TALENT DEVELOPMENT TOOLKIT REQUIREMENTS & ARCHITECTURE STUDY

Version 1.0

Prepared by
Jerry Gordon, CTR

Contents

Executive Summary

This report defines detailed technical requirements, an initial architecture, a phased implementation strategy, and evaluation metrics for the Talent Development Toolkit (TDT), i.e., the operational learning ecosystem for the Intelligence Community (IC). The TDT promises to improve the effectiveness and efficiency of IC talent development by enabling enterprise-wide data and content management; supporting a career-long, learner-centric approach to talent development; reducing duplications of effort through enterprise-level coordination; and establishing transparent governance across the system. This report represents the technical blueprint to move the TDT from concept into prototype.

Scope of Effort

This project was conducted by the Advanced Distributed Learning (ADL) Initiative, within the Office of Deputy Assistant Secretary of Defense for Force Education and Training, in collaboration with the Human Capital Management Office, within the Office of the Undersecretary of Defense for Intelligence (OUSD(I)). The project builds on prior investments in the Total Learning Architecture (TLA), an effort to establish the policy, standards, and specifications for learning ecosystems. Researchers from the ADL Initiative combined the general TLA framework with inputs from OUSD(I) stakeholders to inform a set of specific recommendations for the IC. The resulting report includes the engineering requirements and architectural drawings for developing the TDT's data specifications (e.g., learner profiles) and core services (e.g., content management). It outlines technical guidance for integrating TDT elements with requisite backend services (e.g., identity brokering), and it includes a five-stage *capability maturity model* for migrating legacy learning activities to the TDT vision.

Critical Factors Motivating the TDT Effort

IC stakeholders consistently reported the following three issues, which in turn motivate the TDT effort:

1. **Cost-efficiency: Reduce licensing and maintenance costs.** The IC pays high costs to acquire and maintain its talent development systems because of (a) uncoordinated software acquisition across IC organizations, which increases costs by undermining the IC's bulk buying power and by creating incompatible software configurations, and (b) high reoccurring licensing costs, caused by overreliance on legacy instructional and assessment technologies due to code customization and brittle software federations ("vendor lock").
2. **Security and privacy: Safely and ethically federate data across system boundaries.** To have an accurate portrait of personnel and their learning states, data must be accurately aggregated across training, education, and operational learning experiences. However, the IC's talent development systems are fragmented by organizational and security boundaries. The IC requires a way to securely integrate learning data, while maintaining each individual's unique *identity* across systems and also meeting cybersecurity and Personally Identifiable Information (PII) requirements.
3. **Time-efficiency: Make credentials portable across organizations.** In the IC, individuals' jobs frequently move between agencies, but their credentials (e.g., licenses, training certificates) cannot easily bridge these boundaries. Similarly, when someone leaves the IC, the credentials earned do not readily transition to the private sector. To improve the efficiency of cross-agency transfers and post-career transitions, it is important to develop *credential portability*. This not only involves the

safe and ethical transfer of learning data but also requires mechanisms for evaluating *trust*, negotiating equivalencies (e.g., civilian equivalent of certain classified credentials), and translating credentials into generalizable knowledge and skill components (e.g., *competencies*).

Recommendations

To address these critical factors and realize the TDT vision, the IC needs to transition from disconnected, proprietary, single-vendor learning solutions to an open, "loosely coupled," composable system-of-systems. The following recommendations support the modernization process:

1. **Federate data across stovepipes.** The enterprise needs to federate, or link, talent development data across boundaries—in a way that scales across millions of data elements. The solution requires error-free reconstruction methods for aggregating data across systems, achieved through a combination of ledgering technologies and governance procedures, as well as a network topology suitable for maintaining performance at scale.
2. **Create governance boards and policy structures.** For a system as complex as the TDT, it is impossible to define an effective feedforward design or unchanging data dictionaries. Instead, the TDT will require ongoing negotiation of its business rules and configuration management of its data, software services, and interoperability specifications. The IC should define the stakeholders, authorities, and governance processes for this oversight at different organizational levels.
3. **Establish secure, ethical universal identity management.** To federate data across systems, individuals' identities must be linked across enclaves. The report details requirements for identity management, including a proposed solution for Universally Unique Identifiers (UUIDs) that support nonrepudiation, integrity, and privacy.
4. **Develop a common course catalog.** To build a learning ecosystem, the instructional activities across the system-of-systems must be discoverable and accessible. This is achieved by creating a *common course catalog*, a software service that indexes the available learning resources. The catalog is assembled from linked *activity indices*, which represent the local listings of activity providers (e.g., a certain learning management system), their available content or learning resources (e.g., courses, e-publications), and the mapping of these resources to a competency framework.
5. **Establish mechanisms for maintaining trust.** The TDT requires data integrity. Federated systems must be able to digitally verify incoming data, trace the "chain of custody," assign weighted levels of validity for different elements (e.g., self-reports versus formal tests), and negotiate among competing sources for the authoritative data. This can be accomplished by segmenting authoritative data storage, using globally unique identification, using digital signing technologies, and establishing business rules for deconflicting inconsistent data elements.
6. **Invest in culture change for competency-based talent management.** Standardized competency frameworks create a "common currency" to describe human performance across functional and organizational systems. Competency-based learning also emphasizes the demonstration of personnel capabilities rather than the measurement of instructional characteristics, better linking human performance to mission effectiveness. To realize these benefits, however, many processes across manpower, personnel, training, and education organizations will need to evolve.

Introduction

This report defines detailed technical requirements, an initial architecture, a phased implementation strategy, and evaluation metrics for the Talent Development Toolkit (TDT), i.e., the operational *learning ecosystem* for the Intelligence Community (IC). The target audience for this report includes technical managers and technology subject-matter experts. Managers should focus on reading the introduction, summary findings, and recommendations. Technical performers can review the detailed findings, including the architectural diagrams, requirements, and recommendations to develop the detailed specifications they need for acquiring, modifying, installing, and configuring TDT components.

Project Background

This project was conducted by the Advanced Distributed Learning (ADL) Initiative, a research and development organization under the Office of the Under Secretary of Defense for Personnel and Readiness (OUSD(P&R)), in collaboration with the Human Capital Management Office under the Office of the Under Secretary of Defense for Intelligence (OUSD(I)). The project builds on prior work conducted by the DoD Intelligence Training and Education Board and the Office of Personnel Management's USALearning. It also leverages investments in the Total Learning Architecture (TLA), an effort by the ADL Initiative to establish the policy, standards, and specifications for learning technology ecosystems.

Both the generalizable TLA framework and the specific TDT implementation seek to transition from vendor-dependent Learning Management System (LMS)–centric learning solutions organized around courses to open, data-focused solutions organized around learners. This promises to improve the effectiveness and efficiency of learning and development—ultimately impacting the quality of personnel readiness through optimized talent development, the quality of workforce planning through data analytics, and the long-term sustainability of learning systems by reducing dependency on single-vendor solutions.

TDT Overview

The TDT project aims to implement an interconnected learner-centric ecosystem for DoD Intelligence and Security training, education, certification, and professional development. This ecosystem will:

- Enable enterprise-wide data and content collection, analysis, and sharing;
- Support a career-long, learner-centric approach to talent development;
- Reduce duplications of effort through enterprise-level collaboration; and
- Establish and enable transparent governance across the system.

Implementing the TDT will help the DoD Intelligence and Security community address the Federal-wide President's Management Agenda cross-agency priority for "Developing a Workforce for the 21st Century." Specifically, as directed by this priority area, the TDT will help build interoperability across systems, streamline performance measures, and create the technological foundations to enable automation across workforce systems. The TDT also addresses requirements from the *IC Education & Training Strategy* by establishing a flexible, integrated, data-driven system of common digital services and applications with supporting governance, management practices, and resources. These capabilities will promote learner-centric, adaptable lifelong learning for intelligence and security professionals and make talent development products and services more discoverable, accessible, and relevant to their needs.

The OUSD(I) Human Capital Management Office and the DoD Intelligence Training and Education Board have pursued the TDT vision for several years. This report builds upon those investments, extending the prior work beyond the conceptual stage and operationalizing the concepts into technology guidance.

TLA Overview

The TLA describes a set of technical guidelines, Application Programming Interfaces (APIs), middleware, and data-model descriptions that define how training, education, and personnel management technologies "talk" to each other—both syntactically and semantically. The TLA is intended to provide a "plug-and-play" interoperability backbone across these technologies, or in other words, it is designed to characterize and standardize the structure, abstraction, and communication functions of an "internet for learning."

The TLA will enable integration of various *learning experiences* from formal training and education in a classroom or web environment to simulators, performance aids, and observations made on-the-job. The envisioned system will be learner-centric, meaning it tailors recommendations to individuals and provides lifelong (or, at least, career-long) learning support. From the enterprise perspective, the TLA will facilitate human capital supply chain management, ensuring capable manpower by optimizing the development, credentialing, accession, and retention of personnel. In this way, the TLA (and proposed TDT, which it informs) satisfies the needs of both learners and organizational leaders, as show in ***Figure 1***.

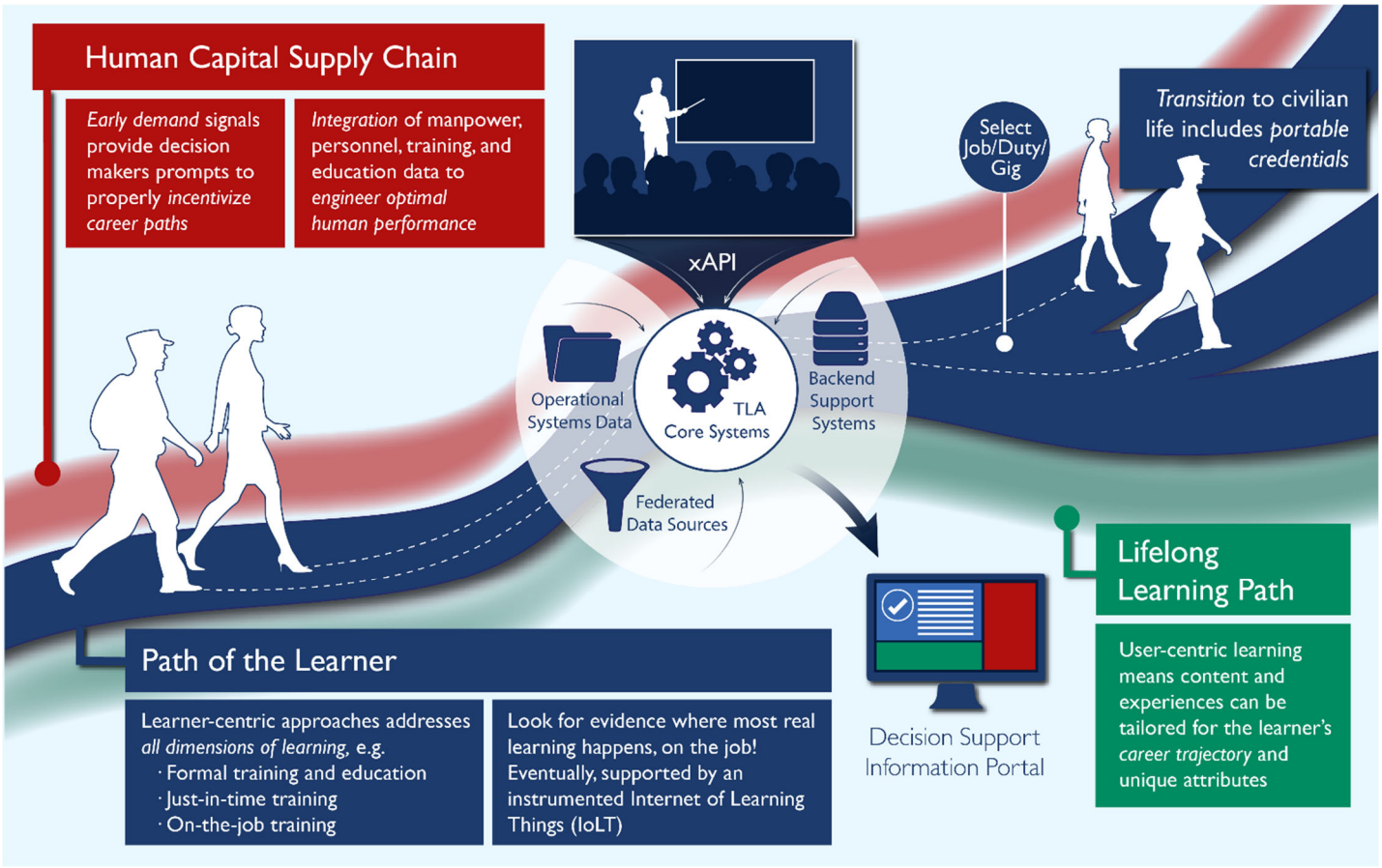


Figure 1 Total Learning Architecture Concept. *The TLA provides a framework for developing the TDT. Lifelong learning support and the human capital supply chain are parallel uses of the same interoperable system-of-systems and aggregated personnel performance data.*

In contrast to the TDT, the TLA effort is a research and development initiative intended to investigate the enabling capabilities required to develop operational learning ecosystems. In other words, the TLA project is investigating the underlying technical requirements and establishing the specifications for *learning ecosystems*—loosely coupled systems, made interoperable through common data models and interface standards. As they mature, the requirements and specifications encompassed by the TLA are anticipated to be formalized in Defense policy, such as DoD Instruction 1322.26, Distributed Learning (Reference A), and standardized through professional standards organizations, such as the Institute of Electrical and Electronics Engineers (IEEE) Learning Technology Standards Committee.

Method

This project sought to translate the general TLA concepts to the specific IC requirements and talent development systems, instantiating them as the TDT. To accomplish this, the researchers first reviewed the *DoD Intelligence and Security Learning Enterprise Functional Analysis* document provided to OUSD(I) by USALearning in April 2017 (Reference C). That document listed concerns, described current tools, and presented an initial set of TDT priorities related to a common course catalog and identity management. Next, in September 2018, the researchers along with OUSD(I) stakeholders from nearly a dozen organizations held a day-long working group meeting to inform the project's scope. During the meeting, ADL Initiative researchers explained the TLA concept and design, established the commonality between it and the TDT, and worked with the IC stakeholders to operationally define the *learning ecosystem* concept.

After the meeting, some IC stakeholders voluntarily responded to a set of unclassified questions about the current state of their training and education systems and their future requirements. These responses amplified the 2017 functional analysis document, provided graphical depictions of the current training and education organizations and technologies, informed a list of definitions of learning terms, and highlighted overarching concerns. After receiving this initial input, the researchers attended a tabletop workshop hosted by the OUSD(I) Human Capital Management Office for their competency and credential working group, and they reviewed the corresponding report (Reference D).

After assembling this initial baseline of information, ADL Initiative researchers conducted one-on-one interviews with subject-matter experts to glean additional requirements. The opportunity to participate was advertised to representatives of all the IC agencies; however, not every agency participated. Detailed interviews were conducted with participants from:

- Office of the Director of National Intelligence (ODNI),
- National Geospatial-Intelligence Agency (NGA),
- Defense Security Service (DSS),
- National Reconnaissance Office (NRO),
- Defense Intelligence Agency (DIA), and
- U.S. Air Force intelligence components.

The researchers used a semi-structured interview format (Appendix A), along with unstructured dialog based on the answers. Responses were captured in written notes by at least two researchers. The researches reviewed these responses in conjunction the background information and existing TLA specifications. From these, they developed early requirements and an initial architectural model, identified modernization priorities, and authored a capability maturity model to inform migration to the TDT vision.

Results

The objective of the TDT is a federated, decoupled, ecosystem of learning technology components interfacing through data standards that captures evidence of personnel competency, provides data-driven insights to learners and decision makers, and schedules learning events in enhanced feedback loops that improve the training, education, and readiness of the IC workforce. However, given the early stage of the overall TDT development, defining detailed software requirements to meet this objective is premature. Instead, this report defines typical behaviors that specify the general capabilities of the TDT in its objective state, with a prioritization scheme and rationales for the requirements or amplifying information to understand them in context. This portion of the report provides enough guidance for technical personnel to conduct a detailed design, evaluate legacy systems, develop data and technology migration plans, and begin execution the overall vision of the TDT.

TDT Learning Ecosystem Description

A *learning ecosystem* is one where the actual boundaries or composition of systems may change over time, as the components are *loosely coupled* and interface through strongly typed *data contracts*. The IC and its constituent agencies already use several different human resources (HR) technologies, LMSs, and assessment tools. To achieve the vision of the TDT ecosystem, these disparate systems must be able to:

- Serve as *authoritative data sources*;
- Link users across organizational boundaries using globally unique identifiers (UUIDs) that both protect *Personally Identifiable Information (PII)* and maintain *non-repudiation* of identity and associated performance records;
- Maintain *chains of evidence* among learning experiences, authorizations and reviews, and conferred credentials and qualifications; and
- Provide a searchable *Common Course Catalog* that enables a unitary list of available content and makes these learning resources discoverable.

TDT Architecture

The proposed TDT architecture relies on the TLA concept of distinguishing *core services* from *edge systems* (as shown in ***Figure 2***). In this case, "core" refers to mandatory systems or data sources, while "edge" refers to optional and potentially externally federated systems or data sources. As the TDT is an ecosystem, it maintains a "fractal" structure when viewed at the macro level; in other words, it is a system-of-systems, made interoperable both horizontally across organizations and vertically from local-to-enterprise levels. Each enclave (that is, each organizationally "owned" technology instantiation) will have its own managed design and beyond this, enclaves and federates may combine, link, and merge as the ecosystem grows. Thus, do not confuse "core" to mean "centralized." In fact, centralized repositories (e.g., of individuals' identities or HR data) are potential "edge systems" in this conception.

Core Services

The core services are primarily concerned with data transactions, data ledgering, and data interoperability. These include:

- Competency Management Services – This refers to a set of services concerned with linking the description of performance characteristics (e.g., individual capabilities and job duties) across technical, functional, and organizational boundaries. This may include, for instance, competency framework management and credential management services. This set of services is also responsible for verifying chains of evidence in terms of learners' performance, handling the associated trust functions, generating authoritative assertions of capability (credentialing or de-credentialing), and making estimations of competence based on granular or inferential data.
- Activity Management Services – This refers to a set of services concerned with scheduling learning activities and capturing data output from those activities. Scheduling learning activities may involve, for instance, a scheduling service, potentially aided by a recommender or content curation service. Scheduled content may be launched from a web client connected to the TDT, such as a federated LMS. Capturing the execution of learning events involves reporting the close-out of learning sessions so that the performance data can be effectively processed. These learning events may include formal training and education as well as ad hoc or informal learning activities not centrally scheduled but instead launched from or reported by remotely federated devices.
- Content and Resource Management Services – These services are concerned with registering and maintaining an accurate reference to the location of learning resources. They are also responsible for the verification of the resources required to access them. Resources may include valid Universal Resource Locators (URLs), certificates or digital signatures (for verifying externally linked content), computational resources (e.g., if a learning activity is hosted in a cloud computing environment), and the identification of physical resources required (e.g., instructors and classrooms, simulator time) to conduct a learning event.

Core Data Stores

The core services are logic *wrappers* that function by managing requests into and out of data stores. These include the four mandatory *core data stores* (listed below) as well as optional ancillary systems that provide additional capabilities (e.g., manpower and personnel databases). The four core data stores are:

- Learner Profiles – Each enclave is expected to have a single learner profiles data store. Learner profiles include user data and locally generated assertions of competence. For the user data, each learner profile includes personal attributes relevant for local learning and reporting activities (e.g., performance on course assignments, local user group membership). Learner profiles may also link to, or create local copies of, externally federated data (e.g., global preferences, such as preferred language, collected from something like a "universal learner record" or an HR system) that have applicability for local actions, such as learning event adaptation and scheduling. The competency or credential data earned locally, and initially stored in a learner profile, can be forwarded-on to these other systems (analogous to "transcripts" and "certificates"), and conversely, federated competency or credential data from edge systems can be ingested into the local learner profiles.
- Competency Framework – Competency frameworks store the data describing competencies, their granular components (e.g., knowledge, skill, attitudes, abilities, motivations), and the relationships among individual competencies (e.g., prerequisites, co-requisites). Also, these frameworks relate competency data with measures of performance (MOPs) and effectiveness (MOEs) based on the demonstration of those elements for a given level of mastery in performance of a job or duty.

- Learning Record Stores (LRSs) – LRSs are part of the Experience Application Programming Interface (xAPI) specification; they archive xAPI-based completion data from learning activities or experiences, which can later provide evidence of competence via one of the Competency Management Services. The mandatory LRS is known as a "transactional LRS," which stores "actionable information" regarding human performance data. At the simplest level, the transactional LRS can be considered analogous to a gradebook. The transactional LRS contrasts with "noisy" LRSs, which may optionally be part of a given activity provider (e.g., a simulator or LMS) and are used to capture finer-grained information (e.g., each page turn or button press) for local analysis. The reason for this separation is to abstract raw performance adjudication (of value only within a limited, timebound state) away from the core systems.
- Activity Index – An Activity Index stores local information about available Activity Providers (e.g., an LMS, e-reader, assessment module, or simulation) and their available learning content (e.g., courses, documents, tests, or scenarios). An Activity Index also stores information on the relationships among content, competencies, activity and content metadata, and evaluated paradata. Together, these data describe the type and instructional value of learning experiences represented within the activity-content-competency couplet. The metadata are used for activity scheduling and for evaluating the impact of a given learning experience on competence. Each TDT enclave may have its own Activity Index, and the (appropriately labeled) elements listed in these Activity Indices can be federated to create an enterprise-level Common Course Catalog. (This catalog may be fielded as a "virtual service," performing searches across the distributed Activity Indices, or it may be uploaded periodically to a separately maintained authoritative data store.)

Publish/Subscribe Messaging

The TLA specifications assume the architecture will use a publish/subscribe (pub/sub) messaging service to connect the core services and core data stores. Numerous pub/sub communication technologies are available off-the-shelf, such as the older Java Messaging Service (JMS), Enterprise Service Bus (ESB), and OpenSplice DDS, as well as more modern streaming services, including Apache Kafka® (used in the ADL Initiative's TLA research) and Microsoft® Azure. The pub/sub approach is recommended for its scalability; however, each organization, particularly during their interim migration steps, may use other communication methods. Most legacy solutions use some variant of client-server or point-to-point messaging protocols.

Edge Systems

Edge systems include all learning providers, web portals, or other interoperable (i.e., TLA-compliant) user interfaces, network backend services (e.g., virtualization/network endpoint management, authentication and identity management), and externally federated data sources (e.g., external Activity Indices, Learner Profiles, and Activity Records from other enclaves, HR systems data, or external competency framework data). These are shown as ellipses in ***Figure 2***. As the learning ecosystem evolves over time, edge systems may expand to include additional types of instrumentation (the "Internet of Learning Things"), or additional data systems. Typical edge systems may include:

- User Interfaces (UIs) – Any number of user interfaces may be created to help users interact with data or systems within a TDT enclave; these UIs may include, for instance, decision support applications used for visualizations or user-management tools that interface with the core services. The UIs are expected to use Representational State Transition (REST) calls to those underlying

services. One example UI is the alert and notification system, which produces messages (e.g., emails) to various users including instructors, supervisors, and learners on, for example, new training assignments or course completions. This component could also be instrumented with xAPI to capture those interactions. The AGILE system currently used by the IC may form a portion of this system in the initial fielding. Requirements for user interfaces as well as authentication and identity management are collectively addressed in User Management Functions subsection under Requirements for the TDT, below.

- Federated Data Stores – It is impractical to have a single repository of data for all IC members because of horizontal scale, multi-level security, and implementation costs. Thus, the TDT ecosystem and TLA specifications assume these data stores must be federated. Federated data includes any ancillary data (such as manpower and personnel system or readiness data) as well as copies of core data located in other enclaves (their Activity Index, competency framework, LRS, or Learner Profile data). The federation requires standardized interfaces and governance to maintain non-repudiable identity management and integrity of authoritative data sources between installations.
- Learning Record Providers – A Learning Record Provider is any system capable of outputting TLA-compliant data about an individual's training, education, or experiential learning. The diverse range of digital learning devices and assessment tools instrumented with xAPI are considered Learning Record Providers. Some Learning Record Providers may also leverage LRS technology to deploy a "noisy" LRS to store narrowly relevant xAPI information at more granular levels (e.g., quiz question answers, each button push, heartbeat data). However, as described in the Core Data Stores subsection above, the TLA specifications and proposed TDT solution recommend Learner Record Providers separate the adjudication of "run-time" performance away from the core data stores and services which are for ledgering data from learning devices as "actionable information." For details, see ***Figure 14*** and related discussion.
- Future Machine Learning – Although not a requirement for the TDT (or TLA), future systems are anticipated to include automation, leveraging the data collected from across the system to feed artificial intelligence algorithms. These algorithms may, for example, make recommendations for individual learning paths, help schedule learning activities across an organization, create visualizations to inform instructor or supervisor decisions, or support the tagging and registration of learning resources (e.g., content metadata descriptions).

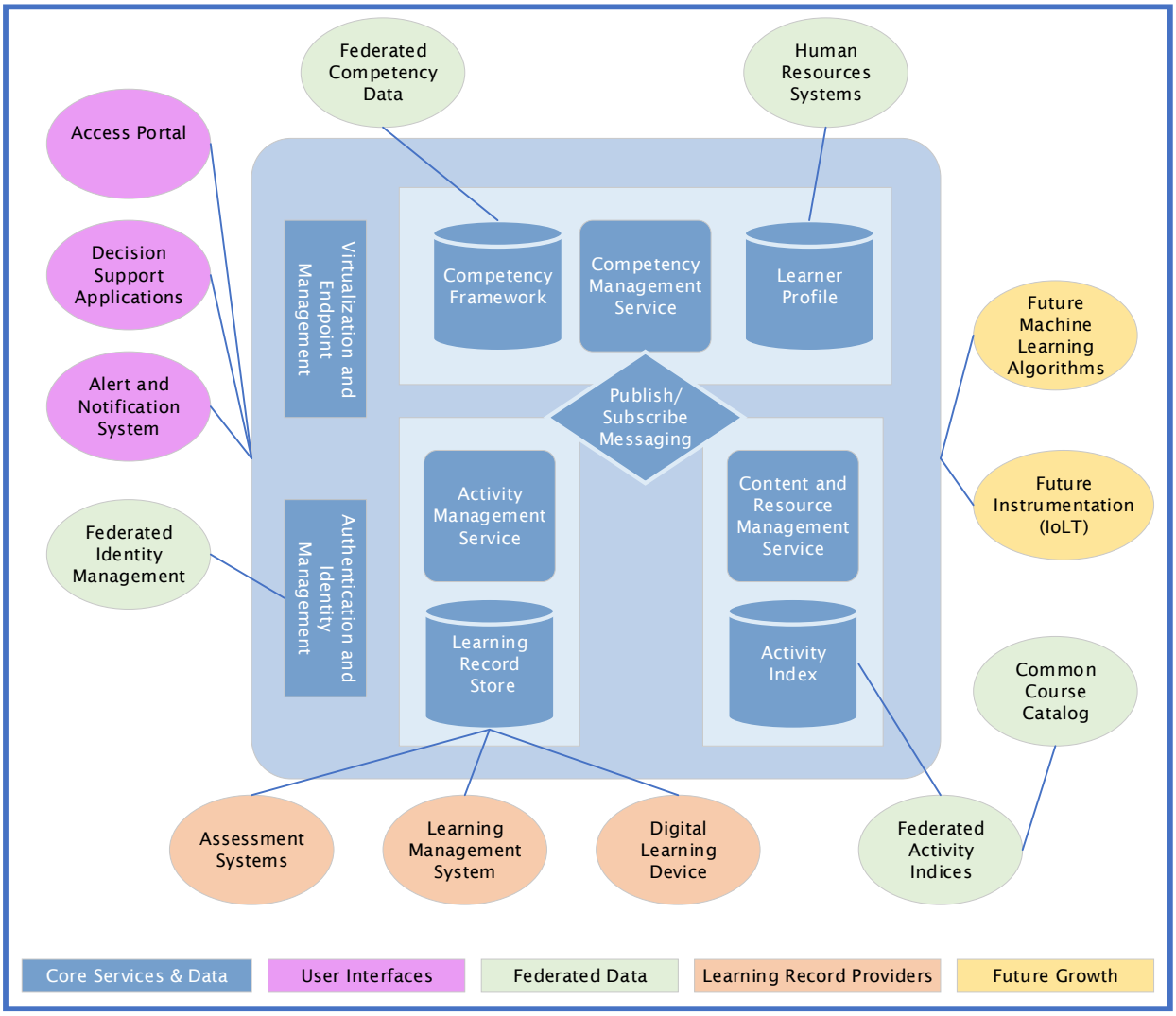


Figure 2 Core Services and Edge Systems of the TLA implemented as the TDT. *The ecosystem allows for multiple boundaries and configurations of components providing final capability.*

Key Concepts and Logical Data Model

The section below introduces a logical data model for understanding the relationship between the concepts used within the TDT architecture, which is depicted in ***Figure 3*** as a Unified Modeling Language (UML) class diagram (Reference N). Technical personnel conducting the TDT design process should use the logical data model as a guide for allocating business logic and software interfaces (i.e., class operations) to the components of their instantiation of the TDT.

The logical data model defines key concepts of the TDT domain as *classes* (boxes) with the types of data *attributes* (listed above the break line in each box) and data *operations* (ending in '( )' and listed below the break line in each box) that generate, store, manipulate, or export the data within the attributes. Each data attribute is constrained by a *data type*, separated by a colon and detailed in ***Table 1***, along with the source or purpose of each attribute. Some of these data types are enumerated "pick" lists. Some are complex data types or lists of attributes (e.g., a C programming language *struct*) in their own right. The enumerated lists and complex data types are shown in ***Figure 4***. Some of the attributes represent user-defined metadata

elements, likely unique within an installation and subject to local governance, with the data type Name-Value-Pair-Set (NVPS). A NVPS is a dynamic array of user-defined attributes, enumerated data types, and values. Notably, the "scope" attribute within the NVPS captures the appropriate level or command equity in governance for standardizing the data dictionary for the array.

Technical personnel developing TDT components should evaluate the attributes for inclusion in the physical schema for databases they develop, using the logical data model as a guide for the physical schema, allocated to the core data structures indicated by the colored balls in each box (and explained via the adjacent legend). The data operations represent the business logic of the TDT core services and are also reflected in the detailed requirements for each functional area in the ensuing sections.

In Figure 3, the key concepts (i.e., software classes) within the logical data model include the following:

Allocated to Activity Index or "Course Catalog" (CC)

- *Activity Metadata* – Activity metadata elements describe the resources required and type of experience provided by a learning activity. Activities work in concert with "content" to provide the learning experience. In traditional e-learning, the LMS is the *activity*, while the courseware within in it serves as the *content*. However, in the future learning ecosystem concept, more diverse activities and content are feasible, and the relationships among the two are not fixed. The same activity (e.g., a simulator) may host multiple content elements (e.g., both a simulation scenario file and a technical e-book) and the same content may be hosted as activities in several different environments (e.g., the same e-book viewed in a simulator and in a standalone e-reader).
- *Content Metadata* – Content metadata elements describe the content, such as documents or courseware, used in activity providers. Each learning experience is formed from an activity-content couplet (i.e., the content and the activity context under which it is experienced).
- *Content Set* – Content Sets are comprised of ordered lists of content metadata elements. They are used to provide a collective identifier for a grouping of content elements (e.g., a publication library). They are also useful for generating TDT content from legacy SCORM Content Aggregation Model (CAM) asset listings. A Content Set may represent the available courses within a traditional LMS or the list of assets within a particular course.
- *Learning Exercise* – Learning exercises represent the intersection of content, used within an activity, for the education purpose defined in a competency.

Allocated to Learning Record Store

- *Learning event – A Learning Event* is the collection of xAPI-based (Reference B) permanent records of learning experiences within an LRS; in other words, it is the data stored within a given LRS.

Allocated to Conformance Suite

- *xAPI Profile* – xAPI Profiles constrain the vocabulary used for a given use-case to generate xAPI Activity Records. They define the possible data elements and their range of values for a certain context.
- *Paradata Context Set* – Paradata are data that describe the execution conditions of a particular learning instance or activity, such as how long someone took to complete an assessment,

malfunctions that occurred during a simulation, or a user's quality rating on the post-course survey. Correspondingly, Paradata Context Sets define the additional attributes that may be evaluated and captured within a particular Learning Record Provider or activity type during the activity's run-time use. In general, paradata should be generated as xAPI statements with their own extensions as defined in the associated xAPI Profile.

Allocated to Competency Framework

- *Reusable Competency Definition (RCD)* – RCD, as per Reference I, represents the atomic-level elements of a competency (e.g., knowledge, skills, attitudes, abilities, attributes, motivations, and other factors).
- *RCD Association* – This association creates a "vector" between competency objects (i.e., RCD, standards, and contexts), with some directionality and cardinality between them, representing a directed acyclic graph (DAG).
- *Competency* – A collection of RCD objects, standards, and conditions. These are related via a DAG vector map to the performance of a job/duty/gig. Competencies are tied to evidentiary records used to make assertions
- *Credential* – a type of badge, diploma, or certificate that represents trust, vested in an authority that a person is capable of performing to some overall standard. Credentials are used as proxies for competency, based on the competency definitions included within the credential.
- *Competency Framework* – A collection of one or more competencies and constituent elements belonging to one or more job/duty/gigs that represent the constellation of trackable competency objects for a domain of practice.
- *Standard* – In this context, "standard" refers to the combination of measures and criteria that define a level of mastery.
- *Required Context* – The required context data elements describe the conditions under which a certain behavior must occur, or be evidenced in, to support the job/duty/gig.
- *Job/Duty/Gig* – This refers to any general employment or other performance activity (e.g., hobby) a learner engages in that requires one or more competencies, at a certain level of mastery, in order to be successfully completed.

Allocated to Learner Profile (LP)

- *Role/Persona* – The role/persona attribute recognizes that people may have multiple aspects to their life that may each require different learning, contribute different experiences, and be at various levels of capability.
- *Person* – This element represents the local proxy of a user, although a globally unique identity record will likely be stored in an authoritative data structure as an edge system (such as an HR system or DoD personnel database).
- *Interest Group* – This element helps group people by interest or user-type, such as a member of a particular functional area. This attribute can be used, for instance, to assign a training objective across a particular group.

Figure 3 Logical Data Model for TDT – Part 1 Class Elements and Relationships. *The various classes of data, the attributes or characteristics of the data, and the operations performed on the data within a TLA-compliant TDT federation.*

<<Enumeration>>
UXRoleEnum

Administrator
Learner
Observer/Instructor/Controller/
Supervisor
Curriculum manager
Competency manager

<<Enumeration>>
KSAOEnum

Knowledge
Skill
Ability
Other
Behavior

<<Enumeration>>
QuotaTypeEnum

Agency Specific…

<<Enumeration>>
AttachmentEnum

Agency Specific

<<Enumeration>>
ContextEnum

Agency and Program Specific

<<Enumeration>>
ResultEnum

MediaTypeSpecific

<<Complex Type>>
OCSTD

ReferenceDocument:URI(Content)
InDocumentReference:$

<<Enumeration>>
Domain

Cognitive
Affective
Psychomotor
Metacognitive
Social
Motivational

<<Enumeration>>
StandardTypeEnum

MOP
MOE

<<ComplexType>>
CompetencyState

SkillSet:RCD[]
Achievements:Competency[]
IsCurrent:BOOL
IsPending:BOOL
IsSuspended:BOOL
IsRevoked:BOOL
EffectiveDate:ISO8601
PendingDate:ISO8601

<<Enumeration>>
DataTypeEnum

Integer
Double
Float
IRI
ISO8601
String
Char
BOOL
RFC 5646

<<Enumeration>>
MOMLifeCycleVerbEnum

Recruited
Assessed
Detailed
Mobilized
Employed
Selected/Screened
Promoted/Demoted
Transitioned
ReleasedPlanned
Augmented
Directed
Requested
Approved/Denied
Explored
Clarified
Captured
Assessed
Asserted
Verified
Validated
Located
Inferred
Conferred
Qualified
Certified
Socialized
Organized
Prioritized
Recommended
Curated
Scheduled
Regulated
Projected
Contextualized
Evaluated
Surveyed
Tracked
Projected
waived
launched
initialized
passed
failed
satisfied
completed
abandoned
terminated

<<Enumeration>>
VerbClassEnum (Cognitive/Psychomotor)

Know		Comprehend	
Count	Read	Classify	Interpret
Define	Recall	Cite	Locate
Describe	Recite	Conclude	Make sense of
Enumerate	Record	Describe	Paraphrase
Find	Reproduce	Discuss	Predict
Identify	Select	Estimate	Report
Label	Sequence	Explain	Restate
List	State	Generalize	Review
Match	View	Give examples	Summarize
Name	Write	Illustrate	Trace
Apply		**Analyze**	
Assess	Instruct	Break down	Examine
Change	Predict	Characterize	Illustrate
Chart	Prepare	Classify	Infer
Choose	Produce	Compare	Limit
Compute	Relate	Contrast	Outline
Construct	Report	Correlate	Point out
Demonstrate	Select	Diagram	Prioritize
Determine	Show	Differentiate	Relate
Develop	Solve	Discriminate	Separate
Establish	Use	Distinguish	Subdivide
Synthesize		**Evaluate**	
Adapt	Invent	Appraise	Interpret
Categorize	Modify	Argue	Judge
Compose	Organize	Assess	Justify
Construct	Perform	Choose	Predict
Create	Produce	Compare & Contrast	Prioritize
Design	Propose	Conclude	Prove
Formulate	Reinforce	Critique	Rank
Generate	Reorganize	Decide	Rate
Incorporate	Rewrite	Defend	Reframe
Integrate	Structure	Evaluate	Support

<<Enumeration>>
VerbClassEnum (Affective/Metacognitive)

ACH-Achievement Orientation
CO-Concern for order, quality and accuracy
INT-Initiative
INFO-information seeking
IU Interpersonal understanding
CSO- customer service orientation
IMP impact and influence
OA- organizational awareness
RB relationship building
DEV developing others
DIR directiveness, assertiveness and use of positional power
TW teamwork and cooperation
TL Team leadership
AT analytic thinking
CT conceptual thinking
EXP technical professional managerial expertise
CST self control
SCF self confidence
FLX flexibility
OC organizational commitment

<<Complex Type>>
LearnerTask

ScheduledEvent:URI(LearningExperience:Handle)
ScheduledTime:ISO8601
SuspenceTime:ISO8601
Authorized:URI(Person:handle)
Assigner:URI(Person:handle)

<<ComplexType>>
Taxon

Framework:$
EnumeratedLevel:Int[]
Enumerated List:$[]

<<ComplexType>>
NameValuePairSet

Attributename:URI
AttributeDataType:DataTypeEnum
AttributeValue: DTC
AttributeDescription:$
Scope:$
TimeStamp:ISO8601

<<ComplexType>>
xAPI

Actor:URI (Person:Handle)
Verb:URI(Profile:Handle)
Object:URI (Profile:Handle)
Timestamp:ISO8601
Stored:ISO8601
Language: RFC5646
Result:ResultEnum
Context:ContextEnum
Authority:URI(Person(handle)|Interestgroup(Handle)|ActivityMetadata(handle)_
Attachments:AttachmentEnum[]
Version:$

<<Complex Type>>
CareerTrajectory

State:xAPI(MOMLIfeCycleverbs)[]
JobList:Job_Duty_Gig[]
CareerEndpoint:Job_Duty_Gig[]
Classifier:$[]
CurrentGoals:URi(Competency)[]

<<Enumeration>>
ContentType

ePublication
Publication
Digital Video
Video
SCORM Course
LMS - Assessment
Assessment - Other
ITS
CMS Material
SocialMediaSharedFile
LVCG Simulation Scenario file
IETM/EPSS
Trainee Guide
OICS Comment Sheet/Checklist
Game Level
ERP

<<ComplexType>>
ConfigurationRecord

SequenceID:LONG
TimeOfChange:ISO 8601
AuthorityForChange:URI(IdentityGroup|Person::Handle)
RecordType:$
AttributeChange:NVPS[]

<<Enumeration>>
CredStatusEnum

Current
PendingReview
OutOfCurrency
Suspended
Revoked

<<ComplexType>>
OpenBadge2

Context:JSONLD
ID:JSONLD
Type:JSONLD
Recipientt:JSONLD
IssuedOn:JSONLD
Verification:JSONLD
Badge:JSONLD
Issuer:JSONLD

Figure 4 Logical Data Model for TDT – Part 2 Complex and Enumerated Data Types. *The pull-down lists of objects, verbs, and attributes used within the data classes of Figure 3.*

Table 1. Logical Data Model Attribute Dictionary. Names, data types and purpose of each attribute.

Class	Attributes	Data Type	Definition
Learning_Event	ActivityStatement	xAPI	Atomic level learning event where leaner did something, where "something" includes review of some type of content or conducting some job experience, as per xAPI standard—used as evidence of competence
Learning_Event	Experience	xAPI Array	A linkage of activity statements that must be taken together to constitute "evidence". The verb of the xAPI statement, used to explain how the user interacted with content to learn
Learning_Event	Paradata	xAPI	Proforma record of the context of the learning experience, including cognitive and environmental effects
Learning_Event	StandardType	StdType_enum	An enumerated data type of the type of evidence (MOP or MOE) that the record defines. MOP come from learning technology, MOE typically come from operational data sets.
Learning_Event	PrivacyLevel	Integer	A scaled level of privacy for the evidence provided by the record.
RCD	BehaviorDomain	DomainEnum	Whether competency element is cognitive, psychomotor, affective, metacognitive, social or motivational
RCD	Importance	INT	Weighted requirement for career progression
RCD	KSAO	KSAOEnum	Identifies whether competency element is Knowledge, Skills, Ability, Behavior, or other
RCD	Metadata	NVPS string	An array of one or more metadata elements that describes the competency object from metadata standard
RCD	Needed at Entry	BOOL	Is competency needed at entry for the job/gig trajectory (part of learning validation logic for pre-requisite skills or experiences,
RCD	RequiredAptitude	String Array	List of user aptitude attributes as prerequisite to attempt achievement of the competency
RCD	SignatureAuth	URI (Person or Interest Group object handle)	Trusted agents that can assert competence from evidence
RCD	Task	String	Task, behavior, or measurable elements (in the case of knowledge competencies) that are demonstrated by the competency
RCD	TaskMetadata	NVPS	Data about the tasks from metadata standard
RCD	Handle	URI	A Uniform Resource Identifier (URI), a string of characters that unambiguously identifies a particular resource
RCD	Origin	URI	The URI of the normative reference (content metadata) that specifies the competency requirement

Class	Attributes	Data Type	Definition
RCD	Verb	String	The the verb that defines the task statement for the RCD if it is sourced from an existing learning objective, or stated as a task.
RCD	VerbClass	VerbClassEnum	Generic category of the task (e.g., operate equipment is “perform”)
RCD	VerbNamespace	String	Community of practice whose definition of the verb applies
RCD	LearningModelLevel	Taxon Array	Defines which learning model framework and level the verb applies (e.g. Bloom, Merrill)
RCD	Version	INT	Version of the competency object definition
RCD_association	Handle	URI	A reference for the vector map represented by the sequence of associations
RCD_association	QED	BOOL	*Quod Erat Demonstrandum*; Association that cascades positively downwards (if high level competency is asserted, lower level is automatically asserted)
RCD_association	Source	URI (of RCD, Standard, or Condition)	Source URI of competency object that is upstream on the association
RCD_association	SQN	BOOL	*Sina Qua Non;* Association that cascades negatively upwards (if low level competency is de-credentialled, the higher level is automatically de-credentialled)
RCD_association	Target	URI (of RCD, Standard, or Condition	Target URI of competency object that is downstream on the association
RCD_association	Weighting	Float	Covariance weight or contribution of the downstream competency object to the upstream object
Credential	IsMilestone	BOOL	Competency establishes a personnel milestone for planning learning trajectories
Credential	AwardAuthority	URI(Person)	Who signs off as the issuing or updating official
Credential	EffectiveDate	ISO8601	What is the status date effective by
Credential	Status	CredStatusEnum	A status on awarding the credential
Credential	Badge	OpenBadge2	Definition of the digitally signed credential in the openbadge 2 standard
Competency	IsMilestone	BOOL	Competency establishes a personnel milestone for planning learning trajectories
Competency	Masterylevel	INT	Level of proficiency or complexity of the competency as defined for use in a particular job/duty/gig
Competency	Name_Description	String	Short reference handle for the competency (as a map of competency objects, level of mastery, associated standards and conditions or contexts, and the relationships between them described as a DAG for defining the competencies

Class	Attributes	Data Type	Definition
Competency	RequiredAptitude	NVPS String	List of user aptitude attributes as prerequisite to attempt achievement of the overall competency
Competency	CnCmetadata	NVPS String	Metadata associated with task (used to scrape for applicable content)
Competency	Handle	URI	Internal handle for referencing the competency network
Competency	Authority	URI (person object Handle)	Person or organization that owns the competency element
Credential	QualificationStandard	URI (ActivityMetadata object handle)	The normative reference, document or instruction (e.g. Field Manual, Technical Instruction) that specifies the need
Credential	OccupationalStandard	OCSTD array	The Occupational Classification Standard (OCSTD) from O*NET that defines the framework
Credential	Handle	URI	Internal handle for referencing the competency network
Credential	Authority	URI (person object Handle)	Person or organization that owns the competency element
Competency	PrivacyLevel	Integer	A scaled level of privacy for the evidence provided by the record.
Competency_Framework	ConfigurationHistory	ConfigurationRecord Array	The ordered list of changed attribute values, authorization and date of change from complex data type
Competency_Framework	Authority	URI (Person or Identity Group object handle)	The person or organization who “owns” the competency framework definition
Competency_Framework	Description	String	A short title for describing the competency framework (may tie to organization, MOS, Rating. Or some subset)
Activity_Metadata	Address	URI	RESTful location of the content metadata mapping within an activity index
Activity_Metadata	AdjudicationAuthority	URI(Person) Array	Trusted agents that can positively or negatively adjudicate learner success at a scenario, exercise or activity
Activity_Metadata	Authority	URI(Person)	The author or registrant of the activity
Activity_Metadata	ApprovalAuthority	URI(Person|Identity Group) Array	Authority to select the content to satisfy a competency element or curriculum
Activity_Metadata	Bookmark	URL	Location within the content
Activity_Metadata	ConfigurationHistory	ConfigurationRecord Array	List of content or competency attributes which have been changed over time in this association
Activity_Metadata	Description	String	Purpose of the learning activity
Activity_Metadata	EstimatedTime	ISO8601	Mean time to complete the activity

Class	Attributes	Data Type	Definition
Activity_Metadata	Handle	URI	Internal reference for the learning activity
Activity_Metadata	Location	String	Mechanism for locating the reference (e.g., content management system, building address, ePublication library reference)
Activity_Metadata	Metadata	NVPS	Data that describes the content from metadata standard
Activity_Metadata	QuotaType	Enum	How cost of attendance at the experience or content is remunerated
Activity_Metadata	Required Resources	NVPS	Consumables, instructors, classrooms, computational resources, laboratories or other materials necessary for the experience
Activity_Metadata	SchedulingAuthority	URI (person or interest group object handle)	Person or interest group authorized to schedule the content or act as registrar
Activity_Metadata	Weighting	Float	Contribution of the activity towards demonstrating competence
Activity_Metadata	ContentAllowed	URI (Content_Metadata) (Array)	Content that can be used with the specified activity
Learning_Exercise	EducationalAlignment	RCD(Array)	List of competencies the activity can satisfy or enhance
Learning_Exercise	Context	URI (ActivityMetadataHandle)	The player, reader or environment used to conduct the learning exercise
Learning_Exercise	Resources	URI (ContentMetadataHandle)	The files or other resources required to conduct the exercise
Content_Set	Author	URI (Person object handle)	Instructor or course manager who approved course
Content_Set	Purpose	String	Catalog entry or description of course, or other purpose for the set
Content_Set	IsCourse	BOOL	Used to index records for common course catalog searches
Content_Set	ReferenceID	String	The agency specific record number for the course listing
Content_Set	ContentList	URI (Array)	An array of the content object handles in the content set
Required_Context	Alias	String	Mapping for “condition” if specified in the associated competency framework more concretely or explicitly (e.g. context, environment, organizational level)
Required_Context	Condition	String	A condition under which the definition of competency is appropriate
Required_Context	Handle	URI	Internal object handle for referencing the condition (used in xAPI extensions)
Required_Context	Name	String	Screen name for describing the condition
Interest_Group	CandidateAudience	BOOL	The group of identified users is assigned to collectively assign a training requirement

Class	Attributes	Data Type	Definition
Interest_Group	Collective Address	URI	Name for referring to the collection of entities (e.g. All pacific commands, section 12 of the 2021 fire controlman class). Typically for classes, it is class number based on year and number of classes being taught.
Interest_Group	IsClassSession	BOOL	Used to filter faster for classes and sections
Interest_Group	Member	URI Array	Internal handle or handles used for identifying humans logged into the local instance of the system (used to protect PII)
Interest_Group	PersonaRole	URI (Persona_role)	Persona role of the learner or group of learners
Interest_Group	Protected	BOOL	Interest group membership changes must be approved by an observer, instructor, controller, or supervisor
Job_Duty_Gig	Authority	URI (Person or Interest Group object handle)	Curriculum or competency definition authority
Job_Duty_Gig	JobCode	String	Branch specific occupational code (e.g., Naval Enlisted Classification, Military Occupational Specification, Air Force Specialty Code)
Job_Duty_Gig	Name	String	Short name for referring to the job, duty or gig (e.g., imagery analyst, collections)
Job_Duty_Gig	RequiredAbilities	URI (Ability object handle) Array	Pre-requisite abilities to pursue the job
Job_Duty_Gig	RequiredSkills	URI (Competency object handle) Array	Pre-requisite skills to pursue the job
Job_Duty_Gig	IsMilestone	BOOL	Job establishes a personnel milestone for planning learning trajectories
Job_Duty_Gig	Handle	URI	Internal handle for referring to the job
Job_Duty_Gig	ManningPlanCode	String Array	Reference number or code in the governing manpower and personnel document that describes or justifies the position
Paradata_Context_Set	Handle	URI	Internal handle for referring to the paradata attribute set
Paradata_Context_Set	Context	NVPS Array	List of potential attributes that can be reported by the activity provider to define the paradata
Person	Ability	URI (ability object handle) Array	The learner's abilities (defined from ability classes)
Person	Aptitude	NVPS Array	The learner's aptitudes (defined from aptitude classes)
Person	Handle	URI	Anonymized internal reference for a person (used as "actor" in xAPI)
Person	CompetencyState	Competency Array	An array of all the competencies the person has had asserted and verified
Person	CredentialState	Credential Array	An array of all of the competencies the person has had certified and conferred

Class	Attributes	Data Type	Definition
Person	LearnerState	MOMLifeCycleVerbEnum	The current learner state as managed by the learning event manager.
Person	LearnerPreferenecAttributes	NVPS Array	Attributes of the learner used for adaptation decisions or algorithms (reference installation specific)
Person	PersonaRole	URI (Role_Persona object handle) Array	Personas or roles of the person (e.g. Sailor, division officer, watch stander, analyst)
Person	UUID	String	Externally valid reference for person (CAC or other UUID)
Person	Goal	Job_duty_gig, RCD, Credential or Competency Array	Lists the fully recursive array of competency objects that are currently pursued by the learner. May be arbitrarily deep and broad.
Person	Career Trajectory	CareerTrajectory	An array of jobs that define the past, present and candidate future jobs for the learner on their current trajectory
Person	ConfigurationHistory	ConfigurationRecord Array	The ordered list of changed attribute values, authorization and date of change from complex data type
Person	TaskList	Learner Task Array	The list of tasks that have been formally assigned as complex types
xAPI Profile	Purpose	String	Type of learning activity or data sources that would use this profile (e.g. eReader, Personnel Database)
xAPI Profile	Owner	URI (Person or Interest group object handle)	Creator of the Profile
xAPI Profile	ObjectLifeCycle	String Array	List of allowable xAPI verbs within the Profile
xAPI Profile	Extensions	NVPS Array	List of attribute and enumerations or string masks for extensions, results and attachments
xAPI Profile	Namespace	URL	Globally unique way of referring to elements within the profile
Role_Persona	Alias	EMailAddr	Internal reference handle provides a name that cannot traced back to PII
Role_Persona	Authority	URI (person object Handle)	Curriculum or professional standardization authority
Role_Persona	Description	String	Short description of the purpose or scope of the job/duty/gig
Role_Persona	Handle	URI	Local code or nomenclature for the job/duty/gig as appropriate (e.g., billet code), which resolves to local database and handles
Role_Persona	Prerequisite	URI (RDC object handle) Array	Required competencies to perform the job
Role_Persona	RequiredAptitude	NVPS	Required Aptitude of the person to perform the job
Standard	Alias	String	Way “standard” is specified in the associated competency framework (e.g. level of proficiency)
Standard	Criterion	Integer	The level of performance that defines the standard
Standard	Handle	URI	Internal object handle for referencing the standard

Class	Attributes	Data Type	Definition
Standard	Measure	Activity Array	The objective measurement for establishing the standard
Standard	Name	String	Screen name for describing the standard
Standard	NormativeRef	URI (ActivityMetadata) Array	Identifies the normative reference defining the standard within the content library (e.g., tech manual that describes a procedural skill)
Standard	Standard Type	Standard TypeEnum	Whether the standard is a MOP for a competency object (means of asserting competency) or an MOE for an entire competency or range of competencies (i.e. organizational or outcome-based performance metric against which to validate individual performance and instructional efficacy)
Content_Metadata	Handle	URI	Internal object handle for referencing the standard
Content_Metadata	Content	URL Array	An array of possible locations the content can be located at
Content_Metadata	Description	String	A description of the piece of content
Content_Metadata	Bookmark	URL Array	A pointer to the content's location on the internet
Content_Metadata	Language	RFC5646	The Language(s) needed to use the content
Content_Metadata	MediaType	ContentTypeEnum	An enumeration of the kind of content the content is, such as ebook, pdf, or movie
Content_Metadata	Metadata	NVPS	Data that describe the content, according to the LRMI, TLA, and local extensions for metadata
Content_Metadata	ConfigurationHistory	ConfigurationRecord Array	List of content or competency attributes which have been changed over time in this association
Content_Metadata	Authority	URI (Person | Identity Group)	The person(s) allowed to assign and edit the content
Content_Metadata	NormativeRef	BOOL	Whether the content is a normative reference for the listed competencies (i.e. tech manual describing a skill)
Content_Metadata	DocumentNumber	String	The record number used to reference the document , especially if a normative reference (e.g. AFM65-10, MCWP 5.0. NATOPS 80R14)
Content_Metadata	Version	Integer	x.x.x version number of the piece of content
Complex Data Type (depicted in Figure 4)			
Class	**Attributes**	**Data Type**	**Definition**

Class	Attributes	Data Type	Definition
xAPI	Actor	URI (Person: object Handle)	The person or system that had the experience; refers to object from user and group management
xAPI	Verb	URI(Profile: object handle)	The action taken by the actor; refers to concept in Profile
xAPI	Object	URI (Profile: object handle)	The activity in which the action was taken; refers to concept in profile
xAPI	Timestamp	ISO8601	When the action was taken
xAPI	Stored	ISO8601	When the LRS stored the xAPI activity statement
xAPI	Language	RFC5646	The language code for the activity
xAPI	Result	ResultEnum	The grade or success of the activity
xAPI	Context	ContextEnum	The caveats explaining the activity (as defined in the index to support the competency object in the educational alignment)
xAPI	Authority	URI (Person, interest group or activity metadata object handle)	The person or system which authorized the creation of the experience record
xAPI	Attachments	AttachmentsEnum	Any allowable files which are included with the activity
xAPI	Version	String	The xAPI version used (automatically populated by LRS)
NVPS	UserDefinedAttribute	String	Name of the locally defined data element
NVPS	UserDefineDataType	DataTypeEnum	List of possible data types
NVPS	Value	Data Type Array	Value placed in the field constrained by data type
NVPS	Scope	String	The level or command designation at which the specific attribute list is managed through governance (e.g. agency, ODNI, USAF, JICPAC)
OCSTD	ReferenceDocument	URI(Content)	The volume or reference ID of the occupational standard reference ID
OCSTD	InDocumentReference	String	Internal section or subsection number
ConfigurationRecord	SequenceID	Long	Record entry ID for changes
ConfigurationRecord	TimeOfChange	ISO 8601	Time at which data was updated
ConfigurationRecord	AuthorityForChange	URI (Identity Group or Person Handle)	Who or what agency authorized the change
ConfigurationRecord	RecordType	String	Class name or record ID where change occurred
ConfigurationRecord	AttributeChange	NVPS Array	List of attribute/field, datatypes and values of change

Class	Attributes	Data Type	Definition
LearnerTask	ScheduledEvent	URI (Learning_Experience Handle)	Reference for the activity/content/competency tuple that the task represents
LearnerTask	ScheduledTime	ISO8601	DTG of when the task was assigned
LearnerTask	SuspenseTime	ISO8601	DTG of when the task must be completed by
LearnerTask	Authorized	URI(Person:handle)	Reference of the person who authorized the training even to occur
LearnerTask	Assigner	URI(Person:handle)	Reference of the person who assigned the learner to the event (may be the learner if it was requested)
CompetencyState	Skillset	RCD Array	All the lower level items, especially those not belonging to core framework, that the individual has demonstrated competency
CompetencyState	Achievements	Competency Array	All the complete competencies, at a given level of mastery, that represent a graph of RCD, that the learner has mastered
CompetencyState	IsCurrent	BOOL	For those competencies that require periodic demonstration observed by a designated person that the learner has maintained currency in the task
CompetencyState	IsPending	BOOL	A Boolean depicting if the competency state needs OICS approval before becoming official
CompetencyState	IsSuspsended	BOOL	The learner has been administratively removed from being considered competent (e.g., medical hold, out of currency)
CompetencyState	IsRevoked	BOOL	The learner has been punitively removed from being considered competent (i.e. revocation of credential)
CompetencyState	EffectiveDate	ISO8601	When was the competency *asserted* or credential *conferred*.(See Figure 14 for states)
CompetencyState	PendingDate	ISO8601	For Credentials, when does a currency requirement need to be evaluated
CareerTrajectory	State	xAPI Array	Used manpower verbs from enumerated data type LearningEventLifeCycleVerb
CareerTrajectory	Job List	JobDutyGig Array	List of jobs the learner has held
CareerTrajectory	CareerEndpoint	JobDutyGig Array	The list of jobs that the learner wants to hold on their current career trajectory – with branches and options
CareerTrajectory	Classifier	String Array	The learner's current career classification (e.g., MOS/NEC/Specialty code)
CareerTrajectory	CurrentGoals	Competency Array or RCD Object Array	Competency objects the learner is currently pursuing or has been assigned by the observer, instructor, controller, or supervisor
Taxon	Framework	String	The name of taxonomy or learning model (e.g. Bloom, Merrill)
Taxon	Enumerated Level	Int Array	Preserves a hierarchical structure or tensor (array index>1) for the taxonomy
Taxon	Enumerated List	String Array	The concepts filling a given level or cell for the taxonomic model

Technology Transition Roadmap

Using the TLA as a guide, the researchers developed priorities for requirements and recommended transition strategies for realizing the TDT. This section of the report describes the prioritization scheme, designed to help developers make informed decisions on how best to sequence their efforts.

Critical Factors Motivating the TDT Effort ("High Drivers")

From the interviews and working meetings, the IC stakeholders indicated three key elements, mentioned repeatedly or manifested in multiple ways, which are driving the need for modernization. These factors are "high drivers," i.e., characteristics that significantly impact the cost, schedule, and/or performance of a system. In systems engineering, high drivers indicate the priorities for the system's technical refresh, because addressing them early yields high return-on-investment.

The high drivers for the TDT effort include:

- Decoupling software from data to provide vendor agility and to address mounting licensing costs;
- Developing data strategies to enable federation, e.g., of identity and learning content catalogs; and
- Creating credential portability to facilitate cross-agency work.

The first high-driver for the TDT modernization effort involves mounting license and maintenance costs. The IC pays high costs to acquire and maintain its talent development systems because of (a) *uncoordinated software acquisition across its organizations*, which increases costs by undermining the IC's bulk buying power and by creating incompatible software configurations, and (b) *high reoccurring licensing costs*, caused by overreliance on legacy instructional and assessment technologies due to code customization and brittle software federations ("vendor lock"). To find some cost savings, several organizations have begun acquiring licenses through the USALearning assisted acquisition process, which helps bundle licenses and negotiate for enterprise discounts across the Federal Government. While this reduces costs to an extent, it does not sufficiently address the acquisition inefficiencies, nor does it address the interoperability issues among the systems. The custom-built nature of organizations' systems, which include multiple point-to-point connections (and sometimes "sneaker net" connections), makes for a brittle architecture that limits freedom in changing components. This, in turn, creates risk and steadily drives up costs as the license fees mount and software products become obsolete.

The second driver for the TDT involves federated identity management. To have an accurate portrait of personnel and their learning states, data must be accurately aggregated across training, education, and operational learning experiences. However, the IC's talent development systems are fragmented by organizational and security boundaries. IC systems operate across five different security enclaves: the commercial internet (WWW), Sensitive but Unclassified (SBU, formerly NIPR), the allied Five Eyes enclave, the Secret Internet Protocol Router Network (SIPRNet), and the Joint Worldwide Intelligence Communication System (JWICS). For training and education systems, there is no general cross-domain solution (CDS) for connecting across enclaves. The IC requires a way to securely integrate learning data across these boundaries, while maintaining each individual's unique *identity* across systems and also meeting cybersecurity and PII requirements. Identity management includes not only universally unique identifiers (UUIDs) for personnel (the *actors* in learning activity records), but also the internal references for managing learning resources (learning activity *objects* and *extensions*). These learning resources may be managed across multiple organizations and may change over time in response to content updates, competency requirements, or curricular changes.

A third driver is credential portability. In the IC, individuals' jobs frequently move between agencies, but their credentials (e.g., licenses, training certificates) cannot easily bridge these boundaries. For example, DSS and the National Intelligence University (NIU) operate schools that provide educational services to other agencies, particularly the uniformed services; those "owning agencies" have their own training and education systems and data sources. Transcripts and other data generated at the schools must federate back to the owning agency. For instance, awarded credentials by an IC school must map to occupational codes from the owning agency, and those agencies need a way to certify the IC certificates and to update their personnel's records upon their receipt. Moreover, the potential for personnel transfers between and among the uniformed and civilian agencies requires a logical mechanism for formally reconstituting a person's identity, without having to clone their entire record with each transfer. To complicate matters, because collegiate accreditation regulations require the archiving of data for a specified period, a clone of the performance data would necessitate multiple copies, which does not preserve a single authoritative source. Another related issue occurs when someone leaves the IC; the credentials earned do not readily transition to the private sector (and vice versa). Hence, to improve the efficiency of cross-agency transfers and post-career transitions, it is important to develop *credential portability*. This not only involves the safe and ethical transfer of learning data but also requires mechanisms for evaluating *trust*, negotiating *equivalencies* (e.g., civilian equivalent of certain classified credentials), and translating credentials into generalizable knowledge and skill components (e.g., *competencies* versus "passed course ENG 1001").

Capability Maturity Model

The ADL Initiative developed a TLA capability maturity model to provide a suggested migration path for existing systems. The capability maturity model proceeds by moving some features to the edge of the ecosystem and by migrating other data sources and services to the core—relying on the data contracts of the TLA specification to ensure interoperability. Combined with the "high drivers" described above, this defines a migration prioritization scheme for the IC.

As IC organizations migrate their legacy systems to the TDT, they should address the high drivers first and then continue to refine their systems over time until they reach the TDT vision (or other desired level of maturity). Each unique installation (i.e., each "enclave," such as an organization or schoolhouse) that implements a TDT federate will decide the level of maturity that suits its needs and when that level should be achieved. The requirements in the following section are prioritized according to the TLA capability maturity model levels, from 1 (least mature) to 5 (most mature). The levels are also shown in ***Figure 5***.

- Level 1 – This level represents the first step towards achievement of a TLA-compliant system. The migration path starts with decoupling learning content and learner performance data from the software systems that deliver or store these data. This involves, in part, incorporating xAPI and associated LRSs with existing identity management systems (e.g., student information systems or HR systems), content, and LMSs. This level can also include using LRSs to capture learner-state records from sources other than LMSs, such as classroom learning experiences (curricula and attendance rosters), e-book student guides, and other training or education materials. LRSs could also receive xAPI-enabled data from assessment technologies, such as the Pearson VUE assessment software use by DSS. In sum, this level begins to decouple Activity and Learning Record Providers from their underlying data and to eliminate the brittle point-to-point federations among these systems.

In building the connections between the LRSs and legacy content or data stores, the legacy applications may require a separate xAPI generation application; for instance, rather than remaking legacy e-learning courses, those courses can be augmented with the xAPI wrapper code (maintained on the ADL Initiative GitHub, https://github.com/adlnet/xAPIWrapper) and the associated xAPI data can be sent to a separate LRS that need not be embedded within the legacy LMS. Beyond this initial stopgap solution, legacy LMS content (presumably in SCORM format) or newly acquired e-learning courseware should be remade or repackaged using the cmi5 specification (Reference E, part of the xAPI family of specifications).

Level 1 also includes the aggregation of content metadata from the course within its LMS (at a minimum). Initially, the content metadata need only be captured for the local enclave and a stored in a local Activity Index. Later these data can be federated or pushed into an enterprise-level Common Course Catalog. The "Content Set" object is designed to provide a bridge from legacy SCORM courses to the curated approach to course creation and delivery. Its conceptual structure uses the same hierarchy as the SCORM CAM, which will help maintain traceability as the legacy SCORM content is migrated to the new TDT data structures.

- Level 2 – After the LRSs are in place and collecting data, the next maturity level adds visualizations and decision logic—to make meaningful use of those aggregated data. The analytics dashboards may provide insights on, for instance, curricula and course-content trends, workforce capabilities, or testing effects within assessments (e.g., systemic failures on certain questions).

  This level also requires data labeling and identity management. UUIDs from federated identity management are required to facilitate enterprise-wide analytics. Data labeling ensures semantic consistency and federated identity ensures non-repudiation of performance data as learner or learning data moves between enclaves.

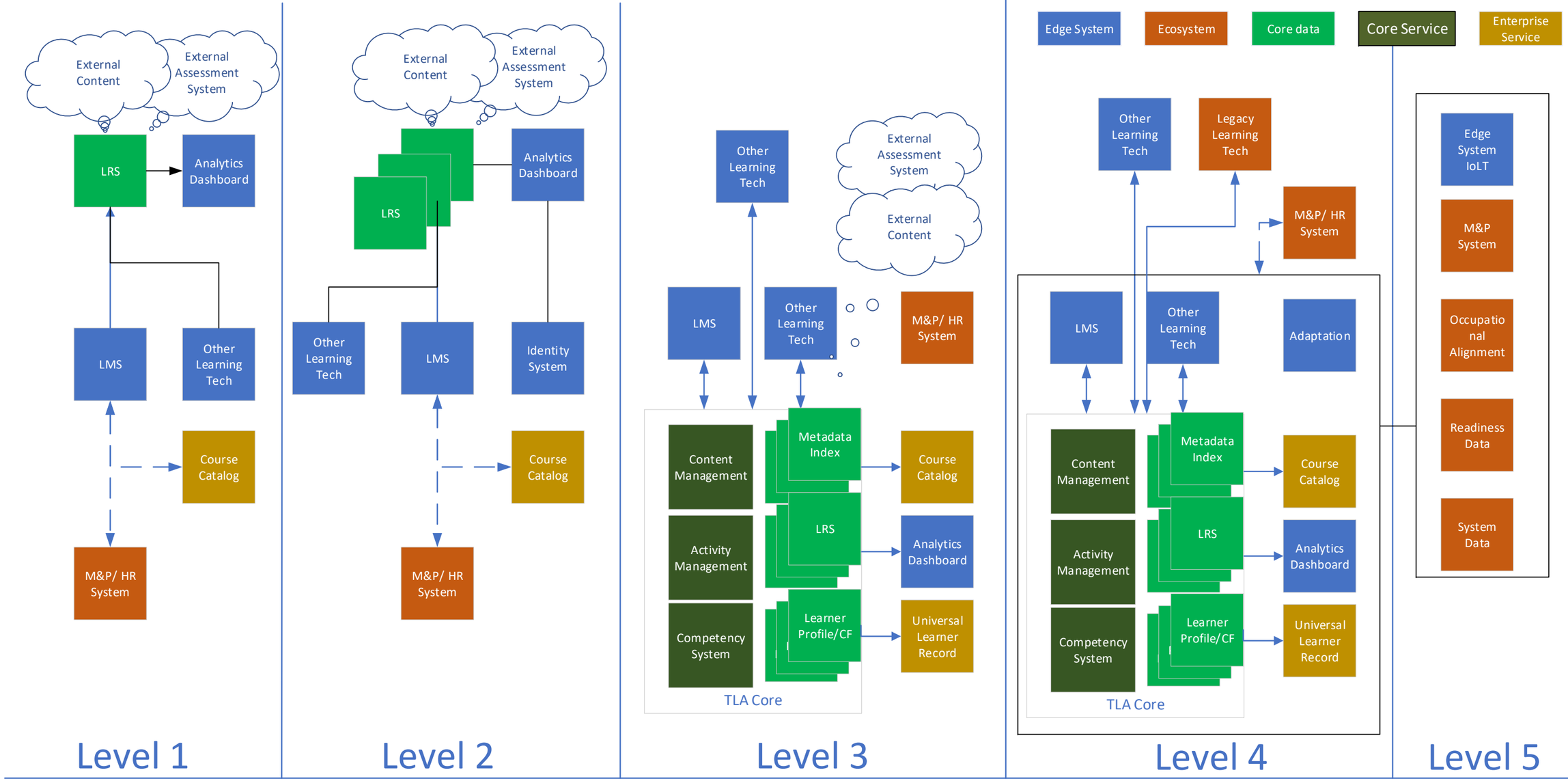
- Level 3 – This is the first level at which legacy LMS functions are broken into a Services Oriented Architecture, comprised of the TLA-compliant TDT core functions (i.e., software services with TLA-defined interfaces). This level incorporates Activity Management, Competency Management, and Content Management Services, and it expands the range of activity providers to include both formal and informal settings. Even with these new features, TDT core systems can still federate with legacy systems at lower levels of maturity as the complete learning system ecology is built out over time, using federated LRS data and credential portability features.

  Level 3 is the driving function for movement from a curriculum-based learning environment to competency-based talent management approach. Competency-based learning promotes more cost-effective use of training and education resources by facilitating the use of ad hoc and work experience to "comp out" of content requirements at schools in the pursuance of a credential or required competency/skill. Competency-based approaches also facilitate better interoperability, as elements of competency frameworks are shared and provide standardization across systems and organizations.

- Level 4 – Level 4 adds more diagnostic functions to the finer-grained and learner-centric data now available in the TDT core, and it provides opportunities to align the lifelong learner path (enhanced by the inclusion of advanced learning technology) with the IC's human capital supply chain management goals. Towards this end, Level 4 requires the TDT to have interoperability across manpower and personnel, acquisition, and readiness reporting systems to be fully effective. Such

interoperable data also necessitates a federated data strategy to support all constituent organizations, and it requires specifications for federated data, including integrated competency portability. The increased fidelity of competency-based data and the "portrait of performance" it creates across the ecosystem in federated LRSs and Learner Profiles will help enable a better fit of the individuals to job than the status quo (coarse-grained credentials and time-in-rate) model affords. Consequently, this level should bring efficiencies across the talent management cycle, from more effective job/assignment placement and lifelong talent development, to more informed enterprise workforce planning decisions and personnel readiness estimates.

- Level 5 – This level introduces diverse, interconnected advanced learning capabilities, including distributed physical and wearable sensors for instrumented ubiquitous learning experiences. (The ADL Initiative colloquially calls this the *Internet of Learning Things* or IoLT.) This level also incorporates machine learning and other artificial intelligence algorithms to aid human decision makers, for instance, in recommending personalized professional development trajectories or informing human capital planning.



Investment:
- Add LRS to decouple training records from Learning technology
- Compile Common Courses

Return:
- Remove Vendor Lock
- Basic analytics
- Support course reuse

Investment:
- Data Labeling (Globally Discoverable Metadata) and Governance
- Address Globally Unique Identity Management and Privacy

Return:
- Enterprise Analytics
- Standardize content curation

Investment:
- Migrate to Service Orientation
- Enable Dynamic Federations
- Catalog is generated from Federated Metadata indices

Return:
- Synchronized Course/Content Catalog
- Improve Curriculum Review cycle
- Shift to CBL, improve throughput

Investment:
- Develop Machine Learning to
  - Improve analytics
  - Automatically generate metadata
  - Perform credential management
  - Perform resource scheduling

Return:
- Optimization of Learning Efficacy
- Support Alignment of Job to performer

Investment:
- Standardize IoLT integration specifications
- Integrate with non T&E data bases

Return:
- Life Long Learning Planning
- Human Capital Supply Chain Integration

Figure 5 Capability Maturity Model. *Five levels of progressive deployment or migration show increasing maturity and capability with investment and returns shown.*

Logical Interfaces in the TDT Architecture

Interfaces Among Core Services, Core Data Stores, and Edge Systems

As presented previously in ***Figure 2***, TLA-compliant systems are envisioned in three main service layers: the core services, core data stores (supported by backend as a service (BaaS) functions), and edge systems. As the IC migrates to the TDT, each training and education organization will initially have its own unique instance; these form the building blocks of the more interconnected, future learning ecosystem.

As discussed earlier, the three service layers within an instance are linked with a messaging system that maintains interconnections between the components in each layer. The ADL Initiative's TLA reference implementation uses a streaming pub/sub service for this. Largely, data flow from edge systems/providers, which generate performance data *evidence* and *assertions* of competence resulting from learning events (i.e., learning record providers); these data *stream* to a *data lake*. The core services pull notifications from the data streams or make requests of the other core data stores (e.g., object IDs, content metadata, learner attributes, competency objects); these are shown as different *topics* or REST web calls below. Those signals will trigger business logic operations (i.e., the operations shown in ***Figure 3***, the logical data model) associated with defining, tracking, planning, reporting, and managing learning. These signals provide input to the user interfaces for planning and controlling functions (e.g., the user interface portal, decision support, alert and notification system) as well as to schedule or initiate launch of learning activities from edge systems connected through a protocol, such as Learning Tools Interoperability (LTI, see Reference K). The general arrangement of logical interfaces among the core services, core data, backend services, and edge systems is shown in ***Figure 6***. This same arrangement of components represents the target state for each site conducting training and education functions as part of its migration to the TDT.

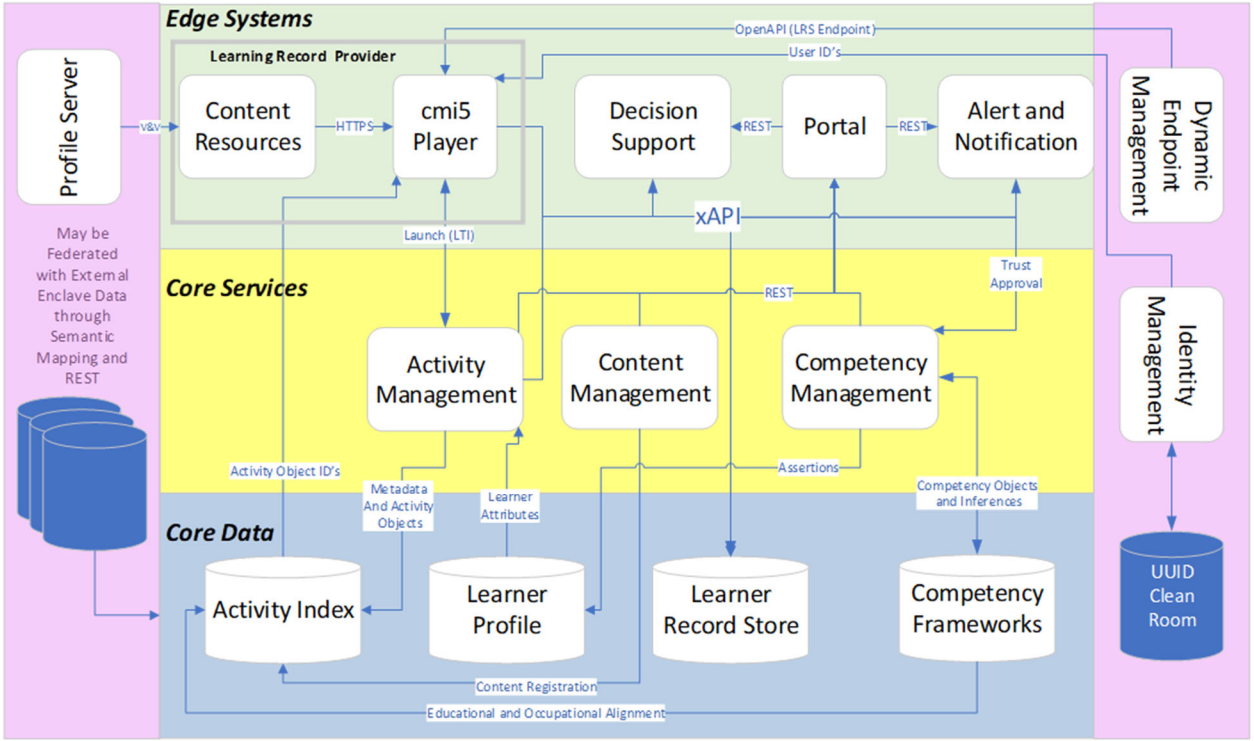


Figure 6 TDT Core Services and Edge Systems: TLA Data Lakes, Services and Information Need Lines.
Shows the publish and subscribe information endpoints between services (boxes) and data lakes (drums).

Interfaces Across Enclaves

Once the core components and interfaces are deployed in a TDT instance, the ecosystem may grow by connecting a particular instance with components of other TDT enclaves (which will have their own "core" data and services). It may also grow by connecting with mobile digital learning technologies that can freely move between instances in multiple configurations. These disparate systems in the ecosystem communicate either through their own open-systems interfaces defined for the Global Information Grid (shown in red in ***Figure 7***) or through TLA-defined interface specifications (shown in blue in ***Figure 7***).

From a cybersecurity perspective, federating components across enclaves raises questions. Data carried from low to high security enclaves may be moved via "sneaker net" or using approved cross domain solutions (CDSs), if available (shown in green in ***Figure 7***). Each site, with the computational assets of its instance, forms an *enclave*, a cybersecurity accreditable boundary (Reference F). (As previously described, an enclave contains, at a minimum, core services and data, and potentially some edge systems, such as learning record providers inside the firewall, a portal web and server, and backend services.) Each operating site must obtain an Authority to Operate (ATO) for its enclave's assets. Ad hoc connections to other enclaves or digital technologies, including mobile devices "in the wild," require Memoranda of Agreement (MOA) and Authority to Connect (ATC) approvals. These ad hoc arrangements represent *federations*. Federations undergo an explicit Federation Development Process, which will be part of the evolving TLA standards, to determine network topology, xAPI profile usage, metadata semantic standardization and namespace management, identity management, and inter-enclave messaging and mapping protocols. The concepts of federation, enclave, and ecosystem are shown in ***Figure 7***.

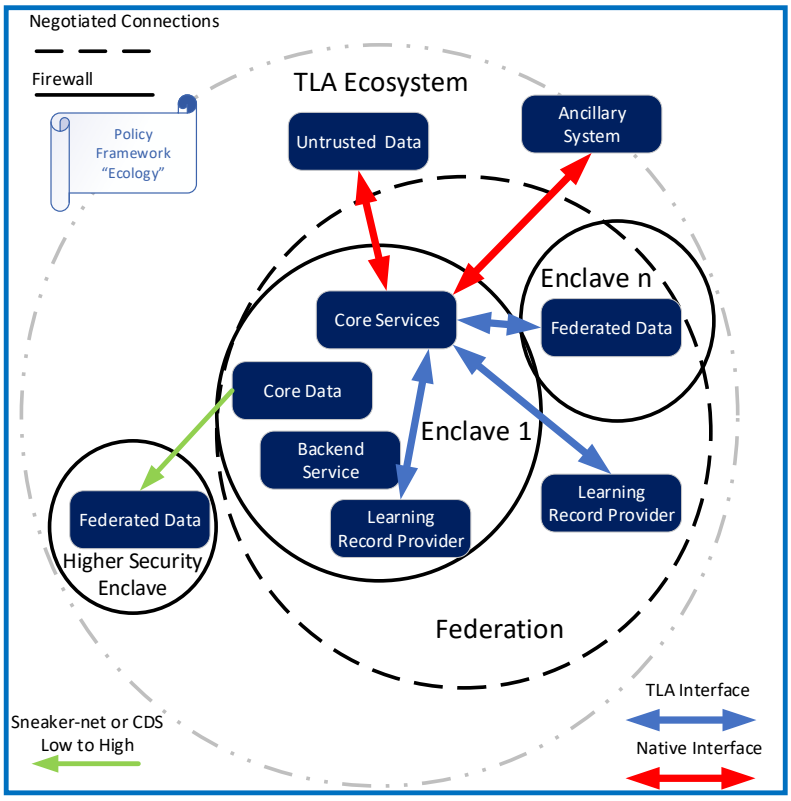


Figure 7 Ecology, Enclave, and Federations in the TLA. *Shows the enclaves accredited to operate, the federations (that are connected, registered, and negotiated) and the ancillary systems providing data in the overall ecology.*

Requirements for the TDT

This section includes detailed requirements, along with associated architectural concepts and drawings, for the key functional areas of the TDT, i.e., user management, content management, activity management, competency management, and the decision-support features of the TDT user interface. The requirements reference the services and data stores depicted in ***Figure 2*** and ***Figure 6*** to organize functionality and internal interfaces. In each requirements table, the "comments" field provides development and fielding guidance. The "priority" column follows the maturity levels presented in ***Figure 3***, and the recommended migration strategy follows the investments and returns logic described in the Technology Transition Roadmap section, above with the Service Oriented Architecture deployment of ***Figure 5*** consistent with level 3 and above as the ultimate objective. The "justification" column highlights key points from the OUSD(I) data collection efforts.

This section does not include comprehensive requirements for Learning Record Providers (e.g., LMSs, electronic publications, simulators, assessment technologies), as they are boundary objects. Their makeup and complexity are dependent on each organization's TDT instantiation, and many organizations already have these technologies in place. However, this section does define interface requirements, especially in terms of data classes, xAPI (as the interface application and presentation layer), and general state management (by using an xAPI Profiles).

Like Learning Record Providers, backend services, user interfaces, and decision-support applications are edge systems. Despite this, requirements for some of these capabilities are included. The subsections below specifically address user-management functions (e.g., roles and permissions, a basic TDT user interface, and alert and notification functions) and decision-support applications (e.g., visualization tools). These functions were considered important early priorities for the TDT and should be included in early TDT implementations, along with the other core services and data stores also described below.

User-Management Functions

While not a core service, basic user-management functions are important for the TDT. Before these can be described, however, the different user roles and their organizational levels need to be considered. Basic user roles are listed below, and the "control loops" that describe levels of organizational granularity are shown in see ***Figure 8***. After the following narrative, ***Table 2*** presents the user-management requirements in a technical format.

Roles and Permissions: Individuals interacting with the TDT will fill at least one, and possibly more, of the following five functional roles:

- Administrator – Administrators are a standalone role with a unique login (per cybersecurity requirements). Administrators have privileged access to all data lakes and can manage users and user groups, update component configurations, and create, read update, and delete (CRUD) most data records while maintaining a change-control log. For example, administrators may serve as the provost or registrar for universities.
- Competency Manager – The competency manager, likely the Program Management Office (PMO) under OUSD(I), owns the competency framework and its constituent competency objects, standards, and credentials for a job/duty/gig(s). The competency manager is authorized to make changes to the configuration of competencies and to create new competency objects, standards, and conditions.

- Content Manager – The content manager is responsible for identifying and registering content for trusted use within the ecosystem. Content may be loaded in a traditional LMS, located on some local content management system, or located as a web resource. Additional experience types beyond traditional digital-learning content (e.g., simulation scenarios, observer checklists, applications for self-reporting of experiences, certification tests) may also be registered as content.
- OIC/S – The Observer, Instructor, Controller and/or Supervisor is responsible for coordinating, mentoring, monitoring, or reporting on learner progress. OIC/S can generate activity records for off-line non-instrumented experiences, report or override grades, recommend and approve learners for training/education, and report on mindset competency objects. OIC/Ss can collect their responsible learners into protected interest groups, and OIC/S may be contacted through the alert and notification system as approvers or requested mentors.
- Learner – The base-level access to the TDT is granted via the learner role; learners can plan, review, and participate in their own learning experiences. They can view their own progress and make requests for access to training, education, and assessment opportunities, as well as report their own job experiences.

Planning and Controlling Functions: The envisioned TDT is an expansive set of interconnected system-of-systems. Users' access to components within this ecosystem must be bounded, both for security controls and to mitigate complexity. This is achieved by setting "apertures," to bound users' access and views to the proper time horizon and grain size (e.g., at a course-level, job-level, or enterprise-level). The apertures relate to the five "control loops" shown in ***Figure 8***. (These control loops are analogous to the "footsteps and breadcrumbs" presented in the *Learning Enterprise Architecture Certification Module* report, Reference D). This report presents technical recommendations to operationalize them through specific data and system requirements.

The control loops are:

- Control Loop One ("Learning Activities") – This level involves accessing, completing, and reporting on individual learning and development experiences. This control loop can also involve the personalized assignment of a given activity, and systems at this control-loop level may provide multiple options for closing the gap between current and desired performance. Example learning activities may include an e-learning course, training exercise, or standalone assessment.
- Control Loop Two ("Credentials") – This level involves the planning and achievement of a credential, which will typically require the completion of multiple learning activities and may also include other requirements (e.g., demonstrated language ability, height/weight, time in grade). Credentials represent the formally accredited achievement of a set of competencies; hence, this level also describes the path towards achieving a certain level of competence or as a milestone in someone's personal development. Multiple potential paths for achieving a credential may exist, and depending on aptitude and background, each person's individual path may differ in both route and time required.
- Control Loop Three ("Job") – This level involves the achievement of competence (as evidences through multiple credentials) for the current job. This might include, for instance, planning and completing major credentials (e.g., school degrees) and other activities, such as work experiences or professional development opportunities, to reach desired job performance levels. Control-loop

three also includes feedback mechanisms for de-credentialing, if proficiency is not maintained in certain skills.

- Control Loop Four – This level involves planning, placement, and evaluation of individuals' careers within a particular career area, including planning their development trajectories (e.g., which jobs to experience in which order, which credentials to pursue beyond those required for the current job) and placing individuals with the right credentials into the right jobs. Like control-loop three, this level includes mechanisms for de-credentialing, when appropriate.
- Control Loop Five – This level involves selecting new career options, such as selecting a new Military Occupational Specialty (MOS), Air Force Specialty Code (AFSC), or Navy Enlisted Classification (NEC), or pursuing a substantively different line of work (e.g., upon separation from military service).

Each of the control loops were described above from an individual learner focus. Similar activities could be described at each level for collective groups; similarly, organizational activities (e.g., workforce planning) also occur at each control-loop level. Optimizing the activities at each control loop, through data-driven decisions and eventually automation, will directly support enhanced mission effectiveness.

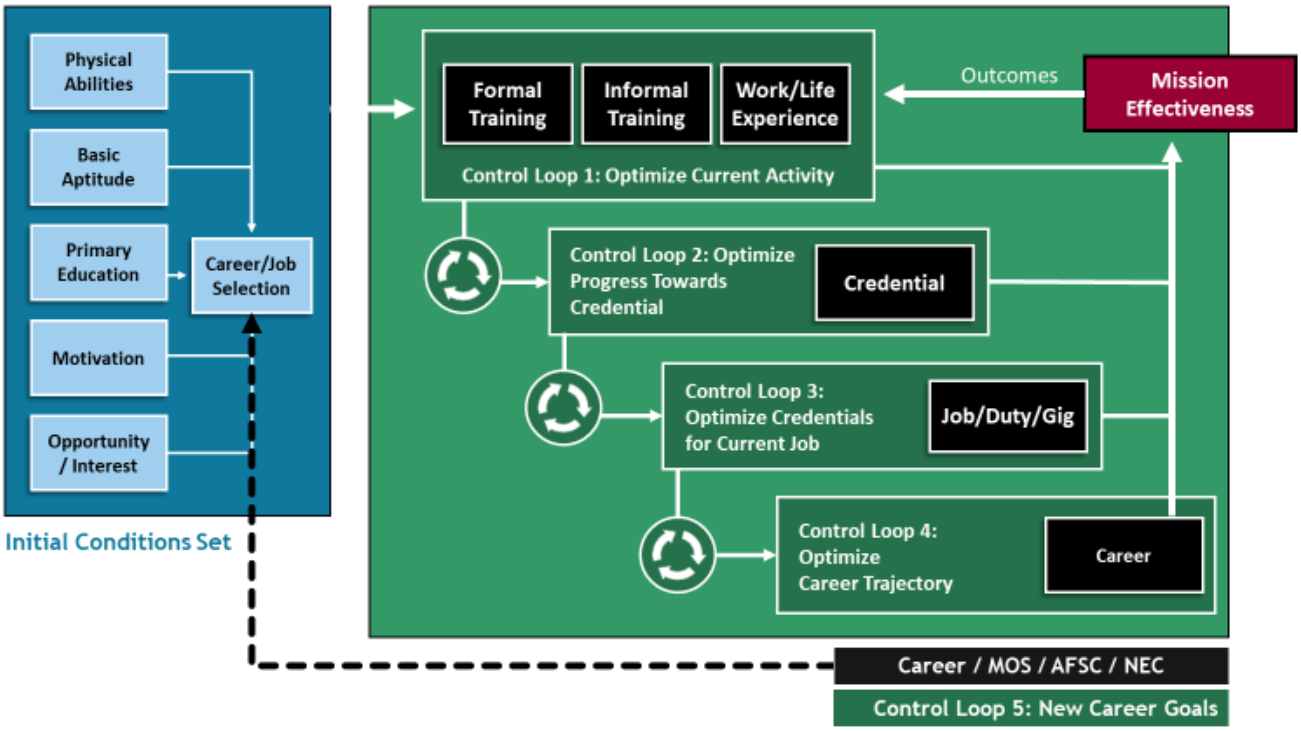


Figure 8 User Experience include Five Performance Control Loops as a Mechanism to Filter and Present Data. *Each control loop has a unique perspective on performance data, its own time horizon, and its own likely set of useful learning interventions.*

Consolidated User Interface (Portal): Each TDT component or federated technology may have its own organic user interface, but a common access portal with Single Sign-On (SSO), identity management, alert and notification services, and end-point management should be developed. The TDT portal can also help

refine presentation of data based upon a user's role and aperture level. Users accessing the portal would have different default views and search parameters through the core data and decision-support applications, to support activities such as the following:

- Review and analyze performance (of self [for learners] or associated learners [for OIC/Ss])
- Locate current learning state (of self [for learners] or associated learners [for OIC/Ss])
- Curate content or goals to achieve a desired state (for self [for learners] or associated learners [for OIC/Ss])
- Evaluate content or curricular efficacy
- Evaluate competency frameworks
- Perform data maintenance (if an admin, content manager, or competency manager)

Notably, a key user-interface function involves the alert and notification system. It may be allocated as part of existing component or a federated edge system (if one already exists), or it could be developed newly from an approved web technology, content management system (e.g., WordPress), or even an email system. Alerts and notifications advertise learning opportunities and, depending upon the technology used, can even provide opportunities for social learning, including sharing instructional resources and peer mentoring.

For its user interface, the ADL Initiative's TLA reference implementation uses a RESTful messaging architecture based on the Open API standard (Reference M) to connect between its prototype portal and other TLA-compatible services, with filters assigned at the portal in the REST calls. These filters represent the aperture setting. The learner state verbs presented later in ***Figure 14*** serve as the "guideposts" for establishing the correct time and search frames for each aperture; these create the mechanism used to bracket search results to populate an appropriate set of decision support templates. In the TLA reference implementation, the graphical user interfaces (GUI) for search and maintenance functions for each core service are organic to that service, but the TLA specifications do not so constrain the design

Table 2. User Management Requirements

Level	Header	Requirement	Justification	Priority	Comments
1	**User Management Service**				
1.1	Roles and Permissions				
1.1.1	Roles and Permissions	The portal login shall provide for administrator level privileges		1	
1.1.1.1	Roles and Permissions	Administrator level permissions shall be able to access and modify user, content, service configuration, activity, resource, and competency service data		1	
1.1.1.2	Roles and Permissions	Administrator level permissions shall be able to assign learners to an OIC/S (for filtering purposes)		3	
1.1.1.3	Roles and Permissions	Administrator level permissions shall be able to assign activities (content/courses/exercises) to an OIC/S (for filtering purposes)		3	
1.1.1.4	Roles and Permissions	Administer level permissions shall be able to assign competency framework elements to a curriculum manager		1	Initial HR system are pri 1, competency/content are pri 3
1.1.1.5	Roles and Permissions	Administer level permissions shall be able to assign competency frameworks or framework segments to a competency manager		1	Initial HR system are pri 1, competency/content are pri 3
1.1.1.6	Roles and Permissions	Administrator level permissions shall be able to create protected user interest groups with assigned users and assign access to these to OIC/S, competency, or content managers	Also serves as registrar role for creating classes	1	Initial HR system are pri 1, competency/content are pri 3
1.1.1.7	Roles and Permissions	Administrator privileges shall include CRUD permissions by segment for each of the data stores (Content catalog, LRS, Learner Profile)	Can assign “users and superusers” to provide least privilege for cybersecurity, especially to prevent unauthorized permanent deletions	1	Initial HR system are pri 1, competency/content are pri 3
1.1.2	Roles and Permissions	The portal login shall provide for learner level privileges		1	Initial HR/LMS system, migrate to competency/activity/content in level three
1.1.2.1	Roles and Permissions	The learner access shall be able to view current progress towards selected or assigned goals		1	Initial HR/LMS system, migrate to competency/activity/content in level three
1.1.2.2	Roles and Permissions	The learner access shall allow for launching of current assigned on-line content		1	Initial HR/LMS system, migrate to competency/activity/content in level three

Level	Header	Requirement	Justification	Priority	Comments
1.1.2.3	Roles and Permissions	The learner access shall present a summary of past attempts at learning activities		1	Initial HR/LMS system, migrate to competency/activity/content in level three
1.1.2.4	Roles and Permissions	The learner access shall present a summary of past grades at learning activities		1	Initial HR/LMS system, migrate to competency/activity/content in level three
1.1.2.5	Roles and Permissions	The learner access shall allow for a summary of past credentials and state		1	Initial HR/LMS system, migrate to competency/activity/content in level three
1.1.2.6	Roles and Permissions	The learner access shall be able to select goals for career objectives		1	Initial HR/LMS system, migrate to competency/activity/content in level three
1.1.2.7	Roles and Permissions	The learner shall be able to search content for future goals		1	Initial HR/LMS system, migrate to competency/activity/content in level three
1.1.2.8	Roles and Permissions	The learner shall be able to search content to support current goal		1	Included within social learning (clearing house for ancillary content)
1.1.2.9	Roles and Permissions	The learner shall be able to view courses and supported competencies and credentials		1	
1.1.3	Roles and Permissions	The portal login shall provide for Observer/Instructor/Controller/Supervisor (OIC/S) level privileges		1	
1.1.3.1	Roles and Permissions	OIC/S level permissions shall allow for logging observed practical exercises for assigned learners as complete- satisfactory, attempted, complete-unsatisfactory	Used for supervisor signatures, instructor observations, etc.—tied through user interest groups	1	Anomalous (non LMS) external content captured in LRS in first iteration
1.1.3.2	Roles and Permissions	OIC/S level permissions shall allow for reviewing progress towards goal, current grades and state for assigned learners		1	
1.1.3.3	Roles and Permissions	OIC/S level permissions shall allow for review of assigned learner performance on assigned activities		1	
1.1.3.4	Roles and Permissions	OIC/S level permission shall allow for review of alerts and notifications sent to assigned learners		1	
1.1.4	Roles and Permissions	The portal login shall provide for competency manager level privileges		1	Maintained in HR system initially

Level	Header	Requirement	Justification	Priority	Comments
1.1.4.1	Roles and Permissions	The competency manager shall be able to create, read, update, delete competency objects (Learning Objectives) from the competency framework for each credential	Program Management Office manages competency requirements	1	
1.1.4.2	Roles and Permissions	The competency manager shall be able to create, read, update, delete links between competency objects from the competency framework for each credential		1	
1.1.4.3	Roles and Permissions	The competency manager shall be able to create, read, update, delete abilities (composed of competency objects and maps) from the competency framework for each credential		1	"Competency map" is professional/training standard initially
1.1.4.4	Roles and Permissions	The competency manager shall be able to create, read, update, delete levels of defined mastery (for each ability) from the competency framework for each credential		1	Levels of mastery might initially require some rework of existing training/professional standards
1.1.5	Roles and Permissions	The portal login shall provide for curriculum manager level privileges	Curriculum manager is analogous to course manager, but also authorizes additional content	1	
1.1.5.1	Roles and Permissions	The curriculum manager shall be able to register new content or content types for a learning activity		1	
1.1.5.2	Roles and Permissions	The curriculum manager shall be able to assign new activities (including on line content) for learners to experience		1	HR system for professional standards should have mapping to courseware at least at the credential level
1.1.5.3	Roles and Permissions	The curriculum manager shall be able to register content from within or external to the enclave		1	For NIPR access to WWW or SIPR outside of enclave
1.1.5.4	Roles and Permissions	The curriculum manager shall be able to link content elements into courses or subordinate units (phases/modules/units)		1	Initially within Content Aggregation Model (CAM) in SCORM manifest as part of LMS, but refactored in later maturity levels to content and competency management records
1.1.5.5	Roles and Permissions	The curriculum manager shall be able to register content to educational purpose for linked competencies		3	Part of migration from 1.1.5.5
1.1.5.6	Roles and Permissions	Users shall be able to create unprotected user interest groups	For social learning - allows users to follow each other for updates to content/areas of expertise, etc.	3	

Level	Header	Requirement	Justification	Priority	Comments
1.1.5.7	Roles and Permissions	User permission profiles shall be exportable to another federate instance of the TDT	If there are multiple instances of TDT to support horizontal scalability, the profiles need to be copied or cloned to allow users to move from one enclave to another	1	May be handled by organic identity management system (e.g. active directory, DRRS interface)
1.2	PPI/PII Protection/Privacy				
1.2.1	PPI/PII Protection/Privacy	The TDT shall be able to create an UUID token		1	
1.2.2	PPI/PII Protection/Privacy	The UUID shall be used to store all service data relevant to a user		1	
1.2.3	PPI/PII Protection/Privacy	The portal shall display the user name, but otherwise use the UUID to request or transmit user data		1	
1.2.4	PPI/PII Protection/Privacy	Sensitive personal data shall be only stored within or transmitted from the backend identity management service		1	
1.2.5	PPI/PII Protection/Privacy	The portal shall utilize a FIPS 140.2 approved encryption of user name to be displayed when received from the identity management service		1	
1.2.6	PPI/PII Protection/Privacy	The TDT shall employ mechanisms to ensure the UUID are globally unique		1	
1.2.7	PPI/PII Protection/Privacy	The TDT shall employ mechanisms to ensure the UUID are non-repudiable		1	
1.2.8	PPI/PII Protection/Privacy	The portal shall have mechanisms to prevent human readable linkage of user name and UUID		1	
1.2.9	PPI/PII Protection/Privacy	The portal shall display only name for associated learners when used in the OIC/S role	Universities that enroll students across agencies need electronic Synchronization of records for credential portability, etc.	1	
1.2.10	PPI/PII Protection/Privacy	The TDT Shall be able to deploy UUID in federated data structures (between organizations and between enclaves)	Part of non-repudiable, global uniqueness is keeping it true in every installation of the TDT components	1	

Level	Header	Requirement	Justification	Priority	Comments
1.2.11	PPI/PII Protection/Privacy	The TDT shall use an anonymizing key for records internal to a "federate" instance		1	It is possible that there will not be a single “IC TDT” but that it exists in federated form, where local instances have finer grained archival requirements, that can be used to update a courser grained (credential level) storage at the OUSD(I) level. Transport between federates may use the UUI.
1.3	Top Level Badges				
1.3.1	Top Level Badges	The TDT shall preserve all completed and in progress credentials for users		1	
1.3.2	Top Level Badges	the TDT shall validate credentials required for a user acting in an OIC/S role for access, observation, or assessment		1	Instructor permissions for LMS in maturity level 1
1.3.3	Top Level Badges	The TDT shall provide a secure digital badge for showing a credential has been conferred	This pertains to the concerns levied during the GSX LEA product review	3	Portable credentials will require MOA with the parent organizations
1.3.4	Top Level Badges	The TDT shall provide an administrator configurable type for naming type of credential, including degree/diploma, certificate, and professional rating		3	
1.4	Common Portal				
1.4.1	Common Portal	The portal shall provide for a user login and 2 factor authentications		1	
1.4.2	Common Portal	The portal shall display an appropriate classification		1	
1.4.3	Common Portal	The portal shall display a consent to monitoring banner		1	
1.4.4	Common Portal	The portal shall allow a user to user to switch between allowable roles		1	
1.4.5	Common Portal	The portal shall require a unique login for a user to act in the administrator role		1	
1.4.6	Common Portal	The portal shall be able to support operation when installed at the unclass (NIPR), GENSER Secret (SIPR) and TS SCI (JWICS) level		1	
1.4.7	Common Portal	The portal shall support access to data and services at lower enclaves when MLS cross domain access is provided		3	Any CDS is outside the TDT enclave, and MLS should be always available in the form of air gapped, encrypted transfer

Level	Header	Requirement	Justification	Priority	Comments
1.4.8	Common Portal	The portal shall enable login, filtering, and presentation of remotely hosted TDT components	Portal does not provide most performance management functions, but is a security and information filtering shell for other systems in the ecosystem	3	The core portal functions may be through an organic interface in the initial maturity levels, but should be a common access point for level three
1.4.9	Common Portal	The portal shall be able to display interfaces to and from services registered within the TLA federation		3	
1.4.10	Common Portal	The portal shall display user summary data applicable to the role and user logged in and aperture setting		1	
1.4.11	Common Portal	The portal shall employ single -sign on for all connected federated services		1	This might be implemented differently for initial maturity levels
1.4.12	Common Portal	The portal shall provide a user configurable registration of federated data sources		3	
1.4.13	Common Portal	The portal shall be able to navigate installation of portal or federated services behind a virtual private cloud or Virtual private network.		3	
1.4.14	Common Portal	The portal shall be able to use UUID to generate query statements to filter data sources by user		3	
1.5	Learning Path Apertures				
1.5.1	Learning Path Apertures	The portal shall be able to select between performance data "apertures" that include: current lesson progress/content, current course progress/planning, planning for next credential, planning for next job, career trajectory planning	Analogous to the “footstep” model provided in the LEA report	2	Requires analytics to support rudimentary capability
1.5.2	Learning Path Apertures	The portal shall allow a user to add or delete themselves from unprotected user interest groups		3	Tied to social learning, there may be an analogy to subscription or the like for the initial streaming service
1.5.3	Learning Path Apertures	The TDT portal shall filter data for a current content window (ancillary content, progress/grade in assignment and impact on current goal)		3	Maturity levels one and two will likely use organic interfaces for LMS/HR systems
1.5.4	Learning Path Apertures	The TDT portal shall filter data for progression planning for current competency/badge/certificate/diploma goal (all content, progress, velocity, gradebook, current proficiency state		3	Maturity levels one and two will likely use organic interfaces for LMS/HR systems
1.5.5	Learning Path Apertures	The TDT portal shall filter data for next assignment: review of available jobs and duties along trajectory, projected competency state, competency gaps		3	Maturity levels one and two will likely use organic interfaces for LMS/HR systems

Level	Header	Requirement	Justification	Priority	Comments
1.5.6	Learning Path Apertures	The TDT portal shall filter data for overall career: Requirements for advancement, job alignment to competency, competency mapping to civilian competencies		3	Maturity levels one and two will likely use organic interfaces for LMS/HR systems
1.6	Skill Decay				
1.6.1	Skill Decay	The TDT shall track the requirement for proficiency, check ride, or continuing education units for conferred credentials	Stated during GSX LEA discussion—concern is that point entering the maintenance phase is not always clear because approval process delays conferral of credential	3	LMS or HR system may have business rules for lower maturity levels that can also accomplish
1.6.2	Skill Decay	The TDT shall allow admins, OIC/S, content managers, and Curriculum managers to set proficiency timers and content requirements to a user interest group or user		3	User controlled business logic for proficiency alerts. This works in concert with the notification system
1.7	Alerts and Notifications				
1.7.1	Alerts and Notifications	The Portal shall display alerts and notifications applicable to the user and role logged in		1	
1.7.2	Alerts and Notifications	Alerts shall require acknowledgement to clear	The notion of streaming and acknowledging alerts was addressed at GSX LEA conference	1	Define alerts as modal and notifications as modeless
1.7.3	Alerts and Notifications	Notifications shall continue on a scrolling message area		1	
1.7.4	Alerts and Notifications	The maximum retention shall be settable by the administrator		1	
1.7.5	Alerts and Notifications	Conferral of a credential shall create an alert that learner is in maintenance phase		1	
1.7.6	Alerts and Notifications	A Just in time training requirement inserted by a content manager shall create an alert		1	
1.7.7	Alerts and Notifications	A regulatory or mandatory training requirement shall create an alert		1	
1.7.8	Alerts and Notifications	An impending (~30 days) proficiency requirement shall create an alert		1	
1.7.9	Alerts and Notifications	Changes to a previously viewed activity/content element shall generate a notification	Used for skills maintenance when changes to competency or content require retraining	3	

Level	Header	Requirement	Justification	Priority	Comments
1.7.10	Alerts and Notifications	Changes to a previously completed credential or in work competency/credential shall generate a notification		3	
1.7.11	Alerts and Notifications	Updates to user information shall create a notification to the user, and any OIC/S, or administrators with interest groups the user is assigned to		3	
1.7.12	Alerts and Notifications	Competency managers shall be able to assign notifications to assigned learners with or working towards those competencies		3	
1.7.13	Alerts and Notifications	OIC/S shall be able to send notifications to assigned user group learners	Class notifications	1	May be organic LMS capability in lower maturity levels
1.7.14	Alerts and Notifications	Content managers shall be able to advertise activities/content to sets of learners as notifications	The ability to advertise courses as available was noted as a key gap during the interview process (DIU)	1	
1.7.15	Alerts and Notifications	Users shall be able to send notifications requesting mentors or tutors in topics	Social media and organizational learning—leverage unprotected user groups	3	May be organic LMS capability in lower maturity levels
1.7.16	Alerts and Notifications	Notifications and alerts shall be able to federate across enclaves and agency domains	Supports class registration requests, and user community learning once learners have changed agency or job	3	
1.8	User Management Integration				
1.8.1	User Management Integration	The portal shall enable single sign on for all subordinate services accessed through the portal		1	May use external backed capability for lower maturing levels
1.8.2	User Management Integration	The TDT shall use existing backend services (e.g. LDAP/Active Directory) for identity management		1	Related to identity management - may use DRRS or similar system for UUID generation
1.8.3	User Management Integration	The TDT shall interface with HR services for credentials	Export of credentials to HR systems for personnel assignments - TDT becomes authoritative record	1	As system matures, HR moves from Core repository to edge consumer of data
1.8.4	User Management Integration	The TDT shall interface with HR services for user assignments		1	As system matures, HR moves from Core repository to edge consumer of data
1.8.5	User Management Integration	The TDT shall utilize cmi5 to capture data from learning management services	Critical to enable maturity level 1 and migrate authoritative data from LMS to LRS	1	

Level	Header	Requirement	Justification	Priority	Comments
1.8.6	User Management Integration	The TDT shall be capable of processing xAPI data for learner performance	Critical to enable maturity level 1 and migrate authoritative data from LMS to LRS	1	
1.8.7	User Management Integration	The TDT components shall utilize backend services for dynamic endpoint management between TDT components and registered content	Required to keep all services and components communicating with portal and each other	1	
1.8.8	User Management Integration	The TDT shall provide a binary level content verification method for registered content which is external to the organization or enclave	To ensure that any www content is still the reviewed and authorized version, in case end user changes it	3	Interface requirement for content management
1.8.9	User Management Integration	The portal shall be available to users across all agencies within the US Intelligence Community		1	May include multiple federated instances, or a single portal hosted at OPM or on centralized SIPR/JWICS instance
1.8.10	User Management Integration	Each agency shall provide access controls for sharing data across the entire IC enterprise	Servicing the entire IC in one contiguous TDT may not be possible if the systems do not horizontally scale, in which case some kind of federated systems approach will be required, where least level of detail is propagated to an OUSD(I) master repository, and individual agencies maintain more granular support data	1	Include export media and FIPS 140-2 (NIPR) or other HW level encryption for moving data between enclaves, if a common CDS is not available. If a CDS is available, then this includes proper classification markings as part of profile to support CDS
1.8.11	User Management Integration	The TDT shall enable federated data services between agencies and enclaves	Servicing the entire IC in one contiguous TDT may not be possible if the systems do not horizontally scale, in which case some kind of federated systems approach will be required, where least level of detail is propagated to an OUSD(I) master repository, and individual agencies maintain more granular support data	1	

Level	Header	Requirement	Justification	Priority	Comments
1.8.12	User Management Integration	The TDT shall leverage trusts between backend identity management services	Servicing the entire IC in one contiguous TDT may not be possible if the systems do not horizontally scale, in which case some kind of federated systems approach will be required, where least level of detail is propagated to an OUSD(I) master repository, and individual agencies maintain more granular support data	1	
1.8.13	User Management Integration	The TDT shall have a configuration capability that registers service and data providers that operate within the ecoservice, to include backend services and data portability between adjacent ecoservices.	Supports governance between enclaves of: xAPI profiles Internationalized Resource Identifier (IRI) creation management for actors, activity records, and activities single sign on and security credential and identity management	1	
1.8.14	User Management Integration	The TDT shall be able to export an approved credential equivalent to linked-in	This requirement was mentioned during GSX LEA briefing as difficult for transitioning personnel with high clearance jobs	3	Supports the "end of career" transition. Part of level three maturity and enabled by competency and credential management service
1.8.15	User Management Integration	The TDT portal shall use a RESTful implementation to connect to federated data services	Design constraint to keep consistent with TLA open system interface policy	3	May be different API for maturity levels one and two. Intent is to use Open API and REST mapping as part of TLA interface specification and federation development process.
1.8.16	User Management Integration	The TDT shall provide a registration service for all federated data sources to manage URI blocks, permission holders, and path name/URL/IP for resources	Since the TDT is an open federated system, the federation requires a registration service	3	Works with governance system above to provide physical registry
1.8.17	User Management Integration	The TDT shall use UUID internally, while minimizing the need to access an identity server for display of user names and data		1	Use of UUID and IRI internally prevent storage of PII outside of clean room environment within the enclave
1.8.18	User Management Integration	The TDT shall interface with agency travel services for billeting, etc.	Part of resource management associated with selecting and scheduling content	3	Organic LMS, Defense Travel System or other for low maturity levels - outyear requirement, probably handled through air gap initially

Competency Management Services

A *competency* includes the elements required to perform some aspect of a job/duty/gig and the relationship among those elements. The relationships are traditionally evaluated during curriculum development; although in practice it is possible, or even desirable, to allow for multiple paths to accomplish the same end state goal. The legacy representation has been simplified to a hierarchy, most commonly captured now as the CAM implementation of the Learning Object Metamodel (LOM) of IEEE 1484.12 (Reference H). The more dynamic and realistic view used in the TLA, shown in the logical data model of ***Figure 3***, models a DAG, which captures the RCD metamodel from the IEEE 1484.20 standard (Reference I). The IEEE Learning Technology Standards Committee manages both.

Traditional training and education curricula capture knowledge, skills, attitudes, abilities and other characteristics as a set of enabling and terminal learning objectives (ELOs/TLOs). ELOs and TLOs represent an abstraction tailored to the training/schoolhouse environment and do not necessarily represent performance under realistic work conditions. Knowledge-based learning objectives represent the artificialities of the classroom or curriculum assessment mode in how they are worded (e.g., list, define, or describe elements of something) and measured. However, in moving from a curriculum-based world to a competency-based world, the tasks, conditions, and standards defined in existing learning objectives provide a starting point.

Key differences between the competency-based approach (as compared to the curriculum-based view of the world) include the following:

- Explicit inclusion of *mindset* elements of the work (e.g., affective domain, metacognitive and soft/social skills, motivation; detailed in Reference G);
- Explicit linking of individual capability to overall mission effectiveness; and
- Focus on demonstration of capability rather than assessment of learning transfer, which shifts from time-structured course completion criteria to objective performance-based criteria.

In contrast, the curriculum-based approach often focuses on:

- Presentation of knowledge and skills,
- Periodic updates of curriculum based on wide systemic effects identified as effectiveness gaps, and
- Formative and summative assessment of material previously presented in linear fashion.

The competency-based approach begins by capturing the relationship among the elements of a competency, tied to performance of a job/duty/gig, and assessed via observable evidence (MOP[1]) against a given level of performance (standard) under relevant contexts (conditions). A key feature of the competency-based approach is that evidence can be collected from informal learning or on-the-job experiences—not only from assessments in a formal training and education settings.

Moreover, competency-based learning allows for multiple paths through the same content, since demonstration of capability (however that capability was developed) determines progress. In some cases, demonstration of one element may also demonstrate de facto capability with a lower-level element, which would then no longer require training or separate validation (a *quod erat demonstrandum* or QED relationship). Similarly, some elements are so critical to a capability that a demonstrated non-proficiency

[1] In some literature, MOPs and MOEs are referred as process and outcome measures, respectively.

in that element shows that evidence higher-order capabilities are suspect and de-credentialing of the higher-level capability should occur (a *sina qua non* or SQN relationship). Each grouping of competency objects and associated standards and conditions represents a given level of mastery for the competency. Competencies may have many levels of mastery and the job requirements for mastery may differ.

Curricular materials in a schoolhouse, online environment, or training exercise—and their associated assessments—become another way to provide evidence of competence. This CBL approach requires the traditional curriculum manager to separate into two roles: the *competency manager* (defining the elements competency, that is, of being capable to perform a given job at a level of mastery) and a *content manager* (identifying mechanisms to provide evidence of that capability).

The record of individuals' achieved competencies is recorded in the Learner Profile data store. Data in the Learner Profiles will exist at multiple levels of abstraction representing and support different control loops within the ecosystem. A local learner profile may simply use observed learning outcomes, collected as xAPI statements, to make assertions of competence. More complex Learner Profiles may combine other characteristics of the learner (e.g., traits, preferences), include evidence from job experiences, and incorporate data from beyond the enclave (e.g., credentials from external schools). Local Learner Profiles are federated, and they call back to a single authoritative data source for identity management (such as a DoD personnel system that stores personal information tied to a UUID). Each enclave uses an Internationalized Resource Identifier (IRI) manager locally to anonymize PII, and the UUID to IRI connection is made in the clean room database.

The relationship between the competency objects, the vectors that make up the DAG of the competency framework, can be viewed as weights in a causal inferencing system. Ultimately, these tie back to operational effectiveness data (by whatever measurements of effectiveness, MOEs, the organization uses to report its mission capability, as an organization). While individual performance and mission effectiveness can be confounded, as the ultimate goal mission effectiveness must be included as a validation of the assessment of competence. In practice the impact of performing a task, or not performing a task, is context dependent, and combining fault-analysis methods, such as Failure Process Modes and Effects Analysis (FPMEA), with the learning analysis will help identify conditions under which satisfactory performance of human tasks is essential to system operation.

Thus, the competency framework and its collection of evidence is used to make inferences about mission capability. The strengths of weights are part of the inferencing system, and over time (especially at the higher levels of TDT capability maturity), machine learning can help refine those weights and improve the system's operation. Weights between competency objects represent the degree of correlation between the objects. Correlation between competency and MOE must be tempered by the exogenous variables that also contribute to readiness (e.g., material condition and environment, leadership, and irreducible teamwork qualities), but this weighted effect is still important in the overall chain of evidence provided by the competency management system.

Competencies may roll up into credentials, which are an exportable and globally understood proxy for the underlying competency. Credentialing services include the features necessary to ensure non-repudiation, by use of digital signatures (equivalent to seals on legacy paper diploma and certificates) and other technology to ensure that the recipient is valid. Competency management provides the same audit trail that a *grade book retention* provides in a legacy educational environment. Key to both systems is *trust*. In the digital case, trust is established by providing a non-repudiable digital audit trail that properly authorized

individuals have certified the evidence of competency achievement (i.e., assertion) and that the competency framework (collection of competency objects and DAG associated with a job/duty/gig) upon which a credential resides was approved by a trusted agent and accessed from a trusted data source. As the TDT migration unfolds, some systems may be established as trusted agents, but until that time trust requires a human in-the-loop for signature and approval.

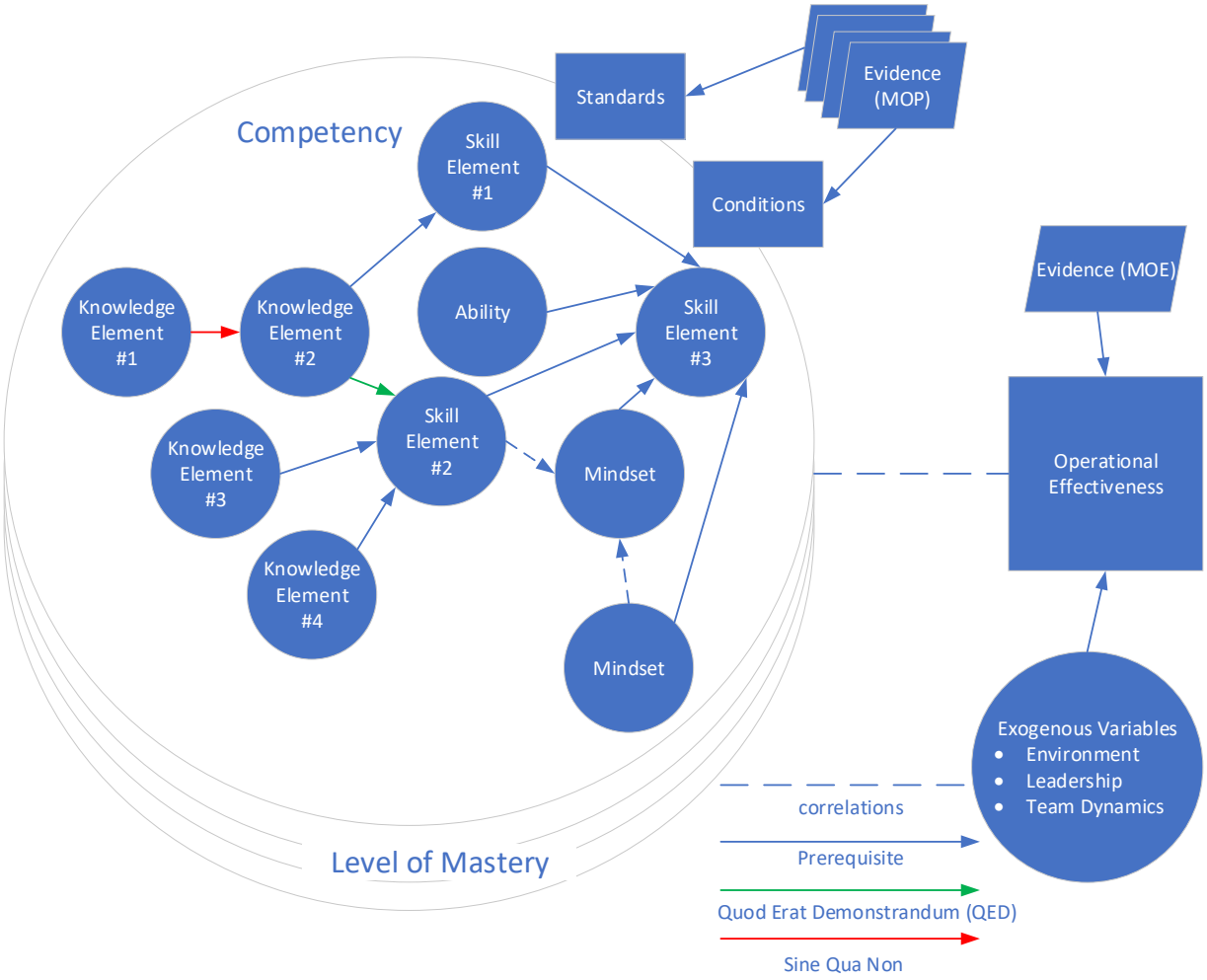


Figure 9 Elements of Competency. *The Directed Acyclic Graph of competency elements is related to the conduct of jobs required for operational effectiveness.*

Most HR systems include a credentialing system in some form, and these HR edge systems will likely remain the trusted data source for credentials in the TDT objective system. The evidentiary chain of assertions in the competency management process will be value-added once the TDT achieves maturity level three. Mathematically, the Competency Management Services within the TDT preserve the elements of the system of equations:

$$\Sigma \text{ (evidence + trust)} = \text{assertions}, \Sigma \text{ (assertions | inferences + validation | inferences)} = \prod_{\text{PersonnelReadiness}}$$

Table 3 lists the requirements of Competency Management Services.

Table 3. Competency Management Services Requirements

Level	Header	Requirement	Justification	Priority	Level
2	**Competency and Credential Management Service**				
2.1	Learner Profile				
2.1.1	Learner Profile	The learner profile shall link back to an authoritative identity management service for personal data: name, rank, SSN, address, phone, UIC	Protection of PII - LP removes details from UUID to prevent multiple copies of sensitive personal information	1	LP is broken out separately at maturity level three, at one and two is probably student management service of LMS, or HR system organic capability
2.1.2	Learner Profile	The learner profile shall maintain a history of training events/exercises attempted and completed, as well as scoring data	The LP becomes the authoritative record with audit trail for personnel data	1	May use linked data to LRS at maturity level three when the LP is broken out. This will be in LRS in maturity levels one and two
2.1.3	Learner Profile	The learner profile shall maintain a list of conferred credentials, CEU state, and effective dates	The LP becomes the authoritative record with audit trail for personnel data	1	LP is broken out separately at maturity level three, at level one and two is probably student management service of LMS, or HR system organic capability
2.1.4	Learner Profile	The learner profile shall maintain a list of authorized access roles		1	May be tied to identity management system or backend security services
2.1.5	Learner Profile	The learner profile shall store educational preferences for most effective content types, learning strategies and effectiveness, and efficiency against defined baseline on achieving targeted credentials.	This supports future adaptation technologies. Those attributes are currently undefined	4	Outyear requirement. May include OIC/S notes for lower maturity levels as part of annotated class records. xAPI profile includes inferences which may include a written record of these observations, to be used in part for HR system, or class evaluations
2.1.6	Learner Profile	The learner profile shall be able to store user specified attribute data required for specialized training	Every training environment may have unique data capture requirements (e.g. shoe size for areas that utilize MOPP gear)	3	May require off line file reference in LMS prior to maturity level three
2.1.7	Learner Profile	The learner profile shall maintain a change log of updates to the profile	Supports auditability/non-repudiation	3	Once learner profile is fully broken out at maturity level three

Level	Header	Requirement	Justification	Priority	Level
2.1.8	Learner Profile	The learner profile shall support deployment in a federation (more than one physical installation, especially between enclaves)	Because the IC uses NIPR/SIPR/JWICS/5Eyes without consistent CDS/MLS solutions, the entire data lake architecture must allow for federation and disambiguation - including moving users from one enclave/installation to another	3	Once learner profile is fully broken out at maturity level three
2.1.9	Learner Profile	The learner profile shall be able to link higher level enclave data with lower level data to form a complete picture of performance	When viewing in concert with lower classification level data at highest level	3	Once learner profile and competency framework are fully broken out at maturity level three
2.1.10	Learner Profile	The learner profile shall be able to follow the learner/user through multiple agencies		1	Part of data federation strategy - will migrate from LMS/SMS in maturity level one and two to LP data portability at level three
2.1.11	Learner Profile	The learner profile shall store current performance goals and sub goals		3	Competency Goals are dependent on the maturity level three migration
2.1.12	Learner Profile	The learner profile shall store current performance state and trajectory, including possible/allowable deviations	Discussed during GSX LEA conference; this is the available career paths (jobs/quals) based on current state (and possibly aptitude, if business logic can be defined)	1	Possibly a function of the HR/LMS systems in maturity level one and two (according to GSX LEA recommendations for near term migration)
2.1.13	Learner Profile	The learner profile shall allow for the creation, retrieval, update and deletion of learner records		1	
2.1.14	Learner Profile	Deleted learner records shall be recoverable/auditable		1	
2.1.15	Learner Profile	The learner profile shall provide a mechanism to ensure credentialing and de-credentialing comes from a non-repudiable and authoritative source		1	Competency system in level three will be of different form than maturity level one and two- which will probably rely on offline signatures and tightly controlled administrator access
2.1.16	Learner Profile	Individual learner profile records shall enable an administrator to conduct a full record purge after a specified period		1	

Level	Header	Requirement	Justification	Priority	Level
2.1.17	Learner Profile	The learner profile shall indicate the current possible career trajectories (badges, jobs, etc.)	Discussed during GSX LEA conference - this is the available career paths (jobs/quals) based on current state (and possibly aptitude, if business logic can be defined)	4	Possibly a function of the HR/LMS systems in maturity level one and two (according to GSX LEA recommendations for near term migration) - may require advanced analytics for TLA level three migration to realize full potential
2.1.18	Learner Profile	The learner profile shall maintain a mechanism to prevent hacking/loss of data integrity	Single authoritative source of qualifications	1	
2.1.19	Learner Profile	The learner profile shall maintain an authoritative profile of credentials obtained and when, competencies achieved at a certain level, and in work/set as goals	Part of credential non-repudiation	1	In maturity level one and two, a master HR system should maintain credentials, to avoid license scalability issues with LMS
2.1.20	Learner Profile	The learner profile shall maintain an unambiguous linkage back to the identity management service	Related to NCAA data visibility and hiding requirements discussed at GSX LEA Conference. This allows for anonymized ID within a TDT instance and non-repudiable export to a globally unique resolvable person identity		If external identity management
2.1.21	Learner Profile	The learner profile shall maintain a profile of user identified attributes defining learner characteristics	Allows for site specific attributes (such as prior military service) that may not apply to all federations	3	Include airman learning record type fields, as well as anything required to support adaptation algorithms of decision support
2.1.22	Learner Profile	The learner profile shall integrate with the competency and credential management services	To support federated data structures	3	This is part of definition of level three maturity
2.1.23	Learner Profile	The learner profile shall support federated data structures between agencies and enclaves	To support federated data structures	3	This is part of definition of level three maturity
2.1.24	Learner Profile	The learner profile shall maintain an auditable log of changes	Support RMF IA auditability	1	May be a COTS 3rd party or external system connected to HR system for maturity level one and two. Use DBMS that supports journaling for maturity level three
2.1.25	Learner Profile	The learner profile shall provide a digital export of credentials for civilian portability	Discussed during GSX LEA conference, there is a call to provide a “civilian equivalent” unclassified credential for resume/transition purposes	1	

Level	Header	Requirement	Justification	Priority	Level
2.1.26	Learner Profile	The learner profile shall allow for deletion of records from searches by an administrator	Data archival—records may be suppressed from searches for search time optimization, but retained for regulatory purposes	3	
2.1.27	Learner Profile	The learner profile shall allow for permanent deletion of records by an administrator	Housekeeping function	3	
2.2	Competency Management				
2.2.1	Manage Competency Framework				
2.2.1.1	Manage Competency Framework	The Competency Management Service shall maintain a list of jobs/duties required of each user roles within the organization		1	Likely included as part of HR system for maturity level one and two, transition to competency management service for level three
2.2.1.2	Manage Competency Framework	The Competency Management Service shall store the knowledge, skills, abilities, and attitudes required to perform a job or duty		1	Likely included as part of HR system for maturity level one and two, transition to competency management service for level three
2.2.1.3	Manage Competency Framework	Each knowledge, skill, or attitude element shall include task and relationships to associated context/conditions and standards	Uses attitude instead of ability to define affective skills explicitly as part of ability required of job, instead of captured separately on performance evaluations - improves matching of person to job	1	CAM within LMS courses maintains a hierarchy for maturity level one and two, but this will be replaced with directed acyclic graph of competency objects and evidence maps for level three
2.2.1.4	Manage Competency Framework	The context and standards under which competencies were acquired shall support determining fitness of the person for a specific job or employment	Supports the lifelong career planning	3	
2.2.1.5	Manage Competency Framework	The Competency Management Service shall define related competency objects (cognitive, psychomotor, affective, social, and metacognitive domains, standards, and context/conditions) at multiple levels of mastery	*Qualified* is end of apprenticeship, and *proficient* end of journeyman, with additional break out levels of mastery defined	3	Levels of mastery might be implicit in LMS course structures (or irreducible emergent qualities in HR systems) but may become a lower level attribute in maturity level three competency frameworks
2.2.1.6	Manage Competency Framework	The Competency Management Service shall specify the competencies and level of mastery required for each job/duty		1	Included in HR system mapping to required courses in maturity level one and two
2.2.1.7	Manage Competency Framework	The Competency Management Service shall generate assertions of competence based on evidence of mastery		3	Supported in transition from course-based to competency-based

Level	Header	Requirement	Justification	Priority	Level
2.2.1.8	Manage Competency Framework	Evidence of mastery shall include SCORM based assessments, externally generated assessments (e.g. Pearson Vue), Manually entered assessments, capture of on the job experiences (including structured and unstructured OJT), and experiences generated from instrumented digital publications or simulations	All learning experiences provide some level of exposure and evidence of mastery. Obviously doing the job unaided is highest level of assurance, followed by formal testing and "heard about it in class" is the lowest form	1	This is preserved in the LRS and is key to the first migration level
2.2.1.9	Manage Competency Framework	The Competency Management Service shall process cascading evidence chains based on competency frameworks (showing all competencies demonstrated by the evidence)	Competency based education is based on real world evidence of skills in context instead of Teach->Measure	3	Thus, real world scenarios may indicate mastery of knowledge that is related to multiple areas (it is a set of many to many relationships, instead of the pure one to many hierarchies of the SCORM content aggregation model, which mirrors course structures
2.2.1.10	Manage Competency Framework	The Competency Management Service shall calculate competencies demonstrated as progress towards a related credential	Credentials in CBE should be based on cumulative ability to perform jobs, not assessments from classroom materials alone	1	This is similar to "comp-ing out" of scholastic requirements. May be included as part of HR system, or overrides in LMS for maturity level one and two
2.2.1.11	Manage Competency Framework	Credentials for a job/duty shall include all competency objects required to perform a job/duty		1	Credentials may include a traditional "degree" or "certificate" as well as "necessary qualifications" to do the job
2.2.1.12	Manage Competency Framework	The Competency Management Service Competency Management Service Competency Management Service shall determine when minimum thresholds for performance are achieved	Comparison against standards for triggering competency update may have multiple standards depending on context and level of mastery	3	LMS in maturity level one and two evaluates assessments, and external assessments have grading pre-activity record, in which case the standard evaluated against is passed - this allows for pushing grading to edge systems, or to be preserved within the competency framework for maturity level three
2.2.1.13	Manage Competency Framework	The Competency Management Service shall update individual user performance records based on assertions of performance		1	For maturity levels one and two, this is a cooperative effect of the LMS and HR systems
2.2.1.14	Manage Competency Framework	The Competency Management Service shall ensure that achievement of a competency requires review and approval by an authorized approval authority	The conferral review process	1	May be an offline process for maturity level one and two

Level	Header	Requirement	Justification	Priority	Level
2.2.1.15	Manage Competency Framework	The Competency Management Service shall be able to distinguish between qualification, proficiency, and mastery		3	May have additional categories specified - but shows currency of capability
2.2.2	Provide Configuration Control of CF Over Time				
2.2.2.1	Provide Configuration Control of CF Over Time	The Competency Management Service shall allow authorized users to create, read, update and delete elements of a competency framework	Data usability was cited as key requirement	1	Simplified version in LMS/HR system for maturity levels one and two
2.2.2.2	Provide Configuration Control of CF Over Time	The Competency Management Service shall generate an alert when an element has been modified		3	Part of social learning/notification
2.2.2.3	Provide Configuration Control of CF Over Time	The Competency Management Service shall maintain a record of changes (user, authority, name-value pairs)	Required for audit/non-repudiation	3	
2.2.3	Compatibility Translation				
2.2.3.1	Compatibility Translation	The Competency Management Service shall provide a mechanism to allow mapping of one competency framework to another at the atomic element level	Discussed during GSX LEA conference, interagency transfers and multi-agency support of schoolhouses like NIU	3	Dependent on competency management service migration at maturity level three
2.2.3.2	Compatibility Translation	The Competency Management Service shall provide a mechanism to allow mapping of one competency framework to another at the badge/credential level	Discussed during GSX LEA conference, interagency transfers and multi-agency support of schoolhouses like NIU	3	Dependent on competency management service migration at maturity level three
2.2.3.3	Compatibility Translation	The Competency Management Service shall provide for export of competency framework data	Discussed during GSX LEA conference, interagency transfers and multi-agency support of schoolhouses like NIU	3	Dependent on competency management service migration at maturity level three
2.2.3.4	Compatibility Translation	The Competency Management Service shall provide a mechanism for user defined business rules to filter exportable data (including association back to identity management (NCAA driven)	Discussed during GSX LEA conference, interagency transfers and multi-agency support of schoolhouses like NIU	3	Dependent on competency management service migration at maturity level three
2.3	Credential Management				
2.3.1	Credential Management	The Credential Management Service shall maintain an auditable log of evidence that led to the credential	Required for audit/non-repudiation	1	Might include linked data (JSON-LD) in xAPI, can include archival of LMS data for maturity levels one and two

Level	Header	Requirement	Justification	Priority	Level
2.3.2	Credential Management	The Credential Management Service shall update the learner profile with the credential achieved, active date, conferral authority, and conferees name and service number	Required for audit/non-repudiation	1	Might include linked data (JSON-LD) in xAPI, can include archival of LMS data for maturity levels one and two
2.3.3	Credential Management	The Credential Management Service shall preserve a digitally signed badge showing the credential achieved, active date, conferral authority, and conferees name and service number	Discussed during GSX LEA, acceptability of digital credentials is in question. This should address the "verification" concern	3	May require full competency and credential system with blockchain or similar technology on top of JSON-LD
2.3.4	Credential Management	The Credential Management Service shall provide a non-repudiable paper export of the digitally signed badge	Some services will only accept paper certificate, and for cache of having certificate to hang on wall	1	Required for maturity level one and two migration
2.3.5	Credential Management	The Credential Management Service shall be able to export digitally signed credentials which are cross referenced to another agency credential	Discussed during GSX LEA conference, interagency transfers and multi-agency support of schoolhouses like NIU	3	Dependent on competency management service migration at maturity level three - 2.2.3.2 addressed level below credential
2.3.6	Credential Management	The Credential management service shall be able to assign user specified business rules for validating credentials to a user interest group (beyond assessments) to include: source agency, military record, time in rate/job, assignment, multiple signature authorities	Used to close gap between "finishing the course and passing the test" and "conferring the degree" - user configured business logic. As discussed in GSX LEA conference	1	May be offline process in maturity level one and two
2.3.7	Credential Management	The Credential management service shall be able to generate non-repudiable alerts to OIC/S role users to establish required conferral and validation signatures	Automated signature routing for conferral process without requiring outside system and manual verification	1	The “signature obtained” becomes the trigger to update credential
2.3.8	Credential Management	The Credential Management service shall monitor achievement of CEU/PDU requirements and issue de-credentials or updates as necessary		1	May be interface to/from AGILE at maturity level one and two, need to update record as well as create notifications
2.3.9	Credential Management	The Credential management service shall support mirroring or data transport at all four enclaves (NIPR/SIPR/JWICS/5Eyes)	No reliable CDS requires synchronization between layers to provide complete picture of competency	1	
2.3.10	Credential Management	The Credential Management service shall provide a user configurable name for digital badges (e.g., diploma, certificate, badge)	Each name has special significance and they are not interchangeable—although they are all credentials	3	

Activity Management Services

Activity Management Services are concerned with the scheduling, prioritization, reporting, and archival of evidence generated by learning record providers. Activity Providers include a wide continuum, from traditional LMS-based SCORM content, digital assessments, online web resources, and electronic publications, to mobile learning, simulations, and other digital content management systems. Learning activities may also refer to resources (e.g., scenarios, interactive technical manuals) present in any number of *in situ* or *ad hoc* learning opportunities, including on-the-job (OJT) training; electronic performance support systems (EPSSs); live, virtual, constructive, or game–based simulations; and operational work performance. Any of these can provide an opportunity to demonstrate some degree of mastery in one or more concepts.

Figures 10 and ***11*** show the sequence of events (as a UML Sequence Diagram) of scheduling learning activities or capturing *ad hoc* learning. TDT core system services are shown in blue with white text, and edge systems are shown in green with black text. These diagrams assume connections on a local enclave with the federated systems including only the portal (UI), a generic activity provider (e.g., LMS), and a HR system. These figures do not depict the low-level communications required for multiple federated data sources, local identity and IRI management, and other detailed design elements.

Use-Case 1 – Formal Learning: Consider the formal learning use-case, where an OIC/S assigns a learning event (e.g., schoolhouse-based class, online tutorial, or simulation) to an individual. The assignment sits in the queue for the learner for some specified time (after which, the individual may get de-credentialed for missing the event or dropped from the assignment or course). Once the learner has accepted the scheduled event, the activity manager generates a launch request. The activity index stores the location and required resources (e.g., bandwidth, classrooms, faculty) to conduct the event, verifies their availability, and launches/initializes the activity provider (which could include a message a human in-the-loop, e.g., to start a simulator, or could involve an automated signal enabled through the LTI standard, see Reference K). If the activity uses digital content, it could be viewed in the TDT portal in a web browser or a separate application. The learner interacts with the activity provider (e.g., completes the e-learning course), and it generates evidence of that experience, sending xAPI-based messages to the transaction LRS that adhere to the given xAPI Profile (see Reference K). Extensions in xAPI might also capture *paradata*, describing the learners' feedback from the experience (e.g., to course evaluation survey results).

The Activity Manager disambiguates the evidence to actionable levels of detail (perhaps using an edge system or relying on the activity provider) and provides updates to the competency manager, which verifies the trust of the evidence according to predefined business logic from the competency framework (acting on activity index metadata values listed for that content/activity). The competency service generates an assertion (positive or negative) of competency which is stored in the LRS and Learner Profile. The activity manager generates any required feedback (which may be as simple as "passed" or could include more detailed data) and passes that information to the decision-support applications. Then the competency manager updates the goal state in the Learner Profile to provide additional feedback and archival. If the achievement of a goal effects a credential, the competency manager evaluates this and all required business logic for conferral of the credential (e.g., certificate or diploma) and sends an update to the HR system of record. This is weakly

sequenced and might happen as a separate threaded process. Learner interaction with, and evidence reporting by, the activity repeats in a loop. This loop continues until the selected goal is met (which may be at, under or above a credential level, depending on the competency framework). This formal learning sequence is shown in ***Figure 10***.

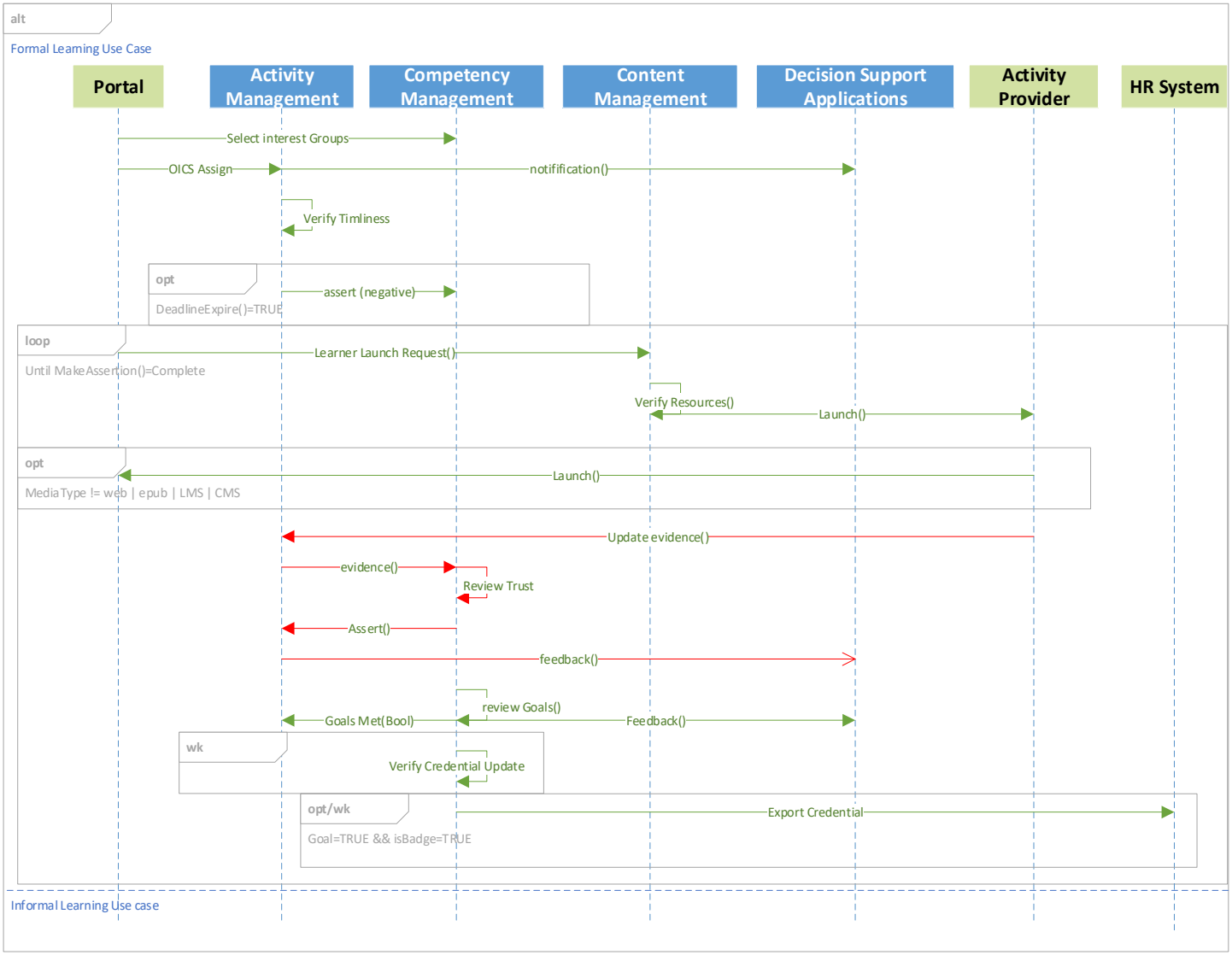


Figure 10 Formal Learning Use-Case. *The TDT Concept of Execution paces through course elements to build competency, like the legacy LMS case.*

Use-Case 2 – Informal Learning: The informal learning use-case represents a majority of learning experiences. These activities include learner-requested content (e.g., asynchronous learning events not scheduled by an OIC/S or additional content to augment scheduled instruction) as well as ad hoc learning opportunities, whether on-the-job or other self-directed learning. In the scenario where a learner requests additional content, the sequence is like the formal learning execution, although it may require OIC/S approval instead of direction. Ad-hoc events are different; they are captured by the system either from a learner input (self-report) or from instrumented learning technologies. In

the latter case, someone might directly access the learning technology itself (e.g., an electronic publication) rather than reaching it through the TDT portal. In both cases the same learner interaction activity evidence loop continues until the content is terminated (e.g., until xAPI statements containing verbs "abandoned," "closed," or "completed" are received).

Other informal learning use-cases may involve operational experiences. For instance, an aircraft pilot may gain experience (and demonstrate a certain degree of competence) through routine flight hours. Like ad-hoc learning events, operational experiences may be captured through human-in-the-loop reporting, inputs from federated edge systems (e.g., personnel system), or instrumented operational systems (e.g., an edge system that reports scheduled flight hours).

Notably, some credentials may expire over time, requiring individuals to periodically reaffirm evidence of their competence. This could entail completion of routine training (e.g., annual training requirements) but could also be met by completion of informal learning activities or operational experiences. However, if no evidence is provided to reaffirm an expiring credential then the TDT system could de-credential it. More precisely, if required evidence of currency is not received, the Competency Manager will issue a de-credential to the learner profile and the HR system which serves as the authoritative data source. ***Figure 11***, which shows the informal learning use-case, also depicts this skill decay de-credentialing sequence. Currently, the IC uses AGILE to provide this service, and that application may continue to be used through the maturation of the TDT.

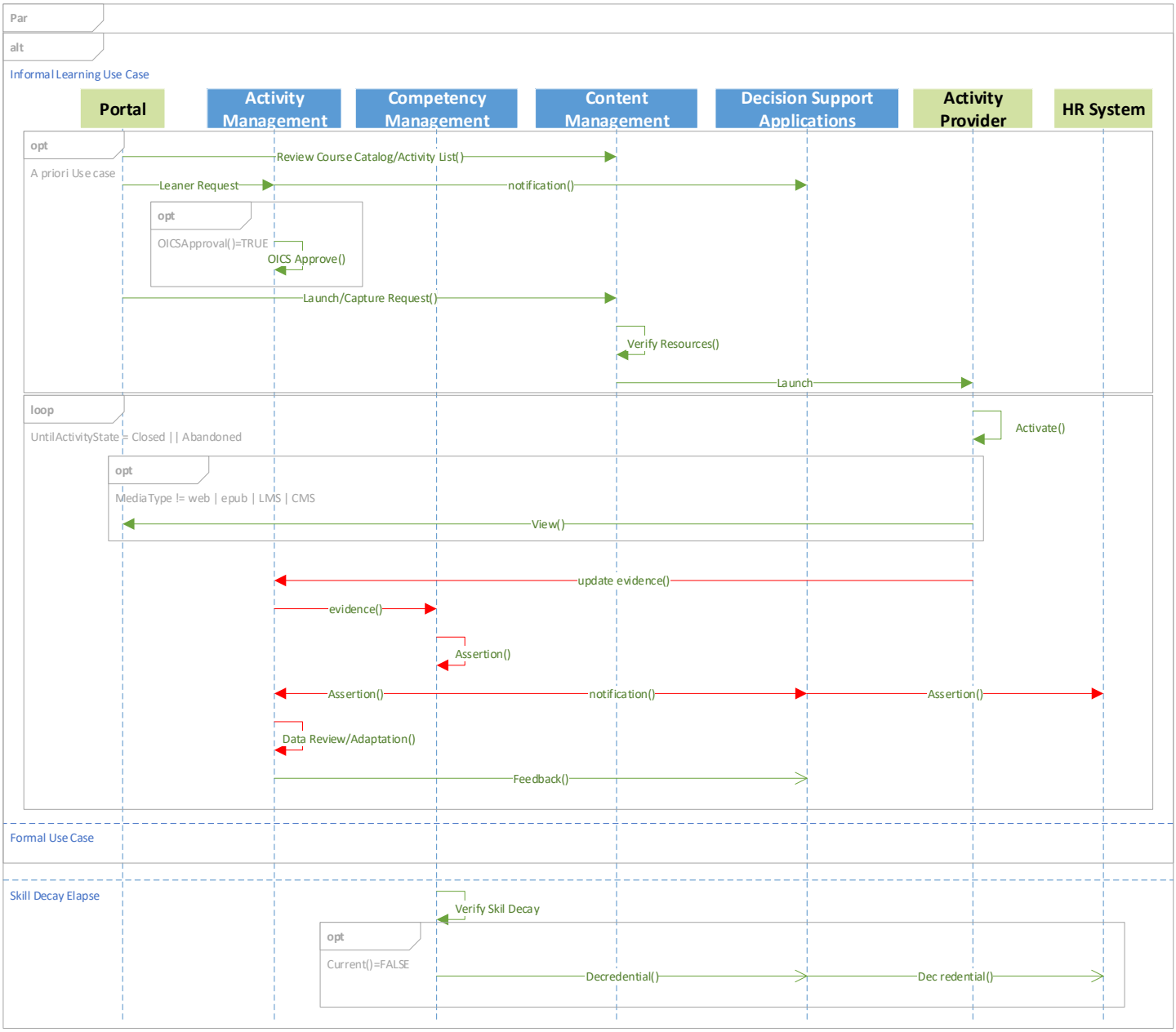


Figure 11 Informal Learning Use Case. *Self-directed and self-determined learning, and OJT represent a novel concept of execution not always supported by a traditional LMS.*

Table 4. Activity Management Services

Level	Header	Requirement	Justification	Priority	Level
3	**Activity Management Service**				
3.1	Learning Record Store				
3.1.1	Learning Record Store	The TDT shall maintain a persistent storage of learning activity records (i.e. LRS)		1	LRS is essential for initial migration
3.1.2	Learning Record Store	The TDT shall capture all xAPI statements generated from learning record providers	xAPI allows for capturing repetition, and for performance of activities outside of SCORM/LMS environment	1	LRS is essential for initial migration
3.1.3	Learning Record Store	The TDT shall ensure that xAPI statements are complete and well formed		1	LRS is essential for initial migration
3.1.4	Learning Record Store	The TDT shall provide a mechanism for administrators to purge old xAPI records	See retention requirement	1	LRS is essential for initial migration
3.1.5	Learning Record Store	The TDT shall maintain a record of purges to show that data has been altered		1	LRS is essential for initial migration
3.1.6	Learning Record Store	The TDT shall provide a mechanism to ensure the integrity of xAPI data stored		1	LRS is essential for initial migration
3.1.7	Learning Record Store	The TDT shall allow storage of xAPI statements for the current user UUID stored as actor	Protection of PII - clear names not associated with data records	1	LRS is essential for initial migration
3.1.8	Learning Record Store	The TDT shall allow use of filters on retrieving xAPI data by user, user interest group, date/time, activity type, verb, user specified extension field values		1	LRS is essential for initial migration
3.1.9	Learning Record Store	The TDT LRS shall support federated data storage between enclaves or agencies	Multiple installations are likely	1	LRS is essential for initial migration
3.1.10	Learning Record Store	The TDT LRS shall be sized to support a 10-year digital data retention store of all evidence	Based on auditing requirements	1	LRS is essential for initial migration
3.2	Manage Learning Path Logic				
3.2.1	Manage Learning Path Logic	The TDT shall allow users to launch activities to complete an assigned formal course	Replicates LMS content launch functionality	1	Organic LMS function for maturity level one and two, replaced by remote (and maybe using LTI standard) launch and addressing capability for maturity level three

Level	Header	Requirement	Justification	Priority	Level
3.2.2	Manage Learning Path Logic	The TDT shall allow users to launch activities to augment learning in a formal course	Replicates LMS content launch functionality	1	Organic LMS function for maturity level one and two, replaced by remote (and maybe using LTI standard) launch and addressing capability for maturity level three
3.2.3	Manage Learning Path Logic	The TDT shall allow users to launch activities within a formal SCORM course (to be used for refresh or support)	Replicates LMS content launch functionality	1	Organic LMS function for maturity level one and two, replaced by remote (and maybe using LTI standard) launch and addressing capability for maturity level three
3.2.4	Manage Learning Path Logic	The TDT shall record the start, stop and pause points for launched courses at each event in xAPI	Replicates LMS content launch functionality	1	Organic LMS function for maturity level one and two, replaced by remote (and maybe using LTI standard) launch and addressing capability for maturity level three
3.2.5	Manage Learning Path Logic	The TDT shall capture a restart, rewind or resume for content that was paused in xAPI	Replicates LMS content launch functionality	1	Organic LMS function for maturity level one and two, replaced by remote (and maybe using LTI standard) launch and addressing capability for maturity level three
3.2.6	Manage Learning Path Logic	The TDT shall capture an “abandoned” xAPI for content that was paused or stopped without completion after an OIC/S specified time out period	Required to “close out” activities which never receive grade and completed state	1	Part of xAPI Master Profile
3.2.7	Manage Learning Path Logic	The TDT shall allow users to launch documents which are not part of a formal SCORM course	Any digital content available on the network is potential for learning experience- This includes student guides, you tube videos, linked documents. Etc.	1	Includes internal and external content - works with resource management
3.2.8	Manage Learning Path Logic	The TDT shall be able to launch SCORM or non SCORM digital content on any connected computational platform and capture state information	Includes LMS as edge system, as well as any other files maintained in a content management system or resourced from the internet (NIPR/WWW, SIPR or JWICS)	3	Requires external launch capability
3.2.9	Manage Learning Path Logic	Launchable documents shall include: PDF, DOC(x), ELS(x), Videos, web sites (including YouTube and active content), eBook documents (Kindle, etc.)		3	Requires external launch capability
3.2.10	Manage Learning Path Logic	The TDT shall allow users to report achievement of simulation or lab scenarios	Capture non-classroom events as evidence of competency	1	Included as part of POI and recorded in LMS for maturity levels one and two

Level	Header	Requirement	Justification	Priority	Level
3.2.11	Manage Learning Path Logic	The TDT Shall capture user performance of LMS assessments, including grade, time to complete, and date/time started	Replicates LMS content launch functionality	1	Organic LMS function for maturity level one and two, replaced by remote (and maybe using LTI standard) launch and addressing capability for maturity level three
3.2.12	Manage Learning Path Logic	the TDT shall capture user assessments from third party assessments (Pearson Vue)	Based on transition from legacy testing requirements	1	
3.2.13	Manage Learning Path Logic	The TDT shall capture assessments manually entered by an associated OIC/S	Based on transition from legacy testing requirements	1	
3.2.14	Manage Learning Path Logic	The TDT Shall capture instructor led content manually entered by an associated OIC/S	Based on transition from legacy testing requirements	1	
3.2.15	Manage Learning Path Logic	The TDT shall capture performance of pop up training (incident reports, etc.) as entered by an OIC/S		3	Used to report and recode status of pop up or regulatory training requirements
3.2.16	Manage Learning Path Logic	The TDT shall provide a batch update of activity for all users in an assigned interest group as a "performed" record (i.e. without a grade or numerical assessment)	Used for off-line activity capture	3	Requires full activity management in maturity level three
3.2.17	Manage Learning Path Logic	The TDT shall allow curriculum managers to schedule a user or user group to content or a course/Content Group		1	May be organic LMS feature for maturity level one and two
3.2.18	Manage Learning Path Logic	The TDT shall allow OIC/S to schedule a user or user group to content or a course/content group		1	May be organic LMS feature for maturity level one and two
3.2.19	Manage Learning Path Logic	The TDT shall allow administrators to schedule a user or user group to content or a course/content group	Supports regulatory training, school registration, and JITT (mishap or incident reviews, etc.)	1	May be organic LMS feature for maturity level one and two
3.2.20	Manage Learning Path Logic	The TDT shall allow content managers, curriculum managers and administrators to assign regulatory required training with a suspense date	To allow mandatory annual or “stand down” just-in-time training	1	May be organic LMS feature for maturity level one and two
3.2.21	Manage Learning Path Logic	The TDT shall allow OIC/S to schedule a user or user group to content in the past (capture ad hoc training)		3	Requires full activity management in maturity level three
3.2.22	Manage Learning Path Logic	The TDT shall be able to capture performance of OJT training/work experience from OIC/S	Most learning occurs on the job, so it is critical for a total training solution to capture it. Training standardization will become an organizational process	3	Requires full activity management in maturity level three. Also used to capture instructor/supervisor observations of competency

Level	Header	Requirement	Justification	Priority	Level
3.2.23	Manage Learning Path Logic	The TDT shall provide a list of applicable content to satisfy a competency objective for selection	This filtering (and potentially recommending service) feature is used to find supporting content to aid in achieving a competency In lieu of or ICW the elements of a formal course	3	Requires "activity index" in maturity level three
3.2.24	Manage Learning Path Logic	The TDT shall validate pre-requisite competencies if required to view content/capture experience	Includes course pre-requisites, safety briefs, etc.	1	May be organic LMS feature for maturity level one and two
3.2.25	Manage Learning Path Logic	The TDT shall display attributes of applicable content to address a competency based on user specified filters	To allow filtering of content by user specified criteria, also in support of adaptation algorithms in later maturity levels	3	
3.2.26	Manage Learning Path Logic	The TDT shall identify any resources required to schedule an activity		3	Includes simulators, range reqs, etc. for full competency system in maturity level three
3.2.27	Manage Learning Path Logic	The TDT shall capture reference of online student guides as an xAPI activity		1	Can be produced in internal or external content management system
3.2.28	Manage Learning Path Logic	The TDT shall capture content provided from mobile sources as an xAPI activity	Support eHelm, PEBL and PERLS Ltech, purpose-built applications or equivalent	1	This is typical of “external content” captured in the LRS; it allows for expansion into modern technology for exporting learning, including mobile learning applications
3.2.29	Manage Learning Path Logic	The TDT Shall capture activities at the same enclave as the activity content is stored	Protect derivative classification	1	
3.2.30	Manage Learning Path Logic	The TDT shall be able to schedule a content element for a learner (admin, course manager, competency manager)	This supports assignment to formal courses which have prescribed order and content	1	May be organic LMS feature for maturity level 1 and 2
3.2.31	Manage Learning Path Logic	The TDT Shall allow learner to request a course to attend/register		1	May be organic LMS or HR feature for maturity level 1 and 2
3.2.32	Manage Learning Path Logic	The TDT shall list a registration approval authority with each content element (admin, OIC/S, Learner)		1	May be organic LMS or HR feature for maturity level one and two
3.2.33	Manage Learning Path Logic	The TDT shall generate alerts for each registration request to the approval authority		1	May be organic LMS or HR feature for maturity level one and two
3.2.34	Manage Learning Path Logic	The TDT shall allow for scheduling of formal courses by an administrator assigned drop dead date		1	May be organic LMS or HR feature for maturity level one and two

3.3	xAPI Profiles and Fields				
3.3.1	xAPI Profiles and Fields	The TDT xAPI Profiles shall include templates for all learning content, activity, and experience types applicable to the federate instance	May have multiple profiles for federated instances	1	
3.3.2	xAPI Profiles and Fields	The TDT xAPI Profile shall include a complete object life cycle (from requirement, to selection, launch, work, and closeout) for each training technology type	To ensure ability to disambiguate in data analysis later	1	
3.3.3	xAPI Profiles and Fields	The TDT shall include an xAPI Profile validation server to ensure compliance with the profile	Off-line capability to ensure data integrity with later additions to the ecosystem	3	
3.3.4	xAPI Profiles and Fields	The TDT xAPI Profile shall include data elements to audit evidence to assertion of competence	To perform audits of evidence to credential	1	xAPI community is examining the use and cautions of linked data
3.3.5	xAPI Profiles and Fields	The TDT xAPI Profile shall include data elements to specify context under which a work event was experienced		3	Works in conjunction with competency-based alignment in maturity level three
3.3.6	xAPI Profiles and Fields	The TDT xAPI Profile shall include data elements to specify context under which an assessment was evaluated		3	Works in conjunction with competency-based alignment in maturity level three
3.3.7	xAPI Profiles and Fields	The TDT xAPI Profile shall include data elements to specify standard context under which an OJT event was experienced		3	Works in conjunction with competency-based alignment in maturity level three
3.3.8	xAPI Profiles and Fields	The TDT xAPI Profile shall include data elements to specify areas not achieved during exams (i.e. grade<100%, what was missed)		3	Works in conjunction with competency-based alignment in maturity level three. This will require capability past the traditional LMS
3.3.9	xAPI Profiles and Fields	The TDT xAPI profile shall include data elements to capture selection and prioritization of competency goals		3	Works in conjunction with competency-based alignment in maturity level three
3.3.10	xAPI Profiles and Fields	The TDT xAPI profile shall include data elements to capture the level of formalism in a learning event	e.g., Structured vs unstructured OJT as a function of evidence	3	Works in conjunction with competency-based alignment in maturity level three
3.3.11	xAPI Profiles and Fields	The TDT xAPI profile shall include fields for simulator and lab exercises to capture details of learner's role, actual scenarios employed, and competencies triggered	Capture of detailed elements of a scenario for populating competency framework "leaf nodes"	3	Works in conjunction with competency-based alignment in maturity level three

Content and Resource Management

Content and Resource Management covers the registration and data labeling of learning opportunities. ***Figure 12*** shows this arrangement of components. *Content* includes any digitally available learning resources (e.g., SCORM or cmi5-based e-learning courses, digital assessments, e-books, simulation scenarios) as well as any nondigital or disconnected learning that can be reported through a digital system (e.g., classroom events, laboratory projects, live training exercises, and human-observed work experiences). The latter are maintained within a digital content management system that preserves universal resource indices or locators for the activities. Content at the unclassified level may also include resources from the world wide web (e.g., third-party videos and websites). Remote launch of activities may use the LTI specification (Reference K), as an example, to enable proper state management and event capture.

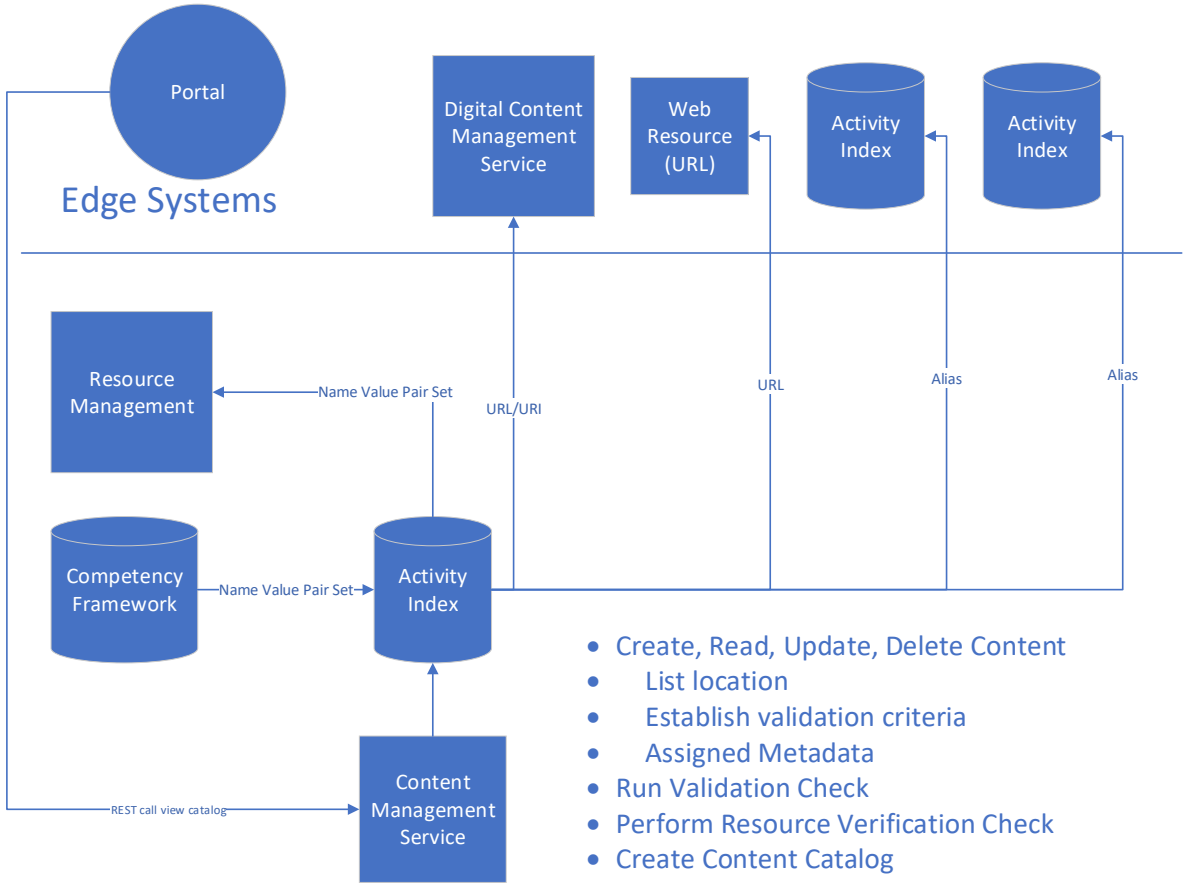


Figure 12 Activity Indices, Content and Resource Management. Information Need Lines between Services and Data Lakes. *Federated data between activity indices enables the common course catalog.*

The Activity Index provides the mapping between the lowest level of definable content (e.g., course module, e-learning course, simulation scenario), the type of Learning Record Provider (i.e., activity) that provides the context for experiencing the content, and its associated learning value in terms of competency objects, standards, and conditions from the competency framework. The Activity Index also stores metadata describing the activities and content, which may be useful (via assigned weights) for executing business logic against evidence records generated by experiencing that content. The business logic can be embedded

within the Activity Index (or it may be allocated elsewhere, such as to the Competency Management System—designers should choose one and remain consistent). Regardless of its architectural design, this business logic is used to:

- Verify trust of the evidence record towards asserting competency
- Prioritize content for selection as a learning activity (media modality to cognitive requirements)
- Determine prerequisites or suitability for a given level of mastery
- Calculate skill decay for condition or time-based de-credentialing
- Authorize the assignment or scheduling of content and authorized expenditures for training and education organizations based on operational demand signals (i.e., "quota control")

Part of the registration process for adding new content is to assign metadata values to the content, as well as define its location and associated resources. The Learning Resource Metadata Initiative (LRMI, Reference L) provides a starting point for defining metadata attributes, however, it is likely each enclave will have unique elements, even though every record must conform to a minimum specification.

For any digital content, a digital verification method must ensure that the content remains valid or uncorrupted. For content under physical custody of the enclave, this may just be a version number tied back to a content configuration management system. For external content (e.g., YouTube™ videos), this should include a binary hashing algorithm like Cyclic Redundancy Check (CRC), a digital signature, or MD5 checksum, depending on the level of risk for hacking, data corruption, or meaconing-type cyber-attacks.

Activity indices are highly federated; that is, content may be located across multiple enclaves and across different security levels. While a single enclave will likely control most its own "curricula," it may still share content with other agencies or enclaves. Moreover, at the enterprise level, a Common Course Catalog can aggregate the data from the local activity indices to summarize elements across all enclaves. Federation across multi-level security is more challenging; however, activity indices and the common course catalog could still provide a pointer to higher-level or lower-level security indices.

Table 5 lists the specific requirements of the content and resource management service.

Table 5. Content and Resource Management Requirements

Level	Header	Requirement	Justification	Priority	Level
4	**Content and Resource Management Service**				
4.1	Common Course catalog				
4.1.1	Common Course catalog	The TDT shall provide a consolidated catalog of courses and registered content available for learning		1	
4.1.2	Common Course catalog	By default, the TDT Course Catalog User Interface shall list courses without supporting content		1	
4.1.3	Common Course catalog	The TDT course catalog shall discriminate between formal courses and supporting content		1	
4.1.4	Common Course catalog	The TDT course catalog shall associate supporting content with formal course elements (e.g. for ancillary teaching materials, extra learning or tutoring, lesson plans and trainee guides)	Allows students to quickly identify materials that support a class without formally being part of it; also enables sharing between class sessions; organizational knowledge	1	
4.1.5	Common Course catalog	The TDT shall also register applicable OJT/work experiences as content types without listing in the catalog		3	Required for full competency-based tracking in maturity level three. May be federated such that only local work opportunities are managed within a given instance within a local version of the activity index
4.1.6	Common Course catalog	The TDT course catalog shall associate all course/content types with the competency element they support (e.g., educational alignment)	Required to filter content that supports a course without being part of it, or for auditing courses as part of CEU/proficiency	1	LRMI/Dublin Core are suggested formats for storing this relationship. In maturity level 1 & 2, the common catalog is a store of LMS courses, in level three, the CC is also supplemented by the local activity index which includes all relevant items
4.1.7	Common Course catalog	The TDT course catalog shall allow filtering of content in the catalog by: top level badge supported, competency framework element, audience type, quota control agency, managing agency, description, length, developer, location, effective date	Catalog filtering capabilities	1	
4.1.8	Common Course catalog	The TDT course catalog shall allow for federated data structures between enclaves and agencies without repeating any courses	Uniformed services already support course catalogs (e.g., CANTRAC), some of which will overlap; as well as enclave and agency differences	1	

Level	Header	Requirement	Justification	Priority	Level
4.1.9	Common Course catalog	Updates to the course catalog shall generate a notification to associated user interest group	Support several use cases of "advertising badges and courses" available	1	May be simple at maturity levels one and two, level three includes integrated social media capability
4.1.10	Common Course catalog	Content/Competency managers shall be able to advertise updates to the content catalog		1	May be simple at maturity levels one and two, level three includes integrated social media capability
4.1.11	Common Course catalog	The TDT content catalog shall list: course name, description, agency identifier, date/time offered, location, length, pre-requisites, competency supported, degree/certificate/badge provided, candidate audience, registrar, quota control, course manager, effective date, billeting	Not every course completes a badge, not every course is registered and paid for by same agency. Some courses require separate billeting arrangements	1	
4.1.12	Common Course catalog	The TDT content catalog shall include data for simulators and labs down to the scenario level of detail	As opposed to tradecraft and onboarding type training, since regulatory are often Just in Time, and separate reporting of completions are required	3	Required for full competency-based tracking in maturity level three
4.1.13	Common Course catalog	The TDT Content catalog shall tag regulatory content as for regulatory review		1	
4.2	Resource Management				
4.2.1	Resource Management	The TDT shall ensure resources (classroom materials, instructors, facilities, server resources) necessary to schedule content are available		1	
4.2.2	Resource Management	The TDT shall reserve the required resources when a content session is requested		1	
4.2.3	Resource Management	If the resource is an OIC/S, a notification shall be sent	The TDT may federate with a class scheduler, so the notification should be for "all OIC/S of a user group to check the schedule" when a schedule update is pushed	1	
4.2.4	Resource Management	The TDT shall manage facility/OIC/S resource requests in batches tied to registrar end date	Prevents the OIC/S from getting flooded with requests	1	
4.2.5	Resource Management	Computational resources shall be scheduled when required to run simulations or host content	Works with FaaS pricing models for hosting content	1	May be offline process
4.2.6	Resource Management	The TDT shall verify on-line (WWW) and digital in-house content is available including the server up and file path is valid	Required for fault tolerance of system (doesn't hang up on broken links)	1	

Level	Header	Requirement	Justification	Priority	Level
4.2.7	Resource Management	The TDT shall verify core data services (competency and learner profile, LRS/activity, management, course catalog) are available to conduct training session	Prevents data loss from missing services to manage audit train		
4.3	Content Registration				
4.3.1	Content Registration	The TDT shall be able to register SCORM courses for use		1	Standard LMS capability
4.3.2	Content Registration	The TDT shall be able to register Instructor Led courses for use		1	Standard LMS capability
4.3.3	Content Registration	The TDT shall employ LMS/SCORM courses which can generate cmi5 messages		1	Standard LMS capability
4.3.4	Content Registration	The TDT shall be able to register digital content stored on agency servers or content management service (e.g., AEM) for use		1	Standard LMS capability
4.3.5	Content Registration	The TDT shall be able to register on line (WWW) web content for use		1	Standard LMS capability
4.3.6	Content Registration	The TDT shall be able to digitally authorize WWW as “valid” and “unchanged” when registered.	Use MD5 or CRC to determine that videos are unaltered, websites not updated without review, etc.	1	Standard LMS capability
4.3.7	Content Registration	The TDT shall require an admin, course manager, or curriculum manager to authorize content for use		1	Standard LMS capability
4.3.8	Content Registration	The TDT shall identify the applicable competency elements and candidate audience (user interest group) for registered content		1	Standard LMS capability
4.3.9	Content Registration	The TDT shall allow delisting of content from the registry		1	Standard LMS capability
4.3.10	Content Registration	The TDT shall allow modification of resource path for content		1	Standard LMS capability
4.3.11	Content Registration	The TDT shall allow OIC/S to list simulators, labs, OJT, EPSS, and user defined work experiences to be registered as valid content types		3	Works in conjunction with competency-based alignment in maturity level three
4.3.12	Content Registration	The TDT shall ensure OJT, EPSS, and other work experiences content types are available to other OIC/S or admins	Allows organizational process to maintain quality control over work experiences	3	Works in conjunction with competency-based alignment in maturity level three
4.3.13	Content Registration	The TDT shall track the status of content updates (i.e. Configuration Management audit trail)		1	LMS don’t normally include an audit capability, so activity index for level one may use journaling to store versions

Decision Support Applications

The decision support applications within a TDT enclave may include dashboards and data analysis algorithms. These algorithms may, for instance, support the adaptation of learning experiences (from the perspective of learners) or help commanders evaluate the collective readiness of their personnel (which, from the perspective of the organization, supports human capital supply chain management). Both perspectives use the five control loops shown previously in ***Figure 8*** and with the purposes summarized in ***Table 6***.

Table 6. Summary of Five Control Loops from the Learner and Organizational Perspectives

Loop	Lifelong learning (Learner)	Human Capital Supply (OIC/S)
1	Pass the Current Class	Increase Class Pass Rate
Feedback	**Content Review (Materials and Assessments)**	
2	Optimize Current Credential	Get Qualified Personnel to Perform Jobs
3	Optimize Credentials in Current Job	Improve Performance to Enhance Options for Next Detail
Feedback	**Curriculum Review (Adequacy of KSAO, standards, and content)**	
4	Optimize Jobs for Career Trajectory	Optimize Detailing Process
5	Future Career Opportunities	Credential Portability and Validity
Feedback	**Impact on Retention**	

Most commercial LRSs include some organic analysis and presentation capability, and the ADL Initiative is pursuing a project called the Data Analytics Visualization Environment (DAVE), intended to provide a standalone capability for developing decision-support "data cards" that provide analytic logic and code snippets that interface with an LRS. The DoD has also invested heavily in Tableau, a commercially available technology for presenting data in commonly understood chart types. Regardless of the technology used, the point is that decisions should be supported with actionable information, created from the chains of evidence stored as xAPI statement in the LRS, along with supplementary information stored in the databases throughout the TDT. This is depicted in ***Figure 13***.

In an effort to normalize adjudication of performance to edge systems, organizations should include edge system xAPI Profiles, which constrain the data elements and range of terms used in them. An initial set of standard xAPI terms is depicted in ***Figure 14***; these align best with control loops 1 and 2. As a complementary step, the most immediate transition path from legacy e-learning courseware to the TDT system involves use of the cmi5 specification (which can be thought of as an xAPI implementation of SCORM). Lastly, shown on the far left of ***Figure 14***, the overall learner career, as received from existing HR systems, includes the states associated with assignment to schools and jobs. These xAPI verbs provide the context to arrange learner data to inform analytics for control loops 3 through 5.

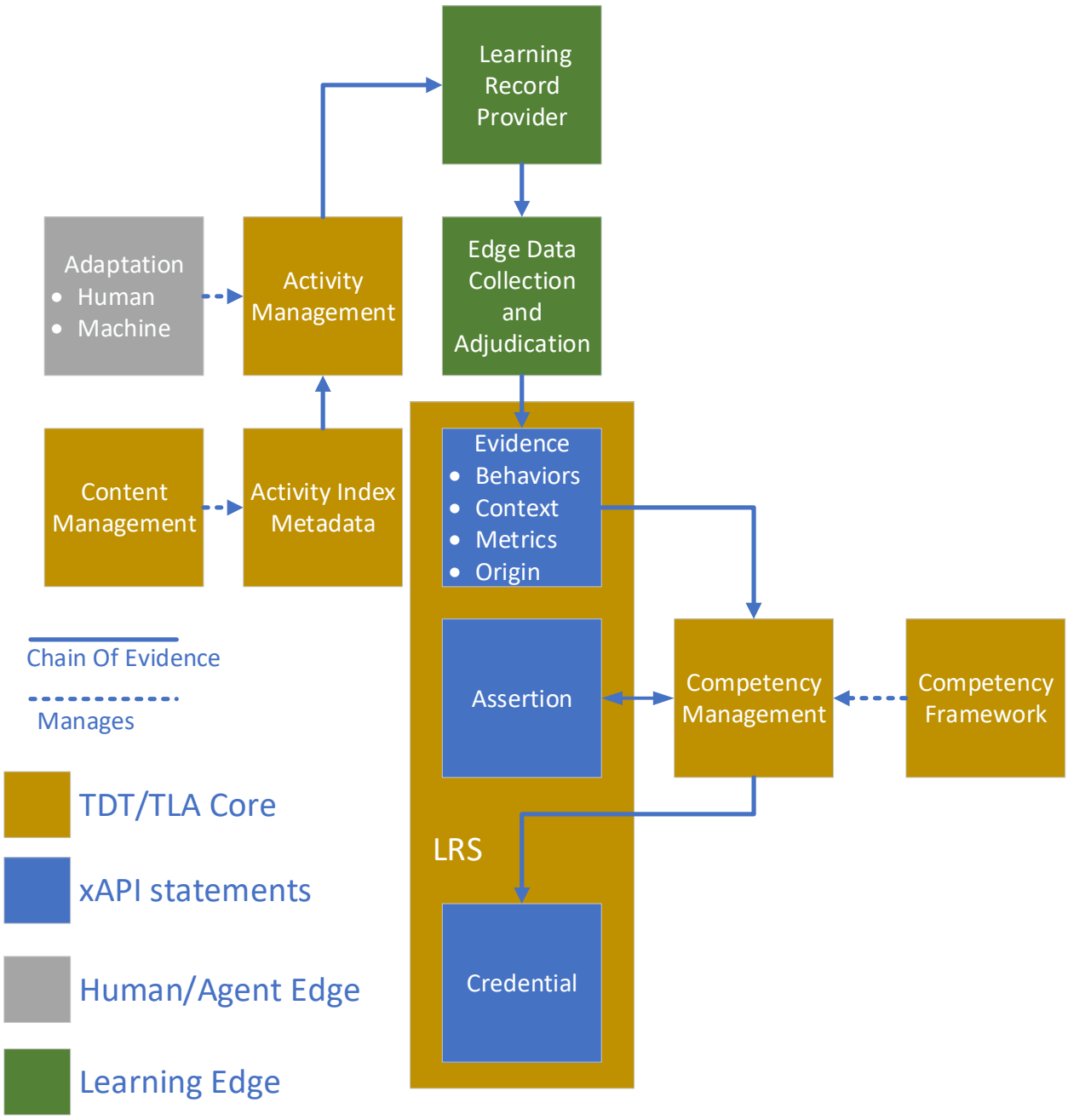


Figure 13 Chains of Evidence Provide Actionable Information. *Linking evidence to assertions provides trust through auditable and non repudiable records of performance.*

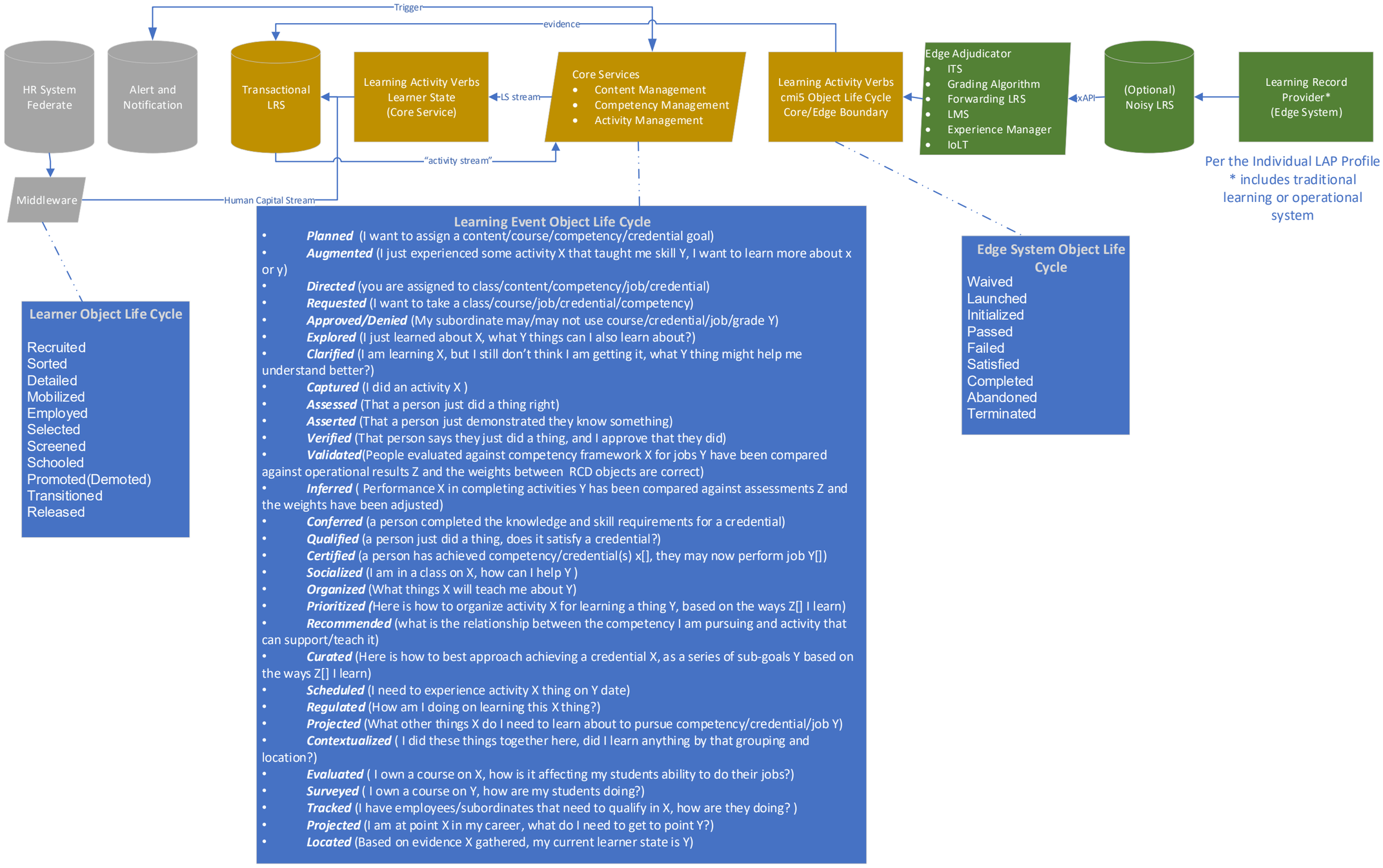


Figure 14 Details of the Evidentiary Chain. *Color coded as in Figure 13, the detailed learner state xAPI verbs generated by activity and competency management provide an evidentiary chain that preserve the context under which learning occurred.*

Table 7. Decision Support Requirements

Level	Header	Requirement	Justification	Priority	Level
5	**Decision Support Management Service**				
5.1	Instructor Review				
5.1.1	Instructor Review	The TDT shall provide decision support view of the collected experience data		1	LMS organic capability, enhanced by LRS (which can track multiple attempts at the same content)
5.1.2	Instructor Review	The TDT decision support shall enable filtering of data		1	
5.1.3	Instructor Review	The TDT decision support shall enable analysis of efficacy of curriculum	Kirkpatrick levels three and four	2	Advanced visualization tools, at maturity level three can compare curricular items to operational outcomes
5.1.4	Instructor Review	The TDT decision support shall enable analysis of efficacy of assessments	typical schoolhouse requirement, links Kirkpatrick level two and three	2	Advanced visualization tools
5.1.5	Instructor Review	The TDT decision support shall enable analysis of media suitability for training to a competency	typical schoolhouse requirement, links Kirkpatrick level two and three	2	Advanced visualization tools, maturity level three competencies may include more robust mapping models
5.1.6	Instructor Review	The TDT decision support shall enable an analysis of grades by user interest group for OIC/S	Typical instructor capability	1	Advanced visualization tools
5.1.7	Instructor Review	The TDT decision support shall enable achievement velocity analysis by user interest group for PIC/S	Learning velocity is used to adjust course length	2	Advanced visualization tools
5.1.8	Instructor Review	The TDT decision support shall enable analysis of efficacy of supporting materials	Ancillary content becomes extension of curriculum materials	2	Advanced visualization tools
5.2	Personnel Manager Review				
5.2.1	Personnel Manager Review	The TDT decision support shall enable analysis of workforce proficiency	Incorporates data from learning and personnel management	3	
5.2.2	Personnel Manager Review	The TDT decision support shall enable analysis of manning levels for projected job requirements	Incorporates data from learning and personnel management	3	
5.2.3	Personnel Manager Review	The TDT decision support shall enable analysis of facility and OIC manpower efficacy	Incorporates data from learning and personnel management	4	

Level	Header	Requirement	Justification	Priority	Level
5.2.4	Personnel Manager Review	The TDT decision support shall enable analysis of learner velocity through training pipeline	Incorporates data from learning and personnel management	3	
5.2.5	Personnel Manager Review	The TDT decision support shall enable analysis of proficiency duty cycle	To update periodicity for skill decay		
5.3	Learner Decision Support				
5.3.1	Learner Decision Support	The TDT decision support shall enable individual learning progression planning for current class/event		4	Supported by advanced mapping and visualizations in upper maturity levels only
5.3.2	Learner Decision Support	The TDT decision support shall enable individual learning progression planning for current competency/badge/certificate/diploma goal		3	Supported by advanced mapping and visualizations in upper maturity levels only
5.3.3	Learner Decision Support	The TDT decision support shall enable individual learning progression planning for next assignment goal		4	Supported by advanced mapping and visualizations in upper maturity levels only
5.3.4	Learner Decision Support	The TDT decision support shall enable individual learning progression plans for service transition or change of career		5	Supported by advanced mapping and visualizations in upper maturity levels only

Governance Procedures

Any ecosystem is necessarily a "living" organization, constantly evolving. Complex human organizations require policy and procedures for governance. Similarly, coordination, continual review, and regular updates are necessary for federated data and systems. For example, governance procedures must continuously address data structure compatibility, message interoperability, coordination between enclaves, and continual review and update of data mappings. Governance is also required for the migration of legacy content and data to the new systems. Governance decision-making bodies must exist at several levels (e.g., at the local enclave level, federated integrated product team level, IC community level, and DoD-wide enterprise level), and they must involve the participants from diverse functional areas. In some cases, the IC TDT system stakeholders will own their own governance policies and processes; in other cases, such as for cybersecurity, they may need to work with other organizations.

Some considerations for the governance roles, responsibilities, and functional areas follow. (This is necessarily an incomplete list.)

- Training and Education Commands: Each organization that delivers training and education (e.g., schoolhouses, field activities), and that presumably owns a TDT enclave, will play a role in its governance. These installations represent the fundamental building blocks of the TDT learning ecosystem, and each will have their own locally relevant user data, collection protocols, and archival requirements. Moreover, they will likely have interest in the data stored elsewhere in the TDT (e.g., federated learner data or external content resources); so, they will have equities in the technology federation and data labeling policies, such as the rules for registering components and content to enable cross-domain interoperability, federated identity management, semantic alignment of metadata, namespace management, and the alignment of activity-content-competency couplet object handles.
- Data Owners—Activity Management Data Owners: Technical experts who oversee the design of learning experiences will also need to help govern the data model used for describing learning activities (e.g., activity providers and content metadata) and for documenting the completion of them (e.g., xAPI terminology). These data owners will need to define and maintain content and resource metadata definitions, the Learner Profile metamodel, and xAPI Profile terms. They will also need to design the metadata NVPS, including their definitions; their local, regional and global attributes; and maintenance of namespaces for semantically equivalent terms.
- Data Owners—Manpower, Personnel, Training and Education (MPT&E) Capability Owners: Organizational leaders will need to oversee the competency-based talent management data, such as the content of competency frameworks, human performance mission requirements, and identification of the competencies associated with various courses, experiences, or credentials. Legacy curriculum owners may absorb some of these new responsibilities, and a central organization, such as the functional area program management office (e.g., Tradecraft PMO) may also need to oversee and coordinate. MPT&E capability policy owners will also need to establish associated processes, such as for the assignment of competency managers, migration of legacy curricula and professional standards to competency frameworks, maintenance of competency frameworks and modifications to them based on changes mission needs, identification of time-based skill decay, de-credentialing policies, and credential reporting.

- Training and Education Technology Specification Owners: The TLA, which forms the basis for the TDT design, is a set of specifications built from other, component specifications, data standards, and business rules. As they mature, the TLA specifications are codified in DoD Instruction 1322.26, "Distributed Learning" (Reference A) and maintained by the Defense Advanced Distributed Learning Advisory Committee, which designated DoD IC personnel may participate in. The component standards included within the TLA library are developed by the ADL Initiative or, more likely, drawn from existing industry standards, governed by constituent professional societies. For example, the following governing bodies oversee these specifications:
    - Credential Engine™ – Credential Transparency Description Language (CTDL)
    - Dublin Core Metadata Initiative -– Learning Resource Metadata Initiative (LRMI)
    - IEEE Learning Technology Standards Committee – xAPI and RCD
    - IMS Global Learning Consortium, Inc. – Learning Tools Interoperability® (LTI®)
    - OpenID Foundation – OpenID Connect (OIDC)
    - OpenAPI Initiative – OpenAPI
    - U.S. Chamber of Commerce (in conjunction with W3C) – Job Data Exchange™ (JDX)
    - W3C – JSON-LD, HTML5
- Cybersecurity, Identity Management, and Data Federations Policy Owners: A basic feature of any system is its cybersecurity posture, including privacy, non-repudiation, integrity, security, and reliability. In the IC domain, this is further complicated by the use of five security enclaves. Currently, the Defense Manpower Data Center (DMDC) and Joint Interoperability Test Command (JITC) have equites in the management cybersecurity and identity (e.g., tokens and protocols). TDT technical personnel will need to coordinate closely with these policy owners for key capabilities including, memoranda of agreement and authorities to connect for federated systems, authorities to operate in multi-level security cross-domain environments, network and server virtualization, dynamic endpoint management, and Global Information Grid (GIG) integration (see the DoDI 8500 series). Similarly, the federate data structures will require broad coordination for networking and file management services (e.g., federated IDs), maintaining integrity and searchability of federated data structures (e.g., the Common Course Catalog), and asynchronous data management (e.g., for deployed units or individuals). Finally, the identity management requirements within the TDT will necessitate ongoing coordination for virtualized identity management (e.g., for SSO and central log-ins), encryption, tokens, and digital signatures, UUID, and PII protection—with the latter including clean room server policies.
- Enterprise MPT&E Owners: Both local and headquarters leaders will have an interest in human capital supply chain management and aggregated personnel readiness reporting. However, at the topmost levels of the organization, the enterprise readiness owners will likely want to oversee the alignment of competency frameworks to mission effectiveness. These stakeholders will also play a key role in using the aggregate data collected by the TDT to inform talent management, readiness, and mission effectiveness evaluations. MPT&E commands or other HR organizations may have an interest in the TDT data, too, as those organizations define job and manning requirements, promote and assign personnel, and conduct workforce planning. In this regard, enterprise personnel analysis organizations, such as the Office of Personnel Analysis (OPA) or Office of the Assistant Secretary for Readiness (OASD(R)), may play a role.

Recommendations

This report has outlined the rationale and concept of the TDT learning ecosystem, defined a migration path for its development, and provided initial data models, requirements, and architectural designs for its achievement. This final section of the report summarizes the detailed findings into six high-level recommendations. These recommendations represent the suggested next steps for the IC towards achievement of the TDT vision.

(1) Federate Data Across Stovepipes

The multiple agencies will have unique systems interconnected as part of the TDT ecosystem. The enterprise needs to federate, or link, the systems and data across functional, organizational, and security boundaries—in a way that scales across millions of data elements. Identity management, content management, Activity Indices, Activity Management, Transactional LRSs, Learner Profiles, and Competency Frameworks all have federated data requirements at the enterprise level. Federating these data across the enterprise includes requirements for non-repudiable (and error free) reconstruction of the disparate data, as well as segmentation of computational resource requirements to ensure processing time does not introduce problematic delays. The solution involves a combination of ledgering technologies and governance procedures, as well as a network topology suitable for maintaining performance at scale.

(2) Create Governance Boards and Policy Structures

For a system as complex as the TDT, it is impossible to define an effective feedforward design or unchanging data dictionaries. Instead, the TDT will require ongoing negotiation of its business rules and configuration management of its data, software services, and interoperability specifications. The IC should define the stakeholders, authorities, and governance processes for this oversight at different organizational levels.

(3) Establish Secure, Ethical Universal Identity Management

To federate data across systems, individuals' identities must be linked across enclaves. This requires *identity management*, that is, a way to identify, authenticate, and authorize individuals or groups across applications, systems, and enclaves by associating user rights and restrictions with established identities. Part of the solution involves the use UUIDs that support nonrepudiation and data integrity. UUIDs must provide a globally unique mechanism to deconflict users' identities across systems while also safely typing those identities to authoritative sources, such as tied to the common access cards (CACs) or other federally maintained identity databases. This federation should also eliminate the need to replicate consistent data (e.g., name, home address) across the local databases.

However, use of UUIDs must be balanced against cybersecurity and PII/privacy considerations. The use of IRIs within an enclave can *anonymize* records against a user, and the IRI user mapping can occur in a protected "clean room" server environment—effectively linking records across enterprise while still using aliases at certain local levels. Identity management is a cross cutting concern, as cybersecurity credential management and two-part authentication must address many of the same problems, the back-end resources used to identify users can provide the TDT clean room if the backend integration is maintained. The clean

room is required to balance the requirements of PII/Privacy constraints and the non-repudiation of trusted data that requites globally unique and resolvable identity credentials.

(4) Develop a Common Course Catalog

To build a learning ecosystem, the instructional activities across the system-of-systems must be discoverable and accessible. This is achieved by creating a *Common Course Catalog*, a software service that indexes the available learning resources. The catalog is assembled from linked *Activity Indices*, which represent the local listings of Activity Providers (e.g., a certain LMS), their available content and learning resources (e.g., courses, e-publications), and the mapping of these resources to a competency framework. The Common Course Catalog can be deployed as a "virtual service" that performs searches when requested across all federated Activity Indices (more challenging to maintain performance but guaranteed to maintain configuration) or as a cloned and centralized archive of data synchronized from the source (will run faster, but more challenging to maintain configuration).

(5) Establish Mechanisms for Maintaining Trust

System trust is key to establishing and maintaining credentials as reliable proxies for someone's ability to meet operational readiness and mission requirements. System trust is maintained both through use of properly cleared and assigned individuals to observe, validate, instruct, assign, supervise, mentor, and assess learners as they use the system, and by providing authoritative data sources using digital technologies to ensure non-repudiation of data generated automatically. Trust is a function of data integrity, privacy, reliability, non-repudiation, and replicability/predictability. Federated systems must maintain integrity by verifying incoming data, tracing the "chain of custody," assigning user validated weighted levels of validity for different elements (e.g., self-reports versus formal tests), and negotiating among competing sources for the authoritative data. Trust is assured when the system recommendations are consistent with human observations or include human evaluations at critical points where there is a low tolerance for error. This can be accomplished by proper human in-the-loop user experience design, segmenting authoritative data storage, using globally unique identification, using digital signing technologies, and establishing business rules for deconflicting inconsistent data elements.

(6) Invest in Culture Change for Competency-Based Talent Management

The TDT vision relies upon interoperable data, meaningful across functional and organizational boundaries. This necessitates a paradigm shift and investment in competency-based talent management. Standardized competency frameworks create a "common currency" to describe across systems. Competency-based learning also emphasizes the demonstration of personnel capabilities rather than the measurement of instructional characteristics, better linking human performance to mission effectiveness. Competency-based learning can also provide the opportunity to streamline learning experiences by letting learners "comp out" of material already demonstrated, which improves the cost performance of the training and education investment. To realize these benefits, however, many MPT&E processes will need to evolve. More robust data schema and software control logic are required, ongoing governance of competency definitions and their alignments to jobs and instructional materials will be needed, and many administrative processes (e.g., time-based management of training and education) will need to change. While it is not necessary to fully embrace all of these factors, for now, it is important to begin the hard work of evolving the organizational culture to support the competency-based approach. The upper levels of TDT maturity require it.

References

(A) DoD Instruction 1322.26, Distributed Learning; see https://adlnet.gov/policy-dodi

(B) Experience Application Program Interface (xAPI) v. 1.0.3 at https://github.com/adlnet/xAPI-Spec

(C) *DoD Intelligence and Security Learning Enterprise Functional Analysis*, 7 April 2017

(D) Intelligence Workforce Certification and Accreditation for the Office of the Under Secretary of Defense (Intelligence) Learning Enterprise Architecture, Certification Module, 23 January 2019

(E) cmi5 Standard (quartz) at https://github.com/AICC/CMI-5_Spec_Current

(F) DoDI 8500.01, Risk Management Framework

(G) Lyle Spencer & Signe Spencer (1993), *Competence at Work: Models for Superior Performance*. NYC: John Wiley & Sons, Inc.

(H) IEEE 1484.12.1, Learning Object Metamodel

(I) IEEE 1484.20.1-2017, Draft Reusable Competency Definition Objects

(J) Industry vocabulary standard at https://schema.org/

(K) IMS Global LTI and Open Badges specifications at https://www.imsglobal.org/specifications.html

(L) Dublin Core Metadata Initiative LRMI at http://www.lrmi.net/

(M) Open Application Program Interface Specification at https://www.openapis.org/

(N) Unified Modeling Language Specification at https://www.omg.org/spec/UML/About-UML

Appendix A – Detailed Questions List

The following questions were used to guide one-on-one interviews with the subject-matter experts from agencies represented in the OUSD(I) TDT Operationalization Project. The questions were drawn from comments made in the functional analysis report and the data calls, and their responses were used to refine the final requirements, migration plan, and TDT project high drivers, described earlier in this document.

Personnel Management Systems

- Do you have a system for managing human resources?
- Does it store credentials at any level to be used in detailing assignments?
- Is there an electronic interface to the LMS system (direct connection or export file format)?
- Is there a propagation of qualifications to a promotion system?
- Is that electronic or manual?
- What is the significance of knowing military status for personnel? (DSS)
- What is your data relationship with DMDC?
- Does the HR system manage course registration?
- Do you maintain training records external to (or in addition to) those in LMS?
- What kinds of attributes beyond identify and work center are required for describing a learner?
    - Why?
- What roles do you have in your training organization?
    - Learner?
    - Instructor
    - Observer/controller?
    - Response cell?
    - Administrators?
    - Course managers?
    - Executive decision makers?
    - Competency Requirements managers?
    - Product Owners?
    - Contractor Support?
    - Assessors?

Protection of PII

- Do you utilize a single sign on system?
- Is this part of your network (LDAP, etc.)?
- Do you need to export any personal data (other than a name or reference #) with credentials for review by other elements within the organization for detailing assignments or other HR purposes?
- How do you manage people with multiple aliases for training record purposes?
    - Do you need to know that they are the same "person" for regulatory compliance purposes?
    - Do you maintain a record of them being the same person?
    - Is that classified?
    - Do they have overlapping or unique training requirements, or a combination of both?
- Do you have other OPSEC concerns for personnel?

- How much training is available over public internet?
    - Intranet
    - VPN
    - NIPRnet
    - SIPRNet
- What security credential systems do you use?
    - Two party?
    - Certificates?
    - CAC?
    - More than one CAC/token?
    - RFID?
- Is that centrally managed by network IT, or is it a unique part of the training infrastructure

Skill Decay

- How do you track currency or maintenance of proficiency for skills?
    - CEU
    - Periodic refresh
    - Periodic retest
    - Other?
- Does this apply only to regulatory requirements or job requirements as well?
- Who sets periodicities or how are they set?

Conferrals

- Do you track “badges”, “certificates”, “diplomas”, or high-level qualification statement?
- What do you call them?
- Is there a tradecraft written standard for defining them?
- Is it classified?
- How often are those standards reviewed?
    - By whom?
- What do you do for people who qualified under older versions of the standard?
    - Grandfather in?
    - Update/refresher training?
    - Supervisory assessment?
- Do you also track level of performance for lower level qualifications that build towards those higher-level qualifications?
- What do you call the elements at each level?
- How do you structure your courses? (lessons, topics, ELO/TLO, Modules, phases, units, etc.)
- Do the conferrals/certificates get transmitted to and recorded in an HR system?
- Which one (e.g., same as above?)

Learning Management Systems and Content Management Systems

- Which one do you use?
- How do you purchase licenses (enterprise, per seat, via OPM bulk, by office, etc.)?

- Do you maintain a centralized repository of records?
- What do you use it for?
    - Classroom and resource scheduling
    - Transmitting custom developed web-based training content
    - Transmitting ad hoc / instructor-based training content (ppts, etc.)
    - Transmitting videos
    - Recording progress of completion
    - Sharing files used by instructor in classroom environment
- Do you track refresher training or practice sessions?
    - How?
- Do you capture field experiences?
- Do you annotate them with any special context data?
- Do you conduct lab exercises (e.g., shoot houses, driving courses, simulators, etc.)?
    - What do you call them?
- Do you use the LMS or CMS to maintain any records?
- Do you conduct team training?
- How do you maintain records of team training?
- How about collective/inter agency training?
- Who assigns learning objectives for team and collective training?
- Who tracks performance?
- How are they scored (go/no go, percentage, qualitative scale, etc.)?
- Do you use SCORM in your instructional content contracts?
- Which version?
- About how many total hours of content do you manage?
- How often does it need to get updated?
- Do you use cmi5 in any of those contracts?
- Do you use xAPI in any of those contracts?
- Do you have agency or office specific extensions to SCORM?
- What information do you not track that would be useful to detailers, supervisors, or instructors?

Content Catalogs and Resource Management

- Who approves content for use?
    - How is that approval archived or certified?
- Do you have a single point for developing tradecraft training within your agency or organization?
    - At what level is it maintained?
- Do you have a central point for developing regulatory training (intel oversight, EEOC, cybersecurity, etc.) within your agency/organization?
    - At what level is it maintained?
- Do you have an agency/organization catalog of classes required?
    - Offered?
    - Does it include other agency/organization classes?
    - If not, do you use them?
    - How are they advertised?

    - How are they scheduled?
    - How are they resourced?
- Do you have an agency/organization catalog of electronic content or resources?
    - At what level is it maintained?
    - Does it include SCORM courses?
    - Does it include other resources? (videos, PDF, etc.)
- Who or how are pre-requisites validated?
- Can they be waived?
    - Based on what?
- What percentage of training provided is regulatory compliance vs onboarding vs tradecraft vs other?
    - Are there others?
    - Does each have a unique conferral authority?
- Why do you require so many signatures/ layers of approval on conferrals?
    - Are they denied or revoked upon review?
    - If so, why?

Learning Path Adaptation

- Do you customize lifelong learning progression for your agency members?
- Is this curated by a supervisor or resource sponsor?
    - How is that captured and scheduled?
    - Who approves?
- Does the member have a say in the path changes?
    - How much?
    - What mechanism do they have to provide that feedback?
- Do you have multiple ways to achieve a qualification?
    - Can you give examples?
    - Experience in lieu of education?
- Do you use any kind of intelligent tutoring applications or simulations?
- Do you use “intelligent OPFOR”, human or machine, in any kind of lab, simulation or command and control exercise?
- Can the learner “lose” one of these exercises?
- Do you explicitly capture classroom participation experiences?

Learning Activities

- What percentage (roughly) of learning and assessment is done in:
    - Formal classroom lecture
    - On line (CBT)
        - Controlled setting
        - From home/mobile
    - Using other electronic resources (in a lab, mediated by instructor or now)
    - On line participation (e.g., blackboard discussions)
    - Live fieldwork

    - Virtual/constructive Simulators
    - Live Labs like shoot houses, driving ranges, etc.
    - In class participation
    - Formal test taking environments
        - Outsourced/contracted?
        - In house?
    - Personal data devices,
    - "microlearning"
    - Smart publications or electronic performance support/job aids
- What do you coordinate for training away from home or home station?
    - Travel
    - Billeting
    - Meals and incidentals
    - Cost reimbursement
- What is the relationship to funding authority for training?
    - Who manages it?
    - Requester or provider?
    - Are they different?
- What do you use to schedule and coordinate instructors?
    - Classrooms?
    - Simulator/shoot house/driving range time?
    - LMS computational resources?
    - LMS license maintenance?
- What kind of Just-In-Time training requirements do you have?
    - Mission Rehearsal?
    - What is time horizon?
    - Rapid equipment fielding?
    - Safety/cybersecurity vulnerability?
    - Other?
- How are these JITT req's usually addressed?
- How much of this training is classified?
- How are they certified as complete?
    - Who authorizes?
- Can the same course or content (or element therein) be used for qualification, PDU, and/or CDE purposes?
- What drives course registration deadlines
- What is the limiting resource for classroom size?
    - Seats/ Size/AC/facility?
    - Computers?
    - Instructor/student ratio?
    - Billeting?
    - Other?

Decision Support

- How do you evaluate the efficacy of courses and content?
- How do you redress deficiencies?
- How do you evaluate the effectiveness of your training structures?
- How do you modify them (course management)?
- How do you evaluate the effectiveness of personnel job/duty descriptions?
- How do you modify them?
- What reports are generated for course effectiveness, school throughput, etc.?
- What format are those reports in?
- Who is authorized to change personnel requirements?
    - Course structure?
    - Course content?
- What contract vehicles are maintained for the above to be performed outside of OUSD(I) resources?
    - Who maintains them?
    - What is mix of CBT content, CLS support, etc.?
    - Do you have an FMS component for ABCA/5 eyes agencies?
        - Other allied and coalition partners?
- What interagency training support do you provide to or receive from:
    - DHS
    - State department
    - DOD
    - State and local police
    - Interpol
- What kind of things would be useful on a personal dashboard?
    - Instructor Dashboard?
    - Supervisor Dashboard?
    - Director/Executive Dashboard?