RT 167: Developing Systems Engineering Experience Accelerator (SEEA) Prototype and Roadmap – Increment 4

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Executive Summary

The Department of Defense faces many challenges related to deploying new systems to meet the needs of the warfighter. Among these are compressed development times and increased required capabilities. There is a real need for systems engineering expertise in the acquisition enterprise to guide the technical design, development, integration and testing of such systems.

At the same time, there is a potential skills gap due to an aging workforce, many of whom are near retirement, and the experience development curve needed to bring new talent up-to-speed. Often this experience development takes many years and spans multiple programs. The idea behind the Systems Engineering Experience Accelerator (SEEA) is to accelerate the experience development so that new talent can become proficient much more quickly to meet DoD needs. This is done by using educational technology, and specifically the notion of role-playing in immersive environments where a learner not only leans the technical skills associated with a systems engineering position, but also critical skills in persuasion and decision-making needed to deploy technical skills effectively.

The original SEEA was developed to let the learner play the role of a chief systems engineer in an acquisition program for a new unmanned aerial vehicle (UAV) system. It was based on the concept of the learners assuming this role shortly after preliminary design review (PDR) and seeing it through until after the start of low-rate initial production (LRIP). The experience was the focus of an initial implementation. However, subsequent work focused only on the first part of the experience, the time from the PDR until the critical design review (CDR).

This project has taken the UAV experience and improved it substantially in a number of areas in preparation for its use in the Defense Acquisition University curriculum for systems engineers. First, several new capabilities have been added. These include a trade study for additional technical content, system reliability as a key performance parameter, and technical debt to allow the learner to see the effect of deferred work. Second, a number of improvements have been made to the experience. Most importantly, the experience lifecycle has been updated so that the work completed earlier to improve the PDR-to-CDR portion of the experience has been done to improve the remaining parts of the experience. Third, the SEEA application has been made compliant with federal law on accessibility for disabled employees and others. Fourth, the research hypothesis that the SEEA can accelerate learning in systems engineering has been tested via its use. Finally, support has been provided for deployment at DAU.

INTRODUCTION

Recent years have seen numerous applications of educational technology in a variety of domains. One such application involves the immersion of the learner in a simulated environment where lessons from a particular domain are taught. This approach is called computer-based experiential learning. The advantage of such an approach is that it not only teaches the material of interest, but it also provides a context for the learner to apply the new knowledge, thus facilitating skill development and potentially promoting interest in learning. This type of approach has advantages over traditional on-the-job training, as well. For instance, the learner can be allowed to learn lessons from failure with little adverse consequence. In addition, once the educational technology platform is available, it can be used for such training at relatively little expense.

Systems engineering includes knowledge from a variety of disciplines. It is not until this knowledge is put into practice in an integrated, real world environment that a systems engineer can develop the necessary insights and wisdom to become proficient. In the workplace, these learning events are often distributed sparsely over time such that an engineer may only see a complete system life cycle over a period of several years. As a result, the maturation time from completion of formal studies to becoming seasoned systems engineer is unacceptably long, particularly when contrasted with the clock speeds of today's society in which career change is the norm rather than the exception. Educational technologies hold the promise of providing customized learning exercises based on real-world situations to reduce the reliance on extensive on-the-job training that is the hallmark of current workforce development. The references section of this report includes numerous research efforts that explore the benefits of educational technology.

These benefits of educational technology motivated the design and development of the Systems Engineering Experience Accelerator (SEEA) as a means to accelerate the learning of systems engineers. The SEEA is a technology platform that promotes learning in cycles, similar to the Kolb learning cycle (Kolb, 1994). The learner is presented with a situation. Then he or she investigates issues to determine problems and root causes. The learner can make decisions or recommendations to address the problems, and those are input to the simulated world. The simulated world advances to a new state based on its trajectory and the learner decisions, and the learner can see the impact of those decisions. A new cycle then starts. The SEEA supports single-learner and multi-learner modes, along with varying degrees of instructor and mentor interaction.

Along with the SEEA technology platform, an initial experience was designed and developed. In this experience, the learner plays the role of a chief engineer in a program that is developing a new unmanned aerial vehicle (UAV) system. The learner assumes this role shortly after the program has completed what appears to be a successful preliminary design review (PDR). The learner is tasked with identifying and correcting issues in the program so that it operates on schedule and within budget, and so that the system meets the technical requirements specified for key performance parameters and technical performance measures with the desired quality level. The experience lasts for several phases corresponding to phases in a DoD acquisition program, with each phase culminating in a milestone review. The last phase in the experience is low-rate initial production, where the learner sees the results of the program design and development work.

The experience was initially prototyped and demonstrated at Defense Acquisition University. Subsequent work then focused on the acquisition phase lasting from preliminary design review to critical design review. This project extends the work done on that particular phase of the UAV experience in a number of ways. The UAV experience is given new features and capabilities, and the work done on the PDR-to-CDR phase is extended to the remaining phases. The experience has also been upgraded so that it complies with the Section 508 Amendment to the Rehabilitation Act of 1973. This law states that federal agencies must give disabled employees and members of the public access to information that is comparable to the access available to others. Finally, learning evaluation and deployment of the SEEA at DAU are addressed.

The remainder of this report is organized as follows. The research overview summarizes the goals to be achieved by the research, describes the baseline SEEA experience developed previously, and outlines the tasks performed in this project. Then each task is discussed in detail along with the approach taken and the results. These include new experience capabilities, new experience features, Section 508 compliance, validation of the research hypothesis, and support for deployment of the SEEA. Finally, the conclusions and future research are presented.

RESEARCH OVERVIEW

This project addresses fundamental issues in the effectiveness of systems engineering education and training in meeting DoD and societal needs in the area of complex systems design development. This section discusses the project goals, a background of the existing SEEA, and the tasks performed in the project to advance the SEEA and prepare it for usage.

RESEARCH GOALS

Problem Statement: Traditional Systems Engineering (SE) education is not adequate to meet the emerging challenges posed by ever increasing Systems and Societal demands, the workforce called upon to meet them and the timeframe in which these challenges need to be addressed.

Program Goal: Transform the education of SE by creating a new paradigm capable of halving the time to mature a senior SE while providing the skills necessary to address emerging system's challenges.

The education of Systems Engineering needs to be transformed to prevent obsolescence and maintain relevancy. We postulate that the new paradigm must be:

- ***Experience Based:*** Providing accelerated learning opportunities through experience-based interactive sessions (Kolb, 1984).

- ***Agile:*** Allowing for quality, timely development of course material that is most appropriate for the target students.
- ***Integrated:*** Provides an integration point of multi-disciplinary skills and a wide range of Systems Engineering knowledge in a setting that recreates the essential characteristics of the practicing environment.
- ***Lean:*** Providing the greatest amount of benefits with the minimal number of steps and least amount of effort.
- ***Leveraged:*** Enabling capability growth through the leveraging of computational and information technologies, and prior Systems work.
- ***Extensible:*** Providing the capability to expand and enhance capabilities for future growth without having to make major changes in the infrastructure.
- ***Implementable:*** Enabling widespread impact through economically viable, rapid development and deployment of educational and training programs for participants with multiple levels of competence and background.

The high-level goals for this program are two-fold. First, the results of this research should result in the creation of a new means of maturing Systems Engineers in substantially less time than normally required to reach a senior level of experience. It is believed that creating new experience-based training, which is integrated with and complements more traditional means of knowledge acquisition, will be necessary to achieve this goal. Secondly, this research should provide the means by which these results can be obtained in an economically attractive manner.

EXISTING SEEA PROTOTYPE

The SEEA was designed and developed in a series of previous projects. This work created the technology platform, as well as an initial experience focused on the design and development of a new unmanned aerial vehicle system.

The SEEA technology provides a graphical user interface allowing the learner to see the program status, interact with non-player characters to gain additional program information, and make technical decisions to correct problems. It also provides the capability to simulate the program into the future based on these learner decisions, so that outcomes can be shown to the learner. This cycle of decision and simulation-into-the-future supports the Kolb cycle of experiential learning; the Experience Accelerator uses multiple such cycles operating through the lifecycle of the program. In particular, this approach allows illustration of the effect of upstream decisions on downstream outcomes in the system lifecycle. The SEEA can support a wide variety of systems domains and areas of expertise through changes to the experience. Multi-player technology has been developed to allow live player support for team-based learning, as well as for an instructor and mentor to provide advice and feedback. The SEEA contains a number of inter-connected modules as shown in Figure 1.

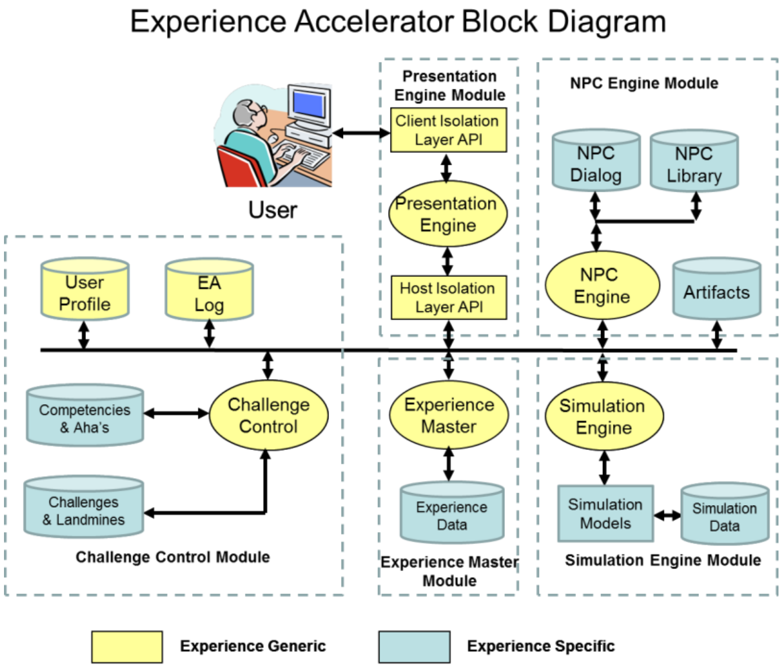


Figure 1. SEEA architecture

- **Experience Master:** contains the overall Experience state and provides control and sequencing for the other major EA modules.
- **Challenge Control:** contains the Learner profiles and Experience history logs and leverages these in conjunction with the competency taxonomy and 'Aha' moments (i.e., generic lessons that successful and experienced systems engineers would know, such as seemingly unimportant upstream decisions can have major negative downstream ramifications) to determine the appropriate challenges and landmines for each Learner.
- **Simulation Engine:** determines the future state of the system and outputs to be presented to the Learner.
- **Non-Player Characters (NPC) Engine:** represents other non-player characters in the simulation and creates and assembles the content for Learner interactions, and
- **Presentation Engine:** accepts inputs from the Learner and provides the presentation of the Experience interface to the Learner.

The SEEA utilizes a cycle-based approach to learning, and it also supports multiple phases, each of which contain learning cycles. In an acquisition program, phases can correspond to the times in between major milestone reviews. Each phase a set of sub-phases and learning cycles. We can also consider each use of the experience by a learner as a high-level learning cycle. This concept is shown in Figure 2.

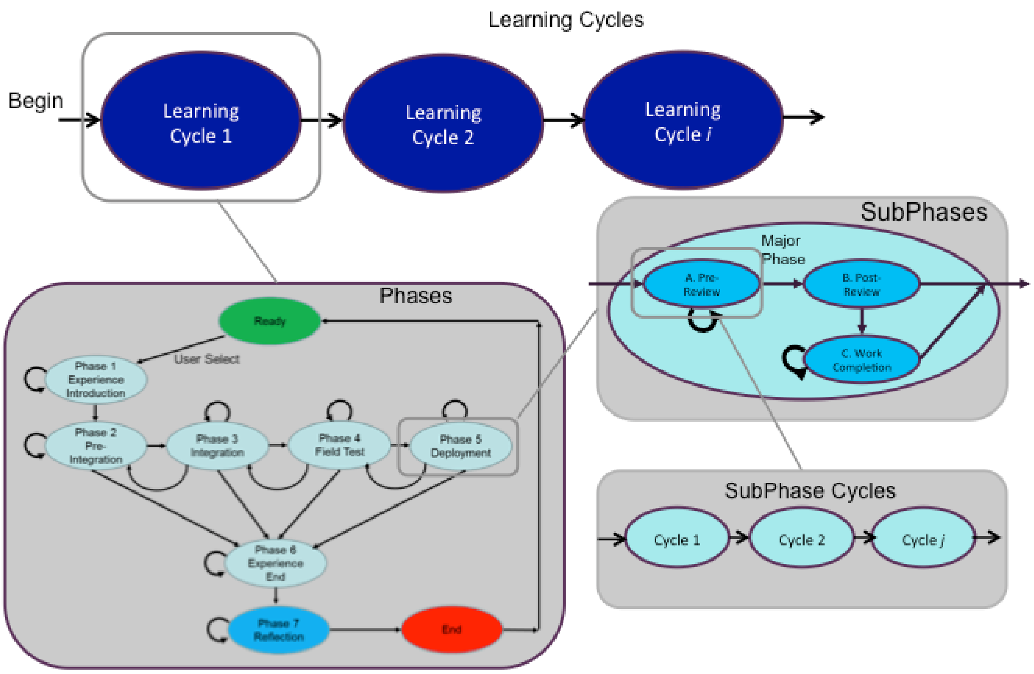


Figure 2. Learning cycles and phases

The UAV experience utilizes the phase and cycle approach, with phases shown in the Figure 3 overview of the UAV experience. The first two phases correspond to familiarization with the SEEA and introduction to the UAV exercise. In the new employee orientation, the learner assumes the role of the chief systems engineer of the UAV program. It has just passed PDR. The learner then goes through a pre-integration phase, culminating with critical design review. Next comes the integration phase, which ends with the flight readiness review (FRR). The field test phase is next, and it ends with the production readiness review (PRR). In the limited production/deployment phase, the learner sees the results of the acquisition program in terms of systems being produced in low-rate initial production. The experience ends with summary statistics, and in a reflection phase the learner is presented with his or her decisions throughout the experience compared to what are judged to be the correct/best decisions.

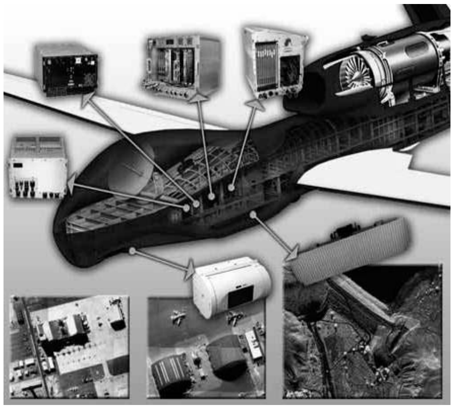
The UAV system is divided into three sub-systems being developed by different sub-contractors, plus a prime contractor overseeing the overall system design, development and integration. The three sub-systems are: the airframe & propulsion system, the command & control system, and the ground station system.

Context:

- Based on SME interviews and a systems dynamics model of large system acquisition and development
- **Complex experience** that covers the entire lifecycle

US DoD UAV System Acquisition:

- Prime Contractor – System
- Subsystem 1 – Airframe and Propulsion
- Subsystem 2 – Command and Control
- Subsystem 3 – Ground Support
- *Subcontract for each subsystem*



UAV KPMs:
Schedule, Quality, Range, Cost

Phases:

- EA Introduction
  - Phase 0: New Employee Orientation
- Experience Introduction
  - Phase 1: New Assignment Orientation
- Experience Body
  - Phase 2: Pre-integration System Development -> CDR
  - Phase 3: Integration -> FRR
  - Phase 4: Field Test -> PRR
  - Phase 5: Limited Production/Deployment
  - Phase 6: Experience End
- Experience Conclusion
  - Phase 7: Reflection

Figure 3. UAV experience overview

During the phases, the learner executes multiple learning cycles. Each cycle is characterized by a presentation of updates to the system state, followed by the learner making a set of recommendations bbto correct any perceived problems or issues. The SEEA provides a form into which the recommendations are placed. A recommendation may be in the form of a drag reduction program, for example, if the air vehicle's drag is too high. This recommendation would come with a target value for drag. The learner can make technical performance recommendations or programmatic decisions (hire additional engineering staff or shift resources).

These recommendations are fed into the simulation module, which is responsible for maintaining the state of the simulated world. This module implements a large-scale system dynamics simulation model to perform this function. The simulation module executes for a period of time, reflecting 3-6 months of the simulated world and allowing the learner's decisions to play out during the time. The learner then is presented with an updated state.

The learner may explore this state in two main ways. First, the simulation module produces a set of graphs that reflect the values of key performance measures that impact technical performance, cost and schedule. The learner may also interact with non-player characters, ask questions to them, and respond to their concerns. The NPCs use condition-based text dialog for simulated emails and phone conversations. The learner may select questions to ask on different topics from a menu, and the NPCs respond with dialog that incorporates the system state. For instance, if drag is a problem, the NPC's dialog would be customized to reflect that situation if the learner asks about drag, and the NPC may also provide clues about root causes or potential solutions. NPCs include the program manager, the lead systems engineer of the prime contractor, the previous chief engineer for the UAV program, a test & evaluation representative, and a mentor. The mentor provides guidance to the learner.

The learning cycle details are shown in Figure 4. The learner can explore the simulated world by viewing a chart (a chart for drag is shown), interacting with NPCs, or viewing the program dashboard which provides a high-level view of program status with respect to technical performance, cost, schedule and quality. Then the learner enters recommendations into the recommendation form. The recommendation form provides updated variable values to the simulation module, which executes and updates the simulated world.

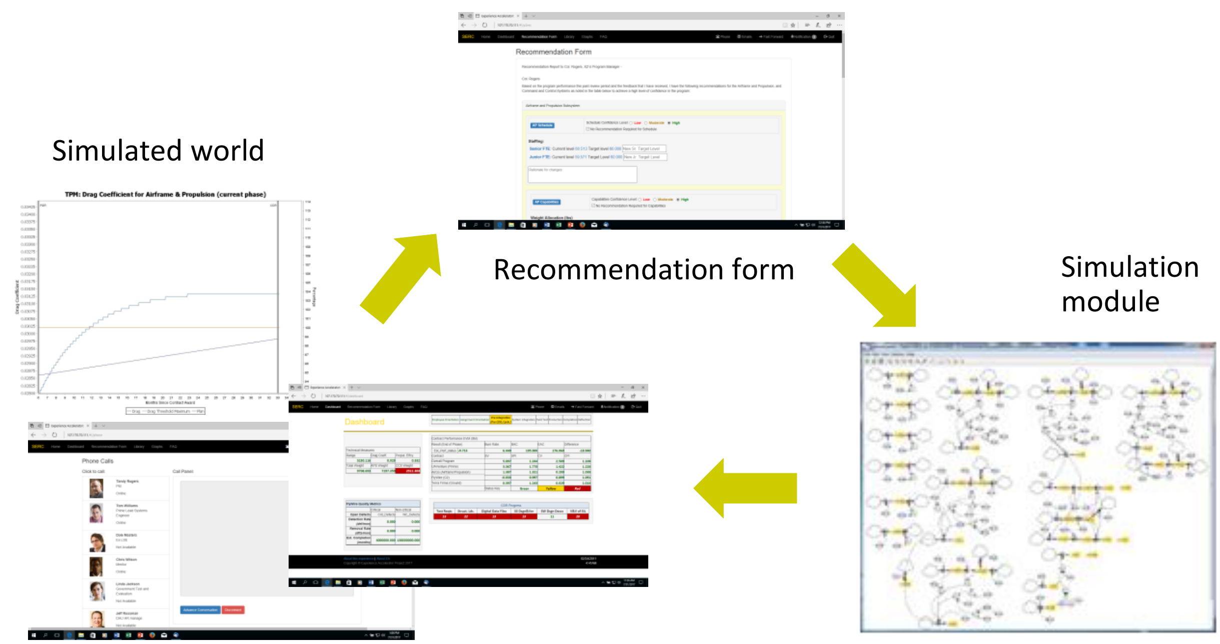


Figure 4. Learning cycle actions

The learner's score is assessed by how well technical performance, cost, schedule and quality metrics result at the end of the experience. If a poor job is done, it is possible that the learner will be terminated from the program.

The SEEA and the UAV experience have been used at Defense Acquisition University and the University of Alabama, Huntsville. The SEEA is implemented as a thin-client web application, which has newly been transitioned from Flash to HTML5. The learner needs only a browser to use the application which is discussed in the deployment guide section of this report. The HTML5-based login screen is depicted in Figure 5.

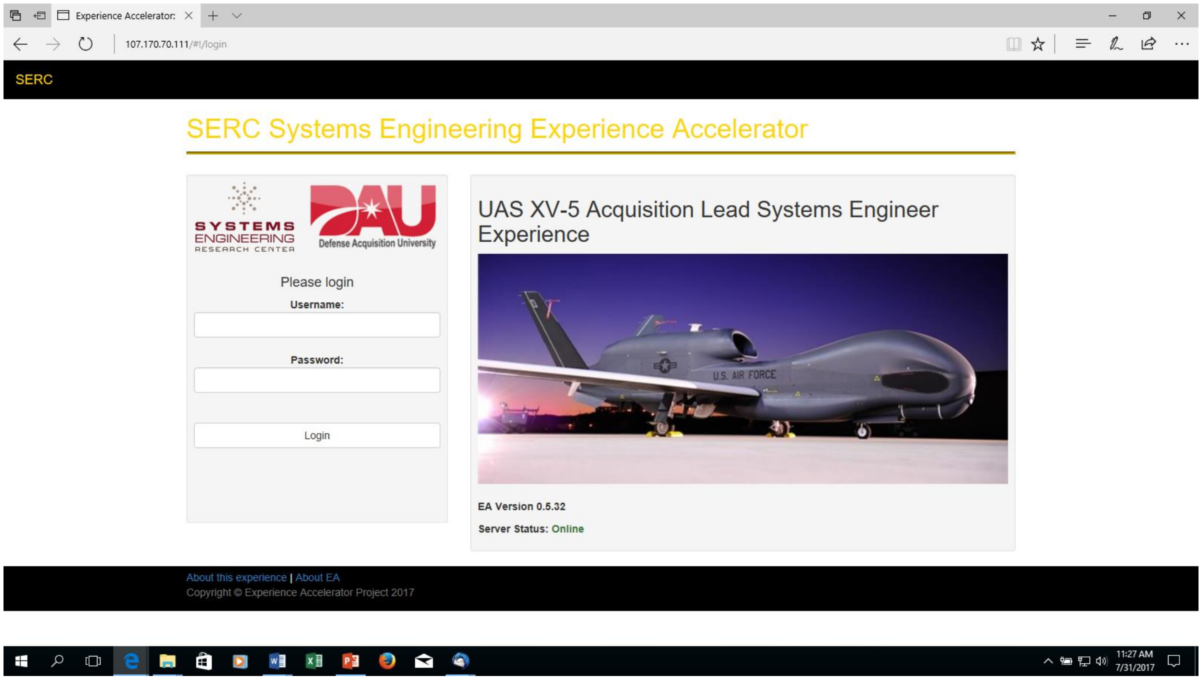


Figure 5. SEEA login screen

SUMMARY OF RESEARCH TASKS

In the prior increments, this research has established a concept and architecture for the SE Experience Accelerator, developed an evolving prototype, and piloted that prototype in DAU classes and industry workshops to refine the concepts and improve the implementation. The Experience Accelerator has continued to mature and now has a variety of capabilities that should support experiences in numerous domains and in several different single and multi-player modes. There is great potential for the EA technology, experiences and tools in a wide range of areas and domains.

The focus of Increment 4 is in four major areas. This first is to increase the scope of the SEEA beyond programmatics to include trade-studies which are a vital part of a systems engineer's job. The second is to improve the features and capabilities of the SEEA in a number of important areas. Some of these include updating the experience through initial production and the inclusion of technical debt and reliability. The third area is to validate the research hypothesis with an evaluation of the learning that occurs through SEEA use. Finally, there is the effort required to support the SEEA in the DAU environment. Below is a description of the work objectives in each area.

1. Task 1. New Experience Capabilities

The current DAU experience is primarily programmatic in its focus. However, systems engineers also need the capability to perform trade studies and make technical decisions. As such, these capabilities need to be added to enhance the current DAU experience to test the hypothesis in these areas. The following summarizes the new EA capabilities:

- T1.1: Add trade study and technical decision making activities. Introduce and validate new Actuation System Re-architecture (Fontaine Master's Thesis) trade study. Incorporate necessary artifacts, dialogs, and simulation capabilities (using new tools)
- T1.2: Add reliability KPP and add technical debt accumulated in one phase to be worked in the next phase.

2. Task 2. Experience Improvements

In addition to the new capabilities, a series of improvements in the current experience need to be made to ensure that the user of the EA can effectively learn the desired lessons. The current DAU experience can be extended in both scope and new capabilities. The experience was designed to support the UAV project from PDR to limited production. Past work addressed the first phase of the experience, namely up until the CDR. Four additional phases have been prototyped. However, these additional four phases have not kept up with the development of the PDR-to-CDR phase which became the focus of the DAU experience. The following research activities support these improvements:

- T2.1: Update simulation, dialog and artifacts to be consistent with the current pre-integration phase throughout the complete the full life-cycle.
- T2.2: Tune simulation per sponsor and pilot feedback.
- T2.3: Complete the NPC role of mentor to better fit DAU course and provide instruction.
- T2.4: Update Lecture/Student Materials to facilitate learning evaluation using logged data from the EA leveraging work from learning evaluations.

3. Task 3. Section 508 Compliance

In the planning stage of this project, the objective is to determine the requirements for simulated learning technologies, specifically the EA, under Section 508. Based on these requirements, the next step is to determine a compliance strategy for design, implementation and validation, and then provide an estimate for this work. The objective for Implementation part is to implement these changes to ensure that the EA is Section 508 compliant. The necessary migration of the Presentation Engine from Flash to HTML5 is being accomplished in the EA Tools Part 3 RT. The work in this project is composed of the following major activities:

- T3.1: Determine methods for evaluating Section 508 compliance, authoring content and developing simulated learning applications.
- T3.2: Determine necessary changes for Section 508 compliance.

- T3.3: Translation of EA screens (login, multi-player, desktop, dashboard, etc.) to compliant formats.
- T3.4: Translation of EA artifacts (documents, email, recommendation forms, charts, dialog) to compliant formats.
- T3.5: Evaluation of 508 compliance.

4. Task 4. Validate Research Hypothesis - Learning Evaluation

The validation of the research hypothesis through the learning evaluation process requires support for classroom instructors, students, and the active capture and analysis of learning results. These evaluations will take place for the DAU experience at DAU and potentially other institutions. Learning evaluation is a critical element to validating the research hypothesis of the SEEA relative to accelerating learning. In addition to the research in Increment 4, research in learning efficacy is taking place through a doctoral dissertation funded by ARDEC, educational research taking place at Stevens, and tools development funded by SERC core funds. However, research needs to be done to determine specifically how learning will be evaluated for the DAU experience.

The following are the items that will need to be completed:

- T4.1: Provide support to DAU and potentially other instructors with EA application, materials and staff.
- T4.2: Support pilot uses of the EA at DAU and potentially other institutions.
- T4.3: Design learning evaluation and collect learning data.
- T4.4: Analyze data, evaluate learning effectiveness, and write report of results.

5. Task 5. Support DAU EA Deployment

Additional work is necessary to create a plan that is specific to DAU needs. Depending on the path that DAU selects, this may require training of DAU staff and the development of additional support materials. The following are the items completed:

- T5.1: Specification of the concrete deliverables so that the EA can be used in the DAU on a long-term basis. This includes criteria, requirements, sustaining support, technical details of the hosting requirements.
- T5.2: Determine Hosting Solution(s) for DAU: Options include commercial support (external network), DAU support (DAU network) and/or support on a laptop within the classroom (classroom network).
- T5.3: Migrate Development to 3rd Party Support: This includes identifying support staff and cost, and determining process and procedures for ticket creation and processing.
- T5.4: Update EA documentation: This includes the concept of operations, system and support specifications, architecture and design document, and experience tools and development document.
- T5.5: Support of deployment plan.

TASK 1 – NEW EXPERIENCE CAPABILITIES

To provide more focus on the technical aspects of an acquisition program, two categories of new capabilities were added to the UAV experience. Based on a student project at Stevens Institute of Technology (Fontaine, 2015), a trade study was the first new capability added to the experience. In addition, system reliability was added as a new key performance parameter, and technical debt was also added so that the learner can understand what occurs when work in a design and development effort is deferred.

TECHNICAL DECISION-MAKING VIA ADDITION OF LEARNER TRADE STUDY

The trade study is implemented in the Experience Accelerator as a new capability. The trade study focuses on leading the learner through a recently evolved issue that requires the leaner to conduct a trade study for choosing the best actuator for the situation.

A high-level flow of the trade study cycle has been established to serve as a storyboard upon which the simulation events, interactions, and recommendation can be built. The major activities in the trade study cycle are shown in Figure 6 below.

Trigger Trade
- **Call from Tom Williams.**
- **Discussion with Col. Rogers**
- **Follow-up with Tom Williams**

Setup
- **Identify candidate architectures**
- **(Optional) Discussion with Mentor for any coaching**
- **Establish Criteria**

Collect Data
- **Provide Learner with technical reference material**

Analyze / Decide / Report
- **Populate and evaluate trade matrix**
- **Document rationale and communicate to PM**

Simulation
- **Update model to new state**

Feedback to Learner

Figure 6 Trade Study Cycle Flow

Two alternative approaches to triggering the trade study were considered – allowing it to occur during any one of the Pre-CDR cycles, or locking it into a specific cycle. For the purposes of the prototype, which will be used as a baseline for evaluating the EA's effectiveness as a teaching tool, the design team determined that consistency would be favored over a more realistic, but less deterministic, approach. At this time, the trade study has been integrated into Phase 2A, Cycle 4. It is enabled by a server-side setting.

The trade is triggered in conjunction with, and signaled by, a step change in system weight. From a storyline perspective, this is explained as a consequence of needing to add shielding and filtering to the aircraft wiring harnesses to meet stringent shipboard electromagnetic interference (EMI) and electromagnetic compatibility (EMC) requirements. This is a common concern for many military systems. Introducing the trade study in this fashion provides an opportunity to make the learner aware of this real world issue.

The trade study starts with special dialogues with the PM, Mentor and the Prime-PSE as shown in Figure 7. The Learner will receive information and comments from PM and Prime-PSE. The Mentor will provide the Learner more detailed information on how to conduct a trade study. Once the trade scope has been established, technical reference material and interactive NPC dialogues are used to inform the Learner of the strengths and weaknesses of each of the alternatives. This information serves as the basis for their recommendation.

Once the Learner has reviewed the information, they will complete a trade study recommendation form. Based on the background information and dialogues, they will determine appropriate values for the relative criteria rankings, score each of the alternatives against the criteria, review the resulting trade scoring (as determined by the calculations in the form), and evaluate the sensitivity of the results against changes to the inputs. They will then document their recommended architecture and rationale and submit the recommendation form to the PM.

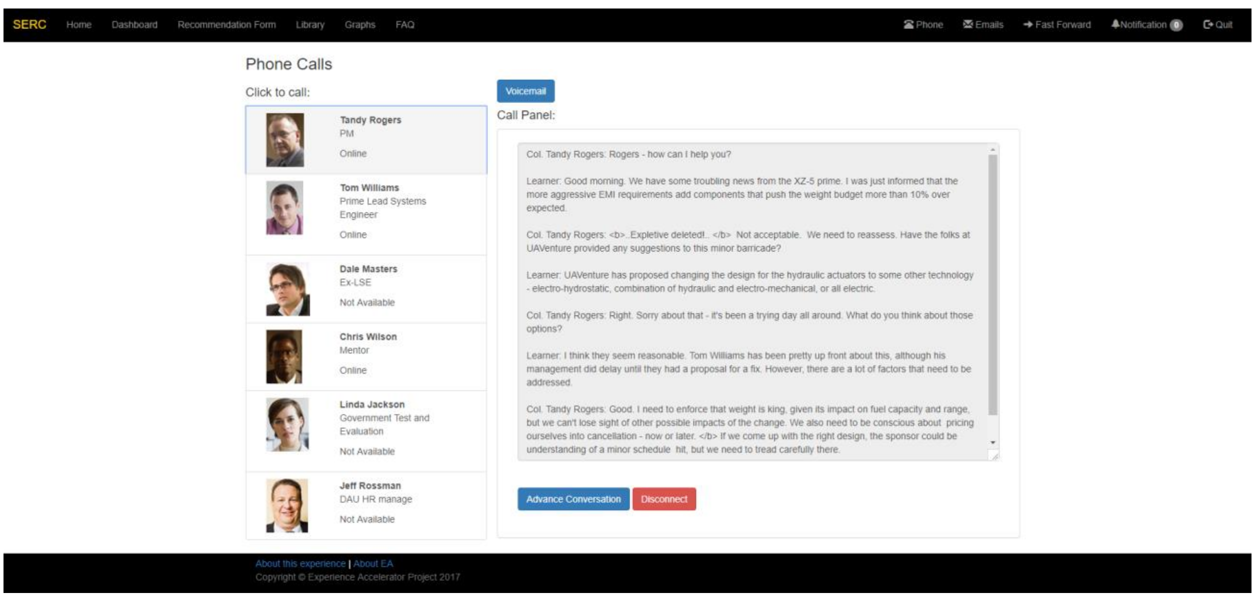


Figure 7 Trade Study Dialogs with PM

For the prototype EA, the actuation system alternatives are:

- **(Baseline) Hydraulic actuators** – This consists of an engine driven hydraulic pump providing distributed hydraulic power to all of the actuators.
- **Electrohydrostatic actuators** – In this configuration, each actuator uses distributed electrical power to drive localized hydraulic rams.
- **Split electromechanical/electrohydraulic** – This is a hybrid combination of electromechanical and electrohydraulic actuators, balancing the actuation needs of each location and function to optimize overall system weight.

  Electromechanical – This configuration is purely electromechanical in nature, allowing for a major reduction in the size of the vehicle's hydraulic system.

For the trade prototype, these four alternative architectures are evaluated against the following evaluation criteria:

- **Non-recurring Engineering (NRE)** – This represents the additional design and development costs associated with a given architecture.
- **Flyaway Cost** – This represents any impact to the final cost of a delivered system.
- **Total System Weight Impact** – This includes the weight increases and decreases to all of the various aircraft subsystems.
- **Schedule** – This is a measure of impact to the system development timeline.
- **Thermal** – This criteria represents impacts to the thermal performance of the UAV, specifically with respect to hot operating temperatures. It is included to highlight the criticality of thermal management for electromechanical actuators.
- **EMI/EMC** – This highlights the differences between hydraulics and electric actuators with respect to emissions and susceptibility.
- **Reliability** – A typical SE metric, Reliability will differentiate the architectures from the perspectives of complexity and redundancy.

  Integration Risk – This represents the level of complexity and associated risk for incorporating a given architecture.

As shown in Figure 8, the learner will be presented by a Microsoft Excel style work sheet where the leaner can input different parameters and weights for actuators' attributes and then decide on which actuator technology to choose. The learner can either work on the online form or download it as an Excel file to work offline. After sending the recommendation to PM, the learner will go back to routine UAV experience with regular recommendation forms. The learner can save the Excel file and then submit them to the instructor for comments or assessment. Figure 9 below shows the design of the worksheet with reference values and inputs.

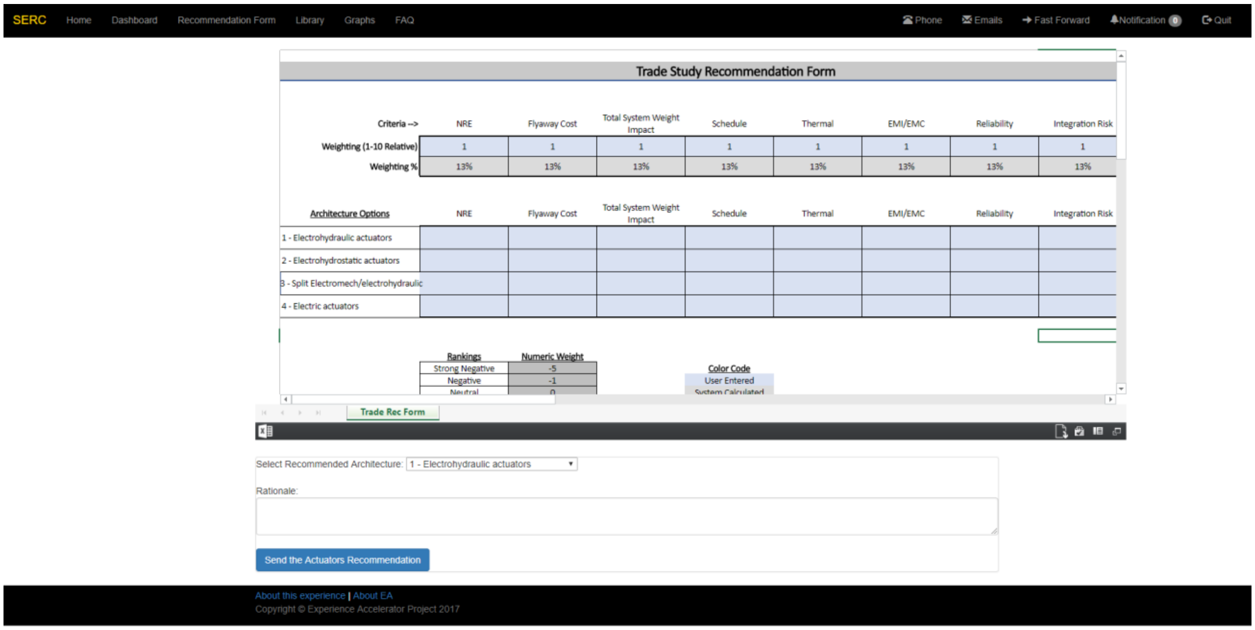


Figure 8 Trade Study Worksheet & Recommendation Form

Criteria -->	NRE	Flyaway Cost	Total System Weight Impact	Schedule	Thermal	EMI/EMC	Reliability	Integration Risk
Weighting (1-10 Relative)	7	1	6	5	10	4	2	7
Weighting %	17%	2%	14%	12%	24%	10%	5%	17%

Architecture Options	NRE	Flyaway Cost	Total System Weight Impact	Schedule	Thermal	EMI/EMC	Reliability	Integration Risk	Weighted Score
1 - Electrohydraulic actuators	0	0	0	0	0	0	0	0	0.00
2 - Electrohydrostatic actuators	-1	-1	0	-1	-5	-1	-1	-1	-1.81
3 - Split Electromech/electrohydraulic	-1	-1	5	-1	0	-1	-1	-5	-0.57
4 - Electric actuators	-1	-1	1	-1	-1	-1	-1	-1	-0.71

Rankings	Numeric Weight
Strong Negative	-5
Negative	-1
Neutral	0
Positive	1
Strong Positive	5

Color Code
User Entered
System Calculated
System Default

Color code is for development visualization only and is not required in the final recommendation form.

Recommended Architecture: 1 - Electrohydraulic actuators

Rationale: Weight savings alone are not enough to justify the drastic increase in technical risk, cost, schedule, environmental compliance, etc. Continuing with the baseline design is the most appropriate course of action for this program.

Figure 9 Trade Study Worksheet Design

The trade study introduces technical issues into the experience that were not there previously. The different alternatives impact several performance factors in particular. Two of these have been added to the experience – actuator reliability and thermal management. A technical performance measure for actuation system reliability is added. Under the baseline actuator system, the reliability is acceptable (above the minimum threshold) and it improves over time to reach a steady state value. If one of the other alternatives is selected, the steady state target value can be changed, thus causing the reliability to drop and perhaps become unacceptable. A graph of actuator reliability over time for the baseline actuator system is illustrated in Figure 10.

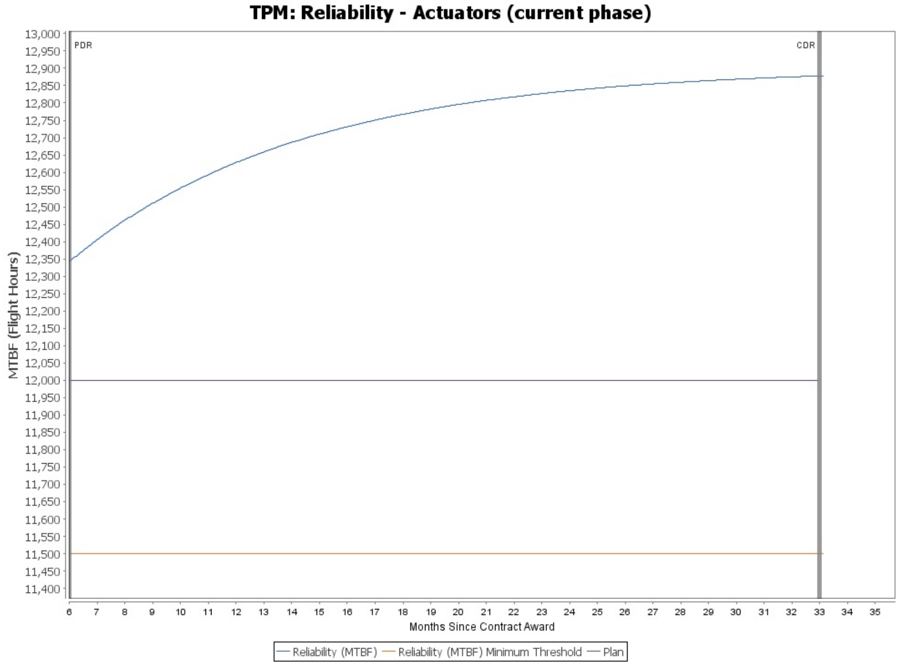


Figure 10. Actuator reliability over time

Heat rejection and heat storage are two metrics introduced for thermal management. Heat rejection refers to the amount of heat created by the actuators that can then be dissipated safely. We consider two cases in terms of heat created – nominal and peak. Nominal refers to heat created under normal operating conditions. We consider that there is a maximum threshold that the actuators can dissipate (in watts). In the baseline actuator system, the nominal heat created is below this threshold. Thus, the actuators can operate safely. The peak is above the threshold, however. This means that heat storage capacity is needed to trap the excess heat during peak loads. We assume that a peak load will last at most five minutes. The heat storage required then is the excess heat (peak heat created minus threshold that can be dissipated) over that five minutes. The heat created per time unit is in watts, and the heat storage needed is then in kilojoules. If the peak heat created is too high relative to the maximum dissipated, the heat storage required can exceed the heat storage maximum. In the baseline actuator system, the heat storage needed is less than the maximum allowed. Heat rejection and heat storage for the baseline actuator system are depicted in Figure 11.

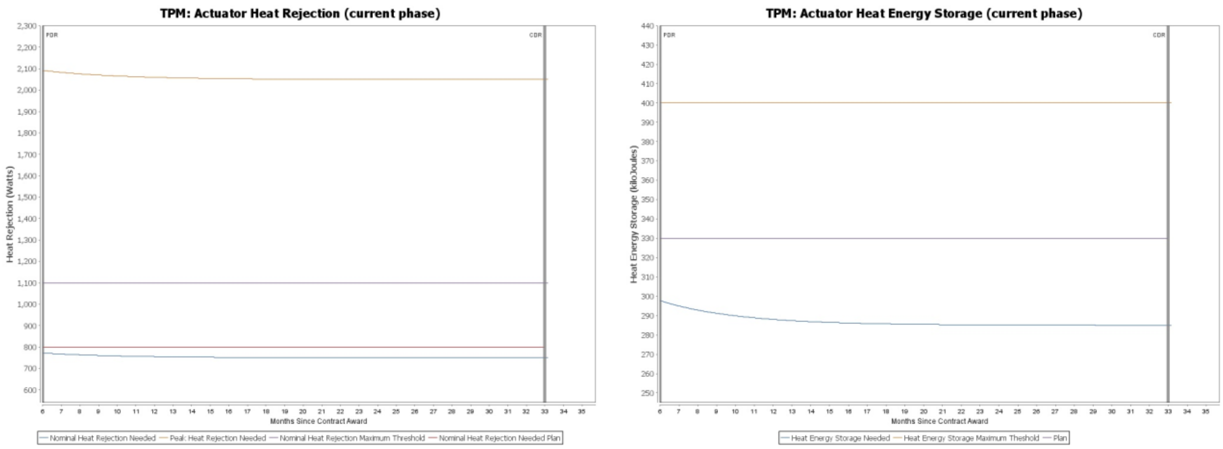


Figure 11. Heat rejection and storage for actuators

If the electric actuators are chosen in the trade study, there is a small negative effect on thermal management, and the target values for nominal and peak heat created can be adjusted to reflect this. If the electrohydrostatic alternative is chosen, there is a large negative effect, and the targets would be adjusted to ensure that the nominal heat created is above the rejection threshold, and that the peak heat created makes the heat storage needed above the maximum allowed.

Reliability KPP and Technical Debt

The current UAV experience specified vehicle range as the single key performance parameter (KPP). This KPP was supported by a number of technical performance measures (TPMs) that affect range, such as vehicle weight, drag and propulsion efficiency. System reliability has been added as an additional KPP.

System reliability is defined as the mean time to failure (MTTF). As MTTF increases, reliability increases. Failure is affected by many different factors relating to sub-systems and components. For purposes of the reliability KPP in the SEEA, we chose to limit this to just catastrophic failures where a vehicle would be lost. In addition, we limited the number of underlying sub-systems that could affect the reliability to three. Thus, a catastrophic failure in one of the following three sub-systems would result in a catastrophic system-level failure.

- **Actuators** – the new trade study focuses on the actuators. If the UAV design is shifted to a new architecture for actuators, there will be an effect on the actuator reliability. Thus, a learner decision may adversely affect system-level reliability so that it becomes unacceptable.
- **Uplink** – the uplink brings in the ground station sub-system as part of the system-level reliability. If the uplink fails, communication cannot be sent to the vehicle, and presumably it will be lost.

- **Command & Control System** – the command & control system clearly is critical to vehicle viability.

In the baseline case (i.e., with no learner decisions), the reliability of each sub-system improves until it reaches a steady state. Currently, the learner recommendation form does not provide alternatives that impact reliability outside the actuator architecture decision, although that could be changed in the future.

The system reliability is determined as a function of the reliability of the three sub-systems. Letting R_a be the reliability of the actuators, R_u be the reliability of the uplink, and R_c be the reliability of the command & control sub-system, we can define the reliability of the system R_s as:

$$R_s = 1/\left(\frac{1}{R_a} + \frac{1}{R_u} + \frac{1}{R_c}\right)$$

Thus, as each sub-system reliability improves, the overall system reliability improves. Figure 12 shows the reliability over time of the actuators and that of the overall system during the PDR-to-CDR phase of the program.

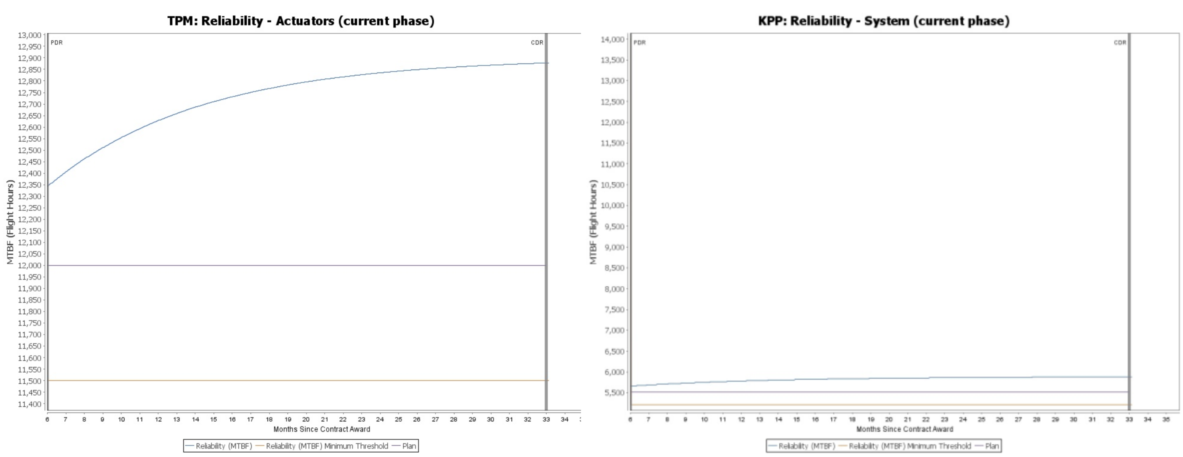


Figure 12. Reliability over time

In addition, technical debt has been added as a feature. Technical debt is deferred work that must be completed at a later date, usually at some sort of penalty. Deferred work can interfere with work scheduled for a future period. In addition, it can be more costly to perform in the future since some tasks may need to be re-learned.

We apply technical debt to the work that is completed to ready the design or prototype UAV for a milestone review. This work is judged complete by whether or not it meets certain entrance criteria for those reviews. The SEEA tracks the progress toward meeting various entrance criteria for critical design review, flight readiness review, and production readiness review. For instance, the CDR entrance criteria include such items as completion of digital design drawings, structural load analysis, and sub-system design and verification for each of the sub-systems.

In the previous version of the UAV experience, which focused only on the PDR-to-CDR phase, the learner could be approved to proceed to CDR without meeting 100% of each of the requirements. Each of the entrance criteria was set with a certain minimum threshold (e.g., 90% or 95%) that needed to be met. This threshold could be varied to make the experience more or less difficult. Since the experience ended with CDR, there was no penalty for the small percentage of work left undone.

However, with the extension of the experience to the remaining phases, there was a need for that unfinished work to be completed in the next phase. This is accomplished through the concept of technical debt.

Each of the milestone reviews has six to eight entrance criteria. Having to track the entrance criteria progress on the current phase plus the technical debt for potentially all of the criteria in the previous phase could be overly complex for the learner. Thus, the technical debt for each sub-system (and corresponding sub-contractor) is rolled into one figure that is a weighted average of the remaining work on each entrance criteria for that sub-system and the percent effort applied to that entrance criterion. The technical debt is then expressed as a percentage of the overall entrance criteria work to be performed by the sub-contractor. Letting TD_i be the technical debt for sub-contactor i, WR_{ij}be the percent work remaining on entrance criterion j by sub-contractor i, and w_{ij} be the percent effort applied to entrance criterion j by sub-contractor i, and n_i be the number of entrance criteria assigned to sub-contractor i,

$$TD_i = \sum_{j=1}^{n_i} WR_{ij} w_{ij}$$

The simulation is programmed so that the workforce for each sub-contractor focuses on technical debt at the beginning of each phase before work is done on the entrance criteria for that phase. Once the technical debt work has been finished, work ramps up on the entrance criteria for the current phase. This of course has the effect of delaying the completion of those entrance criteria. In addition, there can be an interest factor applied to the technical debt such that the amount of work is increased, simulating the additional work that must be done since the workforce is geared toward the current phase work, not that of the previous phase.

Of course, the technical debt has an effect on the EVM for the current phase. The actual cost of work performed contains cost of performing the technical debt up until such time as that work has been completed. Then it shifts to the current work. The budgeted cost of work performed will indicate that the project falls behind schedule since the current work is being temporarily deferred. To show the learner how much of the ACWP is funding technical debt, a new graph is added. This graph tracks the ACWP of the technical debt for the whole program and compares it to the remaining budget from the previous phase. If there is not any budget remaining, then the remaining budget is zeroed out. Figure 13 shows the cost of technical debt from the PDR-to-

CDR phase (Phase 2) that is incurred in the integration phase (Phase 3). Approximately $26 million is left over from Phase 2, with the assumption that those funds are available for the technical debt work-off. The technical debt has erased that remaining budget and resulted in a small over-run.

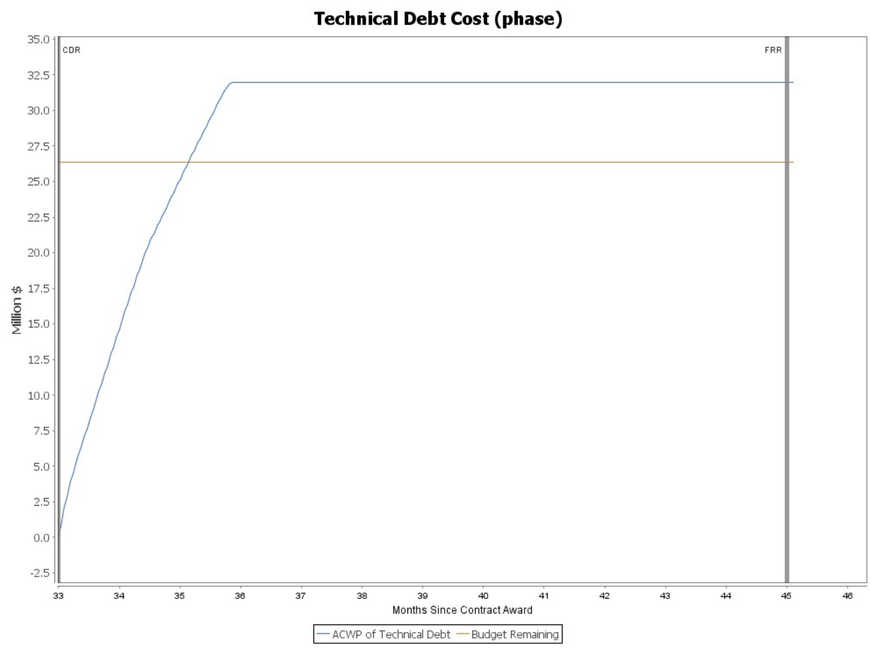


Figure 13. ACWP of technical debt

TASK 2 – EXPERIENCE IMPROVEMENTS

As the EA was piloted by more organizations and used in a variety of modes, it became clear that there were a number of shortfalls in the user interface, the underlying simulation models, and in the scope and the level of experience throughout the life cycle. We addressed these shortfalls by:

- Developing a richer and easier-to-navigate user interface
- Extending the experience's scope from its focus on preliminary design review to critical design review to include all phases through low-rate initial production
- Tuning the simulation to allow for more realism and easier level of difficulty adjustment
- Improving and extending the mentor and help functions, and
- Updating and expanding the lecture and student materials associated with the EA and the UAV experience.

Development of Full Lifecycle

The UAV experience was originally conceived and designed to encompass the design and development of a UAV system from shortly after preliminary design review through low-rate initial production. An initial prototype addressing this lifecycle was developed. However, the sponsor requested focused subsequent work on the part of the experience from shortly after PDR up until critical design review. Thus, a major focus of this project was to leverage the innovations produced for the PDR-to-CDR portion of the experience to improve and complete the remaining phases. Two main areas needed to be addressed: extension of the underlying systems dynamics simulation models, and providing the additional phases with a commensurate level of detail in the user experience.

Systems Dynamics Simulation models

Changes to the underlying systems dynamics simulation models were critical to extending the life cycle as well as improving the user experience. As discussed under Task 1, the concept of technical debt between phases was one critical improvement to enable more realistic transitions between phases. However, additional adjustments to the existing models were also needed.

There are different models applying to the lifecycle as follows:

- Phase 2 – PDR-to-CDR. This is the experience phase that was fully developed previously.
- Phase 3 – CDR to Flight Readiness Review. In this phase, the different sub-systems are integrated into test articles that will be flight-tested.
- Phase 4 – Flight Readiness Review to Production Readiness Review. In this phase, the UAV system is transition from development to initial production.
- Phase 5 – Production Readiness Review to In Service Review. In this phase, the UAV system is initially produced in terms of ground stations and vehicles.

These models have shared variables that ensure certain values are kept consistent throughout the experience. The following work was performed to make the Phase 3, Phase 4, and Phase 5 simulation models consistent with the improvements previously made to the Phase 2 model.

- The dates for the various reviews (CDR, FRR, PRR, ISR) were changed into variables that can be changed by the learner to reflect either schedule advancements or delays of these reviews.
- Previously, the learner set staff levels as one of the recommendations for each sub-contractor. This allowed management of schedule and budget. To reflect the situation that staff levels typically do not adjust automatically but rather ramp up over time, the learner decisions were changed to staff level targets. The simulation then moves staffing levels to these targets over time. These targets are for experienced personnel and inexperience personnel in each sub-contractor, as well as the system integrator.

- The technical performance model was updated to reflect the addition of loiter, true airspeed and payload weight to the range calculation for the aerial vehicle. Loiter is the time that the UAV can hover over a target for mission-related purposes. In addition, drag and lift were changed to drag coefficient and lift coefficient. Propulsion efficiency was changed to thrust specific fuel consumption (TSFC) to be consistent with a turbofan jet. Figure 14 shows the drag coefficient across Phase 2 and Phase 3, illustrating also the notion of shared variables across phases.

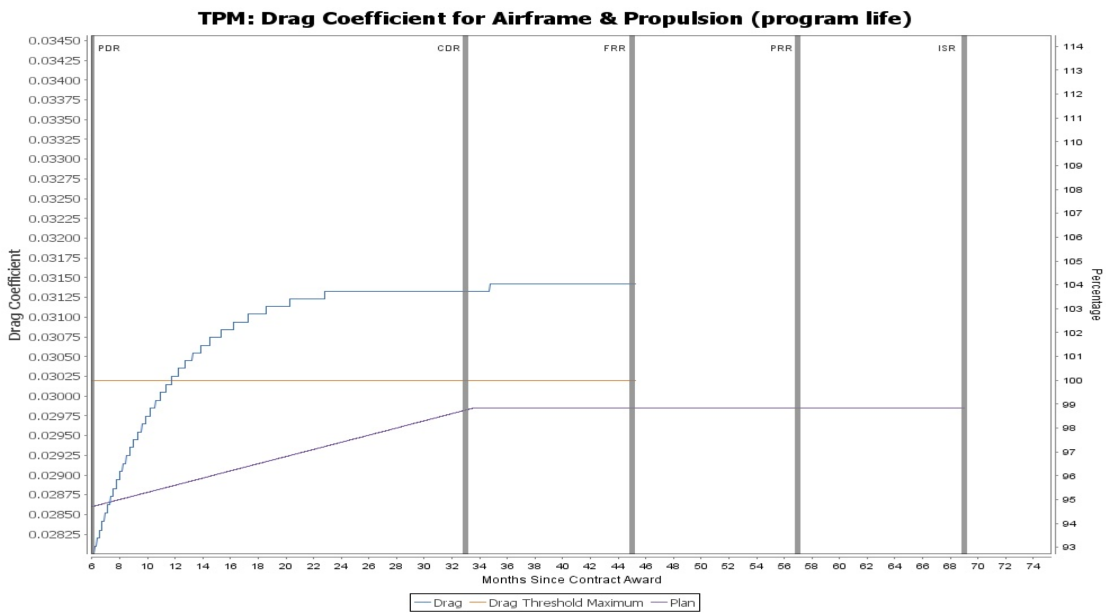


Figure 14. Drag coefficient

- Drag reduction and TSFC improvement programs were added as options for the learner. The learner can set a desired target for both these items to improve range. If the programs are enabled, a fixed number of technical staff are purposed for the program. A variable number of staff are assigned depending on the deviation of the actual drag or TSFC from the desired targets. Having staff allocated to these programs makes them unavailable for work aimed at meeting the entrance criteria for the next review meeting, thus affecting schedule and budget in the earned value management (EVM) calculations. Figure 15 illustrates the revised technical performance model that reflects the drag and propulsion efficiency improvement programs (sub-model on left).

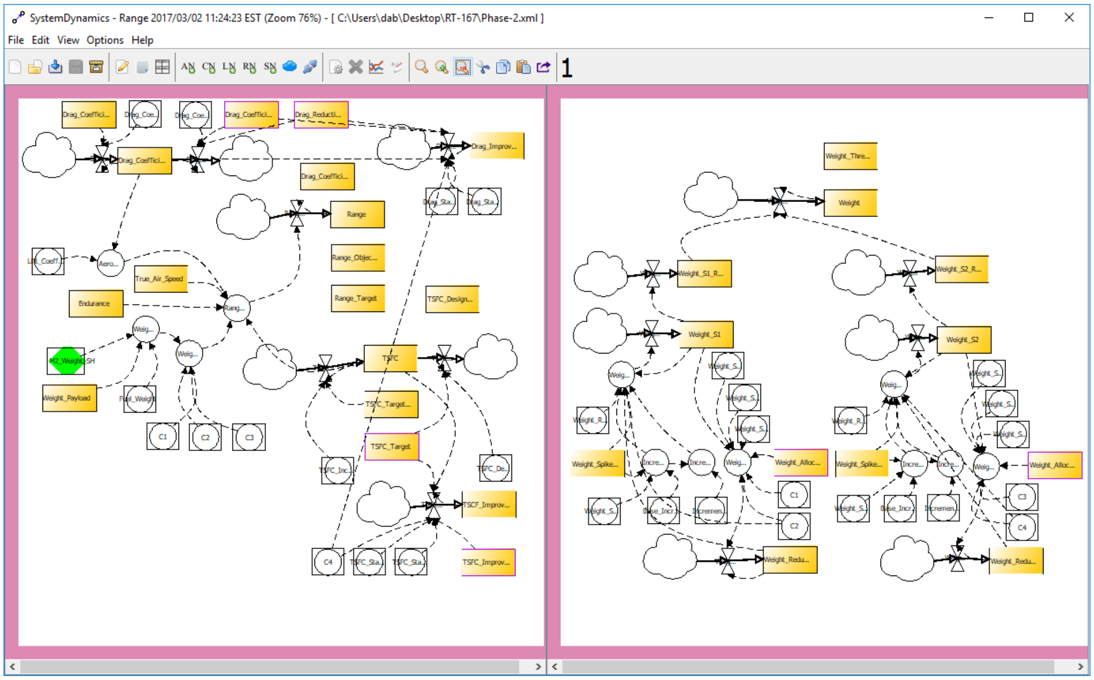


Figure 15. Technical performance model

- Similarly, a weight reduction program was enabled. This exists continuously in the experience, since aerial vehicle weight problems are a main driver of the poor range performance. The learner can shift weight allocations between the two vehicle sub-systems (airframe & propulsion versus command & control). For a particular sub-system, the model allocates technical staff to weight reduction if the actual weight is near the weight allocation. If the actual weight is over the weight allocation, then the model allocates significantly more technical staff to weight reduction. The weight reduction effect is a function of the allocation. The additional staff allocated to weight reduction takes away staff that work on entrance criteria. Thus, there is an effect on schedule and budget for poor weight allocation decisions. Figure 15 also shows the weight reduction program model (sub-model on right)
- Burn rates were added to reflect monthly spending by each of the sub-contractors, the system integrator, and the overall program.
- Productivity rates were added so that the learner can see changes over time.
- Charts were added reflecting the number of experienced vs. inexperience technical staff currently working for each sub-contractor and the system integrator (in terms of full-time equivalents).
- Software error rates were adjusted so that total errors encountered and total errors resolved are tracked. Figure 16 shows a graph tracing critical errors.

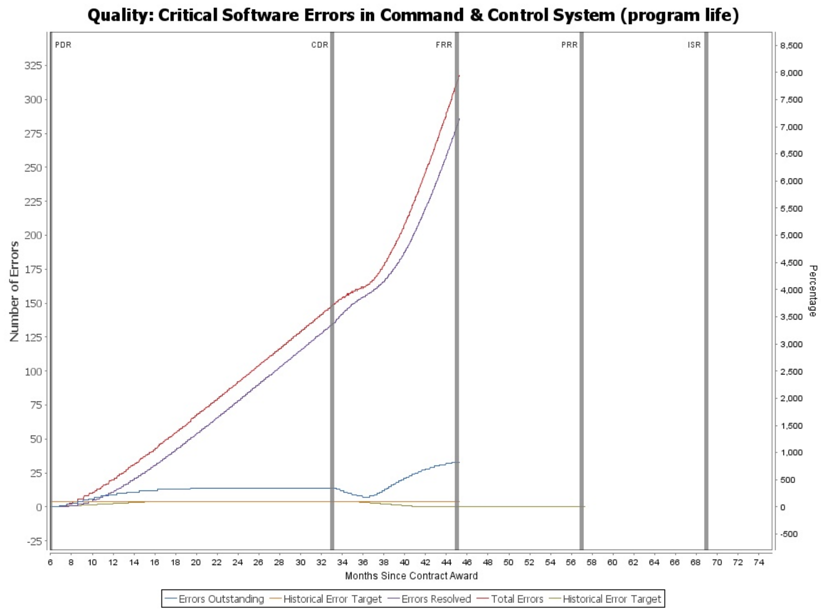


Figure 16. Critical software errors

- The reliability KPP and thermal management tracking were added to the subsequent phases.

DEPTH OF USER EXPERIENCE

Extending the detailed interactions that evolved in the PDR to CDR phase to the remaining phases was more difficult than envisioned. Some parts were relatively easy. For example, the dashboard concept could be easily extended to include the data items that were used in Phase 2 as well as the relatively fewer phase-specific values to be tracked (e.g. unit cost, completion of documentation required for the end-of-phase review).

In contrast, when it came to the story line for the remaining phases, the original prototype design document was less detailed in its descriptions. The most frequent comment on decisions and activities was “Same as Phase 2.” The information describing the phases primarily resided in tables of decisions, actions and expected results; little was provided on the specific information that should lead the learner to make the decisions or take the actions. Additionally, the simulation models needed to be created in order to provide the data-driven responses, models were not created until late in the project, and some of the expected variables were not implemented. The level of effort required to match the Phase 2 depth of experience in Phases 3, 4 and 5, was unexpected, leaving that goal only partially achieved. In the end, the released version used simple dialogs from the original prototype with slight adjustments. Evolving the depth of the later phases will continue to be refined.

Simulation Tuning

The simulation models were tuned to help ensure consistency across the different phases. This work entailed the following:

- Adjusting cost factors in the EVM modules
- Adjusting staff levels among the different sub-contractors
- Adjusting hiring and attrition rates of technical staff
- Adjusting factors related to the reliability KPP and thermal management modules

Role of NPC Mentor

Expanding the scope of Chris Wilson’s role as mentor provided an opportunity to integrate the mentor, the library and the help system to better support the learner.

Originally, the mentor was intended to provide help by explaining some of the technical and programmatic issues. Feedback from instructors and students suggested expanding the role to cover additional information, including how to actually navigate the experience and what to do when a learner was “stuck.”

The team considered several approaches to meeting the expressed feedback and implemented the following features, dividing the information provided between the mentor, the help system, and the home page.

- We established the “home” page as a place where instructions to the learner may be provided as a preview (orientation) for each phase. Cues as to what types of things the learner might expect to see or need to know can be included. While the experience has default contents, it can be edited or replaced by the instructor to fit the class.
- We expanded the dialogs with Chris to address additional subjects.
- We created an initial Help/FAQ page to providebb some of the information to the learner directly and in a more familiar way; the FAQs will be augmented with additional questions captured as more learners and instructors use the EA and provide the information to the developer/maintainer.
- The HTML implementation makes it easier to link to outside resources from the dialogues, library and FAQs. Some of the links provided links are to DoD guidebooks, the DOD EVM webpage, the INCOSE SE Body of Knowledge wiki, several useful blog posts and “Ask a Professor” articles.
- We created a more active role for the mentor to literally guide the learner through the trade study. Chris acts as an interface to outside “experts” that provide information, insight and artifacts to help conduct the study.

UPDATE TO LECTURE AND STUDENT MATERIALS

The lecture and student materials have been updated during this development cycle. The instructors' guide has been updated to version 2.6 with new simulation charts outputs and refreshed content of the recommendation form. Since the Experience Accelerator UAV experience has been extended to representing the entire acquisition cycle, new information about Phase 3-5 is now available. The instructor and student materials have been updated to include this information. A section describing the CDR Criteria functionality that can be used to tune the difficulties of the experience was also added to the .instructor materials

TASK 3 – SECTION 508 COMPLIANCE

In 1998, Congress amended the Rehabilitation Act of 1973 to require Federal agencies to make their electronic and information technology (EIT) accessible to people with disabilities. The law (29 U.S.C. § 794 (d)) applies to all Federal agencies when they develop, procure, maintain, or use electronic and information technology. Under Section 508, agencies must give disabled employees and members of the public access to information that is comparable to access available to others.

Implementation of Section 508 also amends the Federal Acquisition Regulation (FAR) to ensure that agency acquisitions of EIT comply with the Access Board's standards. The FAR change implementing Section 508 was published along with an explanatory preamble in the Federal Register on April 25, 2001 (66 Fed. Reg. 20894) and is effective as of June 25, 2001. The FAR rule can be found on the Section 508 website.

Section 1194.24(c) and (d) of the Access Board's standards require that all training or informational video and multimedia productions which support the agency's mission and which have audio information or visual information that is necessary for the comprehension of the content, be captioned or audio described. Hence, if the production is multimedia (e.g. image and sound) and is considered "training or informational," then it must meet the applicable requirements of 1194.24 (c) and (d) of the Access Board's standards. If the production is web-based, regardless of whether it is multimedia, such as a live webcast of a speech, then it must also meet the applicable requirements of 1194.22. For this reason, we assert that the SEEA is an education tool with a web-based user interface, and acknowledge Section 508 applies to its user interface design and construction.

Outside of the US federal government, a number of voluntary consensus standards have been developed by standards organizations worldwide over the past decade. Examples of these standards include: the Web Accessibility Initiative's Web Content Accessibility Guidelines (WCAG) 2.0, EN 301 549 V1.1.1 (2014-02), "Accessibility requirements for public procurement of ICT products and services in Europe," and the Human Factors Ergonomics Society's ANSI/HFES 200.2 (2008) ergonomics specifications for the design of accessible software.

This evolution of these global standards has led the Access Board to propose revisions to the existing 508 Standards to harmonize it with the newcomers. They believe such a harmonization would support the goals of the US law, while also creating a larger marketplace with commercial competition that could lower costs to federal agencies as well as commercial manufacturers for providing accessible electronic information and communication technology.

Although the changes may take some time to be developed, reviewed and released, we intend to comply with the current Section 508 requirements and include as many additional requirements from the industry standards as seem appropriate. This section describes the research that was conducted to support this goal in the following major activity areas:

- T3.1: Determine methods for evaluating Section 508 compliance, authoring content and developing simulated learning applications
- T3.2: Determine and implement necessary changes for Section 508 compliance
- T3.3: Translation of EA screens (login, multi-player, desktop, dashboard, etc.) to compliant formats
- T3.4: Translation of EA artifacts (documents, email, recommendation forms, charts, dialog) to compliant formats
- T3.5: Evaluation of 508 compliance

For more information, see the document "RT 167: Certifying SEEA Compliance with Section 508", Technical Report No. SERC-2016-TR-116, (Task3, Subtasks 3.1-3.2), November 1, 2016.

METHODS FOR EVALUATING SECTION 508 COMPLIANCE

We took a constructional approach to Section 508 compliance. As we moved forward with building out the initial UAS experience, we adapted the existing software for Section 508 compliance. The following sections describe the three ways in which we accomplished this.

FLASH TO HTML CONVERSION

The EA User Interface was originally developed using Adobe Flash for displaying information. This particular technology has been overtaken by the capabilities include in newer web-based standards, primarily HTML5. The flash technology was neither designed for, nor easily adapted in order to meet Section 508 requirements. However, early in its evolution, HTML acknowledged accessibility as a significant design factor[1], and included a growing number of accessibility-based capabilities. The SEEA team leveraged these capabilities by converting the existing flash interface to HTML5.

[1] "Good semantic HTML also improves the accessibility of web documents (see also Web Content Accessibility Guidelines). For example, when a screen reader or audio browser can correctly ascertain the structure of a document, it will not waste the visually impaired user's time by reading out repeated or irrelevant information when it has been marked up correctly. "https://en.wikipedia.org/wiki/HTML.

This conversion also provides more flexibility and functionality for current and future experience developers than the current implementation. In particular, it allows us to develop a generalized tool with tailorable templates to support designing user interface displays and reactive features for new and existing experiences that align with their specific environments and learning objectives.

COMPLIANCE THROUGH TEMPLATES

Several HTML5 web page templates have been developed in the past few years that are already certified to meet the Section 508 requirements. There are also numerous open source and freeware accessibility components designed to work with HTML5. By redesigning the EA interface and adopting the templates, much of the compliance design burden is lifted. The templates that we have identified have saved significant effort by providing display methods that are by default constrained to accessible requirements such as font, color, contrast, and interoperability with common screen readers and other accessibility enhancement tools. Using a template also greatly reduces the work required to build the user interface design tool.

CERTIFICATION BY TOOLS AND EXPERTS

There are also automated compliance checkers that evaluate web pages using HTML5 code and other languages to assure compliance to a variety of accessibility standards of the webpage software as well as browser-specific concerns. We do not, however, believe that running such checkers constitutes a sufficient compliance case. We have identified additional compliance-checking tasks as we designed and developed the interfaces. We have consulted with Section 508 experts at DAU to be the final authority on compliance certification with DAU testing providing validation of the SERC compliance testing. In addition, we had a Section 508 expert from the Georgia Tech Research Institute review the EA. We used approaches and tools recommended by the DAU experts to test the HTML pages and contents. The used tools are JAWS screen reader and the Microsoft Active Accessibility Object Inspector. We also utilized Tab-check and link checks to ensure all the links and contents are accessible.

REQUIRED CHANGES TO EA INFRASTRUCTURE FOR COMPLIANCE

A number of changes beyond those originally identified were necessary in the EA Infrastructure to support the transition from Flash to HTML5. The necessary changes involved the following functionality:

- **User Interface:** content retargeted from Flash to HTML5. This work was anticipated and planned.
- **Dialog Engine:** While the dialog engine continues to utilize Extensible Markup Language (XML) generated from ChatMapper, the specifics of the new HTML5 user interface required changes to a JavaScript Object Notation (JSON) and XML based dialog parser. A good portion of this work was not anticipated.

- **Client-Server Communication**: The TPC sockets-based communication protocol used in the Flash-based systems is not compatible with HTML5. Thus, a new communication system was written utilizing Web sockets. While this involved a substantial design implementation effort, the net result is a client application that does not require the opening of special ports as was required for the Flash implementation. Thus, the HTML5 implementation can work passing through DoD or corporate file walls within any IT intervention, thus, enabling the support of the EA through a standard web-based third-party server. This required a substantial amount of additional implementation effort.

TRANSLATION OF SEEA SCREENS TO COMPLIANT FORMATS

The existing user interface uses Adobe Flash technology. Flash technology does not provide the essential components for Section 508 compliance. The updated interface includes translation and consolidation of the existing pages, and the updated pages utilize Section 508 compliant assets. Table 1 depicts the changes made to the current user interface pages. The entries in the 508 Issues column refer to the Section 508 paragraphs. These are described in Appendix A.

Table 1 – Changed User Interface Pages

Page	Subpage	Description	508 Issues
User_Profile_Design		Page displaying user's profile	(a)(l)
Profile_Update_Design		Profile update page	(n)
Profile_Design		Welcoming screen	
Logout_Design		Logout screen	
Login_Design		Login screen	(n)
Error_Design		Error screen overlay	(l)
File_Explorer_Design		File explorer screen	(l)
	ProjectStatus_Folder_Design	Chart viewer screen	(a)(e)(f)(i)(l)
Email_Design		Email screen	(l)
	Inbox_Subpage_Design	Inbox subpage	(l)
	Compose_Subpage_Design	Compose subpage	(l)
Desktop_Design		Desktop screen	(l)
RecommendationForm_report_Design		Recommendation form page	(l)(n)
Feedback_Form_Design		Feedback form page	(k)
Multiplayer_Main_Design		Multiplayer main page	(l)
	Multiplayer_Waiting_Design	Waiting page for multiplayer	(l)
	Multiplayer_Lobby_Design	Game searching page for multiplayer	(n)
	Multiplayer_Join_Design	Join page for multiplayer	(n)
	Multiplayer_Create_Design	Game creation page for multiplayer	(n)
Dashboard_Design		Dashboard page	(e)(f)
Callv2_Design		Phone call main page	(e)(l)

	Call_Subpagev3_Design	Phone call subpage	(e)(l)
	Chat_Subpage_Design	Web chat subpage	(e)(l)
	Voicemail_Subpagev2_Design	Voicemail subpage	(e)(l)

TRANSLATION OF SEEA ARTIFACTS TO COMPLIANT FORMATS

The EA system utilizes document artifacts in PDF/SWF format which is not Section 508 compliant. To achieve compliance, we used Adobe or third-party software to make the necessary conversions. The artifacts that required updates were:

- DUAVCdrFormp2.swf
- DUAVCdrFormp3.swf
- DUAVCdrFormp5.swf
- P1-UAV-Program-Info.swf
- P3-UAV-Program-Info.swf
- P4-UAV-Program-Info.swf
- P5-UAV-Program-Info.swf
- UAV Background.swf
- UAV-CDR.swf
- UAV-PDR.swf
- UAV-Status-Chart-Info.swf
- UAV-Status-Chart-Info-0.21.swf
- EVM-Gold-Card-Info.swf
- IUISp1.swf
- IUISp2.swf
- IUISp3.swf
- IUISp4.swf
- IUISp5.swf

EVALUATION OF SECTION 508 COMPLIANCE

An external expert on Section 508 compliance from Georgia Tech Research Institute (GTRI) reviewed the application and code and discovered several accessibility issues which are described below in this report. All of the issues noted have addressed in the final version of the code delivered by this project.

Accessibility Evaluation

Section 508 of the Rehabilitation Act was recently amended to reference the W3C Web Content Accessibility Guidelines (WCAG) 2.0 and apply Level A and Level AA Success Criteria and Conformance Requirements to websites as well as non-web electronic documents and software. Compliance with the updated Section 508 standards is effective January 18, 2018. To ensure future compliance with accessibility legislation and best practices, the application was evaluated against the new Section 508 criteria. The following is a list of issues found when inspecting the application for compliance with Section 508 and WCAG 2.0.

Document Language

Each page of the application is missing the <html lang> attribute. Although the application works with assistive technology, WCAG 2.0 does require that the language of the page be identified.

Forms

Form controls are not properly associated with text labels, so the labels may not be presented to some screen reader users. Looking at the code, it appears that the ngAria attribute should be included to programmatically associate form controls with their labels.

Another issue seen on the Recommendations form is that there is no fieldset provided with the Schedule Confidence Level radio buttons. These radio buttons should be marked up as belonging to a fieldset and the Schedule Confidence Level label should be associated as the description for that fieldset.

Color Contrast

One of the WCAG 2.0 success criteria that will be new to Section 508 is the requirement for minimum levels of color contrast. In general, the color contrast meets the Section 508 and WCAG 2.0 requirements. However, there are a few exceptions.

On the Login, FAQ, Dashboard, and Graph Viewer pages, the header at the top of the page ("SERC Systems Engineering Experience Accelerator," "FAQ," "Dashboard," and "Graph Viewer") fails the WCAG 2.0 requirements with a contrast ratio of only 1.4:1. The text color should be much darker to improve visibility.

On the Home page, the Help and Reset Experience buttons fail the WCAG 2.0 requirements at the AA level. The buttons either need to be darker or the text color changed to black. The Logout button on the Home page as well as the Disconnect button on the Phone page also fail the requirements at the AA level for normal text size but passes for large text. Increasing the text size, making the red background darker, or changing the text color to black would alleviate these contrast issues.

On the Recommendation page, the labels for the Schedule Confidence Level Low and Moderate radio buttons are low contrast. The text needs to be darker to pass the WCAG 2.0 Level AA requirements.

High Contrast Color Scheme

All of the content remains visible and accessible when a high contrast color scheme is activated. High contrast color schemes are useful for some individuals with low vision.

Disabled Style Sheets

When style sheets are disabled, a number of links all titled Recommendation Form appear with the navigation links. This can be confusing especially since there is no discernable difference between all of the links.

Task 4 – Validation of Research Hypothesis via Learning Evaluation

The EA provides a simulation-based systems engineering project experience which is coupled with learning assessment capabilities. During this research, significant work have been completed to improve the capabilities of the EA, namely the improvements on the simulation experience, the learning assessment capabilities and the toolset for analyzing learning data. In addition, efforts have been made to expand the use of the EA into a number of different domains and learning environments.

Support for DAU and Other Institutions

During the development period of this project, numerous institutions sought the usage of the Experience Accelerator and the team has ensured that these deployments were well supported. During this development cycle, multiple pilot uses were conducted. Instructors from University of Alabama in Huntsville (UAH) and Airforce Institute of Technology (AFIT) showed interest of using Experience Accelerator in their Systems Engineering courses. As a result, there have been four pilot uses conducted in UAH so far, and new pilot uses of EA in UAH and AFIT schedule for the fall of 2017.

Pilot Uses of SEEA

The following is a list of the pilot uses of the SEEA.

Pilot use of the EA with multiplayer mode: UAH Feb 2016
The EA was used in a UAH course in multiplayer mode, and performance data was gathered for learning evaluation.

Pilot use of the EA with single player mode: UAH Nov 2016

The EA was used in a UAH course in single player mode, performance data was gathered for learning evaluation.

Pilot use of the EA with single player and multiplayer mode: UAH Feb. 2017 – May 2017

The EA was used in a UAH spring course in both single and multi- player mode. Performance data was gathered for learning evaluation.

Pilot use of the EA with single player mode: DAU June 2017

This pilot will be conducted with DAU teaching faculty to review its use for the DAU. Feedback was gathered on the format and content of the DAU experience.

Pilot use of the EA with single player mode: UAH Aug 2017

This pilot will be conducted targeted to begin on Aug 16th. Multiple runs and control group data will be gathered.

Pilot use of the EA with single player mode: AFIT Aug 2017

This pilot will be conducted targeted to begin on Aug 18th. Performance data of systems engineering experts will be gathered during this pilot.

LEARNING EVALUATION DESIGN AND DATA COLLECTION

Learning assessment is a critical component of accelerated learning. It is crucial to understand the learning results and the efficacy of different types of learning experiences. This is imperative both in assessing the capabilities of the learner, but also to improve the efficacy and the capabilities of the learning experience. While assessment capabilities are critically important, nothing was found in the literature that was directly applicable to automated assessment of systems engineering skills in the SEEA. Therefore, a new experimental design grounded in the literature was devised, along with a set of tools to facilitate its application.

While the Experience Accelerator (EA) has a broader goal of accelerating the learning of critical SE competencies through an experience-based system, systems thinking skills are a key component of the targeted learning outcomes. Systems thinking is at the core of the targeted EA SE competencies and therefore one of the primary competencies to be assessed in order to evaluate the effectiveness of the EA.

Systems thinking seeks to improve decision making and complex problem solving through deep systemic understanding. Typically, in order to assess learning gains in these areas, three approaches are utilized: measuring performance resulting from decisions (such as a game or simulation score), reviewing decisions and actions that were taken, or measuring learner understanding (the rules and mental operations that lead to decision making). Measuring understanding seeks to verify that improved decision making arises from understanding the system and not simply from trial-and-error. All of these approaches are valid and can result in useful evaluations. As systems thinking skills are applied in order to understand and solve complex problems, educational research on the assessment of problem-solving skills can be helpful in designing an effective evaluation.

In order to solve an ill structured problem, students must be able to deconstruct the problem into its constituent parts (e.g., stakeholders, relationships among them, impacts of the problem on them), define the problem in their own words, determine resources to help them understand the problem, determine and pursue learning issues, and develop and test a solution. Research on the evaluation of problem-solving skills tells us that in order to evaluate problem-solving ability, we must assess students' ability to do each of these steps. The EA seeks to accelerate the learning of novice SE's and advance them more quickly to expert SE performance. Experts use heuristics to skip steps; novices typically are not capable of doing this.

A meta-analysis of problem solving assessment literature found that 18 of 23 studies deemed of high quality used cases or simulations as assessment methods. With the EA Simulation, it is possible to measure learner's performance within the experience. Learners make decisions within the EA, the simulation determines the results of those decisions, and we are provided with outcomes that we can utilize in order to assess the effectiveness of learners' decisions.

In order to assess learners' levels of understanding and to determine if the EA improves learning, a more thorough picture of the thinking behind learners' choices is needed. Therefore, to assess learners' understanding, it is required to also elicit their views of the system, the problems they faced, and the thinking behind their decisions made to solve these problems. Emerging literature in systems dynamics increasingly has been seeking to assess learners' understanding or mental models.

Therefore, in order to assess learner performance, one can capture it through EA results, and analyze the actions and decisions taken by the learner. To assess learner understanding, learner approaches to decision-making (through verbal protocols) can be captured and expert choices and protocols can be used as a baseline for "good" decision making.

The evaluation plan therefore focused on:

1. Benchmarking with an objective "score" which is also useful in motivating students.
2. Comparing subject matter experts' EA actions and results to novice systems engineers' actions and results.
3. Comparing subject matter experts' written (or transcribed verbal) descriptions of their decision-making process during the EA to novice systems engineers' written (or transcribed verbal) descriptions of their decision-making process during the EA in first and second run through the SEEA experience.
4. Tracking learning with changes in 1-3 above through a learner's multiple iterations through the experience.

To support this plan, the EA was instrumented to record information to serve as a learning laboratory. Research will be done to determine the requisite data that needs to be recorded and the EA will be updated accordingly. Prior to completing this research, the following data has been selected and will be collected from the EA:

- **Participant Identification:**
  - Learner's Name & demographic information
  - Team Name & other members
  - Instruction Name & Roles played in Experience

- **Experience Session information:**
  - Experience Name and Version
  - Date of Experience Start and End
  - login dates and duration of each session
  - Phases/cycles covered in each login session
  - Elapsed time & number of sessions per Phase/Cycle
  - Links to past experience information

- **Learner Experience Inputs & Actions:**
  - Self-Assessment
  - Initial Recommendation Input
  - All subsequent Recommendation Inputs
  - Workflow sequence with each action recorded with a timestamp
  - Who is called and which questions are asked, in which order

- **Instructor Input**
  - Feedback provided to Learners (dialog, email, etc.)
  - Recommendations accepted/rejected
  - Instructor's observations

- **Simulation Output:**
  - Last phase/cycle completed
  - Results of schedule, cost, range and quality
  - Final Status Charts
  - Final score

- **Reflection**
  - Reflection feedback provided to the Learner
  - Learner's reflection input

Furthermore, a set of analysis tools are being developed to make sense of this information. Test cases are being created to provide benchmarks to baseline this analysis. The tool will provide capabilities to compare a learner's historic experience data with new ones, and use the data to match against the experts' data to determine the maturity levels of the competencies. Finally, a demonstrable set of learning experiences will be recorded and analyzed to provide feedback on the capabilities of the system.

DATA ANALYSIS AND EVALUATION OF LEARNING EFFECTIVENESS

After the pilot courses were completed, the performance data of the students were gathered and compared. The performance measures include range, critical software defects, schedule, CDR artifact completion and budget overrun. The SEEA combines these measures to determine if the CDR can be achieved successfully and determines the risk to proceed with the UAV program. During the pilot, students made different decisions resulting in a range of performances and different program results. Among the twenty-five students participating, most of them were able to complete the whole project cycle and reach Phase 7 to receive performance feedback from the SEEA.

The data gathered during the pilot application was analyzed to provide insights on the students' decision making, their capability to discover issues in the system, their ability to prioritize resources and the outcomes of their decisions. As mentioned earlier, many different types of data is gathered by the SEEA system. Participant identification and experience session information are used to identify the specific learners and their use of the system. Learner experience inputs and actions are valuable data to track the learner's actions and behaviors during the experience, which provides insights into the learner's decision making process. Simulation output data was used to determine the general performance for the learner and it also demonstrates the outcomes of learner decisions. Instructor input and reflections can be used to evaluate the efficacy of the learning and to improve the learning experience.

One example is in range performance. At the beginning of Phase 2, a weight increase in the Command & Control System (CCS) will cause the range to drop significantly. At this point, although the range is still within acceptable range, the trend line is very problematic. Many students expressed their concerns over the range trend and the defects trends. A common student reaction to it is to add more staff to the Airframe and Propulsion System (APS) and CCS development organizations, both to improve schedule and quality. As shown in Figure 17, Student #2 and Student #10 performed very well in the range performance area. As shown in Figure 18, both of them added staff to APS systems to the level of 80 or more staff which enabled them to successfully address the range issues. The approach also helps to reduce the drag coefficient as shown in Figure 19.

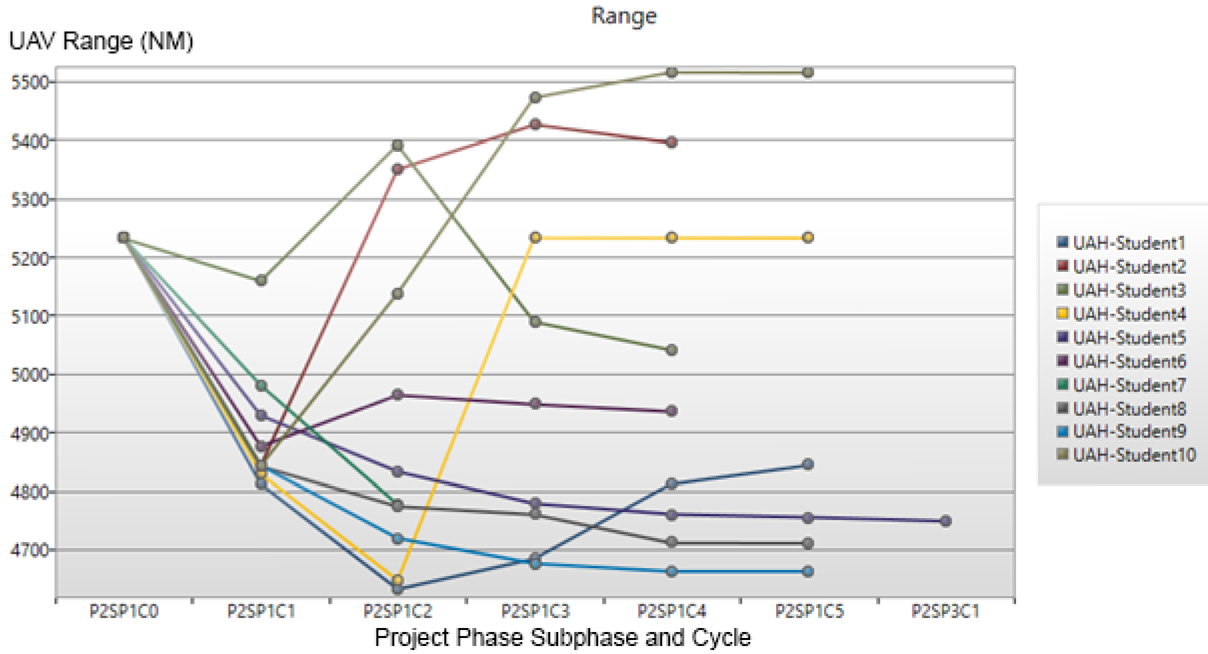


Figure 17 Range Performance

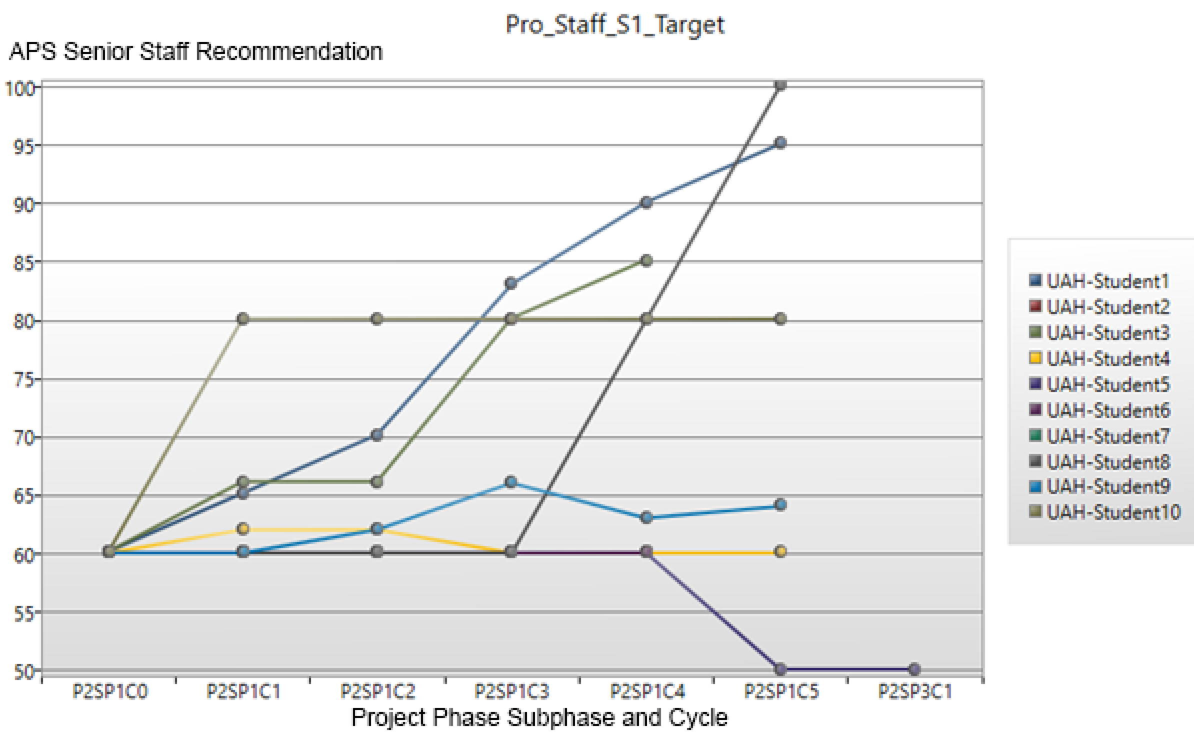


Figure 18 APS System Sr. Staff

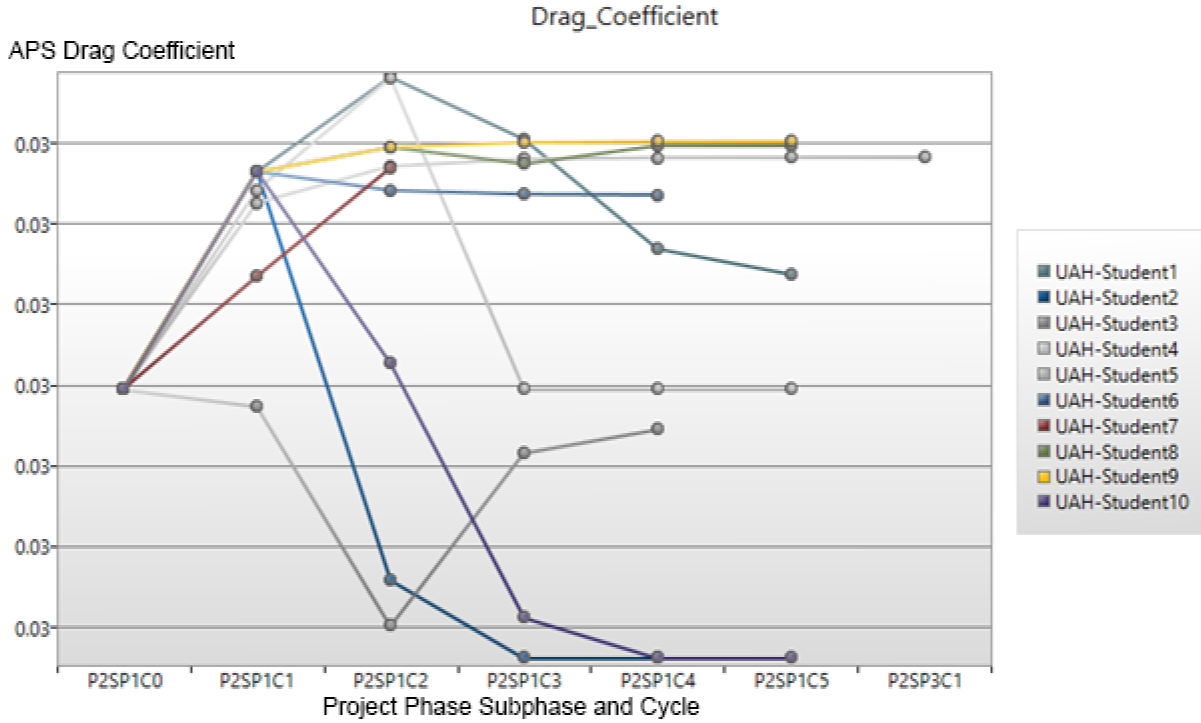


Figure 19 Drag Coefficient Performance

For the learning assessment, the group of students from the UAH pilot received their final grade for the course. The final grade was calculated based on students' performance on multiple home works and exams. The EA practice was counted as 5% towards the final grade, and thus the direct impact of the EA score was low. Figure 20 shows the correlation between the final grade and EA grade given to the students by the instructor based on the students' presentations and comments for the Experience Accelerator homework. The x-axis indicates the homework grade received by the students, while the y-axis indicates their final grades for the course. As shown in the figure, the EA homework grades are not significant as a predictor of final grade.

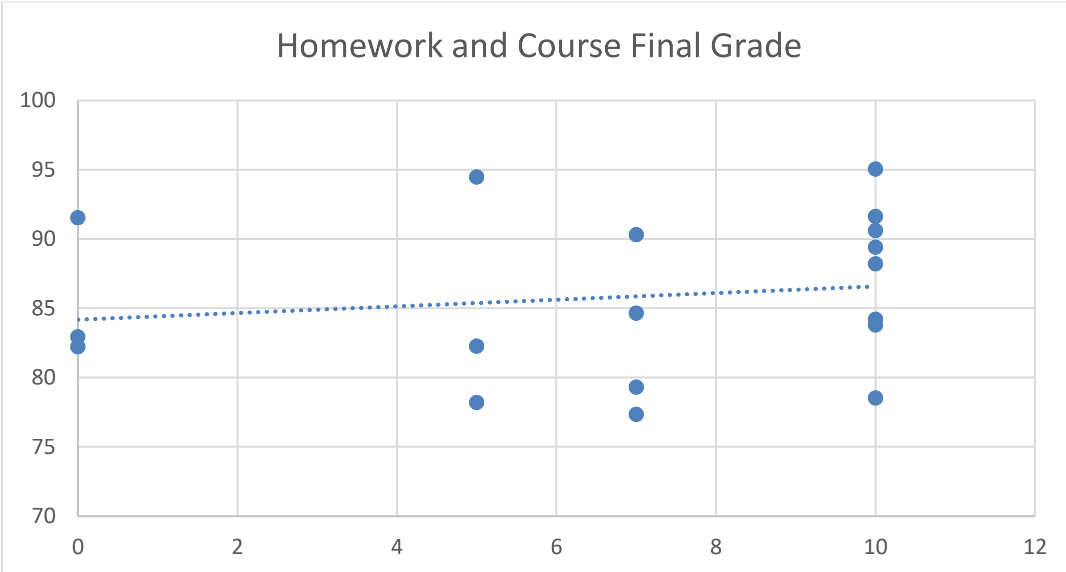


Figure 20 EA Grade and Final Grade

Figure 21 shows the correlation between the EA Final Score and the Final Grade. By comparison, the EA Final Score provides greater significance as a predictor of the Final Grade. The EA Final Score was calculated based solely on the learners' performance in the experience. Four aspects of the performance were counted, including Quality, Schedule, Range and Cost. Each of these aspects weights 25% towards the EA final score.

However, in both cases, the r^2 is too small to consider the homework grade or EA score as significant predictors of the final grade. However, it has to be noted that the EA pilot run was conducted at the beginning of the course and without a second run, it is difficult to accurately evaluate learning.

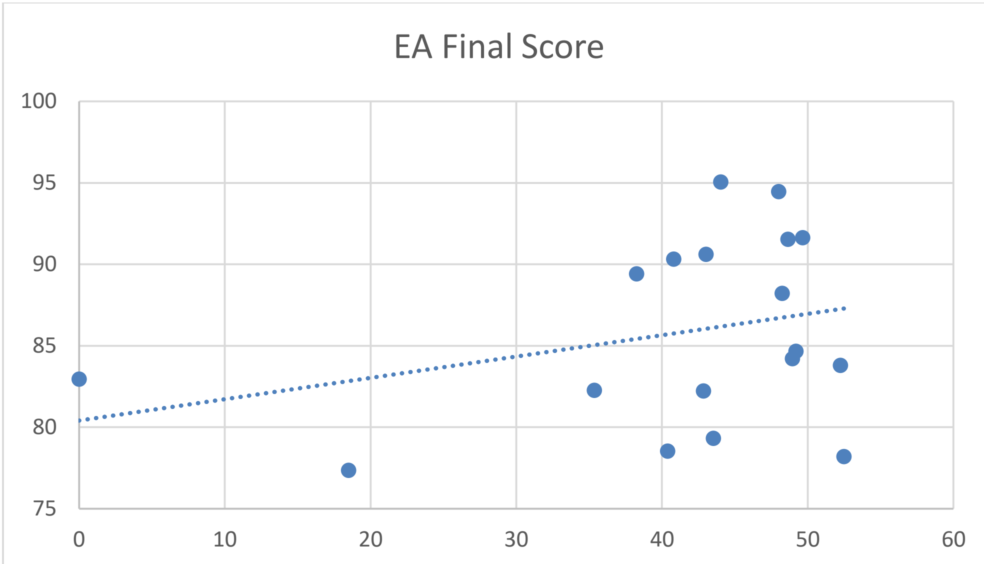


Figure 21 EA Final Score and Course Performance Regression

Also worth noting is that during the 2017 Spring UAH pilot application, about 30% of the students volunteered to use the EA through multiple runs. The data gathered from the runs indicate that a majority of the students who volunteered for the multiple EA runs improved their performance on the Range, Drag, and Weight aspects. These students generally added staff in APS and CCS development earlier in the development phase. Most of the students performed better in each subsequent run through the experience. After analyzing the students' updated rationale for the changed behavior, some degree of learning can be traced to the students describing previous performances and the potential approaches to avoid previously discovered issues. Students who went through the EA experience with multiple runs appear to perform slightly better in the class, with an average grade of 87% comparing to an average grade of 85% by students who went through EA only once in the semester. However, this result is not statistically significant. Figure 22 shows the final grade for the students, while yellow indicating the students who performed multiple runs through the EA.

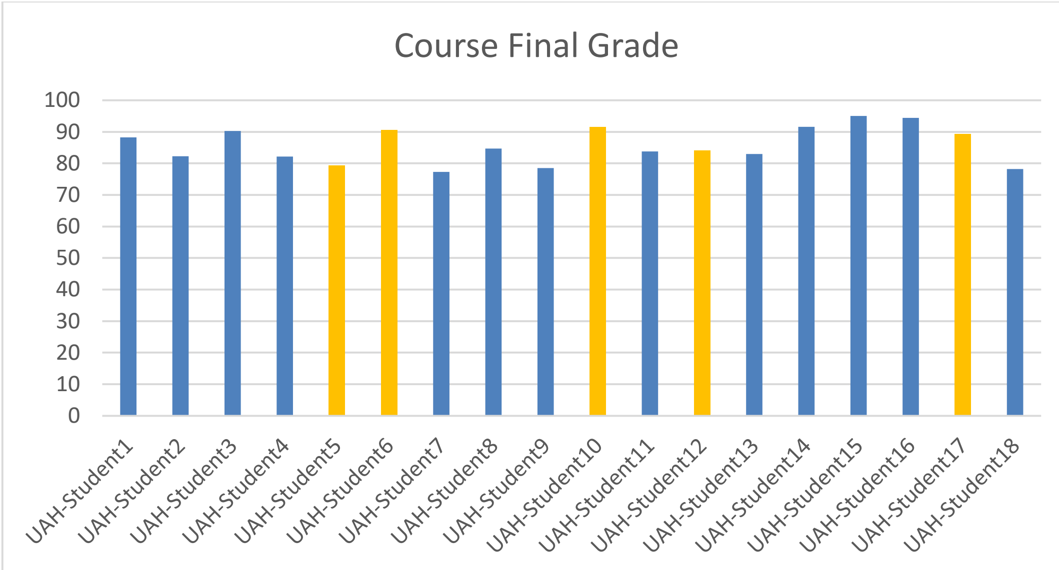


Figure 22 Students Course Final Grade

Figure 23 and Figure 24 show the Drag Coefficient Performance and the Range Performance with the comparison of 2nd run of the EA against the 1st run of the EA experience.

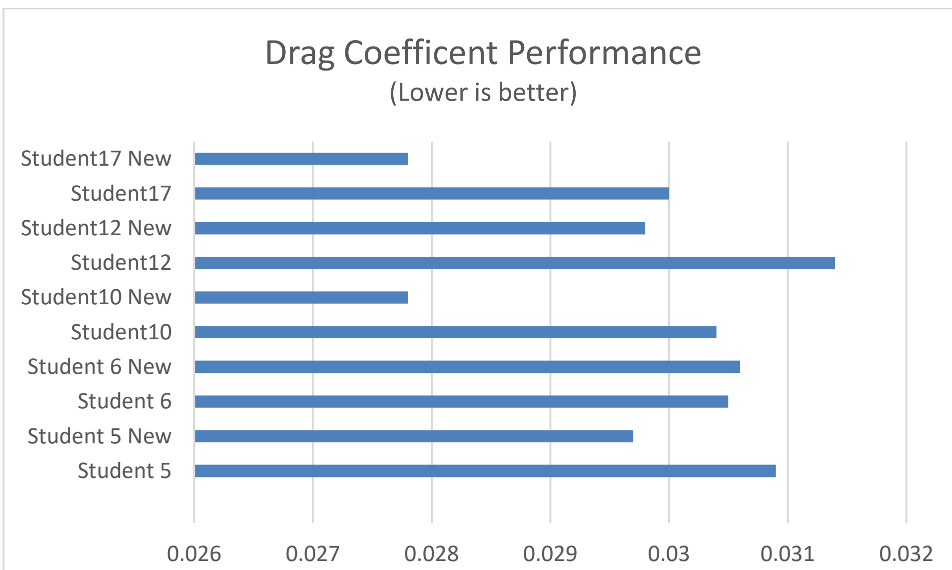


Figure 23 Drag Coefficient Performance

For students who participated in multiple runs, the improvements of the performance were significant. This result indicated that student's performance improves during multiple runs as indicated in EA scores which is reinforced by their self-assessments. However, it has not been validated through a test group the degree to which the EA contributes to overall student learning. Additional research is necessary in this area.

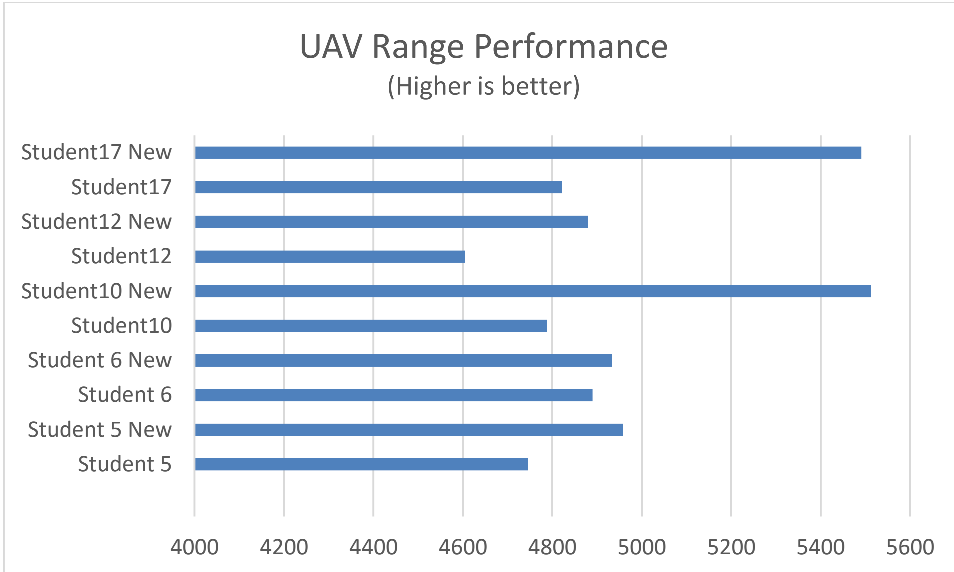


Figure 24 UAV Range Performance

Feedback from the instructor was very positive as he indicated that "the value of the EA is that it integrates into a dynamic simulation several of the key concepts covered in the systems engineering class, including:

- Technical performance measurement and tracking,
- Margin management,
- Earned value management,
- Risk analysis,
- The systems life cycle, and
- Technical reviews.

As such, it greatly augments the lectures and homework assignments for these topics, which tend to be focused on only one of these interrelated topics."

Task 5: Deployment Support at DAU

The following is a description of the concrete deliverables so that the EA can be used in the DAU on a long-term basis. This includes criteria, requirements, sustaining support, technical details of the hosting requirements, and software configuration items.

Software and Hardware Requirements

The following describes the software and hardware requirements for the EA Server, Client and tools.

EA SERVER

The following are the requirements for the EA webserver and application server:

Software Requirements

- Operating System requirement for the SEEA software deployment is Ubuntu 16.04.2 X32
- Required Software Installation:
  - Phpmyadmin Network Administration Tool
  - MySQL Database, version 14.14
  - Apache 2 Web Server, version 2.4.18
  - Java JRE 7

Hardware Requirements[2]

Performance analysis of the Flash-based version of the EA was conducted and documented in the document "Developing the Systems Engineering Experience Accelerator (SEEA) Prototype and Roadmap", Final Technical Report SERC-2013-TR-016-3, December 31, 2013. It was found from this work that the minimum application memory size to avoid performance slowdowns is given by:

*Min_Memory_Size = 181 MB base + 126.4MB * # processes*

It was also found that the time dependence on CPUs for completion of a phase was given by:

$$time = 0.4 \text{ minutes} \times concurrentSimulations \div \# cores$$

Finally, the breakdown of CPU utilization during the Phase-2 initialization and Phase-2 simulations is approximately:

- 20% - startup costs (load and pre-process model XML)
- 5% - actual simulation
- 70% - rendering, encoding, and writing graph files
  - 20% reading CSV files
  - 10% drawing of the graph
  - 20% rasterizing the graph to an image buffer
  - 20% encoding the image buffer and saving as jpeg

Below is the current EA server configuration which successfully supports approximately six concurrent users.

- One CPU core
- 512MB RAM
- 20GB HDD or SSD
- 100/1000M Internet connection

[2] Can be either virtual machine on a cloud hosting solution or physical server.

Based on the prior work, these concurrent users would experience phase updates latencies of approximately 2.4 minutes due to the CPU loading, and would experience additional delays due to the relative lack of RAM (512MB available vs. ~940MB for optimal performance). However, performance optimizations have been made since this performance analysis work was completed and there are other mitigating factors.

First, this performance analysis assumes that the users will simultaneously enter the end of Phase-2 cycle which requires the rendering of a large number of status charts. In actual usage, users will not simultaneously enter an end of phase. If learners spend an average of 15 minutes per phase, this represents a duty cycle of approximately 13% for a two minute phase end execution time. Also, a work queue was added for simulation runs queuing function has been added to the EA which was estimated to reduce average wait time by between 25 and 50%, depending on the number of users. The communication times have also been reduced through the use of files to reduce inter-process communication.

It is believed, but not yet verified, that the HTML5-based implementation will provide less of a burden on the server due to smaller Websocket package size and less frequent server/client communication. A special version of the HTML5 implementation with online chart generation can eliminate the needs for simulator to generate charts, which will significantly reduce both I/O time and simulator running time (70% of execution time is due to rendering, encoding, and writing status graph files). Future research is necessary to measure the actual impact of these performance optimizations.

EA CLIENT

The following are the requirements for the EA Client:

Software Requirements

- HTML5 Compatible browsers which currently include:
    - Microsoft Edge 15
    - Google Chrome 55
    - Mozilla Firefox 53
    - Apple Safari 10

Minimal Hardware Requirements

- Any device with internet connectivity that can support the acceptable browsers. On small screens the appearance may be compromised, but the functionality is intact.

EA TOOLS

The following are the requirements for the EA Tools support:

Software Requirements

- Microsoft Windows 7 SP1 Operating System

- .NET Framework 4.6

Minimal Hardware Requirements

- Intel Core i3 CPU
- 1GB RAM
- 1GB HDD or SSD

HOSTING SOLUTIONS

The following is a description of the possible EA application hosting solutions. Options include commercial hosting (external network), internal hosting (internal network) and/or support on a laptop within the classroom (classroom network).

COMMERCIAL HOSTING

From a logistical perspective, a commercial hosting solution is the simplest to implement. The Experience Accelerator is currently being hosted on a commercial server at the URL http://www.experience-accelerator.org/. This server can be provisioned to provide adequate to customers to ensure adequate response times for instantaneous usage. Students could access this website as they would any other website anywhere there is internet access. This solution also allows for easy access to updates in the Experience Accelerator infrastructure and experiences, and external support for the hosting services.

There are three challenges with this approach. The major one is potential firewall issues. To facilitate satisfactory client/server performance, port 1935 and 80 are required to be opened to support the sockets-based client/server communication protocols in the Flash-based implementation. This is generally not a problem in open environments, but can be an issue in secure facilities. While it is not technically difficult to open firewall ports, this usually requires approval by the organization's IT group, and there may be official policies prohibiting this action. Fortunately, with the HTML5 implementation, this is no longer necessary. The removal of this restriction has been validated with operation within the DAU and other secure environments.

The second potential issue is with the proprietary nature of an organization's experience and learner database. If an organization wishes to protect these details with greater levels of security than are available by a commercial application host, then additional security will need to be instituted or this secure information will need to be obscured by the users.

The third issue is with configuration management. There are many different ways in which a particular experience can be configured in the EA. While it is preferable that each organization has the ability to tune each experience to their liking, allowing this on a commercial host will require the ability to support multiple versions of each experience. Supporting this will require the development of new features in the Experience Accelerator. Such efforts can be achieved by creating a web interface where different experiences can be accessible to users with certain credentials. One potential technical challenge are the TCP ports used by the web application. The current HTML5 implementation utilizes port 80 for the websocket connection to avoid any firewall issues. Multiple EA instances cannot share the same TCP port for server-client communication, therefore it may lead to potential firewall issues for certain organizations. However, mitigation options are available. A gateway server linking to multiple experience servers will allow the use of port 80 and at the same time provide the users with a single easy to use interface to get access to the experiences.

INTERNAL HOSTING

This solution removes the security issues noted above for the commercial hosting solution, but it introduces a number of additional problems. The most significant of these issues is the fact that software needs to be installed inside the learner's firewall. In many organizations, this requires approval by the IT department that may entail a lengthy certification process. The EA contains a significant amount of open source software which might be an issue in some organizations. This approach will also hinder the organization's ability to have updates installed in a timely manner. Finally, it will require internal support by the hosting organization.

CLASSROOM SUPPORT

There are a number of possible solutions that could be supported by an instructor in a classroom situation in which a commercial or internal hosting solution is not possible.

Instructor Hot-Spot

In the case where external internet access is not available, the first solution is one in which the instructor provides a hot spot for the students to a commercial hosting site. If this does not violate security rules, this would be a simple solution with the advantages/disadvantage of the commercial hosting solution, but with the requirement for the instructor to provide an internet hot-spot. There might also be some bandwidth limitations if all learners instantaneously initiate status chart downloads. However, given the availability of the HTML5-based EA, it is believed that only in rare occurrences would the learner not have access to the internet through a corporate firewall.

Instructor Hosting

Another option is a hybrid-solution solution for classroom situations in which there is no access to the internet. In this case, the instructor has the EA server application installed on his/her laptop and allows the students to connect to his system through a personal hotspot or through hardwired Ethernet. The instructor could download and install this software suite on his/her computer through a download facility that the Experience Accelerator team provides. This approach would provide the instructor with the ability to tune the experience as he/she sees fit and would provide what would likely be a low-latency network.

There are a number of issues with this approach. First, there may still be security issues if the laptops used by the students in the classroom are connected to the organization's network. The other issue is that the instructor is now responsible for supporting the EA application. There are likely to be performance issues based on the capabilities of the instructor's computer. Finally, unless the instructor has the capability to use his/her computer as a webserver, the students will only have access to the application when they are in the classroom with the instructor's computer.

Learner Hosting

The final option is where both the client and server application are supported on each student's computer in which case there is no need for networking or internet access. This could be done through an install of the application through a thumbdrive or through a CD/DVD drive. In each case, the students would be provided with the necessary software. This option is simple in that each learner can work independently without reliance on anything that is not on their computer. However, it does have a severe limitation in that multi-player cannot be supported in this mode. In addition, installing software on a work computer usually requires internal IT acceptance and support, which may be more difficult that having the application installed on an internal server. It is likely that unsecure classroom computers would need to be used for this purpose. Thus, interactions between students and the instructor(s) will need to take place by means outside of the EA application. Also, the instructor will not have direct access to the students' experience data.

SUMMARY

The hosting options are summarized in Table 2 shown below. Based on the aforementioned advantages and disadvantages, the preferred option for the DAU, and most other organizations, is to use the third party commercial approach. However, the adopted solution depends upon the organization's security requirements and the relative value and cost of the parameters noted below.

Table 2 – Experience Accelerator Hosting Option

Approach	Security Requirements	Cost	Support Issues	Capabilities
Commercial Host	Protect user data on 3rd party server	Very low	Experience Version management at server	All, Fast upgrades
Internal Host	EA SW certification	Medium	Complete support of EA SW and servers	All, potential delays for certification
Hot Spot	Allow internet on personal networks	Low	Instructor supplies personal network	Potential latency for network
Instructor Host	Allow personal networks	Low	Instructor supplies network and application	Potential computer performance issues
Student Host	Allow computers to run on CD/DVD	Low	Need to burn DVDs with appropriate client/server configuration and content	No multi-player support, instructor loses access to student data

MIGRATION OF DEVELOPMENT TO 3RD PARTY SUPPORT

The following is a description of the resources and efforts for migrating the EA to 3rd party support. This includes identifying support staff and cost, and determining process and procedures for ticket creation and processing.

SUPPORT STAFF AND COST

It is difficult to estimate the support staff requirements and cost necessary to sustain the Experience Accelerator as it is still under active development and has not been productized. Currently, it is difficult to discriminate between development and support issues as new features are actively being developed and debugged, and the code is being refactored in the process to support these efforts. Currently, there are approximately two full-time graduate student equivalents who are supported at approximately 20 hours per week over the year to do research and to update and support the EA codebase, update the tools and develop new experiences. If 20% of their time were dedicated to support, this would be about 2.4 staff-months of effort annually.

The latest major development task that is related to support is the migration of the EA from Flash to HTML5 which provides a number of benefits including Section 508 compliance, removal of significant firewall issues, portability to non-Flash clients (e.g., iPads, iOS devices) and significant improvements in the capabilities and appearance of the client learner's interface. This development effort has been completed which will reduce future support effort issues.

The intention of the Experience Accelerator program is to create an open source organization that will support the EA over time, with support coming from volunteers and a small staff (probably a part-time single developer) that is supported by user donations. There has been significant interest from a number of industrial organizations that could provide the funding for continued EA infrastructure and experience support.

PROCESSES AND PROCEDURES

An agile development process is being used by the EA team in which as series of new features and capabilities are prioritized, developed, and then put back into a series of incremental releases. Weekly meetings are used to synchronize the team on the state of development. The integration and release process takes place at Stevens with the application being released and accessible on www.experience-accelerator.org.

During the past Experience Accelerator Increments, we utilized Trac for project development, management and tracking. And Subversion were used for source control.
Trac (http://trac.edgewall.org/) is an open source enhanced wiki and issue tracking system for software development projects. Trac uses a minimalistic approach to web-based software project management and allows developers freedom in determining their development processes and policies. Trac provides an interface to Subversion and Git (or other version control systems), and

integrated Wiki and convenient reporting facilities. Trac allows wiki markup in issue descriptions and commit messages, creating links and seamless references between bugs, tasks, changesets, files and wiki pages. A timeline shows all current and past project events in order, making the acquisition of an overview of the project and tracking progress very easy. The roadmap shows the road ahead, listing the upcoming milestones.

Subversion is an open source version control system. Founded in 2000 by CollabNet, Inc., the Subversion project and software has had great success over the past decade and has enjoyed and continues to enjoy widespread adoption in both the open source arena and the corporate world.

Subversion is developed as a project of the Apache Software Foundation, and as such is part of a rich community of developers and users. Subversion "exists to be universally recognized and adopted as an open-source, centralized version control system characterized by its reliability as a safe haven for valuable data; the simplicity of its model and usage; and its ability to support the needs of a wide variety of users and projects, from individuals to large-scale enterprise operations." (https://subversion.apache.org/)

After the migration to HTML5 technology, Team Foundation Service was used for HTML5 client source control. Server source control was moved to Bitbucket and SourceTree. In the Experience Accelerator Increment 4, we are moving toward the use of a more robust configuration management and defect ticketing system, most of which will be used in an open source environment. The following are the major elements of this system in the future:

- Software:
  - Project Development, Management and Tracking: GitHub
  - Source control: GitHub
  - Hosting: DigitalOcean
- Content:
  - Dialog files – Chat Mapper
  - Integration: Artifact Integrator Tool, upload to GitHub
  - Software upgrades: versioned release trains with major and minor releases
- Documentation:
  - GitHub

GitHub (https://github.com) is a web based version control repository service. GitHub allows code review, project management, integrations, community management, documentation and code hosting. Projects on GitHub can be accessed and manipulated using the standard Git command-line interface and all of the standard Git commands work with it. GitHub also allows registered and non-registered users to browse public repositories on the site. Multiple desktop clients and Git plugins have also been created by GitHub and other third parties that integrate with the platform. The site provides social networking-like functions such as feeds, followers, wikis (using wiki software called Gollum) and a social network graph to display how developers work on their versions ("forks") of a repository and what fork (and branch within that fork) is newest.

We are currently hosting the EA on Ubuntu 16.04.2 using 512MB Ram and 20GB SSD Disk by DigitalOcean.com. There are many options for this support depending on the specific needs with respect to data storage, memory, processing, bandwidth, availability, security and support.

UPDATE TO EA DOCUMENTATION

The following is a list of the EA documentation:

- Concept of Operations: EA-CONOPS v1.7, August 2017
- Systems and Support Specifications: v1.0, August 2017
- Architecture and Design: EA-System-Architecture v1.3, August 2017
- Experience Design: EA_Design_Document_v1.8, August 2017
- Tools: EA-Tools v3, August 2017
- Instructor Guide: EA_Instructor_Guide v2.5, Jun 2017
- Experience Editor User Guide: Experience_Editor_User_Guide_v0.9, Apr 2017

SOFTWARE CONFIGURATION ITEMS

A detailed description of the Experience Accelerator software configuration items, and runtime and development environment Setup is shown in Appendix A. This includes URLs for all open source software and the access rights for each software application.

FUTURE WORK

A number of future work avenues have resulted from this project. One aspect of the project addressed new capabilities and improvements to the UAV experience. These no doubt will be useful, and there are potential other new capabilities and improvements that will be needed over time.

However, we have received feedback from DAU instructors that they may be more interested in more tightly focused experiences than a multi-phased experience that tracks an entire development program. Thus, it would be useful to review the current multi-phase UAV experience to see how it can be divided into smaller experiences. This would involve learning objective development for each experience module, specification of initial conditions for each module, and tuning of the module components to meet the learning objectives and desired difficulty level.

With the completion of the Section 508 compliance work, we have met the accessibility requirement. Since this requirement may change in the future, there may be additional work needed to keep the SEEA compliant in the future. More interesting, though, is research aimed at assessing the effectiveness of this compliant version of the SEEA with respect to learners who have disabilities. It is one thing to meet a requirement. It is another to meet a need.

While we have made progress on learning evaluation in the systems engineering domain, much work remains. There was not a pilot usage of the SEEA with students at Defense Acquisition University during the project as originally planned. Rather, there was a demonstration. We addressed this situation by conducting learning analysis at universities. While this is useful, there are differences between the university student populations and the student population at DAU, which is more focused on professional development. Clearly, future work must address learning evaluation in the context of courses at DAU. With the increasing data from EA pilots comes the opportunity to develop more sophisticated approaches to analyze patterns in learning and have insight into the capabilities and growth of the learners. This is a very fertile area for future research.

In addition, more focus is needed on system conception and design, as well as technical trade-offs. The UAV experience starts shortly after preliminary design review. Thus, it does not capture the initial work of a system concept and analysis of alternatives. The technical trade study introduced by this project is certainly of value, but it has not yet been tested in a course environment. Thus, we need to evaluate its effectiveness in teaching concepts associated with trade studies.

The existing experience can also be used to introduce other technical trades. For instance, the UAV has range specified as a key performance parameter. The underlying technical performance measures related to range include weight (sub-divided by sub-system), drag coefficient, and propulsion efficiency. (Note that lift coefficient is also a technical performance measure, but it is assumed constant in the current experience.) There are two additional technical performance measures that can be traded against range – loiter and payload weight. Loiter is the time allowed for the UAV to do its reconnaissance and other work over a target, and payload weight obviously is the allowed weight of any weapons or sensor package add-on. These are modeled in the experience, but they are held constant and the learner is not allowed to manipulate them. The experience could be enriched by allowing the learner to trade these against range to facilitate trade study learning.

Furthermore, other experiences can be developed to test the learning effectiveness of the overall SEEA approach. The safety engineering experience developed in conjunction with the UK's Ministry of Defence is a good example of this (Turner et al., 2017). We have also discussed developing an experience based on the Wright Brothers flyer that was developed for the U.S. Army. This is currently a paper exercise used at DAU in the systems engineering curriculum. There is also doctoral work in the area of the assessment of systems thinking capabilities using simulation. A number of Master's projects have completed the design work for the development of simulations for early concept phase systems engineering skills and the learning of engineering economics through an entrepreneurial experience.

Future work also involves the deployment of the SEEA at DAU and other institutions. We have laid the groundwork for this with tests of the technology platform with DAU computers, third-party hosting, and deployment guides. However, these need to be tested in an actual deployment environment.

Finally, there is work to be done in releasing the EA and its tools in open source forms and the development of the open source community and ecosystem. There is significant interest in government, industry and academia to support these efforts.

CONCLUSION

This report has described research done to improve and validate the Systems Engineering Experience Accelerator and the unmanned aerial vehicle program learning experience that is deployed using the SEEA technology platform.

New capabilities were added in terms of support for the concepts that leaners should know in a major systems engineering effort. These include technical trade studies, system reliability, and technical debt. In addition, a number of improvements were made. The experience implementation was extended from critical design review through low-rate initial production as originally conceived. The simulation was tuned to help ensure realism. The non-player character role of the mentor was expanded with additional resources to support the learner. Finally, student and instructor materials were updated and expanded.

Since the SEEA is intended for use at Defense Acquisition University, there is a requirement for compliance with federal law on accessibility. This means that the SEEA must comply with Section 508 Amendment to the Rehabilitation Act of 1973, which governs computer program usage as it affects disabled employees and others. The SEEA was upgraded from an Adobe Flash technology platform to HTML5 in a separate project. This enabled much better ways to comply with Section 508 through existing compliance checking programs.

One of the most important aspects of the project was validation of the hypothesis that the SEEA facilitates systems engineering learning. During the pilot applications, SEEA was unanimously praised by the students in that it provided an opportunity to practice the skills that were illustrated in the classroom. Through the analyses of the gathered performance and behavioral data during multiple pilot uses, it is safe to assume that the EA provides the capability to benefit the learner's systems engineering learning process. Learners' performance generally improved between multiple run of the experience. Furthermore, the data gathered by EA also provides insights into learner's decision making and information analysis process making future training more productive.

Based on the review of the EA with the DAU faculty in June 2017, the use of the EA as a Workflow learning tool is tentatively planned for future work as the EA is not planned to be used during the Engineering 301 course. There are numerous possibilities for this effort which leverages the development work that has already been completed.

Finally, work was conducted to support the deployment of the SEEA at Defense Acquisition University. Primarily, this consisted of developing a plan for third-party support, testing the SEEA application on DAU computers and firewalls, and updating documentation for SEEA deployment and usage.

At project initiation, we identified the risks to successful conclusion of the project. These risks were managed and updated during project execution, and the risks mitigation plans were successful in large measure as described below.

Risk: There is a substantial amount of work that needs to be completed in the remaining two months of the project, in particular in the areas of: 1) completing the experience throughout the lifecycle, 2) completing the trade-study, 3) collecting and evaluating learning, 4) providing the transition path, and 5) ensuring 508 compliance ability to validate the EA at the DAU.

- **Mitigation strategy**: Focus efforts of research team on these tasks in the summer months. Keep close track on progress and report to the sponsor and make trade-offs on any issues that might arise. Bring in additional resources as necessary.
- **Outcome**: The mitigation strategy was used to resolve this risk successfully.

Risk: It is extremely difficult to find appropriate measures for learning in the selected areas.

- **Mitigation strategy**: Review and model research on measuring learning outcomes in constructivist-based learning environments, such as those developed with case-based learning, problem-based learning, project-based learning, and discovery learning methodologies, in order to determine how best to measure critical thinking, problem-solving, and professional skills and competencies, measure learner perceptions of learning in these areas, and capture the EA experience of some learners in order to capture qualitative evidence of learning, as exhibited through user actions and strategies within the simulation.
- **Outcome**: This project has made significant progress in systems engineering learning evaluation. Due to the scale of the research area, additional research is needed to mature the field.

Risk: There are difficulties in achieving Section 508 Compliance.

- **Mitigation strategy**: There is substantial existing support infrastructure for Section 508 Compliance of HTML5 based websites. The EA will leverage these by transitioning from Flash to HTML5 which is the top priority research item in the EA Tools Part 3 project. The effort to complete this conversion has been estimated and is not a significant risk. If the project falls behind, additional resources will be added from other sources.
- **Outcome**: The conversion to HTML5 facilitated the Section 508 compliance work. Updating infrastructure to HTML5 touched more things than originally planned, though. This introduced schedule pressure. However, the Section 508 work was completed.

Risk: The ability to validate the EA at the DAU.

- **Mitigation strategy**: One option is to substitute this as a capstone for a couple sections of 301 (approximately 60 students). Another option is to make this available on the DAU website for open student usage. Additional validation provided through UAH classroom experiences.

- **Outcome**: There was a demonstration of the SEEA to instructors at DAU on June 1. This replaced the previously scheduled pilot class usage. Since there was no class usage, we deployed the SEEA at University of Alabama, Huntsville, and at AFIT for validation. It will potentially be used at Stevens Institute on the future.

Risk: The likelihood of feature creep that prevents the completion of an adequate set of tools for to provide a complete environment for Experience creation.

- **Mitigation strategy**: Utilize agile develop practices to ensure that the highest value features are being developed at all times.
- **Outcome**: This risk was resolved as there was minimal feature creep during the project.

Risk: Ensuring that there are graduate student staff with the knowledge and capabilities required for effective, efficient tool development despite gaps in funding.

- **Mitigation strategy**: Keep current graduate students engaged as much as possible with stop gap funding from other sources. Determine other sources of students or software research developers.
- **Outcome**: This risk was resolved as funding for the EA Tools project provided interim funding for graduate students.

At this point, the SEEA and accompanying UAV experience are ready to be used in a number of university and corporate applications. Clearly, the experience will need to be tuned to meet the needs of the particular student population in terms of learning objectives and difficulty levels. In addition, other experiences have been developed and are in development to support different learning objectives and different contexts. We are pleased to report that the SEEA has produced significant interest in the systems engineering education and training community. One example of this was the reception of the Best Paper Award for Systems Engineering Training at the INCOSE (International Council on Systems Engineering) 2017 International Symposium.

APPENDIX A: LIST OF RESEARCH RELATED PUBLICATIONS

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APPENDIX B: CITED AND RELATED REFERENCES

Journal and Conference Articles and Reports

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APPENDIX C: ACCESSIBILITY REQUIREMENTS/GUIDELINES

Section 508 (§ 1194.22 Web-based intranet and internet information and applications.)

(a) A text equivalent for every nontext element shall be provided (e.g., via ''alt'', ''longdesc'', or in element content).

(b) Equivalent alternatives for any multimedia presentation shall be synchronized with the presentation.

(c) Web pages shall be designed so that all information conveyed with color is also available without color, for example from context or markup.

(d) Documents shall be organized so they are readable without requiring an associated style sheet.

(e) Redundant text links shall be provided for each active region of a server-side image map.

(f) Client-side image maps shall be provided instead of server-side image maps except where the regions cannot be defined with an available geometric shape.

(g) Row and column headers shall be identified for data tables.

(h) Markup shall be used to associate data cells and header cells for data tables that have two or more logical levels of row or column headers.

(i) Frames shall be titled with text that facilitates frame identification and navigation.

(j) Pages shall be designed to avoid causing the screen to flicker with a frequency greater than 2 Hz and lower than 55 Hz.

(k) A text-only page, with equivalent information or functionality, shall be provided to make a web site comply with the provisions of this part, when compliance cannot be accomplished in any other way. The content of the text-only page shall be updated whenever the primary page changes.

(l) When pages utilize scripting languages to display content, or to create interface elements, the information provided by the script shall be identified with functional text that can be read by assistive technology.

(m) When a web page requires that an applet, plug-in or other application be present on the client system to interpret page content, the page must provide a link to a plug-in or applet that complies with § 1194.21(a) through (l).

(n) When electronic forms are designed to be completed on-line, the form shall allow people using assistive technology to access the information, field elements, and functionality required for completion and submission of the form, including all directions and cues.

(o) A method shall be provided that permits users to skip repetitive navigation links.

(p) When a timed response is required, the user shall be alerted and given sufficient time to indicate more time is required.

Notes to § 1194.22:

1. The Board interprets paragraphs (a) through (k) of this section as consistent with the following priority 1 Checkpoints of the Web Content Accessibility Guidelines 1.0 (WCAG 1.0) (May 5, 1999) published by the Web Accessibility Initiative of the World Wide Web Consortium:

Section 1194.22 Paragraph	WCAG 1.0 checkpoint
(a)	1.1
(b)	1.4
(c)	2.1
(d)	6.1
(e)	1.2
(f)	9.1
(g)	5.1
(h)	5.2
(i)	12.1
(j)	7.1
(k)	11.4

2. Paragraphs (l), (m), (n), (o), and (p) of this section are different from WCAG 1.0. Web pages that conform to WCAG 1.0, level A (i.e., all priority 1 checkpoints) must also meet paragraphs (l), (m), (n), (o), and (p) of this section to comply with this section. WCAG 1.0 is available at http://www.w3.org/TR/1999/WAI–WEBCONTENT–19990505.

Web Content Accessibility Guidelines (WCAG)

The Web Content Accessibility Guidelines (WCAG) are part of a series of web accessibility guidelines published by the Web Accessibility Initiative (WAI) of the World Wide Web Consortium (W3C), the main international standards organization for the internet. They consist of a set of guidelines for making content accessible, primarily for people with disabilities, but also for all user agents, including highly limited devices, such as mobile phones. The current version, WCAG 2.0, was published in December 2008 and became an ISO standard, ISO/IEC 40500:2012 in October 2012. Numerous nations are using the WCAG standards as the basis for their accessible regulations.

WCAG is based on the following accessibility principles:

Perceivable

Information and user interface components must be presentable to users in ways they can perceive.

- Guideline 1.1: Provide text alternatives for any non-text content so that it can be changed into other forms people need, such as large print, braille, speech, symbols or simpler language.
- Guideline 1.2: Time-based media: Provide alternatives for time-based media.
- Guideline 1.3: Create content that can be presented in different ways (for example simpler layout) without losing information or structure.
- Guideline 1.4: Make it easier for users to see and hear content including separating foreground from background.

Operable

User interface components and navigation must be operable.

- Guideline 2.1: Make all functionality available from a keyboard.
- Guideline 2.2: Provide users enough time to read and use content.
- Guideline 2.3: Do not design content in a way that is known to cause seizures.
- Guideline 2.4: Provide ways to help users navigate, find content, and determine where they are.

Understandable

Information and the operation of user interface must be understandable.

- Guideline 3.1: Make text content readable and understandable.
- Guideline 3.2: Make web pages appear and operate in predictable ways.
- Guideline 3.3: Help users avoid and correct mistakes.

Robust

Content must be robust enough that it can be interpreted reliably by a wide variety of user agents, including assistive technologies.

- Guideline 4.1.: Maximize compatibility with current and future user agents, including assistive technologies.

Relationship of WCAG 2.0 and Section 508

The following is the general relationship between WCAG 2.0 and Section 508:

- WCAG 2.0 harmonizes with Section 508
- WCAG 2.0 Level AAA is Section 508 compliant
- WCAG 2.0 Level AA is a reasonable standard to strive for
- WCAG 2.0 Levels are prioritized based on time, money, audience, importance
- Priority 1 = Level A is required, you must do it
- Priority 2 = Level AA is preferred, it would be great if you did it
- Priority 3 = Level AAA is optional, it would be nice to have (but required for government use)
- WCAG 2.0 Level AAA is equivalent to Section 508 compliance, it is the government standard

Appendix D: EA Runtime and Development Environment Setup

The following is a detailed description of the Experience Accelerator software configuration items, access rights, and runtime and development environment Setup. This includes URLs for all open source software.

Software Applications

The following is a list of the software used in the development and deployment of the Experience Accelerator (EA). The software is categorized as being used in the Server, Client or Development. For deployment, Server and Client, the only necessary proprietary software is the Adobe Flash Player. A conversion to HTML5 would remove this dependency and allow the EA to be accessed on Apple mobile devices. For development, the only proprietary tool used is Chatmapper for GUI-based dialog creation and management.

Server:

- WampServer (http://www.wampserver.com/en/): Open Source and Free under GNU General Public License. - http://www.gnu.org/licenses/gpl.html
- SystemDynamics (http://sourceforge.net/projects/system-dynamics): Open Source and Free under GNU General Public License version 2.0 (GPLv2) - http://www.gnu.org/licenses/old-licenses/gpl-2.0.html
- JFreeChart (http://www.jfree.org/jfreechart/): Open Source and Free under GNU Lesser General Public License -http://www.gnu.org/licenses/lgpl.html
- Experience Accelerator: Developed under SERC DAU contract, no parties have claimed patent rights and desire the software to be available under open source licensing.
    - Simulation: Georgia Tech development
    - System: Stevens and Purdue development

Client:

- Browser: Proprietary and open source versions exist (Microsoft Edge, Google Chrome, Mozilla Firefox and Apple Safari supported. Mobile versions of these browsers are supported.)

Development:

- Visual Studio 2015: Community Edition Free. - https://www.visualstudio.com/
- Eclipse SDK: Open Source and Free under Eclipse Public License. - http://www.eclipse.org/org/documents/epl-v10.php
- Chat Mapper: $495 for commercial license. Works developed using Chat Mapper are allowed to be distributed under commercial license -http://www.chatmapper.com/eula/, Source Code License available.
- EA Tools: Developed under SERC core contract, no parties have claimed patent rights and desire the software to be available under open source licensing.

Environment Setup

Steps for building and running the experience accelerator on Windows from source:

1. Eclipse Classic
    a. Download - http://www.eclipse.org/downloads/
    b. Extract somewhere
    c. eclipse.exe is used to run (create shortcut for desktop if wanted)
2. Download and install Java: http://www.java.com/en/download/index.jsp
3. Download and install FlashDevelop: http://www.flashdevelop.org/
4. Download and install visual c++
    a. 32bit: http://www.microsoft.com/en-us/download/details.aspx?id=8328
    b. 64bit: http://www.microsoft.com/en-us/download/details.aspx?id=13523
5. Download and install WampServer: http://www.wampserver.com/en/
6. Run WampServer. A W should appear in the icons in the lower right of the taskbar. The W should go from red to orange to green.
    a. You may have to right click and "run as administrator"
    b. You may have to close other programs that use port 80 such as skype before running
    c. If a W still does not appear after trying the above, wait a few minutes and then try step 7.
7. After the W is green, go to 127.0.0.1/phpmyadmin/ in a browser
8. If prompted for a username and password, enter root as the username and no password
9. Once in phpmyadmin, create a new database.
    a. Go to Databases -> create database
    b. Name it expaccdev
    c. Use the default type "Collation"
10. Go to the newly created database and go to Privileges -> Add user
    a. username: expaccdev
    b. host: any host
    c. password: stevens123
    d. Database for user: Grant all privileges on database "expaccdev"
    e. Leave Global Privileges blank
11. Create another user on the database with:
    a. user name: expaccdev
    b. host: localhost
    c. password: stevens123
    d. Database for user: Grant all privileges on database "expaccdev"
    e. Leave Global Privileges blank
12. Import the database. Go to Import->Choose File->choose [EA_source_root]/server/db/expaccdev.sql. Press Go.
13. Setup Eclipse Project
    a. Run Eclipse
    b. File->Import->General->Existing Projects into Workspace
    c. Click next
    d. Click Browse for Select root directory: [EA_source_root]/server
    e. Click Finish

f. Select src.ea.server.TCP_Server.java
g. Run (Green Arrow)
    i. Choose Java Application if asked
    ii. Choose TCP_Server if asked

14. Run client (FlashDevelop project)
    a. Double click [EA_source_root]/client/Client.as3proj
    b. Open src.ea.net.Connection.as
        i. Set USE_LOCAL_HOST = true
        ii. Set USE_PORT_80 = false
    c. Test Project (Blue play button)
        i. May have to first do Project->Clean Project

Server Deployment

Setup LAMP Server

Using DigitalOcean: https://www.digitalocean.com/community/tutorials/how-to-install-linux-apache-mysql-php-lamp-stack-on-ubuntu

Setup Host for Client

Bluehost, GoDaddy, etc

For File Transferring

FileZilla: https://filezilla-project.org/download.php?type=client

Build for Server Deployment

To deploy to a LAMP (Linux Apache MySQL Phpmyadmin) server, follow the steps below:

1. Create a Server.jar file
    a. Open server project in Eclipse
    b. Go to File->Export
    c. Select Java->Runnable JAR file
    d. Click Next
    e. Launch Configuration: TCP_Server – server
    f. Choose an export destination. Name the file Server.jar
    g. Library handling: Package required libraries into generated JAR
    h. Click Finish
2. Copy [EA_source_root]/server to a directory on the LAMP server [EA_server_root]
3. Copy the generated Server.jar file to [EA_server_root]/server
4. In a browser, go to [server ip address]/phpmyadmin/
5. If prompted for a username and password, enter root as the username and no password
6. Once in phpmyadmin, create a new database.
    a. Go to Databases -> create database
    b. Name it expaccdev
    c. Use the default type "Collation"
7. Go to the newly created database and go to Privileges -> Add user
    a. username: expaccdev

    b. host: any host
    c. password: stevens123
    d. Database for user: Grant all privileges on database "expaccdev"
    e. Leave Global Privileges blank
8. Create another user on the database with:
    a. user name: expaccdev
    b. host: localhost
    c. password: stevens123
    d. Database for user: Grant all privileges on database "expaccdev"
    e. Leave Global Privileges blank
9. Import the database. Go to Import->Choose File->choose [EA_source_root]/server/db/expaccdev.sql. Press Go.
10. On the LAMP server, navigate to [EA_server_root]/server
11. To run the server, use the command: java –jar Server.jar
12. On the web server that will host the client, create a directory [EA_hosted_client]
13. Create a Client.swf file
    a. Double click [EA_source_root]/client/Client.as3proj
    b. Open src.ea.net.Connection.as
        i. Set USE_LOCAL_HOST = false
        ii. Set USE_PORT_80 = false
        iii. Scroll down to the Connect function
        iv. Set the server ip address in: var url:String = "ip address"
    c. Go to Project->Build Project
        i. May have to first do Project->Clean Project
14. Copy [EA_source_root]/client/bin/Client.swf to [EA_hosted_client]
15. Copy [EA_source_root]/currentbuild/index.html to [EA_hosted_client]
16. To run the client in a browser, go to [client web server ip address or url]/[EA_hosted_client]

Update Server

1. Create an updated Server.jar file
    a. Open server project in Eclipse
    b. Open src.ea.server.TCP_Server.java
    c. Increment CURRENT_CLIENT_VERSION (should match client version)
    d. Go to File->Export
    e. Select Java->Runnable JAR file
    f. Click Next
    g. Launch Configuration: TCP_Server – server
    h. Choose an export destination. Name the file Server.jar
    i. Library handling: Package required libraries into generated JAR
    j. Click Finish
2. On LAMP server (e.g., DigitalOcean server), stop the experience accelerator if running (Ctrl+C)
3. Replace any updated files on the server (e.g., Server.jar) using FileZilla

4. Make any needed changes to database through phpmyadmin
5. Restart experience accelerator on LAMP server using: java –jar Server.jar

Update Client

1. Replace html/css/javascript files on host (Bluehost, GoDaddy, etc) with newly developed files

Pre-built Local Version

A local running version of the experience accelerator exists for easier running in demos where internet access is not available.

Setup Database for Local Version

1. Download and install visual c++
    a. 32bit: http://www.microsoft.com/en-us/download/details.aspx?id=8328
    b. 64bit: http://www.microsoft.com/en-us/download/details.aspx?id=13523
2. Download and install WampServer: http://www.wampserver.com/en/
3. Run WampServer. A W should appear in the icons in the lower right of the taskbar. The W should go from red to orange to green.
    a. You may have to right click and "run as administrator"
    b. You may have to close other programs that use port 80 such as skype before running
    c. If a W still does not appear after trying the above, wait a few minutes and then try step 7.
4. After the W is green, go to 127.0.0.1/phpmyadmin/ in a browser
5. If prompted for a username and password, enter root as the username and no password
6. Once in phpmyadmin, create a new database.
    a. Go to Databases -> create database
    b. Name it expaccdev
    c. Use the default type "Collation"
7. Go to the newly created database and go to Privileges -> Add user
    a. username: expaccdev
    b. host: any host
    c. password: stevens123
    d. Database for user: Grant all privileges on database "expaccdev"
    e. Leave Global Privileges blank
8. Create another user on the database with:
    a. user name: expaccdev
    b. host: localhost
    c. password: stevens123
    d. Database for user: Grant all privileges on database "expaccdev"
    e. Leave Global Privileges blank
9. Import the database. Go to Import->Choose File->choose [EA_source_root]/server/db/expaccdev.sql. Press Go.

Update Local Version

1. Create an updated Server.jar file
    a. Open server project in Eclipse
    b. Go to File->Export
    c. Select Java->Runnable JAR file
    d. Click Next
    e. Launch Configuration: TCP_Server – server
    f. Choose an export destination. Name the file Server.jar
    g. Library handling: Package required libraries into generated JAR
    h. Click Finish
2. Copy the updated contents of [EA_source_root]/server to [EA_local]/server
3. Copy the generated Server.jar file to [EA_local]/server
4. Create an updated the client files
5. Copy the new client files to [EA_local]/EA to overwrite the old ones

Run Local Version

1. Run WampServer
2. Host the client folder as a localhost website
3. Go to [EA_local] and double click runServer.bat to launch the java server

<u>Add a User</u>

Instructions for adding a new user account on the experience accelerator.

1. Navigate to [EA_source_root]/server/FS_root/users
2. Create a new directory matching the new username
3. In a browser, go to 127.0.0.1/phpmyadmin
    a. Make sure to run WampServer first
4. Go to Databases->expaccdev->users
5. Click Insert
6. Fill in info for new user
    a. Username: should match created folder
    b. Pwd: password
7. Click Go
8. Run the experience accelerator and login as newly created user
9. Click Abort (needed to fill user directory for first time)

<u>Add pdf Artifact</u>

Add a static pdf to the experience accelerator for users to see in the virtual file system.

1. Move the created pdf file to [EA_source_root]/ server/FS_root/common/stat-artifacts
2. Go to [EA_source_root]/server/FS_root/common/eaFileSystem/phases
3. Open the xml file for the phase when the file should become visible
4. Add an entry to the xml: <File name="display page name" path="virtual path" pageName="page name">
    a. Display page name is the name that will appear in the experience accelerator file explorer

b. Virtual path is where the file will appear when using the file explorer in the experience accelerator client.
c. Page name should match the page name from step 1.

Update Simulator

To update the simulator used by the experience accelerator, replace any updated files in [EA_source_root]/ server/FS_root/common/-----/local_sim