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Analysis of the Costs and Benefits of Implementing the Navy's Acquisition Requirements for Training Transformation (ARTT) Initiative: *Integrating Training Needs Analysis and Content Development with Model-Based Product Support (MBPS)*

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Executive Summary

The Acquisition Requirements for Training Transformation (ARTT) project currently focuses on maintenance and troubleshooting curriculum requirements to support engineered systems deployed to the fleet. These systems include computer, communication, navigation, and radar equipment. In particular, ARTT addresses the design, development, lifecycle management, and accuracy of technical training curricula within the Navy's C school. In C school, sailors learn specialized skills within the Navy Enlisted Classification (NEC) system[1] and study advanced subjects for particular NEC codes. For example, NEC code EN-4313 represents an Outboard Engine Mechanic, 0304 represents a Radar Operator/Navigator, and so on. These technicians perform specialized tasks such as maintain surface, subsurface, air, weather, and tactical air navigation equipment; analyze equipment operation; and align, troubleshoot, and repair equipment to the lowest replaceable unit. These are just a few examples of the various Navy engineering systems that require technical training.

A main goal of ARTT is to integrate Navy technical curriculum development software with the Navy's new Model-Based Product Support (MBPS) program to deliver training faster, more accurately, and at a lower cost. With the integration into MBPS, the Navy can close the gaps between the data used in system engineering and configuration management and the data available for developing and managing training curricula. Essentially, ARTT is designed to apply the digital information provided by the Navy's MBPS program to the development of Navy training curricula for new and modified systems related to ships, aircraft, and weapons that require technical training.

Model-Based Product Support

MBPS is an initiative to improve the lifecycle management of Navy technical systems and address data acquisition through its three main components:

- Navy Data Acquisition Requirements Tool (NDART),
- Navy Product Data Model (NPDM), and

[1] Navy Enlisted Classification (NEC) is an advanced specialty within a job. NECs identify non-rating wide skill, knowledge, aptitude, or qualifications to identify people and jobs. Manual of Navy Enlisted Manpower and Personnel Classifications and Occupational Standards. Volume II, Navy Enlisted Classifications, NAVPERS 18068F, January 2020, 1.

- Navy Common Readiness Model (NCRM).[2]

Together, these components deliver product data for designing, building, and supporting Navy systems. These components also enable data configuration management, digital integration, and modeling and simulation to better analyze and optimize the readiness and costs of weapon systems. The Navy will procure technical product data within the industry standards essential for ARTT, including ISO 10303, GEIA-0007, and the S-Series product data standards. The objective is to integrate technical training data with related system product data, including engineering drawings, maintenance plans, and technical manuals in commercial systems that manage product lifecycles. Integration occurs through the use of industry-standard data specifications for all product data. As this study shows, ARTT can close the Navy's gaps between the data employed in system engineering and configuration management and the data available for training curriculum development and management.

End-to-End Course Development Model and Ranges Postulated in Cost Estimates

This cost-benefit analysis addresses how ARTT will impact the processes and resources required to develop technical training courses. Using a Navy end-to-end course development model, the analysis integrates detailed estimates to arrive at overall estimates of savings from ARTT. There has been validation of the savings of ARTT in the planning and analysis phases of curriculum development, although the magnitude has not been quantified. Also, most of the costs of curriculum development are in the design and development phases, and these phases need further empirical testing. Therefore, our analysis relies on estimates provided by subject matter experts (SMEs) and was based on two major factors.

First is the scope of training content that will benefit from ARTT. To demonstrate the possible workload ranges, two cases are postulated of new training content per year—16,000 hours and 30,000 hours. Second, there is a range in the proportion of savings that ARTT will produce. Three overall levels of savings from ARTT are analyzed—5.45 percent, 17.47 percent, and 25.21 percent. Thus, 6 sets of alternative assumptions are considered.

Results of the Analysis

The costs of developing and implementing ARTT's capabilities are taken from 20-year budget estimates based on program planning data in Navy Program Objective

[2] SEA06L, "Model-Based Product Support (MBPS) Overview," PowerPoint Presentation Brief to NSPRP, July 18, 2019.

Memorandum (POM) 22.[3] Our analysis assumes that ARTT's benefits are phased in over a 20-year period, with 5 percent more of curriculum development being affected every year.

The following table summarizes the results of our cost-benefit analysis for the 6 alternative cases. The evaluation is performed using net-present-value analysis as directed by OMB Circular A-94.[4]

Discounted Benefits and Costs of ARTT for 20-Year Period
FY 2022 through FY 2041

Content Hours	Percent Savings	Discounted Benefits ($Millions)	Discounted Costs ($Millions)	Discounted Benefits Minus Discounted Costs ($Millions)	Ratio of Discounted Benefits to Discounted Costs	Break-even Year
16,000	5.45%	86.4	83.9	2.4	1.03	20
16,000	17.47%	276.8	83.9	192.9	3.30	7
16,000	25.21%	399.6	83.9	315.6	4.76	5
30,000	5.45%	161.9	83.9	78.0	1.93	11
30,000	17.47%	519.1	83.9	435.2	6.19	4
30,000	25.21%	749.1	83.9	665.1	8.93	2

As the table shows, ARTT is cost-effective for all cases. The discounted benefits minus the discounted costs are positive. The break-even years, in which cumulative benefits exceed cumulative costs, occur quite early for the two higher estimates of proportional savings.

While our analysis was being finalized, the ARTT Project Manager estimated that one-third of the costs attributed to the ARTT project will transfer to MBPS in the engineering and configuration specialty areas. This implies that ARTT would be even more cost-effective than the table indicates.

Effect of ARTT on Training Delay

Our analysis also covers an additional area of interest, which is the impact of ARTT on training delay, also known as latency—the time between when a system and its supporting technical data is deployed to the fleet and the first notification to training that a

3 "PPBE Process/Program Objective Memorandum (POM)," AcqNotes. A POM is a recommendation from the Services and Defense Agencies to the Office of the Secretary of Defense (OSD) concerning how they plan to allocate funding. Accessed May 3, 2020, http://acqnotes.com/acqnote/acquisitions/program-objective-memorandum-pom.

4 "Circular No. A-94 Revised," Transmittal Memo No.64, Office of Management and Budget, October 29, 1992.

review of associated courses must be made. The analysis includes an investigation using a Navy end-to-end model with effectiveness estimates from SMEs. Our analysis finds the reductions in time to design and develop courses is similar to the cost reductions reported in the above table. That is, latency is reduced by roughly 6 to 36 percent in the cases examined. If all system data stakeholders are on the same workflow for change review notification, and if all ARTT and MBPS business processes are followed, latency will be reduced significantly. This result is important because delivering relevant training to the fleet on time is likely to result in improved operations and maintenance and, thus, improved fleet readiness.

Contents

1. Introduction

A. Background

1. Innovation in Navy Acquisition Product Lifecycle Management

Naval platforms and weapon systems are costly to maintain, and the cost to deliver them and sustain fleet readiness is increasing. This trend is due in part to a lack of an integrated and comprehensive decision-making environment that allows product data, requirements, forecasts, costs, performance, and constraints to inform one another mutually across the product lifecycle and aspects of product support elements. The Navy's Model-Based Product Support (MBPS) project is designed to improve this situation.[1]

The key enabler of MBPS is detailed digital configuration information provided by system manufacturers that conforms to consistent industry standards. This information is derived from manufacturers' computer-aided design (CAD) processes. The resulting item-unique "digital threads" simplify the development of efficient logistics support. These digital threads should also simplify decisions pertaining to policies that determine the appropriate levels of repair and parts stockage.

Aligned with MBPS development is the Acquisition Requirements for Training Transformation (ARTT) project. Just as MBPS is being implemented to improve the lifecycle management of Navy systems, the ARTT project is being implemented to apply the digital information developed for MBPS to training development for new and modified weapon systems. ARTT focuses on maintenance, and troubleshooting to support engineered systems deployed to the fleet. These technical curricula are within the Navy's C school where sailors learn specialized skills within the Navy Enlisted Classification (NEC) system.[2] C schools teach advanced subjects for particular NEC codes. For example, NEC code EN-4313 represents an Outboard Engine Mechanic, 0304 represents a Radar Operator/Navigator, and V22A-AN/SPS-48E is a Search Radar Technician. These technicians specialize in a wide array of computer, communication, navigation, and radar equipment. They perform tasks such as maintain surface, air, weather, and tactical air

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[1] NAVSEA 06L Navy Model-Based Product Support Project (MBPS) Technical Supplement, December 2018.

[2] Navy Enlisted Classification (NEC) is an advanced specialty within a job. NECs identify non-rating wide skill, knowledge, aptitude, or qualifications to identify people and jobs. Manual of Navy Enlisted Manpower and Personnel Classifications and Occupational Standards. Volume II, Navy Enlisted Classifications, NAVPERS 18068F, January 2020, 1.

navigation equipment; analyze equipment operation; and align, troubleshoot, and repair equipment to the lowest replaceable unit. To apply the digital information from MBPS, ARTT will leverage the primary capabilities of three existing Navy models that currently support MBPS: the Navy Performance Ability Model, Navy Technical Instruction Model (NTIM), and Navy Learning Analytics Model (NLAM).

2. Implications of MBPS for Training Development

MBPS was initiated to improve the lifecycle management of Navy systems; similarly, the ARTT project is designed to apply the digital information developed for MBPS to training development for new and modified systems. For ARTT to manage technical data and support the product life cycle, baseline configurations of Navy systems must be aligned with standard industry formats that support the MBPS. Therefore, ARTT relies on the success of the Navy's MBPS project.

ARTT is an initiative that improves the requirements, design, development, lifecycle management, and accuracy of Navy technical curricula that support engineered systems deployed to the fleet. ARTT currently focuses on the maintenance and troubleshooting of these training curricula, which are in the C school domain. Operations training material will be covered in the next phase. Navy C school provides advanced training for specialized skills within a specialty job field or rating. For example, an Aviation Electronics Technician (AT) repairs and maintains navigation, infrared detection, radar, and other complex electronics systems.[3] ARTT integrates technical training data with related system product data, including engineering drawings, maintenance plans, and technical manuals in commercial systems that manage product life cycles. Integration is achieved through the standardized use of industry data specifications for all product data, also called the "digital data thread."

ARTT is a coordinated effort across U.S. Navy Manpower, Personnel, Training and Education (MPT&E) to establish acquisition data requirements and is funded through Ready Relevant Learning. These requirements are intended to transform how the Navy procures, creates, manages, and delivers technical training objectives and curricula. At its highest level, ARTT is meant to close the Navy's data gaps between system engineering configuration data and the development and management of technical training curriculum. Combined with a success in MBPS, ARTT will have the essential baseline technical information to succeed as well.

[3] "Navy Careers: What You Need to Know About Navy Enlisted Ratings," The Balance Careers, accessed May 3, 2020, https://www.thebalancecareers.com/navy-enlisted-rating-job-descriptions-3345844.

3. ARTT and the Training Development Process

When the Navy introduces new equipment into the fleet or modifies existing equipment, training material must be developed or updated to reflect the characteristics of the new system. Details about equipment configuration must be passed to the training development community, and decisions must be made about specific training revisions. The current environment and processes for accomplishing these changes are cumbersome. To significantly improve this situation, ARTT was initiated.

The disconnected flow of data between product development/revision and corresponding training development/revision increases training costs and reduces workforce readiness. This disconnect occurs because of an increase in curriculum latency (the time delay between equipment modification and the introduction of appropriate training) and skill decline. ARTT is designed to smooth the critical data interfaces between equipment configuration control documentation and training curricula development. A cost-benefit analysis is required to determine the return on investment before significantly changing Product Lifecycle Management (PLM) strategies. The Chief of the Acquisition, Manpower, & Training Branch of the Total Force Manpower, Training, and Education Requirements Division in the Office of the Chief of Naval Operations asked the Institute for Defense Analyses (IDA) to perform such an analysis for ARTT.

In 2010, IDA performed a cost-benefit analysis of an earlier initiative that was very similar to ARTT. This initiative, known as the Bridge project (see Appendix A), involved integrating, or "bridging," the development of technical information with the production of Navy technical manuals and training courses.[4] As with ARTT, integration was meant to lower the cost of producing manuals and courses and to increase shipboard readiness by having the appropriate training on hand when new systems and equipment were upgraded and deployed to the field. The Bridge project was meant to integrate product development and curriculum development by designing new software and proposing new technical and business procedures for managing the technical information.

Using the AN/AQS-20A mine-hunting sonar for the Littoral Combat Ship as an example, IDA's analysis focused on how much the Bridge would save in producing future technical manuals and training courses. Extrapolating these results to a larger set of systems (and incorporating an estimate of up-front costs), the study estimated savings of $76 million to $86 million over 10 years.

[4] Daniel B. Levine, "Cost-Benefit Analysis of a Bridge to Integrate the Management of Technical Information for Producing Technical Manuals and Training Courses," IDA Document D-4208 (Alexandria, VA: Institute for Defense Analyses, November 2010).

B. Objective

The objective of this cost-benefit analysis is to estimate the savings achieved with the initiatives associated with ARTT and compare those savings with associated costs. In particular, IDA will:

- Document the PLM processes used by the Systems Commands.
- Summarize the elements of the ARTT initiative.
- Identify the PLM processes that ARTT will affect.
- Outline the analytical approach to estimating the costs and benefits of modifying the processes as envisioned by ARTT.
- To the degree possible, estimate the costs and benefits using the analytical approach. Empirical quantification depends on the extent to which the sponsor can facilitate access to critical data.
- Document the results of the analysis.

C. Scope

This paper is organized as follows:

- Chapter 2 presents an overview of the ARTT project.
- Chapter 3 describes the end-to-end process for curriculum development: the planning and analysis phases, design and development phases, and implementation and maintenance phases.
- Chapter 4 applies an end-to-end model developed by the Center for Naval Aviation Technical Training (CNATT) and documented in Appendix B to estimate the cost of curriculum development without ARTT.
- Chapter 5 describes the potential impact of ARTT on the cost of curriculum development.
- Chapter 6 applies the end-to-end model introduced in Chapter 4 to estimate the cost of curriculum development with ARTT, using efficiency parameters supplied by subject matter experts (SMEs).
- Chapter 7 addresses the potential impact of ARTT on training latency using an end-to-end model developed by the Naval Systems Warfare Center (NSWC) and documented in Appendix C, together with efficiency parameters supplied by the SMEs.
- Chapter 8 applies a cost-benefit model developed by IDA to estimate discounted costs and savings from ARTT for a range of assumptions on curriculum development requirements and ARTT costs and effectiveness.

The paper contains the following appendixes:

- Appendix A. IDA Bridge Study, a 2010 cost-benefit analysis for a project to improve the Navy's Integrated Logistics Support.
- Appendix B. CNATT–Interactive Multimedia Instruction (IMI) Model, a CNATT Interactive Multi Media – Informational costing model guide used by content developers of curricula for interactive multimedia instruction.
- Appendix C. NSWC–End-to-End Model Including Latency, an end-to-end model for developing training materials, including the treatment of latency.
- Appendix D. Sample Data Collection E2E/IMI Model Templates, for collecting field data on man-hour requirements for training development.

2. Foundation of ARTT

Sixty-six percent of Navy training is technical and involves developing curricula from technical data that sailors will use to operate, maintain, and troubleshoot engineering systems and equipment.[5] The purpose of ARTT is to integrate data standardization in PLM into technical training. ARTT is anticipated to leverage existing applications and commercial and open-source software, and integrate them into a Product Lifecycle Management System (PLMS). The PLMS is used to develop, maintain, and deliver more accurate training curricula.

A. Data Types

By implementing selected industry data standards and managing technical data, ARTT will link data by establishing relationships between the following data sources:

- Data models and system data such as 3D Computer-Aided Design (CAD) engineering drawings—consist of system definition information and attributes that fully describe the system and its performance characteristics.
- Maintenance Task Analysis (MTA) data—identifies the maintenance and repair steps, materials, tools, and skill levels needed for maintenance and repairs.[6]
- Technical manuals—link system data such as 3D CAD models and MTA with training data such as objectives, course outlines, and content.

To manage product data and manage and support the product life cycle, baseline configurations of representative Navy systems must be aligned with standard industry formats that support the MBPS project.

The Navy's vision for MBPS is to provide a digital twin of the actual physical system under development. The digital representation includes the shape and dynamics of how the system operates throughout its life cycle[7] and includes the Navy's technical data such as 3D CAD models. The system operators and maintainers can access a digital representation

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5 Wayne Gafford, NSWC/OPNAVN12, "Acquisition Requirements for Training Transformation (The ARTT Project)," April 25, 2018, [PowerPoint slides], slide 4.

6 "Production, Quality & Manufacturing, Maintenance Task Analysis," AcqNotes, accessed April 22, 2020. http://acqnotes.com/acqnote/careerfields/maintenance-task-analysis.

7 SEA06L, NAVSEA, "Model-Based Product Support (MBPS) Overview," July 18, 2019, PowerPoint slides, slide 18.

of the system's product data and everything linked to it. Therefore, the system's product data links become the digital thread through the PLM system. Industry-standard system product data is identified and interconnected for all corresponding systems by parts, assemblies, and tasks; this is the "digital data thread."[8] The connected system product data is designed to maintain data integrity and prevent training content from being lost by being disconnected, delayed, or outdated. This approach should allow training to be developed that lets the sailor more easily review realistic 3D digital content before receiving current maintenance data or performing any system maintenance. Providing accurate, timely data to the sailor is the anticipated outcome of ARTT and fits into the Navy's vision to help accomplish Ready Relevant Learning (RRL)—the ability to deliver relevant, accessible training more quickly to the fleet where and when it is needed. The combination of ARTT and RRL contributes to the Navy's goal of decreasing training latency and improving sailor preparedness. Better prepared sailors who have access to up-to-date digital training content data from anywhere, anytime leads to better sailor performance and overall fleet readiness. To accomplish the digital thread of linking technical data, ARTT incorporates industry data standards as described in the following sections.

To manage and support product data, representative baseline configurations of Navy systems must be mapped into proper Technical Data Packages (TDPs). These packages support product models and follow DoD standard practices in MIL-STD-31000.[9] ARTT will use TDPs as data sources in conjunction with the Navy Product Data Management Model (NPDM). Together, these data sources provide ARTT with an authoritative system baseline management service. In addition, the engineering Bill of Materials (eBOM) reflects the product as it is designed and consists of a product's parts, components, and assemblies. This product data is necessary input for the PLMS to be converted to the ISO 10303 standard. The eBOM also allows digital data to be easily exchanged with product manufacturing information to associate maintenance configuration and parts.

B. Data Standards

The S-Series data models (S3000L, S1000D, and S6000T) and the Government Electronics and Information Technology Association's (GEIA's) GEIA-STD-0007 provide the foundation of the data standards for linking a Navy system's technical data within the PLMS. These standards are defined as follows:

- S-Series S3000L—defines general requirements for Integrated Product Support (IPS), configuration management, analysis activities, and the data model for

[8] OPNAV N12, Total Force Manpower, Training, and Education Requirements, "Acquisition Requirements for Training Transformation (The ARTT Project)," August 13, 2019, 4.

[9] MIL-STD-31000, Department of Defense Standard Practice: Technical Data Packages, November 5, 2009.

information exchange governing the performance of Logistics Support Analysis (LSA) during the life cycle of any (complex) technical system.[10]

- S1000D—provides an XML specification for preparing, managing, and using equipment maintenance and operations information.[11] S1000D data formats are used to develop the course training modules that display and deliver the training content. S1000D-developed training modules consist of illustrated parts data, maintenance and operation, procedures, and troubleshooting.
- S6000T—provides a global specification for defining the process for performing training needs analysis, developing training requirements and learning objectives, and identifying training curricula.[12] S6000T standards support the interfaces for building training objectives. This standard is currently being drafted and is scheduled to be published in early 2020.
- GEIA-0007—provides a data transfer standard that implements logistics data and provides a comprehensive list of data elements generated as a result of the logistics supportability analysis.[13] The standards will be enforced in Navy contracts. The training needs analysis is generated using technical data from the Navy's NDART model. This is important for ARTT future capabilities to measure sailor performances for learning analytics. Activities and outputs associated with ARTT's industry standards are summarized in Table 1.

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[10] ASD/AIA S3000L International procedure specification for Logistic Support Analysis (LSA), accessed August 30, 2019, http://www.s3000l.org/.

[11] "S1000D," Wikipedia, accessed August 30, 2019, https://en.wikipedia.org/wiki/S1000D.

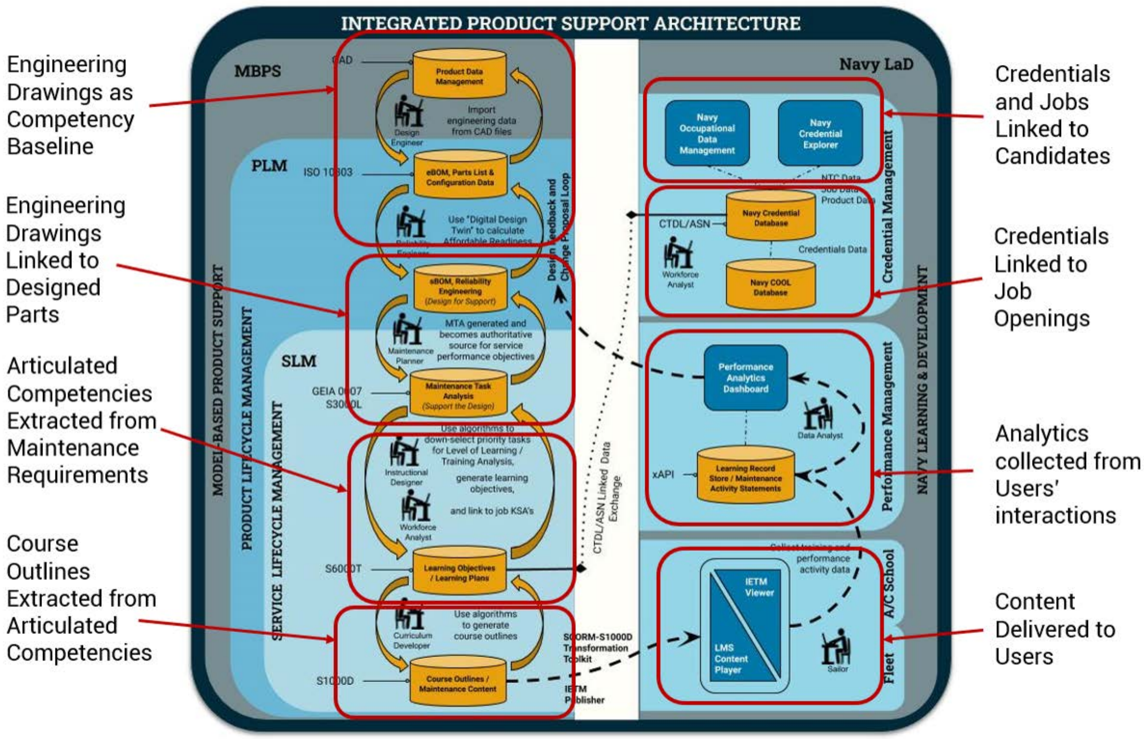
[12] ASD/AIA S6000T, International Specification for Training Information, accessed August 30, 2019 http://www.s6000t.org/.

[13] "Logistics Product Data Handbook GEIAHB0007," SAE International, accessed December 4, 2019, https://www.sae.org/standards/content/geiahb0007/.

Table 1. ARTT Data Model Standard Specifications (MBPS, PLM, SLM)

Technical Data/Activity	Standard	Output/Activity
Technical Data Package	MIL-STD-31000	Product Data Management
Engineering Product Data	ISO 10303	3D CAD, Engineering Drawings, engineering Bill of Materials (eBOM)
Maintenance Task Analysis (MTA)	GEIA-0007, S3000L, S6000T, CTDL/ASN	Logistics Product Data, Job Duty Task Analysis (JDTA), Credentials, Learning Objectives, Performance Objectives, Training Needs Analysis, Performance Tracking, Learning Analytics
Technical Content	S1000D	Training Content, Integrated Product Support (IPS), Interactive Electronic Training Manuals (IETMs)

These specifications are the basis for linking technical system data that may be modified throughout the life cycle to product engineering data. In addition, these specifications are used to derive training content and training curricula implemented with a PLMS. The capabilities of the MBPS provides enterprise product data and readiness analytic services and complies with the standards specified by the S-Series models that are the heart of ARTT (Figure 1).



Source: ARTT – Planning Project Report and Concept of Operations.

Figure 1. ARTT Integrated Product Support Architecture

System modifications can be identified more easily throughout the digital thread by linking technical data about the system. In terms of ARTT, the digital thread links and identifies every piece of data that needs to be reviewed because of a design change or a new system coming online. The digital thread also includes tracking that data directly to the courses and personnel needed to operate and maintain the system.[14] Modifications result from system revisions and require that an OEM or a Project Manager submit an Engineering Change Proposal (ECP). ARTT's ability to more quickly flag an ECP should provide faster awareness to the government Configuration Control Board (CCB), allowing for faster response to proceed for authorization, acceptance, and approval to proceed. The automated flagging of ECP notifications should lead to improved coordination among activities needed to update and quickly deliver training materials to the fleet (Figure 2).

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[14] Gafford, "Acquisition Requirements for Training Transformation," slide 6.

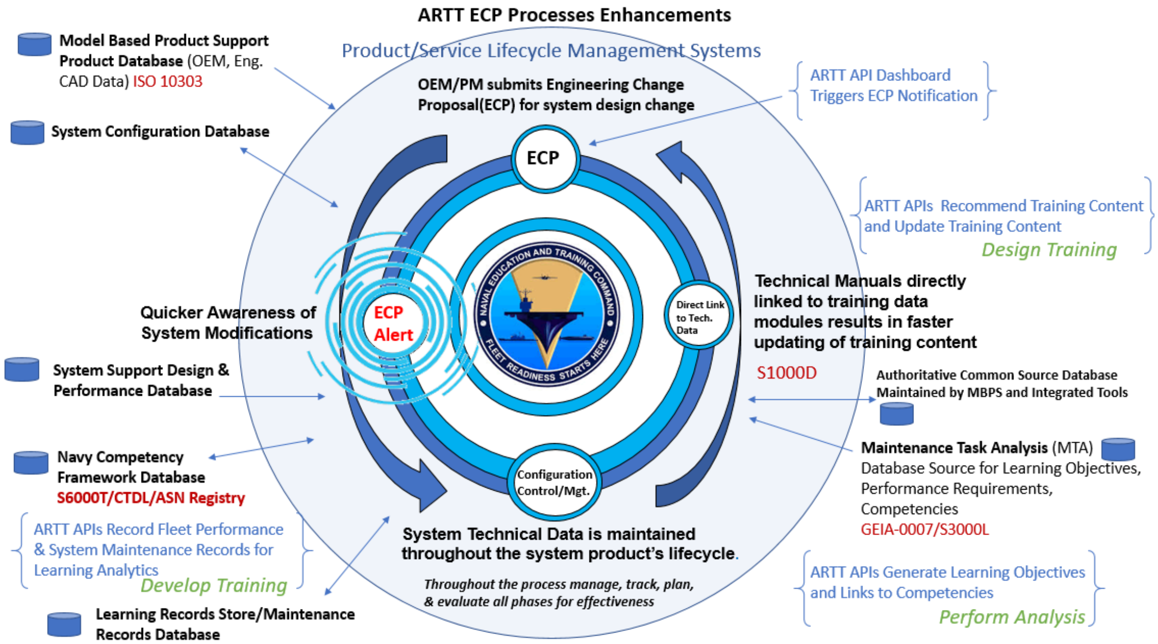

Figure 2. ARTT ECP Overview

C. Integrating Training Data with System Maintenance Data

An important component of ARTT is the integration of training data and system technical maintenance data into PLM and Service Lifecycle Management (SLM) systems through a common source database. This integration is aided by incorporating the industry data standards from ARTT maintenance task data with algorithms to extract competency requirements developed by Credential Engine, a non-profit organization dedicated to bringing transparency to the marketplace of job credentials. Credential Engine provides a web-based suite of services that hosts a centralized Credential Registry. The competency algorithms were developed through a Cooperative Research and Development Agreement (CRADA) that the Navy and Credential Engine signed in 2018 to incorporate sailor competency requirements.[15] These algorithms map competency requirements to performance and learning objectives pulled from maintenance task data. The Credential Engine's common description language supports customized applications to search, discover, and compare types and levels of credentials.

This component of ARTT requires developing algorithms to produce and link performance and learning objectives. This goal is accomplished through maintenance task analysis (MTA) data that are managed in the GEIA-0007 and S3000L industry standards. These standards, combined with ARTT's mapping of Navy Task Classifications taxonomy

[15] Carol Lawrence, "ARTT Aims to Transform Tech Curriculum and Training," PHD News, Naval Surface Warfare Center (NSWC), August 20, 2019, https://credentialengine.org/wp-content/uploads/2019/08/PHD-News-.-August-20-2019-Distro-D.pdf.

to the Department of Labor's Occupational Standards, provide common terminology to compare credentials within the Credential Registry and MTA. MTA identifies the steps, spares and materials, tools, personnel skill levels, and facilities for a repair task, along with the time to perform the maintenance task.[16] The algorithms are implemented to extract competency requirements that relate to Navy training performance and learning objectives. Additionally, these algorithms allow ARTT to automate the production of learning analytics data by linking learning performance data to maintenance task data and training data. Then, ARTT will use the learning analytics data to automatically evaluate and identify the impacts and efficiency of system training. This capability will give the Navy more efficient and effective ways to correct training deficiencies by identifying performance issues through the automated tracking of sailor performance. In addition, this capability should benefit the fleet by analyzing where training may need adjustments to improve and increase skills so sailors are more prepared, in turn improving fleet readiness.

ARTT's integration with PLM applications should improve product supportability, technical data quality, and the accuracy of technical manual publications, with curricula coming from a common source database. The implementation of ARTT should also help transform manual-labor-intensive analyses such as Task Analysis (TA), Training Systems Requirements Analysis (TSRA)/Training Needs Analysis, and Rating Domain Analysis (RDA). The RDA involves analyzing learning objectives in large courses and breaking down training content into smaller modules, which are more closely aligned with real-world work requirements that are derived from the System and Fleet Training and Effectiveness and Evaluation Planning (TEEP). The transformation from labor-intensive analyses should occur by using configuration data management, authoritative data, and common industry data standards maintained throughout the life cycle of the system to produce the relevant analytic products. These products provide standardized configuration data into the MBPS, helping to reduce the costs of their development. With ARTT, technical content data is more aligned with system product data and is easier to manage, integrate, access, and update. As a result, the implementation of ARTT should result in decreased man-hours to produce and update Navy products that support system planning and analysis.

[16] "Production, Quality & Manufacturing, Maintenance Task Analysis," AcqNotes.

3. The End-to-End Process for Curriculum Development

A. Overview

To ensure that training requirements of the fleet are fulfilled, the Navy uses an End-to-End (E2E) methodology for developing, modifying, and revising training. The E2E process draws on various documents and manuals as guidance for curriculum development, instruction delivery, and management and evaluation of training. These documents include:

- Navy Education Training (NAVEDTRA) 130 series of manuals—series of manuals that provides guidance within NETC for developing curricula, delivering instruction, and managing and evaluating training.[17]
- Naval Education and Training Command (NETC) Course Development, Revision, and Modification End-to-End (E2E) Process Standard Operating Procedure—training approach built from approved training requirements that implement realistic training situations, and develop learning objectives based on performance requirements.[18]
- Office of the Chief of Naval Operations (OPNAV) Instruction 1500.76C[19]—current instruction to help plan training to support new and updated systems for the Navy and Marine Corps.[20] The instruction promotes the use of Interactive Multimedia Instruction (IMI) training methods.
- Interactive Multimedia Instruction (IMI) Costing Models—include Interactive Courseware (ICW), simulators, video conferencing, and electronic publications known as Interactive Electronic Technical Manuals (IETMs).

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17 NAVEDTRA 130B, *Task Based Curriculum Development Manual Volume I Developers Guide* (Pensacola, FL: NETC, August 2009), https://www.public.navy.mil/netc/ile/documents/NAVEDTRA130B/NAVEDTRA_130B_(Vol_I).pdf.

18 *Naval Education and Training Command (NETC) Course Development, Revision, and Modification End-to-End (E2E) Process Standard Operating Procedures (SOP)* (Norfolk, VA: Learning and Development Division (N7), NETC, July 2014. https://www.public.navy.mil/netc/ntt/pdfs/End_to_End_Process_SOP_(7-11-14)_Final.pdf.

19 Office of the Chief of Naval Operations (OPNAV) Instruction 1500.76C, Naval Training Systems Requirements, Acquisition, and Management, August 14, 2013, https://www.secnav.navy.mil/doni/Directives/01000%20Military%20Personnel%20Support/01-500%20Military%20Training%20and%20Education%20Services/1500.76C.pdf. Instruction 1500.76C is currently under revision and is expected to be replaced with OPNAVINST 1500.76D.

20 OPNAVINST 1500.76C.

According to Navy training developer SMEs, Navy training curricula increasingly consist of a blend of IMI and Instructor Led Training (ILT). Not all steps or processes within the E2E methodology for any training course development will be affected by ARTT. The purpose of ARTT, by design, supports curricula for the maintenance of technical systems.

Figure 3 displays the six phases of the E2E Process: Planning, Analysis, Design, Development, Implementation, and Maintenance & Surveillance.

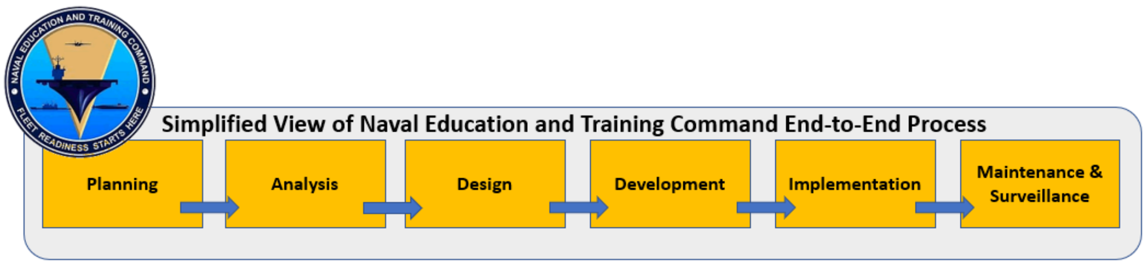


Figure 3. E2E Process of the Naval Education and Training Command

All phases are important for delivering training curricula. The following sections in this chapter describe the E2E phases for developing training materials following the task-based curriculum development methods described in the guidance documents previously identified.

B. Planning and Analysis Phases

The planning phase for a new or modified system involves developing a Training Project Plan (TPP), which addresses the scope, cost, quality, project team, project communications, risk management, and procurement of new training. An approved TPP becomes the authorization for course development.

The purpose of the analysis phase is to determine the content of the curriculum being developed for the new or modified system. This phase includes several subphases and numerous specific elements.

The principal activity that occurs during the planning and analysis phases of the E2E process is the Front-End Analysis (FEA). ARTT capabilities are expected to result in savings on the following products that are produced from the FEA:

- Job Duty Task Analysis (JDTA)/Job Task Analysis (JTA)/Task Analysis (TA),
- Training Situation Document (TSD),
- Training Systems Requirements Analysis (TSRA)/Training Needs Analysis,
- Instructional Performance Requirements Document (IPRD),

- Instructional Media Requirements Document (IMRD),
- Training Decision Coordinating Paper (TDCP),
- Training Effectiveness Evaluation Plan (TEEP),
- Military Characteristics Document (MCD),
- Course Training Task List (CTTL), and
- Rating Domain Analysis (RDA).

The FEA consists of an approved JDTA and the results of other documents such as the TSD, IPRD, and IMRD. The TEEP and CTTL are outputs of the FEA. The FEA must be completed by the Program Manager before any new system or modernized system training curriculum is developed. Training requirements are identified from the JTA or the JDTA. The JDTA is one of the biggest areas in which ARTT can potentially provide savings in the analysis phase.

Identifying the tasks that must be trained is fundamental to developing curricula. A complex system will have 1,000 or more tasks associated with it, but not all of those tasks need to be trained (or can be trained in the time available for training). Identifying the appropriate tasks and prioritizing the tasks to be trained is key to developing an effective training curriculum. The JDTA is also used to perform the JTA to place tasks in context and understand performance requirements, key performance indicators, and levels of proficiency so learning objectives can be determined. One anticipated, primary capability of ARTT is to use the digital thread maintained with the PLMS to capture attributes associated with the identified tasks and link curricula data elements to tasks. Program Managers also complete a TA to document the tasks and subtasks required to operate and maintain systems. The outputs of the TA provide input to the development of the TSRA, TDCP, and MCD. The TA is then submitted to OPNAV N12 and United States Fleet Forces (USFF) command for evaluation on applicable ratings, OCCSTDs, NECs, credentialing, development costs, and analytics for the submission of future Program Objective Memorandum (POM). The TSRA identifies training requirements and recommends appropriate training strategies for new and modified training requirements. The RDA is produced from the TSRA to determine when and where new or revised training is integrated into rating continuums. The TDCP maps the learning objectives and instructional methods identified in the TSRA to instructional media alternatives. The alternatives are justified by risk, cost, and effectiveness through the TEEP. The TSD is used to verify the efficiency of training systems to meet training requirements and to assess the need for new training development. The tasks and skills determined for training are organized into the CTTL. The CTTL is a product of the analysis phase and is used as the foundation for developing the curriculum for the new or modified system training course.

ARTT's usefulness in the planning and analysis phases was demonstrated in the ongoing ARTT pilot project. The goal of the project was to extract technical learning objectives from the maintenance task analyses structured in the GEIA 0007 and S3000L standards.[21] ARTT used the Systematic Curriculum Instructional Design (SCID) model, developed by Ohio State University, to prioritize tasks for training based on data from maintenance task analysis and was demonstrated with an ARTT prototype and an existing Navy system. The Navy teamed with Credential Engine, a nonprofit organization in Washington, D.C., and Eduworks in Portland, Oregon, to develop natural language processing (NLP), which is a form of artificial intelligence. The NLP software was used to construct the learning objectives for the system, while the Eduworks modules determined tasks for training. This software was demonstrated in an ARTT Phase 3 In-Process Review and Demonstration in December 2019.[22] The demonstration used the example of an Integrated Low Pressure Electrolyzer (ILPE), whose design had been changed by replacing the standard self-locking nut. This change resulted in an update to training to address the special technique to properly seat and tighten the nut. With ARTT, the identification of tasks to be trained was simplified substantially: what would have taken an average of 8 hours per task was reduced to 5 minutes per task.

A primary source of system support material is the interactive electronic technical manual (IETM), which is in part a result of the efforts in the planning and analysis phases. The IETM, which is delivered during the implementation phase, is specifically formatted for electronic display. Users can interact with it, and it can guide sailors through operations and maintenance procedures in ways that a paper manual cannot.

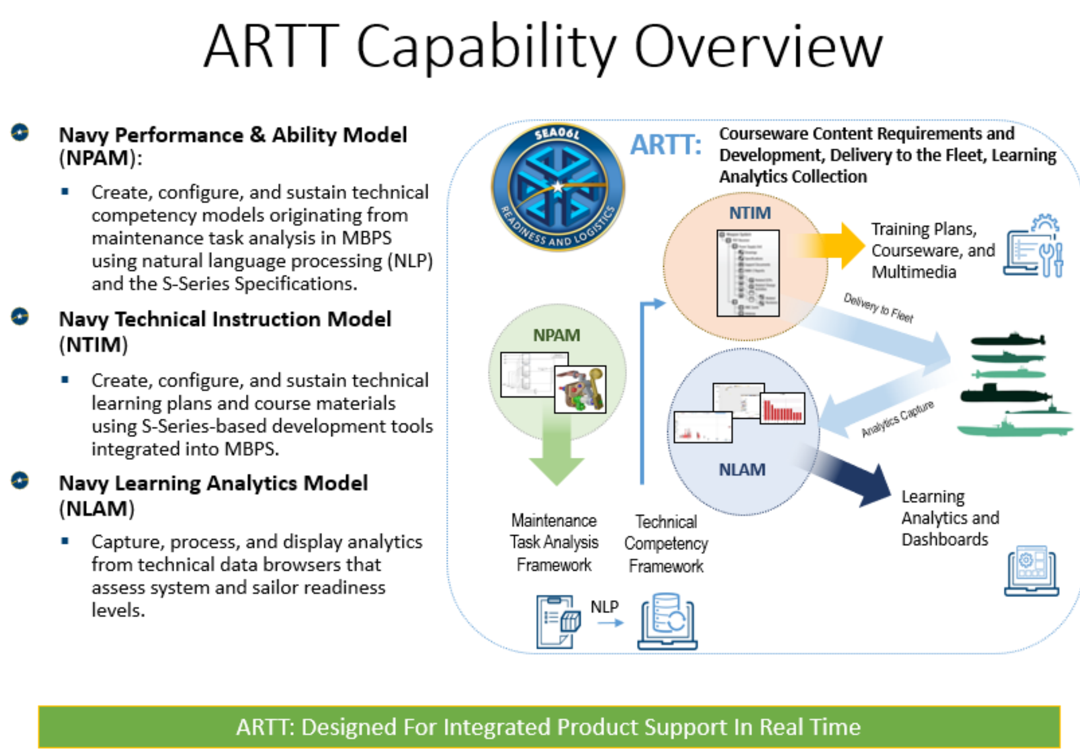
As IETM authors use development tools in a configured common source database, ARTT will depend on curriculum developers to work in the same data environment. Learning content development tools will be integrated Windchill Product Lifecycle Management software at the heart of MBPS for access to authoritative data sources. ARTT's content developers have access to this product data, which technical data developers use to produce content and graphics that improve the accuracy of system content and the delivery time of IETMs. The Windchill software is designed to help minimize inaccurate information in technical manuals using configuration distribution management. A large portion of the IETM may potentially be authored using the MTA, which should improve the maintenance and accuracy of the IETM.

[21] Lawrence, "ARTT Aims to Transform Tech Curriculum and Training."

[22] Wayne Gafford, "ARTT Phase 3 Demonstration, with Training Systems Requirements (Needs) Analysis Integrated with Product Support Analysis," Acquisition Requirements for Training Transformation In-Process Review and Demonstration, McLean, VA, December 17, 2019.

C. Design and Development Phases

The design phase produces the course learning objectives and determines the proper instructional sequence to address those learning objectives. According to SMEs, generating the curriculum outline of instruction (COI) is currently very labor-intensive. It includes setting up the course hierarchy structure that includes course modules, lessons, and sections. Learning objectives (LOs) and their element types (fact, concept, procedure, process, and principle) are determined during the design phase. ARTT is implementing natural language processes through code that generates learning objectives from the essential authoritative database. This capability is expected to significantly reduce the man-hours currently required to produce learning objectives. ARTT accomplishes this by leveraging the Navy Performance and Ability Model (NPAM), which derives technical knowledge, skills, and abilities for deployed systems. ARTT also captures learning requirements that are translated by the Navy Learning Analytics Model (NLAM). ARTT uses this data to create, configure, and sustain competency models using the maintenance task analysis in MBPS. These Navy models and data standards that are part of ARTT's implementation are displayed in Figure 4.



Source: OPNAV N12 – Total Force Manpower, Training, & Education Requirements Division, ARTT Project Information.

Figure 4. Navy Models Supporting ARTT Capabilities

The course delivery methods—such as ILT, IMI, or a blend of ILT and IMI—are designed and developed, and the length of time to teach courses is determined.

The development phase consists of the creation of storyboards and courseware, including presentations and video and audio production. ARTT's access to authoritative data sources of Navy system technical data within the PLMS should provide enhanced technical data for content development. Access to technical data such as 3D models and engineering drawings should decrease the time to develop graphics for training content. ARTT's capability to manage data configuration and data linkages of common system data should lead to less duplication of development effort and increased reuse of training content.

Revisions to training content can be due to an upgraded system or part. The impact of the revision is driven by new materials and how much new content is needed. Based on different SME inputs, it takes 6.5 to 12 hours of development time for every 1 hour of ILT. Since the phases and processes are interrelated, updates and revisions of existing content fall within the other phases as requirements dictate. With ARTT, these times should decrease and reduce the cost of curriculum development.

D. Implementation Phase

The implementation phase begins when the Curriculum Control Authority (CCA) approves the course and the Learning Center authorizes the course to be taught.[23] Since the implementation phase involves the actual piloting of the course and its final approval, there are no expected changes in the implementation phase with ARTT.

E. Maintenance and Surveillance Phases

The purpose of these phases is to monitor, identify, add, delete, and track changes to existing training content. Much of this content exists within the IETMs which, as previously stated, are important sources of technical information for sailors and therefore must be accurate. ARTT shifts the primary technical training requirements analysis away from the IETM and redirects the process upstream to a higher-value product: the maintenance task analysis. As technical product data changes through modifications during the system's life cycle, accurate technical manuals are delivered on time. Updating a system product or modernizing a system is viewed as a new action, similar to a new system being introduced. A significant amount of savings will occur because project managers are notified immediately about these changes through the ECP on MBPS workflow. This approach allows stakeholders to review the changes in real-time, thus reducing the time it

[23] NAVEDTRA 130B, *Task Based Curriculum Development Manual Volume III Manager's Guide* (Pensacola, FL: NETC, September 2009), 10.

takes to update a system's data. By delivering accurate and timely data to the fleet, this approach also decreases latency.

4. The Cost of Curriculum Development without ARTT

A. IMI Cost Model Baseline Template

The IMI Cost Model presented in Appendix B was used to establish a baseline for this analysis. This cost model was developed by the Center for Naval Aviation Technical Training as a guide to support estimating training costs within four levels of interactivity. The levels correspond to how training is presented, from instructor-led to allowing more control to the learner by varying the complexity of how information is presented. The four training levels are:

- Level I—consists of mostly instructor-led training with a potential mix of PowerPoint and video.
- Level II—involves more recall of information through simple simulations in interactive software.
- Level III—allows the learner to access complex information and decision points to solve problems with less prompting through interactive or simulation software.
- Level IV—involves in-depth recall with no training prompts and possibly virtual reality.

We mapped the E2E curriculum development phases into the IMI Cost Model to better characterize tasks within the IMI Model. Aligning the tasks within the phases helps to understand which phases have the potential for the most savings with the implementation of ARTT. This mapping is reflected in Table 2 through Table 4. The planning phase consists of identifying and gathering resource requirements for the training development process. Fewer savings should occur in this phase for new equipment. However, for upgraded equipment, ARTT potentially provides savings from existing resource requirements. We assigned the FEA task to the analysis phase because that is when the FEA is developed and refined. We included the IMI Instructional Design and Storyboarding tasks as part of the design phase. The development phase captures the IMI Graphic Production, Video Production, Audio Production, and Authoring/Programming tasks. The implementation phase includes QA Testing, Project Management, SME/Stakeholder Reviews, Pilot Test, and other tasks. The maintenance and surveillance phase is not included in the IMI model. However, if ARTT ultimately improves feedback on training effectiveness—given that it uses established maintenance requirements to generate learning objectives and collect maintainer activity streams in browsers—it will impact maintenance and surveillance significantly.

B. Costing Models

The IMI Levels and Costing Models tables (Table 2 through Table 6) use the guidance for developing IMI products for delivery of instruction or supporting the delivery of instruction. This section develops an estimate of the man-hour requirements for developing a 200-hour course for a hypothetical new system. Since most courses consist of a blend of ILT and Computer-Based Training (CBT), this example includes three levels of instructional delivery. The assumptions are 60 percent Level I, which is ILT; 30 percent Level II, with student control over lesson scenarios with computer-based simulation training; and 10 percent Level III, which contains more complexity and involves more application to problem solving and applying knowledge at varying decision points.

Table 2, Table 3, and Table 4 show task-level estimates of man-hours required for each instruction level category. These numbers assume complete development for a new course where nothing previously exists. When curriculum content already exists, the numbers are lower. The analysis shows the breakdown of the curriculum, and total man-hours are given at the end.

The process starts with an estimate of the distribution of training materials across the three levels, shown in Table 2.

Table 2. IMI Curriculum Level Breakout

Level	Percentage	Hours
Level I instructor-led presentations with some variety of media (stills, 2D animations, possible video clips)	60%	200 x .60 = 120 hours
Level II (can be instructor-led or self-paced, knowledge-based interactive Courseware (ICW), or a low-fidelity PC Simulation)	30%	200 x .30 = 60 hours
Level III (branching ICW or PC simulation)	10%	200 x .10 = 20 hour

Table 3 shows the Navy's estimate of how many man-hours are expected to be spent per hour of finished courseware on each task for ILT (Level I training).

Table 3. Level I Course Preparation Hours

Phases/Tasks	As-Is Time Spent on Each Task (per instructional hour)	Level 1 Estimation of 60% of Total Curriculum	As-Is Total Man-Hours (for a 200-hour course)
Planning/Analysis Phases			
Front-End Analysis	7.9	120	944
Design Phase			
Instructional Design	10.7	120	1,279
Storyboarding	9.0	120	1,084
Development Phase			
Graphic Production	8.7	120	1,039
Video Production	3.5	120	419
Audio Production	5.5	120	656
Authoring/Programming	13.4	120	1,610
Implementation Phase			
QA Testing	5.1	120	614
Product Management	5.1	120	610
SME/Stakeholder	5.6	120	671
Pilot Test	3.4	120	412
Other	1.0	120	115
Total			**9,453**

Table 4 shows the Navy's estimate of how many man-hours are expected to be spent per hour of finished courseware on each task for Level II training.

Table 4. Level II Course Preparation Hours

Phases/Tasks	As-Is Time Spent on Each Task (per instructional hour)	Level II Estimation of 30% of Total Curriculum	As-Is Total Man-Hours (for a 200-hour course)
Planning/Analysis Phases			
Front-End Analysis	17.4	60	1,042
Design Phase			
Instructional Design	24.7	60	1,481
Storyboarding	20.9	60	1,253
Development Phase			
Graphic Production	22.4	60	1,343
Video Production	11.3	60	677
Audio Production	11.6	60	695
Authoring/Programming	32.2	60	1,932
Implementation Phase			
QA Testing	11.9	60	713
Product Management	11.7	60	704
SME/Stakeholder	11.0	60	658
Pilot Test	7.4	60	445
Other	1.6	60	98
Total			**11,041**

Table 5 shows the Navy's estimate of how many man-hours are expected to be spent per hour of finished courseware on each task for Level III training.

Table 5. Level III Course Preparation Hours

Phases/Tasks	As-Is Time Spent on Each Task (per instructional hour)	Level III Estimation of 20% of Total Curriculum	As-Is Total Man-Hours (for a 200-hour course)
Planning/Analysis Phases			
Front-End Analysis	43.0	20	859
Design Phase			
Instructional Design	62.0	20	1,239
Storyboarding	53.2	20	1,064
Development Phase			
Graphic Production	64.5	20	1,291
Video Production	30.5	20	609
Audio Production	26.6	20	532
Authoring/Programming	86.4	20	1,728
Implementation Phase			
QA Testing	31.5	20	630
Product Management	32.2	20	644
SME/Stakeholder	30.6	20	612
Pilot Test	21.0	20	419
Other	8.6	20	172
Total			**9,799**

The IMI model estimates that for the notional 200-hour course, 79 hours of labor are required for each hour of courseware development at Level I. Each hour of Level II course development requires 184 hours of labor, and each hour of Level III course development requires 490 hours. These totals include all phases, not just the development phase. As Table 6 shows, the total labor requirement for this course is estimated to be 30,293 hours.

Table 6. As-Is Summary of Course Preparation Hours by Phase

Phase	Total As-Is Man-Hours (for a 200-hour course)
Planning/Analysis	2,845
Design	7,400
Development	12,531
Implementation	7,517
Total Hours	**30,293**

5. The Potential Impact of ARTT on the Cost of Curriculum Development

This chapter focuses on identifying tasks and products within the E2E process phases that are likely to be affected by ARTT. We developed various versions of elaborations (see Appendix D) of the E2E model to collect data reflecting the extent to which specific processes within the model are anticipated to realize savings with ARTT. Our depiction of the more detailed process was based on discussions and input from SMEs on how they currently develop training curricula using the E2E methodology and where they anticipate ARTT will provide savings.

A. Linked Data and Data Standards

An essential component of ARTT is the ability to directly link and integrate Navy engineering and configuration management technical data into training data modules. This effort involves product data management and support, which requires the mapping of baseline configurations of representative Navy systems into proper Technical Data Packages (TDP). This mapping must follow DoD standard practices in MIL-STD-31000. Additionally, configuration management plans need to be established for technical design data, 3D CAD drawings, and other OEM data. Legacy and new system technical data must also be standardized and exist in the S-Series data models (S3000L, S1000D, and S6000T). In addition, training content and technical publications may be developed from S1000D standardized data. Also, the GEIA-STD-0007 data models that do not exist will need to be generated for Integrated Product Support (IPS). The S3000L and GEIA-STD-0007 data models generate Logistics Product Data (LPD) to analyze IPS, IETMs, and maintenance task analysis. The JDTA, which drives training tasks for curriculum development, may be derived from the maintenance tasks analysis. Figure 5 shows the data standards that are used to implement ARTT.

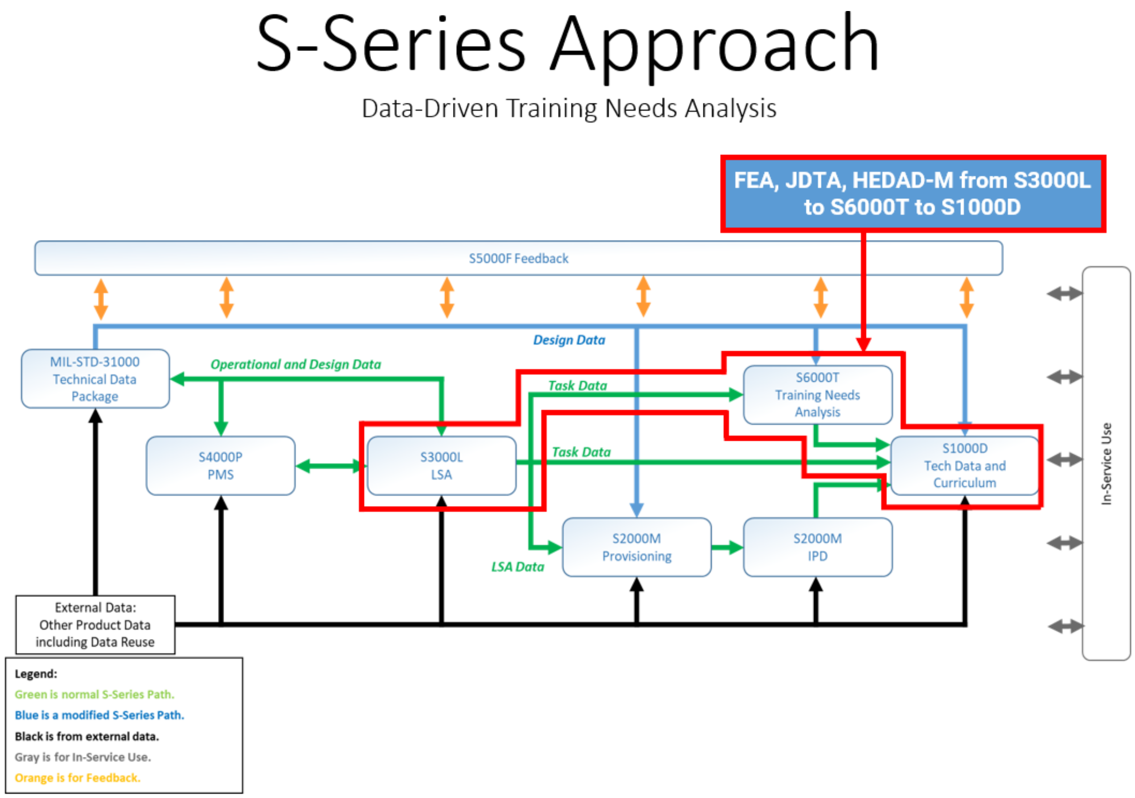


Figure 5. ARTT Data Standard Enablers

With standardized data and appropriate configuration management, the support to sustain systems are available through linked data connections. The CAD drawings and standardized product data model elements will provide mechanisms for better process integration because of clearer, standardized information on parts and design. In addition, configuration management of the technical data will simplify development of engineering bills of materials (eBOMs) and allow for better product management. Efficient use of the data requires PLMS to integrate processes and data standards to support better system PLM. This is the vision MBPS is being built to realize, and ARTT is designed to capitalize on the newly integrated processes and data.

B. Curriculum Outline of Instruction

One important source of anticipated savings is the ability of MBPS to locate and/or update training data curriculum by ARTT triggered updated and associated product data linkages. For a new system, linked data from other systems with similar or the same components are able to be retrieved and used to inform the appropriate phases of the E2E process. This approach is expected to provide significant man-hour savings, especially for complex systems. Within the E2E design phase, the Curriculum Outline of Instruction

(COI) has the most potential to provide savings through ARTT: With ARTT's capability to generate a COI, the Navy will save many man-hours.

By using MTA data structured to industry standards (GEIA 0007 and S300L), ARTT prototyping software has demonstrated the capability to extract Learning Objectives (LOs) from the MTA. ARTT takes the linked MTA data and LOs and generates a COI in the form of a course structure that users can access and manipulate.

The capability to generate a COI and to transform the LO framework into the S1000D industry data standard for use with the learning modules for technical manuals and training curriculums has a huge potential for savings. Projected savings are driven by the data standardization, data linkages, and embedded existing training and support materials for more efficient access.

C. Interactive Electronic Technical Manual

The IETM is a product that benefits from ARTT's data standardization and lifecycle configuration management. A curriculum revision can be due to an upgraded system or part and currently requires significant time and effort to complete. The impact of the revision is driven by new materials—how much new content is being added and the complexity of the upgrade. Based on SME data, it takes 6.5 to 12 hours of development time for every 1 hour of ILT. Automatic notifications will alert IETM developers that the technical data needs to be reviewed for changes and possible updates, thereby saving man-hours. In addition, sailors will receive accurate information more quickly. ARTT's capabilities should expedite changes to training materials and accurately maintain them with the aid of the PLMS surveillance and monitoring capabilities, which track changes to materials and system data linkages.

D. ARTT Software

Eduworks software developers working with the Navy for the ARTT project leveraged technology created by Credential Engine. Through this technology, the engineers used NLP software to extract LOs from system MTA data. Based on the prototyping, the Eduworks software components can:

- Generate performance objectives from tasks,
- Identify new objectives,
- Identify changed objectives,
- Identify individual tasks,
- Identify collective tasks, and
- Offer recommendations of train/no train for tasks.

In addition, the Credential Engine software uses MTA data to link task proficiency requirements to occupations. This linking improves understanding of training readiness and helps identify the Knowledge, Skills, and Abilities (KSAs) required for effective performance in a particular rating or Navy Enlisted Classification (NEC).

The modules for the LOs user interface improve analysts' capabilities to determine KSAs and map them to Credential Engine's achievement standards. Doing so provides information to support the training needs analysis, a savings that will occur in the analysis phase. Future software capabilities may be developed to facilitate the monitoring of gaps in proficiency at the individual and fleet levels. Therefore, this cost-benefit analysis does not have the metrics to quantify the value of performance and credential tracking; these topics are discussed in greater detail in Chapter 9.

6. Cost of Curriculum Development with ARTT

A. Application of the Model

The IMI blended cost model illustrated in Table 7 uses the notional course data from the IMI cost model provided by the Center for Naval Aviation Technical Training (CNATT) (see Chapter 4 and Appendix B). However, the cost model in this chapter displays a low and high range of projected savings using factors derived from data about training content development provided by experienced training developers.

Table 7. IMI Blended Curriculum Breakout

Level	Percentage	Hours
Level I Instructor-led presentations with some variety of media (stills, 2D animations, possible video clips)	60%	200 x .60 = 120 hours
Level II (can be instructor-led or self-paced, knowledge-based Interactive Courseware (ICW), or a low-fidelity PC Simulation)	30%	200 x .30 = 60 hours
Level III (branching ICW or PC Simulation)	10%	200 x .10 = 20 hours

As outlined in the preceding chapter, we used the baseline curriculum hours of 200 for a course and the given percentages of 60 percent for Level I, 30 percent for Level II, and 10 percent for Level III as stated in the IMI Cost Model document. Our cost-benefit analysis is for new course development and uses the IMI blended model's as-is coefficients. Using data provided by SMEs, we derived coefficients for particular elements within the phases for calculating potential savings within the IMI levels that are likely to demonstrate improvements with the implementation of ARTT.

The breakdown of the curriculum between Levels I, II, and II is taken from Table 1 and reproduced in Table 6. Additionally, savings coefficients derived from two SMEs are applied to the as-is requirements (without ARTT) presented in Chapter 4. The overall savings are shown for each level and in total in Table 8 through Table 14.

Table 8 shows the estimated man-hours saved in Level I course development for each task by each SME. In addition, Table 8 summarizes the estimates by the two SMEs and adds an estimate based on additional consideration by one of them. The aggregate savings for Level I range from almost 6 percent by the least optimistic SME to almost 30 percent in the most optimistic estimate.

Table 8. Level I

Phases/Tasks	As-Is Time Spent on Each Task (Per Hr)	Level 1 Estimation of 60% Total Curriculum	As-Is Total Man-Hrs	To-Be Savings Coefficient (SME-Set A)	To-Be Time Spent on Each Task (Per Hr) (SME-Set A)	To-Be Total Man-Hrs (SME-Set A)	To-Be Savings Coefficient (SME-Set B)	To-Be Time Spent on Each Task (Per Hr) (SME-Set B)	To-Be Total Man-Hrs (SME-Set B)	To-Be Savings Coefficient (SME-Alt. Set B)	To-Be Time Spent on Each Task (Per Hr) (SME-Alt. Set B)	To-Be Total Man-Hrs (SME-Alt. Set B)
Planning/Analysis Phases												
Front-End Analysis	7.87	120	944	0.10	7.1	850	0.30	5.51	661	0.50	3.9	472
Design Phase												
Instructional Design	10.66	120	1,306	0.10	9.6	1,151	0.20	10.66	1,279	0.50	5.3	640
Storyboarding	9.03	120	1,084	0.10	8.1	975	0.20	7.22	867	0.50	4.5	542
Develop Phase												
Graphic Production	8.66	120	1,039	0.05	8.2	987	0.30	6.06	727	0.30	6.06	727
Video Production	3.49	120	419	0.05	3.3	398	0.30	2.44	293	0.30	2.44	293
Audio Production	5.47	120	656	0.05	5.2	624	0.30	3.83	459	0.30	3.83	459
Authoring/Programming	13.42	120	1,610	0.05	12.7	1,530	0.30	9.39	1,127	0.30	9.39	1,127
Implement Phase												
QA Testing	5.12	120	614	0	5.1	614	0	5.12	614	0	5.12	614
Product Management	5.08	120	610	0	5.1	610	0	5.08	610	0	5.08	610
SME/Stakeholder	5.59	120	671	0	5.6	671	0	5.59	671	0	5.59	671
Pilot Test	3.43	120	412	0	3.4	412	0	3.43	412	0	3.43	412
Other	0.96	120	115	0	1.0	115	0	0.96	115	0	0.96	115
Totals			**9,480**			**8,937**			**7,836**			**6,682**

Table 9 and Table 10 present the same information for Level II course development and Table 11 and Table 12 present it for Level III. The magnitudes of the estimated savings are quite similar regardless of the level of training being developed.

Since this cost-benefit analysis evaluates how ARTT impacts the resources required for developing technical training courses, it was important to talk with SMEs to understand how training is developed now and how ARTT will enhance training development.

After learning how the Navy develops technical training, we mapped out the Navy's processes within each phase of development. We sent detailed Excel spreadsheet templates to more than 50 SMEs and requested values and coefficients on tasks within each phase of the Navy's E2E process. We also asked how many man-hours are required to perform these tasks, provided details on anticipated ARTT improvements, and inquired what estimated improvements the SMEs might foresee with ARTT. We also had many discussions with experts in the field. In addition, we participated in bimonthly teleconferences on training development improvement with developers throughout the Navy. We received comprehensive data from SMEs that provides the basis for our savings estimates. A SME also provided detailed information on training and latency, which is the time it takes to deliver training. We mapped the latency model into the E2E processes to create an additional estimate discussed in Chapter 7.

Because of the backgrounds and experience of the SMEs, we felt confident that they were representative and accurate sources for our analysis. Also, their responses spanned a wide range of impacts, providing credible upper and lower bounds for ARTT's effect.

Their backgrounds and experiences include:

- Instructional Design,
- Curriculum Development,
- Curriculum Standards,
- Authored Interactive Multimedia Instruction (IMI),
- Recognition as experts in Navy curriculum development using the E2E process,
- Curriculum Lifecycle Maintenance,
- Curriculum Project Management,
- Recognition for Virtual Classroom Training Development,
- Manpower, Personnel, and Training Integrated Product Support,
- More than 30 years' work experience in Training Education Development, and
- Education (Ph.D., Masters degrees in Education).

From the data provided by the SMEs and discussions with additional SMEs, we derived overall percent savings. We accomplished this goal by mapping the task-level savings percentages in the SME-provided data into our application of the Navy's IMI model based on a 200-hour blended course. This methodology and the IMI model are discussed in more detail in Chapter 4. Finally, we used these savings percentages in our cost-benefit model to determine net-present-values as directed by OMB Circular A-94.

We used three sets of alternatives for the impact of ARTT: a lower alternative from SME A and two sets of alternatives from SME B. Estimates from SME B differed from those of SME A in two important ways. First, SME B estimates a larger impact in the planning and analysis phases, the part of the process that ARTT's developers most focused on. Second, they reflect a much larger expectation of impact on the design and development phases. SME B's more optimistic estimate is based on further reflection concerning the degree of impact that ARTT will have on the Front-End Analysis (FEA). We also considered another SME's insights on the FEA that was closely aligned with SME B's more optimistic inputs. Therefore, after taking a third SME's input into consideration with SME B's information and data inputs, we derived SME B's alternative estimate.

Table 9 and Table 10 present the estimated man-hours saved in Level II course development for each task by each SME; Table 11 and Table 12 present it for Level III. The magnitude of the estimated savings is similar regardless of the level of training being developed.

Table 9. Level II Potential Savings with ARTT

	SME-Set A	**SME-Set B**	**SME-Set B Alternative**
Total Man-Hours Savings	543	1,644	2,798
Percent Savings	**5.73%**	**17.34%**	**29.51%**

Table 10. Level II

Phases/Tasks	As-Is Time Spent on Each Task (Per Hour)	Level II Estimation of 30% Total Curriculum	As-Is Total Man-Hrs	To-Be Savings Coefficient (SME-Set A)	To-Be Time Spent on Each Task (Per Hr) (SME-Set A)	To-Be Total Man-Hrs (SME-Set A)	To-Be Savings Coefficient (SME-Set B)	To-Be Time Spent on Each Task (Per Hr) (SME-Set B)	To-Be Total Man-Hrs (SME-Set B)	To-Be Savings Coefficient (SME-Alt. Set B)	To-Be Time Spent on Each Task (Per Hr) (SME-Alt. Set B)	To-Be Total Man-Hrs (SME-Alt. Set B)
Planning/Analysis Phases												
Front-End Analysis	17.36	60	1,042	0.10	15.62	937	0.30	12.15	729	0.50	8.7	521
Design Training												
Instructional Design	24.69	60	1,481	0.10	22.22	1,333	0.20	24.69	1,481	0.50	12.3	741
Storyboarding	20.88	60	1,253	0.10	18.79	1,128	0.20	16.70	1,002	0.50	10.4	626
Develop Phase												
Graphic Production	22.39	60	1,343	0.05	21.27	1,276	0.30	15.67	940	0.30	15.67	940
Video Production	11.29	60	677	0.05	10.73	644	0.30	7.90	474	0.30	7.90	474
Audio Production	11.59	60	695	0.05	11.01	661	0.30	8.11	487	0.30	8.11	487
Authoring/Programming	32.20	60	1,932	0.05	30.59	1,835	0.30	22.54	1,352	0.30	22.54	1,352
Implement Phase												
QA Testing	11.88	60	713	0	11.88	713	0	11.88	713	0	11.88	713
Product Management	11.74	60	704	0	11.74	704	0	11.74	704	0	11.74	704
SME/Stakeholder	10.96	60	658	0	10.96	658	0	10.96	658	0	10.96	658
Pilot Test	7.41	60	445	0	7.41	445	0	7.41	445	0	7.41	445
Other	1.63	60	98	0	1.63	98	0	1.63	98	0	1.63	98
Totals			**11,041**			**10,431**			**9,084**			**7,759**

Table 11. Level II Potential Savings with ARTT

	SME-Set A	SME-Set B	SME-Set B Alternative
Total Man-Hours Savings	610	1,958	3,282
Percent Savings	**5.52%**	**17.73%**	**29.73%**

Table 12. Level III

Phases/Tasks	As-Is Time Spent on Each Task (Per Hr)	Level III Estimation of 20% Total Curriculum	As-Is Total Man-Hrs	To-Be Savings Coefficient (SME-Set A)	To-Be Time Spent on Each Task (Per Hr) (SME-Set A)	To-Be Total Man-Hrs (SME-Set A)	To-Be Savings Coefficient (SME-Set B)	To-Be Time Spent on Each Task (Per Hr) (SME-Set B)	To-Be Total Man-Hrs (SME-Set B)	To-Be Savings Coefficient (SME-Alt. Set B)	To-Be Time Spent on Each Task (Per Hr) (SME-Alt. Set B)	To-Be Total Man-Hrs (SME-Alt. Set B)
Planning/Analysis Phases												
Front-End Analysis	42.97	20	859	0.1	38.67	773	0.30	30.08	602	0.50	21.5	430
Design Phase												
Instructional Design	61.97	20	1,239	0.1	55.77	1,115	0.20	61.97	1,239	0.50	31	620
Storyboarding	53.22	20	1,064	0.1	47.90	958	0.20	42.58	852	0.50	26.6	532
Develop Phase												
Graphic Production	64.53	20	1,291	0.05	61.30	1,226	0.30	45.17	903	0.30	45.17	903
Video Production	30.46	20	609	0.05	28.94	579	0.30	21.32	426	0.30	21.32	426
Audio Production	26.61	20	532	0.05	25.28	506	0.30	18.63	373	0.30	18.63	373
Authoring/Programming	86.39	20	1,728	0.05	82.07	1,641	0.30	60.47	1,209	0.30	60.47	1,209
Implement Phase												
QA Testing	31.51	20	630	0	31.51	630	0	31.51	630	0	31.51	630
Product Management	32.19	20	644	0	32.19	644	0	32.19	644	0	32.19	644
SME/Stakeholder	30.61	20	612	0	30.61	612	0	30.61	612	0	30.61	612
Pilot Test	20.96	20	419	0	20.96	419	0	20.96	419	0	20.96	419
Other	8.59	20	172	0	8.59	172	0	8.59	172	0	8.59	172
Totals			**9,800**			**9,276**			**8,082**			**6,970**

Table 13 rolls up the estimates for the entire training development process, covering all three levels of training. The overall percent changes based on the three sets of SME inputs are 5.45 percent, 17.47 percent, and 25.21 percent for SME Set A, SME Set B, and Alternative Set B, respectively. We estimate the cost-effectiveness of ARTT using each of these factors.

Table 13. Level III Potential Savings with ARTT

	SME-Set A	SME-Set B	SME-Set B Alternative
Total Man-Hours Savings	524	1,719	2,830
Percent Savings	**5.35%**	**21.27%**	**28.87%**

Table 14 summarizes the savings from each phase and the overall savings derived by each SME's input information.

Table 14. All Levels Summarized by Phase with Potential ARTT Savings

Phase	Total As-Is Man-Hours	Total To-Be Man-Hours (SME-Set A)	Total To-Be Man-Hours (SME-Set B)	Total To-Be Man-Hours (SME-Set B Alternative)
Planning/Analysis	2,845	2,561	1,992	1,423
Design	7,401	6,661	6,721	3,700
Develop	12,533	11,906	8,773	8,783
Implement	7,516	7,516	7,516	7,516
Total Hours	**30,295**	**28,644**	**25,001**	**21,422**
Total Potential Savings		**5.45%**	**17.47%**	**25.21%**

B. Note on the ARTT Proof-of-Concept Demonstration

The planning and analysis phases of the Navy's E2E training development as described in Chapter 3 include products such as the JDTA (TA), FEA, TPP, TSRA and Training Needs Analysis. ARTT has been shown to have a major impact on the creation of these products. A demonstration of ARTT in December 2019 produced strong evidence of significant time savings performing a TA for an actual Navy system. MTA data was generated through SLM to support the demo system. The analysis was performed on the Integrated Low Pressure Electrolyzer (ILPE) Navy system, with system data converted to the ARTT-required standard data formats. By ARTT using MTA data in the standardized formats the data properties are able to map to knowledge, skills and abilities by ARTT algorithms to produce task training prioritization and learning objectives into S6000T and

S1000D formats. With ARTT-developed software code and the data conversion, a Task Analysis for the ILPE was studied. One person was able to determine that 50 tasks needed to be trained, and he/she prioritized the tasks in approximately 8 hours. Each task took one SME an average of 5 to 10 minutes to complete. The original development of the Task Analysis cost $100,000 and required 20 people and 1 week to complete. This analysis demonstrated a significant savings in man-hours and costs. Without having to travel or lease space, the cost of one person was about $3,000 for the week, while with 20 people the assumed cost was $100,000 to produce the Task Analysis. These results demonstrate a significant savings on one system for one of the many training products required within the Navy's E2E development processes. The MTA data's value is significant for improving training development.

MTA data supports the creation of models for maintenance performance objectives. The MTA and the outputs generated can be used to more efficiently create course outlines and author training content for technical manuals. It will significantly reduce current manual development time analyzing maintenance tasks (i.e., JDTA) used to make decisions on tasks to be trained and develop training content. Therefore, saving significant man-hours with training content development.

7. Impact of ARTT on Latency

A. IMI Latency Model

Table 15 converts the savings in man-hours presented in Chapter 6 to reductions in the calendar time (or flow time) to develop training.[24] The table uses derived factors based on feedback from Navy training SMEs and is based on the latency table received from NSWC (see Appendix C). The SMEs provided estimates of the development time required under the current system. They also advised that flow time (and, thus latency, the time to deploy new training) would show the same proportional reduction as man-hours due to ARTT.

This illustration represents a new system of average complexity. Developing curricula for a new system would require initially identifying and obtaining necessary resource requirements. If the system were a modified system, it would not be necessary to perform this step in its entirety. It would be assumed that much of the initial material would be available for reuse, decreasing latency time and supporting the assumption in the IMI blended model that there are no potential savings for the planning phase. Until a system has actually been deployed for use, we assume no latency exists for maintenance and surveillance for a new system.

Table 15 displays the Net Flow Time, which is the time required to gather data, information, documents, and equipment necessary to analyze and develop training. Using the projected savings coefficients calculated from SME-provided data, the table displays a range of projected latency time savings with ARTT implemented. Both as-is and to-be flow times are shown for each phase. Total flow-time savings are given in Table 16.

[24] Flow time includes the man-hour time spent gathering data, information, documentation, and equipment to develop the system plus the time to receive data, information, and documentation.

Table 15. New System Latency Model

Task	As-Is Net Flow Time	To-Be Savings Coefficient (SME-Set A)	To-Be Net Flow Time (SME-Set A)	To-Be Savings Coefficient (SME-Set B)	To-Be Net Flow Time (SME-Set B)	To-Be Savings Coefficient (SME Alternative Set B)	To-Be Net Flow Time (SME Alternative Set B)
Plan Phase							
Identify and Document Project Requirements	40	0	40	0	40	0	40
Gather Government-Furnished Information	40	0	40	0	40	0	40
Analysis Phase							
Perform Content Analysis	80	0.10	72	0.30	56	0.5	40
Develop Content Analysis Data Report	40	0.10	36	0.30	28	0.5	20
Review Content Analysis Data Report	40	0.10	36	0.30	28	0.5	20
Update Content Analysis Data Report	16	0.10	14	0.30	11	0.5	8
Approve Content Analysis Data Report	8	0.10	7	0.30	6	0.5	4
Design Phase							
Develop Instructional Media Design Report	40	0.10	36	0.20	32	0.40	24
Review Instructional Media Design Report	40	0.10	36	0.20	32	0.40	24
Update Instructional Media Design Report	16	0.10	14	0.20	13	0.40	9.6
Approve Instructional Media Design Report	8	0.10	7	0.20	6	0.40	4.8

Task	As-Is Net Flow Time	To-Be Savings Coefficient (SME-Set A)	To-Be Net Flow Time (SME-Set A)	To-Be Savings Coefficient (SME-Set B)	To-Be Net Flow Time (SME-Set B)	To-Be Savings Coefficient (SME Alternative Set B)	To-Be Net Flow Time (SME Alternative Set B)
Develop Lesson Specifications	40	0.10	36	0.20	32	0.40	24
Review Lesson Specifications	40	0.10	36	0.20	32	0.40	24
Update Lesson Specifications	8	0.10	7	0.20	6	0.40	4.8
Approve Lesson Specifications	8	0.10	7	0.20	6	0.40	4.8
Develop/Modify Storyboards	160	0.10	144	0.20	128	0.40	96
Review Storyboards	40	0.10	36	0.20	32	0.40	24
Update Storyboards	40	0.10	36	0.20	32	0.40	24
Development Phase							
Generate/Modify Scripts	160	0.05	152	0.17	133	0.35	104
Update Media	480	0.05	456	0.17	398	0.35	312
Modify Lesson Modules	160	0.05	152	0.17	133	0.35	104
Build IMI Functionality	80	0.05	76	0.17	66	0.35	52
Coordinate Update to Paper-Based Training Materials	80	0.05	76	0.17	66	0.35	52
Conduct Alpha Testing	40	0.05	38	0.17	33	0.35	26
Incorporate Alpha Testing Findings	160	0.05	152	0.17	133	0.35	104
Conduct Beta Testing	40	0.05	38	0.17	33	0.35	26
Incorporate Beta Testing Findings	160	0.05	152	0.17	133	0.35	104

Task	As-Is Net Flow Time	To-Be Savings Coefficient (SME-Set A)	To-Be Net Flow Time (SME-Set A)	To-Be Savings Coefficient (SME-Set B)	To-Be Net Flow Time (SME-Set B)	To-Be Savings Coefficient (SME Alternative Set B)	To-Be Net Flow Time (SME Alternative Set B)
Install CBT/IMI at Schoolhouse	16	0.05	15	0.17	13	0.35	10.4
Conduct Instructor Training LEM	40	0.05	38	0.17	33	0.35	26
Conduct Pre-Pilot Conference	40	0.05	38	0.17	33	0.35	26
Conduct Pilot	40	0.05	38	0.17	33	0.35	26
Conduct Post-Pilot Conference	32	0.05	30	0.17	27	0.35	20.8
Update CBT/IMI	160	0.05	152	0.17	133	0.35	104
Implementation Phase							
Coordinate Delivery of Final CBT/IMI and Paper-Based Training Materials	8	0	8	0	8	0	8
Totals	**2,400**		**2,253**		**1,970**		**1,541**

Table 16. New System Latency Summary Table

Task	As-Is Net Flow Time	To-Be Savings Coefficient (SME-Set A)	To-Be Net Flow Time (SME-Set A)	To-Be Savings Coefficient (SME-Set B)	To-Be Net Flow Time (SME-Set B)	To-Be Savings Coefficient (SME-Set B Alternative)	To-Be Net Flow Time (SME-Set B Alternative)
Plan Phase	80	0	80	0	80	0	80
Analysis Phase	184	0.50	166	1.50	129	2.5	92
Design Phase	440	1.10	396	2.20	352	4.4	264
Development Phase	1,688	0.75	1,604	2.55	1,401	5.25	1,097
Implementation Phase	8	0	8	0	8	0	8
Maintenance and Surveillance Phase	0	0	0	0	0	0	0
Total Flow Time	**2,400**		**2,253**		**1,970**		**1,541**
		% Potential Savings	**6.12%**		**17.92%**		**35.78%**

B. Readiness Impact

The information we gathered indicates that introducing ARTT reduces latency time by the same proportion as it reduces the personnel-related costs of course development (approximately 6 percent to 36 percent). This result has important readiness implications.

Frequently, new equipment and equipment modifications are deployed to users in the fleet before operators and maintainers are trained to work with them. The longer the latency period, the longer the period before personnel are up-to-speed. Less proficient people are more likely to cause equipment failures and increase down-time when equipment does fail.

The information in Table 16 shows that ARTT supports the provision of appropriate training up to 20 weeks sooner than is currently the case. To really know the impact of this on readiness, we would have to know how the availability of equipment-specific training relates to the key factors that underlie equipment readiness: failure rates and repair times. Estimating these factors is beyond the scope of our analysis.

The most extreme assumption would be that the equipment is not ready for this entire period because of the absence of training materials, although that seems unlikely. Another possibility is that degraded skill in maintaining the equipment leads to an increased chance of overall mission failure. Again, we cannot quantify the probability of this event or the impact on mission performance.

ARTT leads to a meaningful reduction in the time to deliver relevant training to system maintainers. If the training helps people do their jobs—which we believe, along with most in the training community—readiness is improved through better maintenance. This value of readiness improvement is an unquantified benefit in our cost-benefit analysis.

8. Cost-Benefit Analysis

A. Methodology

In this analysis, we integrate the cost and savings to create a benefit-cost ratio. Costs and benefits are expressed in discounted present value using the discount rate of 1.5 percent prescribed by OMB Circular A-94.

We postulate two cases of new content hours per year:

- Case A – 16,000 hours
- Case B – 30,000 hours

Based on the analysis in Chapter 4, we estimate man-hours per new content hour to be 151.5. Based on interviews with NETC personnel, the estimate cost per man-hour is $75.00, resulting in the following costs before ARTT:

- Case A – $181.8 million
- Case B – $340.8 million

As discussed in Chapter 6, we derive two estimates of percent savings from ARTT. We add to these estimates a third, more optimistic estimate derived from an alternative set of assessments by the second SME. The three estimates are as follows:

- Estimate 1: Percent Savings 5.45
- Estimate 2: Percent Savings 17.47
- Estimate 3: Percent Savings 25.21

Based on Navy cost projections of ARTT used in formulating the FY 2022 POM, we assume that the cost of ARTT will be $6 million per year for the first 5 years, $5 million per year for the second 5 years, and $4 million per year for the next 10 years for the 20-year period from FY 2022 through FY 2041. While the analysis was being finalized, the ARTT Program Office estimated that one-third of the costs attributed to ARTT would have to be borne by MBPS even if ARTT was not implemented. That implies that our quantitative analysis understates ARTT's cost-effectiveness.

Additionally, we assume that ARTT implementation will begin in year 1 of the 20-year period at 5 percent of the new content hours and will continue to be implemented at 5 percent more each year thereafter. This calculation results in 5 percent of new content in year 1, 10 percent of new content in year 2, 15 percent of new content in year 3, and so on until all new content is developed using ARTT.

B. Discounted Costs and Benefits

Table 17 shows the costs and benefits of ARTT for the 20-year period from FY 2022 through FY 2041. This table also shows the year in which the project breaks even—that is, the discounted benefits equal or exceed the discounted costs.

Table 17. Summary of the Cost-Benefit Analysis for Case A and Case B

Content Hours	Percent Savings	Discounted Benefits ($Millions)	Discounted Costs ($Millions)	Discounted Benefits Minus Discounted Costs ($Millions)	Discounted Benefits/ Discounted Costs	Break -even Year
16,000	5.45%	86.4	83.9	2.4	1.03	20
16,000	17.47%	276.8	83.9	192.9	3.30	7
16,000	25.21%	399.5	83.9	315.6	4.76	5
30,000	5.45%	161.9	83.9	78.0	1.93	11
30,000	17.47%	519.1	83.9	435.2	6.19	4
30,000	25.21%	749.1	83.9	665.1	8.93	2

As an additional case, we performed a sensitivity analysis of assumptions that were more pessimistic to the effectiveness and cost of ARTT. If the number of content hours affected by ARTT is reduced to 10,000 per year, and if the costs of ARTT are increased to $6 million per year for the entire 20 years, then savings of 5.45 percent are never cost-effective. However, percent savings of 17.47 percent and 25.21 percent are cost-effective, breaking even in years 12 and 8, respectively.

Figure 6 and Figure 7 show the discounted costs and benefits over time for Case A and Case B, respectively.

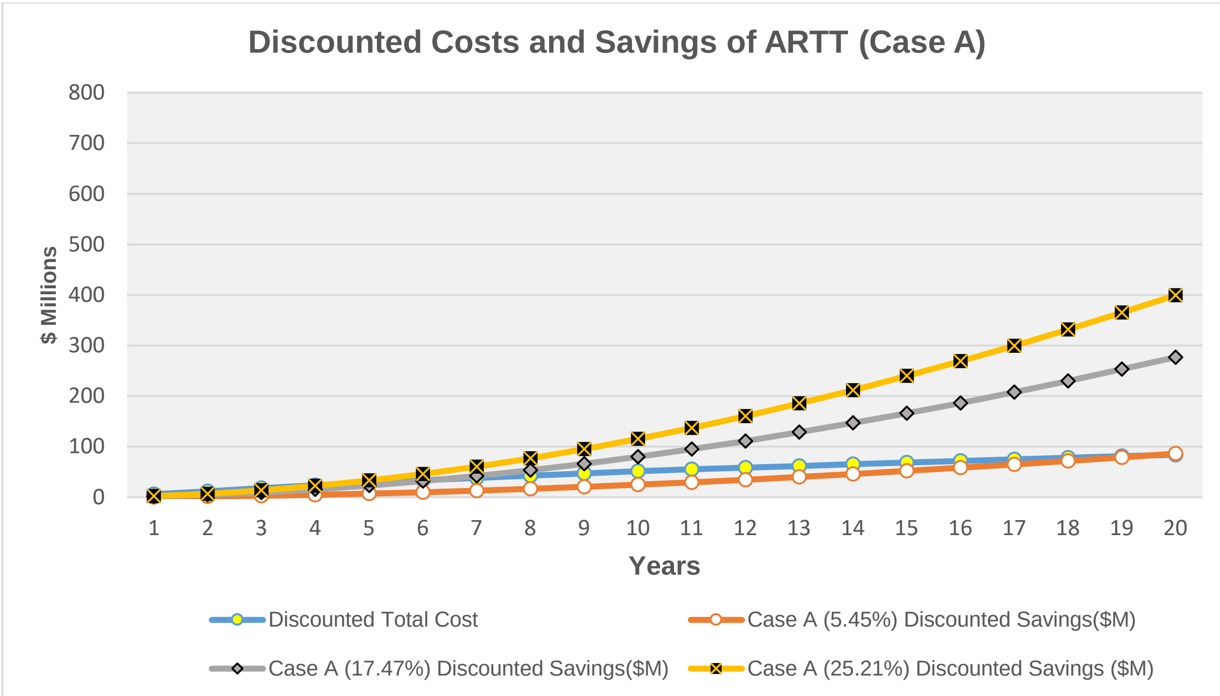


Figure 6. Discounted Costs and Savings of ARTT (Case A)
(assuming 16,000 hours of new content/year)

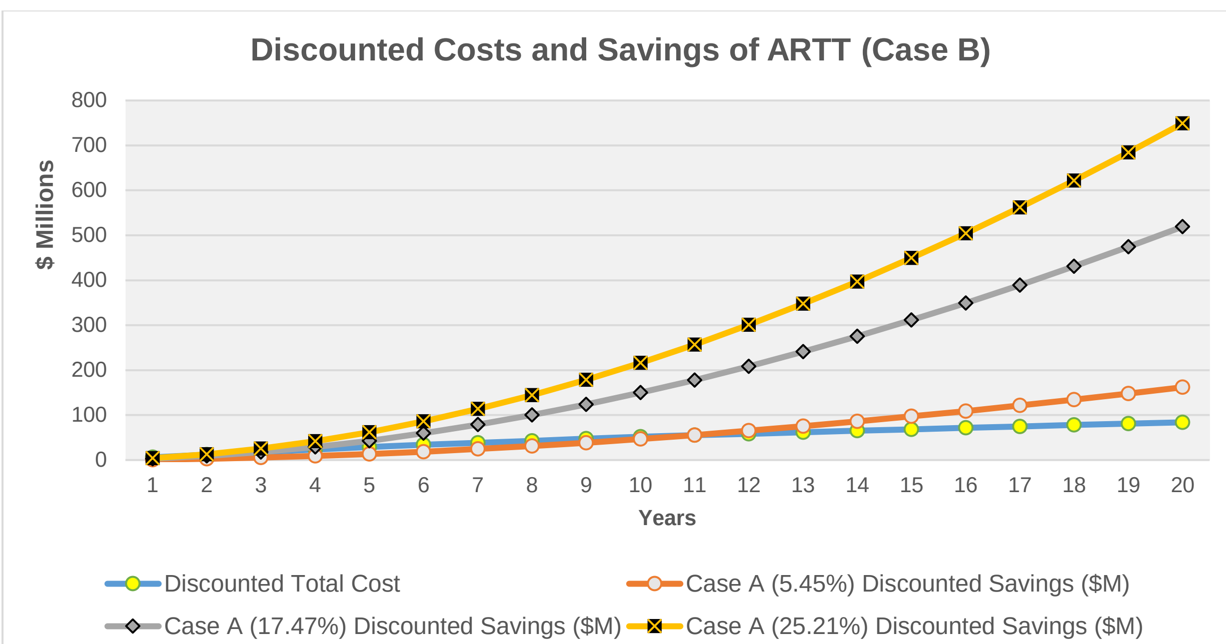


Figure 7. Discounted Costs and Savings of ARTT (Case B)
(assuming 30,000 hours of new content/year)

Table 18 through Table 23 present the details of the calculations of discounted costs and savings.

Table 18. Case A with 5.45 Percent Savings

Year	Total Cost of ARTT ($M)	Discount Factor from OMB A-94 of 1.50 Percent	Discounted Total Cost of ARTT ($M)	Cumulative Discounted Total Cost of ARTT ($M)	Savings of ARTT ($M)	Discounted Savings of ARTT ($M)	Cumulative Discounted Savings of ARTT ($M)	Discounted Savings Minus Discounted Cost	Cumulative Discounted Savings Minus Discounted Cost	Ratio of Cumulative Discounted Savings to Cumulative Discounted Cost
1	6	1.000	6.0	6.0	0.5	0.5	0.5	-5.5	-5.5	0.08
2	6	1.015	5.9	11.9	1.0	1.0	1.5	-4.9	-10.4	0.12
3	6	1.030	5.8	17.7	1.5	1.4	2.9	-4.4	-14.8	0.16
4	6	1.046	5.7	23.5	2.0	1.9	4.8	-3.8	-18.7	0.20
5	6	1.061	5.7	29.1	2.5	2.3	7.1	-3.3	-22.0	0.25
6	5	1.077	4.6	33.8	3.0	2.8	9.9	-1.9	-23.9	0.29
7	5	1.093	4.6	38.3	3.5	3.2	13.1	-1.4	-25.3	0.34
8	5	1.110	4.5	42.8	4.0	3.6	16.6	-0.9	-26.2	0.39
9	5	1.126	4.4	47.3	4.5	4.0	20.6	-0.5	-26.7	0.44
10	5	1.143	4.4	51.7	5.0	4.3	24.9	0.0	-26.7	0.48
11	4	1.161	3.4	55.1	5.4	4.7	29.6	1.2	-25.5	0.54
12	4	1.178	3.4	58.5	5.9	5.0	34.7	1.7	-23.8	0.59
13	4	1.196	3.3	61.8	6.4	5.4	40.1	2.0	-21.8	0.65
14	4	1.214	3.3	65.1	6.9	5.7	45.8	2.4	-19.4	0.70
15	4	1.232	3.2	68.4	7.4	6.0	51.8	2.8	-16.6	0.76
16	4	1.250	3.2	71.6	7.9	6.3	58.1	3.1	-13.4	0.81
17	4	1.269	3.2	74.7	8.4	6.6	64.8	3.5	-10.0	0.87
18	4	1.288	3.1	77.8	8.9	6.9	71.7	3.8	-6.1	0.92
19	4	1.307	3.1	80.9	9.4	7.2	78.9	4.1	-2.0	0.98
20	4	1.327	3.0	**83.9**	9.9	7.5	**86.4**	4.5	**2.4**	**1.03**

Table 19. Case A with 17.47 Percent Savings

Year	Total Cost of ARTT ($M)	Discount Factor from OMB A-94 of 1.50 Percent	Discounted Total Cost of ARTT ($M)	Cumulative Discounted Total Cost of ARTT ($M)	Savings of ARTT ($M)	Discounted Savings of ARTT ($M)	Cumulative Discounted Savings of ARTT ($M)	Discounted Savings Minus Discounted Cost	Cumulative Discounted Savings Minus Discounted Cost	Ratio of Cumulative Discounted Savings to Cumulative Discounted Cost
1	6	1.000	6.0	6.0	1.6	1.6	1.6	-4.4	-4.4	0.26
2	6	1.015	5.9	11.9	3.2	3.1	4.7	-2.8	-7.2	0.40
3	6	1.030	5.8	17.7	4.8	4.6	9.3	-1.2	-8.4	0.53
4	6	1.046	5.7	23.5	6.4	6.1	15.4	0.3	-8.1	0.66
5	6	1.061	5.7	29.1	7.9	7.5	22.9	1.8	-6.2	0.79
6	5	1.077	4.6	33.8	9.5	8.8	31.7	4.2	-2.0	0.94
7	5	1.093	4.6	38.3	11.1	10.2	41.9	5.6	3.6	1.09
8	5	1.110	4.5	42.8	12.7	11.4	53.3	6.9	10.5	1.25
9	5	1.126	4.4	47.3	14.3	12.7	66.0	8.2	18.7	1.40
10	5	1.143	4.4	51.7	15.9	13.9	79.9	9.5	28.3	1.55
11	4	1.161	3.4	55.1	17.5	15.0	95.0	11.6	39.9	1.72
12	4	1.178	3.4	58.5	19.1	16.2	111.1	12.8	52.6	1.90
13	4	1.196	3.3	61.8	20.6	17.3	128.4	13.9	66.6	2.08
14	4	1.214	3.3	65.1	22.2	18.3	146.7	15.0	81.6	2.25
15	4	1.232	3.2	68.4	23.8	19.3	166.1	16.1	97.7	2.43
16	4	1.250	3.2	71.6	25.4	20.3	186.4	17.1	114.8	2.60
17	4	1.269	3.2	74.7	27.0	21.3	207.6	18.1	132.9	2.78
18	4	1.288	3.1	77.8	28.6	22.2	229.8	19.1	152.0	2.95
19	4	1.307	3.1	80.9	30.2	23.1	252.9	20.0	172.0	3.13
20	4	1.327	3.0	**83.9**	31.8	23.9	**276.8**	20.9	**192.9**	**3.30**

Table 20. Case A with 25.21 Percent Savings

Year	Total Cost of ARTT ($M)	Discount Factor from OMB A-94 of 1.50 Percent	Discounted Total Cost of ARTT ($M)	Cumulative Discounted Total Cost of ARTT ($M)	Savings of ARTT ($M)	Discounted Savings of ARTT ($M)	Cumulative Discounted Savings of ARTT ($M)	Discounted Savings Minus Discounted Cost	Cumulative Discounted Savings Minus Discounted Cost	Ratio of Cumulative Discounted Savings to Cumulative Discounted Cost
1	6	1.000	6.0	6.0	2.3	2.3	2.3	-3.7	-3.7	0.38
2	6	1.015	5.9	11.9	4.6	4.5	6.8	-1.4	-5.1	0.57
3	6	1.030	5.8	17.7	6.9	6.7	13.5	0.8	-4.3	0.76
4	6	1.046	5.7	23.5	9.2	8.8	22.2	3.0	-1.2	0.95
5	6	1.061	5.7	29.1	11.5	10.8	33.0	5.1	3.9	1.13
6	5	1.077	4.6	33.8	13.7	12.8	45.8	8.1	12.0	1.36
7	5	1.093	4.6	38.3	16.0	14.7	60.5	10.1	22.1	1.58
8	5	1.110	4.5	42.8	18.3	16.5	77.0	12.0	34.1	1.80
9	5	1.126	4.4	47.3	20.6	18.3	95.3	13.9	48.0	2.02
10	5	1.143	4.4	51.7	22.9	20.0	115.3	15.7	63.7	2.23
11	4	1.161	3.4	55.1	25.2	21.7	137.0	18.3	81.9	2.49
12	4	1.178	3.4	58.5	27.5	23.3	160.4	19.9	101.9	2.74
13	4	1.196	3.3	61.8	29.8	24.9	185.3	21.6	123.5	3.00
14	4	1.214	3.3	65.1	32.1	26.4	211.7	23.1	146.6	3.25
15	4	1.232	3.2	68.4	34.4	27.9	239.6	24.7	171.2	3.50
16	4	1.250	3.2	71.6	36.7	29.3	269.0	26.1	197.4	3.76
17	4	1.269	3.2	74.7	39.0	30.7	299.6	27.5	224.9	4.01
18	4	1.288	3.1	77.8	41.2	32.0	331.7	28.9	253.8	4.26
19	4	1.307	3.1	80.9	43.5	33.3	365.0	30.2	284.1	4.51
20	4	1.327	3.0	**83.9**	45.8	34.5	**399.5**	31.5	**315.6**	**4.76**

Table 21. Case B with 5.45 Percent Savings

Year	Total Cost of ARTT ($M)	Discount Factor from OMB A-94 of 1.50 Percent	Discounted Total Cost of ARTT ($M)	Cumulative Discounted Total Cost of ARTT ($M)	Savings of ARTT ($M)	Discounted Savings of ARTT ($M)	Cumulative Discounted Savings of ARTT ($M)	Discounted Savings Minus Discounted Cost	Cumulative Discounted Savings Minus Discounted Cost	Ratio of Cumulative Discounted Savings to Cumulative Discounted Cost
1	6	1.000	6.0	6.0	0.9	0.9	0.9	-5.1	-5.1	0.15
2	6	1.015	5.9	11.9	1.9	1.8	2.8	-4.1	-9.2	0.23
3	6	1.030	5.8	17.7	2.8	2.7	5.5	-3.1	-12.3	0.31
4	6	1.046	5.7	23.5	3.7	3.6	9.0	-2.2	-14.5	0.38
5	6	1.061	5.7	29.1	4.6	4.4	13.4	-1.3	-15.7	0.46
6	5	1.077	4.6	33.8	5.6	5.2	18.6	0.5	-15.2	0.55
7	5	1.093	4.6	38.3	6.5	5.9	24.5	1.4	-13.8	0.64
8	5	1.110	4.5	42.8	7.4	6.7	31.2	2.2	-11.6	0.73
9	5	1.126	4.4	47.3	8.4	7.4	38.6	3.0	-8.7	0.82
10	5	1.143	4.4	51.7	9.3	8.1	46.7	3.7	-4.9	0.90
11	4	1.161	3.4	55.1	10.2	8.8	55.5	5.4	0.4	1.01
12	4	1.178	3.4	58.5	11.1	9.5	65.0	6.1	6.5	1.11
13	4	1.196	3.3	61.8	12.1	10.1	75.1	6.8	13.3	1.21
14	4	1.214	3.3	65.1	13.0	10.7	85.8	7.4	20.7	1.32
15	4	1.232	3.2	68.4	13.9	11.3	97.1	8.1	28.7	1.42
16	4	1.250	3.2	71.6	14.9	11.9	109.0	8.7	37.4	1.52
17	4	1.269	3.2	74.7	15.8	12.4	121.5	9.3	46.7	1.63
18	4	1.288	3.1	77.8	16.7	13.0	134.4	9.9	56.6	1.73
19	4	1.307	3.1	80.9	17.6	13.5	147.9	10.4	67.0	1.83
20	4	1.327	3.0	**83.9**	18.6	14.0	**161.9**	11.0	**78.0**	**1.93**

Table 22. Case B with 17.47 Percent Savings

Year	Total Cost of ARTT ($M)	Discount Factor from OMB A-94 of 1.50 Percent	Discounted Total Cost of ARTT ($M)	Cumulative Discounted Total Cost of ARTT ($M)	Savings of ARTT ($M)	Discounted Savings of ARTT ($M)	Cumulative Discounted Savings of ARTT ($M)	Discounted Savings Minus Discounted Cost	Cumulative Discounted Savings Minus Discounted Cost	Ratio of Cumulative Discounted Savings to Cumulative Discounted Cost
1	6	1.000	6.0	6.0	3.0	3.0	3.0	-3.0	-3.0	0.50
2	6	1.015	5.9	11.9	6.0	5.9	8.8	0.0	-3.1	0.74
3	6	1.030	5.8	17.7	8.9	8.7	17.5	2.8	-0.2	0.99
4	6	1.046	5.7	23.5	11.9	11.4	28.9	5.7	5.4	1.23
5	6	1.061	5.7	29.1	14.9	14.0	42.9	8.4	13.8	1.47
6	5	1.077	4.6	33.8	17.9	16.6	59.5	11.9	25.7	1.76
7	5	1.093	4.6	38.3	20.8	19.1	78.6	14.5	40.2	2.05
8	5	1.110	4.5	42.8	23.8	21.5	100.0	17.0	57.2	2.33
9	5	1.126	4.4	47.3	26.8	23.8	123.8	19.3	76.5	2.62
10	5	1.143	4.4	51.7	29.8	26.0	149.8	21.7	98.2	2.90
11	4	1.161	3.4	55.1	32.7	28.2	178.1	24.8	123.0	3.23
12	4	1.178	3.4	58.5	35.7	30.3	208.4	26.9	149.9	3.56
13	4	1.196	3.3	61.8	38.7	32.4	240.8	29.0	178.9	3.89
14	4	1.214	3.3	65.1	41.7	34.3	275.1	31.0	210.0	4.22
15	4	1.232	3.2	68.4	44.7	36.3	311.4	33.0	243.0	4.55
16	4	1.250	3.2	71.6	47.6	38.1	349.5	34.9	277.9	4.88
17	4	1.269	3.2	74.7	50.6	39.9	389.3	36.7	314.6	5.21
18	4	1.288	3.1	77.8	53.6	41.6	430.9	38.5	353.1	5.54
19	4	1.307	3.1	80.9	56.6	43.3	474.2	40.2	393.3	5.86
20	4	1.327	3.0	**83.9**	59.5	44.9	**519.1**	41.9	**435.2**	**6.19**

Table 23. Case B with 25.21 Percent Savings

Year	Total Cost of ARTT ($M)	Discount Factor from OMB A-94 of 1.50 Percent	Discounted Total Cost of ARTT ($M)	Cumulative Discounted Total Cost of ARTT ($M)	Savings of ARTT ($M)	Discounted Savings of ARTT ($M)	Cumulative Discounted Savings of ARTT ($M)	Discounted Savings Minus Discounted Cost	Cumulative Discounted Savings Minus Discounted Cost	Ratio of Cumulative Discounted Savings to Cumulative Discounted Cost
1	6	1.000	6.0	6.0	4.3	4.3	4.3	-1.7	-1.7	0.72
2	6	1.015	5.9	11.9	8.6	8.5	12.8	2.6	0.8	1.07
3	6	1.030	5.8	17.7	12.9	12.5	25.3	6.7	7.5	1.42
4	6	1.046	5.7	23.5	17.2	16.4	41.7	10.7	18.2	1.78
5	6	1.061	5.7	29.1	21.5	20.2	61.9	14.6	32.8	2.13
6	5	1.077	4.6	33.8	25.8	23.9	85.9	19.3	52.1	2.54
7	5	1.093	4.6	38.3	30.1	27.5	113.4	22.9	75.0	2.96
8	5	1.110	4.5	42.8	34.4	31.0	144.3	26.5	101.5	3.37
9	5	1.126	4.4	47.3	38.7	34.3	178.7	29.9	131.4	3.78
10	5	1.143	4.4	51.7	43.0	37.6	216.2	33.2	164.6	4.19
11	4	1.161	3.4	55.1	47.3	40.7	257.0	37.3	201.8	4.66
12	4	1.178	3.4	58.5	51.6	43.8	300.7	40.4	242.2	5.14
13	4	1.196	3.3	61.8	55.8	46.7	347.4	43.4	285.6	5.62
14	4	1.214	3.3	65.1	60.1	49.6	397.0	46.3	331.8	6.09
15	4	1.232	3.2	68.4	64.4	52.3	449.3	49.1	380.9	6.57
16	4	1.250	3.2	71.6	68.7	55.0	504.3	51.8	432.7	7.04
17	4	1.269	3.2	74.7	73.0	57.6	561.8	54.4	487.1	7.52
18	4	1.288	3.1	77.8	77.3	60.0	621.9	56.9	544.0	7.99
19	4	1.307	3.1	80.9	81.6	62.4	684.3	59.4	603.4	8.46
20	4	1.327	3.0	**83.9**	85.9	64.8	**749.1**	61.7	**665.1**	**8.93**

9. Additional Benefits of ARTT

Our analysis of the benefits of ARTT is limited to factors for which we could develop quantitative estimates. There are at least two other mechanisms that ARTT is likely to improve that deserve mention. They are:

- Reduction in the length of time between the finalization of equipment design and the start of the training planning and analysis phase, and
- Improvements to the tracking of personnel qualifications and training effectiveness.

A. Expediting the Start of the Training Development Process

The planning and analysis phase of the E2E begins with the TSD, IPRD, and JDTA. The TSD and IPRD support and integrate with the JDTA requirements. Training developers can start reviewing the material to determine the tasks that must be performed and learning objectives to be addressed. Traditionally, there has been a significant lag between the completion of equipment design and the availability of technical documentation. However, ARTT's ability to create MTA data and use algorithms with MTA data properties aids in the development of Training Needs Analysis. This analysis includes developing learning strategies, learning assessment strategies, and learning objectives.

By taking advantage of digital design, and the automatic availability of standardized equipment configuration information that is a key feature of MBPS, ARTT integrates the stabilization of equipment design and the start of the training development process. This approach eliminates the latency associated with new or modified equipment and ensures that appropriately trained personnel are available to operate and maintain the equipment sooner, leading to improved readiness and performance.

Unfortunately, the training development community has not been able to develop estimates of the extent of latency reductions. Therefore, we have not included such reductions in our quantitative analysis. Discussions of the subject at workshops on the progress of ARTT lead us to believe that the timeliness of training availability is significantly improved.

B. Improved Personnel Management and Readiness Tracking

The digital information that allows ARTT to support more efficient training development also provides information on the skills that individual sailors have accumulated. This information facilitates both the assignment of personnel to jobs by taking advantage of their training and the management of careers to ensure the provision of timely training to individuals.

Equally important, the adoption of ARTT will enhance the association between maintenance performance and individual system maintainers. This association allows the assessment of the effectiveness of training and the identification of specific weaknesses in training, facilitating curriculum improvement.

The Navy Learning Analytics Model that is to be developed as part of the ARTT program will support both of these initiatives. This study was not able to estimate their ultimate value, but they should be considered in the overall evaluation of ARTT.

10. Conclusions

A. Method

We have studied the ARTT process to understand its functions in accessing and handling technical data in standardized formats for improving logistics and training. Our major focus is on estimating ARTT's impact on the resources required for end-to-end development of technical training courses. Additionally, using a Navy end-to-end (E2E) course development model, we integrated the detailed estimates of SMEs to arrive at overall estimates of savings from ARTT.

Our method can be summarized as follows:

We postulate two cases of new training content per year—16,000 hours and 30,000 hours. We use three overall estimates of savings from ARTT—5.45 percent, 17.47 percent, and 25.21 percent. We estimate the costs of the course development before ARTT. We use 20-year budget estimates for ARTT based on Navy POM 22 program planning data.

While the pilot case successfully validated the savings of ARTT, our analysis relied on estimates of SMEs and their vast training development experience to validate our conclusions. Even using the lowest set of estimating parameters ARTT demonstrated savings.

B. Results

Incorporating information on the cost of fully implementing ARTT for all relevant Navy course development leads to the findings in Table 24, which demonstrate the benefits and costs of ARTT.

Table 24. Discounted Benefits and Costs of ARTT for the 20-Year Period of FY 2022 through FY 2041

Content Hours	Percent Savings	Discounted Benefits ($Millions)	Discounted Costs ($Millions)	Discounted Benefits Minus Discounted Costs ($Millions)	Ratio of Discounted Benefits to Discounted Costs	Break-even Year
16,000	5.45%	86.4	83.9	2.4	1.03	20
16,000	17.47%	276.8	83.9	192.9	3.30	7
16,000	25.21%	399.6	83.9	315.6	4.76	5
30,000	5.45%	161.9	83.9	78.0	1.93	11
30,000	17.47%	519.1	83.9	435.2	6.19	4
30,000	25.21%	749.1	83.9	665.1	8.93	2

As Table 24 shows, ARTT is cost-effective for all of the cases. The discounted benefits minus the discounted costs are positive. While the analysis was being finalized, the ARTT Program Office estimated that one-third of the costs attributed to ARTT would have to be borne by MBPS even if ARTT was not implemented. That implies that ARTT would be even more cost-effective than the table indicates.

Using sample data that we analyzed for this study, we concluded there is an encouraging amount of savings with ARTT in the planning and analysis phases of curriculum development. However, most of the costs are in the design and development phases, and these have yet to be analyzed empirically. Thus, we must rely on the estimates of the SMEs.

As an additional topic, we investigated the effects of ARTT on latency using another Navy E2E model and find similar overall percent reductions in the time to design and develop courses.

Appendix A.
IDA Bridge Study

This section summarizes an IDA cost-benefit analysis of a project to improve the Navy's Integrated Logistics Support (ILS).[1] The project involved integrating, or "bridging," the management of technical information for producing Navy technical manuals and training courses. Integration would lower the cost of producing manuals and courses and would increase shipboard readiness by having the appropriate logistics support on hand when new systems and equipment upgrades are fielded. The Bridge project achieved the integration by designing new software and proposing new technical and business procedures for managing the technical information.

The Bridge project was funded by the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics (OUSD (AT&L)). The project was part of the Reduction in Total Ownership Cost (RTOC) program conducted by the Office of the Secretary of Defense (OSD). The initial beneficiary of the funding is the Littoral Combat Ship (LCS) Mission Modules Program (PMS 420), which is integrating the mission modules into the LCS.

The costs of the Bridge project covered investment and implementation. Investment is the personnel and related expenses of the project. Implementation is the expense of training technical writers and course developers in using the Bridge, plus the license and user fees to cover the additional costs of maintaining the networks and repositories for processing and storing the technical information.

The study conducted separate cost-benefit analyses for two perspectives. The OSD perspective recognizes OSD's broad interest in determining whether the new software and technical and business processes that constitute the Bridge will lead to net cost savings—benefits exceeding costs—if implemented by the Navy and other Services as a whole. An analysis of this perspective was therefore conducted for an "aggregate" sample: the Navy's yearly production of all Hull, Mechanical, and Electrical (HM&E) technical manuals produced by the Naval Ship System Engineering Station (NAVSSES) in Philadelphia, and all Computer-Based Training (CBT) courses delivered by Navy eLearning (NeL), a part of the Naval Education and Training Command (NETC).

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[1] Daniel B. Levine, "Cost-Benefit Analysis of a Bridge to Integrate the Management of Technical Information for Producing Technical Manuals and Training Courses," IDA Document D-4208 (Alexandria, VA: Institute for Defense Analyses, November 2010).

The second perspective reflected the focus of Program Offices on their individual systems of interest. The analysis for the Program Office perspective concentrated exclusively on the benefit side—whether the Bridge would save money in producing future technical manuals and training courses. This analysis focused on the benefits of a "single-system" sample: the AN/AQS-20A mine-hunting sonar for the LCS. To expect that these savings would cover the full investment and implementation costs of the Bridge would be unreasonable.

The aggregate analysis found that the Bridge would achieve net benefits of $78.1 million in 10-year costs: a savings of $86.8 million in producing future HM&E manuals and NeL-delivered courses minus $8.7 million in investment and implementation costs. The single-system analysis found that the Bridge would produce substantial savings of almost $306,000 over 10 years.

The results were uncertain because of the newness of the Bridge. Although much of the analysis was based on historical data, some of the inputs were projections of the new Bridge's productivity. A sensitivity analysis of the five most uncertain inputs showed a range of 10-year net benefits for the aggregate analysis varying from $32 million to $120 million. These benefits would be much greater if the Bridge were applied to the technical manuals and training courses of the entire Navy and other Services.

Appendix B.
Interactive Multimedia Instruction (IMI) Model

Source: Center for Naval Aviation Technical Training (CNATT)

Purpose: Executive-Level Overview of Interactive Multimedia Instruction (IMI) Levels and Costing Models

IMI

Technological tools and capabilities enable developers to use techniques based on cognitive learning principles. The emphasis is on organizing and presenting information in ways that track with how learners learn—mirroring the way more complex information is received, stored, and retrieved by the mind. For example, research on adult learning has demonstrated the value of embedding training in job-realistic situations, providing learner control of sequence and pace, linking prior knowledge to novel content, and scaffolding the amount of learner support and assistance. These techniques and others can be used to make knowledge and skill acquisition more efficient, as well as less susceptible to decay.

A number of these features have been codified in a descriptive structure known as interactive multimedia instruction, or IMI. The IMI model specifies four levels of interactivity:

- Level 1 includes knowledge (or familiarization), and lessons provided in a linear format (one idea after another). Level 1 is primarily used for introducing an idea or concept. The learner has little or no control over the sequence and timed events of the lesson material. Minimal interactivity is provided by selective screen icons that are inserted into the lesson through typical input/output peripherals and programming protocols. The majority of instructor-led presentations are considered level 1.
- Level 2 involves the recall of more information than Level 1. Level 2 provides the learner with more control over the lesson's scenario through screen icons and other peripherals, such as light pens or touch screens. Simple emulations or simulations may also be presented to the learner.
- Level 3 involves the recall of more complex information (compared to Levels 1 and 2) and allows the user an increased level of control over the lesson scenario. Level 3 involves applying information, even complex information, to solving a

problem or producing a result. Prompting is much reduced, and the learner encounters decision points from which multiple branching occurs.

- Level 4 involves in-depth recall of a larger amount of information with little prompting and allows the user an increased level of control over the lesson. Learners demonstrate that they can perform specific tasks, errors and branches are compounded, training prompts do not occur, and feedback occurs after the learner passes or fails the training.

Costing Models (Source CNATT)

Example: A particular course has 200 hours of curriculum.

Table B-1 shows the breakdown of the curriculum.

Table B-1. Curriculum Breakdown

Level	Percentage	Hours
Level I instructor-led presentations with some variety of media (stills, 2D animations, possible video clip)	60%	200 x .60 = 120 hours
Level II (can be instructor-led or self-paced, knowledge-based Interactive Courseware (ICW), or a low-fidelity PC Simulation)	30%	200 x .30 = 60 hours
Level III (branching ICW or PC Simulation)	10%	200 x .10 = 20 hours

Note: The cost of the level is the estimated percentage of the curriculum and the cost per hour of development. Man-hours are also provided for the contractor to determine required personnel and scheduling. Also, the decision to develop user integrated tools can greatly affect the costing and time of development.

Table B-2 displays the estimated cost per hour of instruction for Level I IMI-type curriculum development for the 200-hour course.

Table B-2. Level 1 Development Time per Hour of Instruction

Tasks	% of Time Spent on Each Task	Time Spent on Each Task (per finished hour)	Level I Estimation of 60% Total Curriculum	Total Man-Hours Required
Front End Analysis	10.00%	7.87	120	944.4
Instructional Design	14.00%	10.88	120	1305.6
Storyboarding	11.00%	9.03	120	1083.6
Graphic Production	11.00%	8.66	120	1039.2
Video Production	4.00%	3.49	120	418.8
Audio Production	7.00%	5.47	120	656.4
Authoring/Programming	17.00%	13.42	120	1610.4
QA Testing	6.00%	5.12	120	614.4
Project Management	8.00%	5.08	120	609.6
SME/ Stakeholder Reviews	7.00%	5.59	120	670.8
Pilot Test	4.00%	3.43	120	411.6
Other	1.00%	0.96	120	115.2
Totals	**100.00%**	**79**	**120**	**9480**

Table B-3 displays the estimated cost per hour of instruction for Level II IMI-type development for the 200-hour course.

Table B-3. Level II Development Time per Hour of Instruction

Tasks	% of Time Spent on Each Task	Time Spent on Each Task (per finished hour)	Level II Estimation of 30% Total Curriculum	Total Man-Hours Required
Front End Analysis	9.00%	17.36	60	1041.6
Instructional Design	13.00%	24.69	60	1481.4
Storyboarding	11.00%	20.88	60	1252.8
Graphic Production	12.00%	22.39	60	1343.4
Video Production	6.00%	11.29	60	677.4
Audio Production	6.00%	11.59	60	695.4
Authoring/Programming	18.00%	32.2	60	1932.0
QA Testing	6.00%	11.88	60	712.8
Project Management	8.00%	11.74	60	704.4
SME/Stakeholder Reviews	6.00%	10.96	60	657.6
Pilot Test	4.00%	7.41	60	444.6
Other	1.00%	1.63	60	97.8
Totals	**100.00%**	**184.02**	**60**	**11041.2**

Table B-4 displays the estimated cost per hour of instruction for Level III IMI-type development for the 200-hour course.

Table B-4. Level III Development Time per Hour of Instruction

Tasks	% of Time Spent on Each Task	Time Spent on Each Task (per hour)	Level III Estimation of 10% Total Curriculum	Total Man-Hours
Front End Analysis	9.00%	42.97	20	859.4
Instructional Design	13.00%	61.97	20	1239.4
Storyboarding	11.00%	53.22	20	1064.4
Graphic Production	13.00%	64.53	20	1290.6
Video Production	6.00%	30.46	20	609.2
Audio Production	5.00%	26.61	20	532.2
Authoring/Programming	18.00%	86.39	20	1727.8
QA Testing	6.00%	31.51	20	630.2
Project Management	7.00%	32.19	20	643.8
SME/Stakeholder Reviews	6.00%	30.61	20	612.2
Pilot Test	4.00%	20.96	20	419.2
Other	2.00%	8.59	20	171.8
Totals	**100.00%**	**490.01**	**20**	**9800.2**

Table B-5 breaks down the personnel and man-hour requirements for the 200-hour course.

Table B-5. Table Breakdown of Personnel and Man-Hours

Average Annual Salary	Level	Tasks	Man-Hours	Percent Performed	Adjusted Man-Hours
Project Manager	Level I	Project Management	609.6	100%	609.6
		Other	115.2	90%	103.68
$80,000-130,000	Level II	Project Management	704.4	100%	704.4
		Other	97.8	90%	88.02
	Level III	Project Management	643.8	100%	643.8
		Other	171.8	90%	154.62
				Total hours	**2149.5**

Average Annual Salary	Level	Tasks	Man-Hours	Percent Performed	Adjusted Man-Hours
Instructional Designer	Level I	Instructional Design	1305.6	65%	848.64
		Storyboarding	1083.6	45%	487.62
$75,000-$90,000		Pilot Test	411.6	45%	185.22
		QA Testing	614.4	5%	30.72
		Graphic Production	1039.2	5%	51.96
		Authoring/ Programming	1610.4	15%	241.56
		Other	115.2	5%	5.76
	Level II	Instructional Design	1481.4	65%	962.91
		Storyboarding	1252.8	45%	563.76
		QA Testing	712.8	5%	35.64
		Pilot Test	444.6	45%	200.07
		Graphic Production	1343.4	5%	67.17
		Authoring/ Programming	1932.0	10%	193.2
		Other	97.8	5%	4.89
	Level III	Instructional Design	1239.4	65%	805.61
		Storyboarding	1064.4	45%	478.98
		QA Testing	630.2	5%	31.51
		Pilot Test	419.2	45%	188.64
		Graphic Production	1290.6	0%	0
		Authoring/ Programming	1727.8	10%	172.78
		Other	171.8	5%	8.59
				Total hours	**5565.23**
Instructional Development/ Technology	Level I	Instructional Design	1305.6	35%	456.96
		Storyboarding	1083.6	45%	487.62
		Pilot Test	411.6	45%	185.22
$85,000-$115,000		QA Testing	614.4	10%	61.44
		Graphic Production	1039.2	25%	259.80
		Authoring/ Programming	1610.4	85%	1368.84
		Other	115.2	5%	5.76

Average Annual Salary	Level	Tasks	Man-Hours	Percent Performed	Adjusted Man-Hours
	Level II	Instructional Design	1481.4	35%	518.49
		Storyboarding	1252.8	45%	563.76
		QA Testing	712.8	10%	71.28
		Pilot Test	444.6	45%	200.07
		Graphic Production	1343.4	25%	335.85
		Authoring/ Programming	1932.0	85%	1642.20
		Other	97.8	5%	4.89
	Level III	Instructional Design	1239.4	35%	433.79
		Storyboarding	1064.4	45%	478.98
		QA Testing	630.2	10%	63.02
		Pilot Test	419.2	45%	188.64
		Graphic Production	1290.6	25%	322.65
		Authoring/ Programming	1727.8	85%	1468.63
		Other	171.8	5%	8.59
				Total hours	**9126.48**
Media Specialist	Level I	Graphic Production	1039.2	70%	727.44
		Video Production	418.8	100%	418.80
$48,000-$66,000		Audio Production	656.4	100%	656.40
	Level II	Graphic Production	1343.4	70%	940.38
		Video Production	677.4	100%	677.40
		Audio Production	695.4	100%	695.40
		Authoring/ Programming for Animations	1932	15%	289.80
	Level III	Graphic Production	1290.6	70%	903.42
		Video Production	609.2	100%	609.20
		Audio Production	532.2	100%	532.20
		Authoring/ Programming for Animations	1727.8	15%	259.17
				Total hours	**6709.61**

Average Annual Salary	Level	Tasks	Man-Hours	Percent Performed	Adjusted Man-Hours
SMEs	Level I	QA Testing	614.4	5%	30.72
		Storyboarding	1083.6	10%	108.36
$55,000-$70,000		SME/ Stakeholder Reviews	670.8	100%	670.80
	Level II	QA Testing	712.8	5%	35.64
		Storyboarding	1252.8	10%	125.28
		SME/ Stakeholder Reviews	657.6	100%	657.60
	Level III	QA Testing	630.2	5%	31.51
		Storyboarding	1064.4	10%	106.44
		SME/ Stakeholder Reviews	612.2	100%	612.20
				Total hours	**2378.55**
QA	Level I	QA Testing	614.4	80%	491.52
$45,000-$50,000	Level II	QA Testing	712.8	80%	570.24
	Level III	QA Testing	630.2	80%	504.16
				Total hours	**1565.92**
Computer Engineer/ Programmer	Level III	Graphic Production	1290.6	10%	129.06
		Authoring/ Programming	1727.8	95%	1641.41
		QA Testing	630.2	20%	126.04
$70,000-$115,000				**Total hours**	**1896.51**

Comment (CNATT)

All of these numbers assume complete, original development when no other software exists. Where curriculum and media already exist, these numbers can drop dramatically.

Please note that the pricings are based on the best qualified and experienced people performing the jobs. Varying the skill sets and experience of personnel will greatly affect actual time and cost.

Table B-5 provides breakdowns by personnel and man-hours. Data for the personnel costs in Table B-5 assumes no reuse for the 200-hour course data. This means all analysis and materials were newly created.

Other possible costs for development are:

- Development software applications,
- Management software applications,

- Developer computer stations,
- LMS investment for courseware, and
- Travel.

Appendix C.
End-to-End Model Including Latency

Source: Naval Surface Warfare Center (NSWC), Port Hueneme Division

Table C-1 describes various activities within the interrelated phases involved in developing training materials for IMI task-based curriculum. At the process start, the stakeholders must identify and gather various technical documents to support training development. This table provides guidance for expected CBT/IMI training development.

Table C-1. Computer-Based Training (CBT/IMI)/IMI Development/Revision Process

Task	Swim Lane	Flow Time	Net Flow Time	Touch Time	People	Per $	Net $ Demand = 2
Identify and Document Project Requirements	Training LEM	40	40	8	1	$0	$0
Identify and Document Project Requirements	CSCS	40	0	8	1	$0	$0
Identify and Document Project Requirements	PO	40	0	8	1	$0	$0
Identify and Document Project Requirements	OEM/SME	40	0	8	2	$0	$0
Gather Government-Furnished Information	Training LEM	40	40	4	1	$0	$0
Gather Government-Furnished Information	OEM/SME	40	0	8	2	$0	$0
Perform Content Analysis	Training LEM	80	80	16	1	$0	$0
Perform Content Analysis	CSCS	80	0	16	1	$0	$0
Perform Content Analysis	OEM/SME	80	0	16	1	$0	$0
Develop Content Analysis Data Report	OEM/SME	40	40	8	1	$0	$0
Review Content Analysis Data Report	Training LEM	40	40	4	1	$0	$0
Review Content Analysis Data Report	PO	40	0	4	1	$0	$0
Review Content Analysis Data Report	CSCS	40	0	4	1	$0	$0
Review Content Analysis Data Report	OEM/SME	40	0	4	1	$0	$0

Task	Swim Lane	Flow Time	Net Flow Time	Touch Time	People	Per $	Net $ Demand = 2
Update Content Analysis Data Report	OEM/SME	16	16	2	1	$0	$0
Approve Content Analysis Data Report	Training LEM	8	8	1	1	$0	$0
Approve Content Analysis Data Report	PO	8	0	1	1	$0	$0
Approve Content Analysis Data Report	CSCS	8	0	1	1	$0	$0
Develop/Revise Instructional Media Design Report	OEM/SME	40	40	8	1	$0	$0
Review Instructional Media Design Report	Training LEM	40	40	8	1	$0	$0
Review Instructional Media Design Report	PO	40	0	8	1	$0	$0
Review Instructional Media Design Report	CSCS	40	0	8	1	$0	$0
Update Instructional Media Design Report	OEM/SME	16	16	2	1	$0	$0
Approve Instructional Media Design Report	Training LEM	8	8	1	1	$0	$0
Approve Instructional Media Design Report	PO	8	0	1	1	$0	$0
Approve Instructional Media Design Report	CSCS	8	0	1	1	$0	$0
Develop/Revise Lesson Specifications	OEM/SME	40	40	8	1	$0	$0
Review Lesson Specifications	Training LEM	40	40	8	1	$0	$0
Review Lesson Specifications	PO	40	0	8	1	$0	$0
Review Lesson Specifications	CSCS	40	0	8	1	$0	$0
Update Lesson Specifications	OEM/SME	8	8	1	1	$0	$0
Approve Lesson Specifications	Training LEM	8	8	1	1	$0	$0
Approve Lesson Specifications	PO	8	0	1	1	$0	$0
Approve Lesson Specifications	CSCS	8	0	1	1	$0	$0
Develop/Modify Storyboards	OEM/SME	160	160	40	1	$0	$0
Review Storyboards	Training LEM	40	40	8	1	$0	$0
Review Storyboards	PO	40	0	8	1	$0	$0
Review Storyboards	CSCS	40	0	8	1	$0	$0
Update Storyboards	OEM/SME	40	40	32	1	$0	$0
Generate/Modify Scripts	OEM/SME	160	160	80	1	$0	$0

Task	Swim Lane	Flow Time	Net Flow Time	Touch Time	People	Per $	Net $ Demand = 2
Update Media	OEM/SME	480	0	2	1	$0	$0
Update Media	OEM/SME	480	480	160	1	$0	$0
Update Media	CSCS	480	0	8	1	$0	$0
Modify Lesson Modules	OEM/SME	160	160	60	1	$0	$0
Build IMI Functionality	OEM/SME	80	80	40	1	$0	$0
Coordinate Update to Paper-Based Training Materials	Training LEM	80	80	8	1	$0	$0
Update Paper-Based Material	OEM/SME	80	0	24	1	$0	$0
Update Paper-Based Material	CSCS	80	0	8	1	$0	$0
Conduct Alpha Testing	Training LEM	40	40	24	1	$0	$0
Conduct Alpha Testing	PO	40	0	24	1	$0	$0
Conduct Alpha Testing	OEM/SME	40	0	24	1	$0	$0
Conduct Alpha Testing	LSO	40	0	24	1	$0	$0
Conduct Alpha Testing	CSCS	40	0	24	1	$0	$0
Incorporate Alpha Testing Findings	OEM/SME	160	160	40	1	$0	$0
Conduct Beta Testing	Training LEM	40	40	24	1	$0	$0
Conduct Beta Testing	PO	40	0	24	1	$0	$0
Conduct Beta Testing	OEM/SME	40	0	24	1	$0	$0
Conduct Beta Testing	LSO	40	0	24	1	$0	$0
Conduct Beta Testing	CSCS	40	0	24	1	$0	$0
Incorporate Beta Testing Findings	OEM/SME	160	160	40	1	$0	$0
Install CBT/IMI at Schoolhouse	OEM/SME	16	16	8	1	$0	$0
Install CBT/IMI at Schoolhouse	CSCS	16	0	8	2	$0	$0
Conduct Instructor Training LEM	OEM/SME	40	40	24	1	$0	$0
Conduct Instructor Training LEM	CSCS	40	0	24	2	$0	$0
Conduct Pre-Pilot Conference	Training LEM	40	40	16	1	$0	$0
Conduct Pre-Pilot Conference	OEM/SME	40	0	16	1	$0	$0
Conduct Pre-Pilot Conference	LSO	40	0	16	1	$0	$0
Conduct Pre-Pilot Conference	CSCS	40	0	16	2	$0	$0
Conduct Pilot	OEM/SME	40	40	40	1	$0	$0
Conduct Pilot	CSCS	40	0	40	1	$0	$0
Conduct Pilot	LSO	40	0	40	1	$0	$0

Task	Swim Lane	Flow Time	Net Flow Time	Touch Time	People	Per $	Net $ Demand = 2
Conduct Post-Pilot Conference	Training LEM	32	32	16	1	$0	$0
Conduct Post-Pilot Conference	PO	32	0	16	1	$0	$0
Conduct Post-Pilot Conference	OEM/SME	32	0	16	1	$0	$0
Conduct Post-Pilot Conference	LSO	32	0	16	1	$0	$0
Conduct Post-Pilot Conference	CSCS	32	0	16	2	$0	$0
Update Paper-Based Training Materials	LSO	160	0	2	1	$0	$0
Update CBT/IMI	OEM/SME	160	160	40	1	$0	$0
Coordinate Delivery of Final CBT/IMI and Paper-Based Training Materials	Training LEM	8	8	1	1	$0	$0
Deliver Final CBT/IMI Update	PO	8	0	1	1	$0	$0
Deliver Final CBT/IMI Update	OEM/SME	8	0	1	1	$0	$0
Deliver Final CBT/IMI Update	LSO	8	0	1	1	$0	$0
Navy Totals:		**5136**	**2400**	**1374**		**$0**	**$0**
NSWC PHD Totals:		**640**	**640**	**158**	**18**	**$0**	**$0**
NSWC PHD MP&T Element Lead Totals:		**632**	**48**	**177**	**19**	**$0**	**$0**

Table C-2 provides the time requirements for gathering data, information, documents, and equipment necessary to perform development for traditional instructor-led training.

Table C-2. Traditional Paper-Based Curriculum Development/Revision Process

TRIGGER	Task	Swim Lane	Flow Time	Net FT	Touch Time	People	Per $	Net $ Demand
6.1	Develop/Update Training Project Plan	Training LEM	40	40	4	1	$0	$0
6.2	LSO Approval of Training Project Plan	Training LEM	40	40	4	1	$0	$0
6.2	LSO Approval of Training Project Plan	LSO	40	0	4	1	$0	$0
6.3	Develop/Update Course Training Task List (CTTL)	Training LEM	40	40	6	1	$0	$0
6.4	Review CTTL	Training LEM	40	40	8	1	$0	$0
6.4	Review CTTL	CSCS	40	0	8	1	$0	$0
6.4	Review CTTL	OEM/SME	40	0	8	1	$0	$0
6.4	Review CTTL	LSO	40	0	8	1	$0	$0
6.5	Update CTTL	Training LEM	24	24	4	1	$0	$0
6.6	Develop Training Course Control Document (TCCD)	Training LEM	80	80	24	1	$0	$0
6.6	Develop Training Course Control Document (TCCD)	LSO	80	0	24	1	$0	$0
6.7	Review Training Course Control Document (TCCD)	Training LEM	40	40	8	1	$0	$0
6.7	Review Training Course Control Document (TCCD)	LSO	40	40	8	1	$0	$0
6.8	Update TCCD	Training LEM	24	24	4	1	$0	$0
6.8	Update TCCD	CSCS/LSO	24	24	4	1	$0	$0
6.7	Develop/Update Lesson Plan and Trainee Guide (Coordinate/Oversight Only)	Training LEM	160	0	16	1	$0	$0
6.7	Develop/Update Lesson Plan and Trainee Guide	OEM/SME	160	160	40	1	$0	$0
6.7	Develop/Update Lesson Plan and Trainee Guide	LSO	160	0	8	1	$0	$0

TRIGGER	Task	Swim Lane	Flow Time	Net FT	Touch Time	People	Per $	Net $ Demand
6.8	Review Lesson Plan and Trainee Guide	Training LEM	40	40	8	1	$0	$0
6.8	Review Lesson Plan and Trainee Guide	OEM/SME	40	0	8	1	$0	$0
6.8	Review Lesson Plan and Trainee Guide	LSO	40	0	8	1	$0	$0
6.8	Review Lesson Plan and Trainee Guide	CSCS	40	0	8	2	$0	$0
6.9	Update Lesson Plan and Trainee Guide (Oversight/Coordination)	Training LEM	16	16	2	1	$0	$0
6.9	Update Lesson Plan and Trainee Guide	LSO	16	0	6	1	$0	$0
6.9	Update Lesson Plan and Trainee Guide	OEM/SME	16	0	6	1	$0	$0
6.10	Conduct Pre-Pilot Conference	Training LEM	40	40	16	1	$0	$0
6.10	Conduct Pre-Pilot Conference	CSCS	40	0	16	2	$0	$0
6.10	Conduct Pre-Pilot Conference	LSO	40	0	16	1	$0	$0
6.10	Conduct Pre-Pilot Conference	OEM/SME	40	0	16	1	$0	$0
6.10.1	Conduct Instructor Training	OEM/SME	40	0	16	1	$0	$0
6.10.1	Conduct Instructor Training	CSCS	40	0	16	2	$0	$0
6.11	Conduct Pilot	LSO	40	0	40	1	$0	$0
6.11	Conduct Pilot	CSCS	40	40	40	2	$0	$0
6.11	Conduct Pilot	OEM/SME	40	0	40	1	$0	$0
6.12	Conduct Post-Pilot Conference	Training LEM	32	32	16	1	$0	$0
6.12	Conduct Post-Pilot Conference	CSCS	32	0	16	2	$0	$0
6.12	Conduct Post-Pilot Conference	PO	32	0	16	1	$0	$0
6.12	Conduct Post-Pilot Conference	LSO	32	0	16	1	$0	$0
6.12	Conduct Post-Pilot Conference	OEM/SME	32	0	16	1	$0	$0
6.13	Update Pilot Course Training Materials (Coordinate /Oversight Only)	Training LEM	40	40	8	1	$0	$0

TRIGGER	Task	Swim Lane	Flow Time	Net FT	Touch Time	People	Per $	Net $ Demand
6.13	Update Pilot Course Training Materials	LSO	40	0	16	1	$0	$0
6.13	Update Pilot Course Training Materials	OEM/SME	40	0	16	1	$0	$0
6.14	Distribute Final Training Materials	Training LEM	8	8	1	1	$0	$0
6.15	Acceptance of Final Training Materials	CSCS	40	0	1	1	$0	$0
Navy Totals:			**2008**	**768**	**574**		**$0**	**$0**
NSWC PHD Totals:			**600**	**440**	**117**		**$0**	**$0**
NSWC PHD MP&T Element Lead Totals:			**600**	**440**	**117**		**$0**	**$0**

Flow Time/Net Flow Time – Time actually spent gathering data, information, documents, and equipment necessary to perform analysis

Touch Time – Time actually spent using data and information gathered to process and develop training

LSO – Learning Standards Office

LEM – Logistics Element Manager

CSCS – Center for Surface Combat Systems, Learning Center

PO – Program Office

Appendix D.
Sample Data Collection E2E/IMI Model Templates

Table D-1. NETC Instruction 1500.19/E2E Data Collection Template Sample

Task	*Please insert or provide as much detail as possible*	As-Is Duration	To-Be Duration	As-Is Manhours	To-Be Manhours
Identify Stakeholders					
	Identify stakeholders				
1500.19 Request for Analysis					
	Needs assessment/Needs analysis				
	The process of defining the requirements based on the trigger				
	Identify a training requirement, which is a result of a trigger (e.g., Training Requirements Review (TRR), Navy Training System Plan (NTSP) revision, or Rating Merger).				
	Training requirement validated through OPNAV or other resource sponsor working with stakeholders and subject matter experts.				
	Determine planned requirements for graduates on board each class ship and method used to establish requirment(e.g., navy enlisted classification, qualification				
	Receive confirmation from the resource sponsor on resource commitment to support the training requirement per reference				
TDA Conduct 1500.19 Requirements Analysis					
	Requirements Sponsor identifies steps NETC must perform to analyze, develop and update training.				
	Note:// During this process ARTT may provide help with identifying similar technical documentation associated with the requirement or similar existing training. It may list any existing related systems				
Perform Training Gap Analysis					
	Conduct JDTA/TRR analysis (Note://With the implementation of ARTT the JDTA may not be necessary the tasks will maintenance plan based and exported from a common database of standardized data listing for selection and review)				
	Identify Training Gap				
	Approve Training Gap analysis				
	Complete Instructional Performance Requirement Document				
Perform Learning Curriculum Development Analysis					
	(1) Perform Training Situation Analysis (MILPRF-29612) Defines the training situation and technology assessment and provides recommendations for training and applicable systems.				
	• Identify and collect source data concerning the existing training situation.				
	• Identify deficiencies in existing training.				
	• Identify student population and management structure.				
	•Review facilities and equipment.				
	• Determine resources.				
	• Analyze data to determine the situation and its impact.				
	• Examine existing training materials for reuse.				
	•Identify solutions and alternatives to the training.				
	• Determine recommendations.				
	Note://Based on an ARTT capability PQS will be linked to the CTDSL/ASN and technical data will be linked to curriculum learning. modules this may speed up identifiying learning objectiives or failures.				

Table D-1. NETC Instruction 1500.19/E2E Data Collection Template Sample (continued)

Perform Learning Curriculum Development Analysis	As-Is Duration	To-Be Duration	As-Is Manhours	To-Be Manhours
(2) Perform Technology Assessment Analysis (TTA).				
Identify technology requirements for the implementation of an instructional program.				
•Analyze requirements to determine optimal mix of technology				
•Identify training resource requirements to teach the course at each planned site to determine if shortfalls exist. This includes Instructor Requirements, Training Device Requirements, Classroom/lab Requirements, etc.				
•Write Training Situation Document (MILPRF-29612).				
(3) Perform detailed task analysis.				
For each job task from the JDTA/TTA,detail how task is performed, under what conditions it is performed, and how well the individual must perform it. Deterimine tasks that do not require formal training and organize the refined list into two categories: tasks for which training must be provided and tasks for which training is considered optional and dependent upon the availability of resources. Other factors to consider include percentage of job incumbents who actually perform the task, task criticality, frequency of performance, task learning difficulty, probability of deficient performance, and immediacy of performance.				
•Prepare job task inventory.				
(4) Write Instructional Performance Requirements document (MILPRF-29612) or Front End Analysis document (NETC).				
(5) Write Business Case Analysis document (NETC).				
(6) Write and submit to NETC a Training Project Plan Package (NETC).				
a. TPP in PDF format or access to appropriate AIM database. b. CeTARS request. c. Requirement Calculator, Convening Planner and ICOMP Excel Spreadsheet or equivalent documentation. d. Risk Analysis Package, if High Risk. e. Source of validated requirement in pdf or access to email (if applicable). f. JDTA in pdf or access via the Content Planning Module (if applicable). g. FEA in pdf or access to FEA (if applicable). h. BCA in pdf or access to BCA (if applicable). i. NEOCS package (if applicable).				
TPP package internal review by Learning Center Departments to include Manpower and Admin, Business, Information Technology, Resources, and Technical Support.				
Submit CetARs request form when TPP ready for approval and obtain new CIN and CDPs.				
Enter projected Course Master Schedule in CeTARS reflecting projected hours of classroom and lab time and student to instructor ratios.				
Prepare coorespondence for submission to NETC.				
Post TPP package to the NETC-governed enterprise-wide training administration database.				
NETC review and concur with TPP Package.				
Learning Center sends letter to Learning Sites to inform that TPP approved and prepare for course given the design, development, implemnetation schedule provided in TPP.				
Analysis returned to NETC for review & forwarding to Requirements Sponsor				
Tasking from NETC to Requirements Sponsor's review and approval				

Table D-1. NETC Instruction 1500.19/E2E Data Collection Template Sample (continued)

Design Phase	As-Is Duration	To-Be Duration	As-Is Manhours	To-Be Manhours
Design Requirement/Curriculum Change (include all other tasks required to fulfill and plan design phase)				
Designate integrated project team to generate Statement of Work (if contracting required).				
Submit SOW to COR for review and forwarding to contractors for proposal submission process (if contracting required).				
Contract proposals reviewed and selection made (if contracting required).				
Designate government curriculum development team (if contracting NOT required).				
Hold Kickoff meeting schedule with fixed time (if not already done)				
Develop learning objectives using Task Analysis that contains list of tasks containing training intervention.				
Sequence learning objectives for delivery.				
Write Instructional Performance Requirements Document (MILPRF-29612). (Specification:DID DI-SESS-81518B)				
Develop plan for assessment activities and strategy.				
Write Test Package. (MILPRF-29612) (Specification:DID DI-SESS-81525B)				
Consider instructional strategies: -Methods to encourage student participation that result in the best retention and transfer of knowledge. -Feedback strategies that provide students with a measure of their performance. -The sequence of the instruction, including advancement for students who are already proficient, remediation for students who need further instruction of difficult tasks, multiple strands, and modular sequencing when the learning sequence is not critical. -Pacing strategies including self-paced, group-paced, just-in-time training, or a combination of the three.				
Write Instructional Media Requirments Document (MILPRF-29612). (Sepcification:DID DI-SESS-81519)				
Write Instructional Media Design Package (MILPRF-29612). (Specification:DID DI-SESS-81520B)				
Create prototype of course materials.				
Develop Phase				
Identify all steps required to produce and deliver new curriculum				
(Note://ARTT may be able to provide suggested curriculum based on standardized data and maintenance task analysis.)				
Submit request for SME and Learning Site support.				
Produce story boards and scripts.				
Develop visuals and other media				
Materials might include Training Course. Produce course materials. Control Document, Lesson Plan, Trainee Guide, SCORM Package including XML output for computer-based instruction (CBI)/ interactive multimedia instruction (IMI) tools, and test questions.				
Submit Instructional Media Package (IMP)				
Implement				
Train the Trainer (T3) Event				
Pre-Pilot Conference				
Pilot				
Pilot Redline Corrections				
Post Correction Pilot				
Courseware Ready for Training Aproval by CO				
Letter of Promulgation				
Evaluate				
Internal Course Review (ICR)				
Formal Course Review (FCR)				
Training Requirements Review (TRR)				
Ready for Training (RFT)				
Requirement Change Completed				
Report Completion to NETC N75 for Action Closout				

Table D-2. E2E/IMI-Based Data Collection Template

	IMI Level II (Per 1 hr of Instruction)	ILT Multiplier	Blended Multiplier	IMI/CBT Multiplier	As-Is Man-hrs system	As-Is Man-hrs Blended Curriculum	As-Is Man-hrs (IMI/CBT)	To-Be Man-hr Coefficient (ARTT Implemented)	To-Be Man-hr Coefficient (ARTT implementd (Blended)	To-Be Man-hr Coefficient (ARTT implemented (IMI/CBT))
Perform Analysis										
Job Duty Task Analysis (JDTA)										
Training Situation Document (TSD)										
Training Systems Requirements Analysis (TSRA) (Maybe combined with TSD)										
Instructional Performance Requirements Document (IPRD)										
Front-End Analysis (FEA)										
Training Project Plan (TPP)										
Training Evaluation Assessment Plan (TEAP)										
Training Effectiveness Evaluation Plan (TEEP)										
Course Training Task List (CTTL)										
Design Training										
Curriculum Outline of Instruction (COI)										
Develop/Construct Learning Objective Module (LOM) w/Content Planning Module (CPM)										
Sequence Learning Objectives										
Describe KSAs to achieve Personnel Qualification Level										
Instructional Media Design Package (IMDP)										
Storyboarding										
Multimedia Production (Incl. Graphic, Video, Audio)										
Narration										
Programming/Testing										
QA Testing										
Prototype lesson										
Develop Training										
Course Materials										
* Includes managing curriculum materials,										
Implementation Support Documents										
* Incl. Training System Support Document (TSSD) (Software Prod. Descriptions for										
Course Pilot Complete (Delivery of full-length course)										
Pilot Course Monitoring Report										
All Course Materials/Software must be cataloged and available. (CCA is responsible)										
Implement Training										
Pilot										
Management										
Support										
Deliver Training Content (IETM)										
Maintenance and Surveillance										
Pilot										
Management (Standard Formal Course Review) (See NAVETRA 136)										
Support										
Existing Content (Incl. Update to IETM)										
Curriculum Revision										
Curriculum Change										

Illustrations

Figures

Tables

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Abbreviations

ARTT	Acquisition Requirements for Training Transformation
CAD	Computer-Aided Design
CBT	Computer-Based Training
CCA	Curriculum Control Authority
CCB	Configuration Control Board
CNATT	Center for Naval Aviation Technical Training
COI	Course Outline of Instruction
CRADA	Cooperative Research and Development Agreement
CTTL	Course Training Task List
E2E	End-to-End
EBOM	Engineering Bill of Materials
ECP	Engineering Change Proposal
FEA	Front-End Analysis
GEIA	Government Electronics and Information Technology Association
HM&E	Hull, Mechanical and Electrical
ICW	Interactive Courseware
IDA	Institute for Defense Analyses
IETM	Interactive Electronic Training Manual
ILS	Integrated Logistics Support
ILT	Instructor-Led Training
IMI	Interactive Multimedia Instruction
IMRD	Instructional Media Requirements Document
IPRD	Instructional Performance Requirements Document
IPS	Integrated Product Support
JDTA	Job Duty Task Analysis
KSAs	Knowledge, Skills, and Abilities
LO	Learning Objective
LSA	Logistics Support Analysis
MBPS	Model-Based Product Support
MCD	Military Characteristics Document
MPT&E	Manpower Personnel Training and Education
MTA	Maintenance Task Analysis
NAVEDTRA	Navy Education Training
NAVSSES	Naval Ship System Engineering Station

NeL	Navy eLearning
NETC	Naval Education Training Command
NLAM	Navy Learning Analytics Model
NPAM	Navy Performance Ability Model
NSWC	Naval Surface Warfare Center
NTIM	Navy Technical Instruction Model
OCCSTDs	Occupational Standards
OEM	Original Equipment Manufacturer
OPNAV	Office of the Chief of Naval Operations
OSD	Office of the Secretary of Defense
OUSD (AT&L)	Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics
PLM	Product Lifecycle Management
PM	Project Manager
POM	Program Objective Memorandum
RDA	Rating Domain Analysis
ROTC	Reduction in Total Ownership
SCID	Systematic Curriculum Instructional Design
SLM	Service Lifecycle Management
SME	Subject Matter Expert
TA	Task Analysis
TDCP	Training Decision Coordinating Paper
TDP	Technical Data Package
TEEP	Training Effectiveness Evaluation Plan
TNA	Training Needs Analysis
TPP	Training Project Plan
TSD	Training Situation Document
TSRA	Training System Requirements Analysis
USFF	United States Fleet Force
XML	Extensible Markup Language

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14. ABSTRACT

The Navy's Acquisition Requirements for Training Transformation (ARTT) project is designed to obtain and use data acquired for systems engineering and configuration management to improve the development of technical training.

Using Navy experts' estimates of the cost reductions that ARTT provides, this analysis evaluates ARTT's cost-effectiveness. Two dimensions of uncertainty are addressed: (1) uncertainty about the scope of training that will be affected, and two cases are postulated of new training content per year; and (2) uncertainty about the proportion of savings that could occur, and three cases are examined. The costs of developing and implementing ARTT's capabilities are taken from 20-year budget estimates based on Navy Program Objective Memorandum (POM) 22 program planning data. The analysis assumes that ARTT's benefits will be phased in over a 20-year period. The evaluation uses net-present-value analysis as directed by OMB Circular A-94.

The analysis finds that ARTT is cost-effective for all six cases. The discounted benefits minus the discounted costs are positive. Further, the breakeven period, the time at which cumulative benefits exceed cumulative costs, ranges from 2 to 7 years for the two higher estimates of proportional savings. However, many uncertainties remain.

15. SUBJECT TERMS

Model Based Product Support (MBPS); Product Lifecycle Management (PLM); S-Series data standards

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