interest lies in the tasking, collection, processing, exploitation, and dissemination (PED) of assured information to support commanders. This includes the following:

- ISR network integration
- FVEYs coalition ISR product PED
- Air reconnaissance interoperability.

Force Application

The Force Application Working Group's attention is on the employment of interoperable FVEYs coalition air power to deliver kinetic and non-kinetic effects across the spectrum of operations. This group's body of work includes the following:

- Command and control (C2), particularly in air campaigning
- Joint battlespace control
- Targeting authority training.

Force Protection

The Force Protection Working Group focuses on expeditionary airfield security and includes a subgroup of experts in chemical, biological, radiation, and nuclear (CBRN) environments. Its scope includes the following:

- Force protection doctrine and tactics
- Nuclear, biological, and chemical (NBC) training standards
- Chemical protection design
- CBRN-explosives (CBRN(E)) defense standards.

Fuels

The Fuels Working Group's interests extend to fuels, oils, lubricants, and gases, and it aims to standardize techniques and procedures in the testing, certification, and acceptance of aviation fuels, including alternative fuels. Standards in this group include the following:

- Petroleum handling equipment
- Sampling techniques
- Contamination limits.

ASIC LIAISON

ASIC recognizes that there is a spectrum of stakeholder involvement in coalition operations, ranging from infrequent, chance, or opportune through to "cheek by jowl" in the conduct of primary business. Although ASIC activities are focused on the air forces of the member nations, consideration is to be given to joint issues. Accordingly, the management committee and working groups must maintain regular liaison with other defense and scientific defense-related interoperability organizations to coordinate their efforts. Working group members must coordinate their activities with other services on a national basis. Liaison requirements are established in order to

- raise awareness of joint standardization requirements,
- maximize information exchange,
- avoid duplication of effort, and
- provide mutual assistance.

What ASIC Can Do for You…

ASIC provides a mechanism to resolve coalition interoperability challenges facing ASIC member nations by leveraging collective expertise to enhance air and space operational effectiveness and efficiency. Interoperability is not a naughty word!

A management committee liaison with the DC-based Multifora is conducted through formal coordination meetings three times a year, enabling the management committee to identify opportunities for collaboration, potential duplication of effort, and interoperability deficiencies. The management committee also conducts an ad hoc liaison with any appropriate forum as necessary to progress specific issues of mutual interest.

PRODUCTS

In addition to facilitating the networking of like-minded SMEs across the FVEYs' community, ASIC's primary outputs are a variety of FVEYs documents focused upon increasing operational effectiveness through enhanced interoperability. They comprise the following:

Air standards: An agreement by all five nations to follow the same procedure, process, or technical standard.

Advisory publications: Providing advice on procedural or material developments where standardization may not be possible or appropriate.

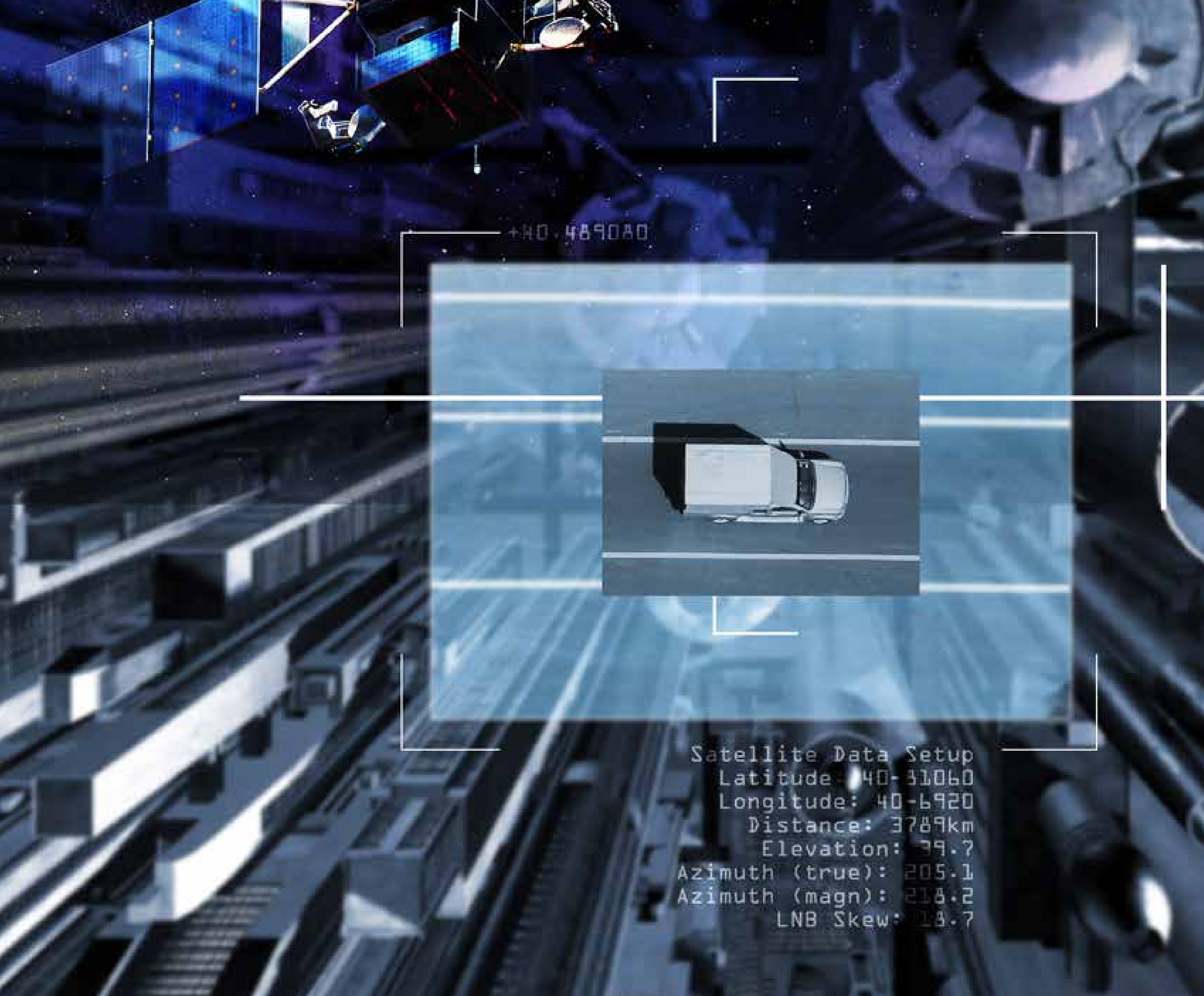
Information publications: A vehicle for the sharing of useful information between nations.

Reports: ASIC acknowledges the benefit of leveraging any liaison opportunity or activity to validate ASIC outcomes and publications and also interact with or provide FVEYs input to those other entities engaged in relevant interoperability-focused events. FVEYs reports will be developed after any such engagement.

Interoperability and Standards for a SATCOM-Connected World

DISA's Satellite Interoperability and Standards Committee

By Henry Tran and Matthew Yingling

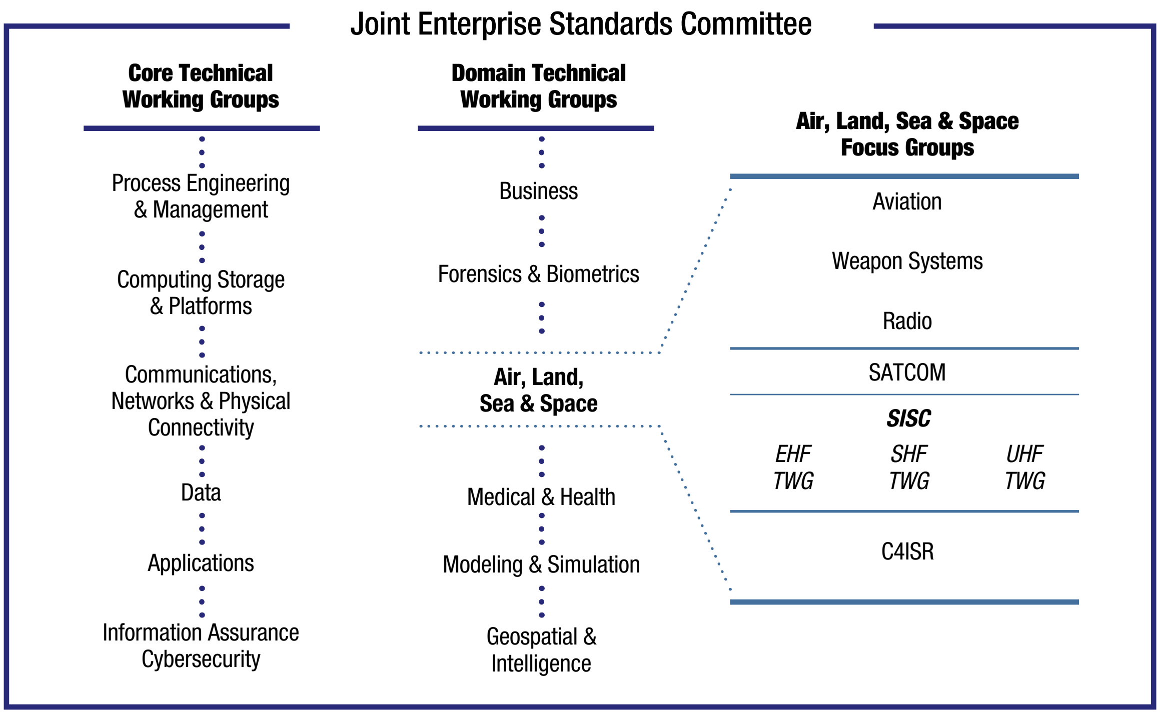


The Defense Information Systems Agency (DISA) established the Satellite Interoperability and Standards Committee (SISC) as a joint management group to oversee all activities involved in maintaining, developing, and approving DoD satellite communications (SATCOM) military standards (MIL-STDs). DISA's authority in this area is derived from

- DoD Instruction 4120.24, Defense Standardization Program (DSP), July 13, 2011;
- DoD Manual 4120.24, DSP Procedures, September 24, 2014;
- DoD Instruction 8310.01, Information Technology Standards in the DoD, February 2, 2015; and
- DoD Directive 5105.19, Defense Information Systems Agency, July 25, 2006.

Figure 1 shows the SISC's relationship with other entities in the Joint Enterprise Standards Committee (JESC).

Figure 1. The SISC's Relationship within the JESC



The SISC operates under the oversight of the JESC as a focus group working under the Air, Land, Sea, and Space Domain Technical Working Group. The SISC primarily reports to the JESC, although it also reports to the Military Command, Control, Communications, and Computers Executive Board (MC4EB) regarding North Atlantic Treaty Organization (NATO) standardization issues.

The centralized use of this committee promotes joint and combined interoperability, which is imperative, as SATCOM resources are scarce and critical to the warfighter. Similar to all standards bodies, the SISC pursues standards identification, development, adoption, and review. However, the SISC focuses on military use of SATCOM, as it fulfills a unique role within IT governance entities. This ensures that DoD-controlled satellite infrastructure is protected from interference or damage from noncompliant systems in multiple-vendor environments. The SISC is chartered to oversee all activities associated with the development, adoption, adaptation, maintenance, and coordination of military-unique satellite communications standards under the Telecommunications Systems Standards standardization area to ensure joint and combined interoperability. The SISC develops, approves, and maintains both new and existing standards related to the SATCOM systems for which DoD has responsibility. Further, the SISC facilitates interoperability by providing assistance regarding the following[1]:

- Implementing applicable SATCOM standards
- Planning and/or performing certification testing on equipment that is required to comply with SATCOM standards
- Evaluating all applicable DoD Information Technology Standards Registry (DISR) change requests forwarded for action
- Supporting JESC and IT standardization processes.

The SISC is especially concerned with DoD-managed SATCOM military standards, but other standards applicable to the SISC may come from industry, international, or federal government entities, including the following[2]:

- General Service Administration and Department of Commerce's National Institute of Standards and Technology
- Commercial, non-governmental standards
- NATO
- Allied and coalition international standardization agreement bodies.

The SISC meets three times a year, or approximately every 4 months, and reviews all SATCOM-related change requests from the DISR enterprise standards base update cycles. It also plays a lead role in guiding military standard development and reviews all SATCOM-related standards until they are handed off to DSP for formal adjudication and publishing. A major goal of the SISC is to foster end-to-end (E2E) interoperability, scalability, effectiveness, and efficiency of DoD SATCOM resources by providing proactive discussions on future SATCOM needs and challenges and reactive efforts to address existing needs and challenges.

SISC standardization activities are reported through the Defense Standardization Program Office.

[1] Satellite Communications Interoperability and Standards Committee Charter, September 1, 2016.

[2] See Note 1.

Committee Membership

DISA chairs the SISC, which has voting membership from each of the armed forces, combatant commands, and other DoD and Intelligence Community (IC) organizations invested in DoD SATCOM standards. DISA also provides a secretariat. Other participants are invited as necessary to support tasks or present SATCOM-related information for the SISC.

The SISC is especially interested in Extremely High Frequency (EHF), Super High Frequency (SHF), and Ultra High Frequency (UHF) radio frequency technologies. For each of these areas, a technical working group is formed to develop new DoD standards and address revisions or updates to existing standards. These technical working groups are made up of SISC members with knowledge in the particular area along with other subject matter experts from the services, DoD organizations, and agencies.

SISC Roles

Many organizations create commercial standards, including the International Organization for Standardization and the Institute for Electrical and Electronics Engineers. There are also standards organizations for coalition forces. NATO creates its own standards, or standardization agreements (STANAGs), that define processes, procedures, terms, and conditions for common military or technical procedures or equipment between the member countries of the alliance. The SISC plays a defining role in determining if such standards meet DoD requirements or if military needs justify drafting new standards documents that DoD will maintain. Even when new standards are required, they may be heavily influenced by existing standards and specifications, with alterations to accommodate the new, unique needs of the DoD community. The SISC also oversees the development of STANAGs for synchronization with respective U.S. military standards. In addition, the SISC plays a role in providing guidance to DoD representatives on NATO SATCOM standards working groups, including the NATO SATCOM Capability Team. Such guidance is passed onto the MC4EB.

Supporting DISR

DISR tracks standards used for interoperability and net-centric services across the Department of Defense Information Network (DoDIN). Standards may be categorized as “emerging,” “mandated,” “mandated sunset,” or “inactive/retired” and may originally come from military, coalition, or industry sources. The SISC serves as the review board for SATCOM standards tracked in DISR.

SISC members have insight into their organization’s SATCOM needs. Corporately they have a wealth of knowledge on existing and proposed systems. With this information, they are equipped to make appropriate recommendations as standards come up for review.

- **Emerging standards** are those under evaluation for future systems or that may be currently in use when no mandated standard is available.
- **Mandated standards** are those core standards defining interoperability for the DoDIN and throughout DoD. These standards are mandated for the management, development, and acquisition of new or improved systems throughout DoD.

- **Mandated sunset standards** are those with predefined events and dates to move the standard to inactive/retired. These events are typically determined outside of the scope of the SISC.
- **Inactive/retired standards** are tracked but should not be used for new or upgraded systems without a waiver. When systems, using a mandated standard, are pulled out of use or upgraded to a new standard, the standard may be reassigned as inactive/retired.

As the SISC representatives are the subject matter experts, the recommendations for DISR standards are then passed onto the JESC for final approval.

Past Work

MIL-STD-188-164, the standard for Wideband Global SATCOM (WGS) terminals, has received several updates over the years. The MIL-STD-188-164B revision added support for SATCOM On-the-Move and two classes of small, disadvantaged terminals. More recently, Change Notice 1 to MIL-STD-188-164B was completed, which included support for phased array-based antennas. This changes to mandatory requirements to define performance metrics and not implementation choices, as well as careful consideration of performance requirements to protect our negotiated spectrum commitments. As traditional antenna designs were not excluded in the new standard, an appendix was added to help partition the requirements applicable to phased array systems.

Recently, the SISC fostered changes to the Integrated Waveform (IW) suite of military standards to incorporate modernized cryptographic requirements. The SISC also oversaw development of the Mobile Objective User System (MUOS) terminal MIL-STD.

Current Work

In addition to its general standardization efforts, the SISC is also actively monitoring the status of the MUOS program and tracking the need to update standards related to terminal interoperability. Standards played the same role in prior IW and legacy SATCOM waveforms.

The Joint Enterprise Network Manager (JENM) and other programs dependent on multi-vendor/system interoperability are also regularly monitored. JENM is used to provision and manage a large number of DoD radios, and each radio must support a set of common interfaces.

The SISC is currently supporting the development of a standard for the new Protected Tactical Waveform (PTW). PTW is heavily derived from existing government waveforms, as no industry-backed waveforms could meet the design goals for PTW. PTW is being designed to be both frequency band agnostic and satellite architecture agnostic, so as to maximize potential applications. The goal is to develop an anti-jam capability that would meet or exceed current capabilities while eliminating the expenses and complexities of features required to perform well in nuclear conflict. The new waveform is being developed with the support of all three major services, which will also promote broad adoption across the U.S. military space community. Industry partners are supporting this effort as well. Government ownership of the standard defining the waveform will allow for broad competition with industry or potential international partnerships.

Future Work

In the coming year, the SISC will continue to monitor the progress of the UHF, SHF, and EHF SATCOM systems and work with DoD components and the IC as they prepare military standards. This work will help ensure that government and industry can broadly adopt the resulting standards. The SISC is also looking into how the latest American National Standards Institute (ANSI)/VITA-49 could benefit DoD resources should the applicable standards be adopted over the prior editions. ANSI/VITA-49 is a series of standards that apply to digital intermediate frequency (IF) communications, allowing multiple vendors to be selected across the whole communication scheme as well as supporting multiple simultaneous operations on each IF packet. The new standards would limit the number of supported packet formats, allowing more devices to be fully compliant with the standards.

Change Notice 2 to MIL-STD-188-164B is being prepared to account for intermodulation products filtering, transmission harmonics, and spurious emissions, to receive chain linearity and alignment and better characterization of maximum linear effective isotropic radiated power for multi-carrier enterprise class terminals.

The SISC is also actively involved in updates to MIL-STD-188-165, the standard for WGS modems. Revision B is being prepared to update content for modern technologies and remove legacy reference devices that are no longer in use. In addition, more supporting references are being added along with theoretical curves to aid in specification.

The most recently announced new work for the SISC is the upcoming Network Centric Waveform (NCW). The WIN-T program office is sponsoring NCW, which is a multi-frequency time division multiple access mesh network with adaptive coding modulation and power control. DISA has announced its intent to use NCW to provide mesh services. The waveform specification will be government controlled, but not the implementation. This will create an incentive for industry sources to reduce modem cost while maintaining interoperability across vendors.

The SISC has recently updated its charter to better reflect today's environment and structure, and it will continue in its third decade of service this calendar year. The warfighter's need for increased use of SATCOM resources is only expected to grow in the coming years. The role of the SISC will remain critical to ensure that communications are available and jointly interoperable.

Summary

DISA's mission for the SISC is to foster adoption, development, and maintenance of necessary SATCOM standards to support warfighters in their ever-increasing need for reliable data and voice communications. By looking at government, international, and commercial entities for potential standards, the SISC can find the most appropriate solutions for each problem. With broad membership and regular meetings, the SISC can identify needs before they become liabilities, while also strengthening warfighter capabilities and options in the field.

DISA Chairperson
Jessie L. Showers, Jr.

Infrastructure
Directorate Executive

DISA Secretariat
Henry H. Tran

SATCOM
Engineering Branch

SISC Membership

The following are members of the SISC:

- U.S. Army
- U.S. Navy
- U.S. Air Force
- U.S. Marine Corps
- National Security Agency
- Defense Information Systems Agency
- Defense Intelligence Agency
- National Reconnaissance Office
- Joint Staff
- Department of Defense Chief Information Officer
- U.S. Army Space and Missile Defense Command/Army Forces Strategic Command
- U.S. Strategic Command.

About the Chairperson

Jessie L. Showers, Jr.
Infrastructure Directorate Executive
Operations Center

Jessie (Jess) L. Showers Jr. is the network infrastructure executive for the Defense Information Systems Agency. He is responsible for planning, resourcing, sustaining, and evolving the Department of Defense Information Network core. The DoDIN core consists of satellite communications, gateways, optical transport, organizational messaging, mobility gateways, and networks. His responsibilities also include Senior National Leadership Communications, U.S. Secret Service support, and Multinational Information Sharing. These networks provide information superiority and a global enterprise infrastructure in direct support to the president, secretary of defense, joint chiefs of staff, combatant commanders, DoD components, and other mission partners. Additionally, Mr. Showers is the senior network expert for the Defense Information System Network and DISA executive for SATCOM. He provides executive oversight for development, management, and operationally responsive SATCOM solutions that enable joint warfighting. He is a tri-chair of the SATCOM Systems Engineering Group and DISA representative at the Defense Space Counsel (DSC) and DSC+1.

About the Authors

Henry H. Tran

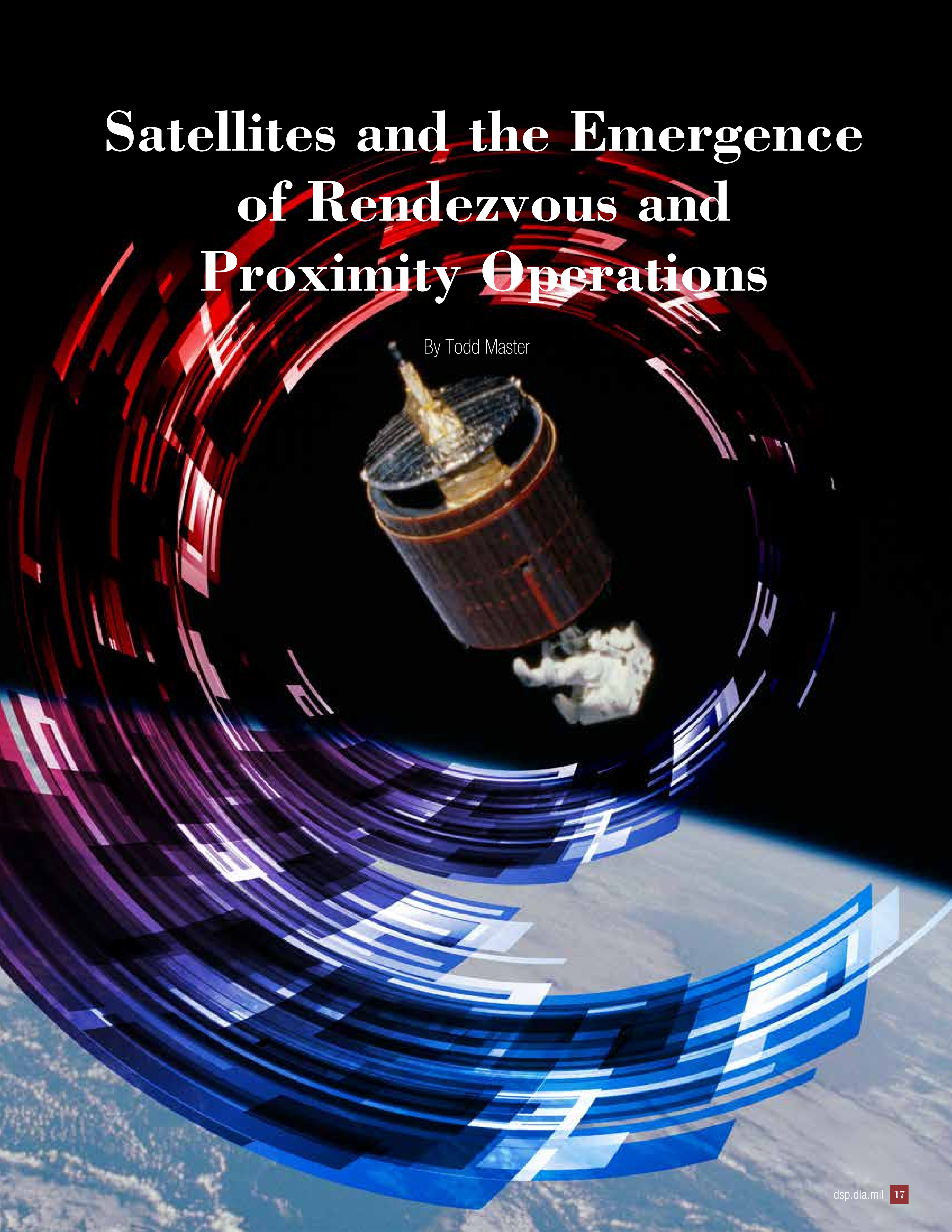
Henry Tran is a senior systems engineer within the Defense Information Systems Agency Communications Engineering Division. Before DISA he had over 25 years of experience in terrestrial wireless and satellite telecommunications, Internet Protocol networking, and electronic warfare systems. He has been a SISC secretariat for the past 8 years and is involved in a lead role in the development of narrowband, wideband, and protected band (UHF, SHF, and EHF radio frequency) military interoperability and performance standards for SATCOM terminals and modems to support E2E DoD SATCOM and national security systems.

Matthew Yingling

Matthew Yingling is a senior engineer at Xenotran Corporation with 12 years of experience in wireless communications. He has been supporting DISA on interoperability standardization and SISC tasks for the past 5 years, with a particular focus in UHF SATCOM systems.

Satellites and the Emergence of Rendezvous and Proximity Operations

By Todd Master



The use of satellites for commercial and government purposes is so ubiquitous in our lives that many people would be surprised to realize the extent of their day-to-day reliance upon them. The general public can relate to services delivered from space such as satellite television and radio, Global Positioning System navigation, and pictures of the next approaching hurricane. Nevertheless, few appreciate the enormous amount of ordinary communications and commerce that rely on orbital assets, and even further from the public eye are the systems that our military relies on daily for command and control, intelligence, surveillance, and reconnaissance, and other critical tactical and strategic purposes. The way we live our lives and work, as civilians and warfighters alike, is wholly reliant on space systems.

The delivery of these services relies on satellites that are always working, with no maintenance required other than software updates. There is no adequate analog in any other infrastructure or military system. We build our ships, aircraft, and ground systems with a plan for maintenance, repair, and upgrade. By contrast, spacecraft have always been designed and built to perform perfectly from their commissioning through the end of their useful life, at which time they are either deliberately burned up in the atmosphere or retired to a graveyard orbit. When we have a problem with a satellite in its initial fielding, it often results in the total loss of the system—with a rebuild and relaunch typically as the only path to recovering capability.

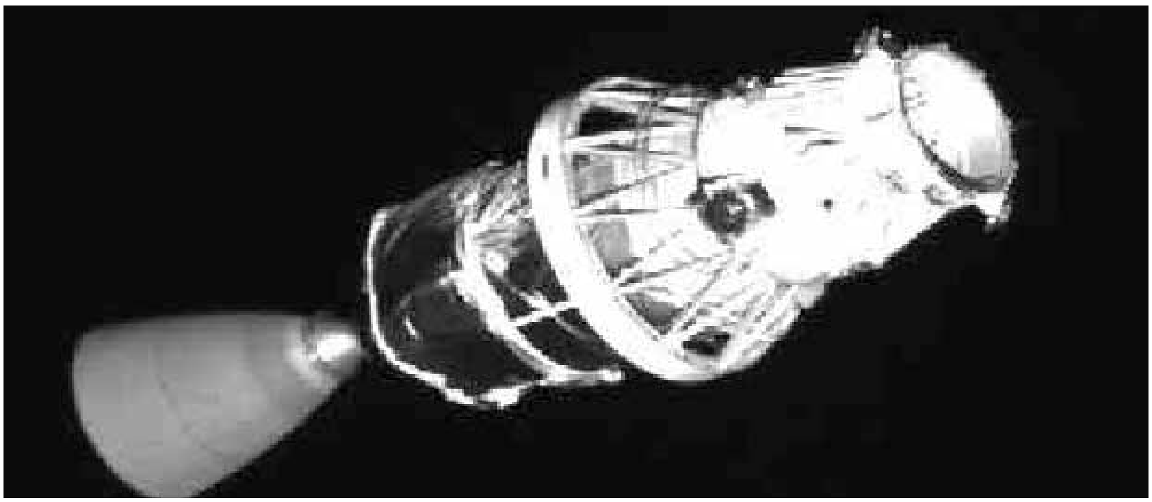
With the exception of the International Space Station, the former Russian Mir Space Station, and a handful of astronaut-led activities during the Space Shuttle era (most notably the Hubble Space Telescope missions), spacecraft placed on orbit have never been repaired or physically upgraded. However, a new era is beginning in which multiple commercial and government entities are pursuing capabilities to bring a range of robotic servicing capabilities to space. These capabilities are planned to include services such as relocation, repair, detailed inspection, hardware upgrades, and refueling.

The act of bringing two unmanned satellites together, a process known as rendezvous and proximity operations (RPO), is fundamental to all of these services. RPO is not new to the United States—the National Aeronautics and Space Administration (NASA) has been performing RPO since 1965, with the rendezvous of Gemini 6 and 7, as shown in Figure 1.

Figure 1. Gemini 6 Spacecraft Observed From The Hatch Window Of The Gemini 7 Spacecraft During Rendezvous Maneuvers, Distance Approximately 9 Feet

U.S. government RPO programs continued from the Apollo era through NASA's manned spaceflight programs and include current trips to the International Space Station. The Department of Defense also has conducted extensive unmanned RPO experimentation, including eXperimental Small Satellite (XSS)-10 (see Figure 2) and XSS-11 and the Automated Navigation and Guidance Experiment for Local Space (ANGELS), and it now has an operational RPO program in the Geosynchronous Space Situational Awareness Program (GSSAP). Beyond unmanned RPO, the Defense Advanced Research Projects Agency (DARPA) and NASA learned even more through the execution of DARPA's Orbital Express program, an advanced demonstration mission that performed docking and refueling between two unmanned systems in 2008.

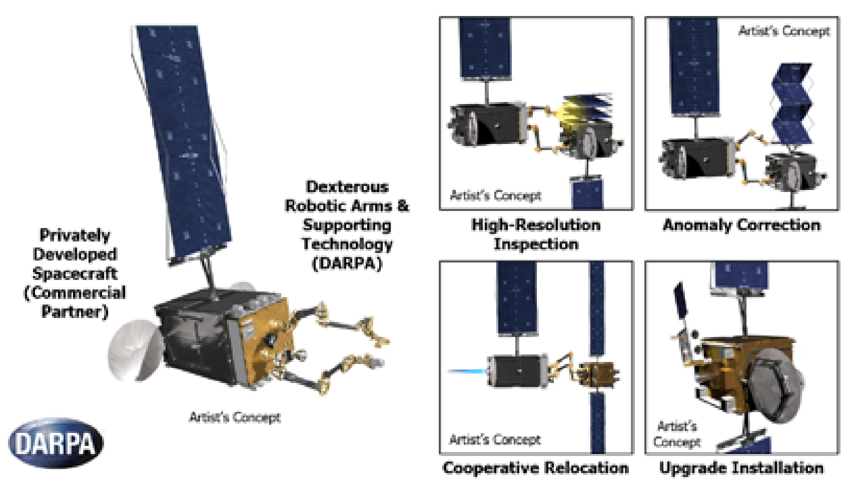
Figure 2. Spent Upper Stage Of The Delta Ii Launch Vehicle Imaged By The Xss 10 Satellite



DARPA and NASA plan to continue the development of advanced servicing capabilities with their Robotic Servicing of Geosynchronous Spacecraft (RSGS) and Restore-L programs, respectively (see Figure 3). In addition to these government pursuits, numerous commercial entities are emerging with plans that span the spectrum from life extension to on-orbit assembly.

Figure 3. Darpa's Rsgs Program Aims To Facilitate Robotic Servicing Of Geosynchronous Satellites

Robotic Servicing Vehicle and Envisioned Missions



As a result of experience gained in all of the aforementioned efforts, the U.S. government has developed an expansive number of lessons learned and operational expertise. However, few of these lessons are published, and the few that are publicly available are typically specific to the hardware platform or specific mission scenario addressed by each program. RPO presents a unique set of technical challenges, yet broad-based best practices that address the "art" of RPO and on-orbit servicing have never been explicitly developed to capture the U.S. government's knowledge of the subject. That is a shortcoming DARPA is interested in addressing.

Why now? The commercial satellite RPO and servicing industry is in its nascent phase. Forward-leaning operators, investors, and insurers are assessing the impact that such servicing might have on their business operations. A small number of satellite developers are building commercial systems that can perform a range of missions—from rendezvous and inspection at a distance to complex operations where the two satellites are docked to each other. Even developers who have no interest in building servicing vehicles themselves are considering how to implement features into their designs that would allow them to be serviced in the future.

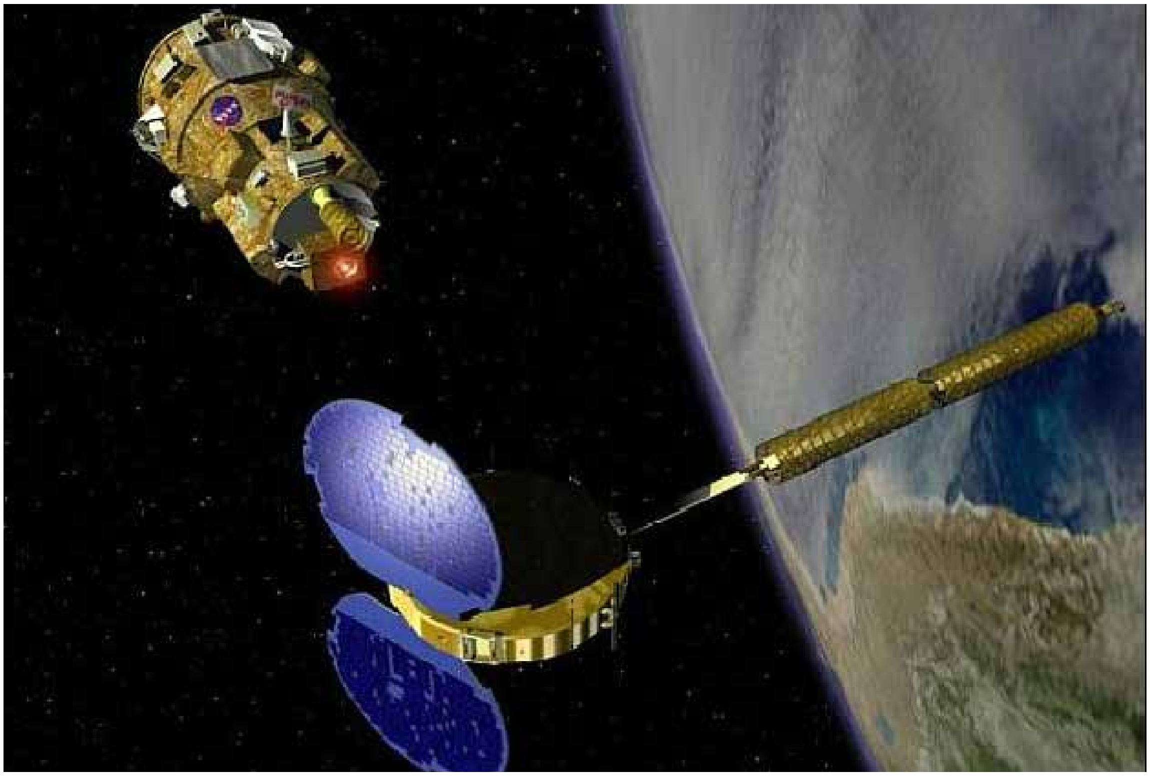
This newly emerging commercial industry is already competitive, but a common interest is shared by all parties: create a new market in satellite servicing and capture the maximum share of that market in the most profitable fashion possible. Still, the growth of a robust satellite servicing market is not a certainty. Many potential pitfalls could upset the market before it takes off. These include regulatory issues, where the government may have challenges clearly defining what is required for companies to safely conduct on-orbit rendezvous and/or servicing operations. In addition to or because of regulatory issues, a lack of certainty on the part of investors or insurers in the satellite servicing market could also disrupt it before it takes off. Most of these uncertainties relate to concern for the safety of these new commercial operations on orbit.

Another potential hurdle is one of mindset and tradition. After all, the intentional bringing together of two commercial objects in space is something that is quite contrary to the normal course of space operations. Indeed, commercial operators are typically trying to consider means to avoid other objects, not bring them together. Toward that end, through a process managed by the Joint Space Operations Center, the U.S. government is constantly on the lookout for intersecting orbital paths and will issue conjunction warnings for satellites that are at risk of colliding on orbit. Understandably, there is some concern that a mistake made during the course of RPO or docking could lead to a debris-generating collision that could affect the operational environment of entire orbital regimes, potentially rendering them useless for either commercial or government satellites. (If you've seen the movie ***Gravity***, you've seen an overdramatized—but not wholly inaccurate—view of how this could happen as high-speed orbital debris rips numerous satellites, a Space Shuttle, and two space stations to shreds.)

In spite of these risks, U.S. RPO operations to date have never resulted in a significant debris-generating collision. That is not to say that operations have been perfect. NASA's Demonstration for Autonomous Rendezvous Technology (DART) was planned to demonstrate rendezvous with another U.S. government space asset, the Multiple Paths, Beyond Line of Sight Communications (MUBLCOM) satellite, and maintain proximity operations at a range of approximately 1 kilometer (see Figure 4).

Due to a series of problems with the relative navigation system and procedures, DART unintentionally collided with MUBLCOM. Thankfully, the collision was at low velocity and did not result in any debris generation of note—but crucial lessons were learned in the process, and this was summarized in a NASA Mishap Investigation Report.

Figure 4. Artist's rendering of the DART mission rendezvous with the DART S/C at top and MUBLCOM at bottom (image credit: Orbital Sciences Corporation).



Within the U.S. government, the lessons of DART were shared and implemented on other systems in development. Moreover, while the DART mission was particularly notable, the design, testing, and operations of other spacecraft have contributed myriad other lessons learned. Because of the potentially high consequences at stake—and because space is a shared domain where a mishap by one can affect all—the U.S. government is eager to share these lessons with commercial providers pursuing similar missions.

In an effort to support the nascent commercial servicing industry, DARPA and NASA are launching a private sector–government consortium, the Consortium for Execution of Rendezvous and Servicing Operations (CONFERS). Its goal is to establish a forum in which to develop non-binding, consensus-based commercial standards for safe operational approaches to rendezvous and servicing operations, leveraging extensive government experience conducting such missions.

Open, consensus-based standards developed collaboratively with the private sector can provide a technical foundation to guide best practices for commercial industry and aid in the development of business models. This collaborative approach benefits both the private sector and government, enabling shared lessons learned. It also prevents any one entity (either government or commercial) from imposing its view or technology approach, which could limit commercial growth opportunities.

A CONFERS secretariat will lead the creation of operational safety standards. The secretariat is responsible for standing up the consortium, selecting its membership, setting the agenda for the consortium, managing its operations, and leading the standards research process. The entity that serves as secretariat will hire an accredited standards development organization to develop and publish RPO and on-orbit servicing operational safety standards, based upon the integration and harmonization of industry and government best practices.

DARPA is providing the initial funding necessary to support the secretariat and consortium operations for up to 5 years, at which time CONFERS would transition to a new, self-funded organization. A critical element of the secretariat is to demonstrate the capability to transition to support by contributions from CONFERS member organizations or another business model. DARPA has decided to provide this initial funding to help advance the on-orbit servicing industry, which DARPA anticipates will provide unique, valuable fee-for-service to DoD in the near future. By promoting industry development of consensus standards, it intends to avoid many of the aforementioned pitfalls.

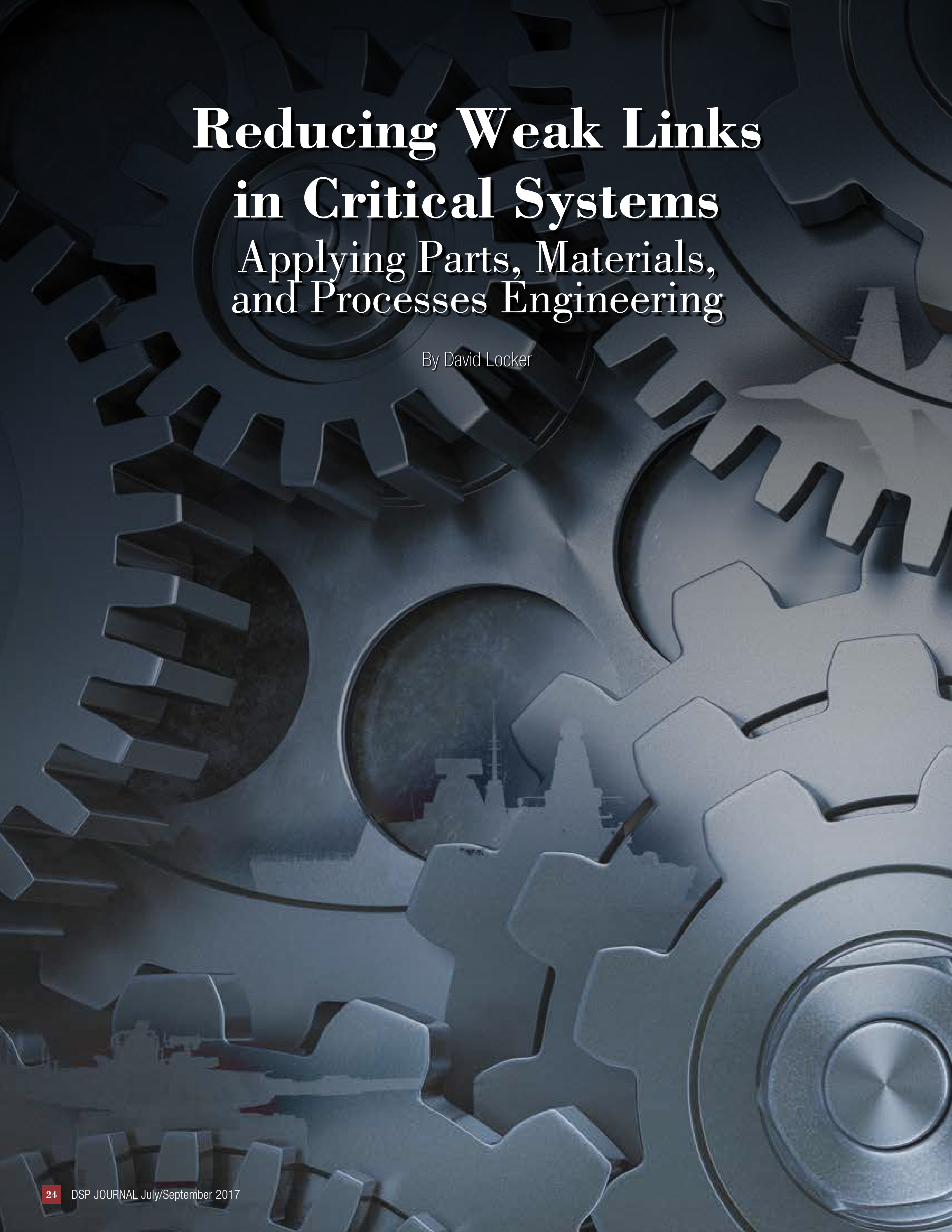
DARPA and NASA have begun work to develop a common, unified U.S. government view on important elements of standards. This work has included addressing elements such as technical definitions of operational techniques, which, in certain circumstances, are used very differently among different organizations. To account for this fact, CONFERS members will determine the specific content of the standards. By defining and agreeing to common language first, we can ensure that the standards written are clear and consistent—a seemingly elementary, but necessary, starting place.

One of the main challenges for CONFERS will be to examine best practices, operational approaches and techniques, and lessons learned from specific missions and hardware and extract the valuable, broadly applicable elements from all of them. Beyond that, there is also a big challenge in writing the standards in such a way that they are neither too proscriptive to be implemented nor too vague to be useful. DARPA is confident, however, that private-sector collaboration in this development process will yield results that are beneficial for all parties.

As the worldwide space industry expands and access to space becomes more routine, the need for norms of behavior—the "rules of the road"—will become increasingly important to preserve the ability of companies and government agencies to safely operate their space systems. Norms can be neither dictated nor externally specified. Rather, they must be determined intrinsically as a result of conduct by the majority of stakeholders. Through CONFERS' publication of clear standards, agreed upon by the world's technical subject matter experts and rooted in operational safety, guidelines for conducting safe RPO and servicing operations will be readily accessible and adoptable. As a result of this effort, we hope to influence norms that allow for expansion of a robust space servicing capability—one that can transform the way we build and operate satellites in the future.

About the Author

Todd Master joined DARPA in April 2016 as a program manager in the Tactical Technology Office. His interests include space launch, space domain awareness, space traffic management, advanced on-orbit operations including robotic servicing, and space policy associated with all of the above. Before joining DARPA, Mr. Master was a mission systems engineer with Orbital ATK, where he was responsible for the development of systems concepts, business strategies, and technical solutions for space situational awareness and other mission areas. He also served as launch operations manager and deputy program director at International Launch Services, directing commercial space launch integration activities on the Russian-built Proton launch vehicle.



Reducing Weak Links in Critical Systems

Applying Parts, Materials, and Processes Engineering

By David Locker

Critical military systems, including any equipment with a high consequence of failure, typically require high system reliability and availability. Effectively accomplishing the high reliability and availability goals requires collaboration among many disciplines, such as systems engineering, quality engineering, and reliability engineering, in addition to parts, materials, and processes (PM&P) engineering subject matter experts. Through disciplined application of PM&P engineering, the design and manufacture of systems can significantly decrease the weak links in the systems development and production phases, to achieve high reliability and availability.

While fault tolerance, such as redundancy, can also improve reliability and availability of a system, such approaches typically induce penalties of increased cost, size, weight, and/or power consumption. In any case, the application of PM&P engineering will increase system reliability and availability. The ***Defense Acquisition Guidebook*** (Chapter 3, Reliability and Maintainability Engineering, Table 48) highlights the importance of applying PM&P engineering in development, production, and sustainment.

Importance of PM&P Engineering and Management

Every system consists of parts and materials and the processes used to assemble them into a product. These elements directly determine the intrinsic reliability of the product as well as the ability to meet performance requirements and key capabilities, such as cost, size, weight, and power requirements. The application of PM&P engineering directly supports the elimination of failure and degradation mechanisms that would preclude a system from meeting its performance requirements.

Properly implementing PM&P engineering principles requires the use of a PM&P management plan on each program to ensure communication of criteria between the supplier and the user. Using a PM&P management plan provides the mechanism to tailor requirements for particular program considerations, but the prevalent similarity of system requirements for military and other high-performance systems allows leveraging of common approaches between programs to aid in controlling costs.

Role of Standards in PM&P Engineering and Management

For parts, materials, and processes used in building military systems, industry and military standards provide the framework to establish common terminology, achieve economies of scale and efficiency, and define level playing fields for competition. Industries with high performance requirements and/or high consequence of failure, such as automotive and commercial aviation, have identified common performance elements that suppliers must address, and many of these elements derive from previous military standards developed primarily for World War II, the Cold War, and the space program. Given the similarities of application requirements and the supply chain entities, these established business practices provide an excellent opportunity for military systems to leverage existing capabilities in the supply chain to achieve high reliability and lower cost.

To take advantage of these similarities, MIL-STD-11991, "General Standard for Parts, Materials, and Processes," uses the same framework as Society of Automotive Engineers (SAE) EIA-STD-4899, "Requirements for an Electronic Components Management Plan." Ensuring effective implementation of PM&P engineering for military systems requires the inclusion of contractual requirements for the development, production, and sustainment of these systems. MIL-STD-11991 and its associated data item, DI-STDZ-81993, provide an efficient mechanism to implement PM&P engineering on a program by including requirements for a PM&P management plan in the contract statement of work.

Elements of PM&P Engineering

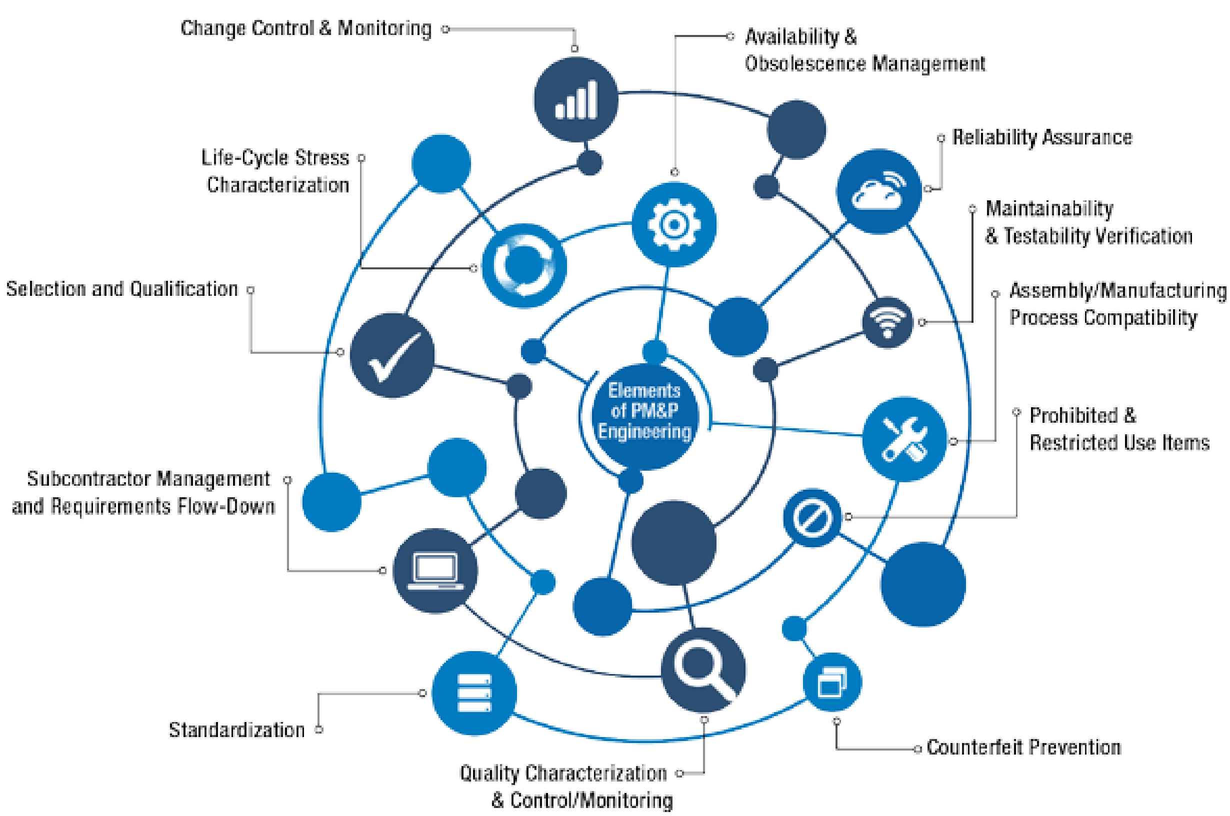
PM&P engineering includes the over-arching elements of

- application life-cycle stress characterization,
- selection and qualification to meet the application, and
- configuration and change management.

As summarized in Figure 1, MIL-STD-11991 defines general and detailed requirements to address these elements and leverages many industry and military standards to efficiently accomplish the goal of assuring that systems meet their life-cycle performance requirements.

In addition to applying basic PM&P engineering principles and standards, the development and use of a lessons-learned knowledge base provides an efficient method to assess design and manufacturing processes for PM&P concerns that typically cause systems to not meet their performance requirements. Practical use of such knowledge bases requires documentation of the technical rationale for application to specific systems, taking into account particular life-cycle environmental and operating stress profiles and reliability requirements.

Figure 1. Parts, materials, and processes engineering and management elements.



Elements of PM&P Management

To effectively ensure that the system design and production address PM&P engineering elements requires establishing and executing PM&P management plans as a part of suppliers' core practices. Such plans provide the vehicle to assure a common understanding between the supplier and the user. To support the consistent and compliant application of program PM&P engineering criteria requires flow-down of the requirements throughout the applicable supply chain parties and establishment of two-way communication of issues and engineering data between each supply chain level. Effective PM&P management plans will aid proper and timely staffing of the PM&P engineering functions at all levels of the supply chain.

Challenges Posed by Commercial Off-the-Shelf Items

For commercial off-the-shelf (COTS) items, parts, and assemblies, the user can impose little or no requirements. This lack of requirements leverage necessitates full performance characterization of the COTS items, particularly for applications with a high consequence of failure. Properly characterizing performance requires a detailed understanding of the design and construction of COTS items to establish suitable qualification criteria. The SAE standard EIA-933, "Requirements for a COTS Assembly Management Plan," provides a framework to address system application concerns for COTS items, and it aids in addressing the considerations identified by the ***Defense Acquisition Guidebook***: "Suppliers can out-source design and assembly, but not responsibility."

PM&P Example: Microcircuits

The considerations required to qualify microcircuits for military applications illustrate the criticality of applying PM&P engineering in developing suitable criteria. Establishing qualification protocols for an item requires knowledge of the mechanisms that degrade the item's performance to the point of failure. The degradation mechanisms depend on the design and construction of the item, sometimes referred to as the "physics of failure." For microcircuits, such an analysis identifies two primary construction types, hermetic enclosure and plastic encapsulated, as shown in Figure 2. Figure 3 provides an outline of the process to determine suitable test protocols for a particular item to meet a particular application requirement. Applying this process to the two microcircuit construction examples in Figure 2 identifies that the encapsulated construction requires accelerated life-cycle moisture testing, as epoxies adsorb and diffuse water vapor, while the hermetic construction requires validation of the hermetic seal that can be accomplished without accelerated moisture exposure.

Figure 2. Comparison of hermetic and encapsulated microcircuit construction.

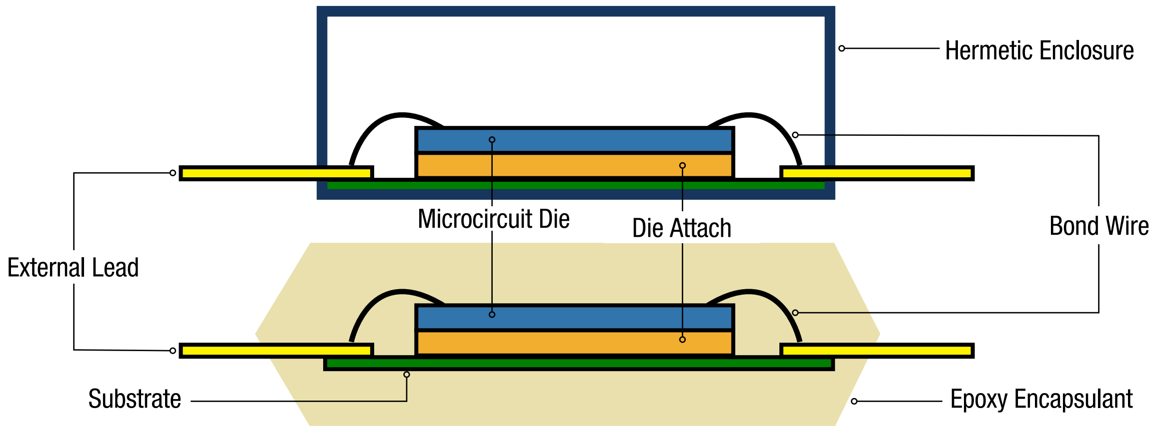
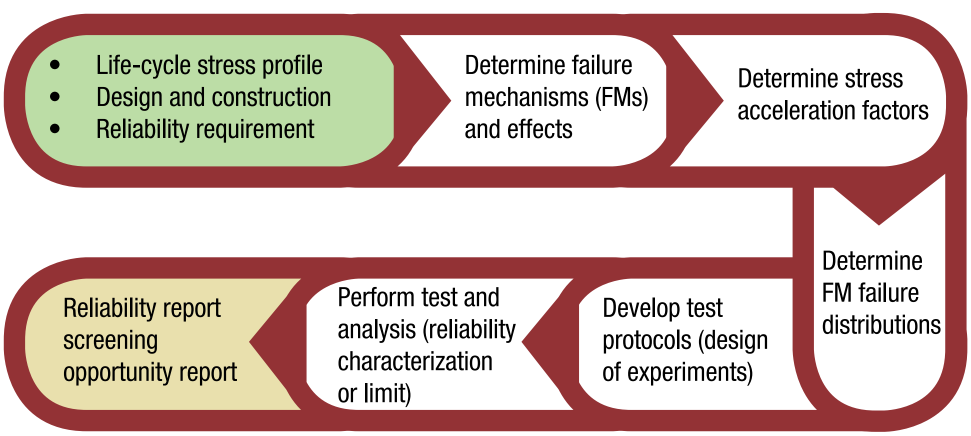


Figure 3. Protocol to develop qualification test requirements for parts, materials, and processes.



Another example of the differences resides in the microcircuit die stress, where in the hermetic construction free space provides the die surface interface, but the encapsulant affects the die surface in the encapsulated construction, leading to different stress test considerations. Vibration and shock will affect these constructions in very different ways. For example, in the hermetic device, vibration or shock can excite the bond wires, but in the encapsulated construction the epoxy restrains the bond wires; however, once attached to a circuit card assembly, vibration and shock stress may transfer through the encapsulant (i.e., "warping" the entire package), yet the typically rigid hermetic construction will have little stress induced by the next level of assembly.

Such detailed analysis indicates that thermal cycling and shock represents the primary stress for hermetic construction, while both thermal cycling and moisture significantly affect the encapsulated construction. Failure mechanism models, such as those documented in SAE SSB-1 and Joint Electron Device Engineering Council (JEDEC) JEP122, provide the methods to translate application life-cycle stresses to suitable accelerated stress qualification tests.

Summary

PM&P engineering provides key capabilities to optimize system designs to meet life-cycle performance requirements in a cost-effective manner. Key industry and military standards provide the framework for consistent implementation of best practices and establish criteria for fair competition among suppliers. Effective implementation of PM&P engineering requires PM&P management plans to document criteria and how the particular system meets the requirements.

About the Author

David Locker has provided parts, materials, and processes engineering support to military programs for 30 years, and he currently works at the U.S. Army Aviation and Missile Research, Development, and Engineering Center. He has participated in multiple industry standards bodies, including the Society of Automotive Engineers, JEDEC, and the Automotive Electronics Council, as well as provided technical input for military standards preparing and review activities.

Program News

Topical Information on Standardization Programs

Nathan A. Godwin

Godwin Named Army Standardization Executive

Nathan A. Godwin was recently named the Army standardization executive, replacing Jim Dwyer, who retired September 30, 2016. He also serves as the principal deputy G-3/4 for Operations and Logistics, U.S. Army Materiel Command (AMC), Redstone Arsenal, AL.

In this role, Mr. Godwin provides program guidance to AMC and its subordinate activities in mission areas including strategic planning, readiness solutions synchronization, and concept development. He also provides integrated planning and execution of logistics requirements that enable efficient and effective execution of AMC's global warfighter support missions.

Mr. Godwin is also responsible for synchronizing AMC's interests and messages with Headquarters, Department of the Army (HQDA), the Assistant Secretary of the Army (Acquisition, Logistics and Technology), and other commands within HQDA's strategic documents and policies.

Events

Upcoming Events and Information

October 16–20, 2017, Washington, DC

World Standards Week

The American National Standards Institute (ANSI) announced that World Standards Week will be held in October in Washington. The annual ANSI-hosted event's purpose is to inspire open dialogue about developments and challenges related to standardization and conformity assessment. To learn more, visit https://www.ansi.org.

December 4–7, 2017, Tampa, FL

DMSMS 2017 Conference: Managing Obsolescence Risk—How to Optimize Budget, Schedule, and Readiness

You are invited to attend the Diminishing Manufacturing Sources and Material Shortages (DMSMS Conference). Qualified attendees (active U.S. military, government, or current DD2354 on file) also will be able to attend the concurrent Defense Manufacturing Conference (DMC) at no additional expense, giving you access to more technical information for the same travel cost. The expanded Exhibit Hall will include all of the leading organizations from both the DMC and DMSMS communities. More information can be found at http://www.dmsmsmeeting.com.

Upcoming Issues
Call for Contributors

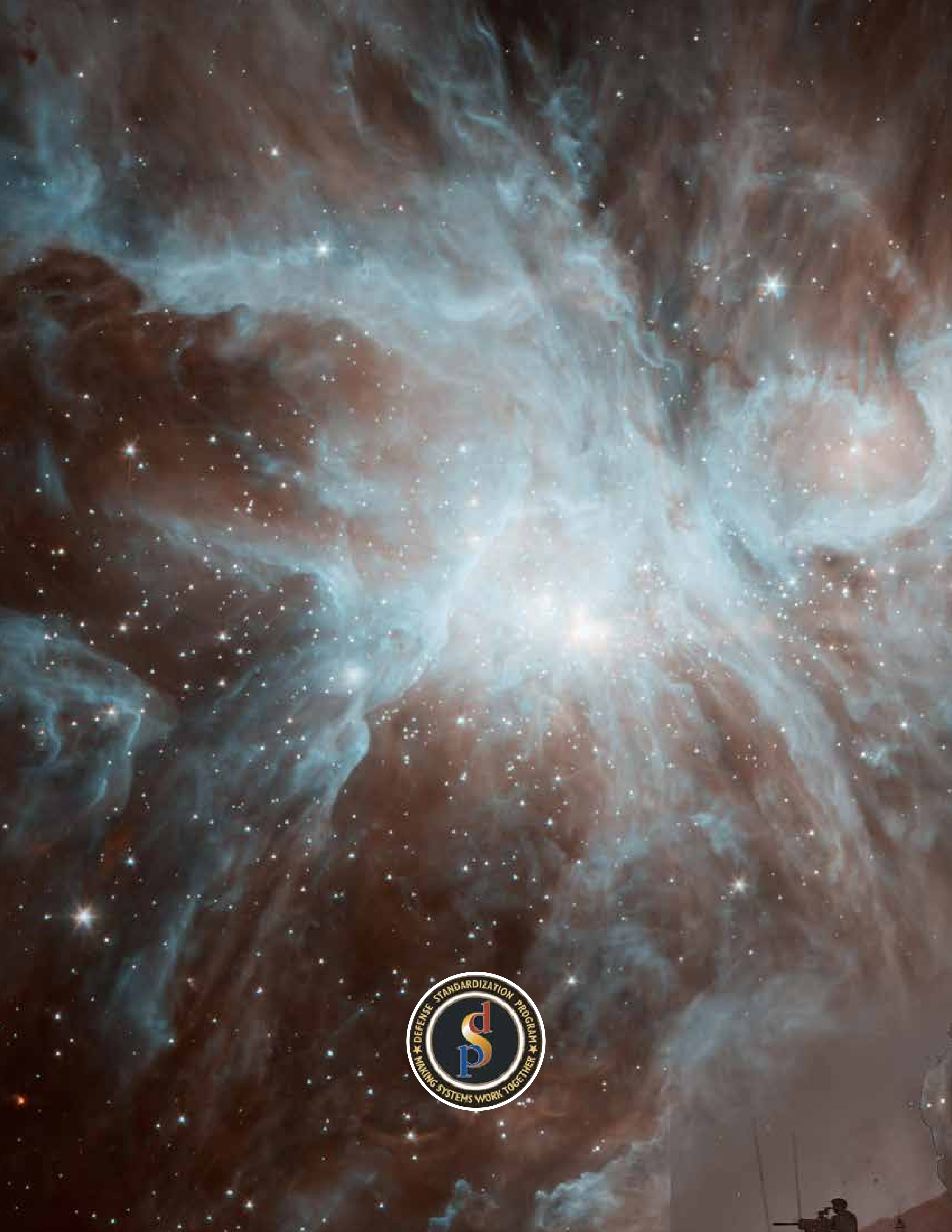
We are always seeking articles that relate to our themes or other standardization topics. We invite anyone involved in standardization—government employees, military personnel, industry leaders, members of academia, and others—to submit proposed articles for use in the *DSP Journal*. Please let us know if you would like to contribute.

Following are our themes for upcoming issues:

Issue	Theme
October/December 2017	Diminishing Manufacturing Sources and Material Shortages
January/March 2018	Standardization Program Tools and Resources

If you have ideas for articles or want more information, contact Nicole Dumm, Editor, *DSP Journal*, Defense Standardization Program Office, 8725 John J. Kingman Road, STOP 5100, Fort Belvoir, VA 22060-6220 or e-mail DSP-Editor@dla.mil.

Our office reserves the right to modify or reject any submission as deemed appropriate. We will be glad to send out our editorial guidelines and work with any author to get his or her material shaped into an article.


DEFENSE STANDARDIZATION PROGRAM
MAKING SYSTEMS WORK TOGETHER