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The Advanced Distributed Learning's Total Learning Architecture: IDA Report 2020

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Executive Summary

Background

The Advanced Distributed Learning (ADL) Initiative is a government program reporting to the Deputy Assistant Secretary of Defense for Force Education and Training under the Office of the Assistant Secretary of Defense for Readiness. The ADL bridges across Defense and other Federal agencies to encourage collaboration, facilitate interoperability, and promote best practices in distributed learning. Its mission, in part, is to enable the highest quality education, training, informal learning, and just-in-time support, tailored to individual needs and delivered cost effectively, anytime and anywhere, to increase readiness, use resources efficiently, and facilitate inter-organizational collaboration.

Distance learning has evolved dramatically since the ADL was formed in the late 1980s. From the Internet to augmented reality, new technologies have dramatically enhanced possibilities for online-learning experiences and for exploring new ways to teach and learn. Learner analytics—the ability to collect and analyze learner activity data in real time—enabled new learner-management paradigms that inform teachers about learners' progress and problems. With adequate data about a learner's prior learning, interests, and likely performance on the job, innovators can implement just-in-time instructional strategies that use the data to improve learning and performance. Data-intensive instructional intelligence systems promise an increasingly more effective level of individualization and learning in education and training. Detailed data about each learner's capabilities enable data-driven talent-management and force-planning innovations that will substantially improve readiness and effectiveness in military or civilian activities.

The ADL has responded and contributed to this onslaught of new learning technologies and the range of innovations being explored in teaching and in learner management. In 2012, working with government innovators and industry and academic experts, the ADL developed the Experience Application Programming Interface, or xAPI, a powerful standard for collecting detailed data about each learner's online activity. Beginning around 2016, this ADL coalition of stakeholders began work on a new architectural model that supported the new realities of online learning, called the Total Learning Architecture (TLA). The TLA will support the full range of innovations in pedagogy and learning management being explored in government and industry training departments, including:

- Anytime, anywhere learning. With mobile devices and the proliferation of online providers, learners today have many options for learning on demand.
- Immersive learning. The training experience has advanced beyond the traditional voice-over-PowerPoint recorded lecture to immersive training technologies that may include simulations, games, and virtual and augmented reality.
- Learning analytics. Because learners are increasingly online, it is possible to collect detailed data about their activity. The data can then be provided to other instructional systems and to teachers and others, using dashboards to analyze learning progress with other monitoring and tutoring applications.
- Data sharing. Job performance data, to the extent that they are available, can be linked back to training needs and training program improvements.
- Competency-based training. Explicitly assessing learners' competence, versus assuming that finishing a course implies competence (time-in-seat), is key to reliable recognition of learners' abilities across departments and organizations. Talent management, team composition, manpower planning, and post-Service transition to civilian life require organizations to adopt a digital competency framework.
- Individualized learning. Artificial intelligence (AI) offers the ability to customize each learner's experiences to their individual needs and preferences. We already see early implementations of AI "recommender" systems that guide learners through a curriculum to achieve their objectives. And AI-based "intelligent tutoring systems" can emulate a human tutor, helping learners with hints and guidance. The impact of AI on training and education will be revolutionary, but AI systems require data from multiple sources—the more data they have about the learner, the more focused and effective their instruction can be.

Assessment

The Institute for Defense Analyses (IDA) has been active in assessing the need and value of the ADL Initiative from the beginning. It has been asked by the ADL office to support a variety of projects over the years. In 2017 and 2018, IDA evaluated the first trials of the Total Learning Architecture at Fort Bragg. Additionally, through its connections to the Institute for Electrical and Electronic Engineers, IDA continued to support the development of accredited international software standards required to realize the economic benefits of the TLA in both government and civilian implementations.

Over the last year, in addition to continued support of the standardization of key TLA software specifications, IDA was asked to organize and lead the ADL's Total Learning Architecture Working Group (TLA-WG). This community-building effort facilitated exchange of information and priorities between the ADL, early adopters of the TLA, and training organizations and schools that were considering TLA-based modernization efforts. Commercial product vendors and systems integrators were included and were key to finalizing and testing the increasingly complex details of the TLA.

The TLA-WG held monthly meetings in 2019 and 2020, updating the community on the latest ADL R&D activity. Each month guest speakers talked about lessons learned and new TLA-related initiatives. In addition, several "subcommittees" were formed to address some of the final architectural issues:

- Consistent representation of learners' competencies and learning objectives.
- Shared records of learner activity and accomplishments across organizations.
- Standardized descriptions of learning content and activities (metadata).
- Universal profiles for collecting learning activity data across all of DoD to support consistent analysis and response.

Each subcommittee reviewed alternative approaches, identified candidate standards, and, when necessary, initiated new standards efforts at the Institute of Electrical and Electronics Engineers and elsewhere. At a TLA Working Group meeting at I/ITSEC 2019, a panel of early adopters of the TLA talked about lessons learned and outstanding issues.

The TLA has now reached a level of maturity that allows for finalization of the key international standards at its core. Several exploratory training modernization efforts across DoD have embraced elements of the TLA and have begun implementing them. Simultaneously, DoD-wide programs to modernize the entire enterprise data infrastructure have provided potential solutions to lingering problems about identity, security, scalability, and sharing learner data across security firewalls.

Findings and Recommendations

Working on the TLA with early adopters across the Services and with the ADL's R&D team over many years has given IDA substantial perspective on the project and its future. Some important findings and recommendations for the ADL and the TLA follow:

- The future of the TLA relies on the success of DoD's overall data-modernization efforts. The ADL should make every effort to ensure that learning activity is fully recognized and integrated into DoD's systems architecture.
- Standardization of data protocols is key to the long-term economic viability of the TLA, since it enables enhanced compatibility and interoperability among

products, allowing “plug-and-play” introduction or replacement of components. Continued participation in standards-development organizations is time-consuming, but critical. Continued support for collaboration among standards organizations is needed to allow the TLA to penetrate all market segments.

- Military personnel should be assured that the training they receive in the military is considered relevant and essential by civilian organizations when they transition to civilian life. This understanding should eventually have a positive impact on recruitment. Success, however, will depend on the implementation of assessment strategies recognized by the companies and other civilian activities that will be hiring veterans. Technology alone is not adequate. Meanwhile, this “lifelong learning” application of the TLA should also support efforts to improve training and readiness. We should anticipate that militaries around the world will be applying AI and other advanced technologies in their training programs.
- The TLA project, which has expanded over the years, is already straining the ADL’s ability to keep up with implementers and potential implementers. The burden will continue to increase as the community grows. Planning for this expansion is essential. The ADL might consider creating a new organization, supported by product vendors and systems integrators, as well as the Services and other government agencies, even international partners, to support the growing TLA community.
- The TLA’s technical complexity is a barrier to adoption for many organizations. The ADL should supplement its TLA Maturity Model with specialized “entry vectors” for organizations with a specific immediate goal: analytics/dashboards, competencies/credentials, AI recommenders and tutors, and so on. Because we now have the experience from early adopters, we know these guidelines should include, besides technical issues, the staffing, training, processes, and organizational incentives needed to succeed in implementing and operating a TLA instance.

Finally, regarding the ADL itself, IDA has found that the ADL is providing a critical and growing capability that is enabling DoD and other government agencies to achieve their missions. It supports innovators, facilitates community dialogue about lessons learned, identifies needed standards, and recommends policy guidelines that dramatically reduce the lifetime costs of state-of-the-art distributed learning solutions.

The ADL must continue to support and learn from distributed learning innovations across the government. In recent years, as all education and training became increasingly distributed, the ADL’s workload and ambitions have naturally expanded. Its ability to support innovative initiatives is stretched thin, and some change in the way its mission is

achieved is inevitable. However, as distributed learning has been broadly embraced in all sectors of the international economy, including militaries, the ADL's ability to monitor and disseminate the latest ideas and innovations is more important than ever. The ADL is a critical component of DoD's readiness strategy.

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1. Introduction: The Mission Has Changed

The U.S. Department of Defense (DoD), the largest and most diverse training organization in the world, has been an early adopter and leading proponent of online training systems. In addition, the Department runs hundreds of schools and online education offerings (K12, higher education, professional development) for Service members, civilian employees, and military families around the world. Education and training activities are large, expensive, and essential components of military operations.

When computer-based training was in its infancy, training materials were largely based on instructor-led courses: PowerPoint slides converted to screens with some written text or voice-over accompaniment. A Learning Management System (LMS) delivered the training. In addition, the LMS kept student rosters, stored all learning materials, tracked student progress, managed contracts with commercial publishers, and reported student scores. When they were first introduced, the LMSs were also the tools used for creating the course materials. As a result, courses could only run on the LMS system in which they were created.

The economic inefficiencies that resulted from having to re-author courses to work on different LMSs was the initial problem that led to the formation of the Advanced Distributed Learning (ADL) Initiative. By 2007, the ADL, working with several international standards organizations, had developed the Sharable Content Object Reference Model (SCORM), a computer-based learning (elearning) standard that separated authoring from delivery and created the architecture depicted in Figure 1.

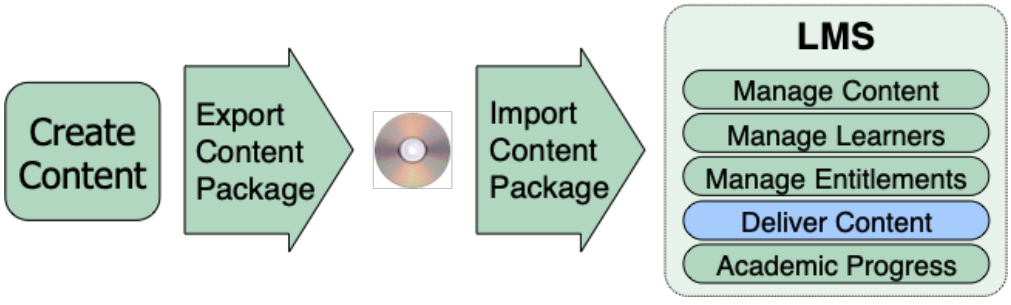

Figure 1. Training Technology circa 2007. From Barr, A., Activity-Based Architecture, Learning Solutions Conference, March 2010.

SCORM defined the way that an elearning course, developed in a SCORM-conformant authoring environment, could be exported in a standard format that could then be imported into any SCORM-conformant LMS. These two product categories, the

authoring tools and the LMSs, defined the learning technology architecture 10 years ago. The disk in the middle of Figure 1, the medium of transport, was a CD-ROM.

The Internet changed everything. Learners no longer had to be in the schoolhouse to receive education or training. Content could be located anywhere on the Internet. Eventually, learners could supplement DoD training with courses from colleges and online providers. Gradually, more and more learning went online. In the DoD, eliminating the costs of sending people to schools was a significant motivator.

The ADL's SCORM platform not only allowed the DoD to economize by reducing elearning procurement and student transportation costs but also had an important secondary economic impact. It created a cross-platform elearning publishing industry, since courses authored in SCORM could run on any LMS. This expansion of the market, in turn, dramatically reduced the costs of many training materials and systems (Dodds & Fletcher, 2004). SCORM continues its contributions to the successful adoption of educational technology around the world.

An unanticipated consequence of the migration to online learning was the ability to easily collect detailed data about the learner's activity. Suddenly, a great deal more data about what learners were actually learning were available, since their online activity could be recorded and analyzed. Data changed everything and, over time, expanded the mission of training organizations dramatically (Walcutt & Schatz, 2019).

The ability to collect and analyze data about the learner's activity to both improve training and drive human resource management, along with the distributed nature of the systems, resulted in a number of innovations, some of which significantly extended the training and readiness mission (see Table 1).

Table 1. Expansion of the Training Mission that Results from New Technology and the Innovative Work of Early Adopters

Innovation	Description	Mission Implications
Anytime, anywhere	Providing training at the convenience of the learner was an important advantage.	Secure Internet access. Identity management. 24×7 operations. Significant changes to the schools and teaching paradigms (e.g., flipped classrooms).
Immersive training	Integrating data from non-LMS, stand-alone learning activities: simulations, serious games, virtual reality, augmented reality, etc.	Collecting consistent data from a variety of stand-alone training systems.
Learning analytics	Unit-level, Service-wide, or Pentagon-level dashboards showing learners' progress and problems. Identifying learners in trouble. Feedback to authors about learning materials.	Data storage and analytics capabilities. Servicing the users of that data: future training, manpower allocation, course developers.

Innovation	Description	Mission Implications
Linking job performance and training	Supplying mobile performance support and training recommendations. Identifying holes in the curriculum.	Collecting data on the job. Linking training systems with operational systems. Offering remediation and just-in-time training. Improving training courses and programs.
Competency-based training	Moving from time-in-seat certifications to assessment of specific competencies.	Agreement with operational units about competencies and assessments. Issuing badges and certificates. Cultural changes in the schools.
Cross-organization records	Learners attend multiple training activities from different organizations and online providers.	Tracking learning activity from multiple sources. Consistent competency and job descriptions across organizations. Bridging data silos and security firewalls.
Talent management, job readiness, team composition	Detailed, up-to-date data about soldiers' abilities improve manpower management.	Collecting and organizing training data across organizations to support mission and institutional goals.
Civilian transition and lifelong learning	Recognition of DoD training by civilian organizations. Ability to carry one's learning history across organizations while passing through schools, jobs, and life.	Developing competency frameworks aligned with civilian industry. Recording military training experience based on formal assessments and competencies vs. time in seat.
Artificial intelligence (AI) enhanced learning systems	Personalized learning, recommenders, coaches, and intelligent tutoring systems are able to use information about what the learner probably knows, probably knew once, probably doesn't know, might be confused about, etc.	Enabling access to training data and learner records across the enterprise. AI systems tend to be complex with complex interactions with other systems. AI tutors may also introduce substantial changes in the school operations.

The move to online learning is not just a name change. It involves new kinds of work, new tools, and new approaches to education and training. Over the past decade, the training and readiness mission has seen fundamental change. Labs, training organizations, and schools across the Services have explored a wide variety of innovative approaches to learning and to managing learners. Some of these technical innovations, in turn, have led to realizations about how to better achieve readiness goals and manage human resources. These realizations led to an expansion of the training and readiness mission and thus to an expansion of the ADL's critical role.

2. The Total Learning Architecture

Starting around 2009, the ADL worked with commercial vendors and training innovators to develop a technology called the Experience Application Programming Interface, or xAPI, that enabled any system to capture and communicate detailed data about learners' online activity to a special database called a Learner Record Store (LRS). This activity stream data enabled advanced analytics—dashboards that showed more than just the learner's status and scores, but could also, for example, identify students who were having trouble or might be on the verge of dropping the course. xAPI was to become the first leg of a new data architecture for learning technologies. (Gallagher, 2010)

In 2016, the ADL started the Total Learning Architecture (TLA) project as an attempt to "sew together" the many new kinds of learning systems that were being explored in labs and beginning to appear on the market: analytics dashboards, AI-based recommenders, digital competency-management systems, and so on. The TLA addressed the management and flow of several data categories, in addition to the learner's "activity stream" data captured with xAPI. The goal was to enable the several different kinds of learning systems to exchange useful information and, eventually, to establish standard formats and interfaces so that components could be easily configured and reconfigured into effective solutions.

A. The 2017 and 2018 Trials

IDA was tasked with organizing a trial of an initial TLA configuration to be held at Fort Bragg in August 2017. The course material focused on cybersecurity and demonstrated the possibility of delivering instruction on multiple platforms (PC, tablet, and mobile phone). The component learning systems included several advanced R&D systems, as well as commercial products:

- Personal E-books for Learning, an interactive e-book platform developed by Eduworks Corporation, accessed through an iPad tablet.
- PERLS, an AI system developed by SRI International that provided learners an individualized path through the material, accessed through an iPod Touch.
- Static content viewer for PDFs and a YouTube video player developed by the ADL, accessed through a laptop.
- Moodle, a commercial, open-source LMS populated with cybersecurity learning materials, accessed through a laptop.

- An Intelligent Tutoring Systems built using the Army Research Lab's Generalized Intelligent Framework for Tutoring (GIFT), accessed through a laptop;
- Sero! a concept-acquisition assessment tool developed by Perigean Technologies, accessed through a laptop;
- The Project ARES cybersecurity serious game by Circadence, accessed through a laptop.
- CyberScorpion cybersecurity simulation environment developed by Sandia National Laboratories, accessed through a laptop.

These cloud-based and mobile systems were modified to exchange learning data, including competencies, metadata, and learner activity streams, using the initial suite of TLA specifications. The ADL R&D team supplied the connective tissue: shared databases, including a Learning Record Store and intersystem communications paths (Gallagher, Barr, & Fletcher, 2016; Gallagher, Barr, & Turkaly, 2017; Gallagher, Folsom-Kovarik, Schatz, Barr, & Turkaly, 2017; Smith, Gallagher, Schatz, & Vogel-Walcutt, 2018).

B. Transitioning to an Enterprise Data Architecture

A second trial run at Fort Bragg in August 2018 had similar results—the students enjoyed the course that, this time, focused on the subject of situational awareness. They felt this kind of material had value both for training and for career exploration, and they appreciated the benefits of online learning.

At the same time, however, the underlying TLA architecture that was based on point-to-point communication between software components did not scale in either trial run. Performance issues were so serious that, starting in 2018, the ADL fundamentally redesigned the TLA as an enterprise data architecture, along the lines of Figure 2. Rather than focus on communication among component systems, the new approach defined shared infrastructure elements for various types of data. All components communicated with these databases, not with each other (Smith & Gordon, 2019; Gordon, et al., 2020 Gordon, Hayden, Johnson, Smith, 2020).

The new TLA is a much more complicated solution. Training organizations that were still LMS-based (see Figure 1) were unlikely to undertake this level of systems development. Fortunately, the DoD stepped in to help. Coincident with the ADL's focus on enterprise data architecture, the Pentagon was implementing a similar enterprise data modernization program (Conlin, 2020). In 2020, each of the Services is preparing to implement its own enterprise data architecture.

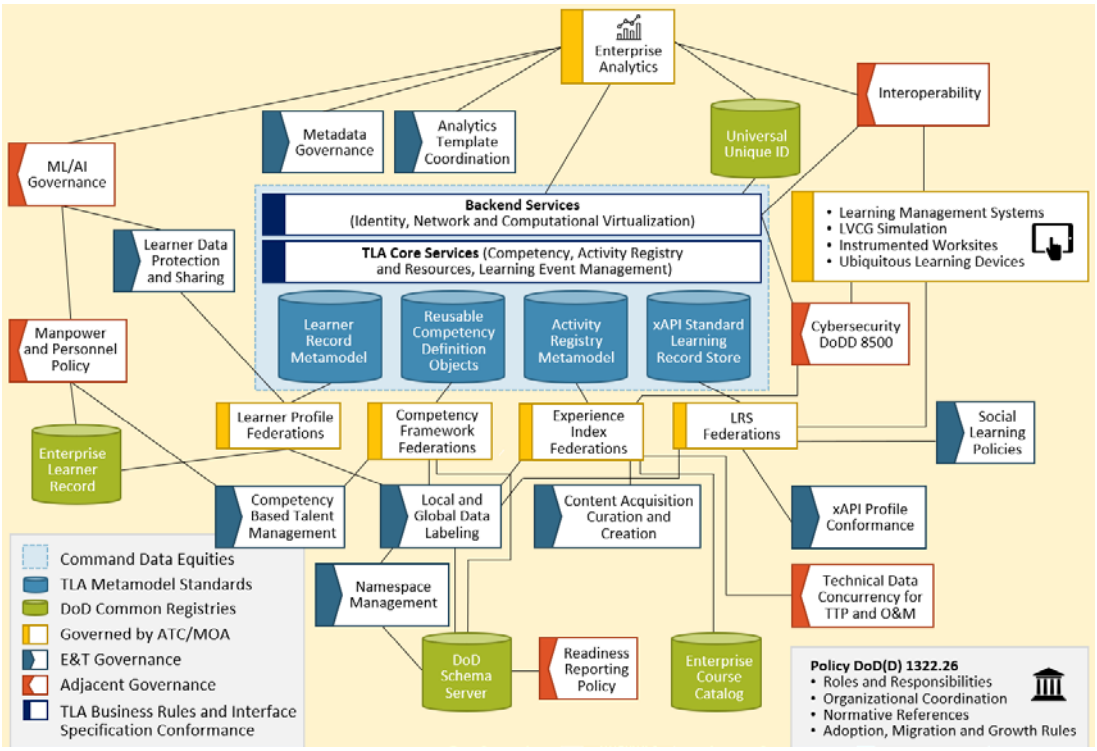

Figure 2. The TLA Ecology. The TLA defines requirements for making existing learning technologies interoperable at the enterprise level. From the ADL's Total Learning Architecture 2019 Report, March 2020.

Piggybacking on the DoD's enterprise-wide modernization efforts will enable training organizations to implement the TLA and will eventually solve several lingering and difficult TLA issues, including security, identity, scalability, single-sign-on, and departmental firewalls. If the Pentagon's modernization efforts succeed and the ADL is able to have learning activity recognized and integrated in the enterprise, adoption of the TLA and implementation of the innovations it affords should accelerate.

The ADL has created a TLA Sandbox, hosted by the Office of Personnel Management's USALearning organization, as an open test bed for exploring the TLA. Several government organizations have already embraced the TLA, or some parts of it, because it aligns with the innovations they are working on:

- The Army Futures Command, Combat Capabilities Development Center is leveraging the TLA Sandbox to explore competency-based learning in the context of team training.
- The Center for Development of Security Excellence is using the TLA Sandbox to explore privacy and security of xAPI data.

- The Air Force's Air Education and Training Command has stood up its own TLA Sandbox to test implementations of the Airmen Learner Record, Competency-Based Learning, and other aspects of the TLA.
- The Defense Health Agency is modernizing its learning infrastructure into a TLA-compliant ecosystem. The Sandbox will provide the computing infrastructure to test and evaluate its own TLA implementation.
- The Office of the Undersecretary of Defense for Intelligence is working with the ADL Initiative on a Talent Development Toolkit for exchanging learner-related data among 17 different intelligence organizations.

C. Standards

One remaining barrier to adoption of the TLA by the DoD and by government agencies around the world is the formal definition of the key software standards that allow learning systems to communicate with the TLA infrastructure components. The four databases at the center of Figure 2 represent the TLA's key data types:

- Learning Activity data—the runtime data produce during a student's session.
- Competency data—used to describe learner's state of knowledge, their learning objectives, the relevance of learning materials, and job requirements.
- Learner records—historical information about the leaner's activity and accomplishments.
- Content descriptive metadata—data descriptions that allow learners and systems to determine which courses or activities would match the learner's current state and help him or her achieve their learning objectives.

The first of these standards, xAPI for learner activity data, has now matured and is about to be published as an IEEE (Institute of Electrical and Electronics Engineers) standard. The other three standards were less mature in 2019. The ADL felt that community involvement would be required to finalize the requirements. That work was undertaken as part of the new TLA Working Group.

3. The TLA Working Group, 2019–20

In 2019, the ADL Initiative tasked IDA with forming and leading the TLA Working Group (TLA-WG). The TLA-WG fosters coordination and collaboration across the TLA community of government schools and training organizations, product vendors, system integrators, learning scientists, and policymakers. This new effort to support the TLA community had the following goals:

- Communicate to the community about ADL activity and TLA developments.
- Obtain feedback from the community about issues and problems.
- Organize monthly presentations by government and industry experts about the TLA and related developments.
- Create and manage subcommittees to investigate and resolve open issues regarding key data standards.

As indicated in Table 2, the working group met online monthly to share ideas, discuss problems, and prioritize issues for the ADL's R&D team. Participants who were new to the TLA could benefit from solutions discovered and lessons learned by earlier explorers. The TLA-WG had about 240 members, about 40 at the monthly meetings, and close to 100 people involved in the subcommittees.

A. Monthly TLA-WG Community Meetings and Guest Speakers

Each monthly TLA Working Group meeting started with a briefing about TLA developments, plans, and current issues. Following a report from each of the subcommittees, we heard from the guest speakers listed in Table 2.

Table 2. Speakers and Topics at TLA Working Group Meetings in 2019 and 2020

Month	Speakers and Topics
June 2019	Brent Smith, ADL R&D. *Introduction to the TLA*. Jerry Gordon, ADL. *Department of Defense Architectural Framework: An Introduction.*
July 2019	Jim Goodell, QI Partners. *The Current State of Competency Standards*. Vincent Villanueva, AETC. *Occupational Competencies in the Air Force*.

Month	Speakers and Topics
August 2019	Jonathan Poltrack, Veracity Technology Consultants. *xAPI 2.0 and related standards activity at the IEEE.* Shelly Blake-Plock, Yet Analytics. *DAVE: The Data Analytics and Visualization Environment.*
September 2019	Aaron Silvers, Elsevier. *xAPI Profiles and the xAPI Profile Server*.
October 2019	Dr. Benjamin Goldberg, Combat Capabilities Development Command – Soldier Center (CCDC-SC), Simulation and Training Technology Center (STTC). *Outcome and Implications of the Ft. Bragg Workshop on Measurement and Assessment Techniques for the Synthetic Training Environment and the Squad Performance Model*. Ajoy Vase, The Chan Zuckerberg Education Initiative. CZI research initiatives that develop technical infrastructure for accelerating learning science and learning engineering.
November 2019	At the Interservice/Industry Simulation, Training and Education Conference (I/ITSEC): Panel on TLA Adoption with Q&A. Erin Baker, Naval Air Warfare Center Training Systems Division. Paul Jesukiewicz, USALearning Knowledge Portal, OPM. Jonathan Poltrack, Veracity Technology Consultants. Brent Smith, R&D Principal, ADL Initiative.
December 2019	Shelly Blake-Plock, Yet Analytics. *The DAVE and DATASIM Projects*. Anne-Marie Dinardo, ADL. *Notes from the TLA-WG Meeting at I/ITSEC*.
January 2020	Panel on commercial competency management solutions: Joshua Marks, Public Consulting Group (OpenSALT™) Fritz Ray, Eduworks Corp. (CASS) Lynn Welch, Education Management Solutions (Competency.AI)
February 2020	Rob Chadwick, Veracity Technology Solutions. *VQL: A Query Language for LRS Data.*
March 2020	Brent Smith, ADL R&D. *The Future of the TLA.* Avron Barr, IDA. *The Training Mission Has Changed*.

B. I/ITSEC Meeting

After 6 months of online meetings, the ADL Initiative's TLA-WG (https://adlnet.gov/projects/tla/) held its first face-to-face meeting during the I/ITSEC conference in Orlando in November 2019. Fifty-eight people participated in the meeting. Since the TLA-WG community includes many non-military participants who don't attend I/ITSEC, the large turnout to the I/ITSEC military training event was auspicious.

After a brief introduction by Dr. Schatz, ADL Director, and a detailed update on TLA developments from Brent Smith, ADL R&D Principal, we convened a panel of people who were involved in implementing aspects of the TLA:

- Erin Baker from NAWCTSD talked about the Defense Health Agency project to track the learner's entire life cycle—from the cradle to the grave. She spoke about trying to remove the stovepipes to promote interoperability. She also discussed the importance of determining early in the adoption process what information about the learner is needed and what data are important to gather to optimize the learning experience.
- Paul Jesukiewicz from the US Office of Project Management (OPM) talked about how OPM's USALearning has partnered with the ADL Initiative to host the TLA Sandbox and the ADL Learning Warehouse, a secure cloud hosting environment where Defense and Federal training and education managers can access and evaluate different platforms, systems, and tools. He emphasized the importance of collaboration to share insight on what did and did not work as part of efforts to further advance the TLA.
- Jonathan Poltrack from Veracity Technology Solutions provided a private sector perspective. Jonathan, who led the TLA project while he was a contractor working at the ADL, discussed the importance of collecting learner data using xAPI. He shared a common challenge he has faced with government clients: They know they want "learner analytics," for instance, but they are not clear about how they will use the data analyses to improve training outcomes. Having the goal clearly in mind is important in deciding what data to collect.

Attendees seemed to appreciate the panel and presented the panelists with many questions about their personnel situation with respect to the TLA and modernization efforts. After the panel, the group broke into subcommittee meetings for the rest of the afternoon.

C. Subcommittees and Standards

Over the course of 2019, the TLA project made concrete, engineering-based steps to solve some of the lingering technical issues facing the architecture and its early adopters. Clarity and consensus depended on creating lines of communication among early adopters, vendors, and the TLA R&D team. The TLA Working Group contributed to that decision-making process.

Four software interoperability standards form the pillars of the Total Learning data architecture: competency management, universal learner records, metadata for describing learning activities, and xAPI for recording learner activity. Installations that adhere to the TLA-recommended standards will benefit from easier installations and plug-and-play replacement of component systems. The formal standards are still works in progress.

The TLA Working Group set up four subcommittees to try to sort out the issues among the stakeholders and come up with a plan to finalize each specification. As is the

case with all enterprise architecture modernization projects, the subcommittees, with varied success, reviewed the technical considerations for each focus area, communicated with members of related government initiatives, debated alternatives, and attempted to build consensus about how the TLA should proceed.

1. Competency Management

Fritz Ray of Eduworks Corporation and Mike Hernandez from the ADL chaired the subcommittee on competency management. Their work continues, but the TLA's competency standard will likely be the IEEE 1484.20.1 Reusable Competency Definitions standard used in SCORM. The definition of a competency, the relationship to other competencies, and the alignment of evidence to help measure proficiency in the competency are all included in this standard. A second standard being developed at the IEEE, P1484.20.2, specifies recommended practices for defining competencies.

2. Universal Learner Records

The Learner Records subcommittee was chaired by Ashley Reardon from the ADL and Richard Cordés of the Cognitive Security and Education Forum. During deliberations of this subcommittee, several major government initiatives were launched that looked at the same issue: How can records of learner achievement be shared across departments and institutions? Initiatives like US Chamber of Commerce Foundation's T3 Innovation Network (US Chamber of Commerce Foundation, 2019) and the White House Interoperable Learning Records Initiative (Data Transparency Working Group, 2019) were well funded and attracted the top experts from every market sector.

As a result of the larger efforts elsewhere, the Universal Learner Records subcommittee monitored those projects and later disbanded as other organizations took the lead. Standards being considered include the Comprehensive Learner Record, a newly released standard from the IMS Global Learning Consortium and a newly proposed IEEE standard, P1484.2 Recommended Practice for Integrated Learner Record (ILR). AI-enhanced learning systems make smart, individualized recommendations by analyzing data about the learner's course history, learning preferences, current goals, favorite subjects, and so on. These algorithms will improve as more data about the learner become available. It may be necessary to include multiple learner record standards in the TLA to accommodate the variety of data formats used by different schools and training programs.

3. Metadata for Describing Content and Activities

Yihua Liu of the ADL chaired the subcommittee looking into standards for describing learning materials, courses, and activities. Practical considerations from current TLA implementers influenced the decision to use the widely adopted Learning Resource Metadata Initiative™ (LRMI) standard developed by the Association of Educational

Publishers, currently stewarded by the Dublin Core Metadata Initiative, and integrated into the schema.org web-search standard.

For the TLA in the long term, the LRMI standard falls significantly short in its ability to describe everything about a learning activity that an AI application might need to know. The original Learning Object Metadata Standard (LOM) used in SCORM, IEEE 1484.12.1, is aging. P2881, a new LOM 2.0 metadata standards project, has started at the IEEE and will presumably meet all the needs of the TLA community.

4. DoD xAPI Profile

The ADL's xAPI standard is quite mature and will be published as an IEEE standard in 2020, IEEE P9274.1.1. xAPI offers the possibility of using data "profiles" (IEEE P9274.2) that establish, for a given type of learning activity or for a specific learning community, what data are to be collected. The profiles can then be incorporated into the authoring process so that instructional designers are not overly burdened with data-collection decisions.

Late in 2019 another TLA-WG subcommittee was started, chaired by Andy Johnson of the ADL. Its goal is to explore the possibility of an xAPI profile for all DoD—what data the DoD should track about the activity of every learner. This is an active group, reviewing the learning data needs across a variety of DoD commands and activities.

The shape of the new standards work reflects the original vision of the Total Learning Architecture—separating learning delivery from learner management, or "learner portability" (Robinson & Barr, 2018). The TLA will allow learners the freedom to choose to work with multiple institutions and online providers. It gives all stakeholders the ability to securely monitor learner activity—enabling and interventions by teachers, administrators, or intelligent agents of all sorts.

IDA's affiliation with the IEEE Learning Technology Standards Committee has been an important part of its work with the ADL and the TLA. ADL staff and former staff have been active participants in, and leaders of, several standards working groups.

4. Concluding Remarks and Recommendations

The TLA has matured dramatically over the last two years. It has evolved into an enterprise architecture that can be directly integrated with modernization efforts going on across the DoD and the Services. At the same time, several training organizations and schools have come to see the TLA's relevance to their own modernization plans. From dashboards to artificial intelligence, new technologies have resulted in an expanded view of the training and readiness mission. As the Services begin to realize the benefits of these pedagogical and talent-management innovations, the TLA will find new adopters and continue to evolve. Table 3 summarizes our understanding of the current state of the TLA project in terms of its strengths, weaknesses, opportunities, and threats.

Table 3. Analysis of TLA's Strengths, Weaknesses, Opportunities, and Threats

Strengths	Weaknesses
• A fully laid out enterprise architecture. • Reference implementations underway. • Support for early adopters. • Sandbox facility for exploration and trials.	• In the field, data are still siloed. • Sharing limited by firewalls, lack of incentives. • Job-performance data are often inadequate • Key standards are still being finalized. • No plans for product certification.
Opportunities	**Threats**
• Systems modernization across the DoD could solve lingering problems like firewalls, security, federated identity, single sign-on, etc. • Establishing Service-wide, DoD-wide, or government-wide infrastructure elements like shared learner records and course catalogs could reduce the barrier to entry for innovators.	• DoD infrastructure modernization must succeed if the TLA is to have broad adoption. • Some training and personnel management systems are brittle and cannot be expanded or integrated fully into the TLA. • The ADL's focus on lifelong learning and credentialing for future employment could divert attention from readiness. • As the size and complexity of learning systems increases, training organizations and schools (in the DoD and elsewhere) must have access to increasingly rare software talent.

A. Recommendations

Based on this assessment, we offer the following recommendations:

1. DoD Enterprise Data Architecture

Over the past year or so, the TLA has made great progress in reformulating itself as an enterprise architecture. This strategy will allow the TLA to be readily incorporated in enterprise-systems-modernization efforts across Services. If the DoD's data-modernization efforts lag or fail, the TLA will fail. The TLA is dependent on these independent systems-modernization efforts to enable essential features, including security, identity management, single sign-on, and firewall workarounds, as well as shared infrastructure elements, including the Universal Learner Record, Enterprise Course Catalog, and other learning-related services. The ADL must have a seat at the table to make sure that learning activity is recognized and integrated into the DoD systems architecture.

2. Personnel Needs in Systems Integration and Training Innovation

In the civilian world, school districts, colleges, and corporate training departments have broadened their staffing requirements to support their increased use of technology. In the DoD, the personnel situation is more complex. The ADL should help DoD schools and training organizations understand the staffing requirements they will face as they deploy aspects of the TLA to support innovations in education and training.

Besides software engineering and learning technology specialists, the ADL should consider helping its clients understand the need for learning engineers. Learning engineering is a new engineering discipline based on the learning sciences and our accumulated engineering knowledge about how to build and deploy increasingly complex physical and digital learning environments.

3. Standards

The ADL should support the collaboration among standards development organizations (SDOs). Recent cooperative work among the SDOs is critical to ambitions to share data across market segments, including K12, higher education, military training, civilian enterprise training, and online providers.

The ADL and the SDOs, including the IEEE Learning Technology Standards Committee, might find ways to accelerate the development and testing of new standards by incorporating draft standards into the TLA sandbox and into other TLA-related projects, where possible. Coordination of the final stages of the standards-development process (the many months after the first draft is complete and before the standard is approved and published) might also yield opportunities to get standards into the operational environment earlier.

Most of the civilian participants in TLA-related standards activities are from small, innovative companies. For the key TLA standards to find broad adoption, it is critical that large companies get involved in the standards process. The ADL might help encourage major DoD vendors and systems integrators to participate in critical working groups.

To support testing of standards early in the process, the ADL should consider having "plugfest-like" events for product vendors. In these events, which ADL has successfully sponsored in the past, vendors are invited to demonstrate their product's implementation of plug-and-play software standards and to test the completeness and clarity of the standard itself.

4. Lifelong Learning

New systems to track Service members' training across their military careers may help them find jobs they are qualified for when they leave the Service. However, these systems are not enough. The entire assessment process must be examined and possibly reworked. When presented with DoD-issued badges and certificates, employers will want to be assured of the nature of the assessments of competency behind the badge. It may prove useful for the DoD to work with targeted industries (e.g., aircraft maintenance, health care, information technology) to create and publicize a rigorous certification program. Such an approach would go a long way toward convincing the public that DoD credentials mean business.

5. Readiness and Re-engineering

Helping veterans find jobs is a great idea that could have a positive long-term impact on recruiting and thus on readiness; however, there is a potential downside. The ADL's intense focus on the TLA's ability to support universal learner records and lifelong learning has taken some attention away from actual training and readiness. But readiness continues to be the primary objective of military training.

The onslaught of new learning technologies is leading to major innovations in the way organizations are teaching and training around the world. For example, AI technologies, once integrated into new ways of teaching and of managing learners, have the potential for dramatically increasing the effectiveness of training while reducing learning time (Fletcher & Morrison, 2014; Fletcher, 2018). More and better training is a serious competitive advantage in every aspect of the DoD's operations. While early adopters will use new technology to streamline the way things have always been done, second-round innovators will rethink the entire educational process, organization, staffing, and systems. The ADL must prepare to identify these radical innovations and help its clients see the potential of "business process re-engineering" in personnel and training organizations. (Hammer, 1990)

6. Managing the TLA

The TLA project has reached a stage that requires a good deal of additional energy. TLA implementers must be supported. Standards must be finalized along with appropriate acquisitions guidance. New organizations will need help getting started. Product developers will need software support, testing opportunities, and certification services. All this support work is in addition to the continued stewardship responsibility to govern, promote, maintain, and update the TLA as the community grows.

Years ago, the ADL and it contractors fully supported the entire SCORM community. The TLA is much bigger and more complex than SCORM. Rather than the two product categories of 10 years ago (authoring and delivering instruction), there will be dozens of different types of learning systems deployed in a typical TLA implementation. The TLA has grown too big for the ADL alone. It needs a broader base of support. The ADL might consider spawning a new organization, supported by product vendors and systems integrators as well as the DoD and other government agencies, even international partners, to support the TLA community.

7. Maturity Model versus Entry Vectors

The TLA is technically complex. Its complexity is partly due to the variety of innovations it supports. It is important to continue soliciting and receiving feedback from early adopters in the DoD to understand these variations. As other government and civilian organizations explore new ways to teach and train, there will be more variation in the way the TLA is used. Unfortunately, complexity is the enemy of adoption. The current TLA Maturity Model assumes that all implementers are on a path toward the most mature and complex implementation. It may discourage organizations with less ambitious goals.

To address this complexity problem, the ADL might consider repackaging its TLA guidance for each of the known innovation strategies: dashboards for learner management; integrating non-LMS and web-based learning data; competency-based training; AI-based recommenders and tutors; credentialing; lifelong learning; and so on. Working out specialized “entry vectors” might motivate more organizations to get started. As we have more experience from early adopters, these guidelines can include, besides resolving technical issues, the staffing, training, and organizational incentives needed to succeed at implementing TLA-based innovation.

B. The Importance of the ADL Initiative

Finally, regarding the ADL itself, IDA remains convinced that the ADL performs a critical function for the DoD and other government agencies. Many of our training systems and processes are aging and brittle. The ADL brings in ideas about new approaches from academia and from the private sector. It supports innovators, facilitates community dialogue about lessons learned, identifies needed standards, and recommends policy

guidelines that dramatically reduce the lifetime costs of state-of-the-art training and education.

The ADL workload supporting research, systems modernization, policy recommendations, strategic guidance, and coordination across an international set of innovators and stakeholders has expanded dramatically over the last decade. The demand for ADL guidance and support will continue to grow as the Services, other government agencies, and our NATO allies explore faster, better, and less expensive ways to prepare soldiers and officers for an increasing complex and technology-laden future battlefield. Our observation is that the ADL is stretched thin and has been working at its physical limit for some time.

Some change is needed: increasing the ADL budget to support additional staff; limiting the ADL's mission; or splitting the organization up and spinning off some of its functionality. Whatever path is taken, the ADL's critical role in modernizing the way we provide education and training must be supported.

The DoD has always been a leader in the deployment of advanced learning technology. Because of the breadth of its education and training mission, there is no better place to show the potential impact of new learning technologies and the training innovations they enable. As distance learning has been broadly embraced in all sectors of the international economy, including militaries, the ADL's ability to monitor and disseminate the latest ideas and innovations is more important than ever. The ADL is a critical part of our readiness strategy.

References

Advanced Distributed Learning (ADL) Co-Laboratories, Experience API Working Group (2017). Part One: About the Experience API. Retrieved from https://github.com/adlnet/xAPI-Spec/blob/master/xAPI-About.md#partone.

Barr, A., Johnson, L., & Roschelle, J. (2015). Partnering for Impact: Increasing Cyberlearning's Influence in Education Markets. CIRCL Synthesis Statement.

Barr, A., Kitchens, J., Marks, J., Robson, R., Scott, R., Sessa, M., Shepherd, E., & Belanich, J. (2018). iFest Competency Standards Panel: Answers to Audience Questions. IDA Document NS D-9047.

Barr, A. & Maylyn-Smith, J. (2016). Looking Ahead: Trends that Will Shape Cyberlearning. NSF Center for Innovative Research in Cyberlearning. Retrieved from http://circlcenter.org/looking-ahead-trends-that-will-shape-cyberlearning/.

Barr A. & Robson R. (2019). Missing Pieces: Infrastructure Requirements for Adaptive Instructional Systems. In: Sottilare R., Schwarz J. (eds) *Adaptive Instructional Systems.* HCII: International Conference on Human-Computer Interaction. Lecture Notes in Computer Science, vol. 11597. Springer.

Conlin, M. (2020). ADVANA - Modernizing our mindset for AI Data Products. Object Management Group briefing, 25 March 2020. https://www.omg.org/events/va-20/special-events/UAF-Summit.htm

Data Transparency Working Group (2019). White Paper on Interoperable Learning Records. US White House. https://www.in.gov/che/files/Interoperable%20Learning%20Records_FINAL.pdf

Dodds, P.V.W., & Fletcher, J.D. (2004). Opportunities for new "smart" learning environments enabled by next generation web capabilities. Journal of Education Multimedia and Hypermedia, 13(4), 391-404.

Fletcher, J. D. (2017). The Value of Digital Tutoring and Accelerated Expertise for Military Veterans. Educational Technology Research and Development, 65. 679–698. DOI 10.1007/s11423-016-9504-z.

Fletcher, J. D., & Morrison, J. E. (2014). Accelerating Development of Expertise: A Digital Tutor for Navy Technical Training. IDA Document D-5358. DTIC AD1002362.

Gallagher, P.S. (2010). The Development of SCORM Sections I and II. In *Learning on Demand – ADL and the Future of e-Learning.* Wisher, R. & B. Khan, B., (Eds.) 49–70. Washington, DC: Department of Defense.

Gallagher, P.S., Barr, A., & Fletcher, D. (2016). Design-based assessment and evaluation of the ADL Total Learning Architecture. IDA research report.

Gallagher, P.S., Barr, A., & Turkaly, S. (2017). Bridging the Archipelago: An Assessment of the Advanced Distributed Learning Initiative's Total Learning Architecture. IDA Document D-9077.

Gallagher, P.S., Folsom-Kovarik, J.T., Schatz, S., Barr, A., & Turkaly, S. (2017). Total Learning Architecture Development: A Design-Based Research Approach. In *Proceedings of the I/ITSEC*. NTSA: Arlington, VA.

Gordon, J., Hayden, T., Johnson, A., Smith, B. (2020). Total Learning Architecture: 2019 Report. Advanced Distributed Learning (ADL) Initiative.

Hammer, M. (1990). Reengineering Work: Don't Automate, Obliterate. Harvard Business Review.

Robson, R. & Barr, A. (2018). The New Wave of Training Technology Standards. In Proceedings of the I/ITSEC. NTSA: Arlington, VA.

Robson, R., Barr, A., & Sottilare, R. (2018). Overcoming Barriers to the Adoption of IEEE Standards. AI in Education (AIED). London.

Robson, R., & Barr, A. (2018). Learning Technology Standards - the New Awakening. In *Proceedings of the Sixth Annual GIFT Users Symposium*. Sottilare, R., Brawner, K., Sinatra, A., & Goldberg, B. (Eds.).

Robson, R., & Barr, A. (2018). Learning Technology Standards - the New Awakening. In *Proceedings of the Sixth Annual GIFT Users Symposium.* Sottilare, R., Brawner, K., Sinatra, A. & Goldberg, B. (Eds.). US Army Research Laboratory.

Smith, B. & Gordon, J. (2019). 2018 Total Learning Architecture Report. Advanced Distributed learning (ADL) Initiative.

Smith, B., Gallagher, P.S., Schatz, S. & Vogel-Walcutt, J. (2018). Total Learning Architecture: Moving Into the Future. In *Proceedings of the I/ITSEC*. NTSA: Arlington, VA.

Sottilare, R.A., Brawner, K.W., Goldberg, B.S., & Holden, H.K. (2012). The Generalized Intelligent Framework for Tutoring (GIFT). Orlando, FL: U.S. Army Research Laboratory – Human Research & Engineering Directorate (ARL-HRED).

Sottilare, R., Domeshek, E., Hampton, A.J., Cockroft, J., Barr, A., Graesser, A., Robson, R., & Tong, R. (2018). In *Proceedings Of The 2nd Adaptive Instructional System (Ais) Standards Workshop.* Menlo Park, CA. Institute for Electrical and Electronics Engineers (IEEE).

Sottilare, R., Robson, R., Barr, A., Hu, X., & Graesser, A. (2018). Exploring the Opportunities and Benefits of Standards for Adaptive Instructional Systems (AISs). Intelligent Tutoring Systems Conference AIS Standards Workshop. Montreal, Quebec, Canada.

US Chamber of Commerce Foundation (2019). The T3 Innovation Network. https://www.uschamberfoundation.org/t3-innovation

Walcutt, J. J., and Schatz, S. (2019) Modernizing Learning: Building the Future Learning Ecosystem. GPO 008-000-01329-2.

Abbreviations

ADL	Advanced Distributed Learning Initiative
AI	artificial intelligence
CASS	Competency and Skill System
DoD	Department of Defense
GIFT	Generalized Intelligent Framework for Tutoring
I/ITSEC	Interservice/Industry Simulation, Training and Education Conference
IEEE	Institute of Electrical and Electronics Engineers
K12	Primary education, kindergarten through high school
LMS	Learning Management System
LOM	Learning Object Metadata Standard
LRMI	Learning Resource Metadata Initiative
LRS	Learner Record Store
NATO	North Atlantic Treaty Organization
NAWCTSD	Naval Air Warfare Center Training Systems Division
OPM	Office of Project Management
PERLS	PERvasive Learning System
SCORM	Sharable Content Object Reference Model
SDO	standards development organization
TLA	Total Learning Architecture
TLA-WG	Total Learning Architecture Working Group
xAPI	Experience Application Programming Interface

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13. SUPPLEMENTARY NOTES

14. ABSTRACT

The field of distance learning in education and training has experienced an onslaught of new learning technologies and a wide range of innovations in teaching methods and in learner management. The Advanced Distributed Learning (ADL) Initiative and its coalition of stakeholders has responded by developing and promoting a new architectural model that supports the new realities of online learning, called the Total Learning Architecture (TLA). The TLA enables the full range of innovations in pedagogy and learning management being explored in educational institutions and in government and industry training departments. This report provides a discussion of the motivation for and history of the TLA development, a description of activities of the TLA Working Group in 2019-2020, and some recommendations for future directions based on an analysis of the TLA's strengths, weaknesses, opportunities, and threats. The report ends with a discussion of the importance of the ADL Initiative. The ADL brings in ideas about new approaches from academia and from the private sector. It supports innovators, facilitates community development and communication about lessons learned, identifies needed standards, and recommends policy guidelines that dramatically reduce the lifetime costs of state-of-the-art training and education.

15. SUBJECT TERMS

Advanced Distributed Learning (ADL); artificial intelligence (AI); Experience Application Programming Interfac (xAPI); Learning Management System (LMS); Sharable Content Object Reference Model (SCORM); Total Learning Architecture (TLA); Total Learning Architecture Working Group (TLA-WG)

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