Modular and Multimodal: Delivering Distributed and Scalable Technical Training

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ABSTRACT

With perpetual and accelerated technical capability advancement across the Department of Defense (DoD), the practical need for versatile and self-service learning tools is growing rapidly. Military platforms and systems become more complex, user backgrounds become increasingly diverse, and information travels with increasing speed over time. How can military training programs serve the needs of highly varied learning communities while managing constrained training budgets and increased mission readiness requirements?

This paper will explore multimodal distributed training systems that enable differentiated and on-demand learning for users of complex military hardware and software platforms. Authors will present the framework of these systems, the impact of these systems on military programs and user communities, barriers to implementation, and opportunities for improvement with specific examples from Fleet and National Guard implementation. Primary use case examples derived from Naval Air Warfare Center Aircraft Division Webster Outlying Field (NAWCAD WOLF) implementations will be discussed. NAWCAD WOLF develops instructional materials and platforms that enable flexibility of modalities, delivery, and presentation and highlight the value of modular interactive courseware (ICW) formats and performance support tools to meet the needs of rapid acquisition training requirements. Utilizing a single, central, automated programming architecture to channel content to specified devices and output formats facilitates open navigation and differentiation; application to mobile, extended reality (XR), and other immersive formats with simultaneous distribution to learning management systems (LMS); and frequent content updates based on system changes and user feedback.

ABOUT THE AUTHORS

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IN-SERVICE ENGINEERING AND TRAINING SYSTEMS DEVELOPMENT

Training dominance enables mission success. Maintaining a ready and lethal military requires warfighters to operate advanced technical systems at the tactical edge of the modern battlefield. To ensure readiness, training systems must be available, relevant, and adaptable to rapid changes in content, curriculum, and policy. Training systems must be responsive; they need to support speed across all phases of the training lifecycle from content analysis through development and deployment and on to sustainment. Widespread adoption and emphasis on increasingly speed-focused and iterative development methodologies for the engineering of in-service military systems is significantly driving the requirement for alignment between system engineering and training development processes. Agile methodologies including the U.S. Navy's (USN) Development Security Operations (DevSecOps) initiative Compile to Combat in 24 Hours (C2C24) promulgate across engineering teams to iterate, automate, and deliver capability and content more often and more efficiently (Red Hat, 2019). From a USN policy perspective, Sailor 2025 Ready Relevant Learning (RRL) aims to modernize training by providing a wider array of impactful and relevant training to the Fleet at the moment of need (United States Fleet Forces Command, 2017). Furthermore, RRL emphasizes the optimization of quantity, quality, and accessibility of Navy eLearning, creating appropriately scaled content for distribution via the right delivery method (Department of the Navy, 2020). These activities highlight a few of the latest in a longstanding commitment by the training community to foster "best practices for using distributed learning to provide the highest-quality education, training, informal learning, and just-in-time support; tailored to individual needs and delivered cost-effectively, anytime and anywhere" (Advanced Distributed Learning Initiative, n.d.). Propelled by an emergent need to adapt instructional design and training systems development approaches to more agile responsive methodologies, the training community requires key enablers at the nexus of engineering speed and training system readiness. The goal of these enablers is to align training development to rapid engineering schedules by exploiting the scalable data architectures and data package pipeline automation capabilities of current and emerging technical practices. Leveraging contemporary instructional systems design models rather than more traditional waterfall approaches for cyclical development favors modularity and multimodality and unlocks training system development potential. Collectively, these enablers facilitate the rapid and cost-effective scaling and delivery of distributed training systems that empower learners to maintain knowledge and skills to enhance their own performance (Kirkpatrick & Kirkpatrick, 2019).

Adding to the body of knowledge surrounding optimally scaled training solutions for the Department of Defense (DoD) environment, this paper will explore the framework of these systems and the impact on military programs and user communities with a discussion of successes, barriers to implementation, and opportunities for improvement. Specific examples from the Naval Air Warfare Center Aircraft Division Webster Outlying Field (NAWCAD WOLF) implementation of such a system used to develop interactive electronic technical manual (IETM) and performance support solutions will be used to illustrate key concepts and lessons learned.

MODULAR AND MULTIMODAL

In a distributed training context, modularity refers to the building blocks of a training ecosystem, such as interactive courseware (ICW), performance support tools, and IETMs. These building blocks encompass both content and functionality. Modular training is intentionally developed with learning material and code that can be segmented, extracted, modified, or replaced without disrupting the stability of proximal units or the total system architecture. Multimodality refers to leveraging unit-level blocks to facilitate deployed content or capability across different delivery vehicles using a "build once, deploy many" approach. In this construct, a training system unit can be designed and developed for one delivery modality such as web-based work instruction, a quick reference card, or a section of an IETM, and then scaled with minimal effort to other modalities to support planned downstream or emergent content or technical insertion requirements.

While the value proposition of building training systems using these key enablers includes production and deployment efficiencies, from a learner perspective, they unlock a means to differentiate and regulate training delivery to personalize how learners access needed content based on learning preferences or convenience. In the 2012 publication *Designing Learning for a 21st Century Workforce*, Van Dam emphasizes that "[l]earning design excellence requires a deliberate and explicit choice of the right modality for the level of learning required" (p. 53). Echoed by Temby and Whitney in 2019, the Defence Science and Technology researchers posit that "there are several enduring and emerging areas [that are]...important for future research to address in support of military training," and these include mobile technologies, personalized training, and multimodal training. They go on to note that "understanding specific methods that work for individuals will be important to inform the development of personalized training protocols" as military training advances (p. 11).

Establishing a training system framework to support modular and multimodal scalability requires engineering technical data feed pipelines and ensuring interoperability and translation between interrelated platforms across the supported system-level ecosystem. Establishing a robust backbone for system architecture enables a number of benefits to be realized by product owners including lower cost per unit to develop content for new delivery platforms, improved configuration management (CM) and knowledge management (KM) due to the utilization of single-source-of-truth data, and faster deployment of new content and capability.

While training systems can be developed using modular or multimodal frameworks independently, employing them in concert magnifies the benefits of the integrated solution. This integrated approach has been implemented by NAWCAD WOLF for USN and other DoD user communities with training needs for tactical air, ground, and sea-based systems. Their implementation aims to facilitate personalized learning by creating training tools that allow learners to self-select specific content and appropriate modalities to fortify or refresh their current understanding. Using modular building blocks to efficiently scale content to higher levels of interactivity and align with sponsor-driven technical insertion requirements, the virtual nature of the implementation permits open and free navigation of instructional content so that learners can focus their time and effort where they recognize it to be needed most. Furthermore, the use of the multimodal and modular enabler set to support single source data architecture and pipelines simplifies instructional content updates by permitting modifications to a single source of technical data which then automatically feeds updates across learning applications or modes in the training ecosystem, including desktop, mobile, learning management system (LMS), and immersive platforms as well as print-based outputs. Using an open-source, Extensible Markup Language (XML)-based scalable solution aligns this modular building block capability through an open, extendable framework to efficiently deliver learning across diverse modalities at the time and point of need.

SCALABLE CONTENT AND FUNCTIONALITY ARCHITECTURES

The DoD training community employs XML data structures to package and translate technical data and learning content in accordance with service level data management policy. Data structured in accordance with S1000D, for example, can conform to the international data specification to benefit content interoperability and management. However, inter- and intra-service level variations on the application of this standard have resulted in a number of implementations, particularly for IETMs, that are not based on a common Application Programming Interface (API), resulting in barriers for fully scaled interoperability across the services (Gafford, 2007). An established architecture enabling modules of S1000D data to interoperate with the gamut of emerging learning technologies easily and cost-effectively would theoretically enable rapid response to technical insertion requirements and adaption to the needs of the learner communities. However, the specification did not always support a wide enough compatibility spectrum of training and performance modalities nor support the speed-to-deployment responsiveness to satisfy some NAWCAD WOLF sponsors' training system development requirements, requiring an innovative and enduring alternative for what started as a core set of technical publication requirements that scaled to include broader training and performance support solutions.

The NavXML Data Pipeline

The NAWCAD WOLF XML-driven training and technical data viewer has been used as the architectural backbone for IETM, training, and performance support solutions for over 25 DoD platforms since 2004, and over 250 incremental releases since 2010. Developed in response to Navy XML policy and training systems development needs to support rapid in-service engineering deployments, NavXML Viewer provided programs in need of training a customizable and scalable solution authorized to operate on all Navy systems. Considered a government off-the-shelf (GOTS) solution, it enables interoperability between GOTS and commercial off-the-shelf (COTS) training platforms, technical data, and program documentation. NavXML was developed with a modular approach driven by the requirements of individual projects, but within the framework of a standards-compliant vision that could enable accelerated development and deployment of follow-on or rapid acquisition training. Feeding the Viewer is a mid-layer database which derives inputs from imported technical data and training content in XML, the universally accepted format for technical data in government and industry. Core to the approach and critical to initial engineering design was leveraging this mid-layer conversion database to consume and translate parsed XML data for exportation to several modalities. Rather than simply converting source documents as whole packages (e.g., converting a word processing document as-is into an immersive reality headset), they are separated into identified units of related content for easier manipulation and downstream scalability. The goal is more than just to convert source materials into other formats; but rather it is to process source information into an unlimited number of output formats, which to date have included desktop and standalone Chromium-based applications, mobile applications, web-based environments, LMS, extended reality (XR) platforms, portable document format (PDF), and paper outputs covering applications from technical manuals to quick reference cards to curriculum materials with instructor and student guides.

Content Conversion Pipeline

The data source component feeding the NavXML architecture follows formatted storyboards that define how every content type will be handled in the integrated framework for output to a given user community. As show in *Figure 1*¸ NavXML automated data conversions import templated content, for example, from Word or Excel to an XML data repository, then transforms it using standards-based Extensible Stylesheet Language Transformations (XSLT) to outputs ranging from HyperText Markup Language (HTML) to customized training ecosystems. During the data conversion, a single source of content can be wrapped in a lightweight XML structure to support simultaneous, multiple output packages including Sharable Content Object Reference Model (SCORM), Experience Application Programming Interface (xAPI), and S1000D. In *Figure 2*, one step from an instructional procedure is shown in the original Microsoft (MS) Word storyboard template followed by how the data appears once converted to XML, with the ultimate output integrated within NavXML Viewer as HTML5.

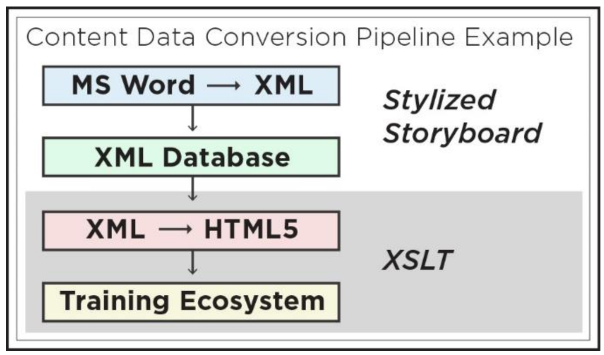

Figure 1. Content Conversion Pipeline

Figure 2. Content Conversion Example

Stylized storyboard templates define how text and images that comprise learning units are consumed by interactive multimedia components and applied to various output modes. As shown in *Figure 3*, content elements are created and changed in accordance with the storyboards, which are codified and implemented in the authoring software, so data sources can be automatically processed for all outputs. This workflow for modifying source material ensures configuration control among all training outputs and has proven to reduce development and sustainment costs while ensuring the efficient dissemination of mission-critical information.

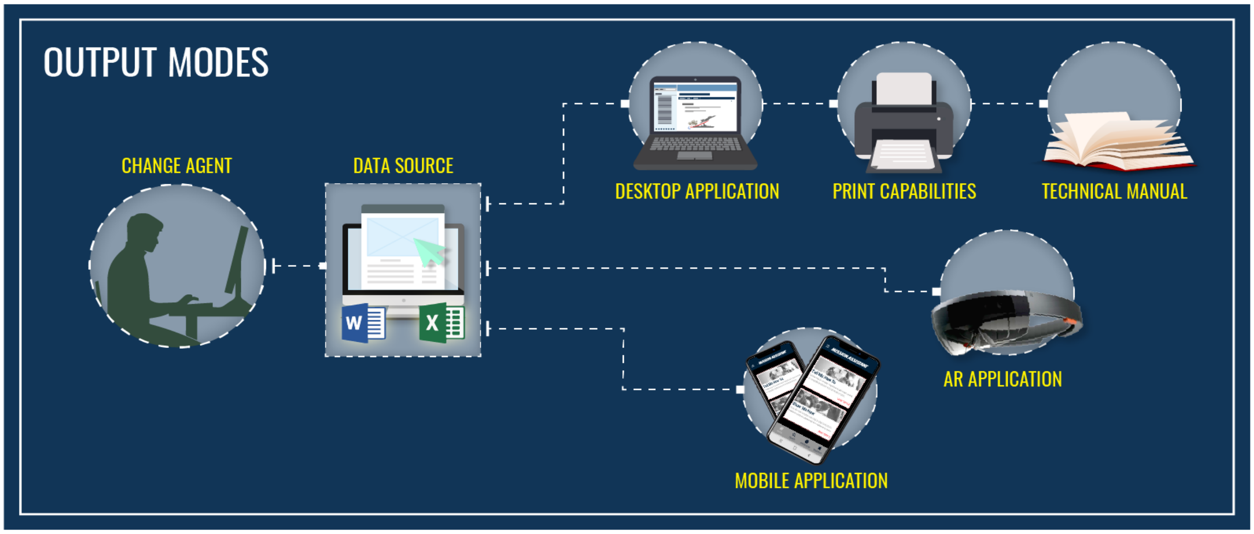

Figure 3. A Single Source of Truth for Several Output Modes – Example

Content packages that feed the various outputs include a variety of customizable, predefined content types. Standard content types used in NavXML were developed to align learning modalities to fundamental learning theories such as multiple intelligences and Bloom's Taxonomy. Each content type uses a unique stylized storyboard template as the data source. *Table 1* describes the current and planned output modes by content type and targeted levels of learning in line with Bloom's Taxonomy.

Table 1. NavXML Current and Planned Output Modes by Content Type

Content Type	Description	PC	Print	AR	Mobile	Targeted Learning Levels
Tell Me How	Step-by-step work instruction with text and images	C	C	C	C	Remembering, Understanding
Tell Me About	System overview information with text and images	C	C	C	C	Remembering, Understanding
Show Me How	Step-by-step video-based work instruction	C		C	C	Remembering, Understanding
Let Me Practice	Simulation for completion of hardware or software procedures	C		P	P	Applying
Mission	Several linked testing simulations to form common scenario sequences	C		P	P	Applying
Let Me Test	Scored simulation for completion of hardware or software procedures	C		P	P	Applying
Watch & Learn	Video-based system or capability overview information	C		C	C	Remembering, Understanding
360-Degree Media	360-degree navigable scenes with informational text pop-ups	C		P	P	Remembering, Understanding
Diagram Viewer	Location and functional diagrams with zooming, panning, and linking to text descriptions	C				Remembering, Understanding
Dynamic Troubleshooting	Guided questions that progress through troubleshooting trees	C				Remembering, Understanding

PC*: Windows Operated JPAs, ICW, and IETMs*
Print*: Technical Manuals, Quick Reference Cards, Just-in-Time Exports*
AR*: HoloLens Head-Mounted Display*
Mobile*: Android Operated Cell Phones*
C *= Current Capability |* ***P*** *= Planned Capability*

Fundamental to this type of architecture is streamlining the development process to provide more content for less cost. Other XML-based approaches to reduce training development costs for military applications include Concurrent

Technologies Corporation's (CTC) streamlined XML-based eLearning development process, which, like NavXML, was intended for government application being developed in support of a collaborative U.S. Air Force, Army, Coast Guard, Navy, and Veterans Health Administration effort (Bandrowski et al., 2009). Their solution leveraged stylized storyboards for content-based XML and sequence maps to allow for course auto-generation at runtime. Like NavXML, the CTC solution relied on XML data, non-proprietary formats, and a core architecture which supported single-source content, SCORM interoperability, and API for scaled navigation formats. Unlike the CTC solution however, NavXML extended beyond traditional, lower-level interactive multimedia instruction (IMI) with sequential course structures, which would ultimately prove invaluable as core IETM requirements expanded in response to a steady increase in the demand for organic, government developed modular and multimodal ICW, job performance aid (JPA), and XR solutions.

Functionality Pipeline

As the XML content conversion pipeline arms change agents and instructional designers with an accessible entry point for feeding new or modified content into a training ecosystem, its unit-based functionality facilitates rapid deployment and upgrade of training system features (*see Figure 4*). Training systems with the framework can receive new functionality in the form of individually wrapped feature sets which can both carry a lightweight footprint (facilitating speed to deployment) and integrate the functionality without comingling the current and new code sets. Maintaining separation between content and functionality therefore allows content changes to be deployed quickly in existing systems across multiple outputs, and also enables the deployment technology itself to be continuously improved to support new infrastructure and user interface improvements.

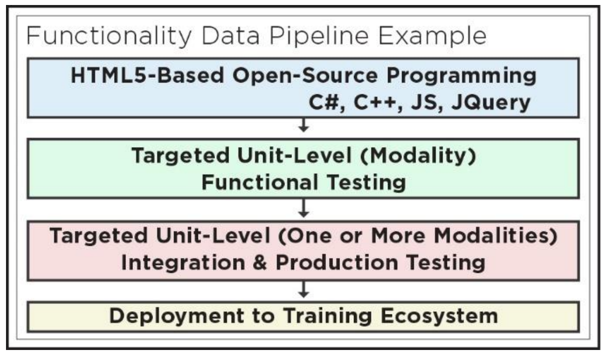

Figure 4. Functionality Data Pipeline Example

Accelerated Development

This type of XML-based architecture supports the evolutionary integration of emerging DevSecOps constructs such as the C2C24 model which is being implemented by the USN. New modalities can be constructed from content defined using contextual XML to translate data from existing data converted into stylized output formats. This capitalizes on the speed of the C2C24 style release chain for the accelerated test and release of new capabilities. The content itself does not undergo any code changes, only the addition of new data maps to allow a framework, such as NavXML, to interface with the exposed APIs and inputs of new systems. This data-driven integration allows for not only a significant reduction in the deployment timeline, but also reduces required quality assurance (QA) by developing, testing, and implementing a data "factory", applying a key element of the Continuous Integration/Continuous Deployment (CI/CD) model of DevSecOps for releasing training in the new format separately from the secure and vetted content which can then rapidly move into the new modality.

Advantages of the Framework

Learners can access content via their preferred modality at the point of need, aligning to some of the core principles of RRL. Content and functionality can be quickly processed for use across the training ecosystem, enabling support for output protocols such as SCORM and S1000D and scaled support for emergent and downstream technical insertion requirements. Because content is easily pulled into a training ecosystem and distributed across modalities, lifecycle sustainment efforts benefit from improved traceability and reduced time to deployment. Programs that previously used disparate vendor support to provide required training systems can leverage this type of framework to reduce their overall contractor support footprint resulting in cost and time savings. Furthermore, as programs expand their ecosystems and add modalities, this can realize a greater distribution and amplified return on investment (ROI) of the "build once, deploy many" approach. From a KM perspective, data sourced as single-source-of-truth content ensures instruction alignment across the ecosystem. Content configuration sets are easier to manage since unique content exists as a single control across the ecosystem and therefore only requires a single document update to feed and refresh the entire content library. Discrepancies in program-level training documentation should not exist; simultaneity benefits the learner community since they see no variations in the instruction across the content types, only variations in how instruction is presented and accessed across the modalities.

Force Multipliers

Several force multipliers amplify the impact of a distributed training system on solution development speed and cost. Having a system that complies with cybersecurity policy requirements—for example, with an Authority to Operate (ATO) for all Navy networks and web platforms—enables rapid development, deployment, and sustainment solution for programs, saving the time and cost to accredit a new system. Implementing a GOTS product avoids licensing and vendor lock issues; and sponsoring programs realize reduced risks of lifecycle obsolescence or end-of-life support problems common with COTS products.

When training must be developed concurrently with tactical systems development, an agile, iterative approach is ideal. Implementing iterative development cycles with automated content conversion and import allows for a cost-effective means to rapidly generate builds loaded with Sprint-level content quantities for frequent QA testing and stakeholder or expert review. For example, training solutions that use NavXML are often created utilizing hybrid Agile / Planning, Analysis, Design, Development, Implementation, Evaluation, and Maintenance (PADDIE+M) instructional design and development methodologies, whereby Sprints are comprised of mini analysis, design, development, and test phases which then feed release testing at stakeholder-defined intervals. Stakeholders are afforded multiple touchpoints during development which enables greater opportunity for feedback throughout production and results in rework cycles that are smaller in magnitude than using a more traditional waterfall development approach.

With the right tools, content conversion activities are not restricted to the functionally aligned software developers on the project team. Certain authoring and conversion responsibilities can be shared within the teams, resulting in less risk of process bottlenecks. This concept can be expanded to enable in-service engineering change agents to self-author and convert content from within the supported program. As a result, there is less reliance on the training development team to execute certain content updates. One practical advantage can be seen in processing of engineering change proposals and technical directives, where content changes can be enacted by the team that first encounters the requirement, reducing time between content need identification and deployment.

CASE STUDIES

The NAWCAD WOLF ePerformance Solutions Team began developing IETMs in the early 1990s. As a point of relevance, in 1991, they fielded the USN's first IETM, which was for the AEGIS Radio Communications System (RCS) on board the CG-68. The team's portfolio has since expanded to include ICW, computer-based training (CBT), performance support systems, mobile learning applications, and XR for a range of user communities across the DoD. In many cases, the team works with Lead Systems Integrators (LSIs) at NAWCAD WOLF and other program offices. Many of the training systems developed and sustained by the team leverage NavXML such as those described in the case studies below.

Matching technical capability with optimized processes, the team's agile training systems development process aligns to iterative in-service engineering by enabling training system development to progress before system development is completed. With training delivered to the user community at or before system deployment, user and maintenance communities are served from the beginning. As shown in *Table 2*, the development team utilizes iterative Sprint cycles within a larger Spiral release construct borrowed from the Software Development Life Cycle (SDLC). A new version of a training system is released every Spiral, which for many projects is typically between four and eight weeks, though deployment schedules or other project parameters may drive shorter or longer cycles.

Table 2. Spiral-Sprint Release Schedule Example

	Spiral 1								**Spiral 2**							
Week	1	2	3	4	5	6	7	8☆	9	10	11	12	13	14	15	16☆
Sprint	1		2		3		4		1		2		3		4	
	☆ *Spiral Release*															

The following case studies describe NAWCAD WOLF NavXML-based training system development for rapid engineering programs sustaining tactical systems across DoD System Commands (SYSCOMs) including Naval Air Systems Command (NAVAIR) and Naval Sea Systems Command (NAVSEA), and the National Guard.

NAVSEA: RCS IETM

Deployed first on AEGIS cruisers (CG) and now destroyers (DDG), the Radio Communications System (RCS) provides communications to meet command and control tasks in support of the ship's mission. The system is developed, installed, and sustained by an engineering group also under NAWCAD WOLF. The RCS IETM is an operator level system manual specific to each ship hull (e.g., DDG-100) that provides ship personnel with technical documentation for operating and troubleshooting communication circuits. The DDG RCS IETM is used in classroom training prior to ships commissioning and as a reference tool for sailors studying for rate advancement. The IETM is also beneficial to sailors who cannot physically access the ship's radio room. Following its first deployment, the IETM gained attention from the broader computing community, including a first-place award from Microsoft in the Government Applications category at the Windows World Open Custom Applications Content in 1992. Since then, the core IETM application and data technologies have been continuously refreshed to modernize the IETM for deployment within Navy information technology (IT) infrastructure and policy guidance.

The first RCS IETM was developed for Windows 3.0, just as the graphical user interface (GUI) was first emerging on desktop personal computers (PCs). In the early 2000s the IETM evolved through proprietary object-oriented and relational database structures toward standardized markup languages (e.g., [Standard Generalized Markup Language (SGML] and XML) that protected sponsor investments in verified content. Preserving content types and relationships with XML has enabled the RCS IETM to evolve through two decades of data structure, display, and deployment technology changes. The RCS delivery framework, initially installed and deployed on standalone laptops, now provides a NavXML package that runs as a portable application using verified, native XML files and can execute on a ship's network or as a standalone desktop application without installing code or opening any vulnerabilities.

Two versions of the IETM are produced for each new DDG 51-class hull. A preliminary version is used for On the Job Training (OJT) in the AEGIS Radio Communications Team Training, a three-week classroom course taught by the system experts at NAWCAD WOLF. An updated version is provided following the ship's Post Shakedown Availability (PSA). This final version captures system modifications following testing and finalization for fleet release. Between four and eight IETMs are released per fiscal year. As there are many system similarities from one DDG RCS system to the next, new IETMs are cloned from previously released IETMs as a starting point. This content reuse saves development time and enables editing directly in NavXML using built-in authoring tools. Next in the technical insertion roadmap, the RCS sponsor has requested instructor and student guides for classroom training. To accommodate this requirement, these integrated guides will display content directly from topics in the IETM, generated by XML-sourced data.

The RCS experts at NAWCAD WOLF rely on ready access to the information in the IETM for long-distance technical assistance communication (calls/emails) with sailors who use the system and for training conducted at every ship visit. Since the IETM is approved for loading on the ship's network, sailors can access the application at any time to refer to operating procedures, troubleshooting instructions, and schematics. During a technical assistance call, the SME and sailor can progress through topics that are relevant to the issue at hand; a troubleshooting tool often resolves matters that could otherwise interrupt system operations. RCS operators/maintainers are also able to use the IETM as virtual training tool in preparation for rate advancement testing.

National Guard / Consequence Management Communication Systems: Civil Support Team Assistant

NAWCAD WOLF Consequence Management Communication Systems (CMCS) is an Acquisition Category (ACAT) III program that develops, and fields integrated communications systems to over 50 National Guard Weapons of Mass Destruction-Civil Support Teams (WMD-CST). WMD-CSTs are proactive and reactive response teams deployed in the event of a domestic natural disaster or terrorist attack. In fiscal year 2018 alone, WMD-CSTs responded to 200 events and participated in 543 live exercises. Having a trained user community is critical to maintaining readiness. The National Guard sponsor and the CMCS program as the organic Lead Systems Integrator (oLSI) have a vested interest in ensuring training systems and performance support tools are readily available and loaded with current content.

Key challenges facing the program's training and performance efforts included inconsistent and outdated materials, lack of a centralized content repository, long wait times cycles between system finalization and training readiness, and reliance on printed technical publications with long update cycles. The program also relied on vendor support across a disparate contractor workforce spanning several companies and contractors to provide the range of required learning deliverables.

In 2018, CMCS sponsored the development of a NavXML-based electronic JPA called CST Assistant which offered platform-level IETM content with integrated virtualized training elements for use on a desktop or laptop computer, government issued mobile device, and an immersive learning extension using MS HoloLens as a hands-free augmented reality (AR) performance support aid. As multimodal platform training with content types spanning levels of interactivity, learners can access step-by-step static and video-based work instruction, hardware and software-based practice simulations, 360-degree media, and technical manual content developed from work instruction curated from a single source of truth. Much of the content in CST Assistant is modularized for quick access and comprehension, applying cognitive load management in instructional design which is of particular advantage for the Guard using the mobile application on-the-go or during moments of need. Content modules are accessible through user-filterable navigation tree menus, which are populated by the XML-based topic manifest. "By providing fast access to short-form learning materials ("microcontent"), mobile applications can make it easy to use brief windows of available time for learning" (Walcutt, 2019, p. 20).

Although the initial driver for CST Assistant was arming the user community with a lightweight computer-based application for new equipment training, the CMCS program would ultimately employ the XML-based application to scale the CST Assistant ecosystem to provide a larger set of single-source content across a range of modalities. The first Spiral release included static system overviews with text and images, step-by-step work instruction with text and images, and step-by-step walkthrough videos for hardware and software procedures. In subsequent Spirals, desktop simulations, a HoloLens extension platform, simulated assessments, an Android-based mobile application, print- and publish-to PDF capabilities, and a quick reference card generation capability source from the core content set were gradually integrated as scaled functionality.

The CMCS program also leveraged the JPA as an instructor-led training (ILT)/virtual instructor-led training (vILT) augmentation tool. CMCS trainers use the application's step-by-step instruction to guide WMD-CSTs through new or refresher training, a tailored practice simulation to assess understanding and ability in real-time, and 360-degree media to provide virtual walkthroughs of new equipment which proved particularly useful during periods of restricted travel due to COVID-19 in 2020 and 2021. With frequent update and release cycles enabled by the XML architecture, content in the Assistant is always current. The trainers ultimately replaced lengthy PowerPoint presentations in favor of embedded content, reducing preparation cost and time for classroom training.

Now in their third year of using NavXML as the core framework of the CST Assistant solution, CMCS has realized several benefits in the form of cost savings due to XML-enabled streamlined development and deployment. This includes reduced reliance on a disparate contractor workforce to provide program required learning materials. CMCS would ultimately leverage the system and its single-source data architecture to translate digital work packages into quick reference cards and printable technical manuals (TMs), which at the start of the project in 2018 were being developed as separate efforts. Additionally, preparation cost and time for classroom training have been reduced as program trainers use the up-to-date CST Assistant to replace PowerPoint materials. Finally, as instructional materials were now available at or before system deployment, knowledge transfer has improved given removal of the lag between new capability rollout and users able to access self-paced training and performance support.

NAVAIR: ARC-210 CBT

The ARC-210 radio is used in over 140 different platforms to provide voice and data communications for air, sea, and land-based missions worldwide across all branches of the U.S. military. The CBT solution described in this case study supports the training needs of NAVAIR Program Management Activity (PMA)-209 Air Combat Electronics. PMA-209, as the LSI, is responsible for providing training for the ARC-210 radio set including hardware and software from various vendors.

In 2015, PMA-209 sought a training solution that encompassed the entire suite of radio set components and scaled content types for various types of learning. PMA-209 also wished to use this opportunity to migrate their legacy CBT to a new platform in preparation for discontinued support of Adobe Flash on DoD systems. PMA-209 desired training that could evolve with each new generation of the ARC-210 system, with flexibility for different learners with varied backgrounds and experience levels, and web-based availability on an LMS. To address these challenges and risks to training continuity, the program sponsored the development of a tailorable and scalable CBT solution using NavXML as the framework to meet the program's training requirements.

NAWCAD WOLF supports PMA-209 by providing a variant-specific CBT for both LMS hosting and desktop application for each new radio generation or software version update. PMA-209 logisticians and SMEs identify how existing training content will need to change as new variants are under development, conduct a comparative analysis to support content updates, and then review storyboards for each development Spiral and make changes prior to conversion and implementation in NavXML. Since much of the training content is reusable from one variant to the next, the team leverages NavXML's scaling capabilities to rapidly copy data from existing CBT builds, using that data as baseline instruction and functionality for the new variant. Because content is already developed as HTML, a JavaScript SCORM wrapper is all that is required to make the desktop course SCORM compatible. The HTML content ports directly to the LMS without requiring modifications to the content to achieve LMS integration.

As a highly complex and tactical system, the ARC-210 program at PMA-209 sometimes faces programmatic challenges that would impact linear waterfall training development. As a mitigation strategy, agile development processes are implemented to focus on iterative design cycles to enable continued progress. Requirements can be rapidly reprioritized in a given Sprint or Spiral to pivot to emergent needs. For example, when PMA-209 needed to transition courses from Navy eLearning (NeL) to Joint Knowledge Online (JKO) due to a change in Controlled Unclassified Information (CUI) hosting policy, they quickly alerted the development team of this emergent need. The priority was quickly elevated in the backlog, and resources shifted their focus to this requirement as the next development effort. The training software framework allowed the XML-based content and HTML compatible shell to be duplicated and modified to quickly deploy a JKO specific instance.

LESSONS LEARNED

Evolving a multimodal and modular framework for scalable distributed training over two decades has resulted in several lessons learned and considerations that would benefit others in the training community seeking to implement a similar solution.

Make the case for sound instructional design early and often. Factor in how different modalities require tailored approaches to instructional design and consider cognitive overload in the user experience. Identifying small "chunks" of learning content often means content that is more modularized, which then of course is even better aligned to a modular training system. Additionally, even though modularized training system frameworks such as NavXML streamline the process of content multiplication and expansion, that does not mitigate the need to have well-structured and sequenced content from the outset of a training development project.

Embrace agile and automated workflows. In the age of RRL, DevSecOps, and C2C24, speed rules. Agile workflows enable more frequent and faster training deployments and can mitigate delays. Automated workflows and content conversion technologies can reduce human interaction for the simple development tasks so resources can focus on more critical ones such as collaborating with SMEs to optimize the instructional integrity of the content and managing the overall training effort.

Seek opportunities to identify mutually beneficial capabilities across programs that use a common training system. If providing training systems to multiple sponsors across a common portfolio or contract vehicle, consider connecting new capability requirements from one sponsoring program to the others. Especially when new capabilities are particularly niche or highly innovative, development and integration can be costly. Therefore, in identifying where multiple programs would benefit from a capability set, a program may be able to distribute costs across the sponsor set and therefore reduce development cost per sponsor. This not only decreases costs to provide new capabilities but may in fact trigger demand for additional capabilities given the lower cost of entry, spurring an overall posture that is more forward leaning with innovation.

Communicate that the value in ROI is in streamlined scaling, improved access, and better performance, not lower up-front training costs. There are costs associated with architecting and engineering the baseline system and then sustaining that system over time (e.g., cybersecurity testing and maintaining an ATO). A significant percentage of this cost comes as non-recurring engineering (NRE) costs; there can be initial sticker shock for programs looking to reduce the cost of training development over time. But that is where the cost savings occur, over time; reductions in time to migrate content to new modalities and platforms lead to improved distribution, resulting in increased use, decreased performance support issues, less sustainment and technical support effort, and increased accessibility. Failure to communicate this value effectively to program sponsors may lead to barriers to a project starting or to project success during execution.

The system is only as good as the IT infrastructure it's hosted on. True of most if not all DoD platform hosted solutions, teams should align requirements to the end-user platform, and level-set expectations with sponsors about the performance limits of those platforms. Having the ability to rapidly upscale training systems and their content is a fantastic capability, but if that content is not cloud hosted, it needs to be distributed through file transfer services or physical media, for which there are transfer time, logistics, and file size implications to be considered by all parties involved from the training development team to the end user. Emerging at a time when training and education stakeholders are seeking improved bandwidth and overall network performance to support hosting more resource-intensive training content, 5G is a promising next-gen technology already an interest area of the DoD (U.S. Department of Defense, 2020). While 5G may serve as a key enabler in supporting upscaled, higher-fidelity content, and, noting the performance limitations imposed by certain hosting networks of today's training systems, modular training systems such as NavXML are meant to be a viable method for transmitting training data quickly and reliably today, functioning well in low-latency or otherwise non-optimal connectivity environments where larger data exchanges might be more prone to failure.

Capture online learning platform interoperability requirements early. Continuing to use non-traditional courseware or training modalities with higher levels of interactivity and immersion as a point of focus, with the ability to more rapidly scale content to those levels, ensure a plan to establish a means to document, record, and recognize those forms of training within organizational constructs (Schatz et al., 2019). This includes early planning of technical insertion points for program identified LMS or Learning Record Store (LRS) interoperability.

Explain new or unique development methodologies. Building training in small increments–especially doing so parallel to tactical system engineering–can be a radical shift from how programs are accustomed to approaching training development. If developing and deploying training content iteratively, ensure program sponsors and the user community have an accessible roadmap for planned content and technical insertions. Having some visibility into the training system backlog can facilitate understanding when so much legacy training has been developed in larger content sets and using more traditional waterfall processes. Moreover, ensure that any relevant program-level training development polices, or standard operating procedures are made available at project start to analyze the impacts of agile training development and where updates or alignments may be required.

FUTURE CONSIDERATIONS

The success of NavXML as an enduring distributed and scalable training system is largely attributed to integration with emerging web-based technologies, including HTML5 and eLearning software specifications such as SCORM. Web-based content hosting technologies including cloud capabilities and web enablers such as 5G are critical considerations for training systems to continue evolving for optimal performance on next-generation infrastructures. Enhanced cloud-enabled content hosting will provide an even greater range of distribution options, and tying into 5G networks will enable training systems and training content to be delivered faster and more efficiently to the points of need. Improved bandwidth and connectivity would also enable higher fidelity and increasingly interactive immersive, training modules to stream more effectively in real-time. As RRL seeks to align processes and standards to further accelerate and optimize training delivery, training programs need to consider current data and cybersecurity policies when adopting such new processes or methodologies; their synergy is required to ensure success not only from a development perspective but ultimately deployment and content retrieval across the Fleet. Additionally, as the training landscape is increasingly virtual, providing interoperability or integration with DoD collaboration systems such as

USN's Flank Speed (USN Office of Information, 2021) may be a natural progression of capability to further empower users to leverage full training ecosystems for information sharing and peer-to-peer learning.

Enabling modernization and new development through non-disruptive replacements of legacy architectures using microservices and the Strangler Application pattern (Rook, 2016) also hold promise in an age where we want to quickly and most efficiently expand capability and integrate new technologies. But as NavXML Viewer and other solutions arm the training community with readily scalable training systems able to adapt and integrate with constantly evolving and emerging technologies, how can we plan for the unknown and fully "future proof" training? How do we plan for the unknown to truly ensure that the modern warfighter can access training content and technologies at the speed of relevance?

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