# Collaborative Development of a Synthetic Task Environment by Academia and Military

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## ABSTRACT

Synthetic Task Environments (STEs) can allow for low-cost and efficient ways to conduct research and provide training compared to live training. However, university researchers, particularly graduate students, often lack resources to develop STEs for research and educational purposes. The accessibility of commercially-available software, like game development engines, allows for the rapid development of STEs. These software platforms allow for the creation of complex environments with limited development expertise. This paper will discuss a collaborative effort between Florida Institute of Technology (FIT) and the Air Force Research Lab's Gaming Research Integration for Learning Laboratory (GRILL) to develop a small Unmanned Aircraft System (sUAS) STE for a search task. The development utilized Unreal Engine to develop the STE in less than nine weeks. The STE consisted of grassland environment, a sUAS with a full interface to complete a sUAS led search and rescue mission. The FIT graduate student led the upfront analysis for the STE, including sUAS operational issues, task analyses utilizing Subject Matter Experts (SMEs), and requirements for the STE. The graduate student then spent a five-week period over the summer co-located with the GRILL and led a team of high school student interns, with daily mentorship from a GRILL software engineer, in development of the STE. This period allowed for rapid buildout of a sUAS environment with the following attributes: (a) high cognitive fidelity with respect to a UAS search task, (b) flexible interfaces for researchers to alter STE parameters, (c) integrated research tools such as questionnaires, (d) fully customizable mission characteristics, and (e) tailored output files for streamlined data analyses. The result was a sUAS STE that allowed for tailored research efforts at FIT and proof of concept technology for the GRILL. This paper describes the collaborative process, methods, and recommendations for other entities pursuing collaborative development efforts.

## ABOUT THE AUTHORS

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## INTRODUCTION

The unmanned aircraft system (UAS) industry is rapidly becoming a central component of both civilian and military operations due to the lower cost compared to manned solutions. Additionally, UAS systems can provide situation awareness, sensor information, and efficiency to missions, above and beyond what can often be achieved with manned teams alone. The use of small UAS (sUAS) has become increasingly prevalent across several domains. Results of a survey of the most frequent non-recreational uses of sUAS was published in the FAA Aerospace Forecast (2019) and revealed that the most frequent uses of sUAS include research, film and entertainment, industrial, and environmental purposes, with smaller sectors including construction, real estate, agriculture, and emergency services. Mika (2009) identified multiple use cases for sUAS operations to aid in emergency services, including: search and rescue, incident imaging for reports, fire investigation, flooding inspection, and information gathering. The FAA noted that 3% (or 8,000) of these sUAS missions are based around emergency and preparedness, but that they are "at the experimental stage" and expected to grow as technology improves (FAA, 2019, p. 47). The FAA projects that the sUAS industry will grow to 1.6 million vehicles for commercial use and 3.5 million for recreational use by the end of 2021 ("FAA forecasts growth", 2017).

In the military domain, the use of sUAS is also on the rise. As many as 5,400 UAS were being used for by the Air Force as far back as 2014 and is expected to grow—becoming 60% of the aircraft for the Air Force by 2035 and up to 75% of the aviation assets for other branches such as the Army (U.S. Department of Transportation, 2014). This growth in the military UAS domain can be attributed to the increased use cases and advanced functionality of UAS including specialized missions, security, reconnaissance and to increase the situation awareness of small squads across various branches of the DoD (Gettinger, 2018).

Despite the increase in utilization of UAS, there is currently a lack of proper training tools to ensure the technology is used safely and effectively (Mouloua, Ferraro, Kaplan, Mangos, & Hancock, 2019). Currently, only written exams are required to become a civilian UAS operator in the United States, with no requirement to gain or demonstrate the ability to safely operate the vehicles. This causes concerns for the safety and performance of UAS operation. Additionally, military UAS training has seen issues with operators not receiving full training or with training programs lacking effectiveness and efficiency (GAO, 2015). In 2017, large shortages of qualified UAS pilots resulted in manned pilots being placed into unmanned positions, and over 80% of units failing to meet annual minimal training requirements by more than half of the hours required (GAO, 2017). Many UAS are operated in automatic flight modes, however, mission operation training is still needed. The growth of the UAS industry in military and civilian operations illustrates the need for proper training, assessment, and research environments. Adequate levels of UAS operation training are critical to prepare pilots for the lack of sensory information normally available in the cockpit (Endsley & Jones, 2004; Center for Strategic and Budgetary Assessments, 2013). Lack of mission operations training can lead to accidents and incidents—even with high levels of autonomous flight capabilities—which we have seen in both commercial and military sectors, including examples such as the predator crashes resulting from human error (Balog, Terwillinger, Vincenzi, & Ison, 2017; Barnes & Matz, 1998; Center for Strategic and Budgetary Assessments, 2013). Despite this need, currently few training opportunities or environments exist for UAS operations for both piloting practice and more importantly mission operations training.

Many factors play into the limitations in sUAS training opportunities. Federal and local jurisdictions, national airspace classifications, and logistical issues all play a role that makes training sUAS operators for commercial purposes in a live setting almost infeasible. Similar roadblocks are faced by researchers attempting to study commercial and military sUAS operations and interfaces as emergency situations often cannot feasibly be replicated in live settings. Many sUAS simulators focus on manual flight skills and do not offer clear performance metrics or configurability for research settings. One of the key constraints limiting the available training and research opportunities is the lack of environments that are relevant to the real-world application (Bennett, Rowe, Craig, & Poole, 2017). Other issues include the ability to create an environment with high enough fidelity to be immersive, similar in cognitive demands, and that can be utilized to assess performance (Bennett et al. 2017; Mouloua et al. 2019). This is compounded by the wide array of sUAS vehicles currently being utilized in civilian and military settings. The deficiencies in current sUAS training environments and the ever-changing nature of sUAS available in the marketplace requires rapid development of synthetic task environments (STEs) to meet this demand. Utilizing a traditional DoD development model to achieve this goal would prove too costly and time consuming. Therefore, we propose here a use case collaboration between academic and the military as a means to rapidly develop high fidelity sUAS STEs which incorporate features to support both research and training for both civilian and military UAS operations.

The Advancing Technology-interaction & Learning in Aviation Systems (ATLAS) Lab at Florida Tech, a STEM university in the southeastern US with a collegiate sUAS training program, teamed with the Air Force Research Lab's (AFRL) Gaming Research Integration for Learning Laboratory (GRILL) to develop a sUAS STE for a search and rescue task. The goal of the effort was to rapidly develop a low cost and flexible STE that could support both operational training and academic research. The following sections detail the methods and resulting STE.

## METHODS

The GRILL and ATLAS Labs were ideal partners for this endeavor. The GRILL, which operates under the AFRL 711$^{th}$ Human Performance Wing's, Airman Systems Directorate Warfighter Readiness Research Division aims to provide research and training technology to increase warfighter readiness and provide training tools to the community. The GRILL utilizes commercial game development software that can support rapid STE development and also provides opportunities for students to become involved in the development process, allowing for an educational experience while simultaneously providing solutions to meet military and civilian needs. The ATLAS Lab at Florida Tech researches issues surrounding cognition and learning in aviation, UAS and beyond, including learning and expertise development and training system design. Further, the ATLAS lab has access to FIT's sUAS training program and instructors and is closely connected with the local community of sUAS operators, including those at Kennedy Space Center, Brevard County Ocean Rescue, and Brevard County Environmentally Endangered Lands Program. The ATLAS Lab's relationships provided the team access to an array of end users to facilitate up-front analyses in order to frame the needs and requirements of the STE, and provide experienced operators for development feedback, refinement and evaluation. The GRILL was able to provide development expertise, a development team, and technical support for the production of a more robust environment compared to currently available systems. The development team consisted of one software engineer from the GRILL, one college intern from the GRILL, four high school student interns from the Dayton, OH area, and one researcher from the ATLAS Lab. The student interns were selected from the Wright Scholar Internship Program and other internship avenues for a summer-term at the GRILL in Summer of 2019. Students consisted of high school juniors or seniors, interested in STEM careers, with high academic achievement; however, with no prior experience in game or software development. The interns completed a nine-week full time paid internship and were mentored by a software engineer from the GRILL. The strengths of the two entities provided a complementary working dynamic to rapidly develop a sUAS STE, which was coined the UAVSIM.

### Phase 1: Upfront Analysis and Requirements Development

The first sUAS STE use case scenario was an emergency search and rescue mission. Prior to the development phase, the ATLAS Lab met with local commercial sUAS operators including those from local Ocean Rescue to discuss the key characteristics that would be needed to ensure that the sUAS STE both mimics real world operations and can be effectively utilized as a training environment. To start, SMEs were interviewed on the experience of a UAS-led emergency response. SMEs were asked to walk through the scenario from start to finish including how they utilize a UAS to assist in an emergency situation and what challenges they face. Next the SMEs were asked a series of questions such as "What features on the drone do you utilize most in your operations?" and "Which flight mode, manual or automated with waypoints, do you tend to use more often?" Details were captured such as unmanned aircraft vehicle (UAV) flight patterns, controls, key elements, interactions and challenges, and the nature of the environment. The ATLAS Lab team then converted these details into features, elements, and functionalities required of the STE in order to facilitate training. This included requirements such as waypoint functionality, gimbal control, satellite map imagery, primary UAS parameters such as height, altitude, and distance, and realistic environmental fidelity with accurate scaling. Next, the ATLAS Lab team determined key data collection and research tools necessary to facilitate use of STE to conduct sUAS research. The first experiment for which the sUAS STE would be utilized would evaluate the effects of heads-up display interfaces in emergency sUAS operations on operator situation awareness and performance. This resulted in requirements for the environment to be able to capture performance metrics, integrate live situation awareness queries, and export all key scenario data out of the simulator for data analysis. Based on the results of these two analyses, a set of requirements were developed and delivered to the GRILL team to develop the STE to facilitate sUAS emergency search and rescue operations. The ATLAS Lab and the GRILL worked closely together and with SMEs to ensure all requirements were feasible, could be delivered, and met the needs of the end users.

## Phase 2: Rapid Development

The GRILL student interns were tasked with the bulk of the STE development and given focus areas such as interface and menu design, UAV physics and lighting, and environment creation. The software engineering and college intern were tasked with more complex coding of STE such as UAV flight dynamics and backend structure along with software packaging and installation. The ATLAS Lab researcher was tasked with query development, scenario development, requirements review, and pilot testing.

### Development Technology

Unreal Engine was selected as the STE development platform for a few key reasons. First, unreal engine provides a blueprint style coding development. This style of coding provides a visual GUI of developing function boxes and drawing connections between functions called blueprints—providing a more user friendly and simplistic approach for novices (see Figure 1). Additionally, Unreal Engine provides a higher level of graphical fidelity with less coding and development required. The project required high visual graphics for immersion and applicability to real world settings. Other game engines such as Unity are more suited for experienced coders and offers more advanced and complex development. The use of a more robust engine such as Unity was not justified given the added expertise required. In addition to the use of Unreal Engine, programs such as GitHub helped facilitate version control and allowed multiple individuals to work on separate aspects of the project at the same time. Multiplayer Unreal plugins were also utilized which allowed for multiple students to edit the same environmental map at the same time.

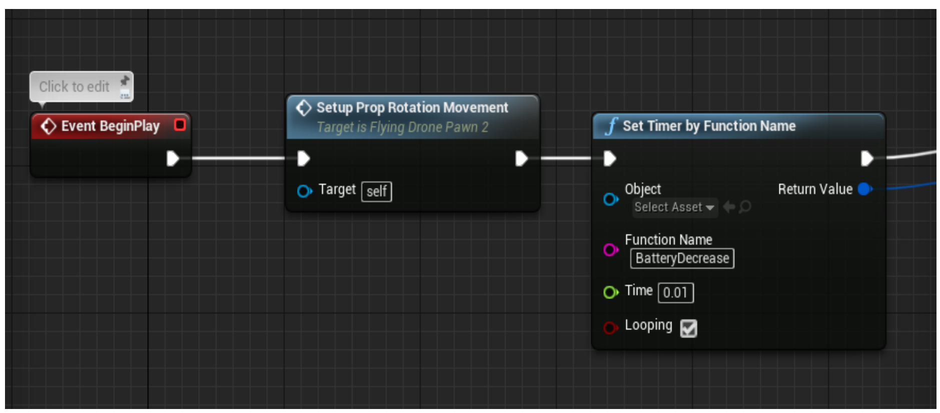


**Figure 1. Example of Battery Level Blueprint**

### Development Process

The initial development process lasted four weeks. The students arrived to the GRILL, began learning Unreal Engine and the development process, which included laying the key functionalities and components of the sUAS STE. During this time, Skype meetings were held between both entities to share the beginning stages of the simulator for ATLAS

Lab feedback. The ATLAS Lab worked on the development of scenario details and situation awareness query development for integration in the co-located phase. In the later five weeks of the student internships, the ATLAS Lab member traveled to the GRILL and was co-located to support rapid development and troubleshooting of technical issues and feedback on design decisions. Videos and screenshots of the STE were shared with SMEs virtually to obtain their input during this phase. During the last two weeks of development the ATLAS Lab team member returned to the ATLAS Lab to conduct a pilot test of the STE with sUAS SMEs to obtain feedback. The final week was utilized to make adjustments based on STE input. The two labs used an agile-like approach that consisted of development, review, and adjust approach throughout the development process. The end result was a STE with all basic functionality needed to perform pilot testing.

**Phase 3: Prototype Evaluation and Final Prototype**

After initial development period, the ATLAS Lab beta tested the STE in Melbourne, FL. SMEs and sUAS operators provided feedback on technical issues and the realism of the STE. The beta testing resulted in identification of several small technical issues to address such as time stamping issues and UAV camera positioning after queries, as well as necessary adjustments to the make the scenario more realistic such as tree height, and human target locations. The ATLAS Lab team member was provided Virtual Private Network (VPN) access to a development computer at the GRILL to make minor changes to the STE as needed without the need for constant intervention from the GRILL team. The GRILL software engineer handled more complex technical issues as they arose. This process was iterative in nature until no more adjustments were needed. Throughout the evaluation process, the STE was posted on an online cloud to allow the ATLAS Lab team to download new iterations as soon as they were published. This allowed for issues to be corrected and new versions of the STE to be rapidly published before the next beta testing the following day. The end result was a polished STE ready for both research efforts and training operations for search and rescue scenarios.

## RESULTS

The final product was a sUAS STE coined UAVSIM, which offered a robust set of features and options for use in sUAS training and research. The UAVSIM provides a multi-monitor or virtual reality experience of flying visual line of sight (VLOS) sUAS operations (see Figure 2). The first use case mission of the UAVSIM was a search and rescue mission in a grassland environment. Those utilizing the STE control a camera gimbal on the UAV while the UAV flies an automatic search pattern consistent with civilian sUAS operations in emergency situations. In desktop mode, operators can pan the camera across environment using a keyboard, while in VR mode users can turn their head to pan the view. Users of the simulation can search for the missing persons in the search and rescue mission and take pictures for the rescue crew using the space bar in desktop mode and a button on the controller in VR mode. The UAVSIM allows for traditional heads-down operation which presents the UAV flying in the environment in one display, and the tablet interface with all UAV parameters in a second display. This is accomplished by using two monitors in desktop mode or a simulated heads down mode with a tablet in hand in the VR condition. Also available is a heads-up interface configuration that can simulate the use of AR interfaces that overlay sUAS parameters over the environment in desktop mode and fixed to the head

**Figure 2. UAVSIM Final Product**

position in VR mode. Also supported are both automated and manual flight mode to support the practice of manual flying skills in the event that automation the vehicle automation fails or is disabled.

**Unique Features of UAVSIM**

The UAVSIM provided a realistic and flexible STE for sUAS research and training purpose. First, UAVSIM allows for high cognitive fidelity as it mentally engages the user by presenting information consistent with real world-sUAS use cases and requires an equivalent cognitive load (Hochmitz & Yuviler-Gavish, 2011). Realistic models of foliage, humans, and UAV structure were integrated for realism. In addition, online databases of satellite imagery were downloaded and used as a guide to recreate real-world locations within the STE. In Unreal Engine, once object models are available as assets, users with minimal game development experience can build environments from the ground up in as little as a few hours. This allows for the recreation of specific real-world locations with which military or civilian operators can practice and become comfortable (see Figure 3). For the first UAVSIM scenario, the common grassland training area near Florida Tech was utilized. Second, the UAVSIM was developed to allow for different interface configurations to be tested such as heads-up display versus traditional heads-down displays. The two modes of virtual reality and desktop mode allowed for the flexibility of use cases based on the end users budgetary, technology, and portability constraints.

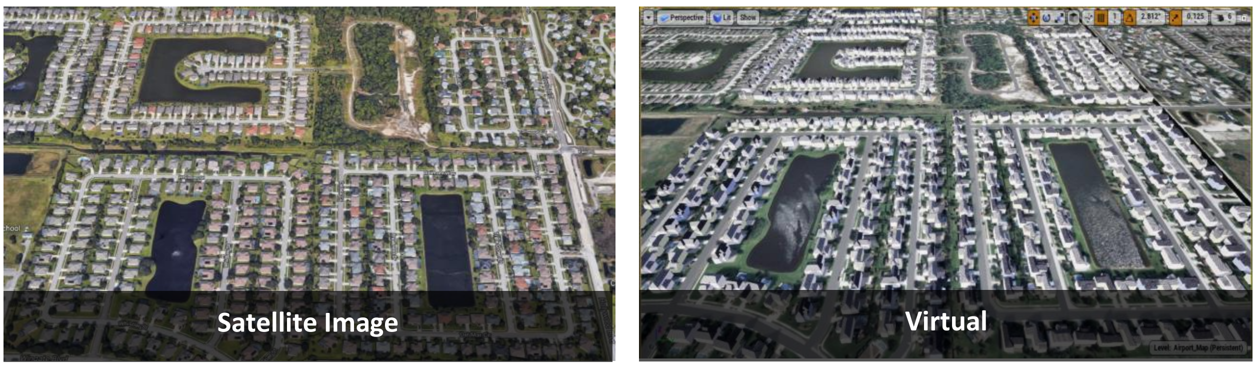


**Figure 3. Comparison of Real versus Simulated Environment**

**Research and Assessment Tools**

Three key research tools were included in development of the UAVSIM to support conduct of research and delivery of training. First, the menus within the UAVSIM allow the facilitator of a research study or an instructor to adjust system parameters such as: environment map, UAV speed, UAV battery life, UAV flight mode, desktop or VR mode, integrated heads up mode or separated heads down mode, sUAS parameter scaling, and auto UAV tracking. Second, the UAVSIM provides a set of tools that are beneficial for evaluation of performance that are not present on other sUAS simulations readily available. An excel spreadsheet for each session is output with time of the session and selected settings, such as route, interface mode and if auto tracking was enabled. In addition are images captured by the participant along with timestamp data that can be utilized to determine target detection rates and detection times for research and sUAS operator performance evaluations. Third, the STE has integrated a freeze-query approach for measuring situation awareness. A facilitator or instructor can develop their own set of questions and time of administration in the mission. This is accomplished by entering them in an excel file and uploading in the setting menu before launch. Facilitators or instructors can use this function to assess situation awareness by asking queries such as “How many search lines has the UAV flown in the last two minutes?” effectively instantiating the SAGAT approach (Endsley, 1995c). However, the flexibility of this method allows the presentation of any question or query within a scenario. The files trigger a pause in the simulation, blanks the screen, and allows for queries to appear on the screen for users to answer. All answers to the queries are exported to the same corresponding excel file. This tool can be utilized to integrate questionnaires and asses various constructs such as situation awareness, workload, and to find faults in a sUAS operators scan patterns by querying the state of the environment. Facilitators and instructors can then use the export data of queries, timestamp data, and image captures, which are organized nicely in a spreadsheet, to assess performance, situation awareness, and various other constructs often captured manually by an observer.

**Configurability**

Lastly, the UAVSIM was developed by the GRILL to allow inexperienced developers to be able to make minor changes without intervention by the GRILL team. The UAVSIM serves as a framework with a starting application of an emergency search and rescue situation. However, the assets within STE development file allow an inexperienced developer to create new environment maps to mimic other real world locations. In addition, users can create “waypoints” for the sUAS to fly to in automatic flight mode that allow the user to define various sUAS parameters at each waypoint such as speed, altitude, connection status, GPS strength and so forth. The altering of these parameters allows a developer to create various automated flight missions with different UAV behaviors and flight patterns. One particularly beneficial use case is the development of this STE as a proof of concept on an unclassified project which can then been tailored and developed for a classified scenario for evaluation and training scenarios. Research in current rapid development of training solutions argues the importance of allowing adjustments to the learning content to ensure training software does not become obsolete. Ensuring training software and content can adapt based on evolving needs and training requirements is imperative for long-standing reduced costs and has currently been an area lacking for U.S. Air Force simulators (United States Air Force Scientific Advisory Board, 2019). UAVSim was developed such that all parameters and environment development techniques can be taught to a novice user, in very little time, to allow rapid reconfigurability based on the scenario needs. This allows research personnel the ability to make adjustments to the simulator and scenario without assistance from a software engineer, further reducing the cost.

**Cost Benefit**

Development of high-end simulations can cost upwards of half a million to five million dollars (Straus, et al., 2019). Research in the game-based training field—even with drastic decreases in costs—can still demonstrate development costs upwards of $700k-$800k per year for complex army training games and $100k for specific application games such as communication training games for NATO personnel (Peck, 2012; Prensky, 2001). Examining the development cost of UAVSim, which included a six-person development team as described above, over a nine-week development period, illustrates the potential for reduced development costs. For example, a team composition utilizing one software engineer with an average salary of $80k, four student interns with an average rate of $16/hr, and a graduate student researcher with an average rate of $20/hr, utilizing free commercially available development tools, would average costs of approximately $45,000 for a nine-week research and development period. Beyond the development period, metanalytic studies reveal that using simulated AR/VR environments can significantly reduce time to skill acquisition, increase amount learned, and improve immersion during learning, making these rapidly-developed simulators appealing as training alternatives (Fletcher, Belanich, Moses, Fehr, & Moss, 2017). SMEs utilized in the development of the UAVSIM and commercial operators recruited for research both expressed interest in the UAVSIM as a training tool and expressed how it unveiled areas of needed improvement in their own operations. The UAVSIM was shown to be effective at revealing performance and situation awareness differences for novices and experts as well as situation awareness improvements in the heads up configuration, demonstrating it as a useful platform for assessing operators performance and novel interface designs (Rebensky, 2020). Further, sUAS training must include a certified visual observer, travel to approved training locations, manually placing targets in the field, and maintaining airspace restrictions. Logistically and financially, live sUAS training opportunities are often limited to only a couple of times per year. UAVSIM provides the ability to train multiple operators on their own time, without risk of sUAS damage, making simulator training an appealing training avenue. Furthermore, the ability to alternate between desktop and VR modes allows for the flexibility in hardware costs.

## DISCUSSION

The collaborative effort between the ATLAS Lab and the GRILL proved beneficial for both parties. The end product was a sUAS STE that could be utilized for research for the ATLAS Lab, used by civilian sUAS operators for training, and used by the GRILL as a framework for other Air Force applications classified and unclassified, which is an area of desire expansion for the Air Force (Headquartes United States Air Force, 2010; Kumm & Burwell, 2017). The flexibility of the UAVSIM will allow the ATLAS Lab to conduct various research studies, while the GRILL can use the approach and STE developed as a framework for military training and evaluation purposes. Furthermore, the student interns gained a valuable experience on the STE development process in an applied setting. Other sUAS simulators offer search and rescue missions such as the *DJI Flight* at enterprise costly pricing, however, does not provide collection of research data or allows facilitators or instructors to recreate local areas. Other simulators such as *Real Flight 9* do allow for custom environment creation; however, do not consist of operationally relevant items in a military or emergency setting and focus primarily on flight performance. Furthermore, affordable simulations such as *Real Flight 9, Pheonix R/C, and Zephyr Drone Flight Simulator* all focus on scenic environments and improving manual sUAS flight skills, but do not provide the features of data collection, detailed environment collection, and applied missions as the UAVSIM.

The collaborative partnership was successful due to a few key reasons.

First, the strengths of each lab complemented each other allowing each team to do what they do best. The structure of the development process allowed for the ATLAS Lab team to provide requirements and feedback to the GRILL for agile-like development sprints. The game development life cycle relies on the development of requirements, often task analyses that can improve effectiveness in simulators, prototyping, production phases, beta testing, and then release (Aleem, Capretz, & Ahmed, 2016; Jones, Hennessy, & Deutsch, 1985). The ATLAS team with expertise in the human factors domain was able to take the lead in the requirements and beta testing components, whereas the GRILL could lead the prototyping and production phases. This relationship allowed for a fluid development process with little to no issues.

Second, many technology support systems were leveraged that allowed simultaneous development, remote collaboration, and discussions using plugins in Unreal Engine, GitHub, and Skype. This has been an area of needed improvement for simulation development for the Air Force to improve its simulation repertoire (Headquartes United States Air Force, 2010). Additionally, leveraging software assets and game engines is gaining traction in the military domain due to the ability to be effectively utilized with minimal development time (Kumm & Burwell, 2017). In software development teams, clear definition of who is responsible for which task and clear collaboration rules are key to effective team dynamics—and collaboration tools and management programs can help facilitate this (Nguyen-Duc & Cruzes, 2013).

Lastly, the co-located sprint allowed for rapid development and decision making. Many domains suggest face-to-face meetings when possible as they allow for connection between team members, which can help facilitate effective virtual communication later (Nguyen-Duc & Cruzes, 2013; Duarte & Synder, 2000). Many distributed teams likely only have a face-to-face kickoff or no in-person meeting at all. Although a face-to-face kickoff is beneficial, the co-located sprint allowed for a whole additional level of effectiveness. Questions from students could be posed to the ATLAS Lab team member and instantaneous feedback could be provided. Any issue that arose could be debated, collaboratively approached, and addressed immediately. The UAVSIM could not have reached the level of complexity it did in the allotted time without the co-located development phase.

## Lessons Learned and Recommendations for Future Research

The collaboration between the ATLAS Lab and the GRILL provides some key insights for future collaborations. First, future entities looking to collaborate between academia and military should ensure team roles are clearly defined. Providing a clear structure and schedule ensured each team knew their respective responsibilities and kept the development team on track. Learning and becoming comfortable with the team dynamics can be supported and expedited by setting expectations, roles, and deadlines at the beginning. Doing so can ensure that the teams hit the ground running. The ATLAS Lab member was only co-located for the last five weeks. Co-located development was beneficial, not only for the development efficiency, but also for building team dynamics that improved remote work effectiveness, which has been shown critical for virtual teams (Duarte & Synder, 2000). It would have been beneficial for the ATLAS Lab member to be co-located for the duration of the project. An additional week prior to the student interns' arrival would have also allowed for a more structured plan to be presented to the students from the ATLAS Lab team member and GRILL software engineer. Second, the technological tools proved vital for developing a robust STE over a short time period. Incorporating team software such as GitHub, Google Docs, and Unreal Engine multiplayer plugin allowed team members to work on the same aspects simultaneously. If the team dynamic relied on these aspects to be handed off one at a time, the STE could not have been developed in such a short time span.

Third, it's important for researchers to get their hands dirty. Despite the focus of the ATLAS Lab team member's roles as non-development, she became involved in the game-development learning experience, which allowed for tweaks within the STE to be made by the ATLAS Lab team after the co-located phase. This facilitated not only independence of the research team from the development team but made brainstorming and communication easier between the two parties. Technical issues or approaches to accomplishing functionality within the simulator was more easily accomplished once the researcher had a hands-on understanding of how Unreal Engine operates. Fourth, it's important to understand the research role. The GRILL presented an understanding and involvement in the researcher goals which allowed for innovation in the UAVSIM to appeal for multiple purposes. Understanding the needs of the researcher side beyond the recreation of live environment is key to developing a novel STE. Lastly, the students selected were from a rigorous selection process and had selected the UAVSIM project as their topic of interest. Allowing students to select the product they are most interested in kept motivation and engagement high. Nevertheless, utilizing student interns required a learning period as they became familiar with game-development. The project could have potentially been completed in less time if students had some form of prior development experience or if experienced software engineers were utilized. However, developers should weigh the financial and educational benefits for the students as opportunities to become this involved in research and development are rare.

## CONCLUSION

Challenges in military and academic settings to replicate real-world missions utilizing UAS fueled a collaborative effort to rapidly develop a sUAS STE. The GRILL Lab was located in Dayton, OH, while the ATLAS Lab was located in Melbourne, FL; however, both entities provided unique skills that could benefit one another. A symbiotic working experience of define, develop, refine between the two teams resulted in a STE that addressed a real-world problem and was developed over the course of a summer timeline. The collaborative experience presented here proved fruitful for both parties, addressed a need, and would be beneficial for various other areas of the military and academic worlds—even over great distances. It is important that we continue to foster research and innovation between military and academia domains as both have unique strengths. We should continue to find ways to facilitate effective working relationships between both worlds to continue to innovate research and training approaches.

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