The DoD Learning Enclave (DLE) as an Enabler of Force-Level Decision-Making

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ABSTRACT

As rapidly as artificial intelligence (AI) capabilities continue to expand in the commercial sector, its effectiveness in DoD applications remains highly dependent on the availability of contextualized and traceable data. Even in unclassified instances, the siloed and restricted nature of DoD policy and governance regarding learning and workforce management data remains a limiting factor in AI opportunities at the individual, group, and force level (DoD, 2023). Extremely large data stacks containing training records, learner records, learner credentials and competencies, and available training resources already exist in numerous places within the DoD. Their value as a source of insight and decision-making are constrained by their lack of connectedness, interoperability, and availability (DoD, 2020).

Advanced Digital Learning (ADL), part of the OSD Personnel & Readiness Directorate's Defense Human Resources Activity (DHRA), has helped develop multiple specifications and standards, such as Experience API (xAPI), created and adopted by the Institute of Electrical and Electronics Engineers (IEEE) to govern the capture and transfer of learning experience data, learning objects, and shared competencies.

These standards comprise the data foundation upon which ADL's DoD Learning Enclave (DLE) is based. The DLE is a set of capabilities attached to a continuous ATO, available in IL2 and IL4, that include a Learning Management System (LMS), Learning Record Stores (LRSs) to gather experiential data, Electronic Course Catalog (ECC) to store and reconcile training content, Enterprise Learner Record Repository (ELRR) to reconcile learner records, and an Electronic Competency and Credential Registry (ECCR). These capabilities also include a schema translation service that can translate data in both format and semantically, which allows interoperability among records systems that would otherwise be incompatible, for which ADL was recognized as a DoD Pathfinder in 2021.

This document will explore these standards to provide a set of best practices for making learning workforce management datasets "AI ready," and how connection of existing legacy systems to the DLE can enable translation and interconnectivity that all of the DoD can leverage.

ABOUT THE AUTHORS

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INTRODUCTION

The widespread enthusiasm surrounding artificial intelligence (AI) has reached unprecedented levels with the explosion in generative AI capabilities over the last several years (Gupta & Davidson, 2024). DoD technology stakeholders and policymakers in areas that historically had no relationship to this technology are suddenly awash in skill growth and funding requests related to reliance on AI tools to solve applied problems (DoD 2023a). DoD leadership recognizes the many possibilities to be gained in force optimization, insights about strengths and gaps, and possible changes to the way we build and deploy our forces (DoD 2023b). The DoD is moving toward a more standardized policy regarding the use and reliance of AI. The effectiveness of AI for improved decision-making begins and ends with the quality and depth of the data upon which those assessments, even those driven by AI, are based.

Workforce data is a rich source of information for the generation of insights and decision-making, but its utility is constrained by the degree to which it remains unstandardized and siloed. One critical effort to address this problem targets the necessity of infrastructure for data sharing. The Advanced Digital Learning (ADL) Initiative has deployed a Defense Learning Enclave (DLE) for just this purpose. Services provided by the DLE benefit from standardized data but can also assist in making that data interoperable. The DLE is one of many efforts that will enable the DoD to be "AI ready" as it advances into the next stage of defending our nation. The DLE capabilities and IEEE standards upon which the modern learning ecosystem has been designed can serve as a roadmap for what forthcoming AI policy and guidance may contain.

THE SPECTRUM OF AI AND ITS POSSIBILITIES

Dr. Craig Martell, DoD's Chief Digital Officer and Chief Intelligence Officer, summarized the DoD Strategy as of November 2023. The focus of the DoD would be to: invest in interoperable, federated infrastructure, advance the data, analytics and AI ecosystem, expand digital talent management, improve foundational data management, deliver capabilities for the enterprise business and joint warfighting impact, strengthen governance, and remove policy barriers. The resulting AI support will yield "superior battlespace awareness and understanding, adaptive force planning and application, fast, precise and resilient kill chains. resilient sustainment support, and efficient enterprise business operations." (Clark, 2024). This vision paints a clear picture of what AI investment by the DoD can accomplish and clearly aligns with the current DoD strategic objectives.

Cheryl Ingstad, DIU Deputy Director of Digital Platforms and Developer Ecosystem, envisions the use of generative AI tools in a secure platform that enables DoD organizations to "seamlessly and securely integrate data sets to help the commercial sector find the best fit for their technology matched to a defense need … while also making commercial and academic solutions visible to department employees trying to solve a mission problem." She argues that the DoD must leverage all available technologies and resources that can be securely brought to bear on DoD problems (Bistarkey, 2025).

Generative AI, large language models, and semantic matching are some of the technologies best suited for addressing this problem, they are only as good as the data they can ingest. We introduce a historical issue that constrains new technology as well as old, the data "push/pull" problem (Gupta & Davidson, 2024).

This problem exists in so many technology spaces but can be articulated in an example involving the update of a best practice. In this example, the Army Combat Fitness Test (ACFT) is being replaced by the Army Fitness Test (AFT) as the official test of record (https://www.army.mil/aft/). All documents that refer to this will need to be updated. Hypothetically, there are ten documents that require this update. The ten document names are known. Should the

Army rely on all those who host any of the ten documents knowing this information and requesting the update (pull) or should Army reach out to every possible host and inform them of this update (push)? Both have immense logistical challenges and reliance on periodically checking for the pull or potential gaps in communication chains for the push, among others. We can use relatively simple AI algorithms to enable a publication/subscription (pub/sub) model, under which the system in question is constantly looking at web resources for updates, updates to data known as metadata that originate from authors of the publication and describe and locate the resource. Those wishing to have information about specific resources can be notified when any change occurs. Absent a pub/sub model, it could be extremely burdensome to identify everyone who needs the information and at what time they need it. An AI enabled pub/sub model can be used in the case of equipment, competencies, software, and many more cataloged and relevant components. Enabling large-scale pub/sub connectivity across the DoD depends on myriad other constraints, unfortunately.

GAO, in a February 2022 report identified DOD's potential AI uses. They indicate that in warfighting operations the uses "include analyzing intelligence, surveillance, and reconnaissance sources; fusing data to provide a common operating picture on the battlefield; supporting semiautonomous and autonomous vehicles; and operating lethal autonomous weapon systems." GAO indicated that "potential non-warfighting uses for AI (i.e., support and business operations) include resolving unmatched financial transactions, predicting maintenance needs, vetting security clearances, and analyzing warfighter health screenings." (GAO, 2022). With all of the current and possible applications, it is critical that DoD both prepares for and embraces AI.

CURRENT STATE OF AI IN THE DOD

As seen in the 23 January Executive Order on AI, it is now "policy of the United States to sustain and enhance America's global AI dominance in order to promote human flourishing, economic competitiveness, and national security" (White House, 2025). While the Action Plan required in this order by Government AI Components has not been published, it is clear that a strategy from the ground-up is of utmost importance. AI already plays a critical role in combat effectiveness, operational efficiency, and safeguarding against espionage and data breaches. It is only a matter of time before many processes that wuld require huge amounts of manpower will leverage AI as part of their solutions. The DoD is creating an environment of accelerated innovation but retaining responsible data practices (Shinego, 2025).

This order represents a shift from previous policy and culture around AI. As with previous technologies in DoD, it isn't often the best solution that is acquired, it is often the solution that is best marketed or that requires the least inertia to overcome. Changing vendors can be seen as an impossibility in some cases. The current Administration has begun to prioritize efficiency and consolidation. AI efforts are bound to follow suit, meaning that not every Component will have its own AI solution, rather there will be fewer, larger AI solutions.

CURRENT STATE OF DATA IN THE DOD

Alexandra Lohr, in *A New Plan for DoD Records Management*, describes the DoD Records Management strategy released in 2023. Defense officials said an overarching goal is to turn DoD's vast storehouses of records into "actionable information." This has not yet been realized in 2025. The strategy references a 2019 Memo requiring a migration of paper to digital data. DoD couldn't transition data records by 2022, so an extension for 2024 was requested. (Lohr, 2023) There has not been an update since 2024, but one could rationalize that without an approach focused on reusability, records were probably scanned documents and not stored effectively in databases for reuse.

Digitizing will only fix part of DoD's data problem. Paper records will automatically make sharing difficult, but even with digitization, data is siloed. Former DoD Chief Data Officer David Spirk, in describing the 2020 DoD Data Strategy, that "Defense officials have expressed that the DOD still has a long way to go in realizing many of the goals in the strategy, like making large databases more widely available and creating military-wide standard application programming interfaces (APIs)." (Bullman, 2020) Spirk referred to the causes of barriers to data sharing as "questions over data security, cultural silos, and bureaucratic morasses" (Bullman, 2020). Data silos are extremely evident when looking at digital training through courses in a Learning Management System (LMS). Not only are the databases connected to LMSs proprietary, typically only the macro level of data – completion and overall score, are consulted, with granular data being ignored or never recorded.

GAO conducted a performance audit from January 2022 to December 2023 in accordance with generally accepted government auditing standards. It covered Army, Navy, Air Force, Space Force, Marine Corps, and many other DoD Components. The interviews that occurred as a part of the audit highlighted that DoD lacked a consistent understanding of its AI workforce and how the workforce is managed. Identified [gapped] practices include having a process to address skills and competency gaps, as well as developing customized strategies to recruit highly specialized and hard-to-fill positions. The 2023 *Data, Analytics, and Artificial Intelligence Adoption Strategy* is intended to help accelerate the adoption of advanced data, analytics, and artificial intelligence technologies within DoD and was considered by GAO as an enabler of DoD "AI Readiness". (GAO, 2023)

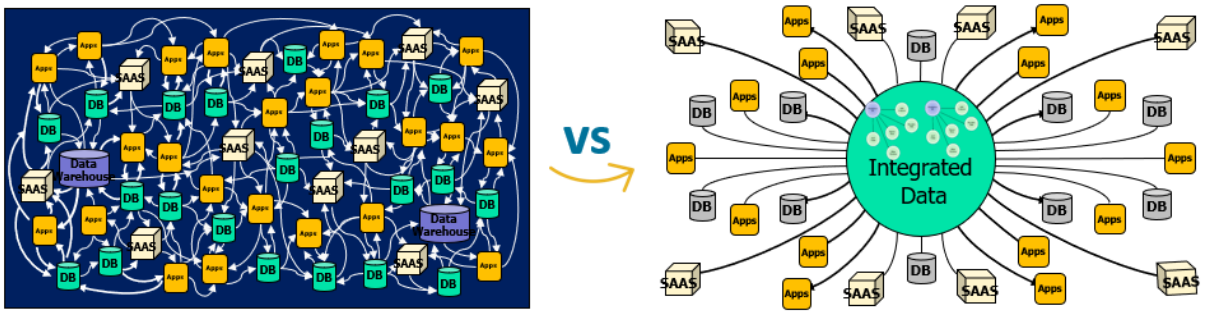

Figure 1. Visualization of the Current versus Future State of Talent Management Data: Siloed and non-Interoperable Systems versus Integrated and Interoperable Stacks.

The apparent lack of effective talent management progress, while often blamed on the maturity of AI technology, is more due to ineffective talent and data management practices, including the interoperability of relevant data and consequently, how those practices scale (see Figure 1). DoD training and education programs historically focus on delivery to the individual, and less so on the capture of rich data representing that learning experience. While DoD training can provide everything warfighters need to do their jobs, DoD systems have historically not been as efficient as possible and frequently may overlook rich data sources like training outliers, failure patterns, or other experiential details that may not be captured in pass/fail records at all. Experience is often measured not by knowledge, skills, abilities, qualifications, and performance, but rather simply in time spent in a position. These shortcomings in talent management ultimately result in reduced readiness.

ROLE OF THE ADVANCED DIGITAL LEARNING (ADL) INITIATIVE

The Advanced Digital Learning (ADL) Initiative is part of the OSD Personnel & Readiness Directorate's Defense Human Resources Activity (DHRA). ADL works collaboratively with the public and private sectors to develop standards, tools, and business systems that facilitate the collection and sharing of learning data for data-driven decision-making across the DoD. This work enables critical information and resource sharing among DoD Components, creating efficiencies and maximizing DoD-wide investments in enterprise digital learning.

The ADL Initiative architects and delivers critical IT infrastructure needed to support core readiness by linking the skills needed for successful and lethal mission success and comparing them to warfighter capability. They had previously focused on research and demonstrating the value of technical standards to the DoD Learning Community. Standards such as the Shareable Content Object Reference Model (SCORM) and Experience API (xAPI) came from their research and development efforts. The ADL Initiative provided tools for conformance testing to provide assurance to DoD Acquisition. They now focus on directly solving the data problems through implementation.

ADL's DoD Learning Enclave (DLE) platform points to the efficient upskill opportunities to achieve warfighter readiness. DLE enables effective command and control, readiness reporting, and data-driven force management decision-making. This integration provides DoD senior leaders, training managers, manpower analysts, and service leaders with the essential data needed for informed decision-making (ADL, 2025).

IEEE STANDARDS IN THE LEARNING SPACE

Standards are critical to both achieving data interoperability and advanced data. Technical standards have evolved in the past decade, moving from rigid data structures based on processing files into a semantic web. The latter is much more suitable for an ever-vigilant AI to crawl, as updates to data resources can be picked up as often as the AI allows. Previous learning standards such as SCORM created system interoperability in that the same resource could be used across systems, but it didn't go so far as to make sure data could be portable and shareable. With these goals in mind, ADL leveraged IEEE to create standards for an advanced data ecosystem.

Experience Application Programming Interface (xAPI)

IEEE 9274.1.1-2023, formerly known as Experience API (xAPI) describes a JavaScript Object Notation (JSON) data model format and a Representational State Transfer (RESTful) Web Service Application Programming Interface (API) for communication between Activities experienced by an individual, group, or other entity and a Learning Record Store (LRS). The LRS is a system that exposes the RESTful Web Service API for the purpose of tracking and accessing experiential data, especially in learning and human performance. (IEEE, 2023). xAPI allows storage and retrieval of any kind of performance data and is critical to sharing learning experience data large and small.

cmi5

One of the first use cases for xAPI was fulfilling the current paradigm of a single learner taking a course in a Learning Management System. The cmi5 specification, which is not an acronym, but is in the lineage of "Computer Managed Instruction", was designed by the Aviation Industry Computer-Based Training Committee (AICC) and later passed to IEEE for standardization in 2026, to use xAPI to track e-learning interactions. The concept behind cmi5 is to provide a common baseline for "normal" course behavior, but to leave open the ability to track any other experience within an online session. While the original use case supports single learners, cmi5 can be used for multiple learners and in any session-based activity, not just courses. (AICC, 2025)

Shareable Competency Definitions

IEEE 1484.20.3, Data Model for Shareable Competency Definitions (SCD), defines a data model for describing, referencing, and sharing competency definitions, and frameworks of competency definitions and rubrics in the context of online and distributed learning and in employment and work. It provides a way to formally represent the key characteristics of a competency in the form of a data structure called a definition, independently of its use in any context or in a defined context. It enables interoperability among learning systems that deal with competency information by providing a means for them to refer to common definitions with common meanings. (IEEE, 2022) SCD allows the connection of learners with the knowledge, skills, abilities, tasks, and any other way that expected performance can be described to opportunities to teach or assess those competencies.

Learning Metadata Terms

IEEE 2881, Standard for Learning Metadata Terms (LMT), describes a series of classes and properties, that intentionally align to a Resource Description Framework (RDF) type of model which can be represented in many formats, including graphs. It centers around different types of Learning Resources and Learning Events, distinguishing between the two as both were often previously categorized as "Learning Objects". It describes an extensible data model that focuses on the principles of sharing learning resources in a learning environment and describing learning events that learners may attend (virtually or in-person). Metadata is using data to describe an object, and in this case, a Learning Object. LMT is a combination of new and existing metadata terms that were contextualized around learning and bundled with the purpose of addressing many of the common use cases of metadata. (IEEE, 2025) The aforementioned DoD Records Management strategy includes use of metadata, as it is critical to search and discovery by humans and computers.

Enterprise Learner Records

IEEE 2997, Enterprise Learner Record (ELR), is a draft standard being worked by an IEEE Working Group. The proposed standard consists of a data model that includes details about the learners' experiences and protocols that specify transfer methods and application programming interface (API) for communicating learner records between services. This Learner API enables privacy and security of learner data as it is transmitted between connected systems

through formal information exchange agreements (e.g., Interservice Connection Agreement). The Learner API follows the guidelines of the Representational State Transfer (REST) software architecture style and is transferred via HTTP requests and responses. The data model is intended to act as a transcript, which includes experiences, results, competencies, learning paths, jobs, etc. The ELR is a valuable "catch all" for all data that would be traditionally part of a Learner Profile.

ACHIEVING AI READINESS

DoD's Chief Digital and Artificial Intelligence Office (CDAO) was established in 2022 to accelerate the adoption and establish/enhance data, analytics, and AI across the Department. They established a "Pathway to AI Readiness" to provide guidance of foundational aspects of AI technology to Government organizations. In addition to linked and referenced resources, there are fourteen identified nodes on this pathway. This paper will highlight three of them critical to AI success –***Interoperability***, ***Data Quality***, and ***Data Management***. (CDAO, 2025a).

CDAO defines ***interoperability*** as "Timely and seamless integration of data, environments, and capabilities across the mission and vendor landscape, ensuring full interoperability within DoD spaces." (CDAO, 2025b). The first mentioned step and DoDI resource (8330.01) describe the ability to share data. Specifically, DoDI 8330.01 INTEROPERABILITY OF INFORMATION TECHNOLOGY, INCLUDING NATIONAL SECURITY SYSTEMS calls out as compliance to achieve interoperability, the use of "IT standards in accordance with the GTG-F DoD IT Standards Registry (DISR), pursuant to DoDI 8310.01." (DoD, 2022a)(DoD, 2022b) Policy and capability can seem to create a "chicken and egg" type of problem to reluctant adopters, but understanding the problem to adoption, whether it is format, policy, or existing infrastructure/acquisitions, is the first step toward data interoperability. Rapid adaptation and adoption of emerging technologies requires a process, and that process would be greatly aided by standards for both data and systems. Cybersecurity cannot be forgotten in this area, as trust between adopting systems is an uncompromisable pre-requisite for sharing data.

CDAO defines their vision for ***data quality*** as "high-quality data that accurately represents mission tasks, enabling on-demand analytics and AI development, while ensuring long-term sustainment." (CDAO, 2025c). Metadata is recognized as critical here, being the first two resources in their explanation reference it. Breaking that down further, the requirements CDAO calls out data formats meeting modern requirements, standardization, machine-readability, and translation capability as criteria for assessing data quality. For data to be considered high quality, it needs to be complete, accurate, and accessible. As all of these require processes, data governance within each organization supplying this data is critical.

CDAO, in providing for a vision for achieving ***data management***, identifies "a data management framework that enables the identification, collection, curation, and maintenance of data across enterprise and tactical spaces, ensuring seamless support for analytics and AI development." (CDAO, 2025d). Of the three nodes on the path, this is the least defined. The questions point at a lack of data transparency across organizations and suggests answering management and process questions to begin to document and share first processes, and later data. By effectively maintaining data, it will be ready for AI, which can then assist in notification and distribution of that maintained data. It references data strategies and other lists of resources, but this is a problem space that needs more direction and leadership.

DOD LEARNING ENCLAVE (DLE) TO ENABLE STANDARDS

To achieve high quality data that is interoperable, the DoD's data practices should expand beyond macro data capture (e.g., credentials, career data) to include rich raw data like activity and event-based streaming data that follows data standards and connects to other standardized data. By promoting data sharing and aggregating these data across different training and education systems, previously unobtainable patterns about learners can be uncovered. These data result in an aggregated learner profile that establishes an evidence-based performance chain of a learner's competencies, preferences, goals, and experiences, which can be ingested by analytics and recommender systems to inform better decision making.

The DLE, created and maintained by the ADL Initiative, is a series of capabilities that allow DoD Component systems to effectively share their data such that it can be accessed by humans and machines. Utilities that interface with DLE systems can be used to transform data into the correct standard required by that system. Each DLE system corresponds to a previously defined IEEE standard. "The DLE is deployed through the Air Force Platform One program. Platform

One is a modern cloud-era platform that provides valuable tooling, hosts CI/CD DevSecOps pipelines, and offers a secure Kubernetes platform for hosting microservices. The integration of the ELRR into the DLE covers a majority of NIST 800-53 RMF controls for hosting applications in DoD Impact Level (IL) 2, 4, and 5 environments." (ADL, 2022b)

The DLE is itself comprised of an open-source instance of the Moodle Learning Management System (LMS), an Electronic Course Catalog (ECC) to store and reconcile training content, an Electronic Competency and Credential Registry (ECCR) to store and reconcile different competency and credential taxonomies and models, an Enterprise Learner Record Repository (ELRR) to reconcile (and enable consolidation of) learner records, and Learning Record Stores (LRSs) to gather experiential data. These systems all exist to connect to existing legacy and archival systems to enable interoperability and translation of learning, learner, and competency/credential records from different systems built with different models. This reconciliation feature is possible because the DLE includes a schema translation service, the Linked Data Schema Service (LDSS), that can translate data in both format and semantically, which allows interoperability among records systems that would otherwise be incompatible, as depicted below in Figure 2. ***This is the arguably most critical feature of the DLE: It enables interoperability and translation without replacement of the legacy stacks or systems involved in the exchange of data.*** Each DLE component is described separately next.

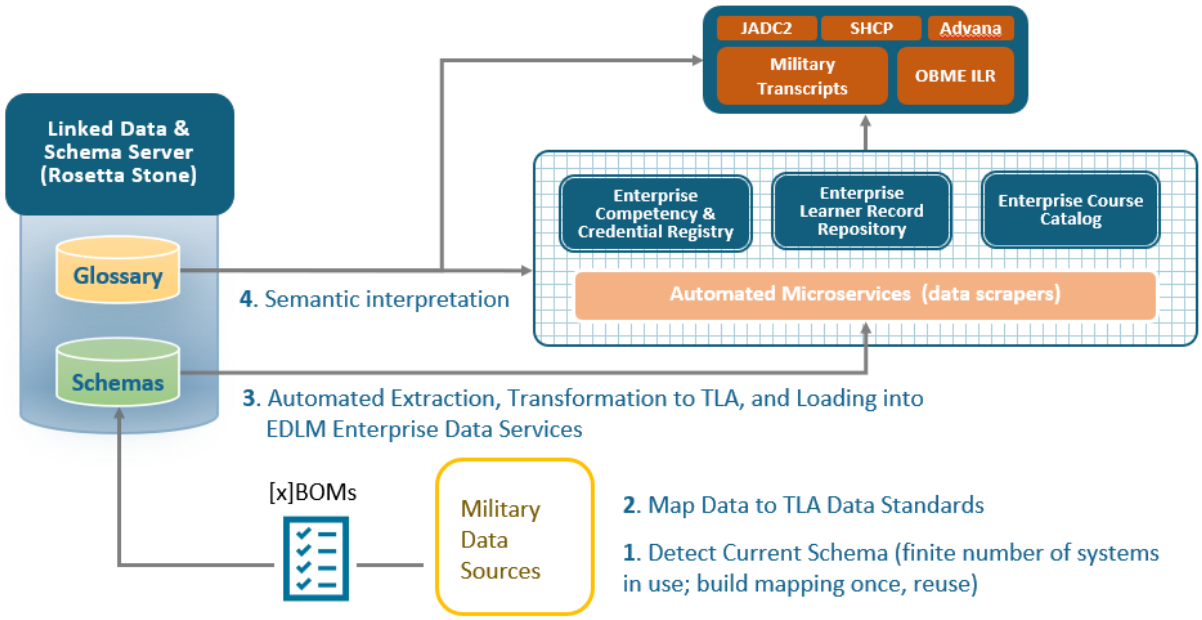

Figure 2. Depiction of the LDSS Translation Capability for Military Data Systems into Inputs Recognizable by DLE Components and Ultimately with Operational DoD Systems.

Enterprise Course Catalog (ECC)

The Enterprise Course Catalog, named because the most common form of digital resource that is searched are courses, is a place where all types of Digital Learning Resources are registered and shared across the Government. The ECC is a learning experience discovery service that aggregates courses and other learning resource metadata housed across various internal and external sources to promote the discovery and accessibility of these learning opportunities (ADL, 2023) It effectively allows migration of entire catalogs of learning resources easily into it, which can then be searched by both Content Administrators to download the raw materials or Content Seekers that simply want to discover an opportunity to take directed or independent learning materials.

Major benefits of ECC reported by participants included time savings due to the portal capability to search multiple course catalogs simultaneously, as well as the ease of use of the portal itself (ADL, 2023). Participants indicated time savings could be realized for supervisors and employees searching for relevant courses; as well as for instructional systems designers searching for training content to leverage, in whole or part, to meet customer training needs. Further, respondents indicated ECC MVP offered advantages over other course catalogs by addressing limitations associated

with access to information contained in multiple sites, difficulty navigating disparate course catalog websites, and limited or niche content.

While the uses of the system are impressive at the human level, it is even more so at the machine level. The ECC stores metadata records, conformant to the IEEE Learning Metadata Terms (2025) Standard, along with application profiles of that standard. This means that any learning experience referenced by URI in any data system that uses xAPI, cmi5, or SCD, among others can comb this data and bring it into models or leverage it in analytics.

Enterprise Competency and Credential Registry (ECCR)

The Enterprise Competency and Credential Registry (ECCR), an improved version of a previous open-source ADL Project named the Competency and Skills System (CaSS; ADL, 2021), allows the creation and registration of competencies and competency frameworks. While those two terms may sound restrictive, they are intentionally broad in application and refer to the nature of the data rather than the function of the data. From a functional perspective, a competency can function as knowledge, skill, ability, attitude, aptitude, behavior, task, or anything else a person can do. It can even function as the data pre-requisite to a credential, which the ECCR allows registration of and the making of this connection. Competency frameworks are structures of all types of competencies in a structured, contextualized, and governed data format.

The ECCR is designed to serve as a competency management registry and creation tool for the DoD. It provides an infrastructure enabling competencies, competency frameworks, and credentialed be managed and accessed by authorized actors, but independent of any given learning management system, course, training program, or credential. Thus, each of the registered data objects in the ECCR is referenceable and capable of acting either in context or generally. Use of the ECCR will improve how credential data are managed and shared, allowing the DoD to better estimate individual learning experiences needed to provide and maintain mission-critical knowledge and skills. (ADL, 2021)

Enterprise Learner Record Repository (ELRR)

A federated Enterprise Learner Record Repository (ELRR) provides the ability to look across many distributed learner records as if they were from a single source and enabling the sharing of local and global learner data across the DoD. This learner data can be pulled from authoritative sources for publishing, customizing, and harmonizing individual profiles, performance records, and training records. ELRR users can access their training records throughout their learning journey at DoD and use this information to ensure they have the skills and credentials required for their career path. (ADL, 2022b)

The ELRR can have many useful applications when linked to other systems, DLE or otherwise, but it first and foremost serves as a data lake for the DoD to allow bi-directional data flow between itself and other DoD systems. By creating proper authentication and authorization both at the system and data layers, data will flow only to the appropriate places. The ELRR allows for aggregate data to be created around an Enterprise Learner Record and ultimately displayed in dashboard capabilities. By creating detailed Learner Records, the DoD can improve education/training efficiency and increase military readiness. The records will also benefit learners themselves as they navigate their career paths within and outside of DoD. (ADL, 2022b)

Linked Data Schema Service (LDSS)

The Linked Data Schema Service (LDSS) is an enterprise “defense-wide capability to generate linked data vocabularies with unique identifiers and schema mapping services to provide immutable Internationalized Resource Identifiers (IRIs) for each term and schema that all DoD technologies can reference.” While this description of the LDSS is simple, it is extremely powerful and versatile. The LDSS capability revolves around being able to decompose locally controlled vocabularies (LCVs) into granular terms and term definitions into Extensible Bill of Materials (xBOMs) which can be simple or complex lists and processes. These are all data forms that can be used by AI and can drive AI functions.

Through decomposition into low-level terms, whether as LCVs or xBOMs (The two become synonymous with complete solutions), machine algorithms can score and compare any term or terms. Term comparison allows for

deriving of semantics despite the syntax of the originating data sources. Use cases for comparing terms include incorporation of data schemes from course catalogs or competency frameworks, term comparison that enables more accurate search and discovery within any DLE system, the consumption of entire catalogs with deconfliction services, translation of user interfaces into familiar (local organization) terms, and many more.

The LDSS is critical to both the onboarding and maintenance of data providers. Those providing courses, resources, competencies, learning records, etc. will all keep their existing taxonomies, or ways of naming and labeling these assets. The LDSS allows transformation of these properties into searchable terms that can be relayed to end users in their own familiar context.

CALL TO ACTION

By following the guidance in this section, organizations can be ready for AI to use their data. Organizations must commit to using and adhering to data standards such as those outlined in this document. Not only is it required in DoDI Instructions such as 1322.26, 1322.35, and 8310.01 (WHS, 2025), but it also is foundational to achieving AI Readiness and therefore battlefield dominance. This commitment should be reflected in acquisition practices at a minimum, but there are some steps that can be taken either before or during standards adoption that will make data transformation into interoperable data possible.

- For an organization's learning resources, learning events, and competencies, agree on the types and document them. This helps cross alignment and referencing of all learning and training opportunities.
- For DoD systems that can synthesize data, provide system access to edit and retrieve metadata. The ECC will be a valuable tool, but systems will need to be able to access it, particularly for AI to adequately "crawl" and derive semantic meaning. All of this is impossible without allowing system-to-system access. Policy can be tough to navigate, so starting early is necessary.
- During acquisition processes, assign metadata properties and workflows to specific roles in the content lifecycle. Too often, metadata is an afterthought and thrown on the system administrator, who is not the person who justified the requirements pre-acquisition nor the subject matter expert. Metadata is a team effort and requires a shared space to adequately perform this team function. A good starting point can be the *Total Learning Architecture Standards Digital Learning Acquisition Techniques Report* (ADL, 2023b), but should be modified to meet organizational requirements.
- For an organization's learner profiles, develop documentation on what each property represents. Describing one organization's learners to another's learners is very difficult as in comparisons that ADL has performed, this has had the most variance.
- For any of the previously mentioned data components, provide unique identifiers, make those identifiers resolvable within that organization's web domain, and register them in DLE systems. Each of those three steps are more like leaps on their own, but each leap is extremely important. Even one leap drastically improves AI readiness. Registration of URIs can be done simultaneously by registering their referenced learning resources, activity data, competencies, or learner profiles in the DLE systems. Support both in terms of a Graphical User Interface per entry or a data migration from either a list-type file or database are available.

It is likely that in the near future that policy will necessitate evaluation of the DLE for both utilization and data sharing. While the scope and nature of these policy updates are still to be determined, DoD stakeholders and technology producers would be well-served by adhering to the guidance outlined in the bullets above. Evaluation of DLE technology for data sharing, hosting, or shared acquisition, is also recommended.

CONCLUSION

AI has the ability to change the way that DoD stakeholders can make informed force-level decisions, and the greatest of these decisions involve our nation's security. Many use cases of AI are already identified, and some are even in practice, but we are still in the infancy of deployment within the DoD. The DoD has recognized and responded to the AI call with policy and direction. Strategically, standards organizations and those who understand the power of standards, particularly data standards, have been preparing for this day for years. There are many existing and emerging data standards that will focus and augment AI's ability to manage high quality data across multiple systems through data interoperability, transparency, and granularity. Adoption of these standards are driven by both policy and results.

To aid the adoption of standards, and through standards, AI, the ADL Initiative has contributed many resources. With a focus now on providing infrastructure to support acquisition, data sharing, and data interoperability, ADL is positioned to serve the entire DoD with systems in the DoD Learning Enclave. These systems allow learner performance, learning activities, competencies, and learner profiles to be created and registered using data standards and then shared across the DoD Enterprise. Leveraging AI, deconfliction services and adjustments to interfaces for end users can make even foreign data feel familiar, so that decisions can be made without needing a great deal of translation. By acting now, DoD Components can prepare their data and systems to leverage the DLE and AI. Organizing themselves around interoperable data and registered data components, such as their learning activities and competencies, will pay great dividends and make them truly "AI ready."

REFERENCES

Advanced Digital Learning Initiative (ADL) (2025a, June 18). *Enterprise Digital Learning Modernization (EDLM)*. Retrieved from https://www.adlnet.gov/guides/tla/service-definitions/extra-resources.html#enterprise-digital-learning-modernization-edlm

Advanced Digital Learning Initiative (ADL) (2025b, June 18). *Resources – TLA Standards*. Retrieved from https://www.adlnet.gov/guides/tla/service-definitions/extra-resources.html#tla-standards

Advanced Digital Learning Initiative (ADL)(2022a, March 22). *Enterprise Course Catalog (ECC) Minimum Viable Product (MVP) Test & Evaluation Report.* Retrieved from https://www.adlnet.gov/publications/2022/03/ECC-MVP-Test-Evaluation-Report/

Advanced Digital Learning Initiative (ADL)(2022b, June 30). *Enterprise Learning Record Repository (ELRR) Initial Operational Capability (IOC) Report*. Retrieved from https://www.adlnet.gov/publications/2022/06/ELRR-IOC-Report/

Advanced Digital Learning Initiative (ADL) (2021, February). *Competency and Skills System (CaSS).* Retrieved from https://www.adlnet.gov/projects/cass/

Aviation Industry Computer-Based Training Committee (AICC). (2025, June 15). *The cmi5 Project*. Retrieved from https://aicc.github.io/CMI-5_Spec_Current/

Bistarkey, Devon (2025, April 3). *One Digital Destination, Millions of Opportunities.* Retrieved from https://www.defense.gov/News/Feature-Stories/Story/Article/4144646/one-digital-destination-millions-of-opportunities/

Bullman, Heidi (2020, October 28). The Department of Defense Eliminates Siloed Data to Support the Mission. Retrieved from https://governmenttechnologyinsider.com/the-department-of-defense-eliminates-siloed-data-to-support-the-mission/

CDAO (2025a, June 16). *PATHWAY TO AI READINESS – Introduction and Intent.* Retrieved from https://www.ai.mil/About/Resources/Pathway-to-AI-Readiness/

CDAO (2025b, June 16). *PATHWAY TO AI READINESS Interoperability.* Retrieved from https://www.ai.mil/About/Resources/Pathway-to-AI-Readiness/Interoperability/

CDAO (2025c, June 16). *PATHWAY TO AI READINESS Data Quality.* Retrieved from https://www.ai.mil/About/Resources/Pathway-to-AI-Readiness/Data-Quality/

CDAO (2025d, June 16). *PATHWAY TO AI READINESS Data Management.* Retrieved from https://www.ai.mil/About/Resources/Pathway-to-AI-Readiness/Data-Management/

Clark, Joseph (2024, February 21). *Pentagon Official Lays Out DOD Vision for AI.* Retrieved from https://www.defense.gov/News/News-Stories/Article/article/3682355/pentagon-official-lays-out-dod-vision-for-ai/

GAO (2023, December). *ARTIFICIAL INTELLIGENCE Actions Needed to Improve DOD's Workforce Management*. Retrieved from https://www.gao.gov/assets/gao-24-105645.pdf

GAO (2022, February). *ARTIFICIAL INTELLIGENCE Status of Developing and Acquiring Capabilities for Weapon Systems.* Retrieved from https://www.gao.gov/assets/gao-22-104765.pdf

Gupta, S., & Davidson, J. (2024). Generative artificial intelligence: A systematic review and applications. *Multimedia Tools and Applications*. https://doi.org/10.1007/s11042-024-20016-1

Lohr, Alexandria (2023, May 23). *A New Plan for DoD Records Management.* Retrieved from https://federalnewsnetwork.com/defense-main/2023/05/a-new-plan-for-dod-records-management/

Shinego, Wes (2025, April 24). *Defense Officials Outline AI's Strategic Role in National Security.* Retrieved from https://www.defense.gov/News/News-Stories/Article/Article/4165279/defense-officials-outline-ais-strategic-role-in-national-security/

The White House. (2025, January 23). *Executive Order on Removing Barriers to American Leadership in Artificial Intelligence.* Retrieved from https://www.whitehouse.gov/presidential-actions/2025/01/removing-barriers-to-american-leadership-in-artificial-intelligence

U.S. Department of Defense (DoD). (2023a, August 10). *DOD Announces Establishment of Generative AI Task Force. U.S. Department of Defense*. Retrieved from https://www.defense.gov/News/Releases/Release/Article/3489803/dod-announces-establishment-of-generative-ai-task-force/

U.S. Department of Defense (DoD). (2023b, June 27). *DoD Data, Analytics, and AI Adoption Strategy*. Retrieved from https://media.defense.gov/2023/Nov/02/2003333300/-1/-1/1/DOD_DATA_ANALYTICS_AI_ADOPTION_STRATEGY.PDF

US Department of Defense (DoD)(2022b, September 27). *DOD INSTRUCTION 8330.01 INTEROPERABILITY OF INFORMATION TECHNOLOGY, INCLUDING NATIONAL SECURITY SYSTEMS.* Retrieved from https://www.esd.whs.mil/portals/54/documents/dd/issuances/dodi/833001p.pdf

US Department of Defense (DoD) (2022a, April 26). *DOD INSTRUCTION 1322.35, VOLUME 1 MILITARY EDUCATION: PROGRAM MANAGEMENT AND* ADMINISTRATION. Retrieved from https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodi/132235_vol1.PDF?ver=1mKICMbRcNsQUXaPf5YUfw%3D%3D

U.S. Department of Defense (DoD). (2020, September 30). *DoD Data Strategy*. Retrieved from https://media.defense.gov/2020/Oct/08/2002514180/-1/-1/0/DOD-DATA-STRATEGY.PDF

White House Services (WHS)(2025, June 20). *DoD Issuances - The Official Department of Defense Website for DoD Issuances.* Retrieved from https://www.esd.whs.mil/Directives/issuances/dodi/