Defense Standardization Program

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International Standards

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Considerations for a NATO Concept of Operations

Evolving NATO M&S Interoperability Standards

Mission Assurance through Energy Assurance

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Nicole Dumm
Editor
Defense Standardization
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Gregory E. Saunders
Director
Defense Standardization
Program Office

Defense Standardization Program Office
8725 John J. Kingman Road, STOP 5100
Fort Belvoir, VA 22060-6220
703-767-6888 | Fax 703-767-6876 | dsp.dla.mil

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Director's Forum

International Standards

On New Year's Eve, I turned in my DoD credentials and ceased to be a U.S. Government employee for the first time in 49 years. It's been quite a career. I began as a GS-3 co-op engineer during my sophomore year in college and came to the Office of the Secretary of Defense and Defense Standardization in 1976. These days, few people stay with one job or organization for a long period, but when I first came into the standardization program, I was in the predecessor office to the one from which I am now retiring as director.

When I started, telephones had rotary dials; computers were as large as buildings and lived in big, environmentally controlled rooms; letters, reports, studies and so forth were written in long-hand and given to a secretary to type on a typewriter—often with carbon copies; urgent messages were sent using teletypes; copies were literally burned onto thermal-reactive paper (that would yellow and turn crispy in a few weeks); large portions of offices were occupied by filing cabinets full of paper; coffee was percolated; and most cars rode on bias-ply tires—radials had just entered the mainstream. There was no internet, email, or cable TV; Lyndon Johnson was president; and everyone wore suits and ties or dresses and heels to work.

Saying that a lot has changed seems trite. I've had the opportunity to help lead the reaction of the standards community to many of the changes that have taken place. I rarely thought about just how influential decisions made at DoD were to the rest of the world—but it's true. I had the privilege of leading one of the largest standards organizations in the world, and representing the United States of America in international standards fora.

I have led, or watched over, or been a part of so many advances in the standards business—moving from paper to electronic libraries; static documents to ones with active links, charts, and formulae; sending out paper "change notices" directing pen-and-ink edits to automatic, near-real-time updating; receiving bound copies of documents in the mail to having nearly instantaneous access online; and so much more. And perhaps more important than any of these physical manifestations, I take some credit for having helped move the Department of Defense, and indeed the entire Federal Government, to greater reliance on private-sector documents, accompanied and accomplished by greater and more effective participation of Federal stakeholders in the activities of private-sector Standards Developing Organizations (SDOs). If there is something I'd like for folks to remember

Gregory E. Saunders
Director
Defense Standardization Program Office

about my career in standardization, it is that I helped to build and use the bridge between private-sector and public-sector standardization activities.

My career has let me visit over 20 different nations. I've met with senators and congressmen, with three different Secretaries of Defense and numerous other Deputy, Under, and Assistant Secretaries. I've testified before Senate Committees; worked on several Defense Science Board and think-tank studies; and become a leader in several different SDOs, most notably Chairman of the Board at ASTM, Aerospace VP at SAE, longtime board member at ANSI, and chairing the Standardization Management Group at NATO. I could go on—it has been a fascinating, exciting, and varied career offering lots of opportunities.

I have always had difficulty talking about my accomplishments. A huge part of that is the fact that none of the things for which I'm given credit could have been accomplished without support, cooperation, guidance, and collaboration from my own staff, and from peers, colleagues, and bosses. I can't overstate how much I have appreciated the relationships I've had that have made accomplishments possible.

Each of the positions I've held has provided rich opportunities, great challenges, and the chance to work with some incredible people. I won't even begin to name people—this message would get way too long and inevitably I would forget to mention someone vitally important. Suffice to say that I have learned from each encounter, I have enjoyed the relationships, and I have been honored to serve in the various positions. We accomplished a lot together and I am indebted to each of you for your support and patience.

Standardization is—as they say about beer, wine, or opera—an acquired taste. I've never met anyone who grew up dreaming of being a professional standardizer. But once in the field, I never looked back. And now I find it hard to let go. We are an amazingly cohesive family. I will miss the day-to-day interaction with my many colleagues and friends. But I am also looking forward to spending time devoted to working in my woodshop, practicing music—vocal and instrumental, and spending more time on various church activities.

I was fortunate to have the chance to recruit and train my successor, and if I do say so myself, I made an excellent choice. Michael Heaphy became the new director of the Defense Standardization Program Office on New Year's Day 2019. He is a Naval Academy graduate, systems engineer, and has been working here since September 2017. He has gained my confidence and support and that of our leadership and of the staff here at DSPO, and has already begun to make his reputation among colleagues in DoD, at other federal agencies, and within the private sector. I am comfortable turning over the keys to Michael.

In closing, let me just say thank you—for the opportunities, for the support, for the learning, for the guidance, for the challenges, and most of all for the friendships.

Standardizing Automated Air-to-Air Refueling

Considerations for a NATO Concept of Operations

Steve McLaughlin, Naval Air Systems Command (NAVAIR)
Mark Pilling, Science Applications International Corporation (SAIC)
Phillip "PD" Weber, Coherent Technical Services Inc. (CTSi)
Ba Nguyen, Air Force Research Lab (AFRL)

INTRODUCTION

Researchers have been studying the possibility of refueling aircraft without a human at the controls for nearly two decades. The aircraft in development are currently automated to fly a predetermined route based on a set of precise instructions. There is no remote pilot actively flying the aircraft with stick and rudder inputs. There is, however, an Air Vehicle Operator (AVO) positioned at a remote control station monitoring the health of the aircraft, standing by to issue updates to its mission as needed, and acting as the pilot in command for the Unmanned Air Vehicle (UAV), or even a set of UAVs. Air-to-air refueling (AAR) refers to the mid-air pairing of two manned aircraft with pilots at the controls physically flying the contact for refueling. When either one or both of those aircraft is replaced by an unmanned or automated aircraft, the process becomes automated air-to-air refueling (A3R), and the contact is made by a computer-controlled flight trajectory. In the United States, the Navy, the Air Force, the National Aeronautics and Space Administration (NASA), the Defense Advanced Research Projects Administration (DARPA), and their industry partners lead A3R development. In 2007, the DARPA/NASA Automated Aerial Refueling Demonstration (AARD) achieved a major milestone with the first automated (piloted but hands off) engagement of a probe and drogue system. Since then, research and development efforts have continued via the Air Force Research Laboratory's A3R program and the NAVAIR X-47B A3R demonstration, which culminated in the world's first contact between an automated unmanned aircraft and a manned tanker.

The NASA AARD program completing the first hands-off engagement. ***Credit NASA***

As the U.S. and other nations continue research and development of UAVs capable of in-flight refueling, the development of an operational system is near. The joint and allied community has spent decades standardizing the AAR mission of creating a mechanical interface (boom mating to a receptacle or probe mating to a drogue). As the community moves toward making A3R a reality, standardization is required to incorporate more complicated systems, such as relative positioning systems, data link systems, and remote AVOs. To achieve a level of interoperability comparable to manned AAR, we must begin the standardization process now.

Understanding this need, the international Aerial Refueling Systems Advisory Group (ARSAG) created a working group to develop recommended A3R procedures. Over the course of three years, the team drafted a concept of operations (CONOPS) and submitted it to the NATO Air-to-Air Refueling Working Group for consideration. Depending on national positions, information from the CONOPS could be included in the NATO AAR Allied Tactical Publication 3.3.4.2 (ATP 3.3.4.2).

A3R CONCEPTUAL OVERVIEW

In the draft CONOPS Systems Requirement Document (SRD), the team formulated baseline assumptions aimed at keeping the process basic, since the idea of A3R is still new to some readers. The procedures currently address single receiver and tanker operations. As system and process development matures, some assumptions can be removed or modified to enable increased complexity.

The overarching assumption is that, to the maximum extent possible, A3R procedures will accommodate current manned AAR standards and procedures. Therefore, the A3R CONOPS uses ATP 3.3.4.2 as a basis while detailing the differences or additional requirements pertaining to A3R. Second, the tanker and receiver pairing can be any combination of manned or unmanned aircraft. UAV has technical capabilities which are assumed to include some degree of autonomy to safely maintain flight and execute a maneuver by selecting from a finite set of predefined actions without supervision unless a human operator intervenes. In the case of manned aircraft, the aircraft may include capabilities for automated refueling, wherein the pilot selects the engagement process as an automated task.

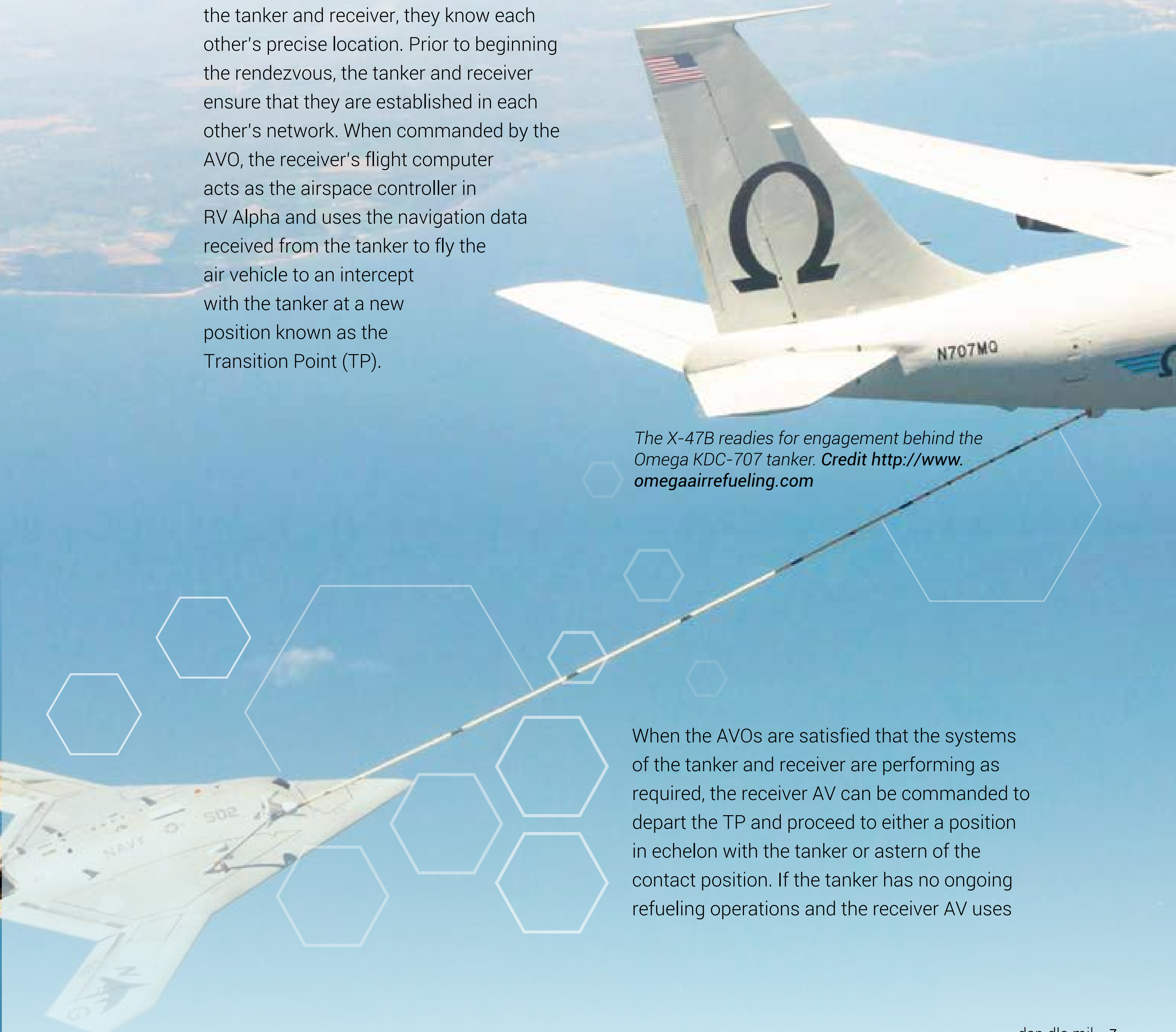
Until unmanned A3R CONOPS are better understood, a key operational assumption is that an AVO gives approval for the UAV to proceed from one phase or position to the next. In this concept, the AAR process is automated within each step but is not a completely autonomous mission. In the future, A3R operations may make full use of autonomy and might need only one message to the AV: Tank. The AV will find the tanker, join, take fuel, depart the tanker, and report tanking complete to the AVO. However, the first step in realizing full autonomy is to exercise and prove the concept of automated operations.

With the AVO approving AV movement from one phase or position to another, it is important to highlight who has operational control of the mission in the air. For these procedures, the tanker aircrew, or AVO in the case of an unmanned tanker, retains control of the airspace around the tanker. The tanker crew or tanker AVO commands the receiving aerial vehicle (AV) (manned or unmanned) through the tanking procedures while the receiver AV crew or receiver AVO responds to the commands, monitors the event, and maintains override authority. These commands are relayed to the AVO, primarily through digital messaging over a datalink, but voice commands may be used to communicate between tanker operator and receiver operator. Enabling the exchange of key navigation and command and control messages requires establishing a datalink network between the tanker and receiver AV. The message content fully defines tanker type, precise position information, control messages, and datalink health status, described in more detail in the following paragraphs.

A3R POSITIONS

To keep procedures simple, a basic rendezvous (RV) procedure, RV Alpha (known to NATO crews and found in ATP 3.3.4.2), was selected. In the RV process, the tanker and receiver join up in flight prior to making contact and transferring fuel. RV Alpha was selected for A3R because of its flexibility and compatibility with unmanned operations. RV Alpha is based on an air traffic controller verbally providing flight vectors to a receiver to join a tanker in an established holding pattern. Because the A3R navigation systems are installed on the tanker and receiver, they know each other's precise location. Prior to beginning the rendezvous, the tanker and receiver ensure that they are established in each other's network. When commanded by the AVO, the receiver's flight computer acts as the airspace controller in RV Alpha and uses the navigation data received from the tanker to fly the air vehicle to an intercept with the tanker at a new position known as the Transition Point (TP).

The TP is 1,000 ft. below and 1,500 ft. in trail of the tanker and is used by the AVO to assess the AV's relative navigation performance prior to commanding the AV any closer to the tanker. Throughout the tanking operation, the AVOs of the tanker and receiver (if both are unmanned) monitor the position of each other and the messaging sent to each AV. If the tanker is manned, the crew monitors position and messaging as well.



The X-47B readies for engagement behind the Omega KDC-707 tanker. ***Credit http://www.omegaairrefueling.com***

When the AVOs are satisfied that the systems of the tanker and receiver are performing as required, the receiver AV can be commanded to depart the TP and proceed to either a position in echelon with the tanker or astern of the contact position. If the tanker has no ongoing refueling operations and the receiver AV uses

Artist rendering of KQ-X in pre-contact position.
Credit DARPA (Defense Advanced Research Project Agency)

a probe and drogue, then the AV can be commanded directly to the tanker's astern (approaching) position of any refueling station (left, right, or center), followed by the contact position. If refueling operations are underway, the AV can be commanded to echelon left to wait its turn. When refueling is completed, the AVO commands the AV to echelon right and then to depart the tanker and continue with the mission.

A3R COMMANDS AND MESSAGING

Since the goal is to seamlessly integrate manned and unmanned operations, A3R will use the existing standardized voice command and control (C2) messages and procedures translated into data link messages an AV's computer can understand.

C2 messages are identified as originating from the tanker or receiver. Using this philosophy and the process described above for control of the airspace and AVs, a message set can cover all operational scenarios. For example, the tanker sends the command "Cleared to tanking position X" where "X" is an approved tanking position, such as echelon left. Upon receipt of the command, the AV responds with a "Wilco," and after successfully achieving the position, sends "Established in echelon left." However, if the AV is already in echelon left, and the tanker command is erroneously sent, the AV responds with "Unable, action already complete." It is incumbent on AVOs to monitor all data link messages and voice communications between the other segments and their respective AVs. At any time, AVOs can override a command sent by the tanker (for safety or other reasons) by sending the correct message. It is also important to note that the AV's responses to C2 messaging, both acknowledgements and actions, are automatic and near instantaneous. Therefore, operators need to be aware of the consequences of commands they issue. The ability to exchange these messages in a quick and timely manner demands a strict set of interoperability guidelines for processing requirements (accuracy, latency) and message structure.

CONTINGENCIES

An important part of automated systems is the ability to respond to off-nominal scenarios. Whether automated or command-based, these responses must be clearly defined and integrated to the process ahead of time. The A3R CONOPS document refers to these responses as contingency responses, and defines a number of them. The most familiar to manned operations is the breakaway maneuver. Either the tanker or receiver AVO can call for a breakaway, at which point the AV separates from the receiver or tanker in both altitude and range to maintain safe flight while the reason for the breakaway is evaluated. Due to the relative navigation and messaging demands of A3R, data link integrity is the key to maintaining safe flight.

If at any time the data link is lost, a lost link contingency maneuver is executed with the receiver descending 1,000 ft. and turning 30 degrees from the tanker's last known position. Some scenarios are unique to boom receptacles, like a boom flight control malfunction or tension disconnect. Others, like fuel leakage, are common to both boom mating and probe mating. The goal in all of these contingencies is to maintain safe flight while safely separating from the other AVs.

SUMMARY

NATO nations have worked hard to achieve interoperability in our current AAR systems, and the interoperability challenges that A3R presents are no less demanding. The procedures introduced in this article are a starting point for standardizing how to conduct A3R, but much more needs to be done. This is no longer a simple mechanical interface. Significant data will be exchanged for each engagement.

A3R requires the use of precision navigation, sensors, and AAR systems combined with a networked data link. Therefore, platforms need to share a specific set of precision navigation, informational, and system status data for successful A3R. At a minimum, requirements for accuracy, integrity, continuity, and availability of the underlying sensors and systems must be defined to enable accurate calculation of a system's own precise location in a reference coordinate frame. All datalink message format and content needs to be defined in a NATO standard. In addition, clearing tanker and receiver pairings for A3R requires significantly more data compared to today's systems.

Overall, the path to operational A3R will be made easier if we begin standardizing the equipment and airworthiness requirements, as well as the procedures, now!

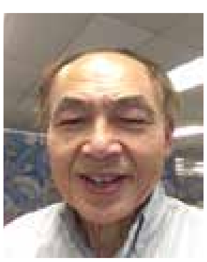
A Calspan Learjet conducts station-keeping exercises as part of the AFRL AAR program.
Credit Calspan

ABOUT THE AUTHORS

Steve McLaughlin *received a master's in mechanical engineering from Clemson University in 1999 and is an engineer at NAVAIR. He has served as a weapons and stores flight test engineer and as a senior engineer for the Fuel Containment and Aerial Refueling Systems Branch. Steve has supported the design and development of the KC-130J, F-35, Buddystore, and X-47 air-to-air refueling systems. He is an active member in the ARSAG, where he serves as co-chair of the Automated Aerial Refueling Group. In 2017, NAVAIR recognized him as an Associate Fellow for Fuel Containment and Air-to-Air Refueling Systems.*

Mark Pilling *is a retired Naval Flight Officer with over 3,500 hours in P-3, F/A-18, T-45, and EA6-B aircraft, and an additional 250 hours in Pioneer UAV as both a mission commander and internal pilot. After retirement in 2003, he joined SAIC as a Program Manager and Senior System Analyst. Mr. Pilling was instrumental in the X-47B demonstration program, assisting in the development, integration, and testing of the carrier-based command and control systems and the tanker-based A3R system. He continues developing and testing advanced aerial refueling system concepts with his support of the Navy's Fuel Containment and Unmanned Carrier Aviation program offices.*

Phillip "PD" Weber *is a Defence Analyst at Coherent Technical Solutions, working on a variety of projects aimed at increasing the effectiveness and lethality of the Carrier Air Wing. A retired career Naval Flight Officer, he served as a Radar Intercept Officer in the F-14A, B, and D, where he completed three operational tours, a tour as an F-14 instructor, a test squadron tour as the F-14 project head, and a command tour. He is also a graduate of the Royal Air Force Command and Staff College. After retirement, Mr. Weber was an advisor to the Republic of China Air Force's operational test squadron. He supports NAVAIR with the X-47B demonstration and the Unmanned Carrier Aviation program.*



Ba Nguyen *graduated from USAF Undergraduate Pilot Training (UPT) under a Vietnamese Military Assistance Program in 1971. He accumulated ~2,500 hours in the A-1, A-37, and F-5 aircraft during Close-Air Support missions, leaving Vietnam on the last day of the war, April 29, 1975. Mr. Nguyen joined the U.S. Air Force Research Lab in 1987 and received a master's in aerospace engineering from University of Dayton in 1991. He has supported the F-16 Variable Stability In-flight Simulator Test Aircraft development, and served as Chief Engineer of Phase I Automatic Air Collision Avoidance System development. As Chief Engineer of AFRL's AAR program, he is AFRL's subject matter expert for AAR development and a senior engineer for autonomy technology development.*

Evolving NATO M&S Interoperability Standards

Wim Huiskamp, TNO, the Netherlands, M&S Standards Subgroup (MS3)
Tom van den Berg, TNO, the Netherlands (MSG-163, MSG-136/MSG-164 co-chair)
Robert Siegfried, Aditerna GmbH, Germany (MSG-136/MSG-164 co-chair)
Adrian Voiculet, NATO CSO, MSCO, MS3 secretary
Björn Löfstrand, Pitch Technologies AB, Sweden (MSG-163, MSG-164)

The NATO Modelling & Simulation Master Plan (NMSMP) calls for the application of Modelling and Simulation (M&S) in areas that include support to operations, capability development, mission rehearsal, training and education, and procurement.

Common standards are essential enablers for simulation interoperability and reuse, including technical architecture standards (e.g., high-level architecture or HLA), data interchange standards (e.g., NATO Education and Training Network [NETN] data model), and best practices (e.g., the Distributed Simulation Engineering and Execution Process or DSEEP).

The NATO Modelling and Simulation Group (NMSG) was officially nominated as the delegated tasking authority for M&S standardization in 2003. NMSG has developed NATO standard agreements (STANAGs), e.g., HLA and Synthetic Environment Data Representation and Interchange Specification (SEDRIS), and standard recommendations (STANREC), e.g., NETN Federation Architecture and Federation Object Model Design (FAFD). A standards profile of existing or emerging standards for M&S is needed. In cooperation with the NATO Standardization Office (NSO), NMSG decided that an allied publication (AP) is the most appropriate document form for a standards profile. In May 2007, NMSG approved the establishment of the M&S Standards Subgroup (MS3), tasked to create and maintain Allied Modelling and Simulation Publication 1 (AMSP-01), "NATO Modelling and Simulation Standards Profile." AMSP-01 establishes a common understanding of the terminology associated with M&S standardization, produces and maintains the list of existing standards (and promising emerging standards) applicable to the M&S domain, and recommends new standardization priorities to NMSG and standards developing organizations (SDOs) based on the identified areas where additional standards are needed.

The Modelling & Simulation Standards Subgroup (MS3) of NMSG coordinates its activities with SDOs, including Simulation Interoperability Standards Organization (SISO), Institute of Electrical and Electronics Engineers (IEEE), and International Standard Organization (ISO), and corporate associations (e.g., National Training and Simulation Association [NTSA] and European Training and Simulation Association [ETSA]).

NMSG is also coordinating research and development of new M&S standards through its MSG task groups. Prominent examples from previous years come from MSG-068/MSG-106 (NATO Education and Training Network) and MSG-073, Generic Methodology for Verification and Validation (GM-VV). Recent and ongoing efforts include the activities on M&S as a Service (MSaaS), which are carried out by MSG-136/MSG-164.

This paper elaborates on the challenges of meeting the alliance's and nation's M&S interoperability needs. The authors comprehensively detail results and current activities. The guidelines and standards developed within NMSG and SISO are based on contributions from national experts and should be leveraged nationally whenever possible to benefit from shared knowledge and improve interoperability.

INTRODUCTION

Modelling and simulation (M&S) has become a critical technology that enables nations and NATO to support operations, capability development, mission rehearsal, training and education, and procurement. Benefits on the training side include saving time, money, and even lives, when training for unsafe scenarios. Economic considerations at the national- and NATO-levels demand a more cost-effective balance between live training and simulation-based training. In addition, M&S facilitates joint and coalition training.

Development of distributed simulations is a complex process requiring extensive experience, knowledge, and skill to design, develop, and integrate systems into a federation that meets operational, functional, security, and technical requirements. Interoperability among distributed systems is a multifaceted problem. It ranges from technical exchange of data through semantic issues dealing with a common understanding and use of information to mutually accepted security measures.

Interoperability is increasingly important, as distributed simulation is rapidly becoming a necessity for mission training. With missions being joint- and coalition-based, we never fight alone. Thus, we need to train together, within and between nations. Standards enable people working with different systems to cooperate and collectively train or experiment. Standards reduce costs and are a natural way to share investments and avoid duplication of efforts on new technologies while reducing risk linked to their use.

Interoperability is especially important to smaller nations. Using international standards

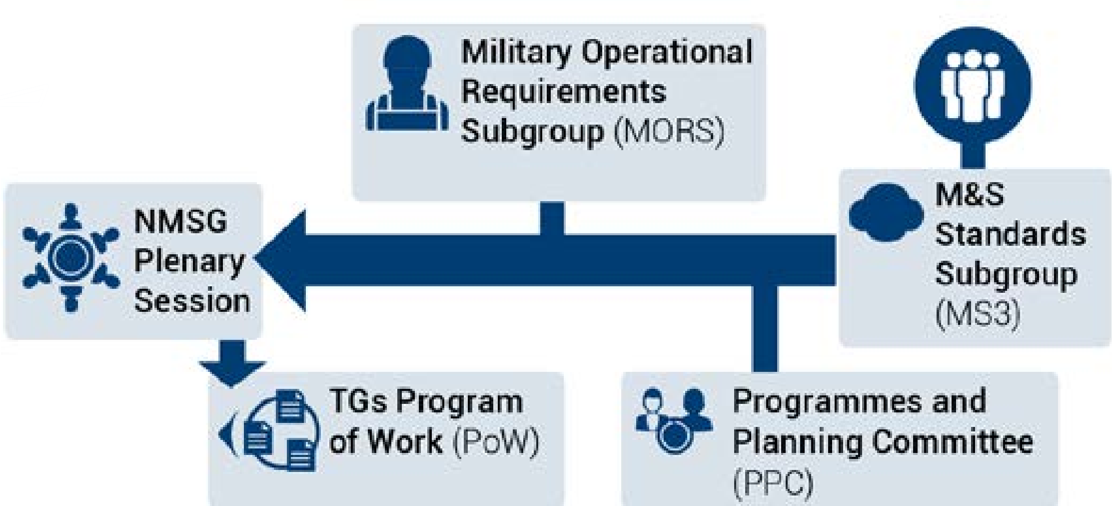


Figure 1: NMSG Structure.

to acquire systems from different vendors in a competitive market makes it is possible for smaller nations to find solutions that are interoperable and within their budgets. Standards protect investments: scenario descriptions, models, and databases may be reused in a variety of applications. They also enable upgrading to newer systems or changing to systems from other vendors. Finally, standards reduce complexity and produce more modular and reconfigurable implementations, reducing development risk.

NMSG

The NATO Modelling and Simulation Group (NMSG) is part of the NATO Science and Technology Organization (STO).[1] NMSG is responsible for coordinating and providing technical guidance for NATO M&S activities undertaken by 33 NATO and partner nations and various NATO bodies.[2] The administration of M&S activities is the responsibility of the NATO Modelling and Simulation Coordination Office (MSCO).

NMSG Mission and Objectives

The mission of NMSG is to promote cooperation among alliance bodies, NATO, and partner nations to maximize the effective utilization of M&S. Primary mission areas include M&S standardization, education, and associated science and technology. The activities of the group are governed by the NATO M&S Master Plan (NMSMP).[3] The group provides M&S expertise in support of the tasks and projects within the STO and from other NATO bodies.

The NMSG was officially named as the Delegated Tasking Authority for NATO M&S standardization.

The organizational structure of NMSG consists of four main elements (*Figure 1*):

- The Programmes and Planning Committee (PPC) coordinates proposals for new research activities and monitoring progress.
- The Military Operational Requirements Subgroup (MORS) identifies M&S gaps based on short-term and long-term operational needs.
- The M&S Standards Subgroup (MS3) is in charge of standards agreements and standards recommendations.
- Multi-national task groups (TGs) carry out M&S research and typically run for three years. These activities are identified as MSG-XXX.

NMSG meets plenary twice yearly to discuss and decide on NMSG activities. Nations have one vote in NMSG.

The challenge of achieving interoperability between different branches of the armed forces and all organizational entities can be daunting but the lessons learned within NATO are also applicable for each nation. The guidelines and standards developed within NMSG and Simulation Interoperability Standards Organization (SISO) should be applied nationally whenever possible. Cooperation within international teams usually results in better solutions and more effective

[1] NATO Science and Technology Organization (http://www.sto.nato.int), NATO STO-Collaboration Support Office (STO-CSO) (http://www.cso.nato.int). The STO was known as the Research and Technology Organization (RTO) before July 2012.

[2] NATO Modelling and Simulation Group (NMSG) (https://www.sto.nato.int/Pages/technical-team.aspx?k=%28%2a%29&s=Search%20MSG%20Activities).

[3] NATO Modelling and Simulation Master Plan (NMSMP) v2.0. (AC/323/NMSG(2012)-015), https://www.sto.nato.int/NATODocs/NATO%20Documents/Public/NATO_MS_Master_Plan_Web.pdf.

use of resources than proprietary solutions. The benefits of improved quality and increased interoperability outweigh the possible additional time needed to achieve consensus.

While security needs to be considered, these concerns are usually related to the actual information exchange during an exercise or event. The High-Level Architecture (HLA), Coalition Battle Management Language (CBML), or GM-VV are meta-standards that define how information is structured and exchanged, rather than what the information content is during run-time. In most cases, security concerns do not prevent achieving consensus on this type of standard.

NATO M&S Master Plan

The first NMSMP was approved by the North Atlantic Council, signed in 1998 by the NATO secretary general, and has served as the implementing document for M&S in NATO since that date. Significant results have been achieved in meeting its objectives. However, many of its provisions are as relevant today as they were when written. The NMSMP has been revised under the coordination of NMSG to reflect changes in NATO structures and organizations and position NATO M&S for the future.

The NMSMP articulates the NATO vision and guiding principles regarding the use of M&S in support of the NATO mission, discusses the impact that achieving this vision will have on NATO M&S application areas, and identifies the governance mechanisms, bodies, and primary NATO M&S stakeholders (*Figure 2*).

The document presents the M&S main objectives and actions required to achieve the vision. One of the main objectives is to establish a common, open-standard technical framework to promote the development of a capability for interoperability and reuse of models, data, and simulations across the alliance. This objective is the driver for NMSG's standardization efforts.

MS3

In May 2007, NMSG approved the establishment of the MS3 as its permanent custodian and coordinating body for M&S standards. The MS3 has a close working relationship with other SDOs, which include SISO,[4] IEEE, and ISO and corporate associations (e.g., NTSA and ETSA).

STANDARDS

NATO recognizes the ISO/International Electrotechnical Commission (IEC) concept of a standard as follows: "A standard is a document,

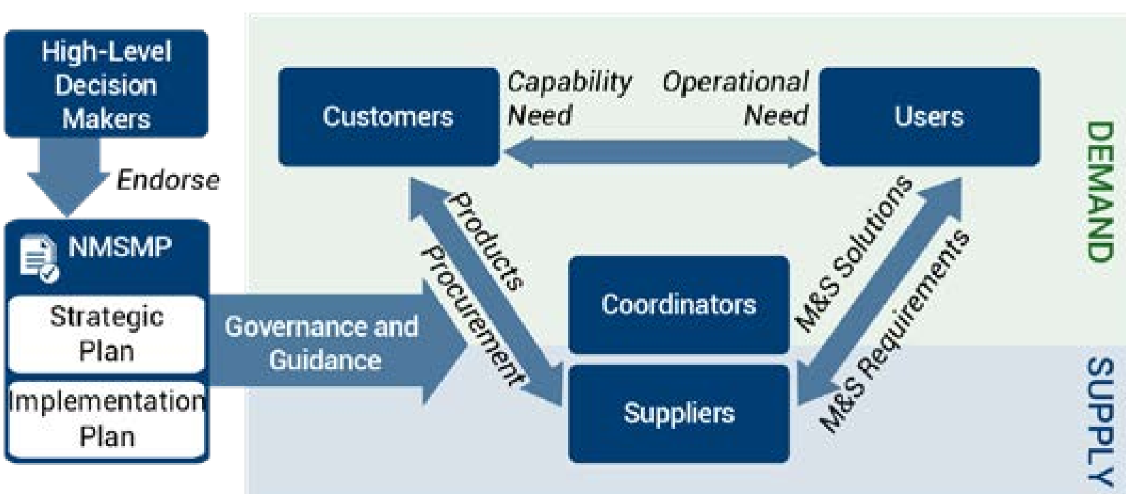


Figure 2: *NATO M&S Stakeholder Relations.*

[4] Simulation Interoperability Standards Organization (SISO), www.sisostds.org.

established by consensus and approved by a recognized Body that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context." It is noted that "a standard should be based on the consolidated results of science, technology, experience and lessons learned."[5]

A NATO standard is developed by NATO and promulgated in the framework of the NATO standardization process. The NATO standardization process proposes, develops, agrees on, ratifies, promulgates, implements, and updates NATO standardization documents. The primary products of this process are covering documents (standardization agreement [STANAG] or standardization recommendation [STANREC]) and allied standards (allied publication [AP] or multinational publication [MP]).

The production of NATO standardization documents is the direct responsibility of the tasking authority, i.e., a senior committee that makes all its decisions by consensus. Member nations are responsible for the ratification or approval and the implementation of the NATO standardization documents, and may identify standardization requirements.

The general standardization policy of NATO is to use civil standards whenever possible and cooperate with SDOs in developing standards that meet its needs via technical cooperation agreements.

This is the rationale for the close relationship between NMSG and SISO, which was formalized in a technical cooperation agreement signed in July 2007.

Characteristics of Good Standards

M&S technology is becoming a mature industry but is still too diverse in general approaches and technical solutions. A mature M&S community does not depend on unique or proprietary solutions, but adopts generally accepted standards. Historically, the need for establishing M&S standards became apparent with the emergence of the distributed simulation concept and its associated technology (in the late '80s and early '90s). Reuse of different simulators and simulation applications developed under different technological approaches and implemented on different platforms became possible: a requirement for developing interoperability protocols or architecture standards emerged. While simulation interoperability spurred the development of many standards, there are other types of M&S and M&S-related standards, e.g., engineering practices.

The main qualities of good standards are the following:

- Relevance to the targeted user or developer community.
- Substantive content, providing meaningful information or results.
- Timely production, in an efficient manner, ensuring the product is useful to the community.
- Vetted by the technical community to which the product applies and widely accepted.
- **Generality:** as general as possible, while still maintaining usefulness, to support the broadest community of current and future users.

5 ISO/IEC, ISO/IEC Guide 2:2004, "Standardization and Related Activities—General Vocabulary" (Geneva, Switzerland: January 2004).

- **Stability:** established and changed only as necessary; prototyped and tested before being proposed for adoption to demonstrate their maturity.
- **Supportability:** maintaining the integrity of the existing product suite and the needs of the user.

After some years of standards development, it appears that existing standards were only partial solutions to the overall interoperability problem. The current situation is improving, but a lot still needs to be done. Standards development and maintenance is an evolutionary process. Existing standards must mature to meet changing requirements. When new requirements emerge or technical innovations become possible, new standards will be needed, possibly replacing existing standards.

M&S Standards

NMSG is the delegated tasking authority in the NATO M&S standardization domain. In cooperation with the NATO Standardization Office (NSO), the MS3 determined that an AP is the most appropriate document form for a standards profile. The MS3 created and maintained Allied Modelling and Simulation Publication 1 (AMSP-01), "NATO Modelling and Simulation Standards Profile."[6]

AMSP-01

AMSP-01 maintains information on M&S standards and recommended practices relevant to achieving interoperability and reuse of components, data, models, or best practices. AMSP-01's recommendations can guide the selection and use of M&S standards for NATO and national activities, e.g., coalition training and experimentation.

Standards are classified in the following categories:

- M&S method, architecture, and processes with subcategories: architecture frameworks, systems engineering processes, verification and validation
- Conceptual modelling and scenarios
- M&S interoperability
- Information exchange data model
- Software engineering
- Synthetic natural environment with subcategories general, data sources and formats, imagery and 3D models, interchange of environmental data, production processes, visualization systems interfacing, multiple
- Simulation analysis and evaluation
- M&S miscellaneous.

There are many standards in existence that have or may have an indirect effect on M&S activities, such as system engineering standards. However, only those standards directly applicable to M&S development, integration, and employment are considered for inclusion in AMSP-01; this document is not intended to be an encyclopedia of standards.

In terms of maturity, standards and guidance documents are characterized as current, emerging, superseded, obsolete, or cancelled, as appropriate.

APPROACH TO M&S CATEGORIES AND LINK TO DSEEP

The identified M&S standards categories of the AMSP-01 were influenced by the DSEEP,[7]

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6 NATO, AMSP-01(D), "NATO M&S Standards Profile" (Brussels, Belgium: February 2018), http://nso.nato.int/nso/zPublic/ap/PROM/AMSP-01%20EDD%20V1%20E.pdf.

7 SISO, IEEE 1730, "Recommended Practice for Distributed Simulation Engineering and Execution Process (DSEEP)" (Piscataway, NJ: January 24, 2011) www.ieee.org. (DSEEP is referenced in the HLA STANAG 4603.)

which is an approved IEEE standard developed by SISO that supports the overall M&S lifecycle.

Figure 3 indicates the relationships between the standards categories and the seven main process steps in the DSEEP. The eight standards topics above and below the center row of DSEEP steps represent the standards categories. Five are linked to the DSEEP steps where the standards are most applicable.

The MS3 issued AMSP-01 in October 2008 and provides regular updates of this document. The current release is AMSP-01 (D) (February 2018) and includes about 30 M&S-related standards. The standards and products included in AMSP-01 are not formally mandated by NATO unless they are supported by a specific STANAG. However, all identified standards and products were included in AMSP-01 following a formal selection and classification process by the MS3 experts and should, therefore, be considered as relevant for the M&S domain.

Emerging Standards

The AMSP-01 includes well-known standards like HLA (HLA IEEE 1516-2010[8]), which are also covered by NATO STANAGs (STANAG 4603). The following paragraphs will not discuss these established M&S standards, but rather present some of the key new standards that have been included in the AMSP-01 as emerging. They are nearing completion or have just recently been released by their respective NMSG task groups, often in close cooperation with SISO.

The prominent examples from recent years resulted from MSG-068 (NATO Education and Training Network [NETN]), MSG-106 (Enhanced Computer Assisted Exercised [CAX] Architecture, Design, and Methodology–SPHINX), MSG-134 (NATO

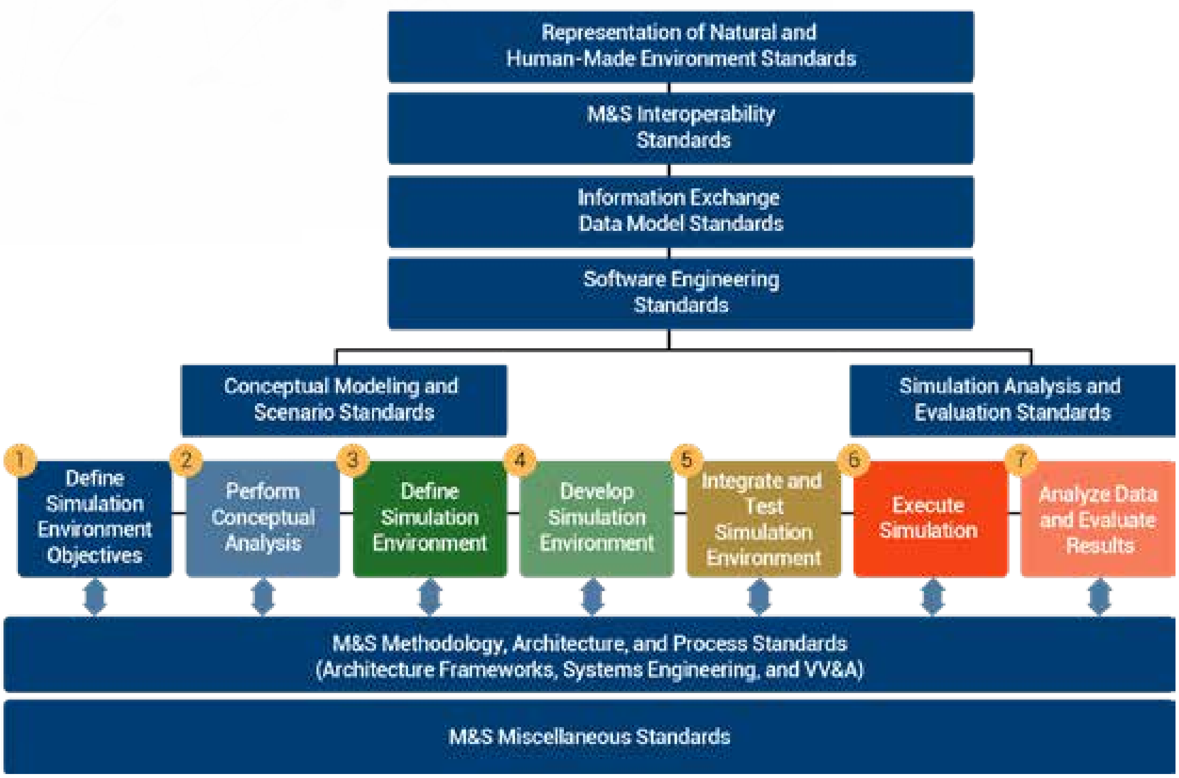

Figure 3: The 7-Step DSEEP Simulation Engineering Process and the Standards Categories.

[8] HLA, IEEE 1516-2010 (Framework and Rules), IEEE 1516.1-2010 (Federation Interface Specification), and IEEE 1516.2-2010 (Object Model Template), www.ieee.org (HLA STANAG 4603).

Distributed Simulation Architecture and Design, Compliance Testing, and Certification), and MSG-136 (Modelling and Simulation as a Service). This article supplies an overview of these standards development activities. Detailed technical explanations would exceed the scope of the article, but may be found in the referenced publications and reports.

EDUCATION AND TRAINING NETWORK

Training of the combined headquarters is the responsibility of NATO, while nations are responsible for the tactical training of the assigned forces. Although NATO and nations trained with geographically distributed simulations in the past, these were always one-off infrastructure that had to be reestablished for every exercise, which was neither the most cost-effective nor responsive to current and future training requirements. A persistent infrastructure is seen as a key enabler to achieving NATO's vision of timely and cost-effective distributed, simulation-based exercises (*Figure 4*). A NATO NETN that consists of a persistent architecture, distributed training and education tools, and standard operating procedures can not only support the training of NATO headquarters but also enable nations to cost-effectively collaborate with the others to train their tactical forces and headquarters. Moreover, it introduces an opportunity to integrate the training of NATO headquarters (i.e., both technically and procedurally) with the tactical forces when needed for short-notice mobile mission rehearsal trainings and other integrated exercising requirements.

To meet this operational demand, Allied Command Transformation (ACT) requested NMSG start a technical activity in 2006. The MSG-068 NETN was chaired by the NATO Joint Warfare Centre and had participants from ACT, Joint Forces Training Centre, NATO Communications and Information Agency, and 13 nations (Australia, Bulgaria, France, Germany, Hungary, Netherlands, Romania, Slovenia, Spain, Sweden, Turkey, UK, and USA). MSG-068 assessed the distributed simulation and learning capabilities that could contribute to the development of an NETN capability. The TG recommended and demonstrated a way forward for interoperability, technical standards, and architectures to link these training and

Figure 4: NATO Vision of Distributed Exercises.

education centers for persistent capability, and also identified and recommended roles and responsibilities of NATO and nations within the scope of NETN. The TG developed, tested, and made recommendations regarding an HLA-based reference federation agreements and federation design document, including a modularized HLA federation object model (FOM).

During 2012–2015, the initial work of MSG-068 was carried forward by MSG-106 to deliver the following:

- AMSP-03: Guidance for M&S Standards in NATO and Multi-National Computer Exercises with Distributed Simulation
- AMSP-04: NETN Federation Architecture and FOM Design
- AMSP-05: Handbook (Best Practice) for Computer Assisted Exercises (CAX).

In 2015–2017, work on NETN continued in MSG- 134 with two primary focus areas:

- Publication of AMSP-04 covered by STANREC
- Compliance testing and NATO certification of HLA federates implementing AMSP-04.

The NATO HLA federate certification service initial operating capability was established by MSG-134 in late 2017 and is provided by the NATO Modelling and Simulation Centre of Excellence.

NETN Federation Architecture and FOM Design

The NETN Reference Federation Architecture and FOM Design (NETN FAFD) comprises the fundamental deliverable of MSG-068 and MSG-106 because it is a key contributor to integrating national systems (*Figure 5*). This reference federation design is intentionally generic for use in live, virtual, constructive, and multi-resolution federations at any level. The NETN FAFD document was delivered and placed under custodianship of the MS3.

After the initial release of the NETN FAFD document, it was applied to the design of multiple distributed, simulation-based CAX, e.g., Viking. The NETN FAFD continued to evolve through community feedback and experiences. In late March 2018, the NETN FAFD was promulgated as an official NATO standard by NSO (reference AMSP-04 covered by STANREC 4800) and made available for public access.

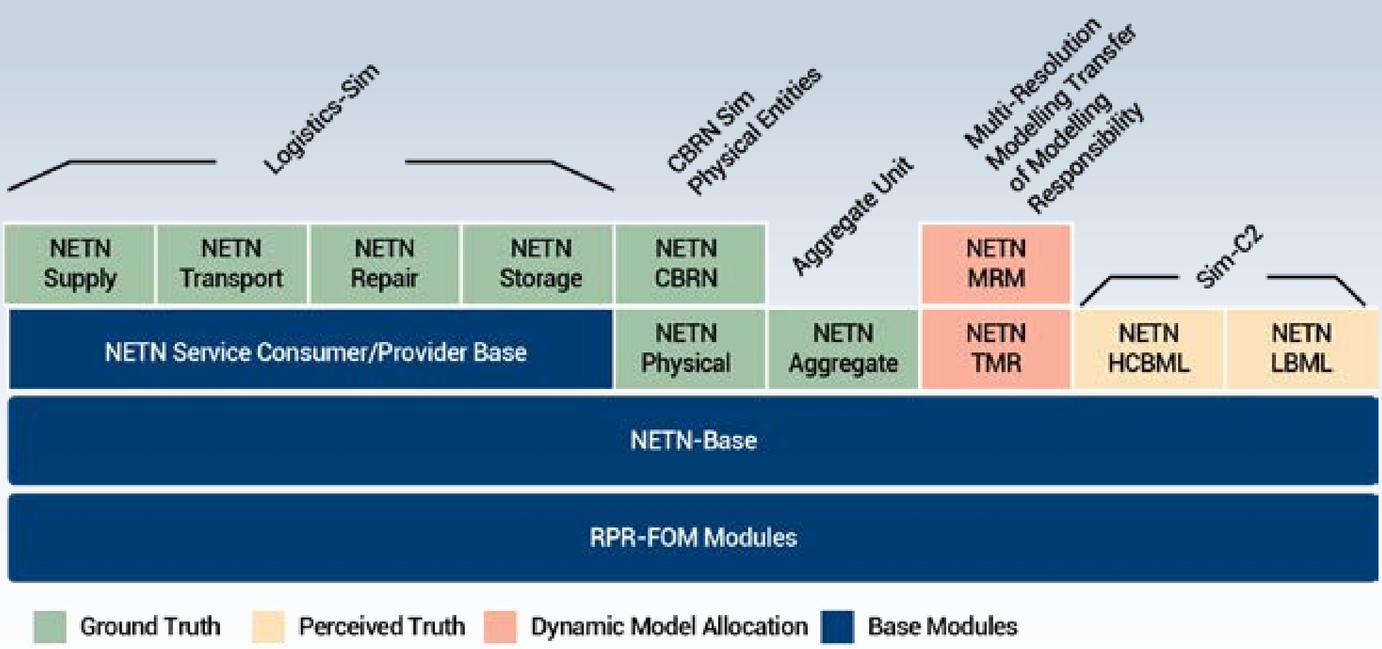

Figure 5: NETN Modular FOM.

Although AMSP-04[9] has been developed mainly to support NATO and coalition CAX, it also defines general purpose design patterns to manage the transfer of modelling responsibilities as well as aggregation and disaggregation of simulated units. The work in MSG-068 and MSG-106 also played a major part in the modularization of the SISO standard RPR-FOM v2.0 on which the NETN FAFD is based.

The NETN FAFD extends parts of the RPR-FOM v2.0 by adding additional aspects to existing classes of simulated objects. Most notable is the inclusion of a unique identifier (UUID) for all simulated units and platforms. This UUID uses the same formats and principles found in the Military Scenario Definition Language (MSDL) standard published by SISO.

The NETN FAFD consists of several modules to support distributed simulation interoperability related to the following:

- Dynamic model allocation including transfer of modelling responsibilities
- Aggregation and disaggregation patterns
- Simulation to C2 stimulation and mediation
- Extended representation of ground truth
- Logistics simulation
- Chemical, biological, radiological, and nuclear events and effects simulation.

The extensions consist of a new basic design pattern for modelling request, negotiation, and delivery of services. The service consumer-provider pattern defines two types of entities: service consumer entities and service provider entities. Federates that model these entities are called service consumer federates and service provider federates, respectively. If these entities are modelled in different federates, the interactions are published and subscribed using HLA services. The NETN logistics extensions to support distributed M&S of specific logistics services for supplies, repair, deposit, and transport are based on the service consumer-provider pattern.

Viking Exercise

The Viking CAX is based on a comprehensive approach, focusing on cooperation between relevant actors in peace operations and international crisis management, with emphasis on realism and current operational concepts. Viking is the world's largest exercise of its kind and Viking 2018 (Viking-18) included more than 2,500 participants from 60 countries and 80 organizations. Viking-18 is the eighth CAX in the series that started in 1999 and relies heavily on simulation systems to create a synthetic representation of the various actors and events in the scenario.

Since 2011, the NETN FAFD has been the basis for the design of a federated simulation system consisting of multiple models running distributed across participating sites. In Viking-18, there were 9 sites in total in Bulgaria, Serbia, Finland, Ireland, Brazil, and Sweden (4 sites). The federated Viking simulation environment is a fairly complex setup, connecting multiple HLA federations with filtering and other means to overcome some of the limitations of the participating systems. Challenges include interoperability between legacy monolithic simulators

[9] NATO Standard AMSP-04(A), "NATO Education and Training Network Federation Architecture and Federation Object Model Design (NETN FAFD)" (Brussels, Belgium: March 2018), http://nso.nato.int/nso/zPublic/ap/PROM/AMSP-04%20EDA%20V1%20E.pdf.

with service-based (MSaaS) components. The major systems used in Viking-18 included the following:

- NATO ITC (Air domain)
- MASA SWORD (Running in Brazil's COTER training system)
- CATS TYR (Aggregate-level joint simulation)
- Unit Generation Service (VR-Forces-based simulation service)
- JCATS (Not federated in Viking-18 but has been successfully federated in previous Viking exercises)
- ORBAT Service (A federate publishing MSDL-based information in the federation)
- EXONAUT (MEL/MIL scripted incidents and injects)
- ReportPump (Simulation service for generating intelligence reports)
- Vessel Traffic Generation Service (VR-Forces-based simulation service for generating AIS data)
- ICC (Air C2)
- SITAWARE (Ground, maritime, and joint C2)
- Common SIM GUI (Web application for controlling multiple CGFs).

From a top-level perspective, the Viking-18 federated simulation system is depicted in *Figure 6*.

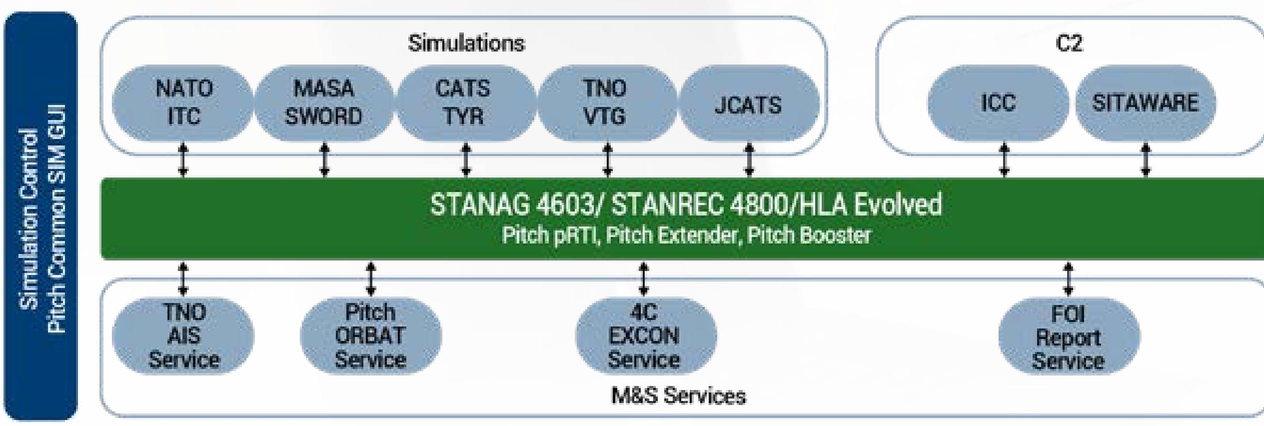

Figure 6: Viking-18 Federation.

Feedback from the experiences using the NETN FAFD in Viking will influence how this standard evolves. Viking has identified the need for both new modules and suggested changes and updates to the existing NETN FAFD.

NETN Future Work

Feedback from using NETN FAFD in real exercises and experimentation is the basis for the evolution of the standard and will continue in MSG-163 (Evolution of NATO Standards for Federated Simulation). MSG-163 was initiated early 2018, will continue throughout 2020, and aims to deliver an updated version of the NETN FAFD that includes improved, updated, and new modules that enable the simulation system architect to design federated systems that meet the requirements of modern distributed simulation.

The shift in system design focus from larger training and simulation systems to smaller, composed services is both a challenge and an opportunity. MSG-163 will evolve STANAG 4603 (HLA) and STANREC 4800 (NETN FAFD) in close collaboration with SISO and MSG-164 (MSaaS Phase 2) to ensure that the future federated systems can be maintained and hosted in modern cloud-based environments in a secure and efficient manner. MSG-163 will also continue MSG-134's efforts to establish tools and procedures for NATO certification of system compliance with HLA and the NETN FAFD.

M&S AS A SERVICE

M&S is a critical technology to support training, capability development, mission rehearsal, and acquisition processes. M&S products are valuable resources. Therefore, it is essential that these products are conveniently accessible to a large number of users.

Recent developments in cloud computing technology and service-oriented architectures offer opportunities to better use M&S products to satisfy NATO critical needs. MSaaS is a new concept that combines service orientation and

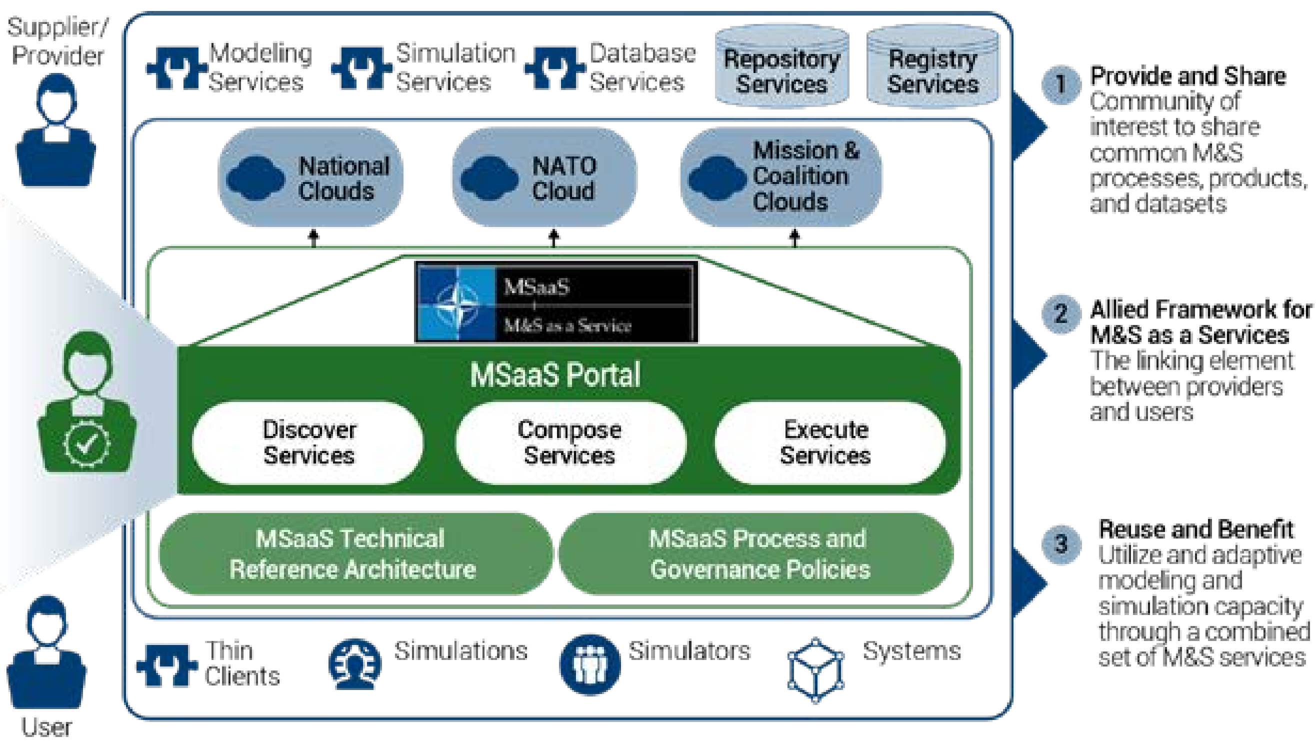

Figure 7: Operational Concept of the Allied Framework for M&S as a Service.

service model of cloud computing to enable more composable simulation environments that can be deployed and executed on demand.

NATO MSG-136 (September 2014–December 2017, "Modelling and Simulation as a Service–Rapid Deployment of Interoperable and Credible Simulation Environments") and MSG-164 (Feb. 2018–Feb. 2021, "Modelling and Simulation as a Service—Phase 2") investigate MSaaS for the technical and organizational foundations to establish an allied framework for MSaaS within NATO and partner nations. The allied framework for MSaaS should become the common approach of NATO and nations towards implementing MSaaS and is currently defined by the following documents:

- operational concept document[10]
- technical reference architecture[11, 12, 13]
- standard operating procedures.[14]

The allied framework for MSaaS is the linking element between service providers and users, providing a coherent and integrated capability with a technical reference architecture, recommendations and specifications for discovery, composition and execution of services, and necessary processes and operating procedures.

The MSaaS paradigm supports standalone use as well as integration of multiple simulated and real systems into a unified, cloud-based simulation environment whenever the need arises.

MSaaS leverages existing simulation standards and technologies, but will—as the concept matures—also embrace standards and technologies from other domains, such as cloud computing and service-oriented architecture.

The documents will evolve as MSG-164 proceeds in its execution. The MSaaS concept is explained in more detail in the following sections.

Operational Concept

MSaaS supplies the user with discoverable M&S services that are readily available on demand and deliver a choice of applications in a flexible and adaptive manner. It offers advantages over the existing stove-piped M&S paradigm in which users are highly dependent on a limited amount of industry partners and subject matter experts.

The MSaaS concept is illustrated in *Figure 7*. MSaaS is an enterprise-level approach for discovery, composition, execution, and management of M&S services. MSaaS links M&S services from a community of stakeholders to be shared and the users that are actually utilizing these capabilities for their individual and organizational needs.

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10 STO, "Modelling and Simulation as a Service–Volume 1: Technical Reference Architecture" (pre-release).

11 STO, "Modelling and Simulation as a Service–Volume 1: Technical Reference Architecture" (pre-release).

12 STO, "Modelling and Simulation as a Service–Volume 2: Discovery Service and Metadata," STO Technical Report STO-TR-MSG-136-SRV (pre-release).

13 STO, "Modelling and Simulation as a Service–Volume 3: Engineering Process, STO Technical Report STO-TR-MSG-136-PRC (pre-release).

14 NATO, AMSP-02, "Allied Framework for Modelling and Simulation as a Service (MSaaS)–Standard Operating Procedures" (to be published).

The allied framework for MSaaS defines user-facing capabilities (front end) and underlying technical infrastructure (back end). The front end is called the "MSaaS Portal" and provides access to a large variety of M&S capabilities. Users select the services that best suit their requirements and track the experiences and lessons learned of other users. They discover, compose, and execute M&S services through the front end, which is the central access point that guides them through the process.

Discover

Through the allied framework for MSaaS, users search and discover M&S services and assets (e.g., data, services, models, federations, and scenarios). A registry catalogs available content from NATO, national, industry, and academic organizations. From this registry, the user assesses available services and assets for their suitability to meet a particular requirement (i.e., user rating, requirements, simulation-specific information, and verification and validation information). The registry also points to a repository (or owner) where that simulation service or asset is stored and can be obtained, including business model information (i.e., license fees, pay per use costs).

Compose

Users compose discovered services to perform a given simulation use case. Initially, simulation services will be composed through existing simulation architectures and protocols (e.g., HLA) and can be readily executed on demand (i.e., with no set up time). In the longer term, distributed simulation technology will evolve, enabling further automation of discovery, composition, and execution than is possible today.

Execute

Users deploy the composed services automatically on a cloud-based or local computing infrastructure. The automated deployment and execution exploits the benefits of cloud computing (e.g., scalability, resilience). Once deployed and executed, the M&S services can be accessed on demand by a range of users (live, virtual, constructive) directly through a simulator (e.g., a flight simulator consuming a weapon effects service), through a C2 system (e.g., embedded route planning service), or by a thin client or dedicated application (e.g., a decision support system using various services like terrain data service, intelligence information service). The execution services support a range of business models and are able to provide data relevant to those models (i.e., capture usage data for a pay-per-use business model).

Technical Concept

The technical concept comprises several volumes:

- **Volume 1: MSaaS Technical Reference Architecture:** discusses layers, architecture building blocks, and architecture patterns.
- **Volume 2: MSaaS Discovery Service and Metadata:** discusses services metadata and metadata for services discovery.
- **Volume 3: MSaaS Engineering Process:** discusses a services-oriented overlay for the DSEEP.

The volumes are discussed in more detail in the following sections.

Volume 1: MSaaS Technical Reference Architecture

The MSaaS Technical Reference Architecture is defined with a number of principles in mind. These are similar to the Open Group Service-Oriented Architecture Reference Architecture (SOA RA) key principles and are the starting point for the architecture efforts of MSG-136. The principles are as follows:

1. Generic and vendor-neutral
2. Modular, consisting of building blocks which may be separated and recombined
3. Extendable, enabling the addition of more specific capabilities, building blocks, and other attributes
4. Compliant with NATO policies and standards (such as AMSP-01 and STANAG 4603)
5. Facilitates integration with existing M&S systems
6. Capable of being instantiated to produce
   a. intermediary architectures
   b. solution architectures
7. Addresses multiple stakeholder perspectives.

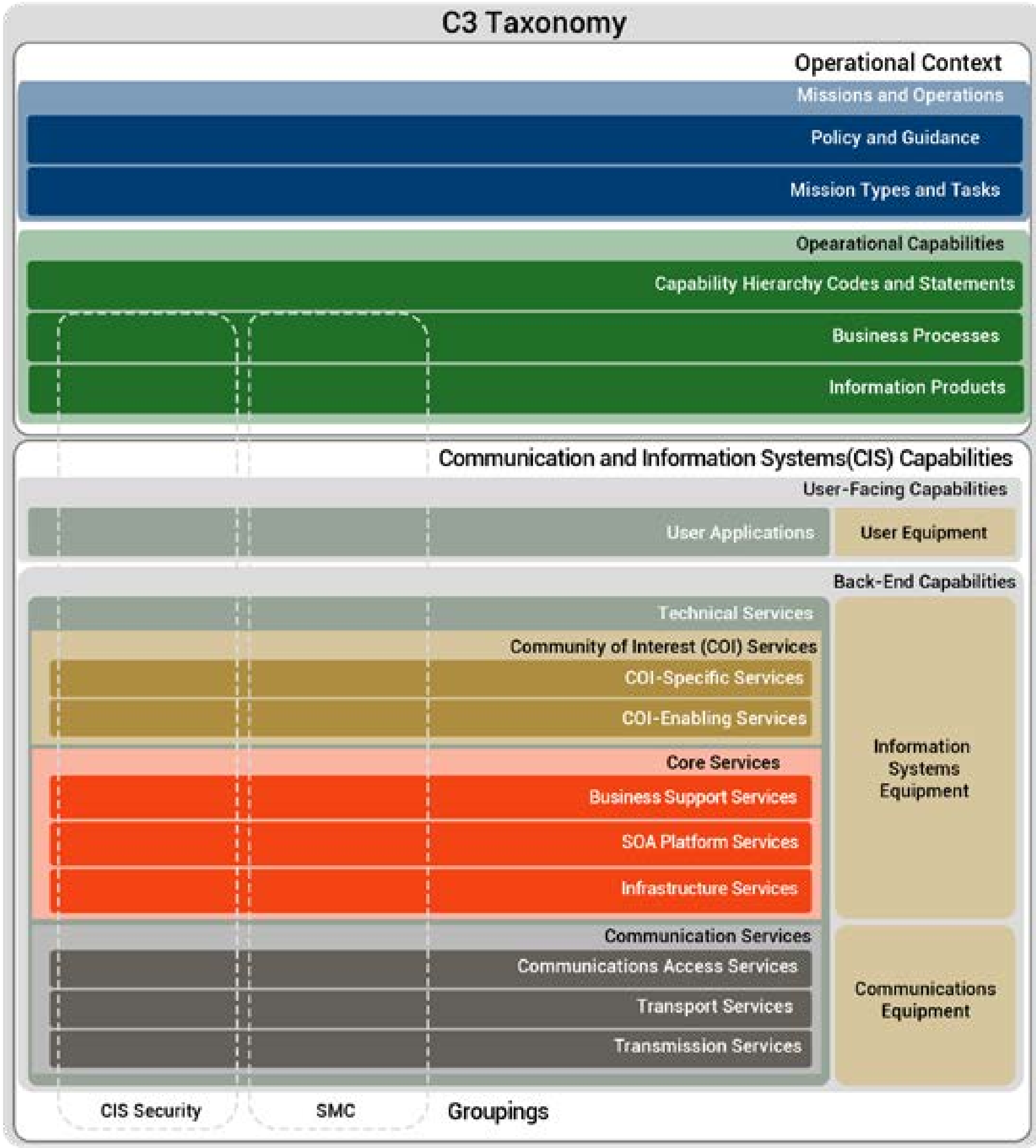

Figure 8: NATO Taxonomy—top-level view.

The MSaaS Technical Reference Architecture is described in the form of layers, architecture building blocks (ABBs), and architecture patterns (APs). A layer includes a set of logically related ABBs that (together) provide some capability. ABBs are the elements that constitute an architecture, and each ABB has attributes that specify its function (i.e., requirements and standards for implementations of the ABB). APs are high-level suggestions for ways of combining ABBs. The ABBs in the MSaaS Technical Reference Architecture are organized in a taxonomy, aligned with the capabilities listed in the NATO C3 taxonomy (*see Figure 8*).[15]

[15] NATO Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance Technology and Human Factors Branch, Allied Command Transformation (ACT), "C3 Classification Taxonomy," Baseline 1.0 (Norfolk, VA: June 15, 2012).

The NATO C3 taxonomy's top-level capabilities are grouped into missions and operations, operational capabilities, user-facing capabilities, and back-end capabilities. Each group of capabilities is further decomposed into more refined and detailed levels of capabilities, such as business processes (in the sense of defense operational processes), user applications, community of interest (COI) services, core services, and communications services. Thus, each category represents a division into capabilities and is further divided into sub-categories; i.e., sub-capabilities. At the leaves of these capability trees, one finds individual operational processes (under operational capabilities), individual user applications (under user-facing capabilities), and individual services (under back-end capabilities). This capability structure is viewed and modified through the C3 taxonomy's enterprise management wiki.

The C3 taxonomy capabilities relevant to MSaaS are user applications, COI-specific services, and COI-enabling services. User applications are loosely coupled front-end apps that can be put together readily and rapidly for the purpose at hand. However, in the transition to true service orientation, C3 taxonomy user applications also include legacy or proprietary monolithic applications, such as legacy command and control information systems, battle management systems, and many simulation systems. The COI-specific services are back-end technical services that are specific to COIs, and the COI-enabling services are more generic cross-COI back-end technical services. The following top-level M&S-particular capabilities are in scope of MSaaS:

- **M&S Applications**. User-facing capabilities containing simulation and modeling applications ABBs for accessing back-end M&S capabilities.
- **M&S Services**. Back-end capabilities containing the simulation services, composed simulation services, and modelling services ABBs.
- **M&S Enabling Services**. Back-end support capabilities pertaining to M&S, e.g., repository services, registry services, M&S composition services, simulation control services, and simulation scenario services.

Each of these ABBs is further decomposed in more specialized ABBs, e.g., the M&S services consist of modeling services, simulation services, and composed simulation services. The latter are the results of composing simulation services, offering entire simulations as a service.

The ABBs are implementation independent and can be realized in various implementations in software deployed at different places at different times. Such implementations are

capability (service and application) providers in the technical sense, where a piece of software furnishes one or more capabilities, and a capability may be supplied by one or several pieces of software. The ABBs are organized in a taxonomy, and each of these ABBs has associated requirements, standards, and other attributes.

The APs show how ABBs in the MSaaS Technical Reference Architecture are related, can be combined or interact, and what information is generally exchanged. The APs serve as reference for solution architectures. An initial set of APs is documented, but the ABBs as well as the APs are a living document and will evolve further as knowledge is gained and technology advances.

Volume 2: MSaaS Discovery Service and Metadata

Volume 2 discusses information and standards related to the description of services and exchange of metadata. More specifically, it

- provides an overview of standards related to services discovery and services interface description and
- presents national initiatives related to the exchange of services metadata and information models that support the (automated) composition, deployment, and execution of simulation environments.

This volume relates to several ABBs in volume 1, such as the M&S composition services for automated composition, deployment, and execution and the M&S repository and registry services for metadata standards.

Volume 3: MSaaS Engineering Process

Volume 3 discusses a service-oriented overlay for DSEEP, adding an overlay for a service-oriented implementation strategy (besides HLA, DIS, and TENA). This volume discusses the activities or tasks related to this implementation strategy.

Governance Concept

A challenging aspect of establishing a persistent capability, like the allied framework for MSaaS, is to develop an effective governance model. Governance ensures that all of the independent service-based efforts (i.e., design, development, deployment, or operation of a service) combined will meet customer requirements.

MSG-136 developed policies, processes, and standards for managing the lifecycle of services, service acquisitions, service components and registries, service providers, and consumers. These will be published as AMSP-02 and define the allied framework for MSaaS standard operating procedures. The standard operating procedures include the following:

- General policies for instituting governance mechanisms of MSaaS-based solutions
- Security policies
- Compliancy policies.

NMSG is the delegated NATO authority for M&S standards and procedures. Nations are encouraged to use the standards nationally or in other multi-national collaborations. After completion of the MSG-136 task group, the NMSG M&S MORS will become custodian of AMSP-02.

Next Steps and Implementation Strategy

MSG-136 performed groundbreaking work in various areas, defining the scope of MSaaS and guiding implementation. By the end of 2017, MSG-136 concluded with several recommendations and an implementation strategy described in its final report, handing over the baton to MSG-164. MSG-136 proposes an incremental development and implementation strategy for the allied framework for MSaaS, facilitating a smooth transition for adoption and describing a route to incrementally build an allied framework for MSaaS. The proposed strategy also supplies a method to control the rate of expansion of the new framework, permitting the iterative development and training of processes and procedures. Finally, it enables those nations that have been early adopters of the allied framework for MSaaS and have national capabilities to accrue additional benefits from their investments and highlight the benefits as well as lessons learned and advice to those nations considering similar investments.

As illustrated in *Figure 9*, the implementation strategy is broken down into three phases.

Phase 1: Initial Concept Development

The initial concept development (2015 until end of 2017) was executed by MSG-136 and consisted of concept development and initial experimentation.

Phase 2: Specification and Validation

From 2018–2021, the initial concept developments are extended (specification of issues and challenges not yet addressed) and validated through regular exercise participation and dedicated evaluation events. This phase includes transformation of standard operating procedures into a NATO standard (AMSP-type) covered by a STANAG or a STANREC, and moving from prototype implementation to operationally usable and mature systems. This phase is executed by MSG-164.

Phase 3: Implementation

By 2025, full operational capability is achieved, including adaptation of many existing simulation-related services to the MSaaS Technical Reference Architecture by adding services to the allied framework for MSaaS.

CONCLUSION AND ROAD AHEAD

NATO is an alliance of many nations and organizations, each bringing their own legacy systems, procedures, etc. Successful cooperation depends on achieving and continuously improving interoperability at all levels. Standards for interoperability are a crucial step towards this goal.

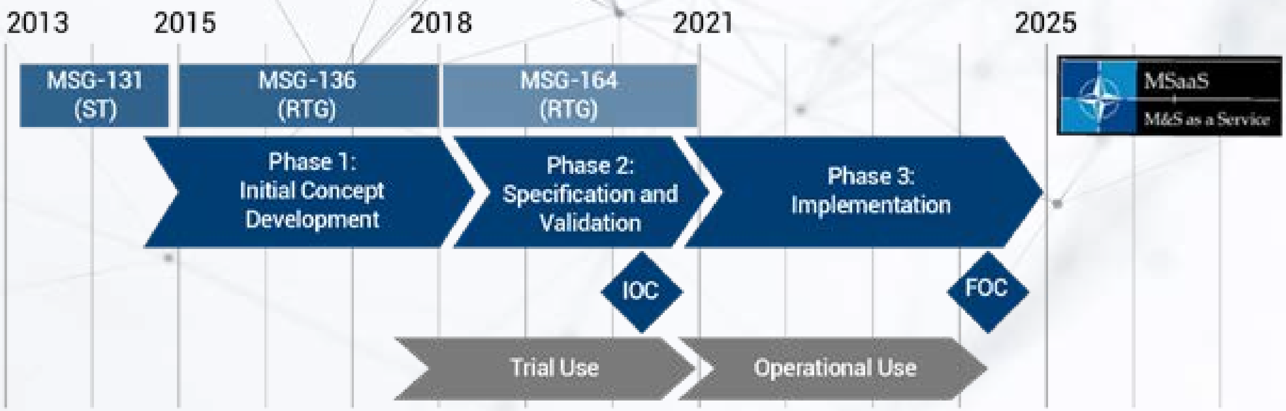

Figure 9: MSaaS Implementation Strategy.

Considering the large number of M&S standards and guidance documents identified in AMSP-01, it is tempting to declare that the situation is satisfactory for the simulation domain. Unfortunately, there are some observations that temper this conclusion. A quick assessment shows that there are overlapping standards in some specific areas and obvious gaps in others. Where there are too many standards in support of a particular domain, there is no real standard, but sometimes many competing technologies or methods. Where gaps or unnecessary overlaps are identified, NMSG needs to cooperate with the M&S community and, in particular SISO, to fill the major gaps and align overlapping standards.

Even where standards do exist, they must be maintained and endorsed by NATO and national organizations. The AMSP-01 is a suitable guideline document for the relevant M&S standards for development and procurement projects. The profile needs to be widely disseminated by NMSG and accepted by nations.

Conclusion

Given the continuously evolving nature of M&S standards and processes, timely updates and reviews of the standards and the AMSP-01 guidance document is required.

There are accepted benefits to identifying and using common open standards. Due to the breadth of applications for M&S, there is no one size fits all.

The guidelines and standards developed and tested within an international context of NMSG and SISO should be applied nationally whenever possible. The improved quality and increased interoperability of international standards outweigh the possible added time needed to reach consensus.

Nations and organizations should actively contribute to developing open standards.

Profile type standards (e.g., AMSP-01) maintained by M&S experts meet the need to be more responsive with regard to guidelines and best practices. A profile can include emerging standards and encourage their use before the standards have been fully completed, acknowledging that technology is evolving rapidly.

The NMSG MS3 has developed several AMSP publications in recent years and more are under development (see the table to the right). The AMSP guidelines are covered by formal STANRECs and serve as recommendations to NATO and nations. Gaps still exist within standards development regarding certain functional areas of M&S and the breadth of application in a functional area. International experts groups, like NMSG and SISO, are crucial to identifying these gaps and initiating activities to address them.

Title	Document ID	STANREC	Comments
NATO M&S Standards Profile	AMSP-01(D)	4815	Promulgated February 2018
NATO MSaaS Standard Operating Procedures	AMSP-02(A)	4794	Under MS3 review
Guidance for M&S Standards in CAX	AMSP-03(A)	4799	Promulgated July 2018
NETN FAFD	AMSP-04(A)	4800	Promulgated March 2018
NATO CAX Handbook	AMSP-05(A)	4801	Promulgated August 2018
NATO Reference Mobility Model	AMSP-06(A)	4813	Under development
UCATT	SISO-STD-016-00 SISO-REF-059-00	4816	Promulgated July 2018
SISO Enumerations	SISO-REF-010-2017	TBA	Under development

Road Ahead

NATO organizations, members, and partner nations are encouraged to contribute additional standards for consideration and participate in MS3. NMSG actively solicits the support of standards development organizations to address gap issues.

Requirements are sometimes specific to a particular community of interest, such as the tactical data link domain or human behavior models. Those communities are encouraged to draft their own standards as required and publish them to contribute to the M&S body of knowledge. These domain-specific solutions should strive to use or build on existing solutions as much as possible. HLA and DSEEP, for example, are explicitly intended for tailoring to a particular domain.

NMSG is active in investigating the need for new or improved standards, evaluating proposals, and developing new standards for M&S interoperability. The examples discussed in this article (NETN, MSaaS) represent those activities. Specific efforts are made by NMSG and nations to encourage focus on identified gap areas, like human behavior models and scenario definition languages.

M&S interoperability is a primary concern of NATO and efforts have to be maintained to improve the current situation of overlapping standards and make progress toward meeting the challenge of substantive interoperability. The formal relationship between NMSG and SISO is beneficial in maintaining close cooperation with the international M&S community and will be continued and increased where possible.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the contributions of NMSG members. Special thanks are due to the MS3 group, the authors of the paper "Meeting the NATO M&S Interoperability Challenge,"[16] and members of the NATO TG MSG-136 MSaaS that provided contributions to the technical reports.

AUTHOR BIOGRAPHIES

Wim Huiskamp *is chief scientist for the modelling, simulation, and gaming in the M&S department at TNO Defence, Security, and Safety in the Netherlands. He received an MSc in electrical engineering from Twente University of Technology. His research areas include system architecture and distributed real-time simulation interoperability problems. Mr. Huiskamp acted as project lead for several national and international simulation (interoperability) projects and he leads TNO's research program on live, virtual, and constructive simulation, which is carried out on behalf of the Dutch Ministry of Defense. He is a member of NMSG and acted as member and chairman in several NMSG technical working groups. He is a former chairman of the NMSG, former chairman of the NMSG MS3, and the liaison of NMSG to the SISO.*

Tom Van Den Berg *is a senior scientist in the modelling, simulation, and gaming department at TNO. He holds an MSc in mathematics and computing science from Delft Technical University and has over 25 years of experience in distributed operating systems, database systems, and simulation systems. His research includes simulation systems engineering, distributed simulation architectures, systems of systems, and concept development and experimentation. He is a member of several SISO product development and support groups, participates in several NATO MSG activities, and is co-chair of NATO MSG-136/MSG-164.*

Robert Siegfried *is senior consultant for IT/M&S projects and managing director of Aditerna GmbH, a company specializing in services and consulting in this area. He earned his doctorate in modelling and simulation at the Universität der Bundeswehr München. For the German armed forces, he has worked on documentation guidelines, model management systems, distributed simulation test beds, and process models. He is co-chair of NATO MSG-136/MSG-164, actively involved in multiple SISO working groups, and a member of the SISO executive committee.*

Adrian Voiculet *is a technical officer in the MSCO at NATO Science and Technology Collaboration Support Office. He received an MSc in electronics and antiaircraft missile systems from the Military Technical Academy, Bucharest, Romania. He served in staff appointments for the ROU Air Force and Military Technologies Research Centre and as ROU voluntary national contribution and help desk officer at the MSCO. On retiring from the armed forces (2009), he joined the NATO MSCO, in charge of standardization in the NATO M&S domain, reuse of simulation resources, and support to NMSG. Mr. Voiculet is currently the secretary of the MS3, admin of the NATO Simulation Resource Library, and liaison officer with NSO.*

Björn Löfstrand *is the services and training manager at Pitch Technologies. He holds an MSc in computer science from Linköping Institute of Technology (Sweden) and has supported HLA federation development and tool support since 1996. He was the technical lead for MSG-068's FAFD efforts and co-lead of the technical subgroup of MSG-106. For MSG-134, he managed all activities related to NETN FAFD. During Viking-18 development, he was a key member of the architecture and integration team responsible for the design and implementation of the Viking CAX NATO standards, such as STANAG 4603 and STANREC 4800.*

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[16] DoD MSCO, "Meeting the NATO M&S Interoperability Challenge," M&S Journal, Summer 2014.

Mission Assurance through Energy Assurance DoD Installations and the Use of ISO 50001

Ann Howard

A popular adage states you can't manage what you don't measure. Perhaps nowhere is this assertion more true than for the nation's largest energy user, the U.S. Department of Defense (DoD). DoD's installations represent 284,000 buildings and over 2 billion square feet, consuming 1 percent of the total energy expended in the United States at a cost of almost $4 billion.[1] These installations depend on a vulnerable commercial grid subject to disruptions from aging infrastructure, severe weather, and terrorism. Furthermore, most bases operate in a fiscally constrained environment. Spending money on water and energy bills means critical mission priorities may have to be sacrificed. Conversely, better resource management can free additional capital to devote to those priorities.

The voluntary energy management standard, International Organization for Standardization (ISO) 50001, "Energy Management Systems—Requirements and Guidelines for Use," provides a framework for integrating energy management into an organization's business processes. Its structure aligns with other ISO management system standards, such as ISO 9001, "Quality Management Systems," and ISO 14001, "Environmental Management Systems." U.S. military installations use ISO 50001 implementation to deliver sustained year-to-year energy and carbon savings and

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1 Jeffrey Marqusee, Craig Shultz, and Dorothy Robyn. *Power Begins at Home: Assured Energy for U.S. Military Bases*, The Pew Charitable Trusts, 2017.

The DoD's Installations

- 4 billion dollars spent*
- 2 billion square feet
- 284,000 buildings
- 1 percent of the total energy consumed in U.S.

* Marqusee, Schultz & Robyn, 2017.

comply with mandates, such as the Energy Independence and Security Act of 2007 and the more recent John S. McCain National Defense Authorization Act. The latter directs military branches to examine "energy and climate resilience" in every installation master plan.

Keys to successful implementation of the standard include a commitment from upper management, establishment of an energy team, identification of major energy users, establishment of energy targets and tracking use, and publication of successes. While some organizations simply implement the standard, others go further by pursuing third-party certification to demonstrate best practices in energy management.

Marine Corps Air Station Beaufort (MCAS Beaufort) and the Oklahoma City Air Logistics Complex (OC-ALC), located at Tinker Air Force Base, implemented ISO 50001 and are already reaping the benefits. MCAS Beaufort is a 7,000 acre Marine Corps air base just outside of Beaufort, South Carolina, and OC-ALC is one of the largest units in the Air Force Materiel Command. A further look at both cases illustrates the advantages of implementing the standard.

MCAS BEAUFORT

In 2013, MCAS Beaufort implemented a state-of-the-art energy management system (EnMS) as part of its energy solution. The goal was to establish a base-wide culture of continual energy performance improvement to meet the energy and water mandates set by Marine Corps Installations Command. MCAS Beaufort proposed a 30-month implementation of an ISO 50001-conformant EnMS in partnership with the Lawrence Berkeley National Laboratory and Georgia Institute of Technology (Georgia Tech). The initiative created a framework that enables MCAS Beaufort to understand its energy usage and subsequently improve energy performance.

Benefits

Some of the benefits of Beaufort's ISO 50001 implementation include the following:

- Visible demonstration of alignment with DoD's strategy for mission readiness
- Better analytical tools for energy management decisions
- Standardized and disciplined energy management practices that survive personnel changes
- Increased awareness and communication regarding energy management performance across the organization
- Energy cost savings.

According to Neil Tisdale, utilities director and energy manager of MCAS Beaufort, "One of the most valuable aspects of the standard is the emphasis on significant energy users. It helped us to concentrate on things that were more important and we were able to generate efficiencies and save money as a result."

An example of a significant energy user is the corrosion control facility, an area used for prepping and painting jets. Temperature, humidity, and exposure to compounds in aerospace coatings must be tightly controlled. In addition, air blowers use large amounts of energy as they push and pull air through the facility depending on the mode of operation. The building was metered to track natural gas and electricity usage, enabling identification of periods when energy-intensive equipment could be turned off. Greater communication from the energy management team to the facility with reminders to switch off equipment when not in use has created accountability, greatly decreasing energy usage.

Challenges

The implementation of ISO 50001 was not without challenges. MCAS Beaufort faced a typical hurdle for most organizations: resource availability. Implementation takes dedication of time and effort; every unit in the installation must be involved. Base personnel, already subject to multiple requirements and inspections, can feel burdened by these additional responsibilities. The varying values placed on energy efficiency caused another challenge. Bases tend to view energy efficiency as a way to comply with statutes and executive orders rather than as an essential element of energy security. Despite these challenges, as of June 2018, MCAS Beaufort is 6.3 percent below its 2015 energy use baseline. The pilot training center, a 100,000 sq. ft. space, has maintained its baseline despite having added additional equipment, such as flight simulators.

OC-ALC

Like other ISO management system standards, ISO 50001 certification is voluntary. OC-ALC was the first federal organization to earn ISO 50001 certification. The complex is the largest tenant at Tinker, using 60–70 percent of the energy on the base as it performs depot maintenance, repair, and overhaul of aircraft and accessory components for the Air Force, Air Force Reserve, National Guard, Navy, and foreign military sales. OC-ALC employs more than 10,000 personnel, has a $3.4 billion local economic impact, and has over 54 facilities, covering 8.1 million square feet. Under normal budgetary conditions, achieving ISO 50001 certification and implementing large-scale capital improvements would not be possible.

However, in December 2016, OC-ALC awarded a 25-year energy savings performance contract (ESPC). The $262 million project is the largest ESPC awarded to date by the Air Force. The ESPC enables the Air Force to fund upgrades using annual energy and operational savings, providing a budget-neutral approach to funding capital improvements. The team at OC-ALC included the ISO 50001 implementation in the ESPC, offsetting costs associated with the initial certification and three-year recertification. ISO 50001 was the glue for the ESPC because it provided a structure capable of supporting such a long-term project. The driver for ISO 50001 certification, according to Joseph Cecrle, OC-ALC energy manager, was "to establish a data-driven management system for energy where our energy management efforts were not responding to crises but rather something that spans the entire organization and uses data to make inform[ed] decisions."

OC-ALC is not new to the concepts of plan-do-check-act or continual improvement. The Air Force mantra, art of the possible, guides the thinking behind a variety of quality systems, such as AS 9110 for aerospace quality management certification. The addition of ISO 50001 was natural and easy to accept. Using the Lawrence Berkeley National Laboratory and Georgia Tech gap analysis of its energy program, the OC-ALC team implemented a structured and systematic approach to energy management and started the certification process in earnest in April 2016.

Benefits

Some of the demonstrated benefits of the ISO 50001 implementation and certification have included

- leadership engagement, including permission and support from the top command in implementing energy management activities;
- cultural change and a sense of organizational pride;
- increased discipline and follow through;
- changes in the procurement process, resulting in more efficient supply chains;
- focus on the process energy versus regular heating and cooling; and
- energy reductions and energy cost savings (14.1 percent below FY15 baseline).

OC-ALC is currently projecting its 2018 fiscal year utility costs at $22.5 million—higher than 2017, but lower than 2014 through 2016. The trend in decreased annual utility costs year over year speaks to the value of the system:

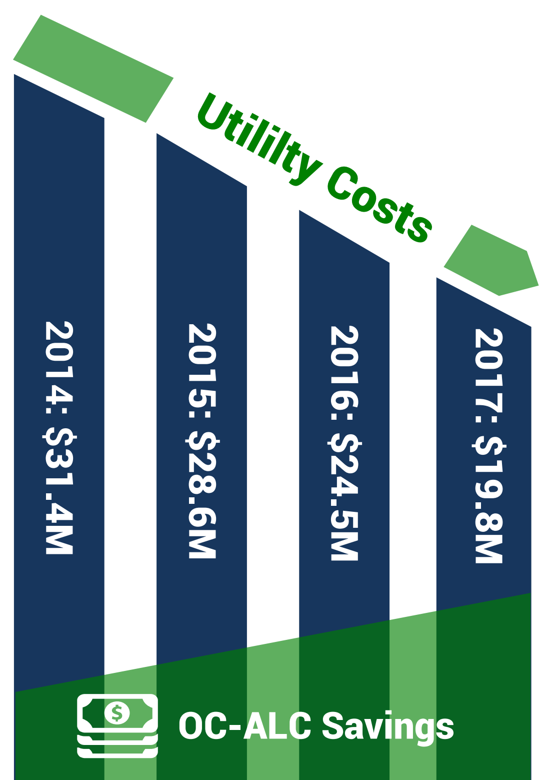
- 2014, $31.4 million
- 2015, $28.6 million
- 2016, $24.5 million
- 2017, $19.8 million.

Challenges

Implementation at OC-ALC wasn't without challenges. ISO 50001 requires increased communication across an organization, which can be daunting with over 10,000 employees. But, through engagement and empowering people to take more accountability and responsibility for energy use, the OC-ALC has benefited from employee-proposed, no cost solutions. Each area of significant energy use has a team, distributing the commitment to the system across the organization. For example, one team identified some cooling towers that were only needed during low use, weekend demand but were being run 24 hours a day, 7 days a week. This opportunity to reduce usage had been overlooked by others because they were not familiar with the equipment and process requirements.

Communicating performance results is also a priority. For its energy performance indicator, OC-ALC developed a control chart that analyzes monthly fluctuations and offers simplicity in communicating energy management in a meaningful way. The control chart reflects the measures taken and illustrates the improvements in energy usage over time. As with MCAS Beaufort, the identification of significant energy users pinpoints areas where efficiencies can be achieved.

According to Joseph Cecrle, OC-ALC energy manager, "In each one of the significant energy use areas, we have a team stood up in that area



that understands their production requirements. We let them set their plans, goals, and objectives because they know their production process much better than I as an energy manger would. We provide the opportunities, support modeling, and data analysis. But they come up with the ideas."

Another challenge is keeping the momentum going. "You just have to keep pushing the cart forward," says Joseph. The commander sets the tone for implementing the EnMS and ISO 50001 certification simplifies the transition when commanders change. "So far, every leadership change has reaffirmed the ISO 50001 system as being part of the organization. In fact, having the system makes the change easier."

The project at OC-ALC began in 2014 when the team initiated market research and continued through achievement of certification in April 2017. The certification process itself took about a year with Ken McKuen heading up the effort as the ISO 50001 program manager. Ken started the process in earnest in April 2016. Advanced Waste Management Systems, Inc. (AWM) performed the certification. Certification bodies, such as AWM, are assessed for competence by an accreditation body, such as the ANSI-ASQ National Accreditation Board (ANAB), which is recognized via successful peer review as ISO/IEC 17011 compliant under the International Accreditation Forum Multilateral Recognition Arrangement.

"AWM is proud to be the certification body for OC-ALC. It has been great to see the leadership and dedication that OC-ALC puts into energy management and the results achieved. The model established should set a great path for other sites to follow. Accreditation by internationally recognized organizations, such as ANSI and ANAB, adds additional value via oversight which confirms the independence and rigor of these audits and substantiates trust and confidence in the OC-ALC achievements." – *Rob Ellis, CEO of AWM*

THE WAY AHEAD

Ogden Air Logistics Complex at Hill Air Force Base and Warner Robins Logistics Complex at Robins Air Force Base (other complexes within the Air Force Sustainment Center, which encompasses OC-ALC and Tinker AFB) are pursuing ISO 50001 certification with the goal of achieving certification by 2020. ISO 50001 transforms the way organizations manage their energy and boosts resiliency. A recent revision to the standard places a stronger emphasis on the role of top management in instilling organizational cultural change. As DoD pursues energy resiliency as a priority and seeks cost effective solutions to improve mission assurance, ISO 50001 supplies a framework for achieving that mission.

ABOUT THE AUTHOR

Ann Howard *is director of Environmental Accreditation Programs at the American National Standards Institute.*

Program News

Topical Information on Standardization Programs and People

The DMSMS achievement awards seek to recognize individuals and teams from the government who are most responsible for significant achievements in proactive DMSMS management and implementation. The awards are based on achievements in the following areas:

- Exceptional DMSMS management
- Significantly improved and quantifiable readiness levels
- Substantial cost avoidance
- Exceptional warfighter support related to, or realized through, mitigation of a DMSMS issue
- Creation or implementation of a DMSMS best practice that increases supportability and availability of systems to the warfighter.

This year, the DMSMS Working Group received nominations demonstrating outstanding performance and varying levels of achievement in mitigating DMSMS. Some stood out as exemplifying extraordinary accomplishment and the evaluators (the service leads and the committee co-chairs of the DoD DMSMS Working Group) selected the following individuals and teams to receive achievement awards for 2018.

LIFETIME ACHIEVEMENT

Mr. Tracy L. Daubenspeck,
Naval Surface Warfare Center (NUWC) Keyport's DMSMS Operations Lead

Photo (Left to Right)
Mr. Michael Heaphy, *Director, DSPO*
Mr. Tracy Daubenspeck, *Award Winner*
Mr. Rob Gold
Ms. Robin Brown, *DMSMS Program Manager*

INDIVIDUAL ACHIEVEMENT

Dr. Jennifer A. Williams,
NUWC Keyport's Lead Research Scientist

Photo (Left to Right)
Mr. Michael Heaphy, Director, DSPO
Dr. Jennifer Williams, *Award Winner*
Mr. Rob Gold
Ms. Robin Brown

TEAM ACHIEVEMENT

NSWC, Port Hueneme Division NATO Sea Sparrow Surface Missile System/Target Acquisition System DMSMS Team

Photo (Left to Right)
Mr. Michael Heaphy, *Director, DSPO*
Ms. Hilary Chadwick
Ms. Jaclyn Pennington
Mr. Rob Gold
Ms. Robin Brown, *DMSMS Program Manager*

Airborne Warning and Control System (AWACS) Block 40/45 Upgrade Program

Photo (Left to Right)
Mr. Michael Heaphy, *Director, DSPO*
Mr. Walter Araya
Mr. Rob Gold
Ms. Robin Brown, *DMSMS Program Manager*

SPECIAL RECOGNITION CHAMPION AWARD

Mr. Robert A. Gold

Photo (Left to Right)
Mr. Michael Heaphy, *Director, DSPO*
Mr. Rob Gold
Ms. Robin Brown, *DMSMS Program Manager*

Award winners were recognized at the annual awards ceremony held during the DMSMS conference on December 4, 2018. The awards were presented by Mr. Robert A. Gold, Director of Technology and Manufacturing Industrial Base in the Office of the Under Secretary of Defense for Research and Engineering.

DMSMS awards citations may be read in their entirety on the DMSMS Knowledge Sharing Portal at https://www.dau.mil/cop/dmsms/Pages/Topics/DMSMS-Awards.aspx.

People

People in the Standardization Community

Mr. Gregory E. Saunders, former DSPO Director, retired after 49 years of dedicated Federal Service. He was the Director of the DSPO for twenty years and responsible for policies and procedures governing the development and use of Military Specifications and Standards, Qualified Products and Manufacturers Lists, use of industry standards, and development of performance specifications and Commercial Item Descriptions. He also oversaw the Government Industry Data Exchange Program (GIDEP) and the Diminishing Manufacturing Sources and Material Shortages (DMSMS) Program. Previously, Greg was the Deputy Director for Acquisition Practices in the Office of the Secretary of Defense, as well as a staff member of the Defense Materiel Specifications and Standards Office. He served on two Defense Science Board Studies, has testified before Congress, and has participated in numerous study groups.

Newly appointed DSPO Director Michael Heaphy presents former DSPO Director Greg Saunders with the Defense Standardization Program Plaque during his retirement ceremony on January 30, 2019, at the Fort Belvoir Officers' Club.

Ms. Trudie Williams retired from the federal government on January 3, 2019, after 40 years of service. She joined the staff of the Defense Standardization Program Office as a program analyst in 1992. Ms. Williams was responsible for DoD-wide Non-Government Standards (NGS) procedures for participation in NGS development and adoption and the Office of Management and Budget report to Congress on Federal Agencies' participation and use of NGS. In addition, she was responsible for market research policy and commercial item description procedures, and for Defense Standardization Program case studies. She was also the DSP representative for Federal Acquisition Regulation Part 11 on describing agency needs. Ms. Williams was a member of the Standards Engineering Society (SES) since 1999 and served on the SES Board of Directors as Technical Council Director from 2009 to 2012. She is also a winner of the SES/Canadian Standards Association Lorne K. Wagner Memorial Award and a 2016 winner of the American National Standards Institute Meritorious service award in recognition of outstanding contributions to the U.S. voluntary standardization system. The DSPO will truly miss her expertise. In retirement, Ms. Williams plans to do more traveling and to continue her volunteer work.

After 43 years of loyal service to the Department of Defense, **Mr. Joseph Delorie** of the Defense Standardization Program Office retired—in 2014! While the DSPO and Mr. Delorie remained in touch, the timing never seemed to line up for a formal retirement ceremony. Finally, on December 18, 2018, Mr. Greg Saunders was able to present Mr. Delorie with his retirement plaques and certificates.

Mr. Greg Saunders, now formerly Director of DSPO, presents Mr. Joe Delorie's retirement plaques to him during an office function.

WELCOME

Latasha R. Beckman has been named the deputy director of the Defense Standardization Program Office (DSPO). Ms. Beckman has more than 20 years of engineering experience, of which 14 years has been devoted to managing DSPO's international standardization program. She has advised DoD personnel and support contractors on defense standardization procedures, engaged with allies and partners on standardization policy matters and training, and participated in multilateral meetings with foreign governments concerning items of mutual interest.

Ms. Beckman appreciates the great privilege and responsibility to help shape the future of the DSPO. While she has interest in a number of initiatives, she is most passionate about modernizing DSP tools and the procedures used by standardization managers to ensure the maintenance of standardization documents. She hopes to leverage innovative business processes to maximize personnel efficiency and to modernize ASSIST to take advantage of more updated technology and industry practices for storing and promulgating documents as digital data.

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
May—August 2019	Standardization Stars
September—December 2019	Modular Open Systems Approach (MOSA)

DEFENSE STANDARDIZATION PROGRAM ★ MAKING SYSTEMS WORK TOGETHER ★