CENTER OF EXCELLENCE FOR TECHNICAL TRAINING AND HUMAN PERFORMANCE
COE-10/11: MODULAR CURRICULUM DESIGN

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1. PROJECT TITLE

COE-10: Western Michigan University

COE-11: Embry-Riddle Aeronautical University

2. RESEARCH FOCUS AREA:

Curriculum Architecture

3. TITLE:

Modular Curriculum Design

4. BRIEF PROJECT DESCRIPTION:

The project team reviewed the current curriculum architecture design and made recommendations for updating processes and systems that would enable modular curriculum development.

5. INVESTIGATION TEAM:

UNIVERSITY TEAM:

Dr. Daryl Watkins, Principal Investigator, Embry-Riddle Aeronautical University

Dr. Matthew Earnhardt, Co-Investigator, Embry-Riddle Aeronautical University

Dr. R. Adam Manley, Principal-Investigator, Western Michigan University

Dr. Chuck Bruce, Co-Investigator, Western Michigan University

Ms. Chelsea Hall, Graduate Student Researcher, Western Michigan University

Ms. Sarah Lewis, Graduate Student Researcher, Western Michigan University

6. INDUSTRY PARTNER:

Mr. Dave Stach, Addx Corporation

Ms. Melissa Arellano, Addx Corporation

7. OBJECTIVE & GOALS:

The goal of this project was to observe the existing curriculum architecture design, create a concept for curriculum architecture design, and discover the gaps between the current and conceptual designs for the FAA-ATO. The purpose was to demonstrate the feasibility of deploying modular and reusable curriculum in a variety of learning modalities.

Objective 1: map existing training delivery system encompassing processes from job-task identification through training delivery and feedback

Objective 2: map new processes to address any gaps identified through mapping the process

Objective 3: develop a curriculum architecture design that will facilitate modular curriculum development

8. PROJECT TEAM BIOS:

Dr. Daryl Watkins – Embry-Riddle Aeronautical University

Dr. Watkins is the Associate Dean of the College of Business and a tenured Associate Professor of Leadership for Embry-Riddle Aeronautical University – Worldwide. Dr. Watkins earned a Doctorate of Management in Organizational Leadership from the School of Advanced Studies at the University of Phoenix, a Master’s of Business Administration from the University of California, Irvine, and a Bachelor’s of Science from the United States Naval Academy. Dr. Watkins was a combat-decorated Naval Aviator, flying F/A-18 Hornets from the USS Midway during Operation Desert Storm. Dr. Watkins worked in the Transportation and Tolling industry as the General Manager of the 91 Express Lanes toll road in Orange County, California. He also worked as in Information Technology Project Management Consultant at the Orange County Transportation Authority where he managed the implementation of dozens of enterprise technology projects.

Dr. Watkins is a Project Management Institute certified Project Management Professional, a Certified Grant Writing Professional by the American Grant Writers’ Association, and a certified Career in Transition Coach from Chapman University. Dr. Watkins developed a Master of Science in Leadership Program and several courses within the program. One course, Leadership Foundations is Research was selected as a Blackboard Exemplary course.

His relevant publications are as follows:

Watkins, D. V., Newcomer, J. M., Earnhardt, M. P., Marion, J. W., Opengart, R. A., & Glassman, A. M. (2016). A cross-sectional investigation of the relationships education, certification, and experience have with knowledge, skills, and abilities among aviation professionals. *International Journal of Aviation, Aeronautics, and Aerospace*, 3(1). doi:10.15394/ijaaa.2016.1101

Glassman, A. M., Newcomer, J. M., Earnhardt, M. P., Opengart, R. A., Watkins, D. M., & Marion, J. W. (2015). Validating the knowledge, skills, and abilities composite measure: An aviation industry pilot study. *International Journal of Aviation, Aeronautics, and Aerospace, 2*(3). doi:10.15394/ijaaa.2015.1067

Earnhardt, M. P., Newcomer, J. M., Watkins, D. V., & Marion, J. W. (2014). An inquiry into the aviation management education paradigm shift. *International Journal of Aviation, Aeronautics, and Aerospace, 1*(4). doi:10.15394/ijaaa.2014.1037

Watkins, D. V. & Earnhardt, M. P., (2015). Developing critical thinking within a Master of Science in Leadership program. *Academy of Educational Leadership Journal, 19*(1), 184-194.

Rietsema, K. W. & Watkins, D. V., (2013). Indian aviation leadership engagement: Case study in leadership development using the Cynefin framework. *The Exchange, 2*(2), December 2013.

Dr. Matthew Earnhardt, Co-Investigator – Embry-Riddle Aeronautical University

Dr. Earnhardt is an Assistant Professor of Leadership Embry-Riddle Aeronautical University – Worldwide. Dr. Earnhardt has a Doctor of Philosophy in Organizational Leadership with an emphasis in Global Leadership from Regent University's School of Business and Leadership; a Master of Business Administration and a Bachelor of Science in Psychology from Liberty University. Additionally, he is finishing a Master of Science in Aeronautics with specializations in Aviation/Aerospace Education Technology, Human Factors in Aviation Systems, Aviation/Aerospace Safety Systems, Aviation/Aerospace Operations, and Aviation/Aerospace Management from Embry-Riddle.

Prior to a career in education at several colleges and universities, Dr. Earnhardt was a military veteran and an analyst for Lockheed Martin Corporation in the intelligence field. Dr. Earnhardt's research is in the areas of project management, aviation and aerospace management, complex adaptive leadership, leadership behaviors, and critical thinking.

His relevant publications are as follows:

Marion, J. M., Richardson, T. M., Earnhardt, M. P. (2016). Project execution: A research agenda to explore the phenomenon. *Journal of Modern Project Management, 4*(1), 71-78. Available at http://journalmodernpm.com/index.php/jmpm/article/view/177

Watkins, D. V., Newcomer, J. M., Earnhardt, M. P., Marion, J. W., Opengart, R. A., & Glassman, A. M. (2016). A cross-sectional investigation of the relationships education, certification, and experience have with knowledge, skills, and abilities among aviation professionals. *International Journal of Aviation, Aeronautics, and Aerospace*, 3(1). doi:10.15394/ijaaa.2016.1101

Earnhardt, M. P., Richardson, T. M., & Marion, J. W. (2015). Project leadership: An emerging phenomena. *International Leadership Journal, 7*(2), 104-125. Retrieved from http://www.tesc.edu/documents/ILJ_Summer_2015.pdf

Glassman, A. M., Newcomer, J. M., Earnhardt, M. P., Opengart, R. A., Watkins, D. M., & Marion, J. W. (2015). Validating the knowledge, skills, and abilities composite measure: An aviation industry pilot study. *International Journal of Aviation, Aeronautics, and Aerospace, 2*(3). doi:10.15394/ijaaa.2015.1067

Earnhardt, M. P. (2014). Romans 12 motivational gifts in the military: An exploration of person job fit, job performance, and job satisfaction. *Journal of Biblical Integration in Business*, *17*(1), 59-72. Retrieved from http://www.cbfa.org/JBIB_vol17_inside_rev-final.pdf

Earnhardt, M. P., Newcomer, J. M., Watkins, D. V., & Marion, J. W. (2014). An inquiry into the aviation management education paradigm shift. *International Journal of Aviation, Aeronautics, and Aerospace, 1*(4). doi:10.15394/ijaaa.2014.1037

Marion, J. W., Richardson, T. M., & Earnhardt, M. P. (2014). Project manager insights: An analysis of career progression. *Organisational Project Management*, *1*(1), 53-72. doi:10.5130/opm.v1i1.3949

Newcomer, J. M., Marion, J. W., & Earnhardt, M. P. (2014). Aviation managers' perspective on the importance of education. *International Journal of Aviation, Aeronautics, and Aerospace*, *1*(2). doi:10.15394/ijaaa.2014.1014

Dr. R. Adam Manley, Principal Investigator – Western Michigan University

Dr. Manley is an Associate Professor of Career and Technical Education at Western Michigan University. He earned a Ph.D. in Career and Technical Education from Virginia Tech; a Master's of Career and Technical Education and a Bachelor of Business Education from Ferris State University. Dr. Manley currently teaches pedagogical courses related to curriculum development and teacher education. Dr. Manley's research is in the areas of competency and task development, standards development, gap analysis, and defining operational infrastructures. He has extensive knowledge of the DACUM, Turbo DACUM, and Delphi Methodologies. Utilizing these methodologies, Dr. Manley has worked with a variety of industry partners such as Boeing to develop curriculum and written/performance assessments related to certain job sets.

His relevant publications and grants are as follows:

Manley, R. (2013). The Policy Delphi: A Method for Identifying Intended and Unintended Consequences of Educational Policy. *Policy Futures in Education*, *11* (6), 755-768

Manley, R. (2012). Teacher and student variables that correlate with workplace readiness (WPR) skill proficiency. *Youth Education and Employment in Russia and Abroad, 2* (1), 19-23.

Manley, R. & Zinser, R. (2012). A Delphi study to update CTE teacher competencies. *Education and Training, 54* (6), 488-503

Manley, R. (2012). Keeping up with business and industry: Secondary-level CTE's struggle. *On the Horizon, 20* (1), 17-23.

Manley, R. (2011). The decentralization of Perkins: History, impact, and recommendations for future CTE legislation. *Journal of Career and Technical Education Research, 36*(2), 119-152.

Manley, R. & Price, W. (2011). The operational infrastructure of secondary-level CTE: Definition, validation, and application. *Journal of Career and Technical Education, 26*(1), 20-31.

Manley, R. & Zinser, R. (July 2014 – June 2015). *Troops to Teachers Marketing Campaign and IOC Informational Website.* Funded through Michigan Department of Education, Office of Career and Technical Education; $9,401.

Manley, R. & Zinser, R. (July 2013 – June 2014). *Michigan CTE Teacher Development Grant.* Funded through Michigan Department of Education, Office of Career and Technical Education; $13,330.

Manley, R. & Zinser, R. (July 2012 – June 2013). *CTE Teacher Professional Development Research and Sessions.* Funded through Michigan Department of Education, Office of Career and Technical Education; $14,573.

Manley, R. & Zinser, R. (July 2011 – June 2012). *Professional Development Needs Assessment and Module Development*. Funded through Michigan Department of Education, Office of Career and Technical Education; $13,670

Manley, R. & Zinser, R. (December 2010 – June 2011). *Updating the Performance Based Teacher Education competencies*. Funded through Michigan Department of Education, Office of Career and Technical Education; $7,344.

Mr. Chuck Bruce, Co-Investigator – Western Michigan University

Chuck Bruce completed his Master of Arts in Career and Technical Education at Western Michigan University in December 2012. He received his Bachelor of Business Administration degree from Western Michigan University with a major in Finance in June 2011. Mr. Bruce teaches courses related to technical curriculum development, teaching methods, and instructional technology. Mr. Bruce's research interests include technical curriculum design, teacher retention, project-based instructional methods, and emerging instructional technology. Before teaching, Mr. Bruce held roles in corporate finance focusing on asset management, cash-flow forecasting, and global risk management.

Ms. Sarah Lewis, Graduate Student Researcher – Western Michigan University

Sarah Lewis is completing her Master of Arts in Career and Technical Education from Western Michigan University. She also graduated with her undergraduate degree from Western Michigan University in 2012 with a Bachelor of Business Administration with a focus on Management. Sarah is the graduate teaching assistant working with Dr. Manley and Mr. Bruce in the Workforce Education and Development and Leadership program. She currently teaches two classes of this program and focuses on research related to employee training practices, assessment, and curriculum design.

Ms. Chelsea Hall, Graduate Student Researcher – Western Michigan University

Chelsea Hall is currently a Business and Marketing teacher at Mona Shores High School in Norton Shores, MI. In 2017, Chelsea received her Master of Arts in Workforce Education and Development from Western Michigan University. Before starting her career in education, Chelsea worked as a social media coordinator for a health technology company.

9. STATEMENT OF WORK:

The following tasks were accomplished:

1. Phase 1

1.1. Task 1: Conduct Literature Review

1.1.1. Activity: Investigators collected, reviewed, and synthesized literature from the body of knowledge related to this project.

1.1.2. Approach: Investigators established a list of relevant topics, searched for scholarly books and journal articles, reviewed the literature, and synthesized into a literature review. Relevant topics included areas of knowledge such as job-task analysis, instructional systems development, curriculum architecture design, and modular curriculum development. The literature review was updated throughout the duration of the project.

1.1.3. Outcome: Literature review

1.2. Task 2: Collect FAA-ATO Artifacts

1.2.1. Activity: The investigators collected key artifacts related to the project. The following represents a subset of necessary documents.

1.2.2. Approach: The researchers relied on structured interviews with key technical stakeholders and collection of electronic documents.

1.2.3. Outcome: The outcome of this task was a collection of artifacts, data, and information necessary to complete future tasks.

1.3. Task 3: Map Current Process

1.3.1. Activity: The investigators developed a map of the FAA ATO processes starting with job-task analysis and assignment through training and delivery.

1.3.2. Approach: The investigators mapped the curriculum design processes to follow existing FAA documentation, noting changes or inconsistencies.

1.3.3. Outcome: Business process documents for relevant processes.

1.4. Task 4: Validate Understanding

1.4.1. Activity: The investigators met with FAA staff to validate the process maps from task 3.

1.4.2. Approach: The investigators distributed a document containing relevant processes to FAA technical experts.

1.4.3. Outcome: Feedback from FAA staff on business process documents

1.5. Task 5: Map New Process (time to complete: 2-3 months)

1.5.1. Activity: The investigators mapped a proposed future state for relevant curriculum architecture processes.

1.5.2. Approach: The investigators received and incorporated feedback on ATO processes into the process documents.

1.5.3. Outcome: a proposed future state for relevant curriculum architecture processes.

1.6. Task 6: Develop concept for enhanced curriculum architecture (time to complete: 1 month)

1.6.1. Activity: Investigators developed a new concept for an enhanced curriculum architecture that would facilitate modular curriculum design

1.6.2. Approach: The investigators sought input from FAA, industry, and academia to identify best practices and novel approaches to the design of the curriculum architecture to enable modular curriculum development.

1.6.3. Outcome: Proposed curriculum architecture that would facilitate modular curriculum development. The investigators submitted a proposal to implement a stackable credentialing system.

1.7. Task 7: Develop list of recommendations (time to complete: 1 month)

1.7.1. Activity: Investigators developed a list of recommendations for implementation of best practices, changes to existing practices, issues that were noticed throughout the project, and recommendations for future phases or actions to continue the efforts begun in this project.

1.7.2. Approach: Investigators consolidated notes and additional thoughts into a comprehensive report.

1.7.3. Outcome: Final report, including list of recommendations

10. SCHEDULE & MILESTONES:

PERIOD OF PERFORMANCE

Start Date: November 1, 2016

End Date: March 30, 2018

MILESTONES

Milestone	Planned	Actual
Task 2: Collect FAA-ATO Artifacts completion	07/15/17	07/15/17

Milestone	Planned	Actual
Task 3: Map Current Process completion	08/15/17	08/15/17
Task 5: Map New Process completion	12/15/17	12/15/17
Task 6: Develop concept for enhanced curriculum architecture completion	01/15/18	01/15/18
Task 7: Develop list of recommendations completion	02/15/18	03/30/18

11. Deliverables:

Literature Review

The Development of Instructional Systems Design

Although there is no seminal moment in the literature marking the start of instructional systems design (ISD), this approach traces its roots to the U.S. Military psychologists of World War II. After the war, many psychologists who had been involved in military training used this knowledge to continue to research and solve instructional problems (Dick, 1987). For example, Miller (1953) proposed a methodology for analyzing the job tasks of man-machine systems. Miller stated that job task analysis “should permit an orderly approach to the determination of highly complex behaviors, many of which may interact with each other in job performance” (p. 3). Instructional systems design emerged at least in part from the programmed instruction movement of the mid-1950s and mid-1960s (Reiser & Dempsy, 2002). Skinner (1954) argued that instruction should be presented in small steps, require active responses, include immediate feedback, and allow for self-paced learning. An essential component of programmed instruction was identifying specific learning objectives that learners are expected to master. Bloom, Engelhard, Furst, Hill, and Krathwohl (1956) created a taxonomy that classifies behaviors from simple to complex, based on specific educational objectives. Bloom et al. stated that:

> It should be clear from the foregoing that objectives are not only goals toward which the curriculum is shaped and toward which instruction is guided, but they are also the goals that provide the detailed specification for the construction and use of evaluative techniques (p. 27).

In *Preparing Objectives for Programmed Instruction*, Mager (1962) wrote about the characteristics of effective objectives that communicate the performance criterion of specific tasks. Although objectives have been used by educators as early as the turn of the twentieth century (Reiser & Dempsy, 2002), objectives continue to play an important role in instructional systems design. In many training contexts, objectives serve as a precedent to the development of instruction, practice activities, and assessments. Objectives are a critical component of instructional systems design and curriculum development.

Between 1966 and 1968, numerous models emerged for "systems approaches" to curriculum design. Twelker (1972) compared five systems approaches from this era and found that common elements included: a) identification of a problem, b) analysis of the setting, c) organization of management, d) identification of objectives, e) specification of methods, and construction of prototypes. Branson et al. (1975) created *Interservice Procedures for Instructional Systems Development.* This model was commissioned by the U.S. Army Combat Arms Training Board and included five major components including a) analyze, b) design, c) develop, d) implement, and e) control. Branson et al. (1975) posited that the ISD process must follow and be informed by an adequate needs analysis. The model is now commonly referred to as the ADDIE model by instructional designers, and it is viewed as a seminal model in the ISD field.

By 1980, multiple ISD models had emerged. Andrews and Goodson (1980) reported over 40 models consisting of discrete steps and substeps. Many of these models are variations on ADDIE, an acronym that stands for analysis, design, development, implementation, and evaluation. The exact origin of the ADDIE model is unknown, although Branson (1978) noted that the Center for Educational Technology at Florida State University worked in conjunction with the U.S. Army to develop the Interservice Procedures for Instructional Systems Development, which closely resembles ADDIE, but is not credited as the source for the ADDIE acronym.

Molenda (2003) stated that there "is no original, fully elaborated model [for ADDIE], just an umbrella term that refers to a family of models that share a common underlying structure." However, after ADDIE several "systems" models evolved with similar elements. Roblyer (2015) compared four models based on systems approaches to instructional design (Dick, Carey & Carey, 2009; Morrison, Ross, Kalman, & Kemp, 2013; Seels & Glasgow, 1998; Smith and Ragan, 1999). Roblyer found that all four systems models involved the steps: (a) needs assessment, (b) task analysis, (c) writing objectives, (d) developing assessments, (e) developing materials, (f) formative evaluation, (g) revision of materials, and (h) summative evaluation.

Wallace (2001) created the *PACT Process for Training and Development.* The PACT process is designed to be performance-based, accelerated, customer or stakeholder driven training and development. The PACT process is comprised of five components (Wallace, 2001):

1) Knowledge and Skill Analysis
2) Curriculum Architecture Design
3) Modular Curriculum Development
4) Instructional Activity Development
5) Project Planning & Management

Wallace explained that Curriculum Architecture Design, Modular Curriculum Development, and Instructional Activity Development are part of instructional systems design.

Technical Training and Performance

Job Task Analysis

Jonassen, Tessmer, and Hannum (1999) discussed that task analysis is the most critical function during the instructional design process. Task analysis articulates what the learners should know, and a task analysis determines: (a) goals and objectives, (b) the operational components of the job, (c) what knowledge is required, (d) what skills or tasks should be taught, (e) the sequence of how work is performed, (f) the design of instructional activities, and (g) the appropriate media required (Jonassen et al., 1999). In other words, task analysis is used to determine what gets taught and organizes "tasks and task components, as well as sequencing them" (Jonassen et al., 1999, p. 8). Roberts (2006) stated that analysis is the foundation needed for success in the instructional design process. An appropriate curriculum architecture design facilitates using the outputs of job-task analysis to produce high-quality instruction.

The literature identified several methods for conducting a job/task analysis. According to Jonassen et al. (1999) task analysis occurs in two phases: the instructional phase (determining the needs and developing analysis tools) and simple task analysis (inventorying, selecting, decomposing, sequencing, and classifying tasks). Koby and Melby (2013) discussed five steps followed in a certification-oriented job task analysis. These include: (a) consulting with subject matter experts to identify job tasks, (b) survey questionnaire, (c) develop a sample of practitioners to respond to the survey, (d) respondents rating each task-oriented item, and (e) determine the importance of each task. Kolby and Melby (2013) designated that after completing these steps that a reassessment is necessary at periodic intervals. Linton, Nutsch, McSwane, Kastner, Bhatt, Hodge, et al. (2011) discussed that the Developing a Curriculum (DACUM) process had been used to conduct job analysis at multiple levels. Linton et al. (2011) stated that the DACUM process operated with the following procedures: (a) experts should define their jobs, (b) jobs can be described in terms of the tasks performed, and (c) all tasks have implications for the KSAOs. The following steps need to be completed in a job task analysis, including (a) create a list of job tasks, (b) verify the job list as valid, and (c) determine what the person needs to do to meet the performance standard (Roberts, 2006). Consequently, job task analysis involves consulting with experts, developing a task list, verification of the list, and periodic reassessment.

Kaml, Fogarty, Wojtala, Dardick, Bateson, Bradsher and Weiss (2013) defined a job task analysis as a formal process to determine the tasks, activities, functions, and attributes to fulfill the responsibilities of a position. Arthur, Edwards, Bell, Vilando, and Bennet (2005) indicated that job task analysis is a process in which behaviors and knowledge, skills, abilities, and other characteristic (KSAO) required for successful job performance are identified. A job analysis can determine the required KSAO for both a particular position and when designing training programs (Chow, Gillespie, Finney & Woodford, 2010). According to Maurer, Wrenn, Pierce, Tross, and Collins (2003), the literature identified many KSAO in the job task analysis domain. Both KSAOs and job task analysis are important to technical training and performance.

Curriculum Architecture

Kim (2015) indicated that curriculum development is necessary for building capacity. Curriculum architecture is a framework that organizes content and adds coherence to the learning process (Kaufmann, 2005). Wallace (2011) defined curriculum architecture design as the "modular design of performance-based instructional and informational content for performance competence development" (p. 23). Curriculum architecture design is a structured process that outputs performance-based models that drive performance-based outcomes. Curriculum architecture is a decision tool for delivery, content, and audience (Kaufmann, 2005). Furthermore, curriculum architecture design supports job performance through configurable modules that segment the training to provide the most significant impact. Snowden (2014) acknowledged that curriculum architecture needs to have a comprehensive approach. Chyung, Stepich, and Cox (2006) indicated that the curriculum architecture should be developed for different audiences and can be developed among levels (e.g., individual contributor, front-line manager), roles (similar job functions), or teams (the group responsible for a set of outcomes). Friedlander (1996) showed that curriculum that is made independent can provide flexibility in delivery and configuration. Several components can be made reusable, including (a) war stories, (b) instructor guidelines, (c) pre/post testing, (d) application, (e) handouts, (f) student material, (g) real-world linkage, (h) instructional content, (i) presentation material, and (j) delivery requirements (Friedlander, 1996). Chyung et al. indicated that building a curriculum architecture structure is costly and time-consuming but is necessary for training development, strategic planning, and learners not only acquiring knowledge that relates to their KSAOs but the capability to apply those KSAOs in a variety of situations. According to Chyung et al. organizations need to create skill-based curriculum architectures that apply to a variety of jobs. In other words, there is a need to modularize certain aspects of curriculum.

Modular Curriculum Design

Lucas (2007) suggested that a shift to a developmental focus on job skills and knowledge has necessitated the need for flexible modular curriculum design. Osipova, Stepanova, and Shubkina (2016) described modular curriculum design as a competency-based approach used to determine program contents and training. Modular curriculum design is an independent, logically completed, structured approach to learning (Osipova, Stepanova & Shubkina, 2016) that streamlines the educational delivery process (Lightfoot, 2006). Sakhieva et al. (2015) indicated that a modular curriculum design provides the foundation for competency-based learning which meets employee requirements.

The literature described several advantages to implementing a modular curriculum design approach. Modular curriculum design links learning outcomes and assessment (Areaya, Shibeshi & Tefera, 2013). Modular curriculum design is innovative, flexible, and reduces the overall cost for the customers (Lightfoot, 2006) through the elimination of duplication in the curriculum (Osipova et al., 2016). This is accomplished through an explicit structuring of the content, systems thinking, and increased cooperation between the instructors (Osipova et al., 2016). Furthermore, this approach allows for better management of curriculum through the use of managers of the different curriculum, which increases quality (Osipova et al., 2016).

Delivery and Tracking of Modular Curriculum

There have been several innovations that enable the delivery of modular curriculum. Hybert (2000) noted that technology has dramatically expanded today's media choices, particularly with the use of computer-based training. The advent of computers also allows for electronic sequencing of job tasks. Changes in instructional technology enable delivery of curriculum in real time via the cloud instead of in a traditional classroom environment. Learners can access a learning management system (LMS) in a self-paced manner that aligns with a specific job task or series of job tasks. Computer-based training is also enabling modularity in traditional laboratory environments. Loveland (1999) explained that many secondary technology teachers are shifting towards a modular approach to teaching software and computer technology, even though classrooms might remain the same. A 2014 study from the Educause Center for Analysis and Research found that 99% of post-secondary institutions have an LMS in place.

Technological innovations are also enabling better tracking of curriculum. Many universities, as well as companies, have adopted learning management systems which allow students to take a self-paced module. Watson et al. (2001) explained that computer technology enabled the University of New South Wales to develop a web-based curriculum management system for medical students that integrated outcomes, content, activities, and assessment into one system. Popular learning management systems can track assessment data and link data to specific outcomes or standards. The tracking of assessment data is an essential component of any modular learning environment.

The Research Team's Approach

For curriculum design, sound methodological processes are critical because they add structure and consistency. Several systemic methods exist (Dick, Carey & Carey, 2009; Morrison, Ross, Kalman, & Kemp, 2013; Seels & Glasgow, 1998; Smith and Ragan, 1999; Wallace, 2001). These practices are grounded in the notion that stakeholders need to play an active role in the process. After reviewing the literature, several approaches were aligned with the scope of this project. The project team used a hybrid approach that integrated systems approach, ADDIE, and Wallace's PACT model. Specifically, the team focused their efforts on Job Task Analysis and Curriculum Architecture, as defined by Wallace, as necessary predecessors to Modular Curriculum Development.

12. PROPOSED CURRICULUM ARCHITECTURE DESIGN

ATO curriculum would benefit from the implementation of a **stackable credentialing system** that could be tracked across the FAA curriculum platform. Stackable credentials are a sequence of discrete qualification that accrue towards advanced qualifications on a career path. For example, the current system does not allow for comprehensive tracking of the skills of each FAA Air Traffic

Controller. Additionally, there are redundancies within the curriculum architecture that could be eliminated by a credentialing system with comprehensive tracking of skills.

Taxonomy of FAA ATO Academy and Shared Academy Task Statements

Identifying the levels of learning (taxonomy) of the task statements is a critical first step in determining the feasibility of modularizing FAA ATO's curriculum. WMU & ERAU team members have analyzed the ATO Academy and Shared Academy task statements in two ways to identify areas that lend themselves to modularity. Figure A shows the cognition levels (learning taxonomy) associated with the task statements. The findings demonstrate that the majority of the curriculum (57.6%) falls within the Application level of learning. This would make sense as the job of air traffic control requires the application of the knowledge, not just the remembering and understanding of it. However, because the job is routinized and standardized, very few of the tasks were identified as higher levels of learning (Creating and Evaluating – 9.1%). This too makes rational sense since the creation of new knowledge is not a requirement of the job of air traffic control. Overall the findings show that 85.5% of the job of Air Traffic focus on the lower levels of learning (Remembering, Understanding, and Application). This finding suggests that the modularization of the curriculum is feasible and potentially beneficial since the development of curriculum that touches on the higher levels of learning is rarely required. See Figure 1 for a graphical representation.

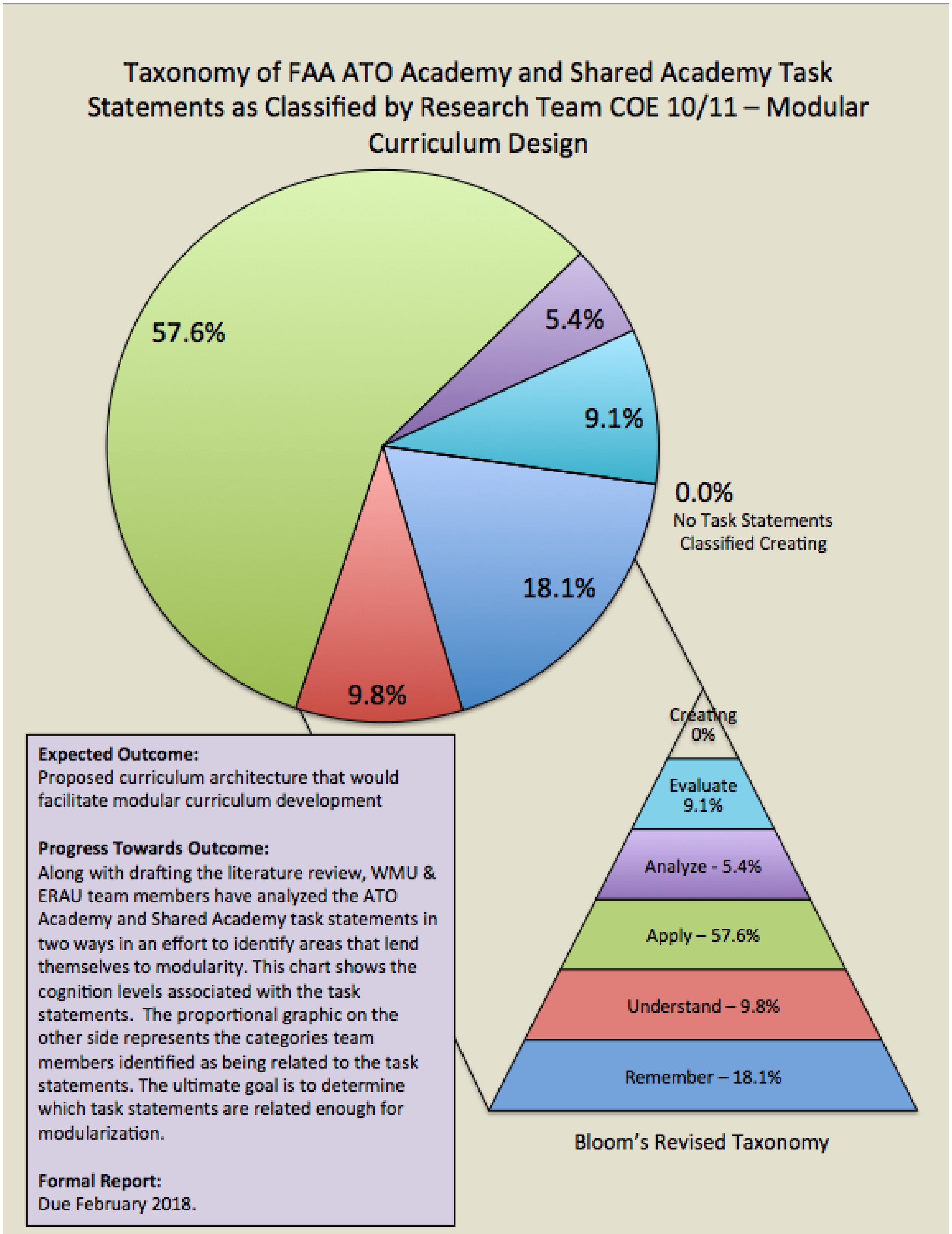

Figure 1. Bloom's Taxonomy level of task statements, as classified by the research team.

The proportional graphic found in Figure 2 represents the topical categories team members identified as being related to the task statements. The ultimate goal of this analysis was to determine which task statements are related enough for modularization. The findings show that 25% of the task statements relate to Communication. Navigation is the second category with the most related task statements (18.4%). While any task or curriculum could be modularized, these two categories have the best opportunity for modularization. Furthermore, these categories should be further examined to determine if these task statements show up in more than one course.

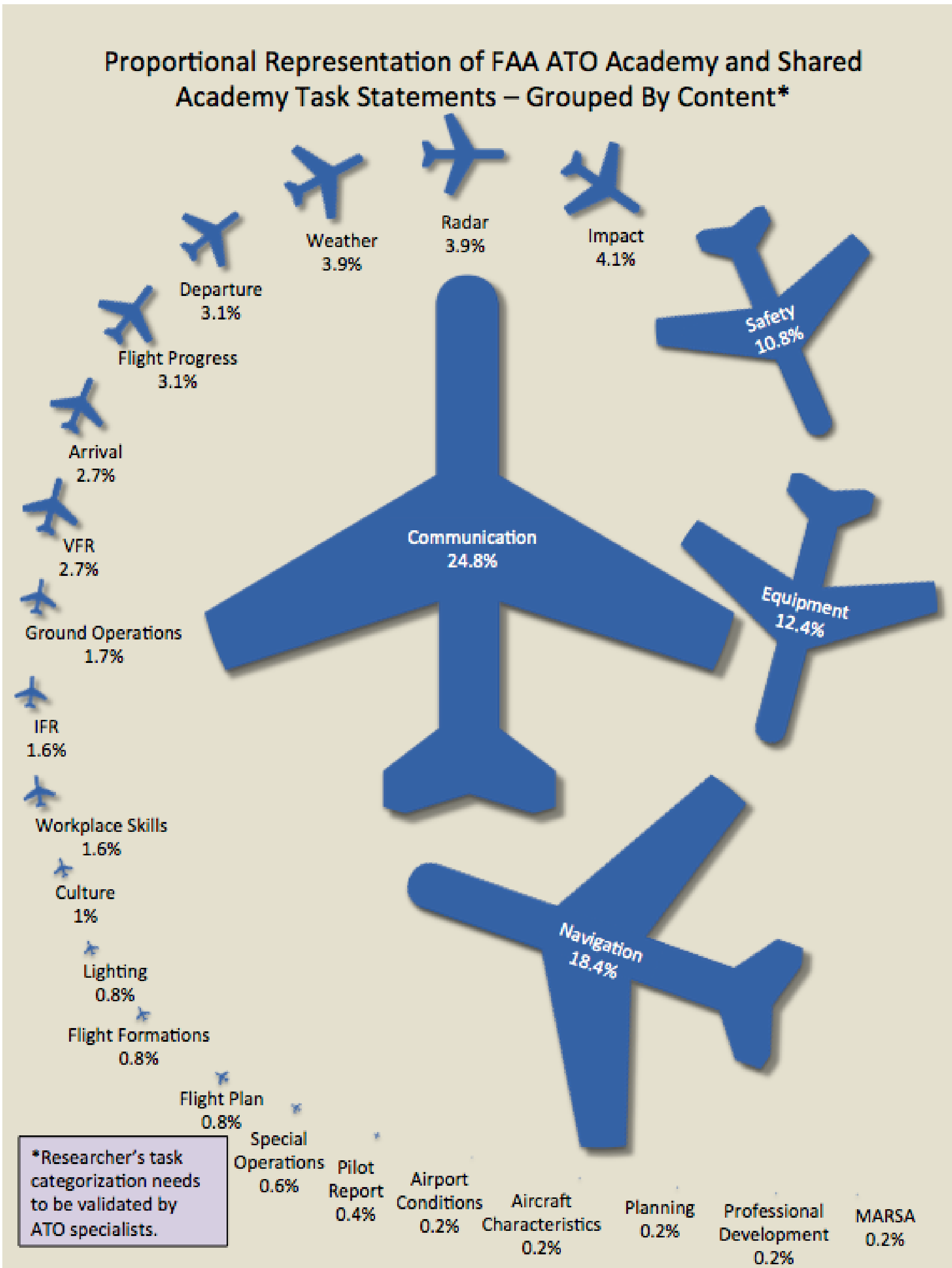

Figure 2. Proportional representation of task statements, by category.

13. RECOMMENDATIONS

The project team conducted a comprehensive literature review; collected, reviewed, analyzed and assessed the current curriculum architecture and processes as codified in hundreds of ATO training documents; and discussed ideas, potential findings, and possible recommendations with ATO technical training representatives. Through this comprehensive process, the team presents the following recommendations and rationale for a curriculum architecture that enables the FAA to begin the transition to a modular curriculum approach.

Course Design Guides

Course Design Guides (CDG) are currently used to help the course developer organize essential elements of the curriculum. CDGs are considered a living document and have evolved over various iterations. The current process requires CDGs for every course developed. This is the case even when the FAA utilizes a vendor to design the course (FAA, 2017). However, a thorough analysis of 45 randomly chosen CDGs found that many courses did not have CDGs or had incomplete CDGs written in different levels of detail. For example, some courses with completed CDGs were missing course objectives, performance criteria, and/or proposed methods of assessment. The team believes it is imperative that the CDGs are completed for each course since the information in the CDGs will be entered into the proposed JETS database (see Knowledge Tracking Database section). Additionally, the CDG needs to be updated to include a Curriculum Evaluation Frequency Scale (CEFS) (see CEFS section). Lastly, the completion of a CDG by a course designer and then approval by the Instructional Design Lead ensures the course or module has been developed using necessary instructional design strategies and techniques. While not a central component to modularity, a thorough CDG outlines the elements needed to support modular curriculum.

Content Delivery

The team suggests that content is delivered in a modular form rather than by courses. Many K-12, higher education, and technical trade groups have transitioned or are currently transitioning to modular curricula. These institutions have found value in this shift due to decreased redundancies and increased application of the curriculum. Furthermore, the transition to modular curriculum has been aided by improved efficiencies in Learning Management Systems (LMS).

Currently, the ATO FAA curriculum is predominantly organized by courses. Therefore, implementing modular curriculum would represent a significant shift in the current approach to content delivery. By nature, developing content that is delivered via a course creates the potential for learners to be exposed to content that is duplicative to what they already know. In talking with FAA staff, it became clear that some courses contain content that learners viewed as duplicative with what they had already learned in previous courses. This could be because course designers never know exactly where to begin and end the content of a course. Additionally, the course designers might not have insight into the content of other FAA ATO courses.

By contrast, modules cover a narrow scope of content, typically linked to a specific job task(s). Designing modules allows instructional designers to give each learner exactly what they need, as opposed to courses, which have content that may be grouped arbitrarily based on past precedent or instructional designers understanding of the entire FAA ATO curriculum. Therefore, there is less chance for redundant curriculum. When a course designer is asked to develop a module that covers a specific set of job tasks that is their primary goal. Because modules are finite, it is easier to develop a course that utilizes a series of separately developed modules. Additionally, modular instruction links retraining to job tasks rather than courses. Therefore, if participants need retraining on specific job tasks, they would not need to take an in-person course; instead, they would complete the module attached to particular job tasks.

Mandatory Course Components

Whether the FAA decides to introduce the concept of modular curriculum into their course delivery or not, specific course components should be included for a course to be grounded in best practices of instruction. More specifically, at a minimum, our team recommends that all courses have the following components - assessment strategies, enabling objectives, terminal objectives, and instructional methods. First, all three are essential because they standardize expected outcomes for course participants. Additionally, clearly outlining these course components enable multiple instructors to teach a course with consistent participant outcomes. More specifically, assessment strategies are critical because every course should utilize a valid and defensible measure of a participant's mastery of the curriculum. Terminal and enabling objectives are often linked to standards and specifically dictate how a learner shows evidence of mastery of the curriculum. Lastly, allowing instructional methods to be determined by instructional designers, rather than left up to individual instructors, will ensure that courses are delivered as intended.

Regarding modularity, the components above are required for the FAA to determine which learners have demonstrated mastery over each specific task/objective/competency. Furthermore, entering this information into a trackable, comprehensive database such as the JETS database (see JETS section) would enable the FAA to answer questions such as:

1. What skills do certain FAA employees possess?
2. How competent are employees in a specific skill, as proven by a valid and defensible assessment?
3. What courses does an employee need to take if they need reinforcement in a particular job task/objective/competency?

Employee Development

In every career, employees must go through some form or method of content knowledge remediation. Given the responsibility of an air traffic controller's position, employee retraining and development is critically important. Currently, participant content knowledge remediation is completed within the field, but not formally tracked. Additionally, there are no formal remediation efforts that occur after a participant has completed a course. Therefore, the team proposes a formalized content remediation process where SMEs and instructional designers define required proficiency levels, as well as, timelines for remediation.

At the present state, employee retraining and development is difficult to track and costly. In a future modular state, employee retraining could be less expensive and much more efficient, saving travel and employee downtime costs. This is in part because employees could be directed to a particular module that is narrow in scope and thus customized to the specific training that employee needs. Furthermore, in this proposed future state, the FAA will already possess valid and defensible assessment data from an employee's last training session. This data could be used to guide future training timelines.

Standard Indicators of Mastery

Institutions and organizations that do in-house training and assessment have standard grading criteria (usually), to include standard assessment definitions. For example, many organizations might utilize a one hundred point scale in all courses and training modules. Additionally, they may have standard delineations between proficiency levels. Within this context, instructional designers and SMEs would still have the flexibility to define proficiency levels. In other words, the standard scale used for all modules may be a 1 to 5 scale, but the instructional designers can determine what assessment outcomes merit a 1,2,3,4 or 5.

In the team's analysis of CDGs, it was clear that there wasn't a standard set of grading criteria utilized across all courses. Additionally, through conversations with FAA staff, it was mentioned that some courses do not have any indicators of mastery other than the receipt of course materials. Although this might be appropriate based on the expedient need for the curriculum, the team suggest a best practice would be that SMEs, working in partnership with instructional designers, define mastery for each course or module that is developed using standard grading criteria.

In terms of modularity, having a standard grading language will allow for different assessment types to be able to deem an employee competent. For example, an employee may master a competency in a course while another employee may master the same competency through on the job training. However, using a common grading language, the agreed upon grading criteria would deem both of these employees equally proficient in the given competency. It is important to note that the team is not suggesting that this recommendation take away from the SMEs' or the instructional designers' ability to determine the indicators of proficiency but to merely use common grading language across the entire FAA ATO curriculum.

Assessment Analysis

Currently, there are a variety of assessment types utilized throughout the ATO coursework. The team found everything from multiple-choice assessments to hands-on simulations. Additionally, the team was made aware that some courses do not have an actual assessment other than the transference of coursework to a participant. The team strongly suggests that all current and future assessments be analyzed to ensure that they are producing valid and defensible results.

In a future state where the FAA ATO curriculum was comprised entirely of valid and defensible assessments for every course or module, the FAA would be able to identify candidates for retraining as well as offer verifiable credentials based on completion of particular course(s) or module(s). This suggestion would also prevent a participant from 'slipping through the cracks' due to inadequate testing. Furthermore, having a robust assessment system would enable the FAA to do more formative methods of assessment that could help identify when a participant would benefit from additional training. In other words, valid and defensible assessments would enable the FAA to be proactive rather than reactive.

If needed, the team is interested in assisting the FAA ATO staff in analyzing their current assessments for validity and defensibility.

Course Approval

The team has reviewed the Safety and Technical Training Standard Operating Procedure manual and suggests that the FAA fully implements these intensive procedures. However, to aid in the transition to modular curriculum, the team suggests that they add procedures for considering what courses or curriculum elements would be better delivered as modules. These procedures would help implement an organization shift where FAA employees begin to view training in a modular context.

Course Prerequisite

Currently, course prerequisites are defined through the courses that participants have previously taken before enrolling in another course, among other things. Instead, the team suggests that prerequisites be defined as competencies rather than courses. This would allow for employees to demonstrate, in multiple ways, their knowledge of the prerequisite content before taking the desired course. For example, an employee might be able to take an advanced level course based on their demonstrated skills and experience instead of being required to take the prerequisite course. For this idea to work, the competencies/task/standards that embody the current FAA ATO courses would need to be identified, if they haven't already. These competencies would then serve as the prerequisites for other courses. As mentioned earlier, the demonstrations of prior knowledge would need to be approved by the FAA as valid and defensible alternative assessments. The idea of prerequisites that are based on competencies rather than courses is the crux of a modular curriculum.

Course to Module Conversion Protocol

The team suggests the development of a conversion protocol document to help SMEs and instructional designers convert existing courses to modules. This written protocol would detail the concept of modular curriculum as well as the steps necessary to dissect a course and identify its modular components. As a result of implementing this protocol, each course would be broken down into its parts. A comparison can be made with other courses that go through this protocol. This process would enable the FAA to identify redundancies within these analyzed courses. Additionally, the end product of this protocol process would be the building blocks of potential modules.

If needed, the team is interested in assisting the FAA ATO staff with developing the protocol.

Curriculum Evaluation Frequency Scale (CEFS)

The curriculum development process is a continual one that requires frequent review of current courses and modules. Therefore, the team proposes that a curriculum evaluation frequency scale (CEFS) be developed and then added to the CDG guide. This scale would allow the instructional designers and SMEs to rate the content of each course and module on its need for revision. The team proposes the CEFS consider factors such as frequency of delivery, risk to safety, technological changes, and other factors identified by SMEs and instructional designers. Content that is rated high on the scale would need to be examined more often for content validity. The data from this scale would help the FAA training personnel prioritize their course updating process. The creation of the CEFS would allow for retroactive analysis of FAA courses to identify areas where updates are needed.

If needed, the team is interested in assisting the FAA ATO staff in developing the CEFS.

Stackable Credentials

To recognize the work FAA personnel put into furthering their education, a credentialing system would be developed that would highlight the completion of courses/modules and proficiency in job tasks. The credentialing system would utilize the JETS database (see below) to track employees' progress towards future credentials. For more information about this concept, please refer to the team's year two proposal (Appendix A).

Job Expertise Tracking System (JETS)

The team suggests the development of a comprehensive database that is designed from the ground up with modularity in mind. The proposed name of the database is the Job Expertise Tracking System (JETS). The JETS database would facilitate a move to modularity of current and future course content. Additionally, it would be the central educational tracking system for ATO employees. In other words, the database would enable the FAA to identify and track the educational path of each ATO employee. Our interviews suggested that training is currently tracked in numerous electronic and physical locations. Also, the JETS database would allow the FAA to monitor when course remediation or relearning would need to occur. Lastly, the JETS database would allow searches of employee knowledge by job task across all training requirements, which is an essential component of modularity.

CONSOLIDATED RECOMMENDATIONS

Course Design Guides	Complete Course Design Guide (CDG) for each course. Update CDG to include Curriculum Evaluation Frequency Scale (CEFS). Ensure Instructional Design Lead (IDL) approves each CDG. Ensure IDL checks for adherence to instructional design strategies and techniques.
Content Delivery	Deliver content in modular form rather than by course. Use modules for narrow scope of content, linked to a discrete job task or minimal set of job tasks. Remove redundant curriculum. Develop content using a series of connected modules to meet learning objectives. Link retraining to job tasks instead of courses.
Mandatory Course Components	Modularity requires that specific components of courses be mandatory for all newly developed courses. All courses have the following components - assessment strategies, enabling objectives, terminal objectives, instructional methods, and target audiences. Enter required components as variables in proposed JETS database.
Content Remediation	Formalize content remediation process. Use SMEs to define required proficiency levels and timelines for remediation.
Andragogy Expert	Use andragogy (adult learning) expert to review stages of new course development, creation, and approval. Consider the andragogy expert for the role of instructional design lead or as a consultant to the course/module design process.
Indicators of Mastery	Use SMEs to determine course/module mastery for all modules. Develop standardized grading criteria with similar scales between course/modules.
Assessment Analysis	Analyze current and future assessments to ensure validity and defensibility.
Course Approval	Develop new procedures to consider/determine what courses or curriculum elements to first deliver as modules to help build a culture that supports modularity. Ensure andragogy expertise in each step of course approval process.

Course Prerequisites	Define prerequisites as job tasks or competencies rather than courses to enable a shift to modularity.
Course to Module Conversion Protocol	Develop and implement conversion protocol to help SMEs and course developers convert existing courses to modules.
Curriculum Evaluation Frequency Scale (CEFS)	Develop a curriculum evaluation frequency scale (CEFS) to add to the CDG guide. Enlist content developers and SMEs to rate the content of each course on its need for revision. Include factors such as frequency of delivery, risk to safety, technological changes, and other factors identified by SMEs. Develop new processes for CEFS rating to prioritize redevelopment and updates.
Stackable Credentials	Develop and implement a stackable credentialing system to include the complete training record for every employee. Develop new systems, processes, and practices to make full use of a stackable credentialing system.
Knowledge Tracking Database	Develop and deploy a comprehensive database proposed as Job Expertise Tracking System (JETS). Use JETS database to enable modularity of current and future course content. Use JETS to centralize all training and education related processes.

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Appendix A

Stackable Credentialing System Proposal

Statement of Work

Center of Excellence for Technical Training and Human Performance

1. **Title:**
   Stackable Credentialing System (SCS)

2. **Description:**

   The researchers plan to investigate commercially available credentialing systems and research the feasibility of implementing them within the ATO curriculum. The final outcome will be a comprehensive list of characteristics and requirements leading to a credentialing system that would work most efficiently and effectively for the ATO's unique curricular needs.

3. **Justification:**

   From the previous grant, the researchers will have developed a future state enabling modularization of the FAA Air Traffic Controller curriculum. One of the findings from the analysis is that the curriculum would benefit from the implementation of a stackable credentialing system that can be tracked across the FAA curriculum platform. For example, the current system does not allow for comprehensive tracking of the skills of each FAA Air Traffic Controller. Additionally, there are redundancies within the curriculum architecture that could be eliminated by a credentialing system with comprehensive tracking of skills.

4. **Investigation Team: *Note: this is just a list of the members and their organization**

   4.1. University Team:

   Dr. Daryl Watkins, Principal Investigator, Embry-Riddle Aeronautical University

   Dr. Matthew Earnhardt, Co-Investigator, Embry-Riddle Aeronautical University

   Graduate Researchers, Embry-Riddle Aeronautical University

   Dr. Adam Manley, Principal Investigator, Western Michigan University

   Charles Bruce, Co-Investigator, Western Michigan University

   Graduate Researcher, Western Michigan University

   4.2. FAA Sponsor:

   Greta Ballentine

4.3. FAA Technical Monitor:

Jay Bachrach

4.4. Industry Partner(s):

Addx Corp. – Mr. David Stach; Ms. Melissa Arellano

Eduworks – Dr. Benjamin Bell

5. Suggested Research Approach:

We propose a qualitative research design that will be fully determined with FAA leadership. See task descriptions.

5.1. Goals & Objectives:

The goal is to help the ATO determine an efficient and effective curriculum system that will meet their needs.

Objective 1: Map current available credentialing systems that fit FAA unique needs
Objective 2: Investigate implementation of credentialing system
Objective 3: Provide criteria for FAA credentialing system

6. Deliverables:

a) Literature Review of Current Stackable Credentialing Systems
b) Report highlighting the results of internal examination of implementation of credentialing system
c) Final report of findings with recommended characteristics and requirements of a customized FAA credentialing system

7. Research Timeline and Milestones:

Task 1 – Research Current Stackable Credentialing Systems

<u>Timeframe</u> – September 1 to February 28

<u>Task Description</u> – The researchers plan to review current stackable credentialing systems in place at large institutions and organizations. The researchers plan to focus on large institutions with scalable systems. The review will comprise an examination of commercially available as well as customized credentialing systems. Additionally, the researchers plan to interview curriculum trainers and organizers that are operating current credentialing systems in large organizations to determine the benefits and risks involved with implementing these systems.

<u>Deliverable</u> – Literature Review of Current Stackable Credentialing Systems

Task 2 – Investigating Implementation of a Credentialing System within the FAA

Timeframe –March 1 to June 30

Task Description – The researchers will interview FAA curriculum designers and technical trainers to determine the characteristics of a credentialing system they believe would be most beneficial to the FAA's curriculum. Additionally, the researchers will validate the findings with a separate group of training experts within the FAA via an electronic survey.

Deliverable – Report highlighting the results of internal examination of implementation of credentialing system.

Task 3 – Generate List of Criteria for FAA Credentialing System

Timeframe – July 1 to August 31

Task Description – The researchers will synthesize the information from Task 1 and 2 into a report highlighting the general criteria needed for the implementation of a trackable credentialing system. The report will include a recommendation of existing credentialing systems as well as a list of characteristics and requirements that would be most beneficial for the FAA. The outcome of this task would be to provide the FAA with information necessary to produce a Request for Proposal (RFP) to a credentialing system vendor (if deemed necessary).

Deliverable – Final report of findings with recommended characteristics and requirements of a customized FAA credentialing system.

Milestone	Planned Due Date
Task 1: Literature Review Complete	February 28, 2018
Task 2: Implementation Considerations Report Complete	June 30, 2018
Task 3: Criteria List Complete	August 31, 2018

8. Budget and Cost Match Commitment:

	FAA Contribution	University Cost Share	Total
ERAU	$ 42,108.50	$ 32,108.50	$ 74,217.00
WMU	$ 79,391.85	$ 60,830.25	$ 140,222.10
WMU Match Carry-over		$ 8,561.60	
Addx.		$ 5,000.00	$ 5,000.00
Eduworks	$ 35,000.00	$ 50,000.00	$ 85,000.00
Total Budget	$ 156,500.35	$ 156,500.35	$ 304,439.10

9. Research Team Experience and Roles:

Dr. Watkins is the Associate Dean of the ERAU-Worldwide College of Business and a tenured Associate Professor of Leadership. He has a Doctorate of Management in Organizational Leadership and holds certifications in project management, grant writing, organization development, and coaching. He is P.I. on COE-11 Grant for Modular Curriculum Design.

Dr. Earnhardt is the Department Chair of Organizational Leadership for ERAU-WW. He holds a Ph.D. in Organizational Leadership. He has a background in the intelligence field and is a consultant in organization development. He holds certifications as an MBTI practitioner and grant writer. He is C.I. on the COE-11 Grant for Modular Curriculum Design.

Dr. Manley is an Associate Professor of Career and Technical Education at Western Michigan University. He earned a Ph.D. in Career and Technical Education from Virginia Tech; a Master's of Career and Technical Education and a Bachelor of Business Education from Ferris State University. Dr. Manley currently teaches pedagogical courses related to curriculum development and teacher education. Dr. Manley's research is in the areas of competency and task development, standards development, gap analysis, and defining operational infrastructures. He has extensive knowledge of the DACUM, Turbo DACUM, and Delphi Methodologies. Utilizing these methodologies, Dr. Manley has worked with a variety of industry partners such as Boeing to develop curriculum and written/performance assessments related to certain job sets. He is P.I. on COE-10 Grant for Modular Curriculum Design.

Mr. Bruce completed his Master of Arts in Career and Technical Education from Western Michigan University in December 2012. He also received his undergraduate Bachelor of Business Administration degree from Western Michigan University with a major in Finance in June, 2011. Mr. Bruce currently teaches courses related to technical curriculum development, teaching methods, and instructional technology. Mr. Bruce's research interests include teacher retention, technical curriculum design, project-based instructional methods, and emerging instructional technology. Prior to his teaching career, Mr. Bruce held roles in corporate finance focusing on asset management, cash-flow forecasting, and global risk management. He is C.I. on COE-10 Grant for Modular Curriculum Design.