

Total Learning Architecture Standards Digital Learning Acquisition Techniques

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TLA Standards Digital Learning Acquisition Techniques

Andy Johnson, ADL Initiative (SETA)
Shawn Miller, Defense Acquisition University

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1.0 EXECUTIVE SUMMARY

The purpose of this document is to provide techniques to assist Department of Defense (DoD) acquisition personnel with the integration of learning technology standards into their Information Technology acquisition processes. This document supports [Department of Defense Instruction \(DoDI\) 1322.26](#) and the [updated DoDI 1322.26 references](#).

This document includes recommendations for how to implement the standards and specifications included in DoDI 1322.26. These standards provide the technical underpinnings of the Total Learning Architecture (TLA), which enables personalized, data-driven, and technology-enabled lifelong learning across the DoD.

Specifically, this document focuses on implementation of three Institute of Electrical and Electronics Engineers (IEEE) standards used within the TLA.

- The Experience Application Programming Interface (xAPI) (IEEE 9274.1.1) is a standard that enables the collection of data about a person's learning experiences, both online and offline, across many different types of learning activities.
- The cmi5 standard (IEEE 9274.3.1) replaces the Sharable Content Object Reference Model (SCORM) and defines interoperability rules for launching, authorizing, reporting, and course structure that inform how a Learning Management System and xAPI-enabled activities communicate with each other.
- The Learning Metadata Terms Standard (LMT) (IEEE P2881) allows for search, discovery, and curation of learning resources and instantiations of those resources (called learning events) through structured descriptions. All digital learning content are considered a part of this standard, whether they are graphics in a repository, a distributable lesson that is integrated into training, or a course offering with a specific course instructor or a specific session slot of a simulator.

Collectively, these standards support the Shareable Competency Definition Standard (SCD) (IEEE 1484.20.3). The SCD standard, released in July 2023, provides a format for defining a competency for a skill, knowledge, ability, attitude, or other learning outcomes. There will be specific techniques on the use of SCD in future updates.

Together, these standards provide a powerful framework for creating and delivering effective learning experiences. Educators can gain valuable insights into learners' progress and create more effective learning experiences by using cmi5 to provide a common baseline to track learning activities and systems, xAPI to collect data about learners' experiences, IEEE P2881 metadata to describe learning resources, and IEEE SCDs to describe competencies in a standardized way.

2.0 INTRODUCTION

The TLA is sponsored by the ADL Initiative and was developed in collaboration with stakeholders from across the defense community, professional standards organizations, industry, and academia. It includes a set of technical specifications, standards, and policy guidance that define a uniform approach for integrating current and emerging learning technologies into a learning services ecosystem. Within this ecosystem, multiple services, and learning opportunities (of various modalities and points of delivery) can be managed in an integrated, interoperable 'plug and play' environment.

The [Department of Defense Instruction \(DoDI 1322.26\)](#) and its [references](#) define the most current technical requirements and best practices for distributed learning across the DoD and are considered pre-requisite requirements to the techniques provided in this document. Where appropriate, specific requirements found in the DoDI or its references will be re-iterated in this document. DoD Components are encouraged to refer to these resources on a regular basis. While the DoDI 1322.26 doesn't explicitly discuss TLA compliance, compliance to individual TLA standards is referenced in the Instruction by the prioritized listing of standards-based solutions. The following paragraphs summarize each TLA standard in this document.

IEEE 9274.1.1, or xAPI, is a learning technology standard and a suite of web-service application programming interfaces (API) that support a simple object-based model for describing, recording, and sharing individual or team performance across digital learning systems. The xAPI standard requires the use of a Learning Record Store (LRS), which is the server-side implementation of xAPI. The LRS allows xAPI data to be shared with other systems that require access to these data. Additional information and access to the standard are available on the [IEEE's GitLab site](#).

cmi5 is a specification on the path to IEEE standardization that includes an xAPI Profile and allows all the functionality of Sharable Content Object Reference Model (SCORM®) but with the added benefits of xAPI. The cmi5 specification replaces SCORM® functionality as the de facto format of online courses and traditional computer-based training. Products that fully support cmi5 will also support xAPI. Additional information and resources are available at the cmi5 Project on GitHub (https://aicc.github.io/CMI-5_Spec_Current/)

The IEEE P2881 Learning Metadata Standard specifies a conceptual data model that defines the structure of a metadata instance and specifies the data elements that compose that metadata instance for any type of learning resource or learning event. While psychological and pedagogy practices are very slow to change, new technologies, such as Augmented Reality (AR) and Virtual Reality (VR), are continually being deployed to support learning and development. Content publication practices have also evolved to fit the expanding modalities of mobile and beyond. The notion of a singular content repository has changed to be more of a cloud-based, distributed solution that connects different content repositories into a learning ecosystem.

2.1 How to Use This Document

This document is not policy. It is a series of techniques founded in practice and often actualized in real acquisitions. Requirements defined in this document are recommended for use in specific acquisitions that revolve around specific situations. Each acquisition is specific to organizational requirements and their vision for the TLA.

Within the document, [Section 3](#) describes a TLA compliance strategy and outlines how the later sections can be used to achieve TLA compliance. Section 3 provides a strategic roadmap for looking at IT acquisition as a holistic TLA solution. Sections 4-6 describe the specific standards necessary for TLA compliance and provide details on how to successfully acquire IT platforms, software systems, and instructional content using that standard. [Section 4](#) describes how to implement xAPI, [Section 5](#) describes how to implement cmi5, and Section 6 describes how to implement Learning Metadata Terms.

Each section provides use cases that include acquisition language and possible criteria/metrics for evaluation. Related documentation, best practices, pitfalls to avoid, and cybersecurity concerns are also provided for each standard. Sections 4-6 are a starting point for implementing the specific standard referenced by each section. Because the cmi5 standard is derived from the xAPI standard, the cmi5 section refers to the xAPI Section rather than duplicating the same requirements. Appendices are included to provide a program-level strategy for deriving and implementing TLA requirements.

Each section includes excerpts of language used within different acquisition documents that supported successful acquisitions (e.g., Request for Proposal, Performance Work Statement). That language is shown in quotes and is introduced by supplemental text. Quoted text not from a contract will be cited (most often, the DoDI 1322.26). Modifications to this text will appear in ***bold italics*** and will be used only if the original language was insufficient or inaccurate. Sections that do not have quoted example language have not been used but have been carefully considered by standards experts and by those with acquisition experience.

Excerpts are also included to show language used that was not ideal. These examples are categorized with a **“FIX”** in front of their quotation followed by an explanation of why it was not sufficient and a recommendation for improving it. Any quotation with a **“FIX”** is not a requirement. If a requirement is mostly correct but just needs clarification to understand/enforce it, a **“Clarification”** is used.

This document uses specific requirements-based language to indicate the level of adherence to be compliant. The terms “shall” and “must” refer to unconditional adherence (this document recommends “shall” but recognizes that existing language sometimes uses “must”). Conversely, “shall not” and “must not” indicate adherence against certain conditions (for functional purposes, “may not” is the same as “shall not” and “must not”). For any Government controlled requirements/responsibilities, “will” is used in lieu of “shall.”

The terms “should” and “should not” indicate best practices in favor of or not in favor of a condition. Some requirements list exceptions to rules and times when not following the typical best practice may itself be a best practice. Any instances of the word “may” indicate that the specific condition was considered and found to be acceptable.

There may be DoD policies that change or organizational processes that override requirements and recommendations in this document. In those cases, DoD/Organizational policies should be followed.

2.2 Glossary

The following terms are useful to know as background to TLA compliance:

Assignable Unit (AU): A piece of learning content launched from an LMS. AUs are separately launchable pieces of content that include the concepts of completion, success, score, and duration. The AU is similar to a lesson inside a course. The AU collects data on the learner and sends it to the LMS.

cmi5 – cmi5 is a “profile” for using the xAPI with traditional learning management (LMS) systems. The cmi5 profile ensures plug and play interoperability between learning content (Assignable Units) and an LMS. The use case for which the cmi5 profile is specifically designed is one when a user launches a content/activity from the LMS’s user interface.

Competency (Conceptual) – This document does not define what a competency is academically or in performance. A competency is any form of organizational data related to personal performance and expectations. These include but are not limited to knowledge, skills, abilities, tasks, duties, jobs, outcomes, or objectives. Often, these are required or demonstrated in the performance of a task or activity within a specific context.

Competency (Technical) – Short for competency definition. The competency definition is a resource that includes a statement describing a competency and may include a specific context and definitions (directly or by reference) of potential proficiency levels. For simplicity’s sake, this document uses just a single definition and considers competencies to be of varying granularity. Rubrics for assessing competencies may also be included within the competency definition.

Competency Framework – A resource that identifies a collection of logically related competencies and how they are associated, related, and contextualized. A Competency Framework is often owned and maintained by different organizations and, therefore, takes on the context of that organization. For example, a marksmanship competency framework may differ between the U.S. Army and the U.S. Marine Corps. The marksmanship frameworks are further differentiated by the context of the training within each organization (e.g., basic training, Military Operations in Urban Terrain (MOUT) training, sniper school).

Course – A collection of Assignable Units (AUs) in a logical grouping. A course is typically an internal data structure. Courses are often assigned to learners and tracked by the LMS. A course can be represented by an external format and/or allocate all resources or links to resources in a course package.

Experience Application Programming Interface/Experience API (xAPI) - The collection of rules articulated in the xAPI standard (<https://opensource.ieee.org/xapi/xapi-base-standard-documentation/-/tree/main>), which determines how learning experiences are defined, formatted, and exchanged so that independent software programs can exchange and make use of this information.

Internationalized Resource Identifier (IRI) - A unique identifier that could be an IRL (same relationship a URL has with a URI). They are used to identify an object, such as a verb, activity, or activity type. Unlike URIs, IRIs can contain some characters outside of the ASCII character set to support international languages. IRIs always include a scheme. This is not a requirement of these standards but part of the definition of IRIs, per [RFC 3987](#).

Learning Management System (LMS) – A software system or a corresponding set of web services that provides academic course management and a user interface for students, educators, and administrators to deliver and track education. Modern LMSs include a set of web services that authenticate a learner, authorize access to learning content, and tracks progress across different courses and Assignable Units (AUs).

Learning Record – A record of a person’s learning experiences, achievements, and competencies that is formatted according to the rules of xAPI. A Learning Record takes on many forms, including statements, documents, and their individual parts.

Learning Record Provider (LRP) – A system that sends xAPI statements to a Learning Record Store (LRS). These statements describe a learner’s experience, such as completing a course or passing an exam. Often, the LRP creates Learning Records while monitoring a learner as a part of a Learning Experience.

Learning Record Store (LRS) – An essential server-based component of the xAPI standard that serves as a repository for learning records collected from connected systems where learning activities are conducted. The LRS is where xAPI statements are stored so they can be retrieved and shared with other systems.

Learning Object - Defined as any digital or non-digital entity used for learning, education, or training. A Learning Object in the P2881 standard is the generic classification of one of three scopes: Asset, Learning Resource, and Instantiation.

Learning Tools Interoperability (LTI): A 1EdTech (formerly IMS Global) standard that allows the connection and sharing of data across learning applications securely. This standard is widely used within Learning Management Systems and their connected applications.

Shareable Competency Definition (SCD) – A standard that describes the referencing and sharing of competency definitions (technical) used across all education, training, and human resource management applications. SCDs define a human / machine readable data structure for competencies, competency frameworks, assessment rubrics, and relationships between competencies and frameworks.

Shareable Content Object Reference Model (SCORM) – An outdated collection of standards and specifications for web-based, electronic educational technology. SCORM facilitated the pairing of individual learners with a single course while being tracked by a Learning Management System.

Total Learning Architecture (TLA) - The Total Learning Architecture is a set of technical specifications, standards, and policy guidance that define a uniform approach for establishing a DoD-wide Learning Ecosystem.

xAPI [Application] Profile: A specific set of rules and documentation for implementing xAPI in a particular context. A profile provides a way to talk about vocabulary concepts, statement templates, and patterns for xAPI data.

[xAPI] Statement - A data structure showing evidence for any experience or event to be tracked in xAPI as a Learning Record. A set of several Statements, each representing an event in time, might be used to track complete details about a learning experience.

Universally Unique Identifier: A unique label (globally unique, not just to the local installation) applied to information in a computer system. For this document, it is synonymous with a globally unique identifier (GUID).

2.3 Acquisition Roles and Responsibilities

This document defines a minimal number of roles. Responsibilities are addressed in the context of the acquisition language used for each standard in Sections 4-6.

- **DoD Component** – an organization acquiring TLA-compliant technology, implementing TLA standards, and is the controller of their organizational ecosystem. “DoD Component” is substituted for the actual organization in the sample language.
- **DoD Component Team** – agents of a DoD Component that perform actions, ideally in compliance with this document.

- **Contractors/Vendors** – agents that produce technology or services for a DoD Component but are not part of the DoD Component Team.

Any responsibility of a DoD Component Team may be offloaded to a Contractor or Vendor at the DoD Component’s discretion.

3.0 TLA COMPLIANCE

The following section describes the current state of TLA compliance. As future versions of this report are released, this section will be updated accordingly. Currently, the focus is only on specifications and standards. For future cycles, the Capability Maturity Models referenced in the [TLA Quick Start Guide](#) may be included.

3.1 What is TLA Compliance?

TLA compliance is defined as strict adherence to TLA standards. This adherence **should be** measured by conformance testing whenever possible. Conformance testing software creates functional tests that directly correspond to documented requirements that exist in standards. Conformance tests cannot test all requirements in standards, but TLA standards are written such that all “shall” requirements are testable by software. Not every TLA standard currently has a conformance test. When conformance testing is not available, the most effective means of achieving compliance to that standard is through mutual agreement between the producers and consumers of the data from that standard.

3.2 Current Compliance Procedures

TLA Compliance is defined around each of the separate standards referenced in Sections 4-6. Currently, conformance testing is done at the system or content layer. Aspects that do not yet have conformance testing are tools, processes, persons, or any sort of software/middleware/APIs that might connect two conformant systems together or federate them. ADL Initiative hosts versions of software products that perform conformance tests as well as maintains records of those who adopt standards (self-asserted) or even take that additional step of passing the software test. There are no plans for certification (3rd party verification with expert testing) at this time.

In the case of xAPI, all LRSs acquired across DoD should be validated by the ADL Initiative’s LRS Conformance Test Suite (<https://lrstest.adlnet.gov/>). Vendors with Conformant LRS solutions are identified in the [xAPI Adopters Registry](#). The cmi5 Conformance Test Suite is available at (<https://github.com/catapult-project/catapult>) and supports testing of both systems (Learning Management Systems) and courses. Users must install and manage the test suite; however, the ADL Initiative may host a version in the future.

3.3 Distributed Learning Requirements

The following requirements apply to all the TLA standards in this document:

- Project planning by the DoD Component Team prior to the acquisition should include data strategy development. Each DoD organization should have a strategic plan that addresses software instrumentation, conformance testing, user testing, operations, and maintenance.
- The DoD Component Team will provide adequate training on all acquisition to personnel that use them.

- The DoD Component Team will leverage both coupling and authentication capabilities in a manner that offers user authorization to create and share data as appropriate.
- The DoD Component Team will take appropriate measures to maximize data integrity.
- The DoD Component Team will require evidence of conformance test claims supplied by Vendors and Contractors.
- DoD Components will follow distributed learning, data, and information technology policy, particularly [DoDI 1322.26](#) and [DoDI 8320.02](#).

4.0 xAPI IMPLEMENTATION

This section describes the acquisition strategy for creating an ecosystem, which is a set of organizational web services that are linked together via data and follow the xAPI/IEEE 9274.1.1 standard. Many web products oriented in different service-based packages (such as a Learning Management System) can become xAPI compliant. These collections of services can be referred to as Learning Record Providers (LRPs) and LRSs. There are also systems that benefit from using the LRS, such as those using the data for analytics and visualizations. For the most part, learning content or authoring tools that produce learning content can be considered LRPs but without any of the communication requirements. In other words, the content should produce xAPI data that can simply be “bounced” by the LRP to the LRS without any reconstruction/revalidation.

Conformance testing for LRSs is available via the [xAPI Conformance Test Suite](#). LRPs are effectively tested by their communication with an LRS, and that communication not returning errors. Vendors may self-report their successes at [The ADL xAPI Adoption Website](#). In addition, xAPI Profiles are very important to creating interoperable data and should be used whenever possible. It is recommended that conformant profiles are used whenever possible from <https://profiles.adlnet.gov/>. More guidance and data conformance testing surrounding xAPI Profiles will be available in the future.

While keeping track of version support of xAPI is important, the [xAPI Accreditation Report](#) indicates that there are very few impacts of the migration from 1.0.3 to 2.0 on xAPI Adopters. The legacy browser support is one difficult issue, but the support of legacy systems is being driven out more by mobile technology and Operating System support. The new use of contextGroups and contextAgents is a small but necessary addition for LRSs to support. LRS Vendors indicated in an IEEE survey that they welcomed all the changes as they bring more stability than additional work.

4.1 Use Cases

The use cases in this document are organized to be simplistic and categorical, such that they can be building blocks for creating high-quality acquisition language. In this way, a set of use cases can be used to match an organization’s requirements as closely as possible. Subsets of use cases will be listed under each use case section.

Each use case in a subset will contain several formats or domain-specific high-level requirements that can be met, often using xAPI Profiles. This document will make general recommendations for the use of xAPI Profiles and will provide either generic links to the xAPI Profile Server such that the profile can be searched for or, when applicable, a specific xAPI Profile will be linked.

Sample requirements definition language will be given in each section and will be structured with the purpose of the language and then the quoted language.

4.1.1 Use Case #1 - LRS Integrated with Current Systems

While it is possible to acquire an LRS for standalone purposes, this use case focuses on aligning and configuring all systems and services in a current ecosystem to the newly acquired LRS.

Applications that can be integrated include but are not limited to:

- AR/VR Support
- Video Tracking
- Course Support (LMS)
- Specific Software Integration (e.g., Alexa, Teams)

Learning Tools Interoperability (LTI) <https://www.imsglobal.org/activity/learning-tools-interoperability> is a common standard many LMSs adopt that allows the sharing of authenticated user information and system information across services. xAPI can leverage this integration if it exists within the organizational ecosystem. Value added of implementing LTI from scratch for the purposes of xAPI has not been calculated as a part of this guidance.

4.1.1.1 Sample Requirements Definition Language

- The LRS shall support authentication using the DoD's Identity, Credentialing, and Access Management (ICAM) (<https://dodcio.defense.gov/Library>) policies.
- To establish the universal nature of the LRS, consider the following: "The LRS must be able to receive different events and activity streams via xAPI to include formal and informal learning, as well as the ability for users to self-report activities."
- To establish the diversity of integration expected, consider the following: **FIX:** "The LRS must be capable of integrating and receiving data from multiple systems within the Defense Acquisition University learning architecture and provide real-time tracking and recording of activity streams from multiple sources, including but not limited to:
 - Informal Learning Activities
 - Formal Learning Activities
 - Real-world activities
 - Games and Simulations
 - Mobile Access
 - Team-based Participation
 - Mentoring
 - AR/VR"

Here is why that was a bad idea – it is not the LRS's function to integrate and receive data. It will do that through functioning as an LRS, provided other systems send it data. Other systems in an ecosystem should leverage the LRS.

- To accurately define integration, consider the following: "Each system that becomes an LRP must be capable of sending statements with actor fields that correspond to an authenticated

- user on that system. For example, a course delivered via LMS would send data about the learner taking the course. Each system must send a statement with structure specified by DoD Component. Practices for adding additional statement types must be well documented.”
- To effectively connect xAPI data to authenticated and authorized learners, consider the following: “It is recommended that LTI is used whenever practical to provide the user information to populate statements with the actor property.”
 - To effectively offload LRS support to a Contractor, consider the following “provide hosting, professional services, training, maintenance & technical support for a cloud hosted PaaS or SaaS LRS solution.”
 - To provide onboarding service requirements for the LRS solution, consider the following: “The Contractor shall conduct all activities required to install and configure the LRS. Installation and configuration tasks are comprised of all activities, including but not limited to:
 - Standing up all environments
 - Configuring initial system level settings
 - Establishing administrator user accounts
 - Establishing base system roles and permissions
 - Configuring management settings
 - Configuring initial authentication settings
 - Enabling out-of-the-box publishing standard capabilities”
 - **FIX:** “Configuring analytics settings, canned reports, custom reports, dashboards, and custom data visualizations.” **Here is why it was a bad idea** – it implies that an LRS must include the capability when it really doesn’t. This capability may come from an entirely different product or existing capability. The requirement should be caveated with an “If provided.”
 - To create reassurances via demonstration, consider the following: “The Contractor shall deliver a comprehensive demonstration to the DoD Component product owner and systems administrators of the delivered LRS environments using Microsoft Teams or Zoom by the suspense date as indicated in section 11. The Contractor must cover in their product demonstration, all features and functionality within the LRS environments.”
 - To provide effective classification of services for the LRS integration, consider the following: “The integration involves establishing the LRS application within the ecosystem and suite of DoD Component applications. The Contractor shall provide Professional Services sufficient to deploy the LRS application, apply the approved LRS system configuration and establish interfaces and conduct testing based on the technical decisions made during the installation and configuration. The integration steps must cover both system and data levels for: unit testing, smoke testing (build verification testing), integration testing and system testing performed by the Contractor with DAU personnel support. The approach, and execution timelines shall be incorporated into overall project planning activities.”
 - To provide effective initial training of the LRS (e.g., including real-time support), consider the language below. This language can be used as a template for any such training that would accompany acquisition. “Contractor shall conduct comprehensive LRS onboarding training pertaining to administration and development activities within the LRS solution, and any integration points. The Contractor shall provide all required course materials, reference guides, job aides, developer docs, and community help resources. Training shall be conducted

virtually using the Contractor's preferred virtual meeting/training platform, recorded, and made available for later viewing."

- To provide effective training materials of the LRS, consider the language below. This language can be used as a template for any such training that would accompany acquisition. "The Contractor shall provide comprehensive LRS training materials for tasks related to system administration, operations, and maintenance. Training materials shall be in any of the following formats: online course modules, videos, reference guides, and help articles, and made available to appropriately scoped user roles for asynchronous self-paced learning."
- To provide effective technical support LRS, consider the language below. This language can be used as a template for any such support that would accompany acquisition of a software system. "The Contractor shall provide support services for the LRS solution, including self-service options, live technical support, and escalation through tier-3 engineering/system development services. Technical support is required to be provided through several channels including but not limited to a Contractor-hosted service management or ticketing system, email, an online support page that connects to FAQs, best practices, tutorials, and telephone. Contractor-provided service level agreements (SLAs) required to support timely issue handling and communication procedures as well as identify and address issues that must be handled immediately."
 - To effectively establish the SLAs, consider the following language: "The Contractor shall provide a standardized SLA covering all managed products and services. All Contractor technical support and maintenance work shall be performed in accordance with established SLAs. The Contractor must provide SLA terms including but not limited to:
 - The Contractor shall provide system availability 24x7x365 with uptime of no less than 99.9%
 - The Contractor shall provide service continuity, disaster recovery and backup operations, including hot and warm failover contingencies, as well as documentation of remediation approaches
 - The Contractor shall provide data ownership policy, rights, and procedures for requesting deletion of Government and visitor data
 - The Contractor shall provide issue, ticket, request procedure thresholds and projected resolution times originating at each identified support service Tier
 - The Contractor shall provide software release management practices, including testing procedures, and advance notification periods allowing appropriate customer planning and communication for major, minor, and patch releases"
- To establish a clear communication structure for requirements/issues, consider an issue matrix as Government Furnished Information and the following language: "The DoD Component will develop and share a backlog of open issues while system administrators work with the Contractor's enablement team to install, configure, and implement the LRS solution. This log will be used as the primary tracking mechanism for all issues, action items, and decision points between the DoD Component and the Contractor prior to system implementation. Both parties will communicate status updates through this log to ensure information tracked and open items are resolved in a timely manner."

- Additional “a la carte” requirements can be found in the following matrix. (Note that these are possible useful requirements and are not specific endorsements of processes over another. All requirements were directly used in a successful LRS acquisition.)

Accessibility Requirements

The LRS user interface must be compliant with Section 508 of the Rehabilitation Act of 1973 Public Law 106-246.

The LRS user interface must be compliant with the Rehabilitation Act Amendments of 1998 (29 U.S.C. 794(d)).

Architectural and Transportation Barriers Compliance Board Electronic and Information Technology (EIT) Accessibility Standards (36 CFR Part 1194).

The LRS user interface must be compliant with the Web Content Accessibility Guidelines (WCAG) 2.0.

Administrator UI/UX/Functional Requirements

Authorized administrators must be able to configure the LRS user interface / Dashboard and reports to conform to the organization's design standards including:

Logo

Backgrounds (images, gradients)

Style sheets (fonts, colors)

Feature, control, and data labels

Instructions and prompts

Authorized administrators must be able to configure client-defined security roles (e.g., Need to be able to configure for users, admin levels, etc.).

Authorized administrators must be able to control the read, write, execute, and delete permissions related to LRS functionality at a granular level for each security role.

Authorized administrators must be able to assign/unassign security roles to users.

The LRS must provide a report of user login dates and times and user logout dates and times, which:

Includes, at a minimum, the user's first and last names, user ID, organization, and role.

The LRS must provide a report listing all user accounts with access to the LRS system.

LRS Functional Requirements to Ensure "Good" Data

Import and export of learner and course tracking data using standardized data interchange formats (e.g., XML, JSON, CSV) without writing high-LOE integration applications.

FIX: “The LRS must support xAPI Profiles to include: [named] profiles within all search, retrieval, visualization, and analytics capabilities. This includes custom searched reports, menus, filters, and data integrity for those Profiles.”

Here is why it is a bad idea – The LRS will not validate xAPI data to a profile. That is a 3rd party service, and it shouldn't be expected of the LRS. The RFP should be specific to which profiles it is talking about and have a strategy for validating that data for conformance to those profiles, just not requiring the LRS to do so.

Ensure data integrity of statements generated by integrated systems and sent to LRS such that the LRS data is directly attributable from one of those systems and could not come from an outside source.

Clarifications to Expected Behavior of an LRS

(Many of these are directly in the xAPI Standard but are helpful to repeat)

The LRS must comply with current ADL Initiative xAPI LRS Conformance Requirements and xAPI 2.0.

The LRS must be able to receive xAPI data from user interactions originating from activity providers' input.

The LRS must accept xAPI statements defined within xAPI Profiles.

(e.g., cmi5, video)

The LRS must expose its endpoint to third party xAPI activity providers.

The LRS must make its xAPI data fully accessible to third party analytics and reporting tools.

The LRS must provide a method to display xAPI activities stored through reporting, queryable data, statement viewer, and analytics dashboards.

LRS must maintain a persistent storage of learning activity records (i.e., xAPI statements).

LRS must capture all xAPI statements generated from Learning Record Providers (i.e., Learning Activities)

LRS must ensure that xAPI statements are conformant.

FIX: "LRS must provide a mechanism for administrators to purge xAPI records. **"Here is why it was a bad idea – "Purging" data in an LRS is done by voiding Statements. It is the only way to "undo" a Statement. Removing data from a database may be necessary administratively for various reasons, but it is not part of xAPI or the responsibility of the LRS. The existence of the Statements is not negated by purging of the database.**

LRS must maintain a record of purges to show that data has been altered.

LRS must provide a mechanism to ensure the integrity of the storied xAPI data.

LRS must be able to identify if an incoming xAPI statement is not well formed. (**Clarification:** "well formed refers to JSON-formatting, which would often be a pre-conformance check and would not make it to the LRS")

LRS must allow storage of xAPI statements for each UUID stored as actor.

LRS must be able to identify that an incoming xAPI statement is not from a registered device.

LRS must be able to identify incoming xAPI statements with an actor that is not a valid user, registered component, or identity group. (**Clarification:** "The LRS cannot reject Statements just because it doesn't know who the actor is.")

The LRS must have a quality assurance process whereby changes to the xAPI spec or the LRS product are regression tested with an internal test suite to ensure strict compliance with the spec.

LRS serves as endpoint and interfaces with systems of work within DoD Component's enterprise architecture through APIs

FIX: Data Viewing/Visualization Requirements

Why this whole section is a bad idea: an LRS vendor may provide these capabilities, but it is thought of as a different and integrated product. An organization might have these requirements, but an LRS shouldn't be penalized for not having these capabilities as they would be considered "add-ons." The TLA looks for modular capabilities with analytics/visualizations across all data, not restricted to LRSs or a single LRS. The following requirements should be considered if adding dashboarding.

The LRS must provide roles-based configurable dashboard views of user data and the ability to associate data with profiles and then users to profiles. (e.g., a learner dashboard pulls in cmi5 data, which is (verblast))

The LRS must provide granular drill down to actual statements (with filters/ search by Activity ID, Verb ID, Agent Value, Agent Property, Context Category, and Context Agent all found in xAPI 2.0).

The LRS must provide a statement viewer function allowing filtering by organization hierarchy or multiple filters to customize defined groups.

The LRS must provide out-of-the-box, predefined and customizable reports, and a wide range of data visualizations.

The LRS must provide permission levels with different kinds of access to dashboards and reports.

The LRS must provide enhanced query capability beyond the basic xAPI specification (**Clarification:** now a standard) requirements by providing the ability to link and/or import data from alternative data sources.

The LRS must provide flexible, robust abilities to create custom reports, both internally and by using external tools.

The LRS must provide capabilities to:

browse xAPI statement data

use canned reports for commonly required data such as test scores

measure business impact (through integration with external BI systems such as Qlik)

The LRS must provide analytics that include graph charting and advanced visualization options like video and multimedia engagement, heat mapping, etc.

The LRS must provide an ad hoc query report capability that enables an authorized administrator to select from a list of data categories.

The LRS must provide authorized administrators to specify a list of report recipients for a given report and schedule automatic one-time or recurring delivery of the report to the recipient list via email.

The LRS must provide configurable field-level restrictions to be placed on all reportable fields, assignable through security role permissions.

The LRS reporting tool must be user-friendly so that ad-hoc reports can be created and run with a minimum of user training.

LRS must allow the use of filters on retrieving xAPI data by Actor, date/time, activity type (object), verb, user specified extension field values

Data Viewing/Visualization Requirements

The LRS must keep a log of all changes made to the LRS configuration and settings to include who made them and when made.

The LRS should keep a log of all user accounts that have access to the LRS system and their actions for auditing purposes.

LRS should send notifications based upon requirements in this category.

System Security/Cybersecurity Requirements

The LRS, like other systems in our ecosystem, must be capable of supporting DoD Component's identity management solution using SAML 2.0 and integrate with DoD Component's Single Sign-On (SSO) solution, Oauth, WS Federation, and OKTA.

The LRS must be able to support Vanity URL/ Bring your own domain (e.g., (LRS.MYORG.MIL)).

LRS must include login credentials utilizing FIPS 140.2 encryption of passwords.

LRS must support the use of FIPS 140-2 encryption.

The LRS must provide Data at Rest encryption for data stored.

The LRS must provide encryption of web services (i.e., REST, SOAP).

The LRS must provide SSL encryption (HTTPS) for all web traffic.

The LRS must provide a solution that enables manual and scheduled batch data management through flat files for routine system administration tasks, including but not limited to user and content import/export, object synchronization, list cleanup, and removal of duplicative data across a variety of system data sources. Scheduled flat file import/export must be secured via SFTP or secure shell (SSH) using public key cryptography.

LRS must allow for connections using REST over TLS

The LRS must be able to pass minimum FedRAMP Impact Level 2 for public-facing cloud solutions and up to IL4 for protection of personally identifiable information when appropriate. For details, see: <https://www.fedramp.gov/> (**Clarification:** This is only for cloud-based solutions that were hosted and are only for FedRAMP accepted solutions.)

Allows configuration for the management of Personal Identifiable Information (PII) in accordance with enterprise and government policy (such as FERPA).

Contains multiple security access levels with ready access to unclassified learning material and more stringent security requirements for Controlled Unclassified Information (CUI).

The LRS must support compliance with Security Technical Implementation Guide (STIG), especially regarding system installation, maintenance, configuration management, and administrative processes. For details, see <https://public.cyber.mil/dccs/>.

The LRS must support compliance with the Federal Information Security Management Act (FISMA), especially regarding information security controls, risk assessment, and monitoring. For details, see: <https://www.cisa.gov/federal-information-security-modernization-act>

The LRS must be able to pass the DoD Risk Management Framework (RMF). For details, see <https://csrc.nist.gov/projects/risk-management/rmf-overview>.

Level of FedRAMP authorization. The product must be capable of being hosted as a Platform as a Service (PaaS) or cloud Software as a Service (SaaS) or on-premises at the DoD Component and/or third-party hosting with applicable Federal and DoD certifications and authorizations (e.g., FedRAMP, FISMA, RMF). If not FedRAMP, willingness to obtain certification and authorization with DoD Component as a sponsor. (**Clarification:** FISMA is not a cloud service, and this requirement is only appropriate if FedRAMP is considered appropriate to the organization.)

Hosting Requirements

The LRS must be installed in multiple server environments, including:

Test: for testing and acceptance, LRS updates, and systems integrations.

Production: for access by end users.

Continuity of Operations: mirrors production environment for failover and disaster recovery.

FIX: The LRS vendor must inform the client of LRS system updates (major and dot releases, updates, and patches) at least 30 days before the intended release date. The vendor must also inform the DoD Component if any of these updates impact any of the integrations/data from other systems (e.g., any API modifications). **Why it is a bad idea –** It is very likely a DevSecOps Pipeline for CI/CD is used, or the DevSecOps of an organization is more restrictive than this.

FIX: The LRS vendor must install a production-ready release of all LRS system updates (major and dot releases, updates, and patches) in a staging environment and provide up to 30 days after the release date for the client to test systems integrations. Once accepted by the client, the release must be installed in production during off-peak hours

on a date and time agreed in advance by the client. **Why it is a bad idea** – It is very likely a DevSecOps Pipeline for CI/CD is used, or DevSecOps of an organization is more restrictive than this.

If not hosted, an on-premise solution must be load balanced across multiple servers.

Documentation Requirements

The LRS vendor must provide documentation to demonstrate its quality process maturity, especially in relation to product enhancement, known bug prioritization and communications, and pre-release testing.

The LRS vendor must provide documentation demonstrating its release management process maturity with its product's release cycle history and future roadmap, including the schedule, frequency, and purpose of patches, dot releases, and major releases.

The LRS vendor must provide documentation demonstrating its support process maturity with its support capabilities, structure, availability, scope, service levels, policies, and active user group forum/s with ongoing discussions.

The LRS vendor must provide documentation to include training services, materials, and resources to support the LRS administrators and pilot users.

The LRS vendor must provide documentation demonstrating its privacy policy and practices, including, but not limited to, a description of how LRS data is stored, accessed, and used.

The LRS must provide well-documented RESTful API calls.

The LRS vendor must provide a name and contact information for the person responsible for privacy at their organization.

Browser Requirements

The LRS should be compatible with the current version and the last two major versions of Mozilla Firefox.

The LRS must be compatible with the current version and the last two major versions of Google Chrome.

The LRS should be compatible with the current version and the last two major versions of Apple Safari.

The LRS must be compatible with the current version and the last two major versions of Microsoft Edge.

The LRS must not require persistent cookies.

The LRS must enable any required cookie to expire upon logging out, closing the browser, or after a configurable timeout period.

The LRS must not require any plugins, including but not limited to ActiveX, JRE, or other Java plugins

FIX: Throughput Requirements

Why much of this section is a bad idea: Scaling is not so much the LRS, but it is the deployment environment that the LRS sits on. Statement size will vary, so numbers are tough to justify without understanding that size. The numbers below are very unrealistic and were not likely met by the acquisition.

The LRS must support minimally 60,000 average concurrent users.

The LRS must be scalable to support up to 100,000 peak concurrent user data record streams.

The LRS should support a minimum of 350,000 active user data record streams

The LRS should be scalable to support 1,000,000 or more total user data record streams

Performs with minimal latency under a variety of use case scenarios and load conditions

Handles user data load efficiently, provisioning and scaling resources to smoothly accommodate fluctuations (especially spikes) in volume of statements sent to it.

4.1.1.2 Sample Evaluation Criteria

Acquisition of an LRS hinges largely on its ability to securely receive data from other systems in the ecosystem. DoD Components may have certain processes and requirements that must be followed. It is important to know if it is possible to perform acquisition of a product that doesn't yet meet such standards but could as a part of the acquisition process. The return on investment of a product that is already meeting requirements versus one that doesn't and would require the extra effort should be calculated by a DoD Component.

Once those requirements are met, the top LRS considerations are as follows:

- 1) Ability to protect and secure data. While meeting a high-level requirement is important, the product itself needs to have safeguards in place.
- 2) Talent consultancy/support with the product. A qualified individual(s) who can provide reach back, act as a sounding board, and allow organizational vicarious learning is important to have available to help figure out all the unknowns associated with any acquisition.
- 3) The overall solution should send Statements to the LRS and rely on different types of systems and modalities of content to send robust data that conforms to xAPI Profiles. Handling of complex queries beyond those required by the LRS is ideal.
- 4) The ability to effectively migrate data in the event of a transition between platforms through Data Portability. The best is LRS to LRS communication. The minimum for Data Portability is the ability to share nested JSON without losing information.

4.1.2 Use Case #2 - xAPI Learning Content Acquisition

Learning content conformant to xAPI will often need to be developed as a part of an acquisition. The old paradigm of a content package and a content system being the only two components in a distributed learning solution are no longer valid. xAPI relies on an LRP taking responsibility for communication to an LRS. This means the LRP must create and send statements. Creation can simply be copying these directly from the content it is running, but it is the responsibility of the LRP, nonetheless. Before accepting ANY xAPI content, a strategy for that content working with an LRP must be in place. Often, the LRP role is filled by an LMS, which a user is authenticated to, courses are registered for, and learning records can be sent from.

Data from xAPI content should be highly directed. It must follow the format of the xAPI standard, but if it doesn't follow xAPI Profiles, it will have interoperability issues outside of the implementing organization and possibly even within when combined with other xAPI data sources. Organizations should supply or work with those creating content to define specific narrative-based xAPI Profiles and then align to existing xAPI data and profiles wherever possible.

While most xAPI properties have flexibility in the xAPI specification 1.0.3, some practices allowed by the IEEE standard 2.0 will produce data interoperability issues if they are used and then stored in an older LRS. Many of these issues exacerbate the need for an LRP in place that can adequately modify "Statement Output" from a learning content to be ready for LRS consumption.

4.1.2.1 Sample Requirements Definition Language

- Learning content of any granularity that includes xAPI support shall have a specific and documented connection to an LRP under the DoD Component's control. The Learning Content is still responsible for sending valid data to an LRP, even if the LRP converts it in any way into an xAPI Statement before sending it to an LRS.
- Learning content of any granularity that includes xAPI support or the LRP it is communicating with shall send Statements with globally unique ids. Contractors should work with DoD Components to determine a strategy for producing globally unique IRI. This strategy should include base IRIs that are organizationally specific and then ensure uniqueness of the other IRI components. Learning Content on its own should not be performing lookup functions to determine statement id uniqueness. Specifically:
 - The following IRI pattern should be adopted by anyone creating new concepts for a profile: <https://w3id.org/xapi/> [profile name] / [concept type] / [concept]. IRI authors should only customize the content in the IRI in brackets. For example, the Video Profile Verb, <https://w3id.org/xapi/video/verbs/seeked>, follows this pattern.
 - Many existing IRIs/concepts do not follow this pattern due to legacy issues and that branching now would cause interoperability issues. They can be considered allowable exceptions to the requirement above.
- Learning Content of any granularity that includes xAPI support or the LRP it is communicating with shall send Statements with Activities with unique IRIs. Contractors should work with DoD Components to determine a strategy for producing globally unique ids. This strategy should include organizationally specific base URIs and then ensure uniqueness of the other URI components. The following requirements/process from Navy Education and Training Command (NETC) is one such interpretation that follows all xAPI requirements that creates an IRI that begins with "https://":
 - The Activity ID shall not include any spaces.
 - An Activity ID shall not end with a trailing slash "/" unless the slash is required to resolve to the URL of an external resource.
 - For an Activity that is a link to an external resource (such as an external website), use that resource's URL as the Activity ID. This requirement only applies to external links.
 - The Activity ID shall not include a file name extension or the location of a file as part of the ID unless it's required to resolve to the URL of an external resource.
 - The Activity ID shall not include any URL-encoded characters unless it's required to resolve to the URL of an external resource.
 - For all other types of activities, an Activity ID shall include a Universally Unique Identifier (UUID) at the end of the IRI to make the Activity ID unique.
 - Do NOT use multiple Activity IDs to represent the same Object or reuse the same ID to represent different activities.
 - DoD Components will maintain an inventory list of Activity IDs used for each project to avoid causing Activity ID collisions by accidentally creating and using the same Activity IDs for different activities. The Activity ID inventory list is a required deliverable.
 - Follow the above guidance for other ids, as appropriate.

- Learning Content of any granularity that includes xAPI support or the LRP it is communicating with shall send Statements with timestamps. In addition, these timestamp values should be in Universal Coordinated Time (UTC).
- Learning Content of any granularity that includes xAPI support or the LRP it is communicating with should send Statements with Actors that use the account/homepage mechanism for identification. Contractors should work with DoD Components to determine a strategy for supplying the correct Actor information based on authentication/permission to use the content. In addition, the homepage shall include a base URI specific to that DoD Component and under that DoD Component's control.
- Learning Content of any granularity that includes xAPI support or the LRP it is communicating with shall implement the following xAPI Data specific requirements unless a specific exception is made and documented (credit to NETC Guidance):
 - If the Actor is a learner, set the actor.objectType property with the value set to "Agent" unless defined differently in a specific xAPI Profile.
 - Set the verb.id to the identifier associated with the relevant Verb.
 - Set the verb.display to the human-readable, past tense representation of the Verb.
 - include a display string in English with the language code of "en."
 - Set the object.definition.name to the language map value that represents the official name or title of the Activity.
 - Set the object.definition.description to the text value that represents a short description of the Activity.
 - Set the object.definition.type to the identifier associated with the relevant Activity Type.
 - The ID of the xAPI Profile (as an Activity) that a Statement is intended to conform to shall be declared in the category array within the context.contextActivities Object. Additional Profile Activity IDs for each Profile shall also be declared in the category array.
 - The registration property is used to identify multiple xAPI Statements that are all part of a particular attempt. The value of the registration property shall be a Universally Unique Identifier (UUID) and should persist throughout all Statements during each attempt.
- Learning Content of any granularity that includes xAPI support or the LRP it is communicating with should send Statements that conform to Statement Templates of known and relevant xAPI Profiles whenever possible. Statement Templates can be found at <https://profiles.adlnet.gov/>.
- If new xAPI vocabulary is needed to successfully implement xAPI in the Learning Content, the DoD Component/Contractor should attempt to incorporate it into an xAPI Profile. Guidance for xAPI concept and profile creation should be followed at <https://adlnet.gov/guides/xapi-profile-server/user-guide/Profiles.html#profile-creation>.
 - If the intended function of an xAPI Verb is slightly different from an existing verb, or additional information is needed, use the xAPI properties context, result, extensions, or other xAPI mechanisms to add this data to the Statement.

- Learning Content of any granularity that includes xAPI support or the LRP it is communicating with shall not send Statements that contain properties that are not either a) specifically in the xAPI standard or b) created as an extension as defined in the xAPI standard.
- DoD Components enforce this DoDI 1322.26 requirement: “Content repositories within the DoD shall be leveraged whenever possible to re-use existing content, whether it be for legacy deployment or modernization to new web standards. Critical to reuse is that DoD Components acquire source files and other software components for each acquisition in accordance with DoDI 5000.87, dated 2 October 2020.”
- Statements should not be communicated to the LRS using Basic Authentication directly from a web-browser.
- LRS credentials and the xAPI payload should not be accessible by learners.

4.1.2.2 Sample Evaluation Criteria

When evaluating criteria for content development, it is important to fulfill all of the pedagogical requirements before technology-based criteria. The following criteria are valuable to determine ROI on developed content:

- Solid IRI design in Statements
- Data conformant to xAPI Profiles whenever possible
- Out-of-the-box capability for insightful data visualizations related to learner activity
- Past performance - Look at reviews from previous customers/contacts
- A cohesive data plan for all tracked data
- Recommended visualizations that are provided out of the box and other innovative/new uses of xAPI
- Select with future work in mind
- Determine if other APIs can be leveraged

4.1.3 Use Case #3 - xAPI Authoring Tool Acquisition

While it is possible to acquire an LRS for standalone purposes due to eventual capabilities not yet being acquired, this use case focuses on aligning and configuring all systems in a current ecosystem to the newly acquired LRS.

An authoring tool does not function as an LRP. The same requirements of Learning Content Acquisition apply to xAPI Authoring Tools. The difference is that the expected output of an authoring tool is less likely to be modified (because it is expected to be published in a final form) than a normal content acquisition. Despite the likelihood, the output of an authoring tool should be held to at least the same level of scrutiny.

Certain functions should be baselined in an authoring tool. The tool should support the ability to apply different standards to content, or at least take in multiple formats of content and then apply xAPI. The authoring tool, at a minimum, must handle its own export formats and be able to change between them upon import. From a migration standpoint, being able to transform SCORM content to xAPI is extremely valuable, such that the content would not have to be completely deconstructed to its raw elements and rebuilt. Re-coding it with an import/export or find/replace type of operation would significantly reduce the required manpower. Tools should be extensible in allowing integrations with xAPI Profiles. Data

validation of xAPI Profiles would be an extremely useful feature. An authoring tool that can import an xAPI Profile and then restrict the user appropriately is even better. Supplying direct access to both a code view and a page layout view is very powerful.

4.1.3.1 Sample Requirements Definition Language

- An xAPI authoring tool shall create Learning Content that meets the criteria of Section 4.1.2.
- An xAPI authoring tool shall not create Learning Content with Statements that are restricted in the UI to a single choice (and otherwise not extensible) and also non-conformant to xAPI Profiles (Note that non-conformant is different from not being found in an existing xAPI Profile; Non-conformance is when a clear best practice has been defined, for example, for a verb and it is disregarded).
- An xAPI authoring tool should not create Learning Content with Statements that are restricted in the UI to a single choice and otherwise not extensible.
- An xAPI authoring tool should not create Learning Content with Statements that are non-conformant to xAPI Profiles (Note that non-conformant is different from not being found in an existing xAPI Profile; Non-conformance is when a clear best practice has been defined, for example, for a verb, and it is disregarded).
- An xAPI authoring tool should directly support the creation of Statements that align with xAPI Profiles. An xAPI authoring tool should directly describe which xAPI Profiles it can create.
- An xAPI authoring tool shall allow export, re-import of that exported content, modification of that content, and re-exporting of that content for the current version of xAPI.
- An xAPI authoring tool should allow the import of SCORM content and an export of xAPI content.
- An xAPI authoring tool should allow validation of Statements/sets of Statements to a selected xAPI Profile
- An xAPI authoring tool should allow the selection of xAPI Profiles and then assist the development via UI restrictions based on that xAPI Profile.
- An xAPI authoring tool should allow direct access to both a code view and page layout view (if applicable).
- An xAPI authoring tool should allow multiple persons/roles to simultaneously access and work on Learning Content. Version control shall be supported in this case.

4.1.3.2 Sample Evaluation Criteria

Evaluation criteria for tools should focus on implementation of as many of the “should” requirements above as possible (“shall statements” are non-negotiable). Interfaces should be simple but produce the desired results. The product shouldn’t require in-depth technical knowledge to apply standards.]

4.1.4 Use Case #4 – Standalone xAPI LRS Replacing Functions of an LMS

This use case focuses on aligning and configuring all systems in a current ecosystem to the newly acquired LRS. Meeting this use case requires creation of interoperable and integrated services. A DoD Component will be aware of which of these are needed, but if looking to move to an LRS solution, it should have a specific implementation strategy for determining what complimentary services are needed. These

include, but are not limited to, LRP responsibilities, Hosting, Resourcing, Financial, Assessment, Authentication, Authorization, and Grade Books.

4.1.4.1 Sample Requirements Definition Language

At this time, there is no “typical” case for replacing an LMS with an LRS; the capability sets are simply too different to suggest that a series of implementation details and requirements could provide predictable success.

4.1.4.2 Sample Evaluation Criteria

Due to the unpredictable nature of such a migration, no evaluation criteria are appropriate. This would be a multi-step process executed by the DoD Component and specifically acquisition.

4.1.5 Use Case #5 - LRS Dashboards/Analytics

A common purpose of acquiring an xAPI-based solution is to make informed decisions and to display data in meaningful ways. However, because of the modular nature of xAPI, these services are separate from the standard. While products in the legacy distributed learning era (e.g., LMS) relied on a specific integration, xAPI data is accessible as a part of the standard such that these components could be separate solutions. Some LRS products will include a baseline dashboards/analytics capability. It is recommended that those Services be considered separate from the other xAPI efforts and scored accordingly. A separate acquisition may be appropriate.

4.1.5.1 Sample Requirements Definition Language

- An xAPI Dashboard or Analytics Capability shall allow configuration of xAPI Statement extensions such that those vocabulary can be used.
- An xAPI Dashboard or Analytics Capability shall make a connection with the LRS that grants access to Statements based on permission.
- An xAPI Dashboard or Analytics Capability should leverage role-based creation and viewing of dashboards. At a minimum, support senior leaders, instructors, subject-matter experts, instructional designers, and students.
- An xAPI Dashboard or Analytics Capability should integrate with outside data sources and be leveraged as a part of a data solution by applications, such as leaderboards so that data can be aggregated even if not all are explicitly stored in that LRS.
- An xAPI Dashboard or Analytics Capability should facilitate the ability to create and discover linkages with the specific learning content the learner experiences.

4.1.5.2 Sample Evaluation Criteria

Evaluation Criteria for dashboards and analytics should focus on implementation of as many of the “should” requirements above as possible (“shall statements” are non-negotiable). Interfaces should be simple but produce the desired results. The product shouldn’t require in-depth technical knowledge to apply standards.

4.1.6 Use Case #6 - Multiple LRSs

This use case focuses on aligning and configuring multiple web services within an ecosystem to different LRSs. Note that this does not mean multiple distinct LRS products are needed. The LRSs can exist in

different configurations and security enclaves and would be on distinct web infrastructures. LRSs can be considered distinct for various reasons, most of which stem from the need to separate data for security or efficiency. The same LRS can be configured to multiple “end points” (or resource locations) where xAPI data can be sent. xAPI data can be properly routed from one LRS to another based on rules. This service is currently beyond the scope of xAPI but is a highly recommended service for xAPI LRS.

4.1.6.1 Sample Requirements Definition Language

- Caveat: “Multiple LRSs” as described below could also be easily accomplished with a single LRS with multiple endpoints.
- For ecosystems requiring at least one primary (meeting this requirement makes it primary) LRS, the primary LRS shall have ability to be configured to connect to multiple third-party LRSs for forwarding, filtering, and routing downstream.
- A learning ecosystem should support dynamic communication between multiple LRSs (e.g., noisy, transactional, authoritative LRSs) as defined in the [ADL Total Learning Architecture](#).
- A multi-LRS solution shall be able to configure multiple endpoints and send data between those “LRSs” via endpoint or other agreed-upon solution with the DoD Component.
- The overall LRS solution should be able to import and export Statements in bulk/totally to another LRS.
- LRS solutions should have both UI (could be CLI or GUI, e.g., a visual aspect may not be necessary) and API support for the transport mechanisms described in this section.

4.1.6.2 Sample Evaluation Criteria

Evaluation criteria for multi-LRS solutions (or even those considering future ecosystem capabilities) should focus on implementing as many of the “should” requirements above as possible.

4.2 Related Policies and References

- DoDI 1322.26 - https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodi/132226_dodi_2017.pdf?ver=2017-10-05-073235-400
- DoDI 1322.26 Reference - <https://adlnet.gov/policy/fungible/>
- DoDI 8320.02 - https://irp.fas.org/doddir/dod/i8320_02.pdf
- xAPI 2.0 Standard - <https://opensource.ieee.org/xapi/xapi-base-standard-documentation>
- ADL Initiative’s xAPI Project Page and Resources - <https://adlnet.gov/projects/xapi/>
- IEEE 9274.1.1 Open-Source Landing Page - <https://opensource.ieee.org/xapi>
- IEEE 9274.1.1_2022_D1 - <https://opensource.ieee.org/xapi/xapi-base-standard-documentation/-/tree/main>
- xAPI Profile Server - <https://profiles.adlnet.gov>
- xAPI Accreditation Report, Impact of 1.0.3 to 2.0 - <https://adlnet.gov/assets/uploads/ADL%20xRAP%20Final%20Project%20Report.pdf>
- Navy Guidance for xAPI Implementation - <https://netc.usalearning.net/xapi-library/all-resources.html>
- ADL’s Hosted Prototype Learning Record Store - <https://lrstest.adlnet.gov>

- ADL’s xAPI Adopters
- Self-asserted products - <https://adopters.adlnet.gov/adopters/0>
- Conformant LRSs as validated by the LRS Test Suite - <https://adopters.adlnet.gov/products/all/0>
- SCORM to xAPI Wrapper - <https://github.com/adlnet/SCORM-to-xAPI-Wrapper>
- xAPI Profile / Profile Server Guidance - <https://adlnet.gov/guides/xapi-profile-server/user-guide/Profiles.html#profile-creation>
- xAPI Developer Resources - https://veracity.it/xapi_developer_ultimate_resource_list_1

4.3 Recommended Best Practices

- In the event of a transition, ensure there is a plan to execute with disruption minimalized and data loss prevented.
- In advance of acquisition and Authority to Operate (ATO), there is significant value in having a PII-free, non-FedRAMP (e.g., no ATO) space to test and prototype proofs of concept. This is not only for technical solutions of systems but also for the management of data, analytics, and visualizations.
- Finalize version support of xAPI using the [xAPI Accreditation Report](#) as a guide.

4.4 Pitfalls to Avoid

- Be aware that security considerations can greatly impact anticipated start times/schedules. Having conversations with IT and Integration Teams is key.
- The “TinCan” packaging and other mentions of “TinCan” are not substitutes for xAPI or cmi5. TinCan was the early name given to the xAPI Specification prior to its documentation specification on GitHub. Protocols were created to ensure it was possible. Some of those tech pieces were picked up by Vendors and put into products. Learn more about these differences at https://aicc.github.io/CMI-5_Spec_Current/tincan/.
- Buying an authoring tool or content that is conformant/compliant with xAPI is not enough. To achieve data interoperability, an authoring tool should adopt specific xAPI profiles and document them as such. For web-based courseware design, the most important of these profiles is cmi5.

4.5 Cybersecurity

As xAPI is a web service-oriented standard that involves communication across defined systems, it is fitting that cybersecurity practices are established for the use of this standard. Cybersecurity, as currently scoped in this document, doesn’t necessitate guidance for xAPI Profiles as they are simply possible data points in the overall matrix of possible data points. While cmi5 does define specific communication protocols, these are also in the realm of possibilities of xAPI and are covered in this section. This guidance is expected to grow over time.

4.5.1 Cybersecurity in xAPI Overview

Because the xAPI data model itself is open source, standardized, and transparent, it is easy to assess the risk posed by the inclusion of attributes communicated via xAPI. The data model itself poses no specific risk as compared to any general data model supporting any RESTful web service — in fact, the open nature of xAPI is a mitigating factor against the “black box” issue often faced by implementing other data models.

Cybersecurity considerations regarding xAPI, therefore, should prioritize analyzing the risks inherent in products implementing xAPI and communicating xAPI data as opposed to over-analyzing the risk of the xAPI data model itself.

Since 2020, an IEEE Working Group has met to work on a set of *Recommended Practices for Cybersecurity in the Implementation of xAPI*. The draft document has been delivered and awaits balloting; it is scoped as follows:

- The recommended practice document defines terms, including stakeholder types.
- The recommended practice documents how secure xAPI implementation fits into the broader category of best practices in cybersecurity.
- The recommended practice document discusses xAPI-specific cybersecurity best practices.
- The recommended practice provides use cases illustrating cybersecurity practices as related to xAPI implementations.

Review and adoption of this published standard is recommended upon its completion.

In a similar effort, from 2020-2022, the ADL Initiative worked with a research team to establish an [LRS Accreditation Project](#) to identify the potential cybersecurity vulnerabilities or accreditation challenges and address these challenges through updates to the xAPI standard and by providing resources that support the accreditation process for xAPI-enabled education and training systems. The final report of this project can be found [here](#).

4.5.2 Cybersecurity in xAPI Research Findings

The following findings can be used to influence acquisition decisions and language:

- An LRP must have some control over the content system or be trusted by the content system to complete the handshake necessary for communication.
 - If not, there is no reliable way to manage a registration between an LRP and LRS. This leads to workarounds that introduce security risks ranging from the ability to simply scrape the LRS credentials from the LRP to the ability to impersonate the authorized LRS.
- When an LRP-to-LRS communication exists (which is normal in xAPI) and the LRP contains an unsecure connection or unencrypted description of the LRS connection inside of it, it introduces risk as the data from the LRP could be trusted by the LRS but not secured.
 - Secure data communication from the LRP to the LRS should require Transport Layer Security, which are established cryptographic protocols that allow the implementer with a means to attain communications security over the network. This includes both encryption in transit and storage encryption at rest.
 - Solid network practices should include either keeping the LRS internal to the local private network of the LRP or creating a secure tunnel between the two.
- When using xAPI and considering transport-level security (the security of the external interface of an LRS), the implementation strategy below will help to mitigate or prevent message interception, Man-in-the-Middle attacks, message/statement alteration at the time between LRP and LRS. The implementation strategy consists of:
 - Strong signing algorithm SHA-256
 - Strong key exchange (Elliptic-Curve Diffie-Hellman)

- HTTPS (For example, HSTS with long duration, including subdomains and preload directive).

4.5.3 Cybersecurity in xAPI References and Resources

The following sub-sections contain references and direct relevant text from those references that specifically relate to cybersecurity.

4.5.3.1 IEEE P7002

<https://standards.ieee.org/project/7002.html>

“This standard defines requirements for a systems/software engineering process for privacy-oriented considerations regarding products, services, and systems utilizing employee, customer or other external user's personal data.”

4.5.3.2 IEEE P7004

<https://standards.ieee.org/project/7004.html>

“This standard provides stakeholders with certifiable and responsible child and student data governance methodologies.”

4.5.3.3 IEEE P7004.1

https://standards.ieee.org/project/7004_1.html

“This recommended practice produces best practices for meeting the requirements of IEEE P7004: Standard for Child and Student Data Governance when designing, provisioning, configuring, operating, and maintaining an online virtual classroom experience for synchronous online learning, education, and training.”

4.5.3.4 IEEE P7005

<https://standards.ieee.org/standard/7005-2021.html>

“This standard defines specific methodologies to help employers in accessing, collecting, storing, utilizing, sharing, and destroying employee data.”

4.5.3.5 IEEE P7012

<https://standards.ieee.org/project/7012.html>

“The standard identifies/addresses the manner in which personal privacy terms are proffered and how they can be read and agreed to by machines.”

4.5.3.6 IEEE P9274.1.1

https://standards.ieee.org/project/9274_1_1.html

“This Standard 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).”

4.5.3.7 IEEE P9274.2

<https://sagroups.ieee.org/9274-2-1/>

“This Standard describes a JSON-LD format that defines concepts, templates and patterns of learner experience data.”

4.5.3.8 NIST Risk Management Framework (NIST)

<https://csrc.nist.gov/projects/risk-management>

“The NIST Risk Management Framework (RMF) provides a comprehensive, flexible, repeatable, and measurable 7-step process that any organization can use to manage information security and privacy risk for organizations and systems and links to a suite of NIST standards and guidelines to support implementation of risk management programs to meet the requirements of the Federal Information Security Modernization Act (FISMA).”

4.5.3.9 ADL Initiative xAPI Accreditation Guide

<https://adlnet.gov/projects/xapi-rmf-accreditation-project-xrap/>

“DoD cybersecurity policies state that any system that stores or transmits information must abide by certain cybersecurity requirements found under the RMF and codified in DoDI 8500.01. This project is evaluating current accreditation efforts for xAPI-enabled learning systems under RMF and developing guidance (e.g., suggested policy updates and Security Technical Implementation Guides or STIGs) to support xAPI-enabled system accreditation across DoD networks. The technical guidance produced under this project conforms to NIST guidelines and Defense Information Systems Agency accreditations required to deploy xAPI conformant solutions across the DoD.”

Hernandez, M., Neeley, M., Johnson, A., (2019). Cybersecurity Strategies for Accrediting Experience Application Programming Interface (xAPI). Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC).

5.0 cmi5

cmi5, which is not an acronym but rather a name that pays tribute to the historical “computer managed instruction” models, is the first and most basic xAPI Profile that is designed to update the current SCORM paradigm. While it technically is more than the xAPI Profile as defined by the xAPI Profile Specification, the concept of an xAPI Profile being additional rules and requirements is still true. These requirements are all centered around a learner’s interactions with learner content through an LMS. cmi5 cannot be implemented without xAPI. It is recommended for any LMS-based solution that both are implemented together.

5.1 Use Cases

The use cases in this document are organized to be simplistic and categorical, such that they can be building blocks for creating high quality acquisition language. In this way, a set of use cases can be used to

match as closely as possible to an organization’s requirements. Subsets of use cases will be listed under each use case section as a bullet.

The use cases for cmi5 include the different products (LMS, content, authoring tools) that would support cmi5 and different migration-based approaches that are likely to be encountered. These approaches are designed for cmi5 data in non-cmi5 systems, cmi5 without an LMS, and cmi5 with multiple LMS/LRS support.

Each use case in a subset will contain several format-specific or domain-specific high-level requirements. It will contain instructions on how the technology can meet those requirements and is a value proposition to the learning ecosystem.

In the subsequent sub-section under each use case, sample requirements definition language will be provided and will be structured to directly mirror the use cases. Every use case has corresponding sample requirements definition language. In this section, there will not be a one-to-one correlation and will instead focus on categories that are introduced, such as “if deploying a competency-based strategy.” At this time, no previously used contract language can be used, and thus will not be quoted.

As a key effort in cmi5 adoption and bridging the gap between SCORM and other pre-xAPI technology to xAPI, The ADL Initiative launched the [CATAPULT](#) effort. The software, open-source code, documentation, and course templates from that effort should be leveraged whenever possible.

5.1.1 Use Case #1 - cmi5 LMS Acquisition

An LMS performs many functions as a software system that includes many Web Services. The cmi5 specification only defines a few of these functions and is agnostic to the rest. This document will not describe the “shall” requirements in the cmi5 specification as they are captured in the specification and tested through the conformance test suite. Due to the critical nature of ensuring the test suite is run correctly, that contract language will be included in 5.1.2. The functions that the LMS is expected to perform within cmi5 are as follows:

- Content Launch Mechanism
- Authentication
- Session Management
- Reporting
- Course Structure

An LMS is typically the central hub of authenticated learner activity. As such, it ties into other services and capabilities. The LMS Administrator is a key role not considered in previous standards, such as SCORM. In many use cases, direct intervention of an LMS Administrator on behalf of a learner is necessary. Those interventions cannot break data implementations of standards. The following are LMS responsibilities that are not requirements of cmi5 but should be taken into account when considering cmi5 support:

- Use of Objectives and/or Sequencing - while much of competency-based education is beyond the scope of cmi5, the specification does support “tagging” in the course structure format. An LMS may wish to use this for integration. Similarly, if sequencing is a requirement, cmi5 does have a best practice for defining it that is much simpler than the version in SCORM. **Cmi5 conformance testing does NOT include sequencing for this version of cmi5 (Quartz).**

- Session and Progress Management - the LMS needs to be accountable for how URLs and session management are handled, particularly when the learner makes progress. In cmi5, the URLs in session management are handled through URLs and “moveOn” criteria.
- Mobile Support - an LMS providing mobile access can support cmi5.
- Authorization - the LMS needs to take all necessary steps to validate the actor. While there are multiple ways to do this, best practices have been found and are documented within cmi5 Working Group Resources ([see Section 5.3](#)).
- Customization - there are times when the criteria for success in a course/AU is different for various learners. This is accomplished through the use of Mastery Score.

5.1.1.1 Sample Requirements Definition Language

- An LMS shall be xAPI compliant as described by all requirements in [Section 4](#).
- An LMS shall pass the “cmi5 LMS Test Suite” within the overall CATAPULT conformance test suite software is available at <https://github.com/adlnet/CATAPULT> and as documented at <https://adlnet.github.io/CATAPULT/>. LMS Vendor shall supply logs of the completed test and should supply a live or recorded demonstration of the Test Suite passing. If an LMS is versioned or a different version is being acquired, the Vendor shall supply new logs and, if possible, demonstrations. This is not a significant technical burden as the process is largely scripted, and an LMS producing such a script once will likely see it completely reusable.
- If an integration is being pursued instead of a product, then the following language could be appropriate: “An LMS shall integrate with the CATAPULT Player Prototype by leveraging code within it to reduce time/effort of acquisition.”
- An LMS should meet as many of the “should” requirements as documented in the cmi5 specification (https://github.com/AICC/CMI-5_Spec_Current/blob/quartz/cmi5_spec.md) as possible. DoD Component should request documentation from the LMS Vendor regarding all such requirements, their product’s implementation or lack of implementation, and rationale.
- Unless a DoD Component finds an exception to its current and future sequencing requirements, an LMS shall implement the cmi5 Extensions as described at https://aicc.github.io/CMI-5_Spec_Current/extensions/. This currently includes “requires” and “collateralCredit” as supported extensions to a course structure format. This is critical because if an LMS doesn’t support the extension, content authors and tools cannot use them.
- An LMS should not attempt to correct bad data and instead reject the bad data in accordance with xAPI/cmi5 requirements.
- DoD Components should work with a product Vendor to ensure cmi5 Objective support aligns to any existing competency-based education or Competency Framework support, if applicable.
- An LMS shall implement the returnURL as described in the cmi5 specification.
- An LMS shall follow all “Fetch URL” in the cmi5 Best Practices, as follows (the two “should” requirements shall be followed unless a better solution is documented and agreed upon by DoD Component and Vendor):
 - “The Fetch URL must be unique for each session
 - The Fetch URL must only return an auth token on the first call. (Subsequent calls must return an error – i.e., it must be a “one time use” URL)
 - The Fetch URL must not reuse auth tokens

- The Fetch URL should return a 4xx HTTP error if an HTTP method other than POST is used
- Since the Fetch URL can only be called once, the auth token should be stored in non-volatile storage (see best practice “Persist AU Session State”)
- An LMS supporting mobile should consider one of the following options of cmi5 implementations when an AU is considered a mobile app.
 - Option 1: Use an app protocol in the launch URL.
 - AU is an app
 - AU has URL with a protocol. LMS launches App using URL with app protocol
 - An app redirecting to a browser is not useful. If using app protocol to launch, don’t use “returnURL”
 - Option 2: Use an HTML wrapper to launch the app. AU is an HTML page (wrapper) that directs from the mobile browser to the app
- An LMS shall reject Statements that do not conform to cmi5. Another way of describing this requirement is that if a Statement is attempting to be “cmi5-defined” per Section 7.1.3 of the cmi5 Specification and not following requirements of the specification, it shall be rejected. DoD Component and Contractor/Vendor should discuss the specific implementation details of fulfilling this requirement. This does not mean that Statements from other xAPI Profiles should be rejected, as these are examples of cmi5-allowed Statements. Statements considered “cmi5-not allowed” shall also not be rejected, and the DoD Component and Contractor/Vendor should have a strategy on how to handle/route those data. Unless a specific exception is granted by the DoD Component, an LMS shall not correct data from an AU in lieu of rejecting that data.
- An LMS shall support use of the “progressed” verb in support of the data requirement below:
 - “For recording progress during a session, it is recommended to use a cmi5 allowed statement with the progressed verb (<http://adlnet.gov/expapi/verbs/progressed>) and a progress extension in the result (see section 9.5.5.1 of specification). Progress statements should not be sent for progress value of 100% as that indicates completion. Once the learner reaches 100% it is recommended that a cmi5 defined “completed” statement be issued instead.”
- An LMS shall create satisfied Statements in the following way:
 - LMS creates a cmi5 “allowed” statement (with a satisfied verb) when an AU has met its moveOn criteria. The statement should also include the same AU activityId used in cmi5 defined statements.
- An LMS shall reject a Statement with an HTTP 403 if the Session ID, authorization token, actor in statement, and actor do not match. This verifies that the Actor in the statement matches the actor provided on the launch URL and that the authorization token provided was the same one issued for that specific launch session.
- An LMS shall not restrict access to querying the LRS for certain data. It may offer filters or configuration options but shall not hide LRS data from an authorized user who wants that data.

5.1.1.2 Sample Evaluation Criteria

The following criteria should be considered when considering a cmi5 system:

- The capability to integrate directly with CATAPULT for testing will establish a pipeline for continued checks on conformance.

- Open APIs that allow cmi5 if not directly supported (meaning not every LMS action needs to have a UI component)
- The capability to leverage Open APIs for other functions
- The system’s ability to leverage a version of LTI that allows integration with existing systems
- The ability to augment an existing system with CATAPULT could be a very large ROI and should be considered in solutions in addition to acquisition of full products

5.1.2 Use Case #2 - cmi5 Content Acquisition

The cmi5 specification creates a clean hand-off between content and system. Using xAPI alone has many challenges. There is no need to determine an LRP’s responsibility in cmi5 because the LMS handles the brokering by the specific way any cmi5 content, in the form of AUs, interacts with it.

Testing is extremely important in content acquisition. The cmi5 Test Suite provides the ability to launch cmi5 content packages, create logs of their conformance, as well as xAPI data generated. Data is also sent to an LRS in a more complete form. These tests are important, but end user tests within the end environment are also important. Usability testing does not currently have supporting software.

An AU developer often acts as the Subject Matter Expert and may implement such behaviors in that AU. AUs should be created diversely and with diverse xAPI data that goes beyond cmi5, as appropriate. As in xAPI, there are data properties that need to be adequately defined. cmi5 provides most of that definition. Lingering factors include lining up the Actor with the LMS account, creating unique identifiers for activities, and creating effective Statement ids and timestamps. Many of these requirements are specific in the cmi5 specification but are articulated here for importance and in alignment with the xAPI requirements.

An AU Developer will produce Content, which consists of both AUs and the Course Structure Format that accompanies the AUs, as well as their collective role as a Content Package.

The following requirements describe Content responsibilities:

- The Course Structure may use Objectives and/or Sequencing as dictated by requirements. While much of competency-based education is beyond the scope of cmi5, the specification does support “tagging” in the course structure format. Similarly, if sequencing is requirement, cmi5 does have a best practice for defining it that is much simpler than the version in SCORM. **Cmi5 conformance testing does NOT include sequencing for this version of cmi5 (Quartz).**
- The AU can respond to a mastery score issued by the LMS. This could be by design of the course as the AU author intended or could be from an LMS Administrator intervention.
- A Course Structure creator needs to specify moveOn criteria.
- An AU needs to handle when a returnUrl is not provided.
- An AU needs a reliable way to track progress through an xAPI Statement.
- An AU creating Statements should maximize their value and discoverability by connecting them to the registration.
- An AU needs to match cmi5-defined and cmi5-allowed Statements’ Actor properties to that in the launch URL, as an LMS will reject otherwise.
- An AU should use cmi.interactions (a part of the xAPI standard) in an interoperable way.

- An AU should be designed to preserve the state of the following operations that have been performed in the case where an operation may break the session when it was not intended.

5.1.2.1 Sample Requirements Definition Language

- Consider all requirements from [Section 4.1.2.1](#) where conflicts with cmi5 do not arise.
- Prior to content delivery, DoD Components and contractors shall use the CATAPULT Test Suite and provide logs of both the Statements generated and success/failure of the content. Analysis of the data sent to the LRS shall also be done to align to agreed-upon requirements, as appropriate.
- Prior to delivery, DoD Components and contractors will test cmi5 content in an environment as close as possible to the end-user environment (cmi5 LMS). If the end-user environment is not available for this purpose, then use the cmi5 Player, such as the open-source player provided by the ADL Initiative, to demonstrate the cmi5 courseware’s functionality.
- AUs act as the LRP and follow all rules within the cmi5 specification to achieve that role.
- AUs shall send Statements with ids that are globally unique. Contractors should work with DoD Components to determine a strategy for producing globally unique ids. This strategy should include base URIs that are organizationally specific and then ensuring uniqueness of the other URI components. AUs should not be performing lookup functions to determine statement id uniqueness.
- AUs shall send Statements with Activities with unique IRIs. Contractors should work with DoD Components to determine a strategy for producing globally unique IRIs. This strategy should include base IRIs that are organizationally specific and then ensuring uniqueness of the other IRI components.
- AUs shall send Statements with timestamps. In addition, these timestamp values should be in Universal Coordinated Time (UTC).
- AUs shall only create and send Statements with Actors that use the account/homepage mechanism for identification. Contractors should work with DoD Components to determine a strategy for supplying the correct Actor information based on authentication/permission to use the content. In addition, the homepage shall include a base URI that is specific to that DoD Component and under that DoD Component’s control.
 - “The “Actor” field should be traceable back to a learner’s DoD ID. The recommended solution is to use the DoD ID as the “Name” property under the Actor’s “Account” property.” (DoDI 1322.26)
- AUs creating and sending cmi5-allowed Statements or non-cmi5 Statements in an otherwise cmi5 solution should conform to Statement Templates of known and relevant xAPI Profiles whenever possible. Statement Templates can be found at <https://profiles.adlnet.gov/>.
- The Course Structure shall use Objectives and/or Sequencing as dictated by requirements. While much of competency-based education is beyond the scope of cmi5, the specification does support “tagging” in the course structure format. Similarly, if sequencing is requirement, cmi5 does have a best practice for defining it that is much simpler than the version in SCORM. **Cmi5 conformance testing does NOT include sequencing for this version of cmi5 (Quartz).**
- The AU shall respond to a mastery score issued by the LMS. This could be by design of the course as the AU author intended or could be from an LMS Administrator intervention.
- A Course Structure creator shall specify moveOn criteria.
- An AU shall handle when a returnUrl is not provided.

- An AU shall track progress through an xAPI Statement and should use the progressed verb.
- An AU creating Statements should maximize their value and discoverability by connecting them to the registration.
- An AU needs to match cmi5-defined and cmi5-allowed Statements' Actor properties to that in the launch URL, as an LMS will reject otherwise.
- An AU should use cmi.interactions (a part of the xAPI standard) in an interoperable way
- An AU should be designed to preserve the state of following operations that have been performed in the case where an operation may break the session when it was not intended.
- The DoD Component will, for the sake of this requirement, be considered the government project lead in the evaluation of this DoDI 1322.26 requirement - "Prior to developing a course, the vendor or government project lead shall determine which xAPI Profile(s) to use, as well as the associated vocabularies and roll-up rules that determine how the xAPI data will be aggregated to support assessment. Failure to adequately address data interoperability will lead to content that cannot be re-used."
- DoD Components will enforce this DoDI 1322.26 requirement: "Content repositories within the DoD shall be leveraged whenever possible to re-use existing content, whether it be for legacy deployment or modernization to new web standards. Critical to reuse is that DoD Components acquire source files and other software components for each acquisition in accordance with DoDI 5000.87, dated 2 October 2020."
- Statements should not be communicated to the LRS using Basic Authentication directly from a web-browser.
- LRS credentials and the xAPI payload should not be accessible by learners.

5.1.2.2 Sample Evaluation Criteria

The ideal content uses CATAPULT Templates for two purposes. First, for better interoperability and integration into cmi5 environments, and second, to reduce the cost of development and cost in legacy content conversion. Evaluations should be done on the overall ROI of the content, which will be significantly higher the more reuse occurs. Content is typically done as a service-based contract, so optimizing development time, cost, and capability will ultimately produce more content.

5.1.3 Use Case #3 - cmi5 Authoring Tool Acquisition

The same requirements of cmi5 Learning Content Acquisition apply to cmi5 Authoring Tools. The difference is that the expected output of an authoring tool is less likely to be modified (because there is an expectation that it is published in a final form) than a normal content acquisition. The nature of cmi5 is to produce courses, blocks, and AUs that are ready to be "plugged in" to cmi5 LMSs. Unlike with xAPI, cmi5 requirements are strict enough that authoring tool output will require modification or configuration to be ready for a cmi5 LMS.

Additional requirements beyond the cmi5 specification involve interoperability, functionality, and usability.

5.1.3.1 Sample Requirements Definition Language

“The solution must provide analytics capabilities with role-based dashboard and visualizations for different users throughout the enterprise.”

5.1.3.2 Sample Evaluation Criteria

Tools that automate should be transparent in what they are changing and provide an audit trail to understand it. Manual ability to insert xAPI/manual code is important as it allows experts to finely-tune. Coding should have real-time error checking of xAPI/cmi5 Statements.

5.1.4 Use Case #4 - cmi5 Profile Data Only Approach (Pre-LMS Acquisition)

cmi5 cannot be considered adopted without an LMS or LMS set of services in play. However, cmi5 does contain an xAPI Profile as a set of its requirements. These data requirements can be adhered to until an LMS is acquired.

5.1.4.1 Sample Requirements Definition Language

“The solution must provide analytics capabilities with role-based dashboard and visualizations for different users throughout the enterprise.”

5.1.4.2 Sample Evaluation Criteria

The most important evaluation criterion is determining if LRS data is xAPI and cmi5 compliant. Anything short of this criterion is failing the use case.

5.1.5 Use Case #5 - LRS Dashboards/Analytics

The primary purpose of acquiring an xAPI-based solution is to make informed decisions and to display data in meaningful ways. However, because of the modular nature of xAPI, these services are separate from the standard. While products in the legacy distributed learning era (e.g., LMS) relied on a specific integration, xAPI data is available as a part of the standard such that these components could be separate solutions. Some LRS products will include a baseline dashboards/analytics capability. It is recommended that those Services be considered separate from the other xAPI efforts and scored accordingly. A separate acquisition may be appropriate.

5.1.5.1 Sample Requirements Definition Language

- “The solution must provide analytics capabilities with role-based dashboard and visualizations for different users throughout the enterprise.”
- A cmi5 Dashboards or Analytics Capability shall allow configuration of xAPI Statement extensions such that those vocabulary can be used.
- A cmi5 Dashboards or Analytics Capability shall make a connection with the LRS that grants access to Statements based on permission.
- A cmi5 Dashboards or Analytics Capability should leverage role-based creation and viewing of dashboards. At a minimum, support senior leaders, instructors, subject-matter experts, instructional designers, and students.
- A cmi5 Dashboards or Analytics Capability should integrate with outside capabilities, such as leaderboards so that data can be aggregated even if not all explicitly stored in that LRS.

- A cmi5 Dashboards or Analytics Capability should facilitate the ability to create and discover linkages with the specific learning content the learner experiences.

5.1.5.2 Sample Evaluation Criteria

Evaluation Criteria for dashboards and analytics should focus on implementation of as many of the “should” requirements above as possible. Interfaces should be simple but produce the desired results. Use of the product should not require in-depth technical knowledge.

5.1.6 Use Case #6 - Multiple LRS/LMS Support

This use case doesn’t change pragmatically from [Section 4.1.6](#). The fact that one of the LRPs is now a cmi5 LMS doesn’t impact the requirements for multiple LRSs (even compliant LMSs that have compliant LRSs) to communicate with each other. No additional details from those provided in Section 4.1.6 are necessary for this use case at this time.

5.1.7 Use Case #7 – Integrated into Training Environment (Multiple Systems)

Solution with authorization across all components. It includes information technology intensive training systems, such as computer-aided and computer-based instruction, augmented and virtual reality training, and a full range of ground-based training systems (GBTS) up to full motion ICAO level seven simulators. The suite of tools will include capabilities for: issue resolution, electronic record keeping, program and performance management, asset management, maintenance management, supply management, configuration management, change management, and a Training Information Management System (TIMS).

5.1.7.1 Sample Requirements Definition Language

- “Contractor must provide a TIMS that meets the cmi5 specification (Quartz or most current)”
- “Asking for proof of cmi5 conformance be provided before Contract Award”
 - “LMS can pass the cmi5 [CATALPULT] Test suite”
 - “Content produced from LMS authoring capabilities passes cmi5 [CATALPULT] Test suite”
 - “CATAPULT content templates function within the LMS”
- The solution must allow for offline/internal network solutions
- “The solution must tailor checklists flexible enough to meet military requirements.”
- “The solution must allow the validation of competency by ‘testing-out’”
 - Can request that the implementation include simple sequencing, a cmi5 documented best practice
- “Video-based tracking has a lot of value for courseware design, and it was noted to ensure instructional designers incorporate the capability.
- Ensure an LRS capability is delivered, either integrated into the same product as the LMS or 3rd party connected.
- Responses to known Pain Points
 - “The solution has to eliminate web browser exposure of exam questions.”
 - “The solution has to reduce poor user experiences.”
 - “The solution has to allow custom/improved analytics compared to SCORM.”
 - “The solution has to allow having the ability to ID who is physically in a simulator.”
 - Conversion of legacy SCORM materials

5.1.7.2 Sample Evaluation Criteria

Evaluation Criteria for an entire training environment are going to be broad and not necessarily focused on cmi5 standards, but there are specifics that can be tracked and “scored.” In addition to hard requirements listed above, the implementation should be assessed on the following:

- “The evidence necessary when assessing the cmi5 requirement included assessing screenshots and supporting evidence describing how the requirement is met.”
- “Information Management/Information Technology (IM/IT) Pre-recorded demonstration”
- “The cmi5 approach used for content development and tracking of course objectives”
- Other benefits/additional points for scoring can include:
 - Course authoring integrated
 - Provide profiles to demonstrate how requirements are met
 - Direct output from LCMS and operate in LMS and send statement to the LRSs
 - Screenshots of logs
 - Number of verbs supported natively by LMS
 - xAPI authoring tools include xAPI profiles and cmi5 links
- “Requested provision of a System Architecture Document (SAD). Some of the evidence to look for in the SAD linked to cmi 5 requirements include:
 - Should describe LMS and LRS tools as well as linkage
 - Separate data visualization and analytics across entire system and individual courses
 - Number of verbs used
 - Number of xAPI profiles used
 - Using xAPI profiles in LMS
 - XAPI capability for simulators
 - LMS capable of tracking activities (AUs and supporting objects)
 - Question bank capability”

5.2 Related Policies and References

- DoDI 1322.26 - https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodi/132226_dodi_2017.pdf?ver=2017-10-05-073235-400
- DoDI 1322.26 Reference - <https://adlnet.gov/policy/fungible/>
- DoDI 8320.02 - https://irp.fas.org/doddir/dod/i8320_02.pdf
- cmi5 Working Group Page - https://aicc.github.io/CMI-5_Spec_Current/
- ADL Initiative’s cmi5 Page - <https://adlnet.gov/projects/cmi5-specification/>
- ADL Initiative’s Project CATAPULT (cmi5 Player and Test Suite) Page - <https://adlnet.gov/projects/cmi5-CATAPULT/>
- cmi5 Content Player, Test Suite, and Templates - <https://github.com/catapult-project/catapult>
- SCORM vs. cmi5 Comparison (by cmi5 Working Group) - http://aicc.github.io/CMI-5_Spec_Current/SCORM/
- cmi5 as SCORM Replacement Article - <http://risc-inc.com/next-generation-scorm-cmi5/>
- cmi5 Working Group / Landing Page - http://aicc.github.io/CMI-5_Spec_Current/
- cmi5 Overview - <https://adlnet.gov/resources/cmi5-resources/>

- cmi5 Code Library - <https://github.com/adlnet/cmi5-Client-Library>
- cmi5 Adopters List - https://aicc.github.io/CMI-5_Spec_Current/adoption/
- cmi5 Best Practices - https://aicc.github.io/CMI-5_Spec_Current/best_practices/
- cmi5 Worst Practices - https://aicc.github.io/CMI-5_Spec_Current/mistakes/
- cmi5 Code Library - https://aicc.github.io/CMI-5_Spec_Current/client/
- cmi5 Sample Statements - https://aicc.github.io/CMI-5_Spec_Current/samples/
- cmi5 Runtime Example video - <https://www.youtube.com/watch?v=nhJRIDNE96Q>
- cmi5 Process Flow - <https://risc-inc.com/cmi5-overview-process-flow/>
- AU Flow - https://aicc.github.io/CMI-5_Spec_Current/flows/au-flow.html
- LMS Flow - https://aicc.github.io/CMI-5_Spec_Current/flows/lms-flow.html

5.3 Recommended Best Practices

- The cmi5 Working Group has documented best practices at https://aicc.github.io/CMI-5_Spec_Current/best_practices/ - many of these were used in the use cases and sample requirements definition language.
- Until an equivalent cmi5 Adopters website to the xAPI Adopters website can be stood-up, the best known list of cmi5 Adopters can be found at https://aicc.github.io/CMI-5_Spec_Current/adoption/. DoD Components should consider this a starting point if searching out cmi5 Products and Services.
- DoD Components considering migration from SCORM should look at the following analysis: https://aicc.github.io/CMI-5_Spec_Current/SCORM/

5.4 Pitfalls to Avoid

- cmi5, like many standards, is based on data management and not on data security. It is expected that data security best practices change faster than data standards. Conformance testing for cmi5 may require certain security to pass tests, but it doesn't mean other security protocols or controls cannot be implemented.
- Basic Auth is not being used as a username/password encoding scheme in cmi5. Basic Auth (RFC 7235) was selected because it was the most widely used scheme at the time the xAPI was created. Basic Auth is used to provide a temporary "authorization" to the LRS (not authentication to the LRS). Authentication to the LRS is expected to be managed by the LMS or some other mechanism. With cmi5, a Basic Auth token is used in the HTTP header of xAPI requests made by the Learning Activity. Actual learner authentication is outside the scope of cmi5.
- "LMS" is used in cmi5 to differentiate between the system responsibilities that it has that are different from an LRS. It is very likely the same product would act as both an LMS and an LRS. The only characteristics that make a product an LMS in the view of the cmi5 specification are those that are documented as requirements. A minimal set of services may be needed to accomplish this, even to the point where it may not look like a traditional LMS.
- The "TinCan" packaging and other mentions of "TinCan" are not substitutes for xAPI or cmi5. TinCan was the early name given to the xAPI Specification before it was documented on GitHub. Protocols were created to ensure it was possible. Some of those tech pieces were picked up by

Vendors and put into products. Learn more about these differences at https://aicc.github.io/CMI-5_Spec_Current/tinca/.

5.5 Cybersecurity

Cybersecurity for cmi5 follows the xAPI cybersecurity restrictions in [Section 4.5](#). While other cmi5 profiles are not likely to introduce additional requirements, cmi5 is a special case in that its launch mechanism and authorization protocols must be met. As The ADL Initiative Research and Development team facilitates the cmi5 Player and Test Suite through cybersecurity processes, any issues that go beyond xAPI will be discovered and documented.

Note that while cmi5 does impose authorization requirements, it does not impose authentication requirements. Authentication of a user to a system is a prerequisite to using cmi5 and its launch and authorization. As the use of the cmi5 Player and Test Suite increases across DoD, additional cybersecurity measures will be reported in future versions of this document.

6.0 LEARNING METADATA

Historically, guidance for metadata within the DoD has been sparse. Legacy documents refer to the documentation of items within software architectures, which doesn't serve the distributed learning paradigm well. Distributed learning guidance simply pointed to the use of SCORM to solve metadata problems. SCORM was one of the few standards that proscribed certain mandatory and optional properties.

Due to the mandatory/optional nature of metadata specifications and standards, being conformant to such a standard can become trivial (e.g., implementing zero of the optional properties). However, forced conformance can become more damaging as many metadata creators did a poor job aligning metadata to content or simply put the required data in the fields as a gate to simply "check the box" for the standard. Some of this "box checking" was justified as some of the mandatory properties in SCORM were simply not useful for DoD use cases.

With these constraints in mind, an IEEE Working Group was formed in 2020 with the purpose of creating a metadata standard that could provide value to the DoD, such that every property was designed with a purpose of aligning to a specific DoD use case. The draft standard P2881 doesn't refer specifically to courses or lessons, rather declares different scopes for Learning Objects, which, in the draft standard are Learning Resources and Learning Events. The distinction between the two will be described as necessary later in the document. For the purposes of this document, ALL such content is generically described unless a particular scope is provided. The current draft of the P2881 that can be located at <https://opensource.ieee.org/lmt>. As DoD-specific P2881 application profiles are created, future versions of this document will spell out their specific data requirements, such as "this property shall be populated with one of the following values: *value a*, *value b*, or *value c*."

Metadata implementations have historically relied on "records" of metadata, which traditionally were XML-based documents that contained all properties of that learning object and itself had an identifier. Current practices consist of another option that uses a graph-based structure with references such that every learning object, property, and values of properties are all in the same space and can cross-reference as a "web." This document recommends the use of a graph structure for metadata, and many properties

will function much more effectively and efficiently with its use. However, the guidance can be applied to both solutions.

6.1 Use Case

This document contains only a single, large use case. The rationale is that the use case of tagging content for metadata will fulfill a variety of use cases and that properties themselves are no longer mandatory/optional but rather mandatory if certain functions are desired. Thus, all sample contracting language will be written in an “if/then” format. For example, if a Learning Object is to be discoverable via a text search, then use of the “keywords” property of P2881 is necessary.

When considering a metadata tagging strategy, a key question becomes, “at what level of granularity should the DoD Component use when tagging a Learning Object with metadata?” In SCORM, these were typically asset, Shareable Content Object (SCO), which was akin to a “lesson”, and the full course (content package). Assets are much more useful if a Learning Content Management System (LCMS) is used that already provides support to course creators in management of these objects for future creation. It is important to understand that a course is not simply the sum of its parts. Decontextualizing Learning Objects at the lesson level may not be as simple as removing them from a course as standalone. Take these into consideration when evaluating metadata use cases, as this document will not recommend a “one size fits all” approach.

As competency-based education and the use of competencies increases to provide time and cost savings to DoD by optimizing time-on-task and other human performance measures, the alignment to Learning Resources and Learning Events cannot be understated. Regardless of the level of hierarchy, it should strongly be considered to tag any level of Learning Object that itself teaches or assesses a competency (see below for details).

6.1.1 Use Case #1 - Tagging Learning Content

This use case brings together a great number of reasons to “tag” content (populating metadata properties) and a description of how to use the P2881 standard and application profiles to execute that process. There are two primary roles that this use case serves: a) a learner or system on behalf of a learner trying to match a learning opportunity to that learner and b) an instructional designer, developer, or curriculum manager looking for a Learning Object for the sake of locating and deploying/reusing it toward an eventual end user.

Sample requirements definition language in the sub-section can be used to adequately provide the requirements and supply the “if/then” language. Bullets in the language will correspond to the bullets in this section. The “if” in each of these bullets is to be considered the condition for ALL sentences/requirements within that bullet.

- Learning Objects are intended to be uniquely referred to both within and outside of the DoD Component. Whether this is a key in a database or a point on a graph, a unique and resolvable identifier is needed.
- Many tools use a basic matching algorithm to locate Learning Objects. The user interface for these basic searches uses a single text box to capture search terms. Algorithms include different weights for different properties that are matched. An adequate number of properties to describe the resource generically are necessary.

- A user of a search-based tool will need to process the search results and have those results be structured in an understandable way. This is often the name of the Learning Object with some descriptive text. Often, a UI will allow the user to click a link to more information (metadata), but curation by the user often uses basic information to decide which to obtain more information about.
- Further curation is required at the next “layer” down of information. This is where the user decides if the learning object is “right” for them based on additional relevant properties.
- Classification of Learning Objects by a subject area is a valuable way to adequately enable systems that understand their relevance. Using these classifications provides valuable context within the systems they are deployed within and often aligns to Competency Frameworks.
- Learning Objects are sometimes created for a specific audience. This can be a classification of people or a generic description of whom the Learning Object is intended to serve. Whether it is a system that looks for a match of users to this classification or information the user gets to self-assess the Learning Object’s audience to themselves, using this property can meet the use case.
- While Learning Objects can be created for an audience, sometimes a particular geographical or regional context is required for intended use of that Learning Object. A property that allows a freeform expression of these contexts, which may or not be integrated with another service that adequately defines them, is necessary to meet this use case.
- Almost every Learning Object will have an audio or text component that has a particular language in which it is being delivered. A property is necessary to capture this language such that they or a system can make an informed decision whether it is appropriate for them or not.
- Learning Objects, by their nature, are associated with learning. Using a property for determining the education level (likely specific to the community of practice that uses it) or instructional method can be a difference-maker in connecting learners to Learning Objects.
- One reason that a single use case can accommodate so many requirements is the notion that a Learning Object can be tagged for its intended purpose using P2881 that wasn’t previously used. By determining as a core concept whether a Learning Object is intended to be a Learning Resources (a strategic learning component intended to be shared and reused) or a Learning Event (deployed learning instance that requires resourcing (e.g., instructors, seat licenses)), significant adjustments can be made to the UI/UX that a supporting system provides. By simply enabling this core concept, user flows can be specifically directed to meet their intended purpose of finding that Learning Object.
- Another core principle in defining a set of metadata properties is that when different properties are applied to Learning Objects, they behave very differently based on their native type. For example, a duration of a video is its run-time, but an online instructor-led course could be measured in weeks. In previous standards, these were lumped together in a single property, and it was left to a system to disambiguate. By defining a specific “type” to a Learning Object, communities of practice can establish properties that are important as an application profile.
 - Learning Objects should have both a component for duration and a time required. Duration is considered a more exact measure of contiguous time, whereas time required considers factors such as schedule. For example, a 6-week course that meets for an hour each week would have a duration of 6 hours but would require 6 weeks.

- In a very similar way, extensibility is a very important part of metadata. Metadata should not be considered non-conformant if it has additional properties. By allowing extensibility through “types,” all use cases can be met simply by defining the Learning Object as a unique type.
- Learning Objects are, unsurprisingly, designed with Learning outcomes in mind that can often be associated with gaining a competency. What makes a competency is beyond the scope of this standard’s guidance. However, Learning Objects are often performing formative and summative exercises and evaluations. Not all Learning Objects do both (e.g., not all Learning Objects are courses, nor do they all both teach the content and evaluate the learner’s progress in that content). It is important that Learning Objects can specify competencies that are both taught by the Learning Object and those that are assessed by it.
- When a system uses role-based permission, there may be the need to restrict availability more deliberately by specific persons, groups, or labels. A property that allows the control of availability of that Learning Object only to authorized individuals is an important property.
- Understanding who owns and who offers Learning Objects will enable effective connections to opportunities based on a learner’s permissions and affiliations.
- For both previous properties that have to do with availability, it does not mean that the metadata drives the system, nor does it mean that the system populates the metadata. However, one of these should be the case. To put it another way, the system is likely the manager of searches that would display based on availability. The metadata can either reflect what the system “knows”, or those records can be changed by authorized individuals, which effectively sets their permission as the system will “read” those records.
- To facilitate a ledger of versions of a Learning Object, keeping track of the revisions is extremely important. By keeping track of a previous and next version of Learning Objects within metadata, the most recent version can then serve to update all the previous versions, with all versions then “knowing” they are the latest. The value of this property does rely on either an LCMS capability to populate it on publication and/or the ability for the URI of metadata of the Learning Object to report/be subscribed to.
- A Learning Object could change drastically in that it wouldn’t be considered simply another version. It could also be (legally) shared and then be changed by a different author, such that they would call it their own derived work. Properties that enable an audit trail, like versioning are important to understand how much re-use has occurred and to allow derived works to “subscribe” to a version of a Learning Object that itself could be updated. For example, a course is freely shared and re-skinned, and the assessment is changed, becoming a derivation. However, the original version of the course is updated by the original author due to the updated doctrine. The DoD Component that acquired that course would appreciate knowing about that update and potentially using the new version. Properties that allow both the knowledge of what the Learning Object derives into and where it was derived from enable this function.
- At times, multiple forms of a Learning Object exist that have a common origin. However, these forms aren’t derivations as they aren’t necessarily drastic changes; they may just be different representations of that same Learning Object. Examples could be different formats of the same source material. In these cases, it isn’t so much of keeping track of a list of versions but rather just the originating source material. Properties that allow forward and backward relationships between the source material and the representations will allow ample notifications and reporting.

- Learning Events often will be temporal in nature and, therefore, have a location, start date, end date, and possibly even an associated schedule. By keeping track of time and place, integrations with a learner’s constraints can be an effective search mechanism. In addition, some Learning Events will have an associated instructor.

6.1.1.1 Sample Requirements Definition Language

- Learning Objects must be tagged according to the requirements in this document. All properties used shall conform to the P2881 metadata standard. The contractor shall work with the DoD Component to ensure all Learning Objects have a globally unique identifier that is also a URI. These URIs should include a “base” controlled by the DoD Component or a persistent URL that resolves to a DoD Component controlled web domain.
- Unless a specific exception is made by the DoD Component on a per Learning Object basis, every Learning Object shall be tagged with a title, description, and keywords. Each of these properties is unique in P2881. In the absence of these specific names of properties, substitutes may be used. The contractor shall work with the DoD Component to determine if keywords are separate entities in a graph model/XML tag or can be considered a single string and which solution is optimal for the DoD Component learning ecosystem.
- Do not design metadata around specific coding bindings (like XML); instead, define subject-predicate-object type relationships as seen in semantic web environments, and design toward each entity (subject or object) existing one time and data pointing to that entity.
- For systems facilitating Learning Object search, discovery, acquisition, and services, an algorithm shall be developed that meets a DoD Component’s needs for optimized searches. Search results shall be constructed in a meaningful way to the user and empower them to choose based on available metadata. Systems should take as many steps as securely possible to connect the user to the Learning Object (e.g., for download or content registration).
- Systems shall enable a UI that will allow the user to obtain all relevant metadata fields (P2881 and extensions) to make an informed choice.
 - System shall provide controls for the user and use contextual information to determine if a user is searching for an available learning opportunity (instantiation) vs. a static resource (learning resource)
- If supported and/or desired by the DoD Component, Learning Objects shall be classified in accordance with a standard catalog of subject areas made available by the DoD Component and captured in the “subject” (or equivalent) property. This catalog MAY include a Competency Framework for reference to determine the “subject” property values such that they are properly populated.
- If supported and/or desired by the DoD Component, Learning Objects shall be tagged to specific audiences provided by the DoD Component. The Contractor shall work with the DoD Component to determine if a classification of people or a generic description of whom the Learning Object is intended to serve is more appropriate.
- If supported and/or desired by the DoD Component, Learning Objects shall be tagged to specific geographical or regional context required for intended use of that Learning Object. DoD Component will determine whether the Contractor or DoD Component is more qualified to provide this context. The Contractor shall work with the DoD Component to determine if

freeform expression of these contexts, or an integration with another service that adequately defines context, is more appropriate.

- Unless the DoD Component makes a specific exception, on a per Learning Object basis, every Learning Object shall be tagged with a language property. This language property shall be populated with values from ISO standards as referenced in the P2881 Learning Metadata standard.
- For each Learning Object, it shall be determined whether it is intended to be a Learning Resource (downloadable/reusable component or large) or a Learning Event (deployed learning instance that requires resourcing (e.g., instructors, seat licenses)) and the “scope” property (or equivalent) is populated with the corresponding restricted vocabulary term. This requirement is non-negotiable for compliance. If it is determined that a Learning Object is of more than one scope, it SHOULD be created as two distinct Learning Objects, one of each scope. For systems facilitating Learning Object search, discovery, acquisition, and services, the Contractor shall work with the DoD Component to determine the impact on UI/UX based on scope type and user intentions/role. For almost all use cases, users should not see results from multiple scopes in the same search (e.g., they are looking for content for re-use, content for deployment, or a learning opportunity and not multiple of these simultaneously).
- Unless the DoD Component makes a specific exception, on a per Learning Object basis, every Learning Object shall be tagged with a “learningObjectType” property (or equivalent). There are very few exceptions that would allow a Learning Object to be completely typeless. The Contractor shall work with DoD Components to apply properties to the specific types of Learning Object in accordance with DoD Component requirements that are not part of the P2881 base model as represented in this document. Whenever possible, P2881 application profiles should be used for the corresponding type when populating additional metadata properties. In the absence of profiles, DoD Component(s) should establish important properties as requirements (which essentially becomes a profile).
- If done in accordance with the P2881 standard, Learning Objects that use additional properties should not be penalized or considered non-conformant. Extensions should be realized using Learning Object types whenever possible.
- If supported and/or desired by the DoD Component, Learning Objects shall be tagged to specific competencies provided by the DoD Component. DoD Components should provide a competency framework/mapping to the Contractor. A competency must be uniquely defined. A competency should use a URI as a unique identifier. A competency should have a representation obtained through the resolution of that URI. That representation is beyond the scope of this standard’s guidance. Contractors should work closely with DoD Components to actualize competency-based alignment from resources to competencies to fit the DoD Component strategy. Learning Objects shall use both the “teaches” and “assesses” properties and adequately populate those properties in accordance with the alignment to which competencies are taught/assessed by the Learning Object. The same competencies are often taught and assessed using the same Learning Object.
- If supported and/or desired by the DoD Component, Learning Objects shall be tagged to an audience that corresponds to those to DoD Component personnel. DoD Components will provide specific integration points or system roles (providing a directory of individuals is not recommended) to the Contractor.

- For that controlled access and for systems facilitating Learning Object search, discovery, acquisition, and services, the Contractor shall work with the DoD Component to determine if the system permissions are used to populate the metadata, whether the metadata is used to inform the system permissions, or if consistency is met through another means.
- Unless the DoD Component makes a specific exception, on a per Learning Object basis, every Learning Object shall be tagged with properties that indicate the “previous revision,” if applicable. Similarly, Learning Objects that have been versioned/revised shall have metadata revisited to populate the “next reversion” (now that it is known). Contractors and DoD Components shall agree upon and document conditions for what a revision is defined as. For systems facilitating Learning Object search, discovery, acquisition, and services, the contractor shall work with the DoD Component to determine if the value of this property does rely on either a LCMS capability to populate it on publication or not. The values of these properties should be the identifier of the referenced Learning Object. Systems are highly encouraged to implement the ability for the URI of metadata of the Learning Object to report/be subscribed to and provide adequate support.
- Unless the DoD Component makes a specific exception, on a per Learning Object basis, every Learning Object that is a derivation or has derivations that come from it shall be tagged with properties that indicate where it was derived from, if applicable. Similarly, Learning Objects that have been derivations shall have metadata revisited to populate which Learning Objects they were derived to (now that it is known). Contractors and DoD Components will agree upon and document conditions for what a derivation is defined as. DoD Components should determine processes by which other DoD Components can share back derivations from their Learning Objects. DoD Components acquiring shared Learning Objects and then making their own modifications should consider it a derivation. For systems facilitating Learning Object search, discovery, acquisition, and services, contractor shall work with the DoD Component to determine if the property’s value relies on either an LCMS capability to populate it on publication or not. The values of derivation properties should be the identifier of the referenced Learning Object. Systems are highly encouraged to implement the ability for the URI of metadata of the Learning Object to report/be subscribed to and provide adequate support.
- Unless the DoD Component makes a specific exception, on a per Learning Object basis, every Learning Object that has different representations shall be tagged with properties that indicate its original pre-representation/publication, if applicable. Similarly, Learning Objects that have been newly represented/published shall have metadata that point back to Objects from which they originated. Not all DoD Components will have Learning Objects with a single representation that becomes multiple. Contractors and DoD Components will agree upon and document, conditions for representations and how they relate to different published formats. For systems facilitating Learning Object search, discovery, acquisition, and services, contractor shall work with the DoD Component to determine if the property’s value relies on either an LCMS capability to populate it on publication or not. The values of representation properties should be the identifier of the referenced Learning Object. Systems are highly encouraged to implement the ability for the URI of metadata of the Learning Object to report/be subscribed to and provide adequate support.

6.1.1.2 Sample Evaluation Criteria

- Evaluation criteria for individual tagging of Learning Objects should simply be a checklist of the if/then style bullets in Section 6.1.1.1 or the LMT draft standard properties. As the end “product” is either a metadata record or a Learning Object in a graph with all corresponding properties mapped, this becomes simply a yes/no evaluation for each property desired by the DoD Component.
- Although not required in the LMT standard itself, this document considers some of the properties in the P2881 as mandatory. It is recommended that DoD Components take these seriously and heavily penalize non-compliance. DoD Components should create explicit requirements for exceptions.
- Extensibility is key for metadata. The more features and flexibility a tool have in creating / graphing additional properties, particularly from other existing metadata standards, and in supporting multiple Learning Object “types” (as application profiles), the better.

6.2 Related Policies and References

With the emergence of TLA Specifications and Standards, most related policies and references will be historical. These historical documents are valuable as they provide the context of what the old paradigm was and how different the new one is. The Working Group approved the P2881 standard as of November 2023, so the standard should be through balloting in early 2024. Metadata standards that influenced and/or that are referenced by P2881 are listed below. The Enterprise Course Catalog (ECC) effort is one that seeks to align content repositories across the DoD to this emerging standard.

- DoDI 1322.26 - https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodi/132226_dodi_2017.pdf?ver=2017-10-05-073235-400
- DoDI 1322.26 Reference - <https://adlnet.gov/policy/fungible/>
- DoDI 8320.02 - https://irp.fas.org/doddir/dod/i8320_02.pdf
- ADL Initiative P2881 Article - <https://adlnet.gov/news/2021/05/28/P2881-and-the-Harmonization-of-Learning-Metadata/>
- IEEE P2881 Page - <https://standards.ieee.org/ieee/2881/10248/>
- IEEE Learning Object Metadata - <https://standards.ieee.org/ieee/1484.12.1/7699/>
- Learning Resource Metadata Initiative (LRMI) - <https://www.dublincore.org/about/lrmi/>
- Dublin Core Metadata Initiative (DCMI) - <https://www.dublincore.org/about/>
- ADL Initiative ‘s Enterprise Course Catalog Page - <https://adlnet.gov/projects/ecc/>
- MIL-HDBK – 29612 Parts 1-5 - No links provided. Only historical value.
- Shareable Content Object Reference Model (SCORM) - <https://adlnet.gov/projects/scorm/>
(Multiple versions – these SCORM documents define the legacy approach to metadata in great technical detail)
- SCORM 1.2 - https://adlnet.gov/assets/uploads/SCORM_1_2_pdf.zip
- SCORM 2004 3rd Edition - <https://adlnet.gov/assets/uploads/SCORM.2004.3ED.DocSuite.zip>
- SCORM 2004 4th Edition - https://adlnet.gov/assets/uploads/SCORM_2004_4ED_v1_1_Doc_Suite.zip

6.3 Recommended Best Practices

- Determine a DoD Component strategy for creating identifiers. This will allow the effective creation of metadata and linking between versions and across derivative works and publications.
- Some properties, if not used, leave the intended meaning ambiguous. DoD Components should determine vocabularies for some properties, such as audience, to ensure the different values are understood by both humans and machines.
- If more detailed publication metadata is needed, it is recommended that the DoD Component document this use case well and share it with the rest of the DoD Community.

6.4 Pitfalls to Avoid

Never populate a metadata property simply to put something in the property. While a lack of data could be problematic or incomplete, “junk data” is worse. This data is anything supplied to simply pass a technology requirement and has no value added.

6.5 Cybersecurity

Metadata in the P2881 standard doesn’t necessitate any additional risks as the standard is only a data model. Effective data management policies should be followed, and processes executed regardless of the data. As P2881 describes learning activities and not individuals, there should not be any Personally Identifiable Information associated with metadata. However, some learning activities could be classified to a higher security level, so data associated with the learning activities should also be considered sensitive and potentially need to have restricted access.

Depending on the implementation of any metadata standard, whether through traditional metadata records or semantic web technology like graphs, there will be technical safeguarding that needs to take place. Those recommendations are beyond the scope of this document.

7.0 CONCLUSION / FUTURE VERSIONS

By leveraging completed acquisitions, sharing language and best practices, and both successes and failures, DoD capabilities will thrive as TLA standards are adopted and those products and services acquired through acquisition processes. This guidance is written in accordance with the DoDI 1322.26 as of 15 December 2023 and all referenced standards and profiles of those standards in their current forms and with current best practices. As standards mature, more best practices are defined, and additional successful acquisitions can be analyzed to produce more successful acquisition language, this document will be updated.

8.0 APPENDIX A: NEXT STEPS AFTER XAPI IMPLEMENTATION

8.1 Introduction:

Consider this document a snapshot of a roadmap, which is at a certain state. Two important milestones to DoD Modernization and implementation of the Total Learning Architecture (TLA) set of standards are the implementation of an LRS to track learner progress in courses and creating a list of competencies. A list of competencies is any form of organizational data as related to personal performance and expectations. These include but are not limited to knowledge, skills, abilities, tasks, duties, jobs, outcomes, or objectives. Given achievement of this state, the following steps are recommended for the near, intermediate, and longer terms. All DoD Components are recommended to seek solutions to get to the state of having an LRS and define, at some level, their organizational competencies and then continue on this roadmap.

If the language below, especially with regard to Statements, is not descriptive enough, please refer to the [cmi5 specification](#), particularly the Document Style Conventions, to determine the requirements from the shorthand below.

8.2 Additional Terms (see [Glossary](#) for others):

Competency and Skills System (CaSS) – An open-source competency management software resource. It provides an infrastructure enabling competencies, competency frameworks, and competency-based learner models to be managed and accessed independent of any given learning management system, course, training program, or credential.

Enterprise Competency and Credentialing System (ECCR) – An instance of CaSS modified for DoD use and stood up at the Enterprise level within a DoD environment. 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.

8.3 Near-Term:

With a list of competencies defined and the ability to generate xAPI data at the “item level” (a question on an exam, for example), the next focus should be on aligning xAPI data to competencies to allow for rich data analysis. The steps to achieve this can be taken immediately and will not require additional products, but will take some development efforts:

- 1) Create URIs for each of the competency “definitions” (a competency definition is the actual data structure of how a competency is defined/described using competency standards like the IEEE Shareable Competency Definition, 1484.20.3(SCD)). These URIs should begin with the organization URL (e.g., <https://adlnet.gov>) and **must be unique**.
 - a. These URIs will eventually resolve to the entire text data of the competency definition, so care must be taken **if** these URIs are to be protected. They can always redirect to a secure location if needed.
 - b. Data about each of the competency definitions should be stored in a table or graph database that references each uniquely using this URI.
- 2) Obtain a copy of the SCD to understand the other data requirements of that standard.
- 3) Create/structure the rest of the data about each competency through the competency definition in a table/graph.
 - a. A competencyStatement is required

- b. Name, description, typeLabel, resourceAssociations, and Rubrics are recommended (more on resourceAssociations and Rubrics below). There are other possible properties. See the SCD for other properties)
 - c. resourceAssociations are technically data objects but can be implemented simply as references to LearningResources at this time. Wait until Step 4 is completed before returning here.
 - d. Rubrics are technically data objects, but at this time, simply text describing how exactly the rubric works will be sufficient at this time. This will eventually map to properties of the rubric. The rubric **must include BOTH how the competency is taught AND how it is assessed.**
 - i. Rubrics also would need to consider if there are specific prerequisites to achieving a competency, such as another competency, credential, or learning resource that must be taken first.
- 4) Create URIs for each of the Learning Resources (a Learning Resource is anything that either teaches or assesses one or more competencies) that will be associated with each of the competency definitions. These URIs should begin with the organization URL (e.g., <https://adlnet.gov>) and **must be unique.**
- a. These URIs should eventually resolve to metadata about the learning resource, so these URIs are to be protected. They can always redirect to a secure location if needed.
 - b. If a learning resource is an active course already known by the LRS, continue to use that “activityId” as the Learning Resource id, provided it is unique, and the domain is under that organization’s control; otherwise, reconstruct/redefine those ids.
 - c. Learning Resources can be created (an id creation is sufficient) at the course, activity, assessment, or item level. The **minimum target is course, assessment, and assessment items.**
 - d. Data about each of the learning resources should be defined and stored in a table or graph database that references each uniquely using this URI.
 - i. This data should follow the P2881 Learning Metadata Terms Standard (available for free at <https://opensource.ieee.org/lmt>).
 - ii. Focus should be only on populating a minimal set but **must include teaches and assesses, each of which link to the specific competencies (via the URIs that they either provide instruction on or perform assessment of – some resources may do both)**
 - iii. Separate guidance will be issued about other properties in other guiding documents, such as [Appendix B](#).
- 5) Return to the Competency database
- a. Populate the resourceAssociations with links to ids of all applicable Learning Resources
 - b. Verify that the rubric, either directly or through adequate description, refers to how the specific Learning Resources teach or assess any differences between options, possibly including effectiveness data.
- 6) Instrument xAPI Statements according to xAPI Profiles. This document will proscribe specific profiles in future updates.
- a. Add a reference to the learning resources as the Object>activityId if they are not already populated.

- b. Add context category id to xAPI Statements corresponding to the competency alignments that both the Learning Resource references in teaches/assesses and the Competency references in resourceAssociations.
 - c. Define in the Moodle Logstore, an event that corresponds to competency readiness. A corresponding xAPI Statement should be issued when Learning Resources that “teach” the relevant competencies have been achieved.
 - i. Specifically, when a Learning Activity is completed, if the set of those that correspond to competencies being taught in the competency rubric is met, then send this Statement with the Object activityId as the competency id.
 - ii. This can be simplified at first to simply send this for any corresponding activity
 - iii. Statement refs to “completion” statements of relevant Learning Resources can be used as context
 - d. Define in the Moodle Logstore, an event that corresponds to competency achievement. A corresponding xAPI Statement should be issued when Learning Resources that “assesses” the relevant competencies have been achieved.
 - i. Specifically, when a Learning Activity is completed, if the set of those that correspond to competencies being assessed in the competency rubric is met, then send this Statement with the Object activityId as the competency id.
 - ii. This can be simplified at first to simply send this for any corresponding set of assessment items meeting an adequate level, likely corresponding to a “passed” status (via Statement(s)) for that set of assessment items.
 - iii. If such a Statement isn’t generated about a set of assessment items that correspond to a competency, consider creating one.
 - iv. Statement refs to “passed” statements of relevant Learning Resources can be used as context
 - v. Consider adding an “expiration date” as a context/result extension or possibly a decay function.
- 7) Instrument Dashboards/Visualizations that leverage this new data
- a. Create a Dashboard that can show an individual all available competencies and which they have actively gained and where they are weaker.
 - b. Create a Dashboard that shows an individual how “ready” they are for examinations.
 - c. Consider sending notifications for exams they are “ready” for
 - d. Create a Dashboard that shows a competency and how frequently it is found across all learners/relevant learners.
 - e. Create a Dashboard that shows “readiness” across all learners/relevant learners.

8.4 Intermediate Term (~6 Months):

With the capabilities of Competencies, xAPI data, and Learning Resources defined, consider the following steps to add further value. Technology acquisition of ECCR/CaSS is required (both CaSS and ECCR use the same underlying system) as is a cmi5 LMS/plugin)

- 1) Create a Competency Framework for the entire Organization. While the competency definitions were created in a table and aligned with resources, there are still many data relationships that have not been captured yet. Follow the SCD for implementation details.
 - a. Leverage CaSS/ECCR to create a competency framework using its User Interface.

- b. Add the Competency Objects (CaSS/ECCR should be able to import the spreadsheet) to the Framework
 - i. It may or may not be fruitful to reference the created competency framework for all competencies in the spreadsheet prior to import.
 - c. Create alignments between the Competency Objects in CaSS/ECCR
 - i. Specifically, define relationships for membership, requirements, and “partitive” (e.g., hasPart). See SCD for details.
- 2) Create additional competency frameworks for each job/credential offered. Follow instructions for #1, but constrain the competencies to only those relevant to the job/credential.
- 3) Migrate Non-course resources, such as policy, into the LMS such that xAPI can track data about those resources that may not have previously sent xAPI data.
 - a. Depending on how deep the integration, instrument xAPI on either the link to the resource or within the resource itself.
 - b. Consider adding a “time on task” event to the Moodle Logstore that triggers when someone has spent a certain amount of “active time” in a resource (Moodle Logstore modification processes will be added in a future version of this document)
- 4) Instrument a cmi5 solution in the LMS. There are no step-by-step instructions for this capability. ADL Initiative has created a cmi5 Plug-in for Moodle, which is available in the Moodle Plug-in Store. There are cmi5 conformant LMSs, and others may be influenced to do so. The cmi5 specification (https://aicc.github.io/CMI-5_Spec_Current/) /standard (IEEE 9274.3.1) has all necessary details for an LMS to implement.
 - a. cmi5 is critical as it will allow authored courses and other materials to send xAPI Statements without customized Moodle Logstore events and from **within activities**. Logstore events are important for in-LMS functions, but distinct types of Learning Activities will need to be able to send data relevant to them. cmi5 “grounds” content in a session and opens the gate to easy creation of xAPI Statements sent from the content as opposed to the LMS.
- 5) Expand the use of P2881 Metadata. See [Appendix B](#) for details.
- 6) Register Competencies in the Enterprise Competency and Credential Registry. More details on how to register competencies across the DoD using this capability will be made available in future updates to this document.
- 7) Register Learning Resources (at the course level) in the Enterprise Course Catalog. More details on how to register courses across the DoD using this capability will be made available in future updates to this document.

8.5 Long-Term (1+ Years):

This section is in progress and will be updated in 2024.

cmi5 content creation via supported authoring tools and templates is the highest priority. The necessary influence on vendor products and acquisition of a supporting LMS/plugin pushes this out but does not undermine its importance.

The notion of a Learner Profile via the Enterprise Learner Record IEEE P2997 (ELR) standard will also be coming online.

9.0 APPENDIX B: METADATA CREATION PROCESS FOR COURSES (FOLLOWING THE P2881 DRAFT STANDARD AND P2881 COURSE PROFILE DRAFT SPECIFICATION)

At the core of optimizing digital learning for human performance is the ability to search, discover, curate, align, re-engineer, and perform many other functions across many roles related to digital objects. The data description of those digital learning objects, in this case, courses, is critical to leveraging technology to perform any of these operations. This guide provides guidance on creation of the data, known as metadata.

9.1 Disclaimer:

This is a guide to filling out metadata based on the construct of courses. It is not authoritative in any way, merely a suggestion on how to adequately separate members in an organization that likely have the best access and knowledge of certain properties or data about the course and the time of the product lifecycle where that could be created and validated. There are plenty of reasons why adjustments to the guidance here would be appropriate, and organizations should implement their optimal workflow, considering the rationale for this guide's suggestions.

9.2 Metadata in the TLA:

Metadata has a key role in the Advanced Distributed Learning (ADL) Initiative's [Total Learning Architecture \(TLA\)](#). Metadata is used to connect TLA systems together and unite the data in a way that can achieve optimization of talent management from the perspective of the individual learner to the entire DoD Component. Metadata is expected to exist within or referenced by xAPI Statements in the form of Activities. Coupled with learner performance, this effectively becomes paradata. These Activities are established contextually in a hierarchy such that data from the lower levels rolls up into higher aggregations. Additionally, metadata is used to establish a key linkage with Competencies. By establishing metadata within competency frameworks, the key question of "How does a person gain a competency?" can be answered by directing them to activities via metadata. Finally, Learner Profile data is highly influenced by the availability of Learning Activities regarding goal setting and career planning. As opportunities are discoverable through the Enterprise Course Catalog and through recommender systems, the key to this discoverability is metadata. Future considerations of the TLA Metadata will include alignment to Data Item Descriptions (DIDs).

9.3 Course Context:

All courses to be described will take on two basic forms. The first is a collection of files or links that make up a collection that can be distributed across systems. These are Learning Resources. Learning Resources take on the form of entire courses, course sections, or single activities, **provided the intention is to share and reuse them**. The second is a Learning Event, which is an instance of Learning Resource that has applied context to it that makes it appear on a **schedule**. Time and resource constraints make a Learning Resource an **opportunity...basically, if you could "miss the opportunity," it is a Learning Event**.

In this narrative, a course will be described from conceptualization to the creation of a content package, then to how it is deployed to multiple systems and across multiple classes. It will be versioned and eventually retired.

With this context, the types of things that will be described are all courses and their subcomponents but also will be LearningResources and LearningEvents. To maintain consistency and narrative form in how these courses and the course components will be described, there will be courses and course offerings, corresponding to LearningResources and LearningEvents. The subcomponents of a course will follow similar patterns for course sections and course section offerings and, finally, activities and activity offerings. Activities, as the lowest level of granularity (assets can certainly be shared using P2881 but are not part of the course profile), are intentionally generic but could have an additional “type” applied to them and have additional properties defined or certain properties populated more specifically. This does not affect whether it is an activity or activity offering; it would be another additional type.

9.4 Competencies:

Competencies are described here only in minor detail. Competencies are data objects that exist in a framework that corresponds to a knowledge, skill, ability, or attitude (KSA) that could be earned by an individual. The TLA looks at them as the “common currency” of learner achievement. In the DoD Environments, the term Competency hasn’t arrived as the replacement to other terms or concepts. In particular, Terminal Learning Objectives (TLOs) and Enabling Learning Objectives (ELOs) are most common. In addition, the term Competency as one of hundreds or more of organizational KSA is not yet agreed upon. Competencies often refer to higher-order skills, such as Leadership, that aren’t necessarily gained knowledge components or easily measured in data.

9.5 Metadata “Records”:

The long-term plan for the notion of metadata “records” to go away. The notions that properties sit in an excel sheet on a desktop or as separate XML files are outdated compared to web-best practices. Ideally, metadata “lives” online so that it can be crawled by machines and used to optimize web services that leverage it. It also makes updating all members involved in lifecycle management a possibility, the push vs. pull problem of metadata records never being solved.

Until such entries can all be placed online, this document will recognize that the storage space for many of these values until someone can formalize that record will likely be some sort of table that is shared across the team. This record will likely be partially entered into the User Interfaces of software services (such as a content repository or LMS). In a truly modernized environment, these properties would all be populated by the correct person during the correct phase such that everyone could access it instantly in the same location, with the web services pulling data from that location and always being updated.

9.6 Roles and Responsibilities:

It is quite possible that a single person takes on multiple roles in the lifecycle of learning resources and events.

Subject Matter Expert (SME): provides domain expertise to ISD, supporting the development of tasks, KSAs, competencies, etc. May provide expertise through focus groups, interviews, surveys, and/or other data collection approaches deemed appropriate by the ISD. Vets and provides feedback on content developed by the ISD and implemented by the Course Developer periodically throughout the development, implementation, and Evaluation cycles. Because a SME is typically more expensive, often a “data dump” will come from a SME and be verified often throughout the process.

Instructional Designer (ISD): Elicits (or receives as GFI) learning requirements. Develops artifacts that are instructionally sound and align to the competency to which they are building learning resources. Develop instructions and details of how all the materials form a cohesive activity/course section/course. The ISD is familiar with all their developed learning resources. **ISDs will do the “chunking” of the data provided by the SME.** Develops artifacts that are instructionally sound and align to the competency to which they are building Learning Resources. Subject Matter experts will provide a series of instructions and details of how all the materials form a cohesive activity/course section/course.

Course Developer (Dev): Uses tools and/or code to create the final technical product that is the Learning Resource. Receives all instructions from the ISD and processes them as an engineer in the desired medium. As the Course Developer takes direction directly from the ISD, any metadata that the Course Developer may populate comes directly from the ISD.

Product Manager (PM): At the organizational level, manages all of the developed Learning Resources and sets guidance and policy around them. Manages the processes of periodic updates to courses, revisions, competencies, and competency frameworks. Included in the PM are Courseware Managers (CMs) that potentially work in a subset of the curriculum.

Learning Management System Administrator of the Developing Organization (SA-DO): The SA-DO is distinguished from that of a receiving organization as the SA-DO will have access to information directly from the PM and can interface with other staff members. The SA-D is responsible for placing all courses within a Learning Management System and setting up the classes that go with deploying the courses.

Learning Management System Administrator of the Benefiting Organization (SA-BO): The SA-BO receives learning resources that it didn't create but is free to place them on their own organization's system. The SA-BO is responsible for placing all courses within a Learning Management System and setting up the classes that go with deploying the courses.

Instructor: Instructors in the context of this document are considered extensions of the System Administrators. They work to provide the SA-DO or SA-BO with the information they need to populate metadata so that it functions correctly in the LMS. Some instructors have advanced permissions that let them act similarly to an SA-DO/SA-BO in their own courses. In this case, consider the Instructor the equivalent role.

Credentialed Body (CB): The credentialing body manages the processes and people with regard to who earns specific credentials and the processes by which that happens. The CB creates and maintains the organization's competency framework and the mapping to the specific products that individuals of that organization would take to potentially gain those competencies.

Training Effectiveness Evaluators (TEE): TEEs determine how an individual is performing in the field and, therefore, how effective training for that individual was by using a Training Effectiveness Evaluation. Could simply be a Supervisor. This is often simply the person monitoring the day-to-day operations of the trained person and not necessarily any specific role – it is more about the evaluation than the evaluator. The evaluation is frequently used to determine if a training system is 'effective' - this can evaluate any level of the Kirkpatrick model, looking specifically at:

- Reaction - learner liked it
- Learning – learner passed training assessments
- Behavior – transfer - changes seen on the job)

- Results - behaviors on the job lead to expected real world outcomes

9.7 Using the Table:

Courses vs. Course Section vs. Activity: Some properties will only occur at the course level or have different roles/timing/instructions based on whether it is a course, course section, or activity. These have been updated as of December 2023 to the P2881 LMT Draft Standard that will go to ballot in IEEE.

Phases: The timing of the application and validation of each process will be done in concert with the phases of the ADDIE model, as well as lifecycle management. These phases are summarized below:

- **Analysis (Pre-Acquisition)** – Analysis is a process to determine the need for a learning resource based on the current state of available learning resources. Analysis occurs before a contract/acquisition to develop a learning resource is created.
- **Design (During Acquisition)** – Design is the strategy for creating a learning resource that includes prototyping, key decision points, and understanding of learner, environment, medium, etc.
- **Develop (During Acquisition)** – The translation of the design into the creation of actual materials that are the learning resources.
- **Implementation (Post-Acquisition)** – The deployment of the learning resources. This is where courses are shared to others as well as turned into course offerings on systems. It includes all usage of these courses and course offerings.
- **Evaluation (Post-Acquisition)** – Feedback is collected and analyzed for process improvements, necessary maintenance, deprecation, and other lifecycle events, including creation of new learning resources.

Additional values of processes can take place outside of the ADDIE process. These include:

- **Revision** – There is a necessary revision of the course or course component that is occurring. Offerings do not have revisions.
- **Derivation** – In the case where something new is created from an existing course or course component. This includes when another organization takes a copy and modifies it as their own.
- **Discontinued** – The course or course component will no longer be supported.

9.8 Table:

The table will be found following the page breaks and is expanded to the whole width of this document as it is quite wide. It may be more effective to copy the table to an excel document for better readability. The table combines both P2881 LMT entries and P2881 Course Profile entries and does not distinguish between the two.

Name	Role of Creator	Timing of Application	Instructions	Validation Process	Timing of Validation
508compliant	ISD	Development	The ISD indicates if the course or course component is compliant with 508 accessibility rules or not.	PM confirms this prior to deployment, if necessary.	Implementation
accreditationAudience	PM	Analysis	Audience of persons that would seek accreditation.	SA-DO or SA-BO can verify the restrictions are in place in the LMS.	Implementation
accreditationId	PM	Analysis	Done at the course level but may be inherited down to components and offerings. If a specific accreditation is linked to this course, the id (could be a langstring if necessary) is provided. If this property is not populated, it can be assumed there is no known accreditation.	SA-DO or SA-BO can verify the any LMS-based rules around accreditation are followed for the relevant id.	Implementation
assesses	PM- Course, SME- Others	Course - Analysis, Others - Design	A course is to be built to a specific set of competencies that it assesses as determined by the PM. The SME will inform which content is used to assess which competencies. Often, a different activity type will be used for assessment in the case where the teaching and assessing are not in the same structure/opportunity.	ISDs evaluate with TEEs how the performance in the course corresponds to performance on the job and if the competencies are correct. Findings go to the PM and CB for final validation.	Course - Analysis, Others - Evaluation
audience	PM	Analysis	The PM decides which audience this is suitable for, likely driven by jobs that require or want this competency. Each of these "audiences" is a type of Agent that uniquely exists within an organization.	PM verifies the data is correct and that the Agent objects are well-defined. ISDs may work with PMs to add additional audiences.	Implementation
costFree	PM	Analysis	The PM of an organization will be able to adequately tag whether the course / component / offering is completely free, provided access is provisioned. This should work in conjunction with useRightsURL but is a "summary" boolean indicating if there is free access.	SA-DO / SA-BO will enforce / allow access to the course / component / offering based on this property's value.	Implementation

courseID	PM	Analysis	A unique ID within the context of the organization that corresponds to some sort of naming scheme within the organization. It is possible that it is the same as the "id" property, but likely, organizations will identify a need and give the course a "catalog entry" type of id for internal use. This is not necessary for course components but could be relevant for course offerings. In the case of offerings, it is assumed this is automated.	ISD verifies that ID is used throughout the course.	Implementation
dataEndpoint	Dev	Development	Text that provides a specific URL and explanation of how data may be collected to/from the course / component / offering. The Dev should be aware of these data dependencies in general.	SA-DO / SA-BO can verify the data is available to/from the system referenced in the endpoint.	Implementation
dateExpired	PM	Discontinued	The PM will tag a course or component as it expires with the date.	The SA-DO pr SA-BO may verify a course has not expired before deployment.	Implementation
datePublished	PM	Implementation	The PM puts the final "stamp" on the finished course and gives it a published date. Managing the components could be done in accordance with the course release or independently. Offerings do not have their own publication dates.	None	None
deliveryMode	PM	Analysis	Identifies the types of modes that the content may be delivered in. A course should be considered an aggregate of the delivery modes of the learning activities within it. PMs should dictate the requirements of the course, and the ISD finalize the course and course components. These should be drawn from known vocabularies.	ISD verifies both course and course components (another ISD or PM could peer review if one ISD designed the deliveryMode).	Development
description	SME	Design	While a course may have a description that serves as the backbone of the design, the	ISD verifies that the course description is suitable for end users.	Implementation

			description to serve end users of the course and course offering should be re-crafted by the SME.		
duration	ISD	Development	ISO 8601 duration DD:HH:MM:SS. It is suggested that a course duration is additive from its course components. The ISD should have access to all of these and make the calculations.	PM can verify if the intention of the course / component was to be of a certain duration.	Implementation
educationLevel	PM	Analysis	The PM decides before the course is created which level of education that it is intended for. Organizations should define such levels and map accordingly.	None	None
endDate	SA-DO / SA-BO	Implementation	A course offering, particularly one with a live component, often has a particular start and end date. Sometimes this is not public information and relates to organizational cycles.	None	None
eventSchedule	SA-DO / SA-BO	Implementation	Course offerings with any sort of live or synchronous support component will keep some sort of schedule. From a data perspective, there are scheduled "objects" with specific formats, so this property should reference one of those and not attempt to create one in text.	None	None
expiredBy	PM	Discontinued	The PM will put the person or organization that decided the course would expire.	None	None
format	ISD	Development	Provide for each course and component the MIME type of the file(s).	For a course only, the PM/SA-DO will validate the course format. Otherwise, no higher validation is required.	Implementation
hasAdaptation	PM	Derivation	Once an adaptation/derivation of the course or course component is created (not relevant for offerings), this property will provide the id of that adaptation.	If the adaptation goes across organization, the PM from the other organization can validate the relationship of this and the previous course or course component.	Derivation

hasEvent	SA-DO	Implementation	When a course or course component is to become an offering, that offering is a new object that this property of the original points to.	PM verifies the data is correct and that inherited properties were done correctly.	Implementation
hasFormat	PM	Publication	As a part of the publication process, all other formats that are the same content will set this property equal to the original course or course components. To be clear, each published different format has a different id.	The PM should also validate the mirroring property on the other course/course component using isFormatOf.	Publication
hasPart	ISD	Development	After course components are created, all resources a lower level (in terms of aggregation) are listed under the higher-level course or course section.	The ISD should also validate the mirroring property on the other courses/course components using isPartOf.	Development
hasVersion	PM	Versioning	As a part of the versioning process, after the new version is created, the previous course or course component lists the new/next version's id in this property.	The PM should also validate the mirroring property on the other course/course component using isVersionOf.	Versioning
id	Dev	Development	A unique ID that uses an organization-based identifier that is also unique will be required for any course or course component that needs to be described. This id should be a globally unique URL that resolves to metadata.	ISD verifies that IDs follow a schema and resolve to what is organizationally appropriate.	Implementation
instructionalMethod	ISD	Design	ISDs can "tag" the course / course component with one or more instructional methods that apply to it. This may be a restricted choice based on organization but is otherwise open. The use of an identifier rather than simply words is recommended such that the method can be further explained.	None	None
instructor	SA-DO / SA-BO	Implementation	At the time an offering is created, if there is an instructor or equivalent, this field is populated. Ideally, this is an Agent object reference / URL to	None	None

			all necessary information about that instructor.		
interactivityLevel	PM	Analysis	The degree of interactivity characterizing the learning experience. Interactivity, in this context, refers to the degree to which the learner can influence the aspect or behavior of the learning experience. Recommended values are integers 1-5, which scale as very low, low, medium, high, and very high. These are equivalent to IMI levels in DoD circles. The PM will set these requirements, and then the ISD will build to them and will be verified again by the PM.	ISD/PM	Development/Implementation
isAdaptationOf	PM	Derivation	Once an adaptation/derivation of the course or course component is created (not relevant for offerings), this property will provide the id of the source of the adaptation.	If the adaptation goes across the organization, the PM from the other organization can validate the relationship of this and the previous course or course component.	Derivation
isEventOf	SA-DO	Implementation	When a course or course component is to become an offering, that offering is a new object and populates this property with the id of the corresponding course or course component.	PM verifies the data is correct and that inherited properties were done correctly.	Implementation
isPartOf	ISD	Development	After course components are created, all resources a lower level (in terms of aggregation) are tagged with the id of the higher-level course or course section. It is also possible that a course itself is part of something "higher," like a credential or degree.	The ISD should also validate the mirroring property on the other course/course component using hasPart.	Development
isVersionOf	PM	Versioning	As a part of the versioning process, after the new version is created, the new course or course component lists references the id of the older using this property.	The PM should also validate the mirroring property on the other course/course component using hasVersion.	Versioning
keywords	SME	Design	The SME should create a list of key concepts that are	The Dev can check back with the SME to make	Development

			effectively implemented by the Dev using one concept per keyword entry. They may wish to include simpler terms and synonyms as well to improve searchability.	sure the new entries are not created erroneously.	
language	ISD	Design	The ISD will determine the language used in this resource. It is defined as the primary language necessary to experience the resource. Do not tag a course or course component just because a small section has a language portion.	None	None
learningOutcomes	SME	Analysis	The learning outcomes should be considered a text summary of all of the possible opportunities the learner has. In some ways, this is a header to all of the competencies that will be taught/assessed. It may be required that the competencies are specifically described in this text.	ISD can verify they are in-line with the expectations of the organization.	Design
learningResourceType	ISD	Design	The entire course will be tagged as a course type, course sections as course section type, and activities as any type of activity that they are. These should be concepts eventually, but it is understandable if they are simply strings until referenceable vocabulary can be agreed upon.	The PM may wish to validate each learning resource type prior to providing this to either the SA-DO or SA-BO.	Implementation
location	SA-DO / SA-BO	Implementation	Location of which this takes place. If a static URL is available for the course/component/offering, depending on the system, the administrator populates this property.	None	None
maximumAttendance	SA-DO / SA-BO	Implementation	Course offerings may have a cap on the number of people, even for asynchronous sessions or those without instructors. Seat licenses are an example. The SA-DO or SA-BO will set this limit.	None	None

offeredBy	ISD	Development	For a course or course component, the property should be assumed to be for the organization the development is for by the ISD. The ISD will likely not be involved in the offering metadata. For an offering, this could be changed, particularly if provided to many organizations. The intention of this property is for each offering.	The SA-DO/SA-BO may also verify this prior to deployment/import onto a system before an instructor might create a course with it. The SA-DO and SA-BO should verify that all offerings have this populated correctly.	Implementation
ownedBy	PM	Analysis	The PM is, in almost all cases, a member of the organization that owns the course or component. The owner doesn't change based on the offering, as the purpose is to say who actually owns the content. If a free derivation is made, they become the new owner.	The SA-DO may verify this prior to deployment to ensure traceability and credit due is in place.	Implementation
prerequisiteCompetency	PM- Course, SME- Others	Course - Analysis, Others - Design	Before taking this course or course component, or an offering of it (course is aggregate in this case), there may be competencies that are required. This likely comes from a Competency Framework but may exist independently. The PM will likely set the requirement at the course level, but the SME will enact at the component level.	SA-DO and SA-BO will verify that logical "blockers" exist prior to deployment in the systems that should constrain the learner.	Implementation
prerequisiteLearningResource	PM- Course, SME- Others	Course - Analysis, Others - Design	Before taking this course or course component, or an offering of it (course is aggregate in this case), there may be specific Learning Resource (in the context of this table – a course, component, or offering) that are required. It is recommended to use prerequisiteCompetency instead as many Learning Resources can satisfy such a requirement, but this property is considered additive (all prerequisites must be met). The PM will likely set the requirement at the course	SA-DO and SA-BO will verify that logical "blockers" exist prior to deployment in the systems that should constrain the learner.	Implementation

			level, but the SME will enact at the component level.		
prerequisites	PM	Analysis	Before taking this course or course component, or an offering of it (course is aggregate in this case), there are specific prerequisites that are either complex or not in data format. This supplies a text or URL that describes them. The PM will set these requirements.	SA-DO and SA-BO will verify that logical "blockers" exist prior to deployment in the systems that should constrain the learner.	Implementation
publisher	PM	Analysis	The PM will understand the publisher information and ensure it is populated as such by default as it is produced. The publisher doesn't change based on the offering, as the purpose is to say who actually published/produced the content. Changing the content could cause the publisher to change, it is up to the organization to decide which magnitude of change suggests a new publisher.	The SA-DO may verify this prior to deployment to ensure traceability and credit due are in place.	Implementation
registrationEndDate (offering only)	SA-DO / SA-BO	Implementation	A course offering is often accompanied by a registration. Many times, registration is instantaneous and always open, but in the cases where it is limited, this field should be populated with the date that registration closes. It may populate even if the registration is closed.	None	None
registrationStartDate (offering only)	SA-DO / SA-BO	Implementation	A course offering is often accompanied by a registration. Many times, registration is instantaneous and always open, but in the cases where it is limited, this field should be populated with the date that registration opens. The date may be in the past relative to the current date or populated after the registration is closed.	None	None
reportingRequirements	PM	Analysis	URL or text that explains how the overall course or offering gets rolled up and reported in a	SA-DO or SA-BO will verify before deployed that the offerings align	Implementation

			chain of information. Could include something like a course certificate description. This is known by the PM in the Analysis phase.	with these reporting requirements.	
safetyFactors	PM	Analysis	The PM should articulate specific safety factors that are overarching factors to consider independent of learned competencies necessary for this course / component / offering. These should be considered independently of any "prerequisite" type of property.D.	ISD should verify in the Design phase that no factors were missed.	Design
spatial	ISD	Design	If there is a geographic region or named place that is important to the audience or contextualization of the resource, then the ISD should consider it. Usually, use of spatial will be part of a larger organizational strategy and the options will be known.	PM verifies the data is correct and that the "spaces" are organizationally defined or approved.	Implementation
startDate	SA-DO / SA-BO	Implementation	A course offering, particularly one with a live component, often has a particular start and end date. Sometimes, this is not public information and relates to organizational cycles.	None	None
subject	ISD	Design	The subject should be aligned with an existing taxonomy or vocabulary of existing subjects. Subject should not be the same as competency alignments; it is intended to be broader and ideally conceptual. Text descriptions are not recommended. Usually, use of subject will be part of a larger organizational strategy and the options will be known.	PM verifies the data is correct and that the "subject" is organizationally defined or approved.	Implementation
subjectGradeLevel	SME	Design	The intended grade level of the subject matter follows the scale of K-12, 16, 20, 24. The ISD should be aware of the requirements.	PM will ensure that the level is adequate for the end audience and deployment.	Implementation
subjectReadingLevel	SME	Design	the intended reading level of any of the written material in the course / component.	PM will ensure that the level is adequate for the	Implementation

			Values correspond to grade. The ISD should be aware of the requirements.	end audience and deployment.	
syllabus (offering only)	SA-DO / SA-BO	Implementation	At the time an offering is created, if there is an instructor or equivalent, this field is populated. This is not the syllabus itself, but rather a URL to it as management of its content likely falls to a person not in the metadata workflow.	None	None
teaches	PM- Course, SME- Others	Course - Analysis, Others - Design	A course is to be built to a specific set of competencies that it teaches as determined by the PM. The SME will inform which content is used to teach which competencies.	ISDs evaluate with TEEs how the performance in the course corresponds to performance on the job and if the competencies are correct. Findings go to the PM and CB for final validation.	Course - Analysis, Others - Evaluation
technicalRequirements	SME/ISD	Design	The technical requirements can be a URL or free text that describes all technical requirements of the course. This could be conceptualized in an organization that tightly defines technical requirements, but in that case, specific vocabulary around those requirements (facilities, for example) would likely function more effectively. Includes any equipment required and any location requirement. The course will be an aggregate of its components in this case. Could include extra requirements in the case of an offering.	Dev will also be aware of some requirements and can validate them to some extent. Lots of back-and-forth is likely necessary to populate this property. SA-DO/SA-BO will add for course offerings.	Development
temporal	ISD	Design	If there is a specific, often named, time period for which this course or component is valid, then the ISD should consider it. Usually, use of spatial will be part of a larger organizational strategy and the options will be known.	PM verifies the data is correct and that the "time periods" are organizationally defined or approved.	Implementation
thumbnail	SME	Design	A URL to an image representative of the course or course component. Useful to	PM will verify the graphic is appropriate	Implementation

			display to the end user to distinguish it when curating search results.	for the organization and course.	
timeRequired	ISD	Development	Approximate or typical time it usually takes to work with or through the content of this work for the typical or target audience. The ISD should generally be aware of the circumstances the course will be used and be able to populate this property. An example of how this would vary from duration would be a self-paced course vs. one that meets with an instructor.	SA-DO/SA-BO likely overwrites this based on the offering and/or deployment.	Implementation
title	SME	Design	While a course may have a title that was given prior to design, the SME may finalize it and will certainly title the course components more adequately. The intention is to serve end users of the course and course offering, which the ISD will validate.	ISD verifies that the course title is suitable for end users.	Implementation
useRightsURL	SA-DO / SA-BO	Implementation	Every organization should have a document that outlines the conditions under which its resources are available. This should include role-based usage. The SA-DO / SA-BO will be most aware of this policy and be able to link to it.	None	None

9.9 Instructions:

Some validation-based entries in the table have a value of “None.” This does not mean validation is unnecessary; rather that, it is done by the same role. A workflow may have ISDs validate each other, or even a superior validates all work of other roles.

Not every property is to be considered mandatory in this table. An organization will provide such requirements. The table indicates Metadata should be populated at the relevant time, provided an organization finds value in it. Not every organization will use every property. Data should not be forced but should also be considered for shareability even if the implementing organization will not use it.

While typically the ADDIE process is more about the instructional design component, this document doesn’t distinguish it from organizational and possibly acquisition-based processes. The PM is the role that is directly involved with any sort of organizational policy enforcement or knowledge of the contractual requirements of acquisitions. In many cases, the PM and team will agree upon these properties prior to the ISD being involved or at least being handed the project.

Implementation is also intentionally inclusive of courses, course components, and offerings and lumps them together as the periods just before the resources are “live” and when they are actually “live.” In this way, once something is out of development and in the hands of the PM or the System Administrators (SA-DO and SA-BO) it will be considered implementation as it can “go-live” as soon as those roles are ready. Going “live” is likely the way a Learning Event is created from a Learning Resource.

9.10 Specifics of P2881:

At the time of publication, there was an open-source draft standard, named Learning Metadata Terms, approved by the IEEE P2881 Working Group to go to IEEE for standardization. It was used in this document and is referred to as “P2881 Core”. Definitions were not provided in this document, rather just general instructions. To effectively implement (moving from just a record to use within systems), leverage the standards as they become available. See below for more details on the P2881 specifications and standards.

P2881 Core:

The repository where the draft standard can be found is at <https://opensource.ieee.org/lmt>

Note that whether metadata applies to a Learning Resource or Learning Event (or both) is shown in the “Domain Includes.” It is quite often that a Learning Event will simply inherit from the Learning Resource.

For all P2881 metadata, any “thing” is either of the class Learning Resource or Learning Event, never both. BUT it will also be a member of other classes, such as Course, Assessment, Simulation, etc., and may be a class of **multiple** types. In addition, there is a learningResourceType property that is meant to aid “Class” assignment.

For the purposes of initial metadata creation, do not focus on all the “learningResourceTypes” the Learning Object could be – try to stick to simply course, course section, and activity.

P2881 Course Profile:

At this time, the xAPI Course Profile is very raw in nature and is not ready for distribution as the definitions have not been fully built. The current properties are listed in the table are the extent to which these have been defined and have not been through the alignment or creation process that the P2881 core has. This document will be updated as the profile is matured, and feedback is collected.

Paradata, potentially part of the P2881 Course Profile.

Paradata being stored and retrieved as metadata is inevitable. Knowing data about how the course was used is valuable and impacts user decisions. One key area to consider is how properties like these will be updated. Ideally, a real-time calculation is done, but many metadata systems will not support that, and for any record-based metadata, paradata updates are going to be very tenuous.

The properties below are being considered initially:

Rating – likely need to determine the nature of ratings and what this means.

Comments – An aggregate of comments captured.

Number of Ratings

Number of Comments

Instructor Rating

Number of Instructor Ratings

Number of Completions for this course

Average score for this course

Completion Rate for this course

Paradata is currently not part of either the LMT or P2881 Course Profile but is expected to be used by Communities of Practice, ideally in an additional P2881 Profile.

9.11 Conclusion:

This document is an early draft and is intended to shape organizational strategies with emerging metadata standards that focus on solving specific use cases. Feedback is welcomed, as is participation in collaborative efforts that expand these standards or create additional application profiles of them.