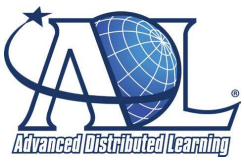
Advanced Distributed Learning

Capability Maturity Model

Technical Report



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Principal Authors: Dr. Naomi Malone, Mike Hernandez, Ashley Reardon, Yihua Liu

Contributing Authors: Brent Smith, Jerry Gordon, Bojana Andrejevic, Mike Neeley

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OUSD Personnel & Readiness
Advanced Distributed Learning Initiative
13501 Ingenuity Drive, Suite 248
Orlando, Florida 32826

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A capability maturity model provides a thorough understanding of where the organization is and, perhaps more importantly, where the organization needs to grow. The purpose of this report is to describe the development of the ADL Initiative Distributed Learning Capability Maturity Model (DL-CMM), illustrate its major components, and explain how it can be used to improve processes.

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A capability maturity model provides a thorough understanding of where the organization is and, perhaps more importantly, where the organization needs to grow.

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Director, ADL Initiative
Dr. Sae Schatz

Principal Authors
Dr. Naomi Malone
Mike Hernandez
Ashley Reardon
Yihua Liu

Contributing Authors
Brent Smith
Jerry Gordon
Bojana Andrejevic
Mike Neeley

Graphics
Elizabeth Bradley

Editing
Edward Ellegood
Tiffani Marlowe

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OVERVIEW

Purpose of the Model

The purpose of this report is to describe the development of the ADL Initiative Distributed Learning Capability Maturity Model (DL-CMM), illustrate its major components, and explain how it can be used to improve processes. The DL-CMM is a tool to appraise an organization's or enterprise's capabilities in its distributed learning processes and functions. This document describes each step of the model's development and provides guidance for the preparation and use of the model for appraisal.

Value of the Model

The CMM has the potential to provide a "total view" of the current distributed learning status of a participating organization. It shows the resources, expertise and capabilities an organization needs to optimize its use of distributed learning. Where these elements are lacking, the DL-CMM provides perspective on what must be implemented to reach the next level of capability.

Who Should Use the Model

Organizations, enterprises, and projects endeavoring to implement distributed learning systems and processes are candidates for using the DL-CMM. Key personnel in senior leadership, learning design, information technology and data management and others invested in the distributed learning implementation process can use the model to gauge their current maturity and improve their distributed learning processes.

INTRODUCTION

Advanced Distributed Learning (ADL) Initiative efforts around the world are trying to determine a) what capabilities their respective organizations have achieved; b) what capabilities other member organizations have achieved to maximize efficient capability sharing; and c) what capabilities need attention in their future efforts. One way to achieve this is by creating a capability maturity model (CMM) to clarify the general areas of focus for distributed learning (DL) and the developmental maturity processes needed to achieve optimal DL capabilities. This paper traces the development of the DL-CMM to explain the pathway to success for full DL maturity. This model will provide the roadmap and the justification to our senior leadership regarding where the best return on investment (ROI) lies and how to achieve it.

Distributed learning is defined as a "unified, technology-enabled interconnected learning paradigm" (Graesser, Hu, & Ritter, 2019, p.18). However, the term is used to define many different elements of distributed learning practices. It is often seen as synonymous with distance education and any teaching that is not face-to-face. Some describe it as a shift from print-based distance education to the use of information and communication technologies for course delivery. Others view it in terms of human-computer interaction or as distributed cognition, where learning is viewed as distributed among individuals. More broadly, distributed learning breaks down the traditional boundaries between face-to-face and open and distance education. Learning is viewed as a shared enterprise distributed between individuals in diverse contexts and not tied to formal institutional settings (Lea & Nicoll, 2013).

The DL-CMM provides a systematic method for understanding existing distributed learning maturity by considering the multiple areas covered by these broad definitions. This report includes a review of other CMMs that address learning and technical processes critical to the implementation of distributed learning within an organization. Grounding the DL-CMM on previous models will provide a useful self-analysis tool as well as a significant addition to the distributed learning knowledge base.

A CMM is a multi-dimensional development model used for measuring the degree of formality and optimization (maturity) of an organization's processes. It has several categories that together make up the major tasks or focus areas within the model. The model is typically used to help assess or benchmark the level of maturity of expected practices in an organization.

Main Goals for Maturity Models

1. **To measure the maturity of the process under consideration (i.e. assign a level to organization's existing process)**
2. **To provide a mechanism of learning to improve the maturity level (Randeree, Mahal, & Narwani, 2012)**
3. **To compare the maturity of an organization to other organizations and/or best practices**

Generally, a CMM includes main components frequently called dimensions. Under each category there are several subcategories that drill down the activities within each key area. Each subcategory then has five levels of maturity (see Figure 1).

These levels have their roots in the quality management field, beginning with the Quality Management Maturity Grid (QMMG), which describes the typical behavior exhibited by an organization at each of the five levels of maturity. The maturity grid suggests that companies are likely to evolve through the five phases of quality management success (Fraser, Moultrie, & Gregory, 2002). Breaking down ADL Initiative's maturity levels using this method can help to create a roadmap toward process improvement.

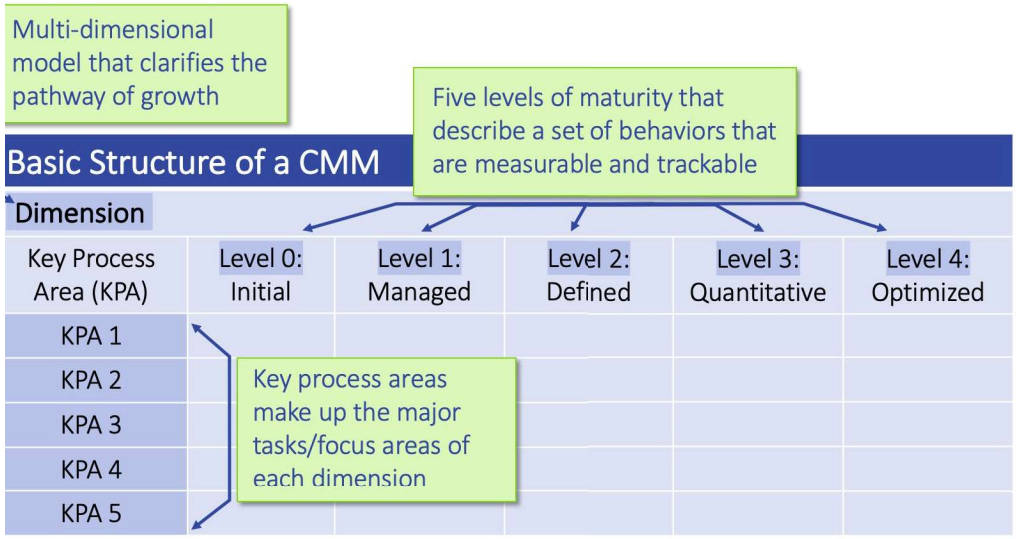


Figure 1: CMM Levels and Key Process Areas

BENEFITS

01 A SINGLE UNIFIED MODEL that integrates the best guidance available from recognized standards and practices related to distributed learning processes.

02 ORTHOGONAL - The model is integrated and harmonized; each source contributes important perspectives. Stakeholders can choose those areas relevant to their needs.

03 ITERATIVELY DEVELOPED by building on the previous and current versions to improve the model.

LIMITATIONS

01 OVERSIMPLIFIES REALITY - Models are characterized as step-by-step recipes that often lack empirical evidence.

02 IGNORES ALTERNATIVE PATHS TO MATURITY that might be just as effective (Teo & King, 1997).

03 STANDARDIZED CMM BLUEPRINTS used by multiple models may not reflect the processes specific to the needs of specific organizations.

MODEL DEVELOPMENT

To mitigate criticisms of the model and establish a realistic set of requirements for the design of the model, development is increasingly done from a design process and perspective (e.g., Becker, 2009; Proença, 2016; Rödlinger, Pöppelbuß, & Becker, 2012).

The DL-CMM model follows the seven design science guidelines originally established by Hevner et al. (2004). Design science is meant to develop a problem-solving artifact that will contribute to current research.

This method was chosen to develop a CMM as an artifact to improve an organization's problem-solving capability. The seven guidelines for design science were revised to meet the specific needs of creating a CMM (from Becker, 2009).

Figure 2 depicts the steps used to develop the DL-CMM. This technical report describes the development process culminating with Step 5. Future steps will include a pilot study and the published results of that study.

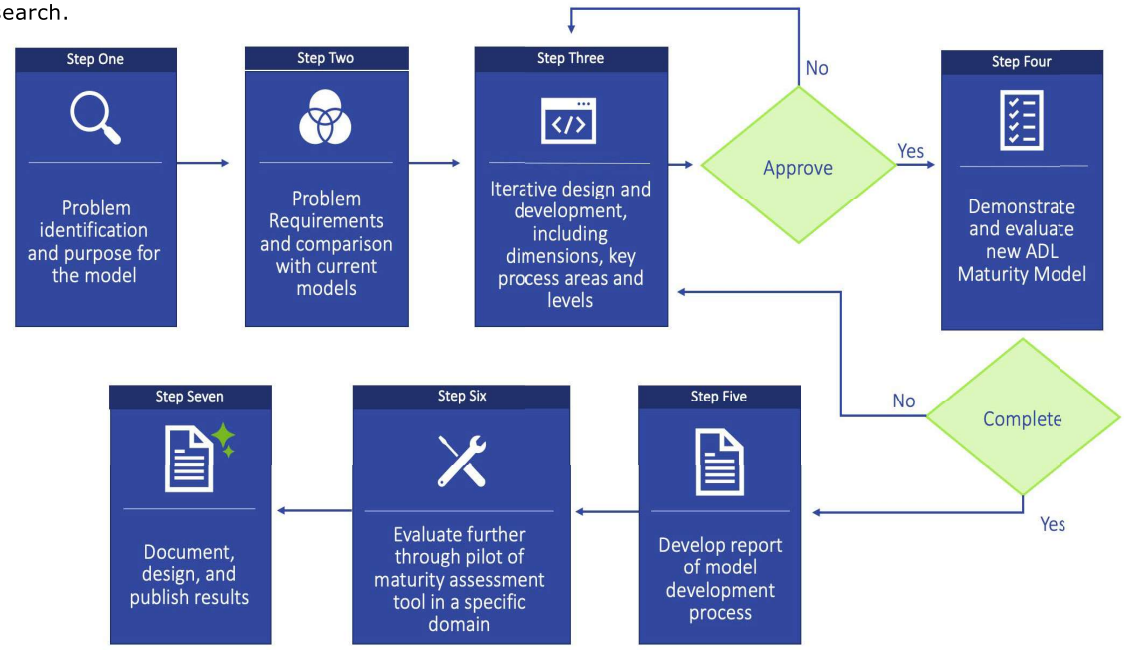


Figure 2: DL-CMM Development Steps

1 Purpose and Problem Identification

The main questions driving the development of this model are:

- How is "maturity" defined for distributed learning organizations, given the recent revolutions in learning science and technology?
- What is the current level of maturity for a given Defense, Government, or Coalition distributed learning organization?
- What are the relative strengths and weaknesses of various Defense, Government, or Coalition distributed learning organizations?
- What steps can an organization take to improve its maturity level?
- What are the challenges to implementing this model?

2 Review of Existing Models

Support for distributed learning processes is becoming indispensable for many organizations. Responsibility for the effective and efficient design and use of distributed learning processes lies with the organization's management. The main goal is to continually improve the processes necessary for an efficient distributed learning organization.

To identify the requirements for developing a CMM, an extensive review and comparison of other existing maturity models was undertaken to determine common components and processes (see Appendix B for a list of reviewed models). Three evaluation criteria were used to select the existing models: 1) Documentation includes reference to a developed model; 2) Documentation indicates steps of the design process; and 3) Validity testing passes at least the weak test as described by Aho (2009). The weak test is passed when an organization's manager is ready to use the CMM for decision-making. The strong test is passed when the CMM is shown to have improved performance in the organization. Table 1 lists the models that met these criteria and were used for comparison.

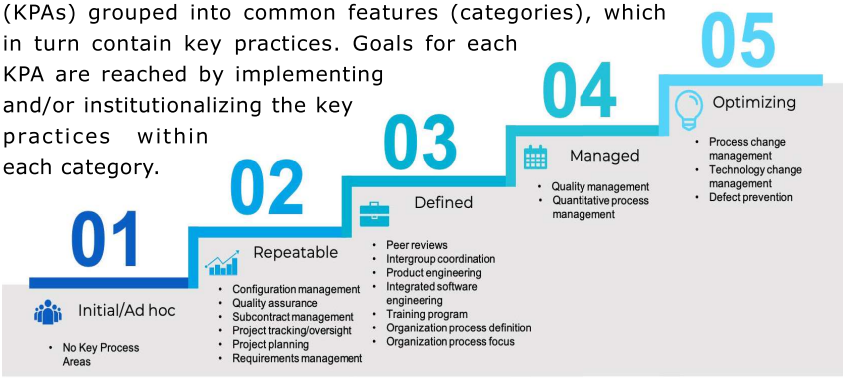
Although there is a wealth of literature about CMMs, many did not meet at least one of the three criteria. Mature models were likelier to meet these criteria if they followed an iterative process of application and development with publication of one or more documents describing the process and/or guidelines for implementation. Some models were also excluded due to lack of public access to documents, such as Gartner's Five Stage Maturity Model for Logistics Excellence (Lisica & Gonzalez, 2019).

TABLE 1: Comparison of Reviewed Capability Maturity Models

MODELS	STATED PURPOSE	COMPARISON WITH EXISTING MODELS	ITERATIVE DESIGN	EVALUATION PROCESS	PUBLISHED RESULTS
CAPABILITY MATURITY MODEL/CAPABILITY MATURITY MODEL INTEGRATED (CMM, CMMI)	Develop a tool for evaluation of software organizations	First CMM model based on Crosby's Quality Maturity Grid for software development	Literature reviews Delphi method Expert interviews	Preliminary versions accessible for review, workshop with 200 experts, widespread application	573-page report and 246-page report detailing the analysis procedure
E-LEARNING MATURITY MODEL (eMM)	Support higher education e-learning systems	Concepts from CMM and Software Process Improvement and Capability Determination (SPICE)	Case studies of applications and workshops to modify the model	First version validated at New Zealand university workshops. Applications in several organizations	Published descriptions of the model and design procedure available to the public; examples
THE DATA WAREHOUSE INSTITUTE'S (TDWI's) ANALYTICS MATURITY MODEL	Focus on business intelligence, data warehousing, and more recently the emergence of analytics and machine learning	The original BI model (Eckerson, 2009) was based on CMM, later adapted to current Analytics model (Halper & Stodder, 2014)	First iteration (Eckerson, 2003) was technology-focused; later versions added cultural and business aspects (Eckerson, 2009; Halper & Stodder, 2014)	Provides a tool for quick overview of an organization's BI ecosystem. Validity is not addressed	Published descriptions of the model, instructions for evaluating benchmark scores for 35 questions within five dimensions
PEOPLE CAPABILITY MATURITY MODEL	Framework to help organizations improve workplace competencies	Complements the CMMI model and expands on Watts Humphrey's (1997) people maturity model	Version 1 implemented for six years, followed by Version 2, which was based on continuing feedback and experience from use around the world.	Implemented by many different organizations (e.g., Boeing, Ericsson, Lockheed Martin). Has been translated into many different languages	Version 1 (1995); Version 2 (2005). Version 2 explains model development, description of the framework and components, as well as description of how to implement the model
ENTERPRISE SPICE	Domain-independent process assessment model for enterprise-wide assessments and improvements	Built on CMMI versions, ISO/IEC 15504-2, and CMM v. 2, developed by the US Federal Aviation Administration	The SPICE User Group released draft models in 2008 and 2009 for feedback	The initial model was published in 2010. Currently in the second phase of development: deployment and usage; phase 3 is still in progress	A technical report was published in 2010, no further publications were found on the Enterprise SPICE website
DEFENCE TECHNOLOGY ENABLED LEARNING (TEL) MATURITY MODEL	To assess TEL maturity on training units, to identify shortfalls that prevent optimization of training	Gartner Digital Maturity Research, Deloitte Digital Maturity Transformation, UK Cabinet Office GDS (The 7 Lenses of Transformation)	Not described in existing documents	Will be integrated into the MMAT to capture TEL capabilities on a unit	Still a working exemplar. No published results.
ENTERPRISE ARCHITECTURE MANAGEMENT MATURITY FRAMEWORK (EAMMF)	Provides a benchmark that can help federal departments and agencies plan for and measure EA program maturity	CMMI for Development v. 1.2; OMB EA Assessment Framework, version 3.1; GAO ITIM Framework, v. 1.1	Versions 1,1.1 were used to perform government-wide reviews The current version 2 builds on the previous versions and feedback from stakeholders	Review of Enterprise Architecture CMMs gives EAMMF the highest rating among four well known models (Suchaiya & Keretho, 2018)	Three published reviews of federal departments and agencies done using v.1.1.

Capability Maturity Model (CMM, CMMI)

Most current models are based on the CMM developed by Carnegie Mellon in the late 1980s (Paulk et al., 1995) and continued with the Capability Maturity Model Integration (CMMI). Both versions of the CMMs specifically focused on improving organizational processes (CMMI Product Team, 2006). Many organizations in diverse sectors have adopted and revised the original CMM to improve process capability maturity. The original CMM describes an improvement path from ad hoc, unmanaged processes to disciplined, mature processes that improve organizational quality and effectiveness. Figure 3 lists the five levels of organizational maturity and the characteristic used in most existing models. Each maturity level contains key process areas (KPAs) grouped into common features (categories), which in turn contain key practices. Goals for each KPA are reached by implementing and/or institutionalizing the key practices within each category.



People Capability Maturity Model (P-CMM)

The P-CMM (Curtis et al., 1995, 2009) focuses on continuously improving the management and development of human resources within an organization. It is widely used by various types of organizations (e.g., information technology, pharmaceuticals, defense agencies, etc.) and has been translated into Japanese, Chinese and other languages.

Based on Watts Humphrey's (1989) evolutionary approach to process maturity as well as the original CMM framework (Paulk et al., 1993, the P-CMM's five progressive levels are meant to transform an organization's culture by providing a pathway for organizations to implement practices for attracting, developing, motivating, and retaining its human capital. Like the Humphreys model the P-CMM integrates three domains: processes, total quality management practices, and organizational change. Its targeted domain is workforce management processes.

Using the CMM architecture the P-CMM's top layer consists of five maturity levels, each representing a well-defined evolutionary plateau institutionalizing that level of capability for improving the organization's workforce. Each maturity level is composed of several process areas which contain goals that establish that process area's capability when the goals are met. Process areas are defined as a set of related practices that satisfy the goals when they are practiced together. The P-CMM has 22 process areas that are linked to specific levels between 2 and 5. The first level does not contain any process areas.

The Data Warehouse Institute's (TDWI) Analytics Maturity Model

TDWI's Analytics Maturity Model (Halper & Stodder, 2014) is an offshoot of its Business Intelligence Maturity Model (BIMM, Eckerson, 2009), developed to help organizations evolve their analytic strategies as an essential element of their business decisions. The original model was focused on the technical aspects of an organization's BI maturity, whereas this model also incorporates maturity for an organization's culture, leadership, governance, and data management beyond the technological infrastructure. There are five maturity levels: nascent, pre-adoption, early adoption, corporate adoption, and mature/visionary. Within this maturity continuum the model describes a chasm between the early adoption and corporate adoption levels.

Enterprises must address four challenges in order to cross this chasm successfully: adequate funding, data management and governance, skill sets, and cultural and political issues. Maturity is measured on five dimensions: organization, data management, infrastructure, analytics, and governance. Evaluation of the organization's analytics maturity is done by administering a 35-question survey across these dimensions that is scored per dimension and stage to allow an organization to gauge in which dimensions they are more or less mature. This model provides a quick way to assess maturity. It does not gauge precisely where an organization is positioned in the continuum due to the limited set of survey questions covering five broad categories.

Enterprise SPICE

Enterprise Software Process Improvement and Capability Determination (Enterprise SPICE Project Team, 2010) integrates codified standards and the ISO/IEC 15504 assessment framework. ISO/IEC TR 15504-7:2008 specifies the conditions for, and contains guidance on constructing an Organizational Maturity Model, performing assessments of organizational maturity, and applying the ratings for process improvement and capability determination.

Benefits of Enterprise SPICE

- One unified and comprehensive model - no need for separate models for each dimension/component of the organization
- Pick and choose areas relevant to the organization
- Authoritative – widely recognized standards are used and mapped
- Reduced costs – training, improvement, assessment is only needed for one model
- Certification – the model will provide certification from accredited bodies

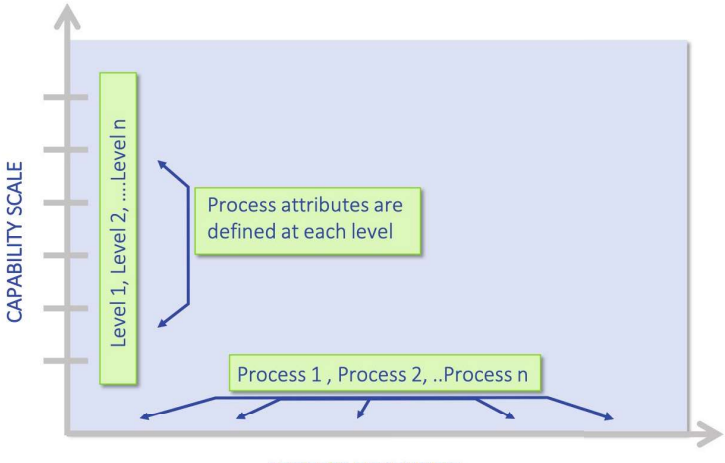


Figure 4: Structure of SPICE Conformant Models

SPICE is a domain independent model that brings together the many improvement models, standards, and approaches that target specific parts of organizations into one integrated model.

SPICE conformant models have two axes to denote processes and process capabilities. The process axis contains the processes grouped into dimensions. The process capabilities axis allows capabilities of each process to be measured independently (see Figure 4). The model is still in phase two of three phases: initial release, deployment and usage, and subsequent releases. There have been no new publications released since 2010 but the model provides a SPICE-based improvement framework as a foundation for developing other models (e.g., Marshall's E-Learning Model).

E-Learning Maturity Model (eMM)

The eMM is a framework designed to support educational institutions to improve their organizational and technological capabilities for complex and changing learning environments (Marshall, 2010). The main goal of the framework is to help organizations collaborate through joint benchmarking projects to identify common areas needing improvement and to share examples from their own organizations' improvement efforts. The model has been applied to several Australian universities (eight as of 2013) with the goal of further applications that will build a corpus of assessments that identify good practices as well as challenges (Marshall, 2013).

The eMM framework is modeled on concepts from the CMM (Paulk et al., 1993) and the Enterprise SPICE model (Enterprise SPICE Project Team, 2002). In the eMM, the Capability concept is defined as the organization's ability to design, develop, and deploy e-learning to meet the needs of the students, staff and institution. From SPICE, the eMM divides Capabilities into five major Process Areas: Learning, Development, Support, Evaluation, Organization. Each Process Area is further divided into Practices that provide the benchmarks for assessment. These Practices are derived from widely accepted guidelines found in Chickering and Gamson's (1987) "Seven Principles" and the Institute for Higher Education Policy's "Quality on the Line" benchmarks (Phipps & Merisotis, 2000). Rather than the maturity levels found in the CMM (see Table 1), the eMM uses Dimensions to describe five capability types for each of the Practices under the Process Areas: Delivery, Planning, Definition, Management, and Optimization. Finally, each of the five Dimensions for the Practices is assessed using a color-coded scheme standing for Fully Adequate, Largely Adequate, Partially Adequate, Not Adequate, and Not Assessed.

Defence Technology Enabled Learning (TEL) Maturity Model

The Defence TEL Maturity Model is being developed to provide a method of evaluation to examine unit training management and governance functions, strategies, and processes that enable or hinder technology enabled learning (TEL). A maturity model was chosen to capture current TEL capabilities that affect method and media selection, allow commanders to self-assess their levels of TEL maturity across several predefined functions, and reveal evidence of areas for continuous improvement and TEL investment for planning and budgeting purposes. The current model has four maturity levels:ad hoc/initial, repeatable, defined, and managed and measured. Six Functional Areas and associated Subfunctional areas are addressed (see Table 2).

TABLE 2: DTEC MM Functional Areas and Subfunctional Areas

Functional Areas	Sub-Functional Areas
GOVERNANCE	None
STRATEGY	Data Strategy, Digital Literacy Strategy; Investment Strategy; Innovation Strategy
USER	Stakeholder Map; Digital Literacy Levels (based on DSTL Digital Mapping Tool); Accessibiity of Materials; Design, Delivery, and Management function
LEADERSHIP	Vision/Mission Statement; Digital Awareness; Promotion of TEL and Innovation; Activities Orientated Across Elements
INTEGRATION-TECHNOLOGY	Architecture; Appropriate Range of Devices; Levels of Connectivity; Standards Recognition and Implementation; Collaboration with Other Units and Entities
INTEGRATION-CONTENT	Course Methods and Media Analysis; Assessment; Range of Medium and Supporting Elements; Analytics; Collaboration with Other Units and Entities

In comparison to the DL-CMM, the Defence TEL Maturity Model can be modified to provide the ability to assess the DL capabilities of training units to provide courses within the larger DL infrastructure. Figure 5 provides an overview of the differences and similarities of the two models. Although different in scope both models could be used in tandem to provide complementary evaluations to benefit both enterprise and course level planning and budgeting.

	DISTRIBUTED LEARNING CAPABILITY MATURITY MODEL (DL-CMM)	DEFENCE TECHNOLOGY ENABLED LEARNING MATURITY MODEL (DTEL-MM)
SCOPE	Enterprise Level	Course Level
PURPOSE	Provide a "total view" of current distributed learning capabilities to facilitate self-appraisal and provide discussion points	Self-assess TEL maturity levels across functions and benchmark across units within their sector or service
KEY SOURCE MODELS	Capability Maturity Model Integrated; Enterprise SPICE; People Capability Maturity Model	Gartner Digital Maturity Research; Deloitte Digital Maturity Research
DIMENSIONS & KEY PROCESS AREAS	Distributed learning processes and technologies; Academic sources	The 7 Lenses of Transformation; Academic sources
STAKEHOLDERS	Senior leaders, learning designers, schoolhouse management, analysis CIO office, Unit level leadership	Commanders

Figure 5: Comparison of DL-CMM to DTEL-MM

Enterprise Architecture Management Maturity Framework (EAMMF) v.1.1, v2

The Enterprise Architecture Management Maturity Framework (EAMMF) version 1.1 was developed and published in 2003 by the Government Accounting Office (GAO) as a way to measure Enterprise Architecture (EA) program maturity in Federal agencies. It was based on guidance from the 1996 Clinger-Cohen Act and subsequent Federal CIO Council's Federal Enterprise Architecture Framework (FEAF) published in 1998. EAMMF version 2 came out in 2010. The GAO (2010) describes EA as an "essential tool for effectively and efficiently engineering business or mission processes and for implementing and evolving supporting systems" (p. 1).

Federal EA was developed according to a collection of five reference models that were established by OMB in 2002:

- **Business Reference Model (BRM)**: Lines of business, agencies, customers, and partners
- **Performance Reference Model (PRM)**: Inputs, outputs, and outcomes, uniquely tailored performance indicators
- **Data Reference Model (DRM)**: Business focused data standardization, cross agency information exchanges
- **Service Component Reference Model (SRM)**: Service domains, service types, business and service components
- **Technical Reference Model (TRM)**: Service component interfaces, interoperability, technologies, recommendations

These models were designed to provide a way to improve cross-agency analysis and identify gaps, duplication of efforts, opportunities for collaboration, and interoperability within and across agencies and departments (GAO, 2010; OMB, 2009; OMB 2012).

Figure 6 provides an overview of EAMMF version 2 with a description of each of 7 stages of maturity. Stage 0 has no core elements because EA awareness is emerging. There are four sets of critical success attributes (called representations) and 59 core elements.

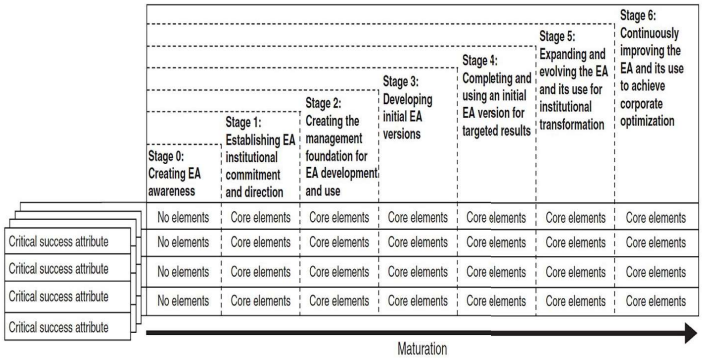


Figure 6: EAMMF Overview with 7 Stages of Maturity (GAO, 2010)

TABLE 3: EAMMF Representations and Critical Success Attributes

Representations	Critical Success Attributes
EA MANAGEMENT ACTION REPRESENTATION	Demonstrates commitment; Provides capability to meet commitment; Demonstrates satisfaction of commitment; Verifies satisfaction of commitment
EA FUNCTIONAL AREA REPRESENTATION	Governance; Content; Use; Measurement
OMB CAPABILITY AREA REPRESENTATION	Completion; Use; Results
EA ENABLER REPRESENTATION	Leadership; People, Processes; Tools

Table 3 names the four representation categories of critical success attributes and their associated attributes.

Version 1.1 was used to perform two major reviews to evaluate the status of EA in the federal government (Gaver, 2010). The first review was federal-wide and was based on four surveys done between 2001-2006. If assumed to be a valid measure of EA, the results showed that federal EA did not mature as it should. Between 2001 -2010, GAO also measured agency-specific maturity and found many problems that needed to be addressed within each agency (Gaver, 2010).

Version 2 was a major update of the previous two versions. GAO used feedback from the stakeholders they surveyed during their evaluations to improve the model and expand its scope. A recent review gave the EAMMF a rating of 100% compared to other current EA maturity frameworks as analyzed by a set of critical success factors: scoping and purpose, communication and common language, business driven approach, commitment, development methodology and tools supported, EA models and artifacts, EA governance, project program management, assessment and evaluation, IT investment and acquisition, skilled team, training, and education, and organizational culture (Suchaiya & Keretho, 2018).

3 Iterative Development

The DL-CMM's framework was developed using the maturity grids found by Maier, Moultrie, & Clarkson (2010). The authors reviewed 24 existing maturity grids used for managing and improving organizational capabilities. This framework was chosen for two reasons. First, unlike models such as the CMM, it does not need to be evolutionary and can cover best practices for the entire organization rather than specific processes like software development and acquisition. Second, the model is structured like a matrix grid, with each cell describing the characteristic trait necessary for performance at each level. Table 2 describes the key elements derived from the review of existing models to develop the DL-CMM.

The DL-CMM based its maturity levels on the original CMM's (Paulk, 1995) five maturity levels to represent the plateaus reached for each KPA rather than the six capability levels for continuous representation described in the new CMMI version. The reason for this is that the DL-CMM is an enterprise-level model that is built to provide a variety of organizations the ability to look at the generic distributed learning practices required for maturity in their organization.

All six reviewed models grouped the key process areas they were measuring into several components or dimensions. However, CMM, CMMI, and other software development maturity models additionally grouped the process areas and dimensions into each maturity level. Enterprise SPICE and eMM did not take this evolutionary approach. Process areas were grouped into dimensions or categories but were independent from maturity levels. The DL-CMM

from maturity levels. The DL-CMM features five dimensions – Commitment, Human Infrastructure, Data Infrastructure, Technological Infrastructure, and Design – that were derived from the ADL Initiative's history of research and development in this area. In particular, the book *Modernizing Learning* (Vogel-Walcutt & Schatz, 2019) provided a compendium of multidisciplinary works on distributed learning that were mined for key dimensions and practice areas.

Another key element of model development involved detailed interviews and discussions with a five-member team of Subject Matter Experts (SMEs). Over a five-month review cycle, SMEs and the internal research team reviewed and discussed each key-dimension area and elicited key process areas as they related to each dimension for clarity, conciseness, and completeness.

TABLE 3: DL-CMM Elements Derived from the Review

Element	Description
Capability	This is what the model measures to analyze and improve processes. The DL-CMM builds on the more general organizational and technological aspects of CMMs to include distributed learning processes for design and delivery of learning to meet the needs of students, staff and the learning organization. (Marshall, 2010)
Dimension	Dimensions are specific capability or process areas that structure key categories of distributed learning. They should be exhaustive and distinct, with each dimension further specified by several key process areas
Key Process Areas	Enterprise SPICE process areas fall under process dimensions. CMM and CMMI process areas are a cluster of related practices in an area that satisfy a set of goals when they are implemented collectively
Assessment	The assessment approach can be qualitative (using descriptions) or quantitative using tools such as Likert scales

4 Demonstrate and Evaluate

The DL-CMM was demonstrated to key stakeholders at Innovation, Instruction, Implementation Fest (iFEST) event in 2019. This annual conference is devoted to sharing the latest distributed learning innovations. It was also reviewed by stakeholders at the 2019 meeting of the NATO Training Group Task Group on Individual Training and Education Developments (NTGTG IT&ED). The model was presented as a tabletop rubric that could be shared and discussed among the evaluators. They found the rubric format easier to share than other formats (e.g., Likert surveys). The DL-CMM will be sent to all member nations to garner feedback at their next meeting.

5 Report

This report documents the history of the DL-CMM's development and use of in-house reviews, as well as a small focus group evaluation to gauge the reliability and validity of the model. Further testing and evaluation will be conducted to accurately measure the extent to which the model is a reliable indicator of an organization's maturity at each of the five levels for each KPA.

Structure of the DL-CMM

The core structure of the DL-CMM is composed of three major sections; 1.) Dimensions, 2.) KPAs, and 3.) Levels (See Figure 5). Dimensions represent the breadth of core organizational structures upon which practices, structures, responsibilities, or approaches can be measured.

Dimensions of the DL-CMM

1. **COMMITMENT:** Collective coordination across communities
2. **DESIGN:** Design of learning components, systems, and environments built on learning science and learning engineering
3. **HUMAN INFRASTRUCTURE:** Multidisciplinary coordination of human contributors to the learning ecosystem
4. **TECHNOLOGICAL INFRASTRUCTURE:** Technology-enabled learning architecture: instructional systems, interoperability standards, software services
5. **DATA INFRASTRUCTURE:** Digital infrastructure to promote data sharing and usage

Architecture of the model

The DL-CMM contains five dimensions that are orthogonal to each other. Orthogonality is important to avoid conflicting outcomes from data gathering. By creating severable outcomes, the model can be tailored to the resources of an organization and its data can feed assessments that consider actions taken to determine effectiveness.

Cost to implement the model

The model requires the participation of senior leadership, personnel proficient in analysis, and access to material and subject matter expertise across a range of disciplines in a given organization. This can be accomplished with minimal investment.

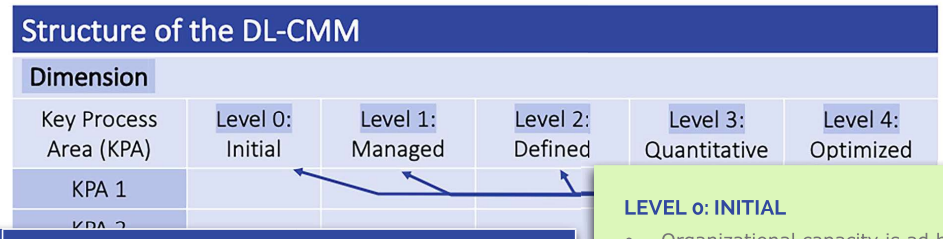
Access to SMEs is a known cost for any analysis, so organizations should carefully plan SME participation to lessen significant impact of organizational workflow.

Value of the model

When properly applied, the DL-CMM will provide both vertical data points on how leadership vision is being implemented and horizontal data points on how different activities are integrated to provide mature learning ecosystems.

Leadership should be particularly interested in the outcomes of how data is being leveraged in relation to leadership intent. The KPAs for data provide insight on how knowledge can be captured and inform processes. Without strong infrastructure and management, that knowledge will not promulgate into positive impacts on individual efforts.

These evaluative criteria should be interpreted individually based on organizational goals. The intention of the model is to communicate important organizational components at various levels of maturity that can be applied and validated across a wide swath of domains and organizational levels.



DIMENSION	KEY PROCESS AREAS	
COMMITMENT	• Vision • Professional Development	• Financial Planning • Granularity of Training Records
DESIGN	• Learning Policy • Learning Environment • Pedagogy, Andragogy, Heutagogy	• Business Rules • Instructional Design • Curriculum Design • Assessment Design
HUMAN INFRASTRUCTURE	• Workforce Development • Professional Development Programs • Mentoring & Coaching • Identification of Training Requirements	• Knowledge Management • Learning Resources • Quality Assurance • Change Management • Standards
TECHNOLOGICAL INFRASTRUCTURE	• Governance • Extensibility • Ubiquitous Learning Environments • Training Management	• Security • Privacy • Learning Identity Management
DATA INFRASTRUCTURE	• Data Strategy • Data Analysis • Data Management • Data-Driven Decisions	• Data Interoperability • Human Resources • Data Rights

LEVEL 0: INITIAL

- Organizational capacity is ad hoc and occasionally chaotic
- Few, if any, defined processes exist
- Success depends on the abilities, efforts and organization of individuals

LEVEL 1: MANAGED

- Systems for managing training & education are in place
- Some areas of distributed learning management are applied in isolated projects

LEVEL 2: DEFINED

- Sharing of expertise between areas
- Processes used are codified and there is shared responsibility for maintaining these processes
- Common training programs are implemented among areas

LEVEL 3: QUANTITATIVE

- Systems and procedures (e.g., learning support, instructional design processes) are organization-wide
- Common datastore for collecting and measuring training and education activities
- Well-defined and consistent metrics to aid training and education goals

LEVEL 4: OPTIMIZED

- Continuous improvements are adopted by reviewing and updating processes through incremental improvements of methods and technologies

Figure 7: Dimensions and Key Process Areas of the DL-CMM

HOW TO USE THE MODEL

When incorporating the DL-CMM, it is critical to tie in senior management and business leaders, specifically in communicating the value of organizational improvement via the associated risks and benefits. When considering these factors keep in mind specific instances of where the organization has already failed and illustrate personalized scenarios that demonstrate the benefits of scaling maturity. The bottom line is that CMM implementation is a large-scale effort and needs buy in from senior management and business leaders in order to truly incorporate the change needed to reap the potential benefits. Communicating the risks of non-incorporation and potential benefits to those large-scale decision makers will help educate those equipped to create change.

We recommend following the structure of the DL-CMM when implementing it in your organization. If the model is applied piecemeal or adapted to an organization based on the availability of SMEs and leadership, it will still offer value but the outcomes may be difficult to map to the referenced literature reviews.

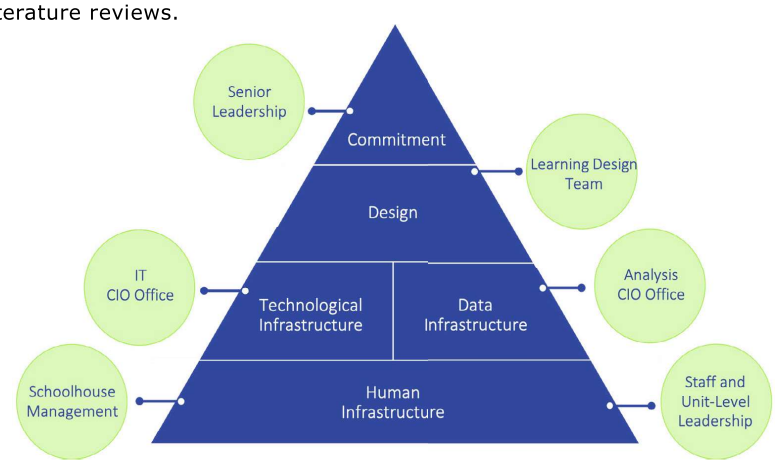


Figure 8: Key Stakeholders for Each DL-CMM Dimension

STEP 1: PREPARE

- Establish relationship with senior leadership and obtain consent on executing study
- Identify risks and benefits to the organization and present to senior management and business leaders
- Identify stakeholder team to conduct CMM analysis (see Figure 6 for recommended stakeholders)
- Develop milestones and schedule aligned to costs and availability of stakeholders

STEP 2: FIT DL-CMM TO THE ORGANIZATION

- **Determine organizational goals**
- **Tailor the KPA selection for the study to fit the approved schedule and to make the best use of approved organizational resources**
- **Assess desired organizational level per KPA, as it relates to overall organizational goal**

STEP 3: ASSESS MATURITY

- **Ask allocated stakeholders to assess current organizational maturity aligned to KPA levels**

STEP 4: IMPLEMENT RESULTS

- **Report findings to senior management and business leaders**
- **Develop strategies for achieving desired maturity**
- **Implement strategies to achieve desired outcomes**
- **Document outcomes**

CONCLUSIONS

Recommendations

Research conducted by Meta Group (2004) revealed two organizational challenges to any initiative for deploying CMMs. The first challenge is the perception that distributed learning processes are primarily technology driven. A fundamental objective of the DL-CMM is to link strategy to organizational processes in which technology might play an important but supporting role. The second challenge is organizational resistance. Deploying the model can change the existing infrastructure of power and control. It is important to develop a training program for end users to deal with lack of user confidence in the system (Frolick et al., 2006). Senior leadership must recognize the commitment required to implement the maturity model. Otherwise they will become disillusioned and withdraw support. They should recognize that the DL-CMM is not a single project but a gradual building of skills, awareness and technology that must be implemented in iterative phases over time (Newman & Logan, 2008).

- Make the DL-CMM part of the effort to educate senior management, so they understand the phases of the enterprise distributed learning organization's journey.
- Illustrate the risks of not having the DL-CMM, look for examples where the organization has already failed because of poorly managed distributed learning processes.

Future Steps

This is a working exemplar of a living document that continues to be developed in an iterative design process. The DL-CMM has many potential uses and types of application. To further improve the benefits of the model and validate its use, we recommend applying it to organizations and through focus group sessions to determine whether its objectives are met or not.

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APPENDIX A: DL-CMM MODEL

Commitment

Collective coordination across communities

Key Process Area	Level 0	Level 1	Level 2	Level 3	Level 4
VISION: Does the organization have a vision for education and training?	Each subordinate organization has its own set of standards that guide organizational goals, vision, and purpose.	Each subordinate organization has its own set of standards that guide organizational goals, vision, and purpose. There are some established channels of communication and reporting to enable education and training.	Each subordinate organization has its own set of standards that guide organizational goals, vision, and purpose. There are established channels of communication and reporting to enable education and training.	The organization is making progress in transferring the philosophy of collective purpose to partner organizations. The principles and practice of leadership are well developed among workers and learners.	The organization's policies enable partnerships through specifications and standards. There is a growing commitment to the success of partner organizations and mutual ability to improve learning, technology, and data analytic goals across the enterprise.
PROFESSIONAL DEVELOPMENT: What is the maturity of policy to develop the best possible personnel?	The workforce receives opportunities like taking external courses but this is not formally tracked.	Although effective workers are known within the organization and provided with extra courses, there is no official acknowledgment.	Career growth and leadership opportunities are extended to workers based on talent identification.	The career development process is linked to leadership development and workforce planning tools.	Using workforce planning tools, workers are trained to meet future organizational needs across different functional areas within the organization.
FINANCIAL PLANNING: Does the organization leverage Financial Planning for education and training across the enterprise?	Local activities request and manage funding to meet their own education and training needs.	Funding is optimized across organizational departments by coordinating learning to reduce duplication for funding to meet their own education and training needs.	The organization holds approval authority over local funding expenditure but does not have stringent oversight on quality.	The organization holds approval authority over local funding and defines minimum acceptable levels of technical quality.	The organization holds approval authority over local funding, and defines minimum acceptable levels of technical quality that meet 3rd party accreditation requirements.
GRANULARITY OF TRAINING RECORDS Does the organization represent education and training records with proper specificity and granularity?	No representation of credentials is present in the talent pipeline. No common system is used for managing credentials.	Minimum required credentials are represented in the talent pipeline. Minimally viable systems exist for managing workforce credentials.	The talent pipeline includes a transcript of credentials that manages recertification requirements. The organization has established processes and systems that provide deeper insight into workforce credentials.	The talent pipeline manages credentials and training requirements aligned with career growth and workforce planning tools. Credentials are defined using Credential Transparency Description Language (CTDL) to enable insight into the competencies each credential represents.	In addition to Level 3 requirements, the talent pipeline tracks learning experiences, competencies, and credentials. These data are shared across the organization's other functional areas to improve overall workforce efficiency.

Design

Design of learning components, systems, and environments built on learning science and learning engineering

Key Process Area	Level 0	Level 1	Level 2	Level 3	Level 4
LEARNING POLICY Are there policies that govern the education and training of individuals within the organization?	There is no formal learning policy.	Policy exists but is limited and fragmented across organizational components.	Policy exists but is not consistently enforced across the organization.	Policy is well-defined, enforced, and communicated throughout the organization. Policies are regularly updated and integrated with other organizational policies.	Policy is well-defined, enforced, and communicated organization-wide. Policies are regularly updated and integrated with other organizational policies. Learning policies are tied to other education and training tools within the organization to manage conformance.
LEARNING CULTURE How mature are the organization's education and training practices?	Teacher-centered training techniques are employed to meet mandatory requirements. Training is based on organizational policies rather than from the needs of the students.	Management recognizes the need for learners to have more ownership of their learning. The learner's development and career needs are starting to be recognized as important to the health of the organization.	Learners are given tangible methods for steering their own development and careers. The organization is starting to create an enabling environment that nurtures learners and recognizes skills and abilities.	A learner-centric culture is employed. Learners demonstrate accountability for their own learning. The organization provides opportunities to design their own learning paths. Staff use credentialing and badging to recognize achievement.	A deep culture of learning exists and is encouraged by policies and promoted by management. Learning opportunities are available across the organization and the workforce is rewarded for participating through promotions or incentive programs. Processes are in place for piloting new training-related tools or technologies.
LEARNING ENVIRONMENT How pervasive are resources for learning across the organization? Are there programs in place to afford access for learners to leverage them?	Learning resources are primarily located in physical locations. Access to learning is based on industrial classroom-based models. Emergent training requirements are reactionary.	Online and physical learning resources are available as stand-alone capabilities. Learning resources are not connected to other organizational resources. Training effectiveness evaluations are periodically conducted to address the overall quality of different learning environments.	Online, mobile, and physical learning resources are available as stand-alone capabilities. Learning resources are connected to other organizational resources using the Experience API (xAPI). Learning resources may be blended together into a single program of instruction.	Online and physical learning resources are available as stand-alone capabilities. Learning resources are centrally managed and connected to other organizational resources. Formal programs facilitate education and training access for a widely distributed workforce. Learning resources are regularly blended into programs of instruction. Environments are described using LRMI metadata. Learner performance within the learning environment is tracked using xAPI.	Learning centers of excellence and a centralized management function provide support across different learning environments. Policies exist to manage the incorporation of new training tools or technologies. Blended learning opportunities are pervasive through distributed access. Learning environments are matched to learner needs and mission requirements. Learning environments are described using LRMI metadata. Learner performance within the learning environment is tracked using xAPI. Emergent training requirements are proactively developed and learner environments are continuously evaluated to measure effectiveness.

Design (continued)

Design of learning components, systems, and environments built on learning science and learning engineering

Key Process Area	Level 0	Level 1	Level 2	Level 3	Level 4
INSTRUCTIONAL DESIGN Are there prescribed processes for creating instructional experiences within the provided learning environments?	Policy prescribes the processes and methodologies used in the creation of basic training programs that meet knowledge-based objectives. There is minimal use of assessments.	Policy prescribes the processes and methodologies used in the creation of blended training programs that meet organizational objectives. There is moderate use of scaffolding, knowledge checks, assessments, and other practice exercises.	Policy prescribes the processes and methodologies to create blended training programs that meet organizational objectives. There is policy-driven use of scaffolding, knowledge checks, assessments, and other practice exercises. Active learning methods like case studies, hands-on practice, or collaborative exercises are minimally used across the organization.	Policy prescribes the processes and methodologies used to create blended training programs to meet organizational objectives. Learners can test out of previously learned course components. Policy-driven use of scaffolding, knowledge checks, assessments, and other practice exercises are in place. Active learning methods like case studies, hands-on practice, or collaborative exercises are moderately used across the organization. Policy requires review of instructional design artifacts to ensure quality.	Policy enables the development of learning environments that support a high degree of cognitive fidelity to support advanced decision-making skills. Learners are able to test out of previously learned course components. Instructional strategies, design artifacts (e.g., job duty task analysis, cognitive analysis) and assessments are digitally archived to support enterprise analytics. Policy mandates the review of all instructional design artifacts to ensure quality.
CURRICULUM DESIGN Are there prescribed processes for identifying and aligning instructional topics from the organization's mission?	Curriculum design policies and processes are ad-hoc. There are no policies or recommended practices for controlling the curriculum design process. Few processes are defined, and success depends on individual effort.	Basic curriculum design processes are established at the course level. The focus is to design clear and measurable learning outcomes at the course level.	Curriculum design policies and processes are formally documented, standardized, and integrated to support the design of activities, courses, or instructional programs designed to meet organizational requirements.	Detailed curriculum design policies and processes are defined, standardized, and adopted organization-wide. Policies are in place to align learning outcomes with organizational goals, and a process for identifying key performance indicators in the operational environment exists to provide feedback to curriculum designers.	Continuous process improvement is enabled by policies requiring quantitative feedback from key performance indicators in the operational environment to be available to support the curriculum design process. Data driven design principles are incorporated into the curriculum and external resources are available to learners to support higher levels of learning.
ASSESSMENT DESIGN How pervasive is the use of learner assessment data across all the different experiences a learner encounters? Is a learner only assessed in formal environments?	No policies are in place relating to the design and reporting of assessment. Learning analysis metrics remain unidentified and uncaptured.	The use of xAPI enabled learning assessments is sporadic across the organization. Data collected is primarily focused on completions and satisfying higher level course requirements.	The use of xAPI enabled diagnostic assessments is moderate across the organization. Collected assessment data provide more granular details of learner proficiencies and deficiencies. Assessments inform remedial learning opportunities.	The use of a wide range of xAPI enabled assessments is institutionalized. Learner proficiency is also assessed using operational performance built around key performance indicators in the work environment. Assessments inform new learning opportunities.	The use of a wide range of prescriptive assessments continually optimizes and tailors assessments to individual learners. Assessment data from across the organization are aggregated to make predictions about the learner's future potential. Learner proficiency is also assessed using operational performance built around key performance indicators in the work environment. Assessments inform new learning opportunities.

Human Infrastructure

The multidisciplinary coordination of human contributions to the learning ecosystem

Key Process Area	Level 0	Level 1	Level 2	Level 3	Level 4
WORKFORCE DEVELOPMENT What is the maturity of workforce development, training, and mentoring opportunities?	There is unstructured on-the-job learning, minimal informal knowledge exchange, and very little teamwork.	There are some formal training programs. Mentoring, sporadic knowledge sharing, and teamwork are managed ad-hoc in the organization.	Training and mentoring structures are promoted organization-wide. Professional development and communities-of-practice are encouraged.	Workers are empowered to take charge of their own training and mentoring. Career growth opportunities are promoted throughout the organization.	Professional development programs are actively promoted and supporting systems are in place for identifying and aligning professional development opportunities across the workforce.
PROFESSIONAL DEVELOPMENT PROGRAMS What is the maturity of policies to develop the best possible personnel?	The workforce has opportunities, such as external courses, to improve on-the-job skills.	Effective workforce development programs are established but are not consistently used or universally promoted across the workforce.	Career growth and leadership opportunities are extended to the workforce based on talent identification.	A career development process is linked to leadership development and workforce planning tools.	Using workforce planning tools, workers are trained to meet future organizational needs across different functional areas within the organization.
MENTORING AND COACHING How consistent are the policies for mentoring and coaching programs?	There is some mentoring and coaching, but it is not organizationally driven. There are mainly individual efforts.	A policy for mentoring and coaching is being devised but is not yet coherent. There is no clear delineation between mentoring and coaching and roles are not clearly allocated.	A distinction is made between mentoring and coaching, with roles given to the workforce. Learners can mentor and coach each other, especially in tutoring or peer teaching roles, with support from the organization.	There is a developed policy for mentoring and coaching that is linked to performance management and leadership development.	Systematic formal mentorship programs are in place at the enterprise level to offer mentoring and coaching opportunities. They track and measure participation and training effectiveness across the organization.
IDENTIFICATION OF TRAINING REQUIREMENTS Is there a standardized set of processes for capturing feedback from operations to education and training?	Requirements management is event driven and training requirements are updated reactively to negative events (e.g., accidents).	Subject Matter Experts define training requirements based on industry best practices and personal experience. Requirements vary across organizations.	Subject Matter Experts uniformly define training requirements based on established set processes derived from industry accepted best practices.	Policies are in place to support continuous process improvements for revising training based on operational feedback. Feedback is incorporated. Content is updated proactively.	Policies are in place to support data-driven training requirements that are regularly revised.

Human Infrastructure (continued)

The multidisciplinary coordination of human contributions to the learning ecosystem

Key Process Area	Level 0	Level 1	Level 2	Level 3	Level 4
LEARNING RESOURCES Are there organizational policies to standardize the acquisition of information?	No policies are in place related to learning resource requirements.	Organizational policies exist to outline technical and usability requirements of any acquired learning resources. Policies are minimally enforced and not consistently promoted across the organization.	Organizational policies exist that outline technical specifications and usability requirements of any acquired learning resources. Policies are moderately enforced but not consistently promoted across the organization.	Organizational policies exist that outline technical specifications and usability requirements of any acquired learning resources. Policies are fully enforced and consistently promoted across the organization. The organization provides adequate resources and funding for quantitative evaluation of learning resources.	Organizational policies outline technical specifications and usability requirements of any acquired learning resources. Policies are fully enforced and consistently promoted across the organization. The organization provides adequate resources and funding for quantitative evaluation of learning resources. Policies guide the establishment of enterprise data dictionaries that are continuously updated for the organization. Learning resources adhere to the standards outlined in the data dictionary.
QUALITY ASSURANCE How mature are policies and processes for verification, validation, and accreditation?	Local activities have the authority to verify, validate, and accredit instructional materials and processes.	Local activities have primary authority with some oversight from the organization.	The organization has common outside accrediting requirements.	The organization proactively engages with common outside accrediting requirements	The organization has common outside accrediting requirements as a cultural norm that is incentivized.
CHANGE MANAGEMENT What is the maturity of organizational change management policies in response to mission needs?	No formal change management tools, processes, or documented initiatives are in place.	Change management is performed on an ad-hoc basis across the organization on a department by department basis.	Organizational policies formalize a change management strategy across the enterprise. Policies are minimally enforced and not consistently promoted.	Organizational policies formalize a change management strategy across the enterprise. Policies are moderately enforced but not consistently promoted.	Organizational policies formalize a change management strategy across the enterprise. Policies are fully enforced and consistently promoted.
STANDARDS Are standards, such as ISO, ABED Accreditation, and Six Sigma, followed?	Each activity has its own local usage of standards.	Local activities have recommended standards from the parent organization.	Local activities have required standards from the parent organization.	The organization has identified common standards for use across the organization. Adherence to standards requirements is moderately enforced.	The organization actively follows a standards-based management plan after receiving certifications and accreditations.

Technological Infrastructure

The organization's technological-enabled learning architecture: instructional systems, interoperability standards, software services

Key Process Area	Level 0	Level 1	Level 2	Level 3	Level 4
GOVERNANCE How mature is governance in support of innovative learning technologies?	Activities deploy their own IT infrastructure without common planning. There are disparate networks and learning technologies.	Organizational components maintain a common IT infrastructure resulting in multiple network enclaves that don't interact. Governance is managed at the local level.	An enterprise infrastructure facilitates distributed education and training learning activities. Standard and configurable IT infrastructures are used to host dedicated learning capabilities. Policies manage the acquisition and maintenance of key IT systems.	An enterprise infrastructure facilitates distributed education and training delivery and human performance improvement. Governance results in globally managed and compatible learning systems and records accessible on a common network. Policies manage the acquisition and maintenance of key IT systems and technology insertions.	An enterprise infrastructure facilitates distributed education and training delivery, in conjunction with external partners. Organizational governance results in globally managed, standards-based IT infrastructure that supports emerging learning technologies. Organizational policies manage the acquisition and maintenance of key IT systems and technology insertions.
EXTENSIBILITY How mature is the IT environment for deploying innovative learning technologies?	IT Infrastructure supports open and closed solutions but does not adhere to specific guidance or standards.	IT infrastructure supports open and closed solutions based on prescribed standards and guidance.	A pervasive IT infrastructure supports standards-based architecture solutions. Organizational policies drive IT requirements and define the process for acquiring, integrating, and accrediting new IT infrastructure.	Extensible services support any learning modality (e.g., simulator platforms, cyber range) and the specialized IT requirements to support each activity. Organizational policies drive IT requirements and define the process for acquiring, integrating, and accrediting new IT infrastructure.	Extensible services to support any learning modality (e.g., simulator platforms, cyber range) and the specialized IT requirements to support each activity. Organizational policies drive IT requirements and define the process for acquiring, integrating, and accrediting new IT infrastructure. Federated data management and cloud hosting is driven by policy throughout the organization.
UBIQUITOUS LEARNING ENVIRONMENT(S) Does the organization have policies to afford education and training across time, space, path, mode, and access?	Learning environments are strictly facilitated through organizational assets. There are no clear ubiquitous learning policies and defined objectives to guide ubiquitous learning.	Clear objectives are set to guide the development of a ubiquitous learning environment. There is a need to evaluate existing systems and implement pilot prototypes.	Investment in ubiquitous learning technologies grows along with the development of clear guidelines aligned to the organization's core and technical visions.	Best practices have been defined and implemented. Methods of measuring effectiveness of ubiquitous learning systems are developed and put in place. Procedures and policies are refined and improved to reflect changes in technologies.	The organization is constantly evaluating its ubiquitous learning environment to ensure continuous improvement and optimization.

Technological Infrastructure (continued)

The organization's technological-enabled learning architecture: instructional systems, interoperability standards, software services

Key Process Area	Level 0	Level 1	Level 2	Level 3	Level 4
PRIVACY What is the maturity of policies and systems to protect private information?	Privacy management is locally defined and follows industry standards.	Policies and procedures are in place to detect privacy breaches reactively, support remediation, and audit the information disclosed.	Privacy management is organizationally defined and enforced at all levels.	Reactive and proactive policies and controls are in place to prevent, detect, and respond to loss of privacy information. Effectiveness of controls are quantifiable.	Privacy management establishes a clear understanding and a positive relationship with learners and their data. Formal processes are in place for regular auditing. The policy enforces user control of data, including the right to be forgotten.
LEARNER IDENTITY MANAGEMENT How pervasive is the learning identity management solution?	Local sign-on credentials are required per application or computer/device.	Local sign-on credentials are required per organization.	A secure token-SSO, like a Common Access Card (CAC), is used only within the closed government infrastructure.	A secure token-SSO, like ID.ME, is used within the closed government and private infrastructure.	Federated SSO is required across disintermediated enclaves.

Data Infrastructure

The organization's infrastructure to promote data sharing and usage

Key Process Area	Level 0	Level 1	Level 2	Level 3	Level 4
DATA STRATEGY Is there an education and training strategy for managing data?	Data from education and training activities are captured using disparate tools and technologies with proprietary data formats.	Some education and training activities capture learner performance data in xAPI format but are not integrated into a common LRS.	xAPI is required by policy for all education and training activities to capture learner performance data. LRMI formatted metadata is required by policy to describe learning resources (activities, content, experiences, and courses). Competency Frameworks are required to use the Reusable Competency Definition (IEEE 1484.20.1) to define competencies, the relationship between competencies within a competency framework, and the alignment of different types of evidence to assess proficiencies.	xAPI is required by policy for all education and training activities to capture learner performance data. LRMI formatted metadata is required to describe learning resources (activities, content, experiences, and courses). Competency Frameworks are required to use the Reusable Competency Definition (IEEE 1484.20.1) to define competencies, the relationship between competencies within a competency framework, and the alignment of different types of evidence to assess proficiencies.	xAPI is required by policy for all education and training activities to capture learner performance data. LRMI formatted metadata is required by policy to describe learning resources (activities, content, experiences, and courses). Competency Frameworks are required by policy to utilize the Reusable Competency Definition (IEEE 1484.20.1) to define competencies, the relationship between competencies within a competency framework, and the alignment of different types of evidence to assess proficiency for a particular competency. An Enterprise Learner Record is required to support credential management, global learner attributes, and local learner profiles that contain the chain of evidence for earned credentials.

Data Infrastructure (continued)

The organization's infrastructure to promote data sharing and usage

Key Process Area	Level 0	Level 1	Level 2	Level 3	Level 4
DATA MANAGEMENT How well is data managed throughout the organization?	Management of data is a proprietary component of disparate software systems across the organization as defined by commercial technology implementation plans.	Some subordinate units have mature data management within their systems, but this has not been normalized across the organization.	There is ad-hoc use of federated data internal or external to the organization. Formal processes are established for obtaining Authorities to Connect to disparate systems.	Policy guides federated data systems. Formal processes are established to enable access, authentication, and anonymization while also ensuring protection of Personally Identifiable Information (PII) and cybersecurity.	Policies drive federated data strategies with an enterprise approach to federated identity and access management for evidentiary chains of learner performance data. Formal processes enable access, authentication, and anonymization while also ensuring protection of PII and cybersecurity. Enterprise services enable data owners to maintain ownership while sharing across the organization.
DATA-DRIVEN DECISIONS How formalized is the review of data when making education and training decisions?	Decision-makers do not consider data analytics in education and training planning.	Data analytics are considered on an ad-hoc basis across the organization.	Data analytics are used by high-level decision makers on an ad-hoc basis.	There is systemic use of data analytics across the organization by high- and mid-level decision makers.	Data driven decision making is institutionalized across the organization and is managed by policy. Analytics and tools are accessible by anyone in the organization.
DATA INTEROPERABILITY How consistent are the policies governing data interoperability?	Organizational components procure education and training systems as needed without overarching policy dictating how education and training data will be promulgated through the organization.	Organizational education and training systems use common commercial and government developed data standards. Interoperability is primarily focused on the exchange of data between systems for internal consumption.	Organizational education and training systems are required by policy to use commercially developed data standards and store these data on a common network so they are available for other education and training tools.	Interconnected education and training systems use commercially developed data standards and store data on a common network available for other education and training tools. All data transforms are saved to preserve semantic meaning from the perspective of the source from their interoperable data.	Internal and externally connected education and training systems are required by policy to use commercially developed data standards and store these data within a data lake that supports federated access. All data transforms are saved to preserve semantic meaning from the perspective of the source from their interoperable data.
HUMAN RESOURCES How integrated are the education and training systems with the HR systems?	There is no Credential Management within the organization. Credentials are managed ad-hoc or by individuals.	Minimal credential management capabilities are available within the HR system. Credentials are listed but not aligned with learning opportunities or career path planning.	A credential management capability is required by policy to support CTDL to enable a common way of describing the competencies represented by each earned credential.	An established credential management capability is required by policy to support CTDL. Competency Management capabilities collect evidence from education and training systems and are available for use within the HR system.	Centralized credential management capability generates badges based on individual performance in the operational environment (e.g., performance reviews, integration with digital systems). Enterprise adoption of competency-based learning principles.

APPENDIX B: REVIEWED CMM MODELS

Category	Name	Citation	Levels	Dimensions/Categories	Included in Final Review	Reason
BUSINESS INTELLIGENCE	Enterprise Business Intelligence Maturity Model (EBI2M)	Chuah, 2010; Chuah & Wong, 2012	initial, managed, defined, quantitatively managed, optimizing	Key processes are described per level, not grouped into dimensions/ categories	No	Still in development. One qualitative pilot study
	Gartner Enterprise Information Management (EIM) Maturity Model	Newman & Logan, 2008	unaware, aware, reactive, proactive, managed, effective	vision, strategy, metrics, governance, organization roles, life cycle, accessible infrastructure	No	Information not readily accessible
	Ladder of Business Intelligence (LOBI)	Cates et al., 2005	facts, data, information, knowledge, understanding, enabled intuition	3 process areas: technology, process and people	No	Incomplete, not well documented, criteria for evaluating maturity levels are not well defined. Highly IT-specific, other BI components are excluded
	TDWI's Analytics Maturity Model	Halper & Stodder, 2014	nascent, pre-adoption, early adoption, corporate adoption, mature/visionary, with a chasm between 3 and 4	Organization, Infrastructure, Data management, analytics, governance	Yes	Meets documentation and weak test requirements
	The Data Warehouse Institute's (TDWI's) Business Intelligence Maturity Model	Eckerson, 2009	infant, child, teenager, adult, sage (sometimes level 0 of prenatal)	Scope, sponsorship, funding, value, architecture, data, development, delivery	No	Older version updated by the TDWI Analytics MM
EDUCATION & TRAINING	Defence Technology Enabled Learning (TEL) Maturity Model	Defence Academy of the United Kingdom, 2019	ad hoc/initial, repeatable, defined, managed and measured	Governance, Strategy, Leadership, User, Integration: Content; Integration: Technology	Yes	Although still in development, included due to its relevance to the DL-CMM
	E-Learning Maturity Model (eMM)	Marshall, 2010; 2013	not practiced/not adequate, partially adequate, largely adequate, fully adequate	Delivery, planning, definition, management, optimization	Yes	Developed model, provides documentation, meets strong test
	eQETIC Maturity Model for Online Education	Rossi et al., 2015	sufficient, intermediate, global	Didactic-Pedagogical; Technology; Management; Support; tutorial; Evaluation	No	Preliminary model, not well documented; criteria for evaluating maturity levels not well-defined
	M-Learning Maturity Model	Alrasheedi & Capretz, 2013	preliminary, established, defined, structured, continuous improvement; descriptions for each level	Key processes are described per level, not grouped into dimensions/ categories	No	Incomplete, not well documented, criteria for evaluating maturity levels are not well defined.
INTEROPERABILITY	Information Systems Interoperability maturity Model (ISIMM)	Van Staden & Mbale, 2012	manual, ad-hoc, collaborative, integrated, unified	data interoperability, software interoperability, communication interoperability, physical interoperability	No	Still in development; pilot study
	Levels of Conceptual Interoperability Model (LCIM)	Tolk & Muguira, 2003	none, technical, syntactic, semantic, pragmatic, dynamic, and conceptual	The levels are divided into three categories: integrability (L0-2), interoperability (L3-4), and composability (l5-6)	No	Technical reference model
	Maturity Model for Enterprise Interoperability	Guedria et al., 2015	5 levels: 0-4: unprepared, modeled, adhered, mapped, accommodated	"Categories: Conceptual, Technological, Organizational; KPAs for each dimension: Business, Process, Service, Data	No	Still in development. Future work is in planning to perform case studies in enterprises
	Organisational Interoperability Model	Clark & Jones, 1999	Independent, ad-hoc, collaborative, integrated, unified	Preparedness, Understanding, Command Style, Ethos	No	Technical reference model

Reviewed CMM Models (continued)

Category	Name	Citation	Levels	Dimensions/Categories	Included in Final Review	Reason
HUMAN RESOURCES	People's Capability Maturity Model	Curtis et al., 2009	initial (inconsistent management), managed (people management), defined (competency management), predictable (capability management), optimizing (change management)	Each maturity level is composed of several process areas. Each process area contains a set of interrelated practices that satisfy a set of goals for achieving the maturity level.	Yes	Built on CMM, CMMI. Well documented, published research on use cases
ORGANIZATION	Business continuity management (BCM) maturity model for the UAE banking sector	Randeree et al., 2012	ad hoc, managed, defined, integrated, optimized; 2nd access: BCM process quality; BCM process scope	BCM program management; planning and analysis, development of the BCP, implementation, maintenance	No	Incomplete, not well documented, criteria for evaluating maturity levels are not well defined
	Corporate Performance Management (CPM) Capability Maturity Model	Aho, 2009, 2012	unaware, ad-hoc, repeatable, defined, managed, optimized	Management & Organization, Technology, People & Culture, Processes	No	Provides a quick way for organizations to see where they are and where they need to go next. Works as a communication and change management tool
	InfoSys KM Maturity Model	Kochikar, 2000	default, reactive, aware, convinced, sharing Each level is characterized by three factors: knowledge acquisition, knowledge dissemination, knowledge reuse	People, Process, Technology	No	Not well documented; criteria for evaluating maturity levels are not well defined
	Enterprise Architecture Management Maturity Framework (EAMMF)	Government Accounting Office, 2010	7 Stages	4 representations, core success attributes for each representation	Yes	Published results, relevant to DL-CMM
SOFTWARE DEVELOPMENT/ TECHNOLOGY	Capability Maturity Model (CMM), v.1, 1.1, 2C	Paulk et al., 1991, Paulk et al., 1993, Paulk 1997	initial, repeatable, defined, managed, optimizing	Key processes are grouped by level	Yes	Most maturity models are based on this CMM and subsequent models from the Capability Maturity Model (CMMI) Product Team
	Capability Maturity Model Integration (CMMI), v.1.1,	CMMI Product Team. (2002).	initial, repeatable, defined, managed, optimizing	Process Management, Project Management, Engineering, Support	Yes	Developed model, provides documentation, meets strong test
	IT Performance Measurement Maturity Model	Becker, 2009	non-existent, initial, repeatable, defined, managed, optimized	Still in development	No	Incomplete, not well documented, criteria for evaluating maturity levels are not well defined


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