TOTAL LEARNING ARCHITECTURE

2021 Update - TLA Functional Requirements Document

Prepared by
The ADL Initiative

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14. ABSTRACT

This document covers the objective end-state for Department of Defense (DoD) learning organizations migrating to Total Learning Architecture (TLA) compliant data and microservices. This document is issued as a 2021 update to a 2019 version. Comments and feedback on all TLA documentation is encouraged and updates will be made to each document as the TLA matures. As the tools, technologies, and methodologies used in the future learning ecosystem change, TLA artifacts will be updated accordingly.

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1.0 SCOPE

1.1 Identification

This document covers the objective end-state for Department of Defense (DoD) learning organizations migrating to Total Learning Architecture (TLA) compliant data and microservices. This document is issued as a 2021 update to a 2019 version. Comments and feedback on all TLA documentation is encouraged and updates will be made to each document as the TLA matures. As the tools, technologies, and methodologies used in the future learning ecosystem change, TLA artifacts will be updated accordingly.

1.2 System Overview

The human capital supply chain is a complex network of systems with inherent challenges to accommodating TLA operability. Even within a single organization, the specific composition and arrangement of learning technologies will differ and change over time. This becomes a greater issue when looking across several organizations. The capabilities desired for a DoD learning ecosystem come not from individual components or databases, but from the enterprise-level collection, dissemination, and analysis that support the planning and controlling of human capital accession, including education and training.

The TLA defines a set of policies, specifications, business rules, and standards for enabling this enterprise level learning ecosystem. It is designed to benefit from modern computing technologies, such as cloud-based deployments, microservices, and high Quality of Service (QoS) messaging services. TLA standards help organize the learning-related data required to support lifelong learning and enable defense-wide interoperability across DoD learning tools, products, and data. Business rules and governance strategies enable the management of these data across connected systems. The TLA relies on common data standards and exposed data interfaces to enable a wide range of functions. This abstracts away any dependencies on a single component and enables these functions to be performed by any connected component.

The TLA Data Strategy provides a common set data standards and technical specifications designed to be implemented across DoD's education and training community. This overarching strategy ensures that all data resources are designed in a way that they can be used, shared, and moved efficiently across the organization. The ADL Initiative is working with the Institute of Electrical and Electronics Engineers (IEEE), an internationally recognized standards-development organization, to formally establish the data standards required for successful TLA implementation. While these standards will continue to evolve, DoD education and training communities are urged to adopt and employ them now. These commercial standards describe the data within the four pillars of the TLA Data Strategy.

As a policy driven architecture, the TLA data pillars do not require any mandatory components. There are only required behaviors, organized into functional groups around each data pillar. The TLA data pillars must be exposed through common interfaces, asynchronous services, and standard data formats for communicating and storing data. Interfaces between components and data stores use the Secure Hypertext Transfer Protocol (HTTPS – part of an architectural pattern called Representational State Transfer or REST) and message payloads are created using the Experience Application Programming Interface (xAPI), and a JavaScript Object Notation (JSON) for encoding grammatical triples (noun/verb/object). Physically, the interfaces may be exposed at any point or points, depending on the physical components. This allows a gradual migration of legacy systems by having them expose interfaces rather than having to replace components.

1.3 Document Overview

This document is organized into sections that describe each data pillar and the systems / interfaces used to manage this data. It introduces the overall requirements for a TLA compliant network of hardware and software resources, data structures and other services maintained within a logical cybersecurity boundary. These boundaries can be organizational (e.g., school, command, business area) or specific to the myriad of different platforms used to deliver training and education experiences in the commercial marketplace (e.g., LMS, LXP, Simulation System). These requirements provide a blueprint for migrating existing Learning and Development tools to the future DoD TLA learning ecosystem.

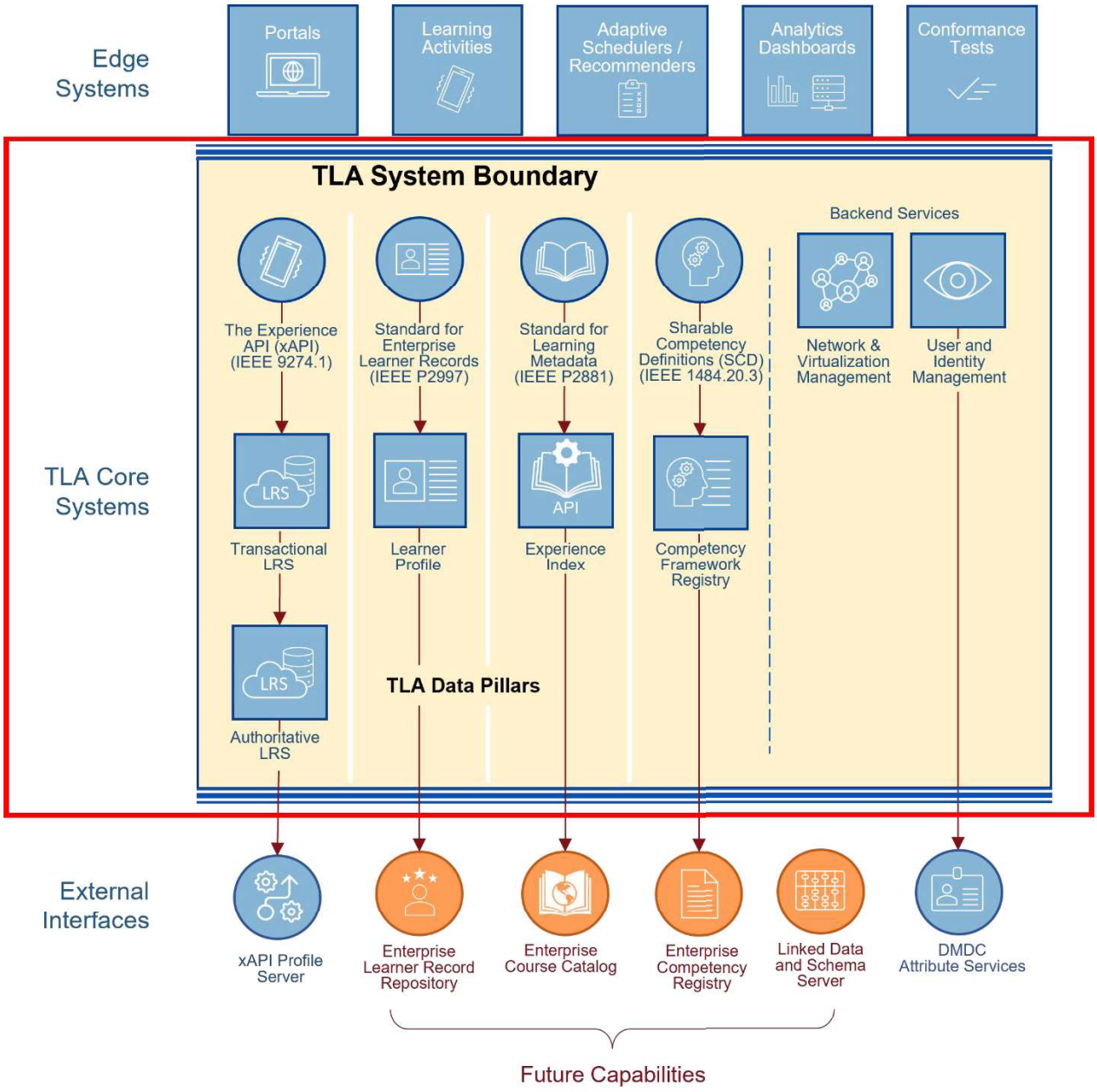

Figure 1. TLA Core Systems Align to the TLA Data Pillars. Edge systems connect to the TLA Core to use or generate data. Edge systems often use and generate data that must be stored within the TLA Core. Edge systems connect to the TLA core using the TLA Master Object Model (MOM) described in section 3.2.1

Figure 1 shows the TLA core and the decomposition of the data pillars into their required interfaces and data structures. The TLA core represents the core training and education data contained within any network, system, or platform. Each data pillar is built around commercial standards developed through the Institute of Electrical and Electronics Engineers (IEEE), Learning Technology Standards Committee (LTSC). These data standards include:

1. *Experience API (xAPI):* The xAPI standard is used to track learner performance from different systems (e.g., learning activity, registration system). The standard defines the general structures for creating xAPI statements. These statements are stored in a Learning Record Store (LRS), which is formally part of the standard. At a local level, such as within a given training simulation, xAPI data are stored in a "noisy" LRS. These local data stores capture extensive and granular data, which may be inapplicable outside of the immediate situation. The TLA Master Object Model (MOM) is used to rollup xAPI statements to a Transactional LRS that sits within the TLA Core.
2. *Standard for Enterprise Learner Records:* The IEEE P2997 Standard for Enterprise Learner Records facilitates the aggregation, management, and sharing of learner data generated from diverse, connected systems. Everyone within an organization will have an Enterprise Learner Record, which includes information about completed learning experiences, competencies, credentials, and employment history as well as administrative information (e.g., identification of the organization inputting data into the record). Additionally, each record includes local and global attributes about the person applicable to learning contexts, and these can be shared across connected systems using the Learner API.
3. *Standard for Learning Metadata:* The IEEE P2881 Learning Experience Metadata standard defines a framework for describing and sharing descriptive information about formal and informal learning activities, such as academic courses, training exercises, instructional simulation scenarios, or instructional videos. Within a large-scale organization such as DoD, each of these learning resources is assigned a unique identifier, and then data about them are stored in a local Experience Index. The metadata are maintained locally so that training and education owners (e.g., schoolhouses, training centers) can manage how they define and share information about the content they own.
4. *Sharable Competency Definitions:* The IEEE 1484.20.3 Sharable Competency Definitions data standard defines a model for describing the content, required Knowledge, Skills, Abilities, and Other attributes (KSAOs), contexts, mastery levels, and credentials associated with competencies. The standard also defines Competency Frameworks, which articulate the relationships among competencies. The frameworks are hierarchical in nature, but a single competency may be used across numerous frameworks, creating a many-to-many relationship among competency elements.

Every device or software service that connects to a TLA-defined learning ecosystem is considered an Edge System. Edge systems are considered a Learning Record Provider (meaning it pushes data out), and/or a Learning Record Consumer (meaning it ingests TLA Core data). The various components plug together, like LEGO® bricks, to form the comprehensive system. The specific composition of learning technologies within any organization will differ, and the arrangement of these systems can change over time. However, the overarching enterprise architecture will remain—similar to how the connection points on LEGO® blocks enable interconnectivity, even when the assembled castle or spaceship is modified.

This document is separated into sections that provide detailed requirements for the systems, services, and interface specifications around each data pillar. TLA core data structures are aligned to the TLA standards. These structures store the data generated within each data pillar. They may be federated between enclaves so they can communicate with the enterprise level assets through an interconnected set of messages and data relays known as a "data fabric."

- A **Learning Record Store** (LRS) is the server-side implementation of the xAPI standard. It is used to store learner records in the form of xAPI statements. xAPI statements are created by learning activities (or the systems that manage learning activities) and are structured according to the xAPI profiles that govern the xAPI implementation for each activity type. The TLA requires a federated set of LRS solutions. Each LRS federation maintains a different set of xAPI learner records. An edge system such as a learning activity might include a "Noisy" LRS to store the raw xAPI learner data at a very granular level of detail. At key points in the learning experience, additional xAPI statements are used to roll up the reporting of learner performance data to the Transactional LRS inside the TLA Core. The "Authoritative" LRS maintains validated competency assertions and validated conferrals of credentials in the form of xAPI statements.
- An **Experience Index** is a data structure that contains metadata about each connected learning experience. Metadata are used to decompose courses into Activity-Content tuples that describe the different learning experiences a user will encounter. These metadata provide the context for how and why the learner participated in that activity. Metadata are also used to link different learning experiences to the competencies they support. The Experience Index acts as the "data fabric connector" for the Enterprise Course Catalog (ECC), publishing experiences or sets of experiences as courses and curated lists.
- A **Competency Framework Registry** is a common repository of competency definitions that can be shared with connected systems; tailored to meet local conditions, context, and performance standards. Different competency frameworks can be aligned to identify gaps in KSAOs required to perform job tasks, duties, or responsibilities. They guide the fulfillment of educational objectives and inform the associated standards and contexts/conditions that describe each level of mastery.
- A **Learner Profile** is used to record a learner's competency and credential history, aptitudes, local and global preferences, career trajectory and state, and local learning state (e.g., assigned learning goals, tasks, in-progress events). Learner profiles act as the data fabric "connector" and make learner records within the profile globally discoverable.

The functional requirements included in this document provide detailed descriptions of the core services and data within each data pillar. Section 3.1 addresses the required modes and states, while Section 3.2 addresses TLA core functions for each data pillar include:

- **Learning Experience Management** (Section 3.2.1) —This function is not a single component. This function uses xAPI to monitor core services or edge systems for behaviors that are indicative of learning events unfolding. Every TLA enclave will likely deploy this in a different way, depending on the mix of data and systems. At the date of this publication, these services are primarily focused on the connection between learning activities and the TLA's core services. However, the requirements defined in this document include connectivity from schedulers, recommenders, and other systems used to manage the delivery of education and training to learners.

- **Activity and Resource Management** (Section 3.2.2) – This function uses the P2881 Standard for Learning Metadata to provide connected systems access to the detailed metadata that describe each learning experience. These metadata are stored in the Experience Index. Each learning experience has a unique identifier (ExperienceID) that is used to track its usage and derive statistics from the data generated about the experience including any activities or content that was used as part of that experience, its effectiveness, and its alignment to different competencies.
- **Competency Management** (Section 3.2.3) – This function involves the management of competency definitions, competency frameworks, and the roll up of learner performance data (i.e., xAPI) into records of learner proficiency. To demonstrate competence at a given level, an individual or team must show evidence of performance of certain behaviors or skills at that level of proficiency. This function considers data about the learner (e.g., Learner Profile), the competency being taught (the Sharable Competency Definitions), and the activity generating the learner performance data (e.g., Learning Metadata). This function also links competencies and competency frameworks into credentials, occupations, and career pathways; hence, they become a broker between the education/training community and the Human Capital Supply Chain.
- **Learner Profile Management** (Section 3.2.4) – This is the primary data pipeline for aggregating and interpreting xAPI learner records; tracking and managing lifelong learning; and correlating learner performance with career field competencies and required credentials. A unique user ID is used to track learner performance across all connected activities using xAPI statements. xAPI statements include linkages to the other core data repositories to provide additional information to any connected system that requires it.
- **User and Identity Management** (Section 3.2.5) – Identity, Credentialing, and Access Management (ICAM) comprises a set of processes that help organizations authenticate, authorize, and federate users on their networks. Specifically, *identity management* allows an organization to establish, maintain, and terminate identities. *Credential management* allows an organization to issue, track, update, and revoke credentials for identities. *Access management* involves authorizing access to documents or applications within an organization, so that only approved individuals can read or interact with those files or systems.
- **Network and Virtualization Management** (Section 3.2.6) – This is a required function to operate in any cloud or virtualized environment. System boundaries must be exposed such that edge devices can dynamically manage the physical location of logical endpoints for required services and data.

Section 3.3 describes the TLA messaging topology. The TLA treats every data source or service as either a Learning Record Provider (LRP) that generates TLA core data or a Learning Record Consumer (LRC) that processes TLA core data. Within DoD, enterprise assets also represent mandatory external interfaces for any TLA compliant system. The interface requirements for the enterprise assets are listed in Section 3.3, including:

- xAPI Profile Server
- Enterprise Learner Record Repository
- Enterprise Course Catalog
- Enterprise Competency Registry
- Linked Data and Schema Server

- Authoritative Data Source for Identity (e.g., DMDC Attribute Services)

In general, core services and data may act as both an LRP and an LRC. Edge systems include training devices and user interfaces (LRP), decision support displays (LRC) and ancillary services (e.g., machine learning recommenders, schedulers). Edge systems must conform to the interface requirements of Section 3.4.

2.0 REFERENCED DOCUMENTS AND NORMATIVE STANDARDS AND SPECIFICATIONS

- TLA Master Object Model Profile: GitHub - adlnet/MasterObjectModel: The xAPI Profile to use when integrating with the Total Learning Architecture
- IEEE P9274 Experience Application Program Interface (xAPI): https://site.ieee.org/sagroups-9274-1-1/
- IEEE P9274.2.1 xAPI Profile Specification (TBD)
- IEEE 1484.1 Conceptual Model for Learning Technology Systems (CM4LTS - undergoing revision)
- IEEE P2997 Enterprise Learning Record (Pending IEEE approval)
- IEEE 1482.20.3 (undergoing revision) Sharable Competency Definition Objects: https://standards.ieee.org/project/1484_20_1.html
- cmi5 specification: http://aicc.github.io/CMI-5_Spec_Current/
- IEEE P2881 Learning Metadata
- IMS Global Learning Tools Interoperability® 1.3: https://www.imsglobal.org/activity/learning-tools-interoperability
- Total Learning Architecture Data Reference Model (TBD)
- Total Learning Architecture Architectural Reference Model (TBD)
- NIST SP 800-53 Security and Privacy Controls for Federal Information Systems and Organizations
- FIPS 120 201.2 Personal Identity Verification (PIV) of Federal Employees and Contractors
- NIST SP 800-122 Guide to Protecting the Confidentiality of Personally Identifiable Information (PII)
- NIST SP 800-63 Digital Identities
- NIST SP 800-207 Zero Trust Architecture
- IEC/RFC 8446 Transport Layer Security (TLS) 1.3
- World Wide Web Consortium Hypertext Transfer Protocol (HTTP) 1.1
- FIPS 186-4 Digital Signature Standard (DSS)
- FIPS 140-2 Security Requirements for Cryptographic Modules
- IETF 3987 Internationalized Resource Identifiers (IRI)
- ISO 8601 Data elements and interchange formats – Representation of dates and times
- OpenBadge: https://openbadges.org/
- Credential Transparency Definition Language: https://credreg.net/ctdl/handbook
- Open Identification (OpenID): https://openid.net/

3.0 REQUIREMENTS

The requirements defined in this document specify the functions and interfaces that would be deployed at a given location to enable the ledgering and interoperability requirements that create the TLA capabilities. A key component of the overall TLA strategy is legacy recapitalization of a learning organization's existing IT infrastructure. Migration from the legacy systems will occur in stages, which means not all requirements need to be deployed in an initial rollout.

3.1 Required Modes and States

TLA compliant systems are intended to operate continuously. Servers deploying data and components should be selected for robust scalability and availability. Operations on TLA components happen in two main modes – maintenance mode and operational mode.

- **Maintenance mode**. The TLA compliant services and data provide a ledger of information about learners, the skills these learners learn (competencies), and the way this learning occurs or is evaluated (activities and content). There is both a real-time and a static component to the data that provide this ledgering capability. Maintenance mode is concerned with the update of the static components that manage the introduction of new users, or movement of users between locations, the assignment and metadata attribution of new activities and content, and the import, export, or modification of competency elements.
- **Operational mode**. The TLA compliant services work together to search static data and historic performance data, plan and control new learning opportunities, collect performance data about them, and update learner states based on those data. The operational mode is continuously in operation. All learner data are not required to be collected in real time but do have a quality of service associated with time of receipt and processing.

Maintenance mode is stateless at the system level, although individual databases and applications have login, data entry, commit, and verification states depending on the technology used. The operational mode similarly has component states based on the products being used.

To enable a true ecosystem, the TLA's constituent services, devices, and data are loosely coupled where they interact only through specified data contracts. These data contracts do not depend on the nature of the upstream source or downstream use of the message. Every device or service in the ecosystem appears as either a learning record provider (LRP) and/or a learning record consumer (LRC). The resulting architecture is asynchronous, and event driven. This makes it perfectly adapted to using modern high-performance messaging systems, as well as migration to microservices to satisfy functional requirements. It also means that there is no single system responsible for coordinating the execution between components. This statelessness is essential for the loose coupling required to be a true ecosystem.

Within the TLA, the learner is the critical element to defining overall system behavior. The learner is the only constant when considering lifelong learning and within the TLA, it is the learner state that defines the context under which learning services should respond. To model the dynamic behavior of the learner, the TLA Master Object Model (MOM) was developed. Learning is a lifelong and continuous activity that is highly connected to prior learning experiences. The MOM provides a way to link specific learning context and connections (e.g., learner pathways), instead of managing throughput of an entire cohort through a prescribed curriculum (e.g., the factory model).

The MOM defines the object life cycle of learners executing a single "thread of learning" that culminates in the reporting and evaluation of a learning event. A MOM conformant xAPI statement represents the finest reporting granularity of a learner intersecting with other people, learning resources and organizational factors during a single learning experience (e.g., course, activity). The thread of MOM statements generated by each learning experience includes the same general sequence, although the nature of the activities, and whether they are explicit or implicit, may change with each event.

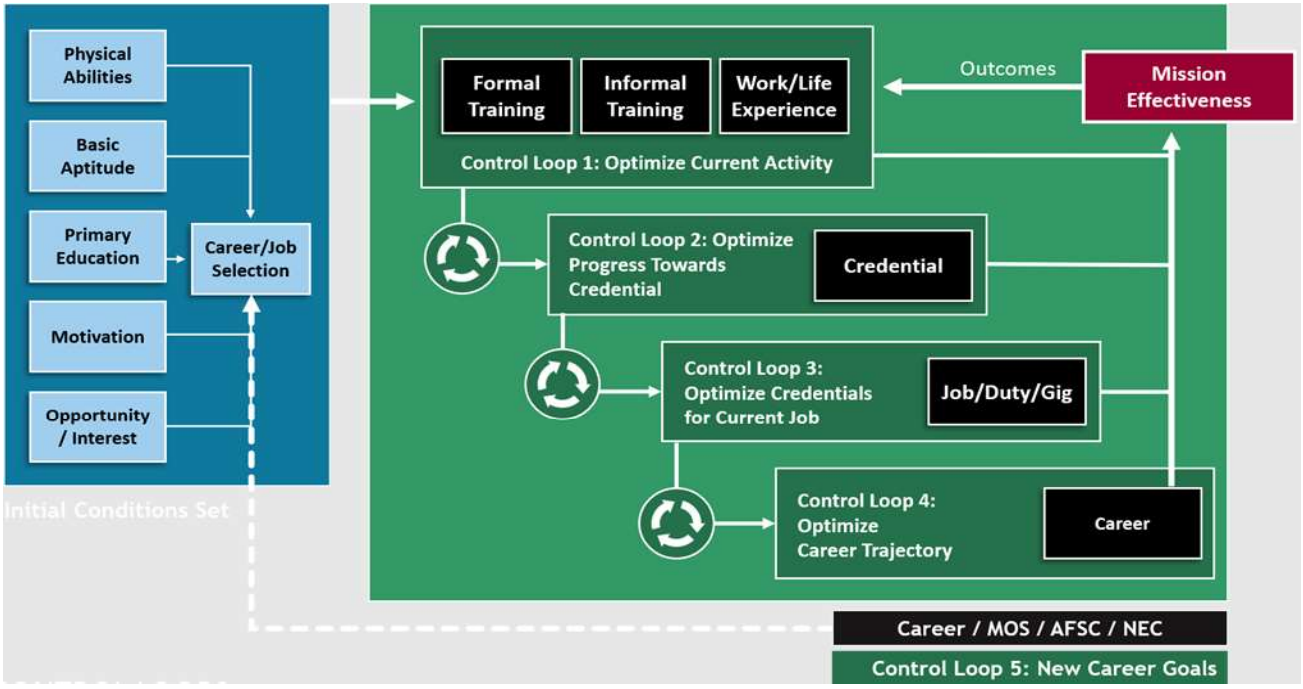

Figure 2. TLA Control Loops. *TLA Control Loops operate in parallel but provide a convenient way to limit and categorize data displayed in decision support aids. The TLA MOM profile helps organize these filters.*

The TLA MOM covers lifelong learning from the macro (i.e., career state) level to the micro (i.e., learning experience) level. The aggregation of TLA MOM messages can be viewed as populating a series of five nested "control loops," shown in ***Figure 2***. The five control loops in order of ascending time horizons address:

- **Control Loop 1**: Improving a learner's mastery of competencies within the current learning experience (e.g., intelligent tutoring, instructor support). This control loop typically uses the xAPI data stored in a Noisy LRS.
- **Control Loop 2**: Optimizing a learner's progress toward a credential. This control loop uses TLA MOM statements and the P2881 Standard for Learning Metadata to optimize the delivery of different learning experiences in pursuit of a Credential (e.g., degree, certificate, license).
- **Control Loop 3**: Prioritizing the pursuit of credentials or activities to meet requirements for a job. This control loop uses the TLA MOM statements and Sharable Competency Definitions to optimize an individual's learning plan in pursuit of a job.
- **Control Loop 4**: Career field management including the planning and execution of education and training goals for an overall career trajectory. This control loop uses all TLA Core data and introduces a new component to the TLA's competency pillar. The Credential Transparency Description Language (CTDL) and Job Data Exchange (JDX) standard is used to decompose position descriptions into their required competencies and credentials.
- **Control Loop 5**: Provide options for supporting post-career transition and retraining to pursue other career goals. This control loop relies on the historical TLA data generated by a learner to identify gaps between the competencies and credentials they currently have and the requirements for the new job/duty/occupation they wish to pursue.

The control loops show that learning data may be viewed from different perspectives requiring different levels of granularity and fidelity over different time horizons. In other words, the same data collected from a single learning experience may be used in different ways depending on the purpose for which it is being used. For example, a learner may be pursuing a specific job credential required for promotion. They need to participate in one of more courses (e.g., a sequence of learning activities) in support of their career trajectory. This example can be viewed in the context of control loops 2, 3, and 4.

The TLA's MOM verbs are grouped to represent the learner state within the different systems a student interacts with for each of the 5 control loops. The MOM includes statements that describe key learner milestones for tracking and managing learner progression within each control loop. Some MOM elements are indicative of a learner passing from one control loop to the next.

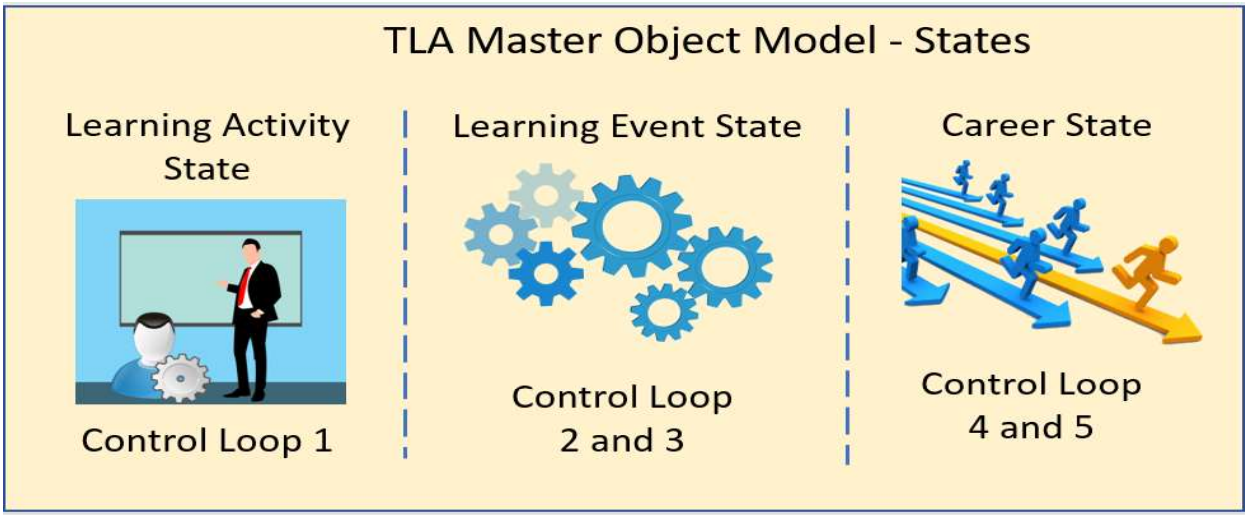

Figure 3. The TLA MOM states and their relationship to control loops. When coupled with adaptive algorithms based on machine learning, these represent meta, macro, and micro adaptation.

As shown in ***Figure 3***, the Learning Activity State defines the key learner interactions a user will perform in control loop 1 (immediate learning activity) from initialization to completion or termination. TLA MOM verbs in this state conform to the cmi5 data standard, which follows the lifecycle of the legacy SCORM run-time data model. The use of cmi5 normalizes performance data and allows edge systems to perform their own adjudication so there are no conflicts within the TLA core data of what "correct performance" looks like. Each procuring agency and schoolhouse maintains its own performance assessment equities.

Learning event states are associated with the activities that occur both before and after a learner has interacted with a learning experience. Beforehand, these include verbs such as requested, approved, scheduled, recommended, among others. They describe the context under which the learner pursued their learning (associated with control loops 2 and 3). TLA verbs for this state are also generated after learner performance evidence has been generated or when an activity has been completed. These verbs are used to contextualize learner performance against a related set of competencies (e.g., validated, qualified, conferred, inferred, among others).

Career states are the verbs associated with career progression across career arc. These MOM statements could be generated by Career Field management tools, human resource systems, or other systems associated with control loops 4 and 5. Career states change slowly over time as a learner moves from job to job and meets different career milestones (e.g., promoted, detailed, selected, among others).

Throughout a career, learning may unfold in a variety of ways from self-regulated learning to formal programs of instruction. The data generated in control loops 2, 3, 4 and 5 inform individual learning goals. These are organized according to their required competencies and credentials. Learning activities and experiences are aligned to these competencies and organized to achieve the underlying learner goals. The TLA MOM states provides the mechanism to track the learner as they progress through these formal or informal programs of instruction. In either case, the launching and capture of the TLA MOM's Learning Activity State provides the evidence for demonstration of competency. Other connected TLA systems use this information for a wide range of purposes.

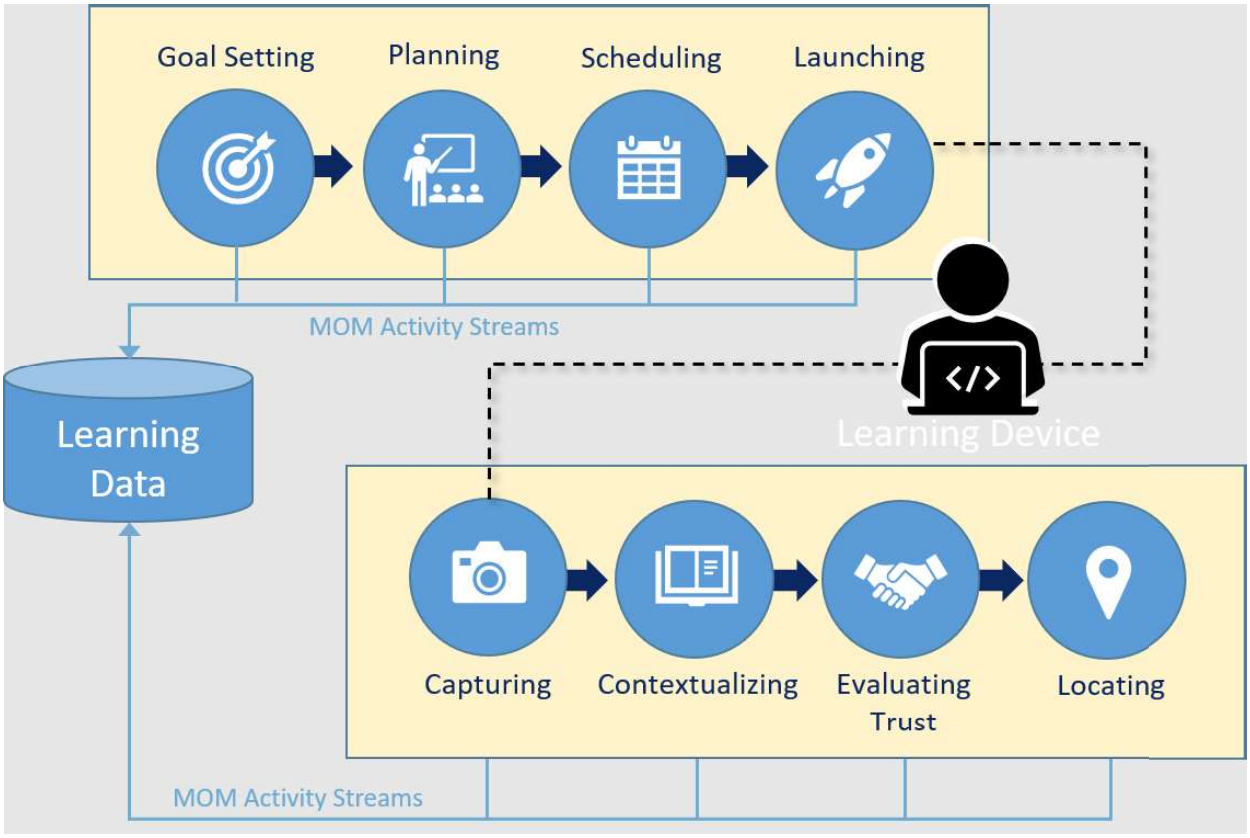

Figure 4. Lifecycle of a Learning Experience. *These are defined in the Master Object Model (MOM), which are generated by the interactions between the learner and the activity.*

As shown in ***Figure 4***, the lifecycle of any learning experience is defined by a series of state transitions that are generated within each activity as the user accomplishes major milestones. The evidence captured from the TLA MOM's lifecycle of verbs is weighed against the assessment and evaluation requirements defined within the competency definitions. This information coupled with the Learning Experience metadata contained in the Experience Index, allows the activity's impact on learning to be contextualized.

The competency management function evaluates the evidence and updates a learner's competency and credential state located in their learner profile (and ultimately up to the Enterprise Learner Record Repository). The linkage of global records to local records and supporting evidence provides the "trust chain" for performance data. Each learning event starts a new cycle of event states.

3.2 System Capabilities

The TLA assumes a set of enterprise services and associated infrastructure to ensure semantic interoperability, maintain digital identity for users, and operate within the needs of the *internetworked* digital world. The overall management of learning functions exists in context with other human resources and business operations functions such as manpower and personnel, acquisition, and readiness. Each organization maintains a data equity in educating, training, qualifying, or employing people in jobs or duties that contribute to military readiness. TLA core services and data are designed to be shared with these other connected systems. In the future learning ecosystem, this allows disparate local ecosystems to be fully integrated amongst themselves and digitally interconnected. Compliance with TLA standards allows for the creation of ad hoc "federations" of shared data between enclaves.

Each TLA instance is called an enclave. A TLA enclave is defined as a specific set of computational and data resources managed by an organization charged with a manpower, personnel, training, and education (MPT&E) mission. The TLA is designed such that there are no mandatory *components* that make up a TLA compliant enclave, but there are required functions, data structures and functional interfaces that must be exposed in each enclave. It does not matter whether these are exposed in a single monolithic system, deployed entirely as microservices, or something in between. The system will be "TLA compliant" if it meets the following criteria:

- Provides and exposes the functions associated with Learning Event Management; Learner Profile Management; Activity and Resource Management; and Competency Management core services.
- Provides and exposes User and Identity Management, and network virtualization management backend functions.
- Follows the interface structure of the TLA Architectural Reference Model for these functions.
- Communicates between "core" functions and "edge" systems (learning devices and decision support tools) using the MOM xAPI profile.
- Treats an event edge device or core service as either an xAPI learning record provider and/or a learning record consumer.
- Exposes Learner Profile, Experience Index, Competency Framework and Learning Record Store data using Representational State Transfer (REST) over Transport Layer Security (TLS).
- Follows the data structure of the TLA Data Reference Model for these stores.
- Can connect to adjacent enclaves or edge systems using REST TLS.

The following sections provide additional detail for each of the core and backend functions, data structures and interfaces required to create a "TLA compliant" enclave, as well as define the interfaces and capabilities of the enterprise assets.

3.2.1 Learning Experience Management

Learning Experience Management (LEM) is a distributed set of functions in the future learning ecosystem, rather than a dedicated component. This LEM function tracks the actions required to monitor and provide context under which every learning experience is conceived, created, executed, and evaluated. Each unique set of learner interactions defines conditions for being in a particular TLA MOM state, and the appropriate message for each state is defined within the "Management of Learning Path Logic" requirements listed in ***Table 1***.

The Noisy LRS collects all xAPI statements generated by a learning experience (e.g., activity). The granularity and fidelity of these data are governed by xAPI Profiles. Within the TLA, these are considered edge systems and therefore contain data that sit outside the TLA core. The LEM services enable the creation of TLA MOM statements at key points within the lifecycle of each learning experience. These are stored in the Transactional LRS but contain linkages to the Noisy LRS to maintain the chain of evidentiary learner performance data. The Transactional LRS is a component of the TLA core that tracks the dynamic nature of a learner Pathway across learning experiences. The TLA's LEM services also store learning goals (e.g., career targets) to the Learner Profile using the TLA MOM. The relationship between overall TLA data and services and the associated MOM verbs is shown in ***Figure 5***.

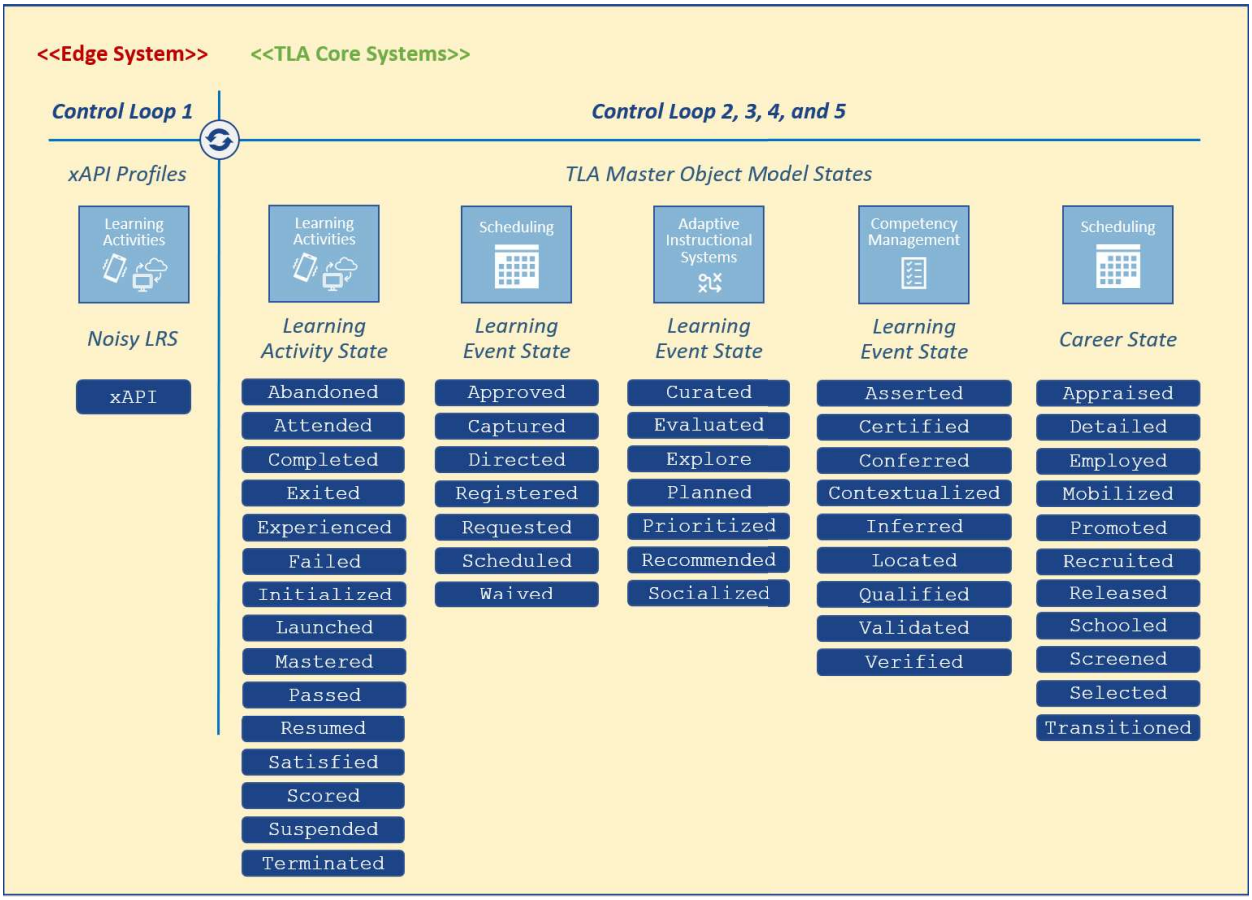

Figure 5. TLA core data and services and edge systems with associated Learning Experience Management States. TLA MOM statements are used to track learner progress against a set of learner goals and assigned courses (e.g., learning activities) that are established by other connected systems (e.g., Career Field Management Tools, ATTRS, Learner Selected)

LEM services may be deployed natively within any edge system, or they may be developed as a set of microservices, or "listeners" for the native APIs of edge systems or the core services developed from legacy monolith applications. Learning experiences are defined as the different education and training resources that an organization has available; however, they may also represent other unique opportunities to enhance or demonstrate learning. For learning experiences, TLA MOM statements are formatted using xAPI to include the following:

- **Actor**: Unique User ID used to track an individual across all connected learning activities. For the DoD, this is currently the 16-digit DoD ID used on CAC credentials.
- **Verb**: Track and manage the context of how a learning experience was scheduled and completed, and evaluations throughout the life of the learner.
- **Object**: Each learning experience has a unique identifier (i.e., ExperienceID) that is used to associate that activity with its metadata.
- **Context**: MOM statements may include additional context that provides additional insight into how a learning resource was used in the context of individual learner experience. These data can be used to build granular insights into individual learning paths and learning velocities to inform future adaptive instructional systems.

Table 1 below describes the LEM requirements required to complete the lifecycle of learning. While these components are logically separated in ***Figure 5***, multiple different LEM services may be integrated within a single learning technology.

Table 1. Learning Experience Management Requirements. *The Learning Experience Manager is a set of services associated with goal selection, planning, and scheduling of learning activities, and the capture and contextualization of those events.*

Header	Requirement	TLA CMM Level	Comments
TLA MOM – Learning Activity State			
Learning Experience MOM	TLA compliant learning experiences (e.g., education and training activities) must generate xAPI statements that are conformant to the TLA MOM.	Level 2	Draft released by ADL Initiative
Learning Experience MOM	TLA compliant learning experiences (e.g., education and training activities) must use a unique, organizational user ID (UUID) to populate the 'actor' field of the TLA MOM statement.	Level 2	DoD ID is the unique 16-digit PIV associated with each DoD learner
Learning Experience MOM	TLA compliant learning experiences (e.g., education and training activities) must be able to generate the "abandoned" verb when a learning activity is abnormally terminated by a learner's action.	Level 2	
Learning Experience MOM	TLA compliant learning experiences (e.g., education and training activities) must be able to generate the "attended" verb when a learner is present at a virtual or physical event or activity.	Level 2	e.g., attending a conference or sessions within a conference or a webinar / seminar
Learning Experience MOM	TLA compliant learning experiences (e.g., education and training activities) must be able to generate a "completed" verb when a learner finishes or concludes the learning activity.	Level 2	
Learning Experience MOM	TLA compliant learning experiences (e.g., education and training activities) must be able to generate a "experienced" verb when a learner encounters a learning situation (i.e., activity) that links to a competency.	Level 2	(e.g., NALCONIS tasking records for aviation maintenance, mishap analysis, lesson learned) – predicated on having those activities aligned to competencies

Header	Requirement	TLA CMM Level	Comments
Learning Experience MOM	TLA compliant learning experiences (e.g., education and training activities) must be able to generate a "failed" verb when a learner does not successfully pass an activity to a level of predetermined satisfaction.	Level 2	
Learning Experience MOM	TLA compliant learning experiences (e.g., education and training activities) must be able to generate an "Initialized" verb when a learning successfully starts a learning activity.	Level 2	
Learning Experience MOM	TLA compliant learning experiences (e.g., education and training activities) must be able to generate a "launched" verb when a learner attempts to start a learning activity.	Level 2	
Learning Experience MOM	TLA compliant learning experiences (e.g., education and training activities) must be able to generate a "mastered" verb when a learner achieves the highest level of comprehension or competency.	Level 2	
Learning Experience MOM	TLA compliant learning experiences (e.g., education and training activities) must be able to generate a "passed" verb when a learner successfully passes an activity to a level of predetermined satisfaction.	Level 2	
Learning Experience MOM	TLA compliant learning experiences (e.g., education and training activities) must be able to generate a "resumed" verb to indicate when a student has continued or reopened a suspended learning activity.	Level 2	
Learning Experience MOM	TLA compliant learning experiences (e.g., education and training activities) must be able to generate a "satisfied" verb when all learning activity requirements are met.	Level 2	
Learning Experience MOM	TLA compliant learning experiences (e.g., education and training activities) must be able to generate a "scored" verb to indicate when a student has received a numerical value related to their performance within a learning activity.	Level 2	For when you need to decouple the pass/fail or completed. (e.g., a ranking, grade curve)
Learning Experience MOM	TLA compliant learning experiences (e.g., education and training activities) must be able to generate a "suspended" verb to indicate when an activity has been temporarily halted but will be resumed at a later time.	Level 2	
Learning Experience MOM	TLA compliant learning experiences (e.g., education and training activities) must be able to generate a "terminated" verb to indicate when a learner has successfully ended an activity.	Level 2	
Learning Experience MOM	TLA compliant learning experiences (e.g., education and training activities) must be uniquely defined by an IRI that links to an 'Experience Index', the server-side component of the P2881 Learning Activity Metadata.	Level 3	Follows the concept of xAPI where the LRS is the server-side implementation of the xAPI

Header	Requirement	TLA CMM Level	Comments
Learning Experience MOM	TLA compliant learning experiences (e.g., education and training activities) must use a unique, organizational Activity Identifier (ExperienceID) to populate the 'object' field of the TLA MOM statement.	Level 3	
Learning Experience MOM	TLA compliant learning experiences (e.g., education and training activities) must use the 'Results' extension in TLA MOM statements to report scores, grades, Noisy LRS endpoints, or other learner performance information.	Level 3	
Learning Experience MOM	TLA compliant learning experiences (e.g., education and training activities) must use a unique Competency Definition Identifier (CompetencyID) to populate 'xAPI Context Extensions' when reporting competencies within the TLA MOM statement.	Level 3	
Learning Experience MOM	Each TLA MOM CompetencyID must be uniquely defined by an IRI that links to a Competency Registry.	Level 3	
TLA Scheduling MOM – Learning Event Management State for Scheduling			
LEM Scheduling MOM	TLA compliant systems used to track, manage, or schedule learning experiences (e.g., education and training activities) must generate xAPI statements that are conformant to the TLA MOM.	Level 3	Draft released by ADL Initiative
LEM Scheduling MOM	TLA compliant systems used to track, manage, or schedule learning experiences (e.g., education and training activities) must utilize a unique, organizational user ID (UUID) to populate the 'actor' field of the TLA MOM statement.	Level 3	
LEM Scheduling MOM	TLA Registration and Scheduling services must be able to generate an "approved" verb when a learner has been accepted to participate in a learning experience (e.g., training and education activity).	Level 3	
LEM Scheduling MOM	TLA Registration and Scheduling services must be able to generate a "registered" verb when a learner has enrolled in a learning experience (e.g., education and training activity).	Level 3	
LEM Scheduling MOM	TLA Registration and Scheduling services must be able to generate a "requested" verb when a learning experience (e.g., training and education activity) is submitted to an approval authority by a learner.	Level 3	
LEM Scheduling MOM	TLA Registration and Scheduling services must be able to generate a "scheduled" verb when learning resources are reserved for an enrolled learner.	Level 3	
LEM Scheduling MOM	TLA Registration and Scheduling services must be able to generate a "waived" verb when a learner is relieved of the requirement to enroll in a learning experience (e.g., testing out of a course, medical limitation).	Level 3	
LEM Scheduling MOM	All learning experiences (e.g., education and training activities) that are being tracked, managed, or scheduled must be uniquely defined by an IRI that	Level 3	Follows the concept of xAPI where the LRS is the server-side

Header	Requirement	TLA CMM Level	Comments
	links to an 'Experience Index', the server-side component of the P2881 Learning Activity Metadata.		implementation of the xAPI
LEM Scheduling MOM	TLA compliant systems used to track, manage, or schedule learning experiences (e.g., education and training activities) must use a unique, organizational Experience Identifier (ExperienceID) to populate the 'object' field of the TLA MOM statement.	Level 3	
LEM Scheduling MOM	TLA compliant systems used to track, manage, or schedule learning experiences (e.g., education and training activities) must use a unique Competency Definition Identifier (CompetencyID) to populate 'xAPI Context Extensions' when reporting competencies within the TLA MOM statement.	Level 3	
LEM Scheduling MOM	Each TLA MOM CompetencyID must be uniquely defined by an IRI that links to a competency registry.	Level 3	
TLA Goal Setting MOM – Learning Event Management State for Adaptive Instructional Systems			
LEM Adaptive Instructional System MOM	TLA conformant systems used to select, track, manage, or schedule learning experiences (e.g., education and training activities) must generate xAPI statements that are conformant to the TLA MOM.	Level 4	Draft released by ADL Initiative
LEM Adaptive Instructional System MOM	TLA conformant systems used to select, track, manage, or schedule learning experiences (e.g., education and training activities) must utilize a unique, organizational user ID (UUID) to populate the 'actor' field of the TLA MOM statement.	Level 4	
LEM Adaptive Instructional System MOM	TLA conformant systems must be able to generate a "curated" verb when a connected system creates a curated list of learning experiences (e.g., education and training activities).	Level 4	
LEM Adaptive Instructional System MOM	TLA conformant systems must be able to generate a "deselected" verb when a learner goal has been removed.	Level 4	Must have a different IRI from the HR MOM definition of selected
LEM Scheduling MOM	TLA conformant systems must be able to generate a "directed" verb when a learning experience (e.g., training and education activity) is required by a connected resource.	Level 4	e.g., remedial material
LEM Adaptive Instructional System MOM	TLA conformant systems must be able to generate an "explored" verb when a learner has selected a learning resource that aligns to a competency that is not part of an established learner goal.	Level 4	Generated by ECC or another course catalog
LEM Adaptive Instructional System MOM	TLA conformant systems must be able to generate a "prioritized" verb when a list of suggested learning experiences are ranked by a connected system to optimize the achievement of selected learning goals.	Level 4	Recommenders, Intelligent Tutors, or any system where learning activities can be ranked
LEM Adaptive Instructional System MOM	TLA conformant systems must be able to generate a "recommended" verb when a learning experience (e.g., training and education activity) is suggested by an adaptive instructional system.	Level 4	

Header	Requirement	TLA CMM Level	Comments
LEM Adaptive Instructional System MOM	TLA conformant systems must be able to generate an "searched" verb when a learner has created a list of related learning experiences (e.g., education and training activities) related to a specific competency (i.e., learner goal).	Level 4	
LEM Adaptive Instructional System MOM	TLA conformant systems must be able to generate a "selected" verb when a learner goal has been chosen.	Level 4	Must have a different IRI from the HR MOM definition of selected
LEM Advanced Scheduling MOM	TLA conformant systems used to select, track, manage, or schedule learner goals must use a unique Competency Definition Identifier (CompetencyID) to represent Learner goals.	Level 4	
LEM Advanced Scheduling MOM	TLA conformant systems used to select, track, manage, or schedule learner goals must populate 'xAPI Context Extensions' when reporting competencies within the TLA MOM statement.	Level 4	
TLA Competency Management MOM – Learning Event Management State for Competency Management			
LEM Competency Management MOM	TLA compliant systems used to manage learner competencies must generate xAPI statements that are conformant to the TLA MOM.	Level 3	Draft released by ADL Initiative
LEM Competency Management MOM	TLA compliant systems used to manage learner competencies must utilize a unique, organizational user ID (UUID) to populate the 'actor' field of the TLA MOM statement.	Level 3	
LEM Competency Management MOM	TLA competency management systems must be able to generate a "asserted" verb when a learner demonstrates proficiency or competence for a competency.	Level 3	
LEM Competency Management MOM	TLA competency management systems must be able to generate a "certified" verb when a learner meets additional criteria to perform duties associated with a competency or credential.	Level 3	
LEM Competency Management MOM	TLA competency management systems must be able to generate a "conferred" verb when a learner has completed all the steps required for a credential (e.g., pin, badge, license, diploma, certificate).	Level 3	
LEM Competency Management MOM	TLA competency management systems must be able to generate a "inferred" verb when achievement of one set of competencies predicts proficiency in others.	Level 3	
LEM Competency Management MOM	TLA competency management systems must be able to generate a "qualified" verb when a learner has completed the competency objects or curricular/assessment requirements to complete a credential.	Level 3	
LEM Competency	TLA competency management systems must be able to generate a "validated" verb when the conferral of a	Level 3	

Header	Requirement	TLA CMM Level	Comments
Management MOM	competency has been validated against different competency frameworks.		
LEM Competency Management MOM	TLA competency management systems must be able to generate a "verified" verb when digital evidence was received from an untrusted source and was checked and approved by a trusted person	Level 3	
LEM Competency Management MOM	TLA compliant systems used to manage learner competencies must use competency definitions that are uniquely defined by an IRI that links to a 'Competency Registry'.	Level 3	
LEM Competency Management MOM	TLA compliant systems used to manage learner competencies must use a unique, organizational Competency Identifier (CompetencyID) to populate the 'object' field of the TLA MOM statement.	Level 3	
LEM Competency Management MOM	TLA compliant systems used to manage learner competencies must use a unique Competency Framework Identifier (CompetencyCFID) to populate 'xAPI context extensions' when reporting competencies within the TLA MOM statement.	Level 3	
LEM Competency Management MOM	Each TLA MOM CompetencyCFID must be uniquely defined by an IRI that links to a Competency Registry.	Level 3	
TLA HR MOM – Career State			
LEM Career Management MOM	TLA compliant systems used for career field management or human resources must generate xAPI statements that are conformant to the TLA MOM.	Level 4	Draft released by ADL Initiative
LEM Career Management MOM	TLA compliant systems used for career field management or human resources must utilize a unique, organizational user ID (UUID) to populate the 'actor' field of the TLA MOM statement.	Level 4	
LEM Career Management MOM	TLA compliant systems used for career field management or human resources must generate an "appraised" verb upon update of a learner record with an initial career trajectory.	Level 4	Listener appended to HR or M&P system
LEM Career Management MOM	TLA compliant systems used for career field management or human resources must generate a "detailed" verb when an individual learner has been assigned to a job outside the organization (e.g., detached from a command).	Level 4	Listener appended to HR or M&P system
LEM Career Management MOM	TLA compliant systems used for career field management or human resources must generate an "employed" verb when an individual learner has reported to an organization for the purpose of work.	Level 4	Listener appended to HR or M&P system
LEM Career Management MOM	TLA compliant systems used for career field management or human resources must generate a "mobilized" verb when an individual learner is deployed to a location away from their normal job location.	Level 4	Listener appended to HR or M&P system, may be performed locally at mobilizing command

Header	Requirement	TLA CMM Level	Comments
LEM Career Management MOM	TLA compliant systems used for career field management or human resources must generate a “promoted” verb when a learner has been promoted and enters a new career category based on promotion.	Level 4	Listener appended to HR or M&P system
LEM Career Management MOM	TLA compliant systems used for career field management or human resources must generate a “recruited” MOM message when a learner has been recruited for a specific job.	Level 4	Listener appended to HR or M&P system, indicates a new record
LEM Career Management MOM	TLA compliant systems used for career field management or human resources must generate a “released “verb when their learning record is disestablished and archived.	Level 4	Listener appended to HR or M&P system
LEM Career Management MOM	TLA compliant systems used for career field management or human resources must generate a “restricted “verb when the learner has been restricted from one or more activities related to a position description.	Level 4	
LEM Career Management MOM	TLA compliant systems used for career field management or human resources must generate a “schooled” verb when an individual learner has reported to a school or training facility.	Level 4	Listener appended to HR or M&P system
LEM Career Management MOM	TLA compliant systems used for career field management or human resources must generate a “screened” verb when a learner has been satisfied the criteria to open a restricted portion of their nominal career arc.	Level 4	Listener appended to HR or M&P system
LEM Career Management MOM	TLA compliant systems used for career field management or human resources must generate a “selected” verb when a learner has been approved for a new opportunity (e.g., job, duty) on their career arc.	Level 4	Listener appended to HR or M&P system, Different IRI from selected verb used in AIS / Goal Setting
LEM Career Management MOM	TLA compliant systems used for career field management or human resources must generate a “transitioned” verb when a learner has been reclassified into a new career arc.	Level 4	Listener appended to HR or M&P system
LEM Career Management MOM	TLA compliant systems used for career field management or human resources must use Job Position Descriptions that are uniquely defined by an IRI that links to an authoritative source.	Level 4	
LEM Career Management MOM	TLA compliant systems used for career field management or human resources must use a unique, organizational Job Position Description (JDXID) to populate the ‘object’ field of the TLA MOM statement.	Level 4	
LEM Career Management MOM	TLA compliant systems used to store the authoritative Job Position Descriptions must use the Job Posting schema standard that is part of the Job Data Exchange (JDX) program to decompose job position descriptions into competencies and credentials.	Level 4	

The Learning Record Store (LRS) is the server-side component of the xAPI standard. In the TLA, it is federated into a noisy, transactional, and authoritative segment. All three segments may be the same physical database and access layer depending on the specific application. All generated xAPI statements are eventually validated by and permanently archived in the LRS. ***Table 2*** lists the requirements for LRS.

Table 2. Requirements for the Learning Record Store.

Header	Requirement	TLA CMM Level	Comments
Learning Record Store			
LRS	TLA compliant LRS must be fully compliant with the xAPI standard IEEE 9274.1.1.	Level 1	
LRS	LRS must maintain a persistent storage of learning activity records (i.e., xAPI statements).	Level 1	
LRS	LRS must capture all xAPI statements generated from Learning Record Providers (e.., Learning Activities).	Level 1	
LRS	LRS must ensure that xAPI statements are complete and well formed.	Level 1	
LRS	LRS must provide a mechanism for administrators to purge old xAPI records.	Level 1	
LRS	LRS must maintain a record of purges to show that data has been altered.	Level 1	
LRS	LRS must provide a mechanism to ensure the integrity of xAPI data stored.	Level 1	
LRS	LRS must allow for connections using REST over TLS.	Level 1	
LRS	LRS must include login credentials utilizing FIPS 140.2 encryption of passwords.	Level 1	
LRS	LRS must support the use of FIPS 140-2 encryption.	Level 1	
LRS	LRS must be able to identify if an incoming xAPI statement is not well formed.	Level 1	
LRS	LRS must be able to identify that an incoming xAPI statement is not from a registered device.	Level 1	
LRS	LRS must allow storage of xAPI statements for each UUID stored as actor.	Level 1	
LRS	LRS must be able to identify incoming xAPI statement with an actor that is not a valid user, registered component, or identity group.	Level 1	
LRS	LRS must allow use of filters on retrieving xAPI data by Actor, date/time, activity type (object), verb, user specified extension field values.	Level 1	
LRS	LRS must support federated data storage, search and retrieval between the Noisy, Transactional and Authoritative LRS.	Level 2	
LRS	TLA Compliant Enclave must include a Transactional LRS as part of core data that stores only data generated according to the TLA MOM profile.	Level 2	
LRS	Transactional LRS shall be sized to support a 10-year digital data retention store of all evidence.	Level2	
LRS	The Transactional LRS must be able to identify that an incoming xAPI statement references an invalid ExperienceID.	Level 3	

Header	Requirement	TLA CMM Level	Comments
LRS	The Transactional LRS must allow streaming of TLA MOM messages to all TLA core systems while preserving the original learner UUID in the 'xAPI actor' field.	Level 3	
LRS	TLA compliant systems must have an Authoritative LRS that stores digitally signed xAPI statements of "conferral", "qualification" and "certification" for competency assertions and conferred credentials.	Level 3	
LRS	The digital signatures must support the client-side component of digital badges associated with each credential.	Level 3	
LRS	Authoritative LRS must be able to federate data from transactional LRS located in multiple enclaves.	Level 3	
LRS	Transactional and Authoritative LRS shall preserve the traceability between evidence, assertions, qualification, certification, conferrals, and globally discoverable digital credentials.	Level 3	

3.2.2 Activity and Resource Management

Within the TLA, each learning resource (course, publication, activity) is described using metadata. Each learning experience has a unique, organizational identifier (ExperienceID) that is used to update and manage these descriptions. Metadata include important information about different learning activities and the content being delivered as part of each learning experience. This information enables connected TLA systems to link learning outcomes to raw learner records (e.g., LRS endpoints, alignments, competencies). Other metadata are used to support acquisition lifecycle planning, adaptive instructional systems, and other elements that describe their fitness for use in an instructional setting. Metadata also includes real time telemetry about each learning resource's usage, effectiveness, and relationships with jobs, duties, platforms, and other DoD systems.

Learning Metadata is stored in an 'Experience Index' that is maintained locally so that organizations can add additional metadata attributes and promote data for content they own. Learning Experience Metadata attributes may be populated during development of the learning resource, or they may be populated using values that are derived from other connected systems. For example, a course survey system might allow a learner to rate their experience; when combined with other learner ratings an 'AggregateRating' value can be calculated.

The Activity and Resource Management (ARM) functions are associated with the creation, review, update, and deletion of Learning Experience Metadata (e.g., activities, courses), as well as publishing that information to other connected systems (e.g., Enterprise Course Catalog) using the interfaces described in Section 3.4.4. Learning experiences are defined as the different education and training resources that an organization has available; however, they may also represent other unique opportunities to enhance or demonstrate learning.

The Resource Management services are concerned with computational or physical assets, infrastructure, consumables, and staffing (e.g., observers, instructors) required to conduct a learning activity. Devices are registered as part of a Zero-Trust Network (ZTN) architecture. Device registration works with the identity and virtualization management services for security and integrity of the data generated and processed from each device. Devices may be linked to anything from an LMS, other Learning Experience Providers, mobile platforms, or any number of future technologies. This allows users to use the organization's computational resources, or their own personal devices once registered.

Specific requirements for ARM are listed in ***Table 3.*** The requirements for the related Experience Index are listed in ***Table 4***.

Table 3. Activity and Resource Management Requirements.

Header	Requirement	TLA CMM Level	Comments
Activity Management Function			
Activity & Resource Management	TLA ARM services must be able to register connected learning experiences (e.g., training and education).	Level 3	
Activity & Resource Management	Each registered learning experience must have a unique, organizational identifier (ExperienceID).	Level 3	
Activity & Resource Management	TLA ARM services must support the identification of learning activities delivered through connected platforms or systems using its ActivityID.	Level 3	(e.g., LMS, eBook)
Activity & Resource Management	TLA ARM services must identify whether a learning experience requires permission to launch or schedule.	Level 3	
Activity & Resource Management	TLA ARM services must allow delisting of learning experiences from the Experience Index.	Level 3	
Activity & Resource Management	TLA ARM services must support decomposition of learning experiences into types, activities, and content.	Level 3	
Activity & Resource Management	TLA ARM services must allow for creation of curated lists.	Level 3	
Activity & Resource Management	TLA ARM services must allow local administrators to arbitrarily group experiences into “interest groups” available for subscription in the local and global interfaces.	Level 3	
Activity & Resource Management	TLA ARM services must support the identification of structured courses, supporting content, and ancillary activities.	Level 3	Supports ILT/blended learning curation process for ancillary teaching aids
Activity & Resource Management	TLA ARM services must allow other connected systems to update learning experience metadata.	Level 3	
Activity & Resource Management	TLA ARM services must maintain a log of all changes by source, date, record affected, old and new version.	Level 3	Would this be the XI?
Activity & Resource Management	TLA ARM services must be able to import a named content set list from a federated (connected) Experience Index.	Level 3	
Activity & Resource Management	TLA ARM services must generate a notification alert when learning experiences (e.g., education and training activities) are updated.	Level 3	Interface to alert and notification system
Activity & Resource Management	TLA ARM services must generate a notification alert when a learning experience (e.g., training and education activity) needs authorization for use.	Level 3	Interface to alert and notification system

Header	Requirement	TLA CMM Level	Comments
Activity & Resource Management	TLA ARM services must generate a notification alert for version updates to content that provide normative references.	Level 3	Requires interface to PDSS systems
Device Registration Function			
Device Registration	TLA ARM services must require registration of any device that will communicate with its LRS.	Level 3	
Device Registration	TLA ARM services must be able to register devices authorized to communicate with a particular LRS.	Level 3	
Device Registration	TLA ARM services must include standalone client (e.g., mobile device) or server-based devices.	Level 3	
Device Registration	TLA ARM services must support the synchronization of available learning activities installed on the device.	Level 3	
Device Registration	TLA ARM services must expose endpoints for xAPI messages and launch commands.	Level 3	
Device Registration	TLA ARM services must use OIDC or SAML to synchronize user ID between core and device.	Level 3	
Device Registration	TLA Device Registry must secure operation using the zero-trust architecture.	High	
Resource Management Functions			
Resource Management	TLA ARM services must validate that the resources necessary to schedule experiences are available.	Level 4	e.g., connected to scheduling component
Resource Management	TLA ARM services must reserve the required resources when scheduling a connected learning activity.	Level 4	Probably a separate class scheduling component
Resource Management	TLA ARM services must manage facility/OIC/S resource requests in batches tied to registrar end date.	Level 4	Probably a separate class scheduling component
Resource Management	TLA ARM services must schedule computational resources when required to run simulations or host content.	Level 4	May be offline process
Resource Management	TLA ARM services must verify online, and on-premises digital content is available when scheduling a connected learning activity.	Level 4	
Resource Management	TLA ARM services must provide a binary level content verification method for registered content which is external to the enclave and on unprotected resources.	Level 4	Interface requirement

Table 4. Experience Index Requirements.

Header	Requirement	TLA CMM Level	Comments
Experience Index			
Experience Index	The Experience Index data must conform to the Learning Metadata standard IEEE 2881 and the TLA Data Reference model.	Level 3	

Header	Requirement	TLA CMM Level	Comments
Experience Index	Learning Experience Metadata must be stored in the Experience Index and referenced using an Internationalized Reference Identifier (IRI) using the same format as the experience object reference handle for use in xAPI statements.	Level 3	
Experience Index	Learning Experience Metadata must use IRIs to reference controlled vocabularies stored on the DoD Linked Data and Schema Server when appropriate.	Level 3	
Experience Index	ARM services must require administrator privileges to create, update, or delete learning experience metadata.	Level 3	
Experience Index	ARM services must allow local administrators to specify and update which metadata attributes can be federated (i.e., shared) and which are only available locally.	Level 3	
Experience Index	ARM services must allow local administrators to update metadata attributes (e.g., quota numbers, contact information).	Level 3	
Experience Index	ARM services must allow local content owners to determine eligibility requirements for learning experiences they own.	Level 3	May include student content lists, instructor content lists, scenarios, student guides, etc.
Experience Index	ARM services must distinguish between local learning experiences (e.g., education and training activities) and those that are federated from external sources.	Level 3	
Experience Index	Learning experience registration services must distinguish between structured learning experiences, ancillary activities, and supporting (or related) content.	Level 3	
Experience Index	Learning experience registration services must be able to report inherited metadata for included activities and content.	Level 3	
Experience Index	Learning experience registration services must allow for the listing of a single SCORM/cmi package as a single learning experience.	Level 3	
Experience Index	Learning experience registration services must allow for the listing of a decomposable SCORM/cmi package as a collection of 'CourseSections' that have associated competencies and metadata for each uniquely launchable portion of the package.	Level 3	
Experience Index	ARM services must allow for the curation of a hierarchical "course" or content set from any allowable combination of activities and content which have not been otherwise packaged using SCORM or cmi5.	Level 3	
Experience Index	ARM services must provide a list of allowable activities or content types to be used with a learning experience.	Level 3	
Experience Index	ARM services must provide curated lists to connected TLA systems based on search criteria and filters built around the P2881 Learning Experience Metadata standard.	Level 3	
Experience Index	The experience index must report changes to learning activity metadata to the Enterprise Course Catalog (ECC).	Level 3	

3.2.3 Competency Management

Competence is a set of demonstrable behaviors, characteristics, and skills that enable the efficient performance of a job[1]. Competency-Based Learning (CBL) is a learning design model that focuses on the mastery of competencies required for a particular job. Each competency is broken down into the specific KSAOs required to perform a job at different levels of proficiency. To demonstrate competence, an individual or team must be able to perform (i.e., demonstrate) certain tasks or skills at a required level of proficiency.

Within the TLA, Sharable Competency Definitions (SCDs) describe the specific details, contexts, related standards, mastery levels, and credentials required to demonstrate the KSAOs necessary to perform a job in an operational environment. Competency frameworks define the relationships between RCDs. They are hierarchical, but a single RCD may be used across numerous frameworks (e.g., jobs, occupations) so a 'many-to-many' relationship between RCDs is required.

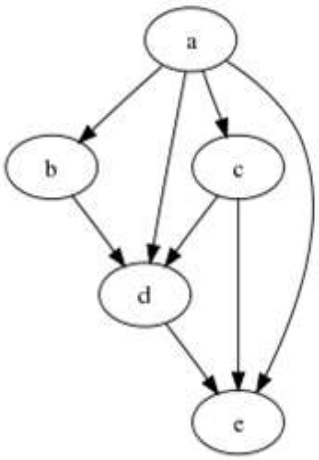

Figure 6. Competency Framework. Instantiated as a Directed Acyclic Graph

As shown in ***Figure 6***, this structure is known as a "Directed Acyclic Graph" and requires different data structures than traditional XML or relational databases. A graph database meets the TLA's requirements for semantic queries using nodes, edges, and properties to represent and store RCDs and their associated frameworks. The edges that connect each node (i.e., competency) are directional so that learners will never get caught within a closed loop as they progress through their career goals. The development of these models requires expertise in the science of learning as well as operational experience to accurately define each measure of competency, acceptable assessment strategies, and evidentiary requirements.

A high-level description of an RCD is shown in ***Figure 7***. The evidence for competence comes from interacting with different learning activities that have been instrumented with xAPI. Each KSAO element is mapped to evidentiary requirements to establish the criteria for *asserting* competence. For DoD, a department-wide Linked Data and Schema server provides shared vocabularies and alignment services to preserve semantic interoperability across the scope and breadth of DoD competencies and credentials.

Competency management is the process for evaluating learner performance and predicting proficiency levels against approved RCDs for individual's teams, and organizations. Within the DoD, an individual's learner data are currently stored in dozens of different systems encountered over the course of a career as they navigate through different schoolhouses, training environments, and Professional Military Education opportunities.

The TLA's federated LRSs (i.e., Noisy, Transactional, Authoritative), described in Section 3.2.1, enable a system of digital trust that provides auditability, privacy, and data integrity for the lifelong learning chain of evidence (i.e., raw learner performance data) used to assert proficiency levels for individuals or teams against one or more competency models. This approach maintains ownership and integrity of learner data while creating an audit trail that provides linkages to each authoritative source of learner data that a student has amassed throughout their career.

[1] White, R. W. (1959). Motivation reconsidered: The concept of competence. Psychological Review, 66(5), 297–333. https://doi.org/10.1037/h0040934

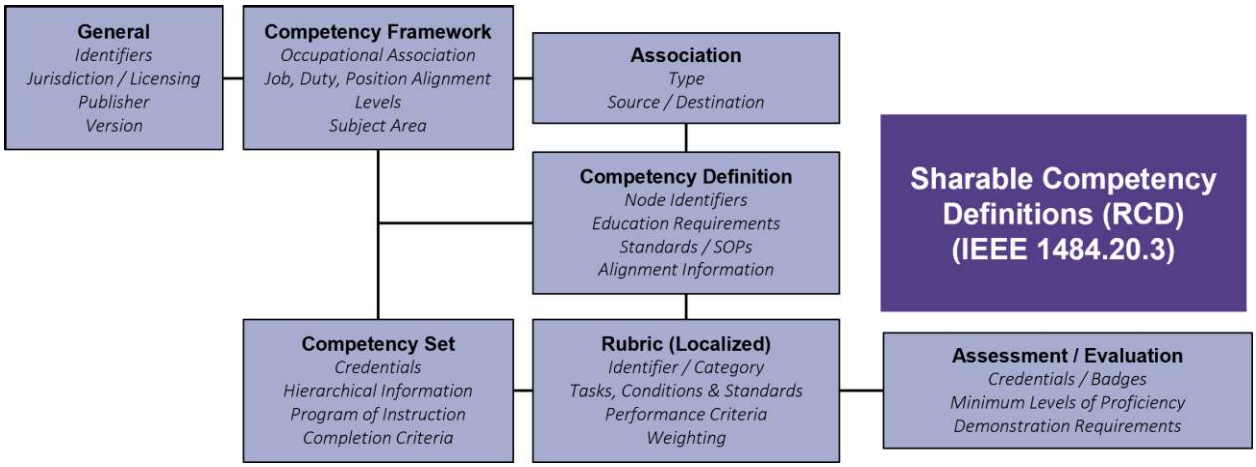

Figure 7. Sharable Competency Definitions in the TLA. *Competencies are defined by the IEEE 1484.20.3 Sharable Competency Definition (RCD) standard, which formalizes the way competencies, their interdependent relationships, and proficiency requirements are communicated to other TLA components.*

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Adjudication of learner performance (e.g., pass, fail, score) is done by the learning activity that generates the TLA MOM statements. Once sufficient evidence has been relayed to the Transactional LRS, the competency management system makes an "assertion" of competence. If the sequence of learning activities supports the conferral of a credential, additional criteria may be required to verify and validate that all requirements have been met prior to conferral. The Authoritative LRS includes signed evidentiary records related to a learner's awarded credentials (e.g., badges that represent course completions, certifications, degrees, or licenses required for different professional associations).

Figure 8 shows the TLA's competency management services and their dependency on other TLA data standards.

1) Learning activities generate xAPI statements and store them in the Noisy LRS.
2) Learning activities are described using IEEE P2881 metadata stored in the Experience Index.
3) The Noisy LRS stores xAPI statements generated from one or more learning activities.
4) The TLA MOM is an xAPI profile used to roll learner performance up into the key milestones associated with any learning activity.
5) TLA MOM statements are stored in the Transactional LRS. The Transactional LRS collects TLA MOM statements from one or more Noisy LRSs.

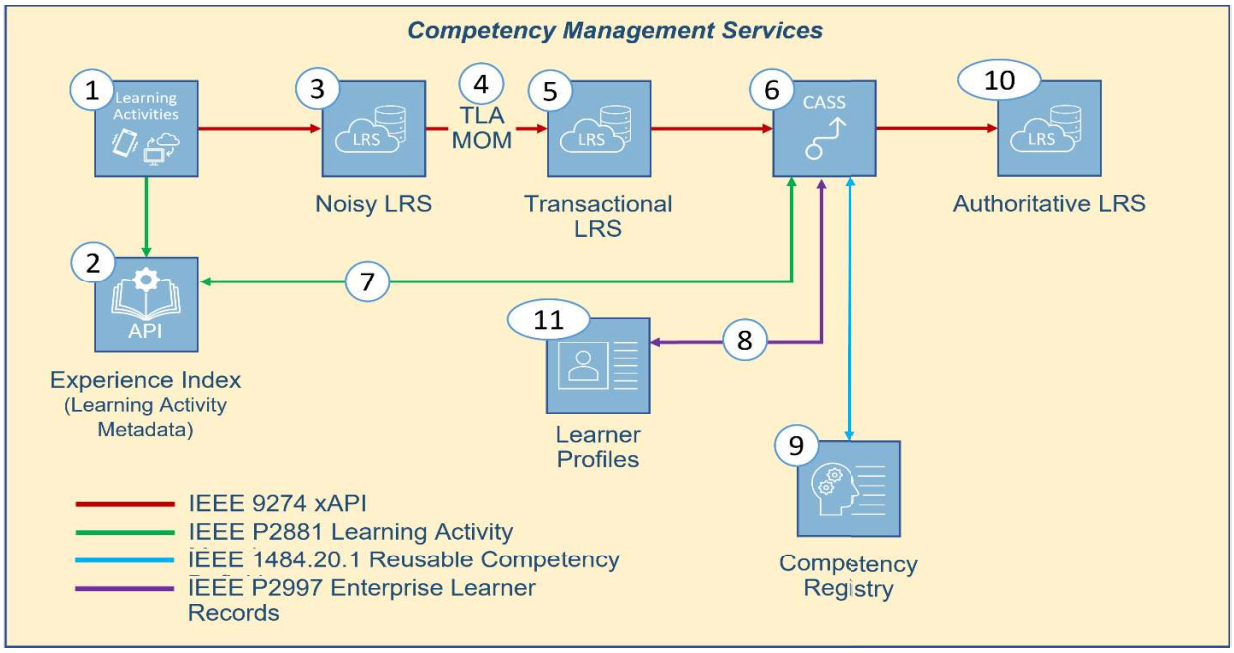

Figure 8. Competency Management Services. *TLA MOM statements are used by the TLA's competency management services to link individual learners, their learner profiles, and the activities generating xAPI statements with competencies located within the competency framework registry.*

6) A competency management system uses TLA MOM statements to make predictions about learner proficiency against defined competencies.
7) The competency management system imports P2881 metadata about the learning activity sending a TLA MOM statement using the unique Activity ID that populates the TLA MOM object field.
8) The competency management system imports the learner's profile using the unique user ID that populates the TLA MOM actor field. The learner profile is updated to reflect each learner's current state based on the data housed in the Transactional LRS.
9) The competency management system imports RCDs from the Competency Registry. It knows which competencies to import based on the alignment attributes included in the learning activity metadata.
10) As competency assertions are validated and credentials are conferred, they are stored in the Authoritative LRS. The learner profile is also updated with this information.
11) Learner profiles conform to the IEEE P2997 Standard for Enterprise Learner Records. They include linkages to the authoritative data repositories where an individual's raw learner data are stored.

Specific requirements for the competency management services are listed in ***Table 5*****.** The requirements for the related Competency Registry are listed in ***Table 6***. The requirements for the related Credential Registry are listed in ***Table 7***.

Table 5. Requirements for the Competency and Credential Management Services.

Header	Requirement	TLA CMM Level	Comments
Competency Framework			
Competency Framework	TLA Competency Frameworks must be developed IAW IEEE 1484.20.1 RCD model and the TLA Data Reference Model.	Level 3	
Competency Framework	Competency frameworks must be accessible via a URL.	Level 3	
Competency Framework	A competency framework must be expressed as a directed acyclic graph of competencies.	Level 3	This prevents a close loop scenario
Competency Framework	The local competency framework must differentiate between controlled and not controlled competency elements.	Level 3	Controlled elements managed by the local agency. Uncontrolled elements are linked or copied from another agency
Competency Framework	Competencies must be measurable. To be measurable they must be observable or able to be tested in some way.		
Competency Framework	Competency definitions must use IRIs to reference controlled vocabularies stored on the DoD Linked Data and Schema Server when appropriate.	Level 3	
Competency Framework	IRI assigned to competency elements shall be globally unique.	Level 3	
Competency Framework	Each competency definition within a competency framework must use a unique competency identifier.	Level 3	
Competency Framework	Local competency frameworks must be able to add additional criteria (e.g., board review, signoff) to confer a credential over and above the proxied competency elements.	Level 3	
Competency Framework	Local competency frameworks must be able to add additional competency elements to any competency definition.	Level 3	
Competency Framework	Local competency frameworks must be able to add additional competencies to any competency framework.	Level 3	
Competency Framework	Controlled elements shall implement IRI as references from a block registered with the competency and credential registries only.	Level 3	
Competency Management			
Competency Management	The competency management service must generate xAPI statements that are conformant with the TLA Competency Management MOM profile.	Level 3	
Competency Management	The competency management service must connect to the Experience Index to access the metadata about the learning activity that generates each MOM statement.	Level 3	
Competency Management	The competency management service must connect to the Learner Profile to access each learner's previous learning records.	Level 3	

Header	Requirement	TLA CMM Level	Comments
Competency Framework			
Competency Management	The competency management service must be able to connect to a competency registry to read in one or more competencies.	Level 3	
Competency Management	The competency management service must be able to calculate learner proficiency against related RCDs.	Level 3	
Competency Management	Learner competence must be calculated based on evaluation of evidence from xAPI statements generated by edge system learning record providers.	Level 3	
Competency Management	The competency management service must evaluate the trust level of the device, learning activity, or human generating the evidence record.	Level 3	
Competency Management	Proficiency ratings for establishing competence must consider the level of mastery required to complete each learning activity and any previous learning experiences the learner has completed.	Level 3	Previous learning experiences are contained in the learner profile
Competency Management	Proficiency ratings for establishing competence must consider the cognitive alignment of the activity generating the evidence and the cognitive requirements of the RCD.	Level 3	
Competency Management	Proficiency ratings for establishing competence must consider a decay function for time elapsed between evidence received for some competencies.	Level 3	
Competency Management	Proficiency ratings for establishing competence must consider a decay function for repetition for some competencies.	Level 3	
Competency Management	The competency management service must consider proficiency levels of subordinate competencies (e.g., those with “sine qua non” or “quod erat demonstrandum” relationships).	Level 3	
Skill decay			
Competency Management - Skill decay	The competency management service must track the requirement for continuing education requirements for maintaining proficiency for conferred credentials.	Level 4	Might be separate service, Learning Event Management Listener
Competency Management - Skill decay	The competency management service must allow admins, OIC/S, content managers, and Curriculum managers to set proficiency timers and content requirements to a user interest group or user.	Level 4	Might be separate service, Learning Event Management Listener
Credential Management Service			
Credential Management Service	The credential management service must use names for credentials controlled by the credential registry.	Level 3	
Credential Management Service	Credentials must only be conferred when digitally signed by an approved authority.	Level 3	

Header	Requirement	TLA CMM Level	Comments
Competency Framework			
Credential Management Service	Credentials must include a discoverable public key for portable badging/certificates.	Level 3	
Credential Management Service	Credentials must store the digitally signed conferral via xAPI message in the authoritative LRS.	Level 3	
Credential Management Service	The credential management service must maintain the digitally signed record for a minimum of 15 years.	Level 3	
Credential Management Service	Credentials must include awards for locally controlled credentialing standards as longs as the awarding authorities are part of the local user/identity management.	Level 3	Ships assign "SWO" pins, but the standards are centrally managed
Credential Management Service	The credential management service must enable local authorities to add additional requirements to an externally defined credential for local qualification.	Level 3	
Credential Management Service	Credential definitions must include all related competencies, standards, contexts, levels of mastery or other criteria needed for conferral (e.g., all bills paid, final board).	Level 3	
Credential Management Service	Credentials must be able to use proxies for credentials that may not have complete competency mappings.	Level 3	Proxies are any educational framework that a credential is aligned to

Table 6. Requirements for the Competency Registry

Header	Requirement	TLA CMM Level	Comments
Competency Registry			
Competency Registry	A competency registry must be used to store and share competency frameworks with connected systems.	Level 3	
Competency Registry	A local competency registry must conform to the IEEE 1484.20.1 RCD standard and the TLA Data Reference model.	Level 3	
Competency Registry	The competency registry must support the search and discovery of one or more RCD attributes across different competency frameworks within the registry.	Level 3	
Competency Registry	The competency registry must support the alignment and comparison of multiple different competency frameworks.	Level 3	
Competency Registry	The competency registry must support RCD conformant competency management services to push/pull competency data between connected systems.	Level 3	
Competency Registry	The competency registry must support the search and discovery of competencies based on jobs, skills, credentials, or career paths.	Level 3	Use JDX and CTDL
Competency Registry	The competency registry must support configuration management and versioning of competency frameworks and their associated competency definitions.	Level 3	

Competency Registry	The competency registry must generate a notification alert when competencies are updated.	Level 3	
Competency Registry	The competency registry must connect and share competency data with other competency registries upon receipt of formal approvals.	Level 3	
Competency Registry	The competency registry must support role-based permissions.	Level 3	
Competency Registry	The competency registry must support distributed authoring, updates, and maintenance of competency definitions and competency frameworks.	Level 3	Support different centers of excellence to own different frameworks
Competency Registry	The competency registry shall preserve the naming conventions and the logical locations of the controlling institution for competencies and competency framework fragments.	Level 3	
Credential Registry	The credential registry shall preserve the naming conventions and the logical locations of the controlling institution for competencies and competency framework fragments.	Level 3	
Credential Registry	The credential registry shall log all locations with authorized officials that can confer a credential (which may extend past the agency maintaining the standard definition).	Level 3	
Competency Registry	The competency registry must be able to link competencies to jobs, career paths, and other manpower & personal systems.	Level 4	
Competency Registry	The competency registry must support harmonization and alignment with a global DoD competency registry.	Level 4	

Table 7. Requirements for the Competency Registry.

Header	Requirement	TLA CMM Level	Comments
Credential Registry			
Credential Registry	A credential registry must be used to store and share credential definitions and their related competencies.	Level 3	May be part of the competency registry or can point a 3rd party system
Credential Registry	The credential registry must use the Credential Transparency Description Language (CTDL) to define credentials and related competencies.	Level 3	
Credential Registry	The credential registry must decompose credentials into unique RCD competency identifiers with accessible links to their definitions.	Level 3	Might be the competency registry, or defined competencies hosted by an industry association
Credential Registry	The credential registry must support the search and discovery of credentials based on jobs, skills, credentials, or career paths.	Level 3	

Credential Registry	The credential registry must support configuration management and versioning of credential definitions and their associated competencies.	Level 3	
Credential Registry	The credential registry must generate a notification alert when credentials are updated.	Level 3	
Credential Registry	The credential registry must connect and share credential definitions with other connected systems upon receipt of formal approvals.	Level 3	
Credential Registry	The credential registry must support role-based permissions.	Level 3	
Credential Registry	The credential registry must support distributed authoring, updates, and maintenance of competency definitions and competency frameworks.	Level 3	Support centers of excellence to own different frameworks
Credential Registry	The competency registry must support harmonization and alignment with a global DoD competency registry.	Level 4	

3.2.4 Learner Profile Management

The purpose of the learner profile is to aggregate and manage learner data generated from connected systems within an organization for sharing with other systems or organizations that require it. It includes information about learning experiences, competencies, credentials, and employment history, as well as authoritative identification of the organization that is writing to a learner's record. More importantly, it includes local and global attributes about the learner that can be shared across connected systems using the Learner API to improve analytics, promote adaptive instruction, and tie learning and development activities to Key Performance Indicators in the workplace.

The learner profile conforms to the IEEE P2997 Standard for Enterprise Learner Records. This standard defines the learner profile's underlying data model and API to be used when communicating learner records back and forth between connected systems across the enterprise. Within each learner profile, linkages to the evidentiary chains of learner data enable different views of the data to support different users in the organization. The aggregation of these data is critical to support future Artificial Intelligence (AI) and Machine Learning applications that support key elements of the human capital supply chain. For example, AI-enabled software platforms such as Intelligent Tutors and Adaptive Instructional Systems may require the raw data a learning activity generates; while other systems, such as career field management tools, may use completion data from activities to automate the comparison of learner paths and learner velocity across all learning activities in pursuit of a career.

Learner profile management includes the administration, delivery, reporting, and assessment of a learner's progression through the myriad of different learning experiences they encounter. TLA MOM messages are used to define the context around the different learning activities that a learner completes and links each learner to their historical performance evidence that is stored within different systems across the DoD enterprise. The learner profile parses the TLA MOM statements to track learning activities, competencies, credentials, and other learning events that an individual has experienced over time. The TLA MOM provides linkages to learner performance data (i.e., evidence of learner performance), descriptions of learning activities that generate this evidence, and the definition of competencies or credentials that each learning experience is aligned to.

Specific requirements for the learner profile management services are listed in ***Table 8.***

Table 8. Requirements for the Leaner Profile Data Store.

Header	Requirement	TLA CMM Level	Comments
Learner profile			
Learner Profile	A learner profile must manage the lifelong learning history for all learners within an organization.	Level 3	
Learner Profile	The learner profile must only collect data from authoritative sources.	Level 3	
Learner Profile	The learner profile must be able to process and store learner records based on TLA MOM statements being received from connected systems.	Level 3	Each learner profile contains numerous learner records about an individual
Learner Profile	The learner profile must be able to cache and store learner state data.	Level 3	
Learner Profile	The learner profile must be able to interface with the TLA's competency management services.		
Learner Profile	The learner profile must be able to list competencies, credentials, and/or job/duty/gigs as learner goals and learner sub-goals.	Level 3	
Learner Profile	The learner profile must be able to identify learning experiences (e.g., courses) that have been assigned.	Level 3	
Learner Profile	The learner profile must be able to link learning experiences to their listing in the Experience Index.	Level 3	
Learner Profile	The learner profile must indicate whether assigned learning experiences have been attempted and their completion status.	Level 3	
Learner Profile	The learner profile must support assigned learning experiences that are not learner goals.	Level 3	e.g., Extremism stand-down
Learner Profile	The learner profile shall associate assigned learning experiences with learner goals when possible.	Level 3	
Learner Profile	The learner profile shall capture learner state as they work to complete their assigned learning experiences.	Level 3	
Learner Profile	The learner profile must be able to track and manage completed learning experiences that are not assigned.	Level 3	
Learner Profile	The learner profile must be able to track and manage completed learning experiences that are not scheduled.	Level 3	
Learner Profile	The learner profile must be able to track and manage completed learning experiences that are not aligned with learner goals.	Level 3	
Learner Profile	The learner profile must be able to contain user settable criteria for purging completed goals, tasks and events from the archive.	Level 3	
Learner Profile Chains of Evidence			
Learner Profile Chains of Evidence	The learner profile shall preserve linkages to evidentiary records being stored in external 'transactional' or 'authoritative' LRSs for conferred competencies or credentials.	Level 3	

Header	Requirement	TLA CMM Level	Comments
Learner Profile Chains of Evidence	The learner profile must be able to preserve locally designated learner data.	Level 3	
Learner Profile Chains of Evidence	The learner profile must preserve globally relevant learner data.	Level 3	
Learner Profile Chains of Evidence	The learner profile must report changes to globally relevant learner data to the ELRR.	Level 3	
Learner Profile Chains of Evidence	The learner profile must correlate each new learner being entered into the system with the individual's learner data contained within the ELRR.	Level 3	
Learner Profile Chains of Evidence	The learner profile must link competencies and credentials to definitions contained in competency or credential registries.	Level 3	
Learner Profile Chains of Evidence	The learner profile must integrate competency management services for reporting of competencies, credentials and de-credentials.	Level 3	
Learner Profile Chains of Evidence	The learner profile must update the ELRR with competency and credential updates for each learner.	Level 3	
Learner Profile Chains of Evidence	The learner profile must update the ELRR with Unit Identification Code of issuing command for any conferred competencies or credentials.	Level 3	
Learner Profile Chains of Evidence	The learner competency and credential reporting and auditing services shall be able to disambiguate local learner profile identity keys to the globally unique identity.	Level 3	
Learner Profile – Learner Records Management			
Learner Profile – Learner Records Management	The learner profile must maintain a list of locally asserted competencies and effective dates within a single TLA enclave.	Level 3	
Learner Profile – Learner Records Management	The learner profile must report locally conferred credentials and effective dates to the ELRR using the Learner API.	Level 3	
Learner Profile – Learner Records Management	The learner profile must be able to store user specified attribute data defining learner preferences.	Level 3	
Learner Profile – Learner Records Management	The learner profile must be able to assign learner personas (aliases).	Level 3	
Learner Profile – Learner Records Management	The learner profile must maintain a record of aptitude definitions.	Level 3	

Header	Requirement	TLA CMM Level	Comments
Learner Profile – Learner Records Management	The learner profile must support policy-based access control (PBAC).	Level 3	
Learner Profile – Learner Records Management	The learner profile must allow for the creation, retrieval, update, and temporary deletion (from search indices) of individual learner records.	Level 3	
Learner Profile – Learner Records Management	The learner profile must maintain a mechanism to prevent hacking/loss of data integrity.	Level 3	
Learner Profile – Learner Records Management	Deleted learner records shall be recoverable/auditable for at least 15 years.	Level 3	
Learner Profile – Learner Records Management	The learner profile must maintain an auditable log of changes.	Level 3	
Learner Profile – Learner Records Management	The learner profile must provide for housekeeping of learner goals (e.g., competencies), activities, and milestones (e.g., credentials) that have been completed.	Level 3	
Learner Profile – Learner Records Management	The learner profile must indicate learning activities (e.g., courses) that have not been closed out with completed, terminated, or abandoned.	Level 3	
Learner Profile – Learner Records Management	The learner profile must be able to update learner goals that have been satisfied.	Level 3	Based on interface with Competency system, may be separate listener with decision logic
Learner Profile – Learner Records Management	The learner profile must be able to associate learner goals with competencies via a unique identifier for each competency.	Level 3	
Learner Profile – Learner Records Management	The learner profile must be able to list learning activities completed without goals.	Level 3	
Learner Profile - Goal Setting			
Learner Profile - Goal Setting	LEM services shall allow selection of one or more learner goals at an arbitrary level from within a selected competency framework.	Level 3	Requires integration with competency mgt service
Learner Profile - Goal Setting	The learner profile must allow selected learner goals to be assigned a priority.	Level 3	
Learner Profile - Goal Setting	Selected leaner goals shall be stored persistently in the local learner profile until achieved.	Level 3	
Learner Profile - Goal Setting	LEM services shall allow an OICS to assign learning goals or learning activities to a learner or identity group.	Level 3	

Header	Requirement	TLA CMM Level	Comments
Learner Profile - Goal Setting	LEM services shall allow for goals that are objective: screen/select/promote requirements, Jobs, Credentials, or competences at any level.	Level 4	

3.2.5 Identity Management

From a digital learning perspective, Identity, Credentialing, and Access Management (ICAM) enhances DoD's ability to track, manage, and optimize lifelong learning. ICAM enables DoD to link an individual's unique identity to education and training records created and stored across various DoD schools and training sites.

Identity information for the DoD community is managed through the Defense Manpower Data Center (DMDC). It operates the Defense Enrollment Eligibility Reporting System (DEERS), which includes the Person Data Repository (PDR). PDR is the primary identity attribute repository for PKI certificates for all DoD persons, including military, civilian, and contractors. DoD's Common Access Card (CAC) combines PKI with a physical ID card, and CACs have become the cornerstone of trust for identifying and authorizing access to DoD personnel.

When using digital learning content, tools, systems, or services that generate xAPI data, the "Actor" field should be traceable back to a learner's DoD ID number. The recommended solution is to use the DoD ID as the "Name" property under the Actor's "Account" property. There is no specific recommendation on the "HomePage" property other than making sure it is under DoD control. No Personally Identifiable Information (PII) under the Actor property should be provided in any xAPI statement.

The DoD ID number is not considered PII if relevant security procedures for the user's organization are followed. The DoD ID Number was historically used by DoD information systems to facilitate machine-to-machine communications and to authenticate digital signatures. However, the DoD ID Number does not constitute any level of authority to act on that individual's behalf. In other words, as detailed in DoD Instruction 1000.30 ("Reduction of Social Security Number Use Within DoD"), exposure of the DoD ID Number shall not be considered a breach when used as a part of a DoD business function.

User and Identity management works closely with the TLA data and services in either the core, or from edge systems. Detailed requirements are listed in ***Table 9*.**

Table 9. Detailed Requirements for Identity Management.

Header	Requirement	TLA CMM Level	Comments
Roles and Permissions			
Roles and Permissions	TLA compliant systems must enable policy-based access control (PBAC).	Level 2	
Roles and Permissions	Administrator level permissions must be able to access and modify user, content, service configuration, activity, resource, and competency service data.	Level 2	
Roles and Permissions	Administrator privileges must include CRUD permissions by segment for each of the data stores (Experience Index, LRS, Learner Profile).	Level 2	
Roles and Permissions	TLA compliant systems must enable login with learner level privileges.	Level 2	

Header	Requirement	TLA CMM Level	Comments
Roles and Permissions	The learner must be able to select, deselect and prioritize goals (Jobs, credentials, or competencies).	Level 2	
Roles and Permissions	The learner must be able to select current scheduled courses.	Level 2	
Roles and Permissions	The learner must be able to manage (CRUD) curated experience lists.	Level 2	
Roles and Permissions	The learner must allow for launching of current selected experiences, curated lists, or assigned courses.	Level 2	
Roles and Permissions	The learner must be able to search the Enterprise Course Catalog.	Level 2	
Roles and Permissions	The learner must be able to filter and search the local experience index.	Level 2	
Roles and Permissions	The learner must be able to view learner state information from the leaner profile.	Level 2	
Roles and Permissions	The learner must be able to review their personal performance data.	Level 2	
Roles and Permissions	TLA compliant systems must enable login with OICS level privileges.	Level 2	
Roles and Permissions	OICS level permissions must allow for logging observed learning experiences for assigned learners as complete-satisfactory, attempted, complete-unsatisfactory.	Level 2	
Roles and Permissions	OICS level permissions must allow for reviewing progress toward goal, current grades, and state for assigned learners.	Level 2	
Roles and Permissions	OICS level permissions must allow the review of assigned learner performance for assigned activities.	Level 2	
Roles and Permissions	OICS level permission must allow for review of alerts and notifications sent to assigned learners.	Level 2	
Roles and Permissions	TLA compliant systems must enable login with Competency Management Service level privileges.	Level 2	
Roles and Permissions	The Competency Management Service must be able to create, read, update, delete competency definition objects and relationships for assigned competency frameworks.	Level 2	
Roles and Permissions	The Competency Management Service must be able to create, read, update, delete links between competency definition objects from the competency framework for each credential.	Level 2	
Roles and Permissions	The Competency Management Service must be able to create, read, update, delete job, duty, gigs and competency frameworks.	Level 2	
Roles and Permissions	TLA compliant systems must enable login with Experience manager level privileges.	Level 2	
Roles and Permissions	The experience manager must be able to register new activities, content, or content types for a learning activity.	Level 2	
Roles and Permissions	The experience manager must be able to assign and attribute new activities and content for learners to experience.	Level 2	
Roles and Permissions	The experience manager must be able to register activities and content from within or external to the enclave.	Level 2	

Header	Requirement	TLA CMM Level	Comments
Roles and Permissions	The experience manager must be able to link content elements into courses or subordinate units (phases/modules/units).	Level 2	
Roles and Permissions	The curriculum manager must be able to register experiences to educational purpose for linked competencies.	Level 2	
Roles and Permissions	User permission profiles must be exportable to another federate instance of TLA compliant systems.	Level 2	
Privacy/PII Protection			
Privacy/PII protection	TLA compliant systems must be able to create a locally unique anonymized identity reference.	Level 3	
Privacy/PII protection	The anonymized identity token must be used to label "user" for all locally stored data (e.g., actor in xAPI statements).	Level 3	
Privacy/PII protection	TLA compliant systems must reconcile local identity to a globally resolvable identity (e.g., UUID/EDIPI) when transferring data between enclaves.	Level 3	
Privacy/PII protection	TLA compliant systems must use FIPS140-2 compliant encryption when transferring data between enclaves that includes globally resolvable identities.	Level 3	
Privacy/PII protection	Sensitive personal data protected by the privacy act must be only stored within or transmitted from the back-end identity management service.	Level 3	
Privacy/PII protection	TLA compliant systems must maintain a connection to a globally available authoritative data source for identity.	Level 3	
Privacy/PII protection	TLA compliant systems must employ globally unique Identities for third party identification verification (UUID, e.g., EDIPI).	Level 3	
Privacy/PII protection	TLA compliant systems must incorporate Identity Assurance level 2 in zero trust network solutions.	Level 3	
Privacy/PII protection	TLA compliant systems must be able to reconcile anonymized local identity used between enclaves.	Level 3	
Privacy/PII protection	TLA compliant databases must support “reserved” fields (e.g., grades) that cannot be updated by the user.	Level 3	
Privacy/PII protection	TLA compliant databases must support “protected” fields (e.g. grades) that cannot be viewed by the user.	Level 3	
Privacy/PII protection	TLA compliant systems must enable configurable privacy settings by function, database and data element (i.e., record) level.	Level 3	
Privacy/PII protection	TLA compliant systems shall have a mechanism to filter data exports or visualization based on privacy and user login settings.	Level 3	
Identity Groups			
Identity Groups	TLA compliant systems must be able to associate users with identity groups that will link data common to all users within that group.	Level 3	
Identity Groups	TLA identity groups must interface with the alert and notification system.	Level 3	
Identity Groups	The TLA identity groups must be discoverable in federations for determining applicability of learning event records.	Level 3	

Header	Requirement	TLA CMM Level	Comments
Identity Groups	Users must be able to create and subscribe to user interest groups.	Level 3	
Identity Groups	OICS and administrators must be able to create protected interest groups and assign users to them.	Level 3	Class creation
Identity Groups	OICS and administrators must be able to view records associated with all users in appended user groups.	Level 3	
User Data			
User Data	TLA compliant systems must include the use of single sign on solution to maintain automated user and role-based logins.	Level 3	
User Data	Edge Systems that support single sign on must be integrated with the core single sign on for user identity.	Level 3	
User Data	TLA complaint systems must be able to reconcile xAPI actor ID from edge systems.	Level 3	
User Data	Identity management services must be able to assign personal attribute data.	Level 3	DIV-2
User Data	Identity management services must be able to assign personas to a user.	Level 3	DIV-2
User Data	Identity management services must be able to assign privacy data to user records.	Level 3	
User Data	Identity management services must be able to reconcile UUID to person identity in back-end services.	Level 3	As applicable for 2019
User Data	Identity management services must be able to export a user record audit.	Level 3	
User Data	Identity management services must be able to implement dynamic multi-factor authentication.	Level 3	
User Data	Identity management services must be able to resolve internal identity tokens to a globally unique identity	Level 3	
User Data	The access policy manager must include local, regional and global business rules for data access.	Level 3	
User Data	User data must incorporate proper encryption for identity tokens and personal data.	Level 3	
User Data	User data must be resolvable between individuals and identity groups, and between multiple local identity tokens.	Level 3	

3.2.6 Virtualization Management

Virtualization often includes computer-generated versions of hardware, operating systems, storage devices, and more. This allows organizations to partition a single physical computer or server into several virtual machines. Each virtual machine can then interact independently and run different operating systems or applications while sharing the resources of a single host machine.

By creating multiple resources from a single computer or server, virtualization improves scalability and workloads while resulting in the use of fewer overall servers, less energy consumption, and less infrastructure costs and maintenance.

Table 10 lists the detailed requirements. Aggregate System-level performance requirements are also located here.

Table 10. Detailed requirements for Virtualization Services.

Header	Requirement	TLA CMM Level	Comments
Virtualization Management Service			
Virtualization Management Service	Virtualization services must utilize back-end services for dynamic endpoint management between components, data, and services.	Level 1	
Virtualization Management Service	Virtualization services must enable federated data services between enclaves.	Level 1	
Virtualization Management Service	Virtualization services must leverage trusts between back-end identity management services.	Level 1	
Virtualization Management Service	Virtualization services must provide a registration service for all enclave and federated data sources to manage IRI blocks, permission holders, and path name/URL/IP for resources.	Level 1	
Virtualization Management Service	Virtualization services must utilize mechanisms to track and update network and physical hosting of virtual private networks, computational resources, and containers in a contracted Platform as a service (cloud) environment.	Level 1	
Virtualization Management Service	Virtualization services must verify core data and services (competency and learner profile, LRS/Learning event, management, experience catalog, Competency Management Service, competency framework, learner profile) are available to conduct training session.	Level 1	
Virtualization Management Service	TLA systems must have sufficient load balancing, failover, and redundancy.	Level 1	
Virtualization Management Service	TLA systems must have data backups to prevent loss of data even in event of core data or service failure.	Level 1	
Virtualization Management Service	TLA systems must have sufficient memory and storage resources to maintain 10 years of credential trust audit trail (i.e., preservation of reviews and awards).	Level 1	
Virtualization Management Service	TLA systems must have sufficient memory and storage resources to maintain evidentiary records for competency in accordance with local regulations.	Level 1	
Virtualization Management Service	TLA systems must have sufficient memory and computational power for 90% peak duty cycle for 120% of projected user base.	Level 1	
Virtualization Management Service	TLA systems must have a security audit system that logs server down time, VM load shifting, attempted communication time outs, unauthorized users, or devices, and rejected xAPI statements.	Level 1	
Virtualization Management Service	TLA systems must implement NIST 800 controls for identity, access, zero trust device management, behavioral controls and authentication.	Level 1	
Interfaces			
Interfaces	TLA systems must use existing back-end services (e.g., LDAP/Active Directory) for identity management.	Level 1	

Header	Requirement	TLA CMM Level	Comments
Interfaces	TLA systems must provide an access point to Virtual Private Cloud resources for client devices in the federation.	Level 1	
Interfaces	TLA systems must comply with cybersecurity policies for the installed enclave.	Level 1	

3.3 Internal Interface Requirements

3.3.1 Experience Application Program Interface (xAPI)

Table 11. Master Object Model Requirements.

Header	Requirement	TLA CMM Level	Comments
MOM Profile			
MOM Profile	TLA compliant enclave and federation must be able to process learner state IAW the TLA MOM as received from edge devices.	Level 2	
MOM Profile	TLA compliant enclave and federation must be able to process learner state IAW the TLA MOM as received from the alert and notification system.	Level 2	
MOM Profile	TLA compliant enclave and federation must be able to process learner state IAW the TLA MOM as received from a user interface.	Level 2	
MOM Profile	TLA compliant core services and data must process performance evidence from actionable information IAW the TLA MOM.	Level 2	
MOM Profile	TLA compliant enclave and federation must be able to process learner state IAW the TLA MOM as detected from interaction with TLA data resources and services.	Level 2	
MOM Profile	TLA compliant system must process learner career state IAW the TLA MOM as received from user interfaces.	Level 4	
MOM Profile	TLA compliant system must process learner career state IAW the TLA MOM as received from federated HR systems.	Level 4	

3.3.2 Representational State Transfer (REST)

Internal messages to TLA compliant components should comply with the IEEE 9274.1.1 xAPI standard. Systems should use secure HyperText Transfer Protocol (HTTPS), with communication using transport layer Security (TLS), over TCP Port 443. Components and services with core facing interfaces should look at either xAPI learning record providers and/or learning record consumers (LRP/LRC) from a message protocol perspective. xAPI over REST is the only internal data format exchanged.

3.3.3 Messaging Topology

The internal messaging topology should be configured such that an inbound, or internally generated, xAPI message can be relayed to all interested (i.e., “subscribing”, if using Publish/Subscribe message services) core learning record consumers before being deposited in the Learning Record Store, so that the originating actor is preserved for all components interested in the message. This can be accomplished in several ways, depending on the specific LRS and messaging service used. Effectively, xAPI communicates along a logical parallel data bus.

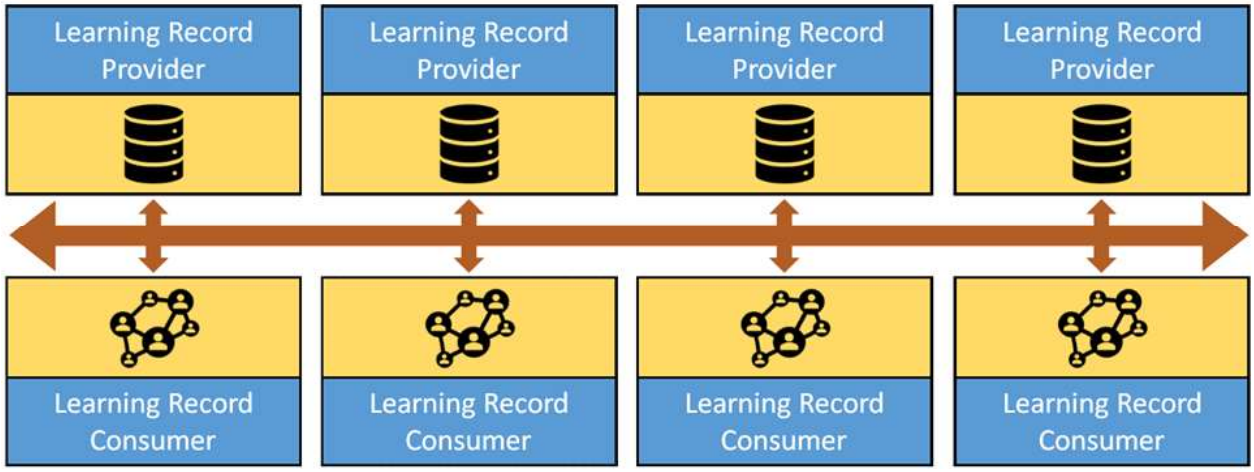

Figure 9. Logical Parallel Bus of LRP and LRC. *All TLA compliant components look like LRC and/or LRP in xAPI exchanges. Messaging systems should have internal communications that preserve the original actor ID, and external connections that enable jumping off from dissimilar internal communication systems.*

From a systems security and stability perspective, every data transaction in the future learning ecosystem should look like a singular Learning Record Provider/Learning Record consumer (***Figure 9***). This makes the overall system resilient and fault tolerant, as well as easier to test and extend/port/scale over time in response to technology change. It is also necessary to maintain the learner providence of messages so that complete learner analytics are possible. The logical parallel bus approach ensures that the learner is never more than one transaction away from archival, even if the message is intended to flow to multiple locations.

3.4 External Interface Requirements

3.4.1 Learning Activities

TLA edge devices include all learning record providers that create learning or assessment opportunities. The TLA supports any edge system topology if the boundary is compliant with the TLA internal interfaces and business rules. External topologies within the ecosystem may include fully TLA compliant devices, server-based systems that manage their own client communications and report compliant xAPI from the server, or systems with their own LRS and profiles, with gateway systems on the boundary to convert internal data to TLA compliant data. Detailed Requirements are listed in ***Table 12*****.**

Table 12. Edge Device Requirements.

Header	Requirement	TLA CMM Level	Comments
Learning Device Requirements			
Learning Activity Requirements	Learning experiences (e.g., education, training activities) must have a boundary to the TLA core that conforms to the MOM profile for xAPI messages.	Level 1	
Learning Activity Requirements	Learning experience (e.g., education, training activities) content packaging must use the lowest level grain size for independent "bookmarks", performance reporting, and catalog registration metadata.	Level 1	
Learning Activity Requirements	Learning experience (e.g., education, training activities) boundaries must synchronize user identity with core identity management.	Level 1	

Header	Requirement	TLA CMM Level	Comments
Learning Activity Requirements	Learning experiences (e.g., education, training activities) must be registered with the Experience Index as activities and resources.	Level 1	
Learning Activity Requirements	Learning experiences (e.g., education, training activities) must include mechanisms to export local corpora of experiences for catalog registry.	Level 1	
Learning Activity Requirements	Learning experiences (e.g., education, training activities) must comply with cybersecurity requirements for the local enclave.	Level 1	
Learning Activity Requirements	"Bring Your Own" learning experiences (e.g., education, training activities) must comply with zero trust risk architectures.	Level 1	
Learning Activity Requirements	Learning experiences (e.g., education, training activities) must be deployed as LTI Tools in conjunction with the launch features of the LEM.	Level 1	
Learning Activity Requirements	Learning experiences (e.g., education, training activities) with locally installed content shall synchronize that content identification with the Experience Index.	Level 1	
Learning Activity Requirements	Learning experiences (e.g., education, training activities) must use a Noisy LRS if they generate xAPI that does not conform to the MOM profile.	Level 1	
Learning Activity Requirements	Learning experiences (e.g., education, training activities) with their own xAPI profile shall register that profile with the xAPI Profile Server.	Level 1	
Learning Activity Requirements	Learning experience (e.g., education, training activities) boundaries must register endpoints to Transactional LRS as part of device registration.	Level 1	
Learning Activity Requirements	All performance adjudication shall be performed outside of the core boundary.	Level 1	
Learning Activity Requirements	Learning experiences (e.g., education, training activities) that perform fine grained performance adaptation shall be registered at the highest level and report lower-level results as required.	Level 1	
Learning Activity Requirements	Learning experiences (e.g., education, training activities) must use a "Noisy" LRS to segregate data for device specific profiles.	Level 1	
Learning Activity Requirements	All xAPI profiles, including those that store data in Noisy LRSs, must comply with IEEE P9274.2.1 (the xAPI Profile specification).	Level 1	

3.4.2 User Interfaces

The TLA policy framework assumes that each service group (Activity Registry and Resource Management, Competency Management, and Learning Event Management) will have its own organic user interfaces, but that a single sign-on capability enabled from a common portal will streamline user access to comply with the concept-of-execution for the entire TLA instance as a federation of components. The portal operates through redirects and filters and serves as the access point to core services, edge decision support services, and potentially a launch context for web-based clients of learning devices.

Table 13. Requirements for Alerts and Notifications.

Header	Requirement	TLA CMM Level	Comments
Alerts and Notifications			
Alerts and Notifications	Alerts and notifications applicable to the user must be provided across connected TLA systems.	Level 4	
Alerts and Notifications	Alerts must require acknowledgement to clear.	Level 4	
Alerts and Notifications	The maximum retention of notifications must be established by the administrator.	Level 4	
Alerts and Notifications	Conferral of a credential must create a notification that a learner is in maintenance phase.	Level 4	
Alerts and Notifications	A Just in time training requirement inserted by a content manager must create an alert.	Level 4	
Alerts and Notifications	A regulatory or mandatory training requirement must create an alert.	Level 4	
Alerts and Notifications	An impending (~30 days) proficiency requirement must create an alert.	Level 4	
Alerts and Notifications	Changes to a previously viewed activity/content element must generate a notification.	Level 4	
Alerts and Notifications	If the resource is an OIC/S, a notification must be sent to that system user of their schedule.	Level 4	
Alerts and Notifications	Updates to experiences listed with local authorities must generate notification alerts to other TLA systems that subscribe to AR notifications.	Level 4	
Alerts and Notifications	Changes to a previously completed credential or in work competency/credential must generate a notification.	Level 4	
Alerts and Notifications	Updates to user information must create a notification to the user, and any OICS, or administrators with interest groups the user is assigned.	Level 4	
Alerts and Notifications	Notifications from the Competency Management Service must be sent to assigned learners with or working toward those competencies.	Level 4	
Alerts and Notifications	OICS must be able to send notifications to assigned user group learners.	Level 4	
Alerts and Notifications	Content managers must be able to advertise activities/content to sets of learners as notifications.	Level 4	
Alerts and Notifications	Users must be able to send notifications requesting mentors or tutors in topics.	Level 4	
Alerts and Notifications	Notifications and alerts must be able to federate across enclaves and agency domains.	Level 4	
Alerts and Notifications	Learner Requested courses must generate a notification to the assigned OICS.	Level 4	
Alerts and Notifications	Assigned learning activities must generate a notification to the associated learner.	Level 4	

3.4.3 Conformance Suite

TLA compliant systems must prove compliance by using conformance testing tools or services. TLA core systems shall comply with the MOM profile. Additional edge devices may have their own profiles, which can include “noisy” data with additional detail. Profiles support clean data simulation, use for xAPI best

practices, and may support decision logic or mapping between edge systems and boundaries to the core systems using the MOM profile.

Table 14. xAPI Profile Requirements.

Header	Requirement	TLA CMM Level	Comments
xAPI Profiles and Fields			
xAPI Profiles and Fields	TLA compliant systems must use validated xAPI concepts and profiles located on the xAPI profile server.	Level 1	
xAPI Profiles and Fields	The xAPI profiles of TLA compliant edge systems must include templates for all learning content, activity, and experience types applicable to the federate instance.	Level 1	
xAPI Profiles and Fields	The xAPI profiles of TLA compliant edge systems must include a complete object life cycle (from requirement, to selection, launch, work, and closeout) for each training technology type.	Level 1	
xAPI Profiles and Fields	TLA compliant edge systems must use validated xAPI profiles and concepts.	Level 1	
xAPI Profiles and Fields	TLA compliant core systems must use validated TLA concepts and the MOM xAPI profile.	Level 2	
xAPI Profiles and Fields	A TLA compliant system's xAPI profile must include data elements required to audit evidence of assertions of competence.	Level 2	
xAPI Profiles and Fields	A TLA compliant system's xAPI profile must include data elements to specify context under which a work event was experienced.	Level 2	
xAPI Profiles and Fields	A TLA compliant system's xAPI profile must include data elements to specify context under which an assessment was evaluated.	Level 2	
xAPI Profiles and Fields	A TLA compliant system's xAPI profile must include data elements to specify standard context under which an OJT event was experienced.	Level 2	
xAPI Profiles and Fields	A 'TLA compliant systems xAPI profile must include data elements to specify areas not achieved during exams (i.e. grade<100%, what was missed?).	Level 2	
xAPI Profiles and Fields	A TLA compliant system's xAPI profiles must include fields for simulator and lab exercises to capture details of learner's role, actual scenarios employed, and competencies triggered as paradata.	Level 3	

The TLA ecosystem relies on several DoD level data repositories to work and can leverage non-education and training databases to provide additional capabilities for education and training.

3.4.4 DoD Schema Control

The JavaScript Object Notation (JSON) provides for the use of linked data, which must trace back to the DoD's Linked Data and Schema Server. This capability is in the process of being built and is not fully operational at this time.

Schema control and linked data are essential to preserving the chains of custody and evidence without performance degradation that comes from retransmitting the entire list every time. Linked data provides for data integrity, and disaster resiliency, and the schema repository anchors the linked data strategy.

Table 15. Semantic Schema Server Requirements.

Header	Requirement	TLA CMM Level	Comments
Semantic web			
Semantic Web	The linked data and schema server must be used to ensure consistency of controlled vocabularies that are used to populate TLA data models.	Level 3	
Semantic Web	The linked data and schema server must be able to assign, query and resolve namespaces.	Level 3	
Semantic Web	The linked data and schema server must support use of JSON-LD.	Level 3	
Semantic Web	The linked data and schema server must support data integrity and non-repudiation of asserted competencies and conferred credentials.	Level 3	
Semantic Web	The linked data and schema server must support semantic standardization of metadata regarding learning activities, assessment activities, competencies, credentials, and evidence of competencies and credentials stored as xAPI records.	Level 3	
Semantic Web	The linked data and schema server must allow for at least three tiers of data linking, a global standardized dataset, an intermediate data set using a common metamodel, but with regionally unique extensions and schema elements, and a locally defined schema.	Level 3	