Interoperability Standards Analysis (ISA)

A report by

The Standards Committee

of the

National Defense Industry Association (NDIA) Robotics Division

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Abstract

Interoperability standards are a central theme in the realm of unmanned systems. The importance of interoperability continues to grow as more unmanned systems are fielded – including ground, air, surface, and underwater vehicles. The SAE Joint Architecture for Unmanned Systems (JAUS) and NATO Standardization Agreement (STANAG) 4586 enjoy considerable attention from both policymakers and industry. Systems using STANAG 4586 are not currently interoperable with systems using JAUS. The standards serve similar functions in many respects, and have some similarity in their message sets, yet have differing approaches to accomplishing levels of interoperability. As a result, the Standards Committee of the NDIA Robotics Division performed a study to investigate the differences and similarities between key interoperability standards and recommend an unmanned systems standardization strategy to support improved interoperability and cost reduction. The findings of the study are presented in this report.

The Importance of Interoperability Standards

As more and more unmanned systems are fielded, the need for a common method of communicating between those systems becomes more important. Interoperability standards provide this common medium, serving as the "glue" for unmanned systems. Interoperability standards offer the following benefits:

- **Reduce life cycle costs** – the cost to develop, integrate, and support unmanned systems is reduced by eliminating custom, "stovepipe", implementations
- **Reduce development and integration time** – common communications prevent the reinvention of the wheel, allow for code re-use, and speed integration since proven technology is being employed.
- **Provide a framework for technology insertion** – with a common interface, as new technologies are created, those technologies can be easily integrated with minor to no modification to existing systems.
- **Accommodate the expansion of existing systems with new capabilities** – with the framework to support new technologies, the types of missions that current systems can perform increases.

The U.S. Government has recognized the importance of standards within the Department of Defense (DoD) to support the rising number of unmanned systems. The 2001 National Defense Authorization Act [1] clearly stated the Government's intention to increase the number of unmanned systems used within the DoD, by requiring one-third of Future Combat System (FCS) assets be unmanned. Public Law 109-364 (October 6, 2006) [2] reinforced this mandate by stating that the DoD also prefers unmanned systems over manned systems.

These mandates have consequently generated strong requirements for interoperability standards within the DoD. For example, referring to Figure 1, interoperability standards lie at the core of the FCS framework. Specifically, the Joint Architecture for Unmanned

Systems (JAUS) [3] has been required for all unmanned ground vehicles, air vehicles, and unattended ground systems within FCS. JAUS and NATO Standardization Agreement 4586 (STANAG 4586) [4] have been mandated for the Navy. At the AUVSI Plenary Session held on June 29th, 2005, Rear Admiral William Landay, III mandated that “the Navy is adopting two standards: STANAG for UAVs, and JAUS for everything else” and “if you bring us a UGV, USV, or UUV that’s not JAUS-compliant, we’re not interested”.

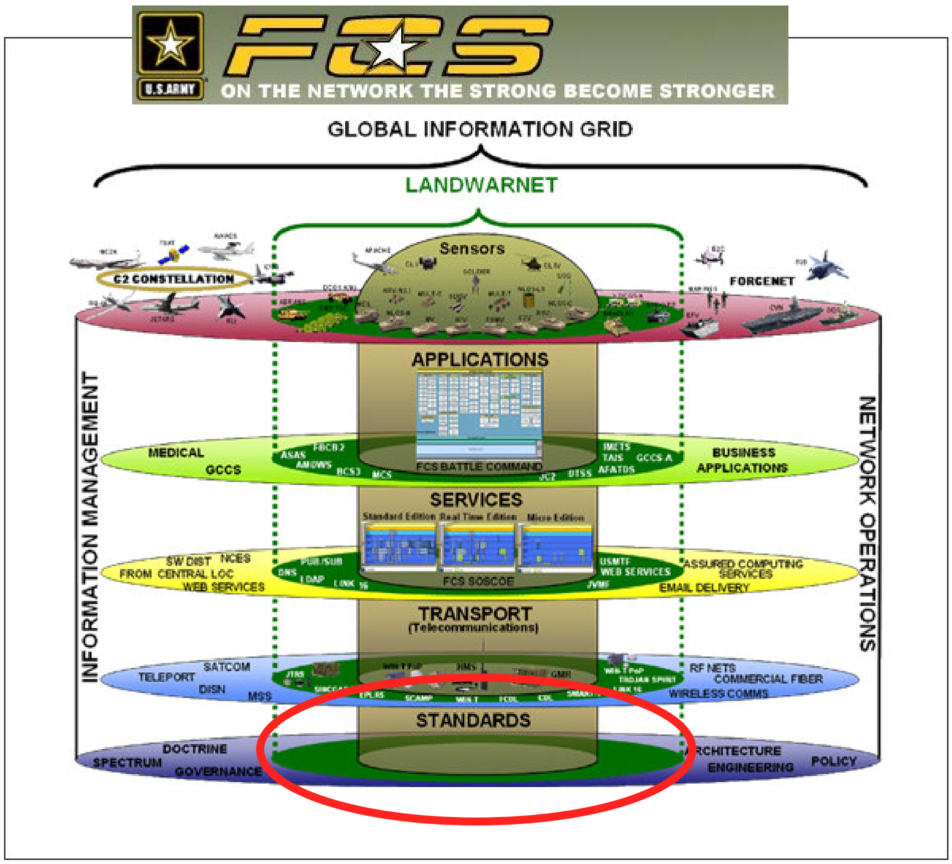

Figure 1: Standards are the core of the US Army’s Future Combat System (FCS)

Interoperability standards are now being written into Public Law, specifically with regards to STANAG 4586. For example, Public Law 109 -163 [5] from January 6, 2006 states that: "(2) those vehicles use data formats consistent with the architectural standard for tactical unmanned aerial vehicles known as STANAG 4586, developed to facilitate multinational interoperability among NATO member nations.”

In addition to the DoD, standardization is beginning to span various divisions of the Government. This is partially due to Section 1401 of the 2003 National Defense Authorization Act [6] which encourages technology transfer from the DoD to other Federal, State, and local first responders in support of homeland security. As a result of the 2001 and 2003 National Defense Authorization Acts, unmanned system mandates and standardization requirements are beginning to emerge outside the DoD. For example, the

National Bomb Squad Commanders Advisory Board (NBSCAB) mandated that bomb squads must have at least one robot by 2009 in order to stay accredited. Secondly, all robots acquired through federal funds must be JAUS compliant [7].

It is clear that the US Government is committed to increasing the number of unmanned systems, as indicated by the 2001 and 2007 National Defense Authorization Acts. Interoperability standards are imperative in order to support this proliferation of unmanned systems.

Preference for Non-proprietary, Open Standards

The Defense Standardization Program (DSP), formed in response to the 1952 Defense Cataloging and Standardization Act [8], advocates the use of commercial standards developed by open, consensus-based bodies. Specifically, the U.S. Government is concerned that the process for developing standards be transparent, fair, and effective for all concerned and that it represents U.S. interests effectively [9].

The preference for commercial, open standards has been promoted by the DSP since 1962. The National Technology Transfer and Advancement Act of 1995 (NTTAA) [10], Public Law 104-113, and Office of Management and Budget (OMB), Circular A-119 [11] firmly directed federal agencies to use voluntary standards in lieu of Government standards whenever feasible. OMB Circular A-119 contains four goals:

- Eliminate the cost to the Government and decrease the cost of procured goods
- Provide incentives and opportunities to establish standards that serve the national interest
- Encourage long-term growth for US enterprises and promote efficiency and economic competition through harmonization of standards
- Further the policy of reliance upon the private sector to supply Government needs for goods and services

Need for Harmonization of Interoperability Standards

The Government advocates the harmonization of standards, yet several interoperability standards have emerged over the past decade with overlapping capabilities. Two of the most prominent interoperability standards employed by unmanned systems today are JAUS and STANAG 4586. The Office of the Under Secretary of Defense (OUSD) Acquisition Training & Logistics (AT&L) [12] has a vested interest in both JAUS and STANAG 4586. The Joint Ground Robotics Enterprise (JGRE) division of OUSD AT&L funds many programs utilizing the JAUS standard and the Unmanned Air System (UAS) division of OUSD AT&L funds many programs using the STANAG 4586 standard.

A collaboration strategy is clearly required to advance the various disparate standards into a solution which can support interoperability across all domains (i.e. all types of manned and unmanned assets). JAUS and STANAG 4586 are clearly duplicating efforts on many fronts. Each standard came into existence by addressing a specific requirement for different domains. JAUS was originally developed to meet the requirements of UGVs and STANAG 4586 was originally developed to meet the requirements of UAVs. However, JAUS and STANAG now address other UxV domains. For example, JAUS is mandated for, and is currently being implemented on many UUV and USV projects. Future force systems will be deploying teams of unmanned vehicles (i.e. air, ground, maritime, and underwater) which will need to communicate and share information with each other. Consequently, a strategy must be devised for the collaboration of existing standards in the pursuit of system-wide interoperability and cost reduction.

Interoperability Standards Analysis Approach

The Interoperability Standards Analysis (ISA) utilized a phased approach to compare and contrast the different interoperability standards and identify a strong long-term standardization strategy for unmanned systems. The first phase of the study asked the question “where are we now?” Phase I identified the current state of key standards being used for unmanned systems within the DoD. The second phase of the study asked the question “where do we need to go?” Phase II explored what capabilities are needed for interoperability standards in the future. The third and final phase asked the question “how do we get from where we are now to where we need to go?” Phase III investigated several alternate strategies for harmonizing current standards toward a solution to support the growing unmanned systems industry for years to come. The goal of this three-phase approach was to determine which standard, or combination of standards, provides the best path for interoperability across all domains.

Focus on JAUS and STANAG 4586

During Phase I of the ISA, the first step was to identify the interoperability standards being used on unmanned systems today. To accomplish this, the Standards Committee assembled a collection of standards experts and industry leaders. Membership included experts from industry, academia, and government agencies. As standards were identified, leaders of those standards joined the committee. Standards representation included, but was not limited to: JAUS, STANAG 4586, MIL-STD-1760, ASTM F41, UAI, and Joint Unmanned Aircraft System. Additionally, other standards and commercial solutions were considered such as 4D/RCS, SOSCOE, ASTM F38, Microsoft Robotics Studio, etc. During Phase I of the ISA, emphasis was placed on JAUS, STANAG 4586, F41, and MIL-STD-1760. The Phase I effort quickly revealed that MIL-STD-1760 did not need to be looked at separately since both JAUS and STANAG 4586 intended to adopt MIL-STD-1760 for interfacing to weapon systems. Based on the quantitative analysis performed, it was clear that the focus should be placed on JAUS and STANAG 4586 since those two standards had the majority of mandates and requirements spanning multiple domains. The remainder of the report focuses on these two standards. However, the Standards Committee of the NDIA Robotics Division will continue to be inclusive of all key existing and emerging standards in order to recommend standardization strategies for improved interoperability and cost reduction.

Evaluation of JAUS and STANAG 4586

A quantitative analysis of several key interoperability standards was conducted during Phase I of the ISA. Each standard was listed along the X axis and each evaluation criterion was listed along the Y axis, providing a side-by-side comparison of the standards. The high-level evaluation criteria were:

- Span and scope of the standard
- Governance
- Classifications
- Adoption audience
- Process and configuration management
- Technical approach, status, and plans

JAUS and STANAG 4586 are both message-based standards. Consequently, duplication of effort exists in terms of capabilities and the domains targeted by both standards. For example, both JAUS and STANAG 4586 continue to introduce functionality in order to support unmanned surface vehicles (USVs). However, STANAG 4586 is still primarily focused on UAVs and JAUS is primarily focused on UGVs.

There are some technical differences between the standards. For example, JAUS places most of its emphasis on the command and control (C2) of unmanned systems, whereas STANAG 4586 places more emphasis on the data from payloads onboard UAVs. Consequently, JAUS currently supports some different capabilities than STANAG 4586 in terms of representing the environment surrounding unmanned systems and providing functionality for avoiding obstacles. Another technical difference between the standards is that JAUS treats unmanned systems as generic assets, whereas STANAG 4586 employs Vehicle Specific Modules (VSMs) within the standard.

The quantitative analysis also revealed that both standard bodies concur that a Service Oriented Architecture (SOA) currently offers the best path for future interoperability of unmanned systems. The JAUS committee is currently documenting its implementation of an SOA. Similarly, the STANAG 4586 committee plans to incorporate an SOA in Edition 4.0 of STANAG 4586 (Edition 3.0 of STANAG 4586 should be promulgated in early 2008).

Both JAUS and STANAG 4586 have been validated on various systems over the past decade. A representative sample of systems which have used or are using each standard are listed in Table 1.

Example JAUS Systems	Example STANAG Systems
ARTS	MQ-1 Predator
USMC Gladiator	Shadow 200
Air Force REDCAR	Aeronsonde Mk. 4.3
Navy JUSC2 ACTD	ScanEagle A
Army FCS	Raven-B
NGEODRCV	Spyhawk
Navy MTRS	DTI Kestrel-T
Army MDARS-E	Pioneer
Navy Spartan ACTD	Grasshopper
Army PM-FPS FIRRE	Silver Fox

Table 1: Sample systems using each standard

Classification was one of the most important criteria during the analysis. Most of the standards evaluated are unclassified. However, STANAG 4586 is defined as "NATO UNCLASSIFED". Simply put, STANAG 4586 is only accessible by organizations in NATO member countries – on a need-to-know basis. This has implications on the industrial base for unmanned systems. For example, Japan, which is not a NATO member nation, does not have access to the STANAG 4586 standard. If a Japanese company wanted to market a sensor payload for a UAS, it would need to make a special petition to NATO to gain access to the standard. Without access to the standard, the sensor payload product would not be interoperable and would require custom integration. The NATO UNCLASSIFIED designation intentionally limits dissemination and knowledge of the standard, which has the consequence of reducing the number of eligible systems integrators and qualified vendors. Access restrictions such as NATO UNCLASSIFIED can limit the vendor base of unmanned systems. Consequently, NATO is currently entertaining the possibility of placing STANAG 4586 into the public domain.

Potential Strategies for Standard Harmonization

Phase I of the ISA provided a snap-shot of where JAUS and STANAG 4586 stand today. The goal of the Phase II effort was to identify what *an* interoperability standard should be. Although a definitive goal was never established during the study, the Standards Committee agreed on a general functionality framework that an interoperability standard must support for the next generation of unmanned systems. At the very highest level, an interoperability standard must:

1. Provide a method for transferring data between entities (where entities can be unmanned systems, manned systems, control units, payloads, etc.) across all domains
2. Support discovery and dynamic configuration/registration of those entities.

The JAUS and STANAG 4586 committees have both adopted the idea of using an SOA as the mechanism for achieving this high-level goal.

Phase III of the ISA investigated various strategies for moving toward this high-level goal. The standardization strategy must support interoperability across all domains, support discovery and dynamic registration *and* drive cost reduction for unmanned systems. Using the information accumulated from Phases 1 and 2, the investigation focused on identifying strategies that demonstrated a viable path towards a cohesive UxV standards framework. Four main strategies emerged from the investigation in Phase III:

1. Dissolve one standard for the other
    a. Dissolve JAUS and adopt STANAG 4586 for all UxVs
    b. Dissolve STANAG 4586 and adopt JAUS for all UxVs
2. Dissolve both JAUS and STANAG 4586, and create a new standard for UxVs
3. Maintain JAUS and STANAG 4586 and define translation modules between the two standards
4. Systematically fuse JAUS and STANAG 4586

All of the above strategies are viable options, but the implications of each option must be carefully considered. Regardless of the strategy selected, significant investment is required by both industry and the Government. The following subsections discuss the implications of each strategy.

Dissolve One Standard for the Other

The first strategy would entail abandoning one of the standards for the standard which would offer the best framework for achieving interoperability across all domains. This strategy would solely adopt either JAUS or STANAG 4586 as the interoperability standard for all UxVs.

If STANAG 4586 were adopted as the sole interoperability standard, as described by option 1a, serious implications are felt both by industry and by the programs which have generated requirements for JAUS. Many companies have invested in a JAUS code base which would be abandoned. Although a unified standard would result from this approach, the "NATO UNCLASSIFIED" classification of STANAG 4586 hinders the use of the standard in non-NATO applications. With the Government's congressional mandate for dual-use technologies with first responders, this strategy may prevent civilian and military systems from communicating, for example, since some civilian systems may not be able to gain access to the NATO standard.

Similar to option 1a, selecting JAUS as the sole interoperability standard, as described by option 1b, would cause serious ramifications in that companies would be losing investments in STANAG 4586 and programs would need to restructure requirements. Most importantly, dissolving STANAG 4586 requires reversing congressional language mandating STANAG 4586 to be used for tactical UAVs. Specifically, Public Law 109-163 from January 6, 2006 would need to be specifically addressed under this strategy.

The principle advantage of this strategy is a strong designation of *one* official standard for all unmanned systems. This designation would provide a clear path forward for government and industry and promote adoption of the standard in future systems. It remains unclear whether this singular advantage is strong enough to overcome the limitations mentioned above.

Creation of a New UxV Standard

The second option would take the lessons learned from both standards and form a new standard. The best attributes of JAUS and STANAG 4586 would be merged into a new standard. Like the first option (both 1a and 1b), significant investments in JAUS and STANAG 4586 will be lost (see Table 1 for examples of systems using these standards). As in option 1, the main advantage lies in designating a primary standard for UxVs. Industry adoption is favored as more companies would begin investing in the new interoperability standard because there would be a clear path toward interoperability defined. Similar to option 1b, a significant hurdle exists in that Public Law 109-163 would need to be overturned. Finally, this option also poses major impact on both JAUS and STANAG 4586 programs in that the new standard would most likely not be backward compatible with both JAUS and STANAG 4586.

Maintain Existing Standards – With Translation

The third option would maintain concurrent development of the two standards while defining translation modules to allow the two standards to communicate. For example, UAVs running STANAG 4586 could communicate with UGVs running JAUS through "translators" – a software mechanism that understands both standards and can communicate between the two. This strategy would continue to incur duplication of efforts. In addition, it introduces a tertiary 'translation component' that would need to be maintained as both JAUS and STANAG 4586 continue to evolve. Currently, this option is the de facto strategy being implemented. Many companies are hedging their investments by implementing a 'dual use' scenario because they are unsure about which standard to adopt. In fact, this activity represents the most significant flaw with this approach: many companies are resistant to adopting either JAUS or STANAG 4586 because there is no clear strategy of how interoperability for UxVs will really manifest. The Government's current funding of duplicate efforts dissuades companies from whole-heartedly adopting interoperability standards.

Systematic Fusion of Existing Standards

Finally, with the fourth option, JAUS and STANAG 4586 are initially maintained, but then are incrementally fused, allowing for backward compatibility and uninterrupted standard advancement in pursuit of a unified interoperability standard for all UxVs. Under this approach an SOA would serve as the framework for fusing the two standards. Since both JAUS and STANAG 4586 intend to migrate toward an SOA currently, this is a natural catalyst for unification of the two standards.

The SOA would serve as the foundation for domain-specific services. Domains might initially include UGVs, UAVs, USVs, UUVs, UGS, etc. For example, a UGV domain might define "UGV teleoperation" services based on currently defined JAUS messages and a UAV domain might define "UAV teleoperation" services based on currently defined STANAG 4586 messages. Or perhaps, as shown in Figure 2, STANAG 4586 could provide the services for the militarized, "NATO UNCLASSIFIED" version of the resultant standard for all unmanned systems. In this example, the services would be based on messages defined in the STANAG 4586 standard. Likewise, for non-military operations, currently defined JAUS messages could serve as the foundation for commercial UxV services.

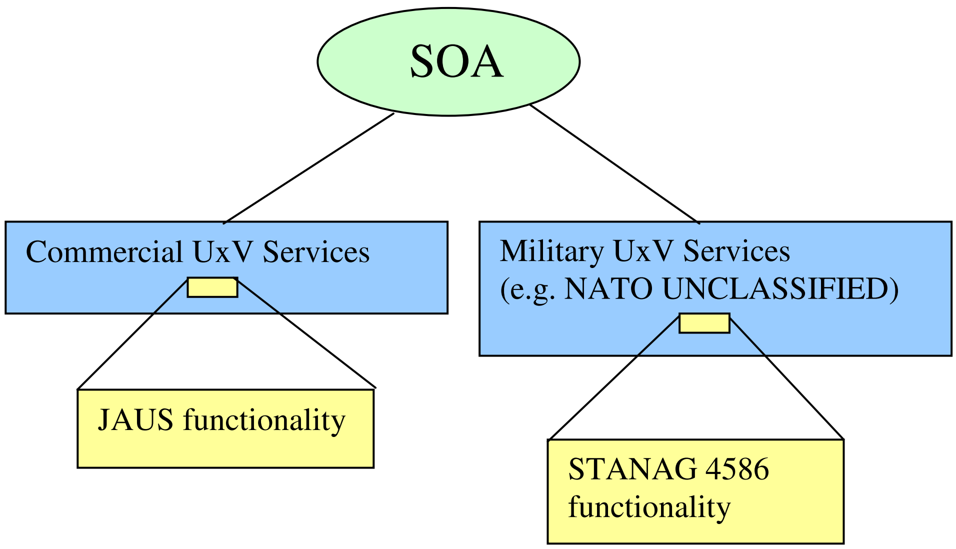

Figure 2: One embodiment of Option 4

A summary of each of the options presented is provided in Table 2. A comparison of each option is measured against key evaluation criteria such as the impact on industry and policy.

	Option 1A Dissolve JAUS and adopt STANAG 4586	Option 1B Dissolve STANAG 4586 and adopt JAUS	Option 2 Dissolve both JAUS and STANAG 4586 and create a new standard	Option 3 Maintain JAUS and STANAG 4586 and define translation modules	Option 4 Systematically fuse JAUS and STANAG 4586
Impact on industry	Many companies have invested in a JAUS code base for their systems. That investment would be lost.	Many companies have invested in a STANAG 4586 code base for their systems. That investment would be lost.	Many companies have invested in either JAUS or STANAG 4586 and a new code base will need to be developed by those companies.	Whether a company invested in JAUS or STANAG 4586, that investment is not lost.	Whether a company invested in JAUS or STANAG 4586, that investment is not lost.
	More companies will invest in STANAG 4586 because there is a clear path toward interoperability	More companies will invest in JAUS because there is a clear path toward interoperability	More companies will begin to support the new interoperability standard because there is a clear path toward interoperability	Companies may still resist implementing JAUS or STANAG 4586 due to the continued segregation	Companies currently implementing JAUS and STANAG 4586 will continue to advance the evolving standard and new companies will be more likely to adopt interoperability standards due to the clear path
Impact on policy		STANAG 4586 is written into Public Law 109-163 (January 6, 2006), so new law would need to be established	STANAG 4586 is written into Public Law 109-163 (January 6, 2006), so new law would need to be established		
Impact on programs	Many programs have JAUS requirements	Many programs have STANAG 4586 requirements	Many programs have JAUS and STANAG 4586 requirements	Current program requirements are maintained	Current program requirements are maintained
Implications of transition	Systems using JAUS must be reimplemented to use STANAG 4586	Systems using STANAG 4586 must be reimplemented to use JAUS	There will be delays in standards technology advancement while the new standard is being developed	Standard advancement will be delayed due to continued segregation	Backward compatibility with existing JAUS and STANAG 4586 systems can be realized
					Incremental fusion allows for uninterrupted standard advancement
					Significant coordination between NATO and SAE is required
Unified Standard	STANAG 4586 serves as the unified standard once expanded to support all UxVs	JAUS serves as the unified standard once expanded to support missing UAV functionality	The new standard would serve as a unified standard	A unified standard is never realized	JAUS and STANAG 4586 incrementally fuse into one unified standard
Knowledge retention	There is a high risk that experience and functionality embodied by the JAUS standard would be lost	There is a high risk that experience and functionality embodied by the STANAG 4586 standard would be lost	Experience and functionality from both standards are used to develop the new standard	Experience and functionality is maintained for the existing standards	Experience and functionality is maintained for the existing standards
				Knowledge remains segregated	
Classification	NATO UNCLASSIFIED hinders use of the standard in non-NATO applications				NATO applications can continue to have a protected (i.e. NATO UNCLASSIFIED) part of the standard

Table 2: Summary of viable strategies versus the implications of each strategy

Findings

By the end of the ISA study, which spanned a 10 month period, it became clear that a standardization strategy needs to be established in order to support the proliferation of unmanned systems. JAUS and STANAG 4586 were the focus of the ISA due to the strong mandates and requirements for both standards over multiple domains. Four viable strategies were identified during the ISA.

The four primary strategies presented are all viable options that require significant investment by both industry and the Government to execute properly. Options 1 through 3 have significant ramifications that need to be seriously considered. With option 1a, the greatest implication is that STANAG 4586 is NATO UNCLASSIFED, so sole adoption of that standard would severely hinder its use on non-NATO systems. With options 1b and option 2, dissolving STANAG 4586 would require reversal of congressional law. With option 3, the de facto strategy, knowledge remains segregated, duplication of efforts would continue, and the industry would be less likely to commit to one standard for fear of committing to potentially the "wrong standard". With any of the above strategies, the detailed technical solution is not yet developed, but based on the consensus of the Standards Committee, a viable technical solution exists for each option.

The fourth option presents a strategy which minimizes the negative implications, but requires significant coordination between the JAUS and STANAG 4586 standards bodies. Among the advantages of this strategy is the ability to systematically and incrementally merge common focal points. Although the first three options require a significant and abrupt change in policy, option 4 allows a transition over time to a unified framework. The strengths of option 4 clearly outweigh the weaknesses. Therefore, option 4 offers the ideal future standardization strategy, provided a clear, high-level policy mandate, followed by a detailed Memorandum of Agreement, is established between SAE International's AS-4 committee and NATO's STANAG 4586 committee.

There are several potential technical embodiments for option 4, one of which will be presented as an example for clarification. The ISA revealed that the JAUS committee is currently documenting the JAUS Service Interface Definition Language (JSIDL) and the JAUS Service Specification (JSS). JSIDL presents the formal language for defining generic services. JSS is the JAUS-specific set of services for addressing UxV. Given that significant investment has been made into the development of JSIDL and JSS, one embodiment of the fourth solution would be to have JSIDL serve as the framework for JAUS and STANAG 4586 to come together. This approach could create services based on specific UxV domains and uses as depicted in Figure 3.

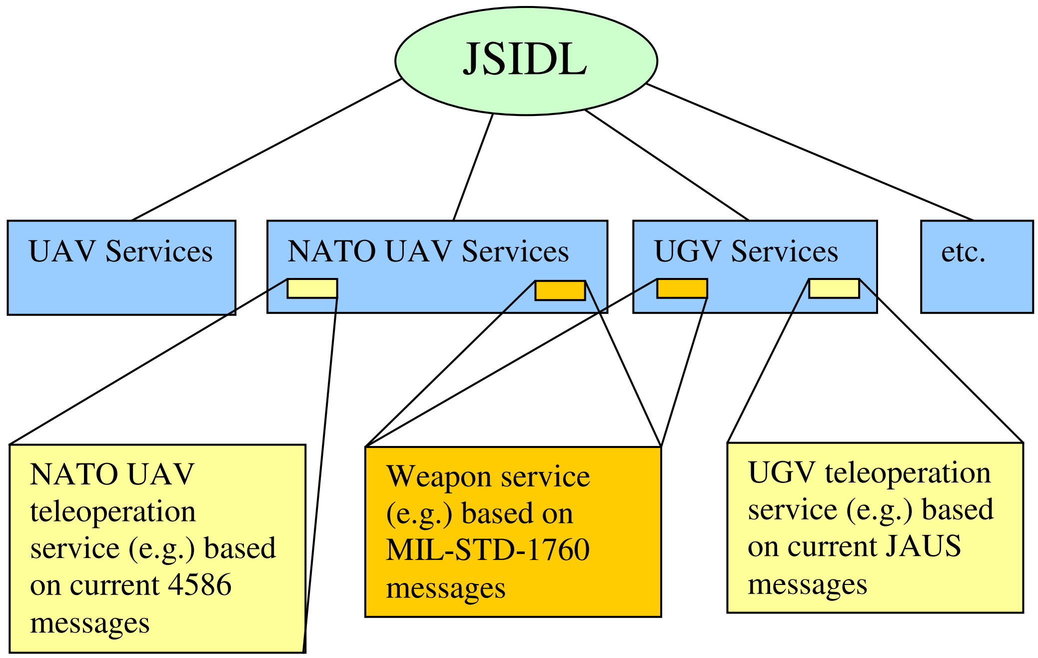

Figure 3: Another embodiment of Option 4

Referring to Figure 3, services can be logically separated into UxV domains. For example, one set of services might be defined for UGVs, whereas another set of services might be defined for UAVs. For NATO-based UAVs, perhaps a separate set of services would need to be defined. One example service that could be defined for UGVs is "UGV teleoperation", which might by based on existing UGV teleoperation messages currently defined in JAUS. If a UGV were to subscribe to this service and an Operator Control Unit (OCU) were to subscribe to this service, then that OCU would be able to communicate with and teleoperate that UGV. Similarly, another service could be defined for NATO UAVs called "NATO UAV teleoperation", which might be based on UAV teleoperation messages currently defined in STANAG 4586. If a UAS were to subscribe to this service and a UAV Control Station (UCS) were to subscribe to this service, then that UCS would be able to communicate with and teleoperate that UAS. This approach would allow for immediate backward compatibility with existing JAUS and STANAG 4586 systems. In this example, if the UCS wanted to control the UGV as well as the UAS, the UCS could subscribe to the UGV teleoperation service.

Continuing the example, since both JAUS and STANAG 4586 are adopting MIL-STD-1760 for weapon control, a new shared service could be defined which would apply to both UGVs and UAVs. The concept of incrementally creating shared services allows for systematic fusion of the two standards. Initially, a separate "UGV teleoperation" service and "UAV teleoperation" service will need to be defined, but eventually through a MOA, the JAUS and STANAG 4586 committees can develop a more generic "teleoperation" service which could apply to both UGVs and UAVs. Many shared services could be defined, such as a "world modeling' service. Such a service could be used by all UxVs to describe the environment surrounding a UxV in a standard manner. Eventually, all services would become shared and the concept of JAUS versus STANAG 4586 would fade away as a new unified standard emerges.

Conclusion

The four strategies which emerged from the ISA are all feasible methods for supporting interoperability across all domains. Regardless of the strategy pursued, a Government level mandate is required to successfully realize unmanned systems interoperability. Without a new strong Government mandate, the third strategy presented above will be pursued by de facto, where JAUS and STANAG 4586 will continue to be developed in parallel. The end result of this strategy will produce ad hoc translation solutions and dissuade industry from strongly investing in either standard. Only the adoption of a unified standard, coupled by strong policy, will be able to truly achieve unmanned systems interoperability.

All strategies evaluated present significant challenges. However, the first three strategies present the greatest hurdles. For example, the sole adoption of STANAG 4586, with its current classification of "NATO UNCLASSIFIED", would greatly hinder the ability to support non-NATO systems and would require changing requirements for programs which currently refer to JAUS. Likewise, dissolving STANAG 4586 in support of a new standard or in favor of JAUS would require the dismantling of existing congressional language and requirements for programs pointing to STANAG 4586. The fourth strategy, however, is the sole strategy which can allow for both standards to continue to exist, yet begin to merge in an incremental manner. A cursory technical analysis indicates that a technical solution is viable, provided that the JAUS and STANAG 4586 committees establish a detailed MOA in the pursuit of incremental fusion. In order to realize this strategy, and stop the momentum currently supporting development of disparate standards, strong Government policy needs to be instated.

Acronym List

ASTM	American Society for Testing and Materials
C2	Command and Control
DoD	Department of Defense
DSP	Defense Standardization Program
FCS	Future Combat System
ISA	Interoperability Standards Analysis
JAUS	Joint Architecture for Unmanned Systems
JUAS	Joint Unmanned Aircraft System (JIPT)
JSIDL	JAUS Service Interface Definition Language
JSS	JAUS Service Specification
MIL-STD	Military Standard
MOA	Memorandum of Agreement
NATO	North Atlantic Treaty Organization
NBSCAB	National Bomb Squad Commanders Advisory Board
NDAA	National Defense Authorization Act
NDIA	National Defense Industry Association
NTTAA	National Technology Transfer and Advancement Act
SAE	Society of Automotive Engineers International
SOA	Service Oriented Architecture
STANAG	Standardization Agreement
UAI	Universal Armament Interface
UAS	Unmanned Air System (equivalent to UAV)
UAV	Unmanned Air Vehicle (equivalent to UAS)
UCS	UAV Control Station
UGS	Unattended Ground System
UGV	Unmanned Ground Vehicle
USV	Unmanned Surface Vehicle (e.g. unmmaned boat)
UUV	Unmanned Underwater Vehicle (e.g. unmanned submarine)
UMV	Unmanned Maritime Vehicle (i.e. UUVs and USVs)
UxV	Unmanned Vehicle, including UGVs, UAVs, USVs, and UUVs
US	Unmanned Systems

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