UAV Mission Planning Methods and Preparedness Gaming Platform applied to Informal Undergraduate STEM programs to Track and Improve Machine Learning, Automation, Robotics and Space Systems (MARS) Internships and Job Placement

Sara Moola
SOFWOLF
Park City, Utah
smoola@sofwolf.org

Mike Vaughn
VATC, Inc.
Tampa, Florida
mvaughn@vatcinc.com

ABSTRACT

WOLF Evolve is a multi-year project that researches, develops and tests the academic value of integrating mission planning methodology, systems and open-source gaming platforms into Advancing Informal STEM Learning (AISL) undergraduate environments for improved STEM internship and job placement. This evidence-based mission planning approach to educate and train first responders in mission preparedness currently serves as a cloud-based framework developed commercially for joint military forces to objectively plan, train, collaborate, and evaluate performance of the wargaming scenarios in live, virtual, and constructive environments. Mission objectives, scenario generation and visual data analytics on this platform that track and assess military assets, would be modified to support informal STEM learning programs to generate video gaming scenarios and live exercises to train undergraduates in gaming logic utilizing autonomous and semi-autonomous robotics. The visual data analytics dashboard would serve to link students' gaming capabilities into internship and entry level MARS (Machine Learning, Analytics, Robotics and Space) related job placement, while increasing students' confidence and capability in a live and virtual collaborative gaming environment. Using a proven cloud-based wargaming scenario generation tool, cloud-based mission planning and assessment tools, and a 3D open-source gaming engine, WOLF Evolve will leverage proven joint international military training methodology and supporting technology to link the academic curriculum (also referred to in this approach as the 'game scenario') to "world technology relevant" mission objectives -- identifying individual strengths in game based scenarios into to performance-proven skills needed for available internships and/or entry level job placement.

ABOUT THE AUTHORS

Sara Moola is the President and co-founder of Warrior Outdoor Leadership for the Future, or WOLF, a nonprofit organization that provides college or career-bound children of fallen Special Operations soldiers with informal STEM education and leadership skills; WOLF also provides introduction to industry leaders for mentoring and future career opportunities. Since its founding in 2011, WOLF has provided mentorship and career-building to over a hundred student leaders from across the country. She started her career serving first in Togo, West Africa, as a Peace Corps volunteer, followed by positions supporting U.S. State Department support for USAID, the World Resources Institute as a GIS Analyst providing map based indicators on the state of environment to prioritize funding by multilateral agencies, ESRI as Geospatial Solutions Manager, improving legacy IT systems with geospatial analysis, Skyline Software Systems as Vice President of 3D network based solutions, and then developed the business plan and launched Visual Awareness Technologies and Consulting that she has grown exponentially over the past 17 years. She has an undergraduate degree in psychology, and a master's degree in GIS and international development.

Mike Vaughn is the co-founder and President of VATC, the leading provider of global strategies, training and technology for secure operations around the world for the U.S. and its partners. Mike leads VATC's global operations, ensuring the company's ability to develop, deliver and execute advanced training solutions in support of complex missions. He is a Special Operations Forces (SOF) Veteran, serving as an AC-130 gunship navigator and fire control officer, Joint Special Operations Planner, and Operations Director for Training at Air Force Special Operations Command, participating in several joint training and operations events around, the World, and providing lessons learned and subject matter expertise in worldwide joint special operations. He pioneered Distributed Mission Operations capabilities at Air Force Special Operations Command and across USSOCOM, and was the chief subject matter expert in developing the first ever AC-130 gunship Simulator. After retirement he joined Lockheed Martin as Assistant Director of Operations for Training support for Air Force Special Operations Command (AFSOC), and then the USSOCOM Liaison to Joint Forces Command for the integration of SOF into the Joint Chiefs of Staff, Joint Training Program. He joined in his partnership at VATC in 2004. Mike Vaughn has an undergraduate degree in earth science and Meteorology, and a master's degree in engineering from Embry-Riddle.

BACKGROUND

[SOF] WOLF – [Special Operations Forces] Warrior Outdoor Leadership for the Future – is a non-profit founded in 2012. Its mission is to serve the Goldstar Youth - undergraduate-aged sons and daughters of the fallen U.S. Military – by providing leadership skills, mentoring and ultimately internship opportunities in the career areas of interest. For the past seven years of serving over 100 youth, it was apparent that the majority of SOFWOLF students have much interest in Technology and Engineering. Given that the world economy is and will be increasingly dependent on the rapid advancement and integration of new technology and engineering capabilities along with an increasing focus on space-based capability, SOFWOLF had to become more aggressively focused and capable in advancing its Informal STEM Learning (AISL) curriculum so the skills learned in the SOFWOLF program are relevant to the skills necessary in global job market. Leveraging Amazon's founder Jeff Bezo's acronym from his invite-only conference MARS, SOFWOLF will build a standardized, cloud-based mission planning and exercise architecture that will develop Machine Learning, Automation, Robotics and Space (MARS) skills based upon SOFWOLF's founders' expertise, mentors from the MARS environment, and the academic community support to generate ISL scenarios and assessment criteria set to national guidelines in the area of undergraduate STEM programs. Utilizing proven mission planning methodology, collaboration enabling technology, and partnerships with the BYU C-UAS and National UAV Training Center, we will plan, execute, and evaluate missions with our students focused on Search, Rescue, and Recovery in the Wasatch Mountains of Utah with the ultimate objective of building skills in the students that translate to the needs of the global workforce, and creating a standardized data model and a system in a cloud based architecture that enables other ISL programs that are open to underserved communities like SOFWOLF. This transformation of the SOFWOLF program is referred to as WOLF EVOLVE and will be implemented in the pilot summer ISL program the end of July 2020. WOLF EVOLVE will execute with Financial and operations support from Visual Awareness Technologies and Consulting (VATC), curriculum and operations support from the National UAV Training Center at Sinclair College in Ohio, and operations support from

NSF funded Center for Unmanned Aerial Systems (C-UAS) at Brigham Young University in Provo, Utah.

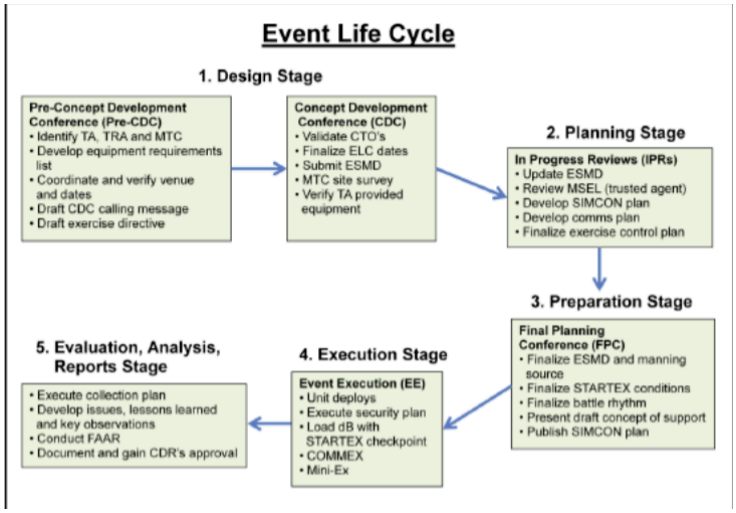
WOLF EVOLVE PROGRAM DESCRIPTION

The WOLF Evolve program mission is ultimately training Goldstar undergraduate aged, underserved youth from across the United States to hone technical and leadership skills that supply what the market demands. The measurement of this preparedness for the future generation in MARS skills will adopt the proven methodology of mission planning, training and evaluation used in aviation, first responder communities, and perfected by US Special Operations Forces in planning, training, exercise, and operations worldwide. The commercial mission planning cloud-based platform "EPIC" will be used as the collaborative analysis, planning, execution, and assessment environment.

While there are several programs that provide STEM education in an informal setting to underserved youth, it is the goal of WOLF EVOLVE to design an Advanced Informal Stem Learning (AISL) curriculum online architecture that is as dynamic as the market demand; all while providing a fun way to learn and achieve technical skills by utilizing real world use case scenarios; WOLF EVOLVE, over a five year period will ultimately provide a cloud-based platform/exchange for scenario template sharing, objective input/output of results such as skill achieved vs financial investment, job placement success rate, and visual analysis of the skills trained aligned with market demands in global technology, engineering and the space race economy so that the program curriculum, and operations remain relevant to that demand. It will be scalable so that it can extend and optimally serve all underserved youth in the United States.

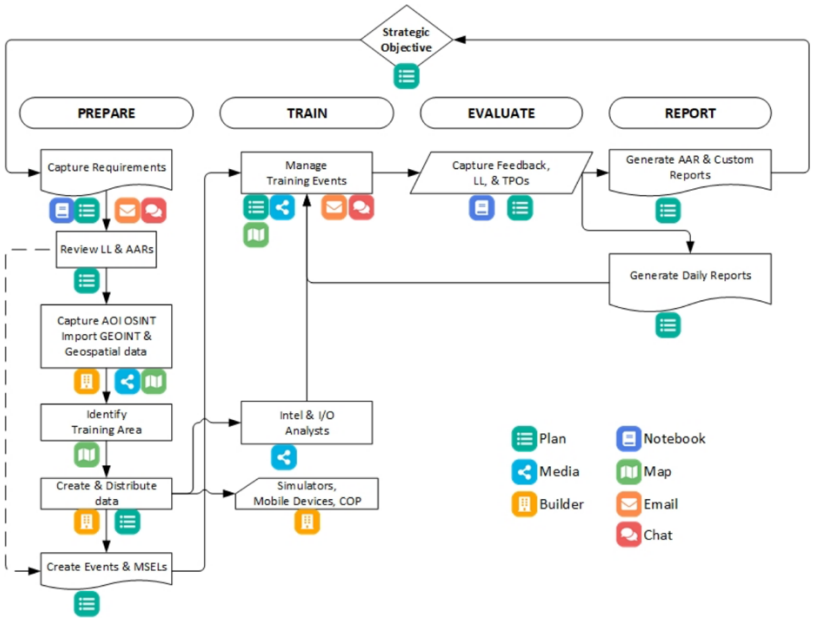
MARS READINESS LIFE CYCLE

MARS refers to the types of skills necessary to teach our future generations. The AISL online mission planning system uses an evidence-based methodology that allows the curriculum to be dynamic, and the performance of the students to be objectively assessed and analyzed. The amount, content, and accuracy of all data will determine the increasing reliability and value of the system. This cloud-based environment, if outreach is successful, will lend itself to be scalable and therefore available to AISL research analysts to review and interpret the strengths and weaknesses of using joint mission planning methods to objectively assess our nations' underserved youth to MARS Readiness (ex. student success rate in job placement in the competitive market of advanced technology and engineering).



MARS Readiness Event Implementation for the WOLF EVOLVE program in July of 2020 focuses on five key Phases of the readiness life cycle: **Objective**- 1) national strategic guidance aligned to AISL readiness, 2) scenario objectives based upon marketable skills to be developed in real world business cases, and 3) respective accredited tasks associated with each objective, **Prepare** – Capture of requirements, Analysis of Lessons Learned, Define Missions, Define Tasks and Resources, Design Scenarios for the training and exercise, and Plan the missions; **Train** – Execution, monitoring and contingency planning, **Evaluate** – Assessment of exercise performance and **Reports**

The words in bold reflect the mission planning modular system that WOLF EVOLVE will use for the Search and Rescue scenario – see below for the system diagram.



PREPARE

Exercise: WOLF Evolve 2020, July 2020
Duration: 5 Day
Exercise Scenario: Search and Rescue
Participants: WOLF students = 10, Graduate students = 10,
Educator = 1, 2= Evaluators, SOF Veteran Mission Planners = 2
Role Players = 5 (EMT, Cyber Threats)
Training Area: BYU Timpanogos Lodge, Wasatch Mountain Range, Utah
Physical Geography: alpine mountains, rivers, high desert
Physical Map: USGS Quad, FAA aeronautical charts
Geospatial data/Application: TBD
Eval Plan: to be generated from mission planning application for evaluators
ROI Indicator: Cost to educate each student and return on investment determined by internship and/or job placement

Strategic Objectives/National Guidance

WOLF EVOLVE will follow the national strategic guidance for the advancement of informal STEM learning:

'The National Science Foundation's (NSF) Advancing Informal STEM Learning (AISL) program seeks to advance new approaches to and evidence-based understanding of the design and development of STEM learning opportunities for the public in informal environments; provide multiple pathways for broadening access to and engagement in STEM learning experiences; advance innovative research on and assessment of STEM learning in informal environments; and engage the public of all ages in learning STEM in informal environments.'

Exercise Scenario Objectives

The search and rescue scenario will set the objectives of the exercise to align with marketable MARS skills. The MARS technical skills objectives will be gathered from market demand reports in advancing technology domain. For the 2020 exercise, there are 11 objectives:

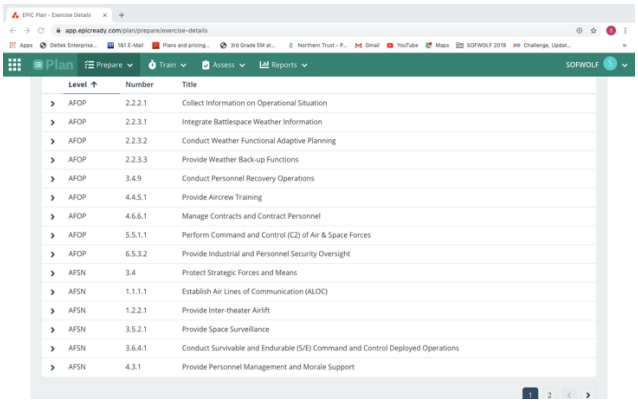
Objective Title	
	Understand various navigation systems - FPV, Semi-autonomous and autonomou
	Understand the use of Robotics in repetitive tasks and articulate how automation Efficiency in real-world application
	Programming
	Present System and Mechanical Solution
	Gather Situational Awareness
	Familiarize with various unmanned aerial systems
	Design, Build, Fly- robotics system that improves real-world case scenario
	Design System Architecture
	Conduct Vulnerability Assessment
	Conduct User Needs Assessment
	Build EMS with Robotics

When entering the exercise scenario objectives into the joint mission planning application, the application then prompts the educator to enter each objective's 'measure of performance' and measure of effectiveness'. See example below – these will be the dashboard measure of effectiveness:

Familiarize with various unmanned aerial systems

Exercise Objective
Gain insight on commercially available systems for surveillance systems
Measure of Performance
Complete workshop with National UAS training Center leadership on various commercial robotics to understa strengths and weaknesses including but not limited to motion control, sensors, machine learning for autonomo and precision maneuvers.
Measure of Effectiveness
Each WOLF Pair (WOLF Pack Student with BYU student) selects their preferred drone and presents/demonst on why it was selected in the scope of its proposed Remote robotics emergency response system design.

Accredited Tasks
The scenario objectives are then linked to 'accredited' tasks. Currently, these 'accredited tasks' are linked to conventional Air Force accredited objectives, which are apropos for the UAV-focused SAR scenario for WOLF EVOLVE 2020. In the future, it will also classify accredited skills (accredited being recognized by university and accrued into college credit) statistically by the market demand yielded on social media career sites (ex. LinkedIn) and verified by conferences (ex. Bezos' MARS Conference).



Exercise for WOLF EVOLVE Design and Development

For the WOLF EVOLVE program of 2020, **the Informal STEM exercise will conduct a five-day, Search and Rescue (SAR) Scenario in Wasatch Mountain State Park, Utah**

It will be a five-day exercise focusing on virtual and live training in a search and rescue event with joint coordination of agencies.

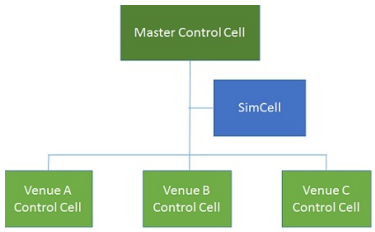
The goal of this pilot WOLF EVOLVE search and rescue exercise is to design, build and demonstrate a planning, monitoring, and assessment system with a supporting unmanned aerial architecture that merges with the Utah search and rescue protocol to improve the speed, coordination, accuracy and ultimate success of first responders. Achieving the design and execution of this exercise will ideally build marketable skills in the MARS/advancing technology job market and open doors for internships and entry level jobs.

Role Players – Local Law Enforcement, Park Rangers, lost scout, cyber threat injection to UAS, replicated social media environment.

Injects – Injects are used to drive exercise play. Master Scenario Events List (MSEL) injects serve three primary functions: linking simulation to action, enhancing exercise experiences for players, and reflecting an incident or activity that will prompt players to implement the policy or procedure currently being evaluated. The MSEL is integral to conducting realistic operations-based exercises. Attached is not the actual MSEL created for WOLF EVOLVE however, it provides an overview of what will be designed to execute the exercise.

Trigger and Responses and the Control Structure
Injects will trigger a various type of responses, including the cyber threats or social media impact in terms of how the search and rescue is handled. The mission planning system will be used to replicate the public sentiment and other input via a replicated social media environment, and also

to inject cyber threats to the UAS that the WOLF students design and fly for the emergency response support. A control structure will be created in the mission planning application to shift between the simulated environment (ex. social media, virtual training) and the live land/air/space venues of the exercise. This will be designed by the National UAS Training Center.



TRAIN

Implement the MSEL and evaluate performance. The Mission Planning System will track completion of tasks and visually display daily SITREP (situational reports) of the percentage of skills completed and open tasks/skills to complete. The students will receive courseware description and material prior to arrival (See below):

Inland SAR Planning Course (Course downloaded-and modified- from www.forcecom/uscg.mil)
The five (5) day Inland SAR Planning Course is a comprehensive, "graduate-level" look at search theory and its application to land and air searches for missing persons and aircraft, focusing on wilderness, not urban, searches. The course consists of classroom lessons and practical, tabletop exercises and incorporates daily field training. Emphasis is on the planning and unmanned aerial system UAS injection necessary for effective area-type searching during an extended search using Probability of Success (POS), rather than just a few elements of POC or POD, to allocate limited resources to their best effect.
In essence, what to do after the rapid (hasty) search and specialty resources have not found the search object. Additional topics include pre-plan development, legal aspects, UAS, Cospas-Sarsat (search and rescue satellite-aided tracking) System, and federal SAR roles and responsibilities. The course does teach some search tactics or technical procedures, with the wilderness activities designed by the retired U.S. Special Operations Forces Reservists and Veterans.

The course is directed toward undergraduate/graduate pairs that are interested in how robotics, space based technology and data science can be designed and implemented to assist emergency services and law enforcement, as well as Civil Air Patrol, international, and volunteer SAR agencies -- those few people who are responsible for the planning and overall conduct of inland search missions. Aiming to "find the objective fast," **the course centers on engineering tools to help SAR decision makers determine where to search, how to divide an area between limited search resources, and how to craft the overall search effort to gain the best increases in likelihood of success at each step. The tools are mathematically based and not for the faint of heart; they help quantify the uncertainties of the search problem to allow consistent application throughout a mission.**

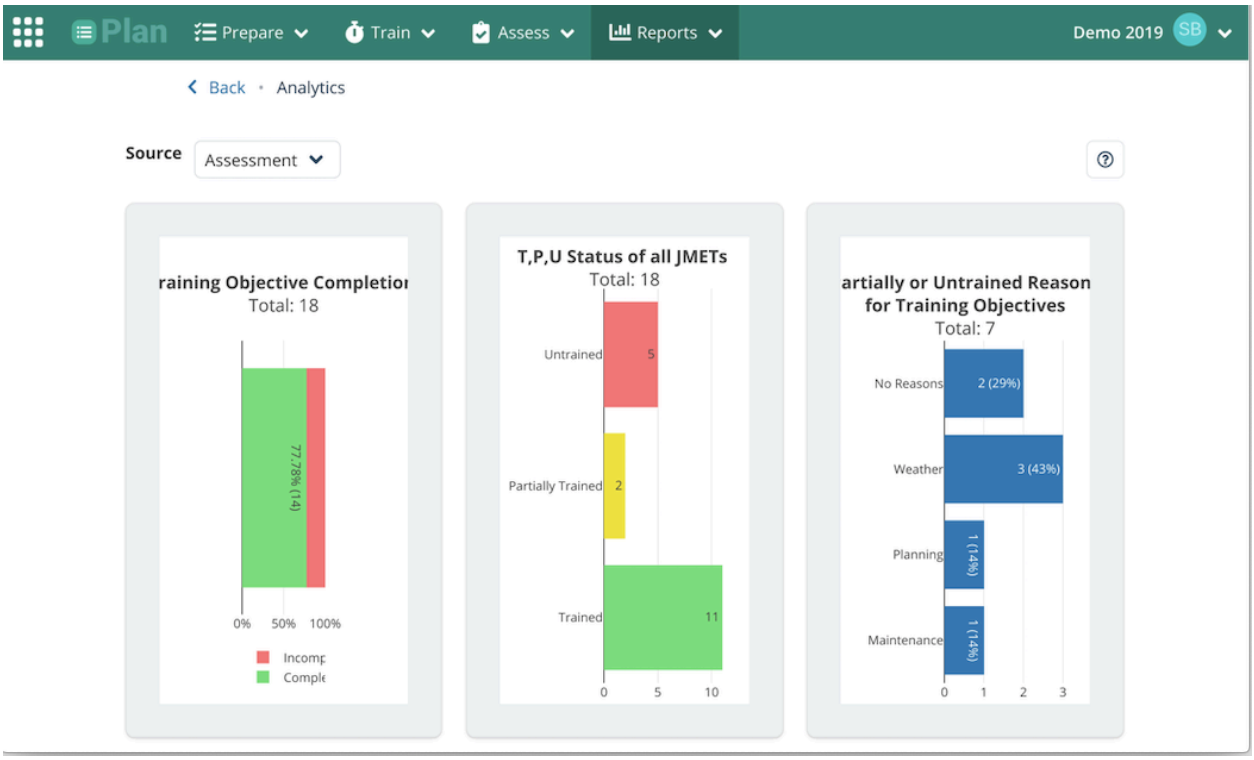
Classes begin promptly at 0800 on the convening date and full-blown exercise is held the fifth day to test and hot wash UAS designed by the WOLF EVOLVE students. Prior to class, students should review and be conversant on the following from their own agencies in order to make class discussions more useful and help integrate class materials with their own search environments back home:

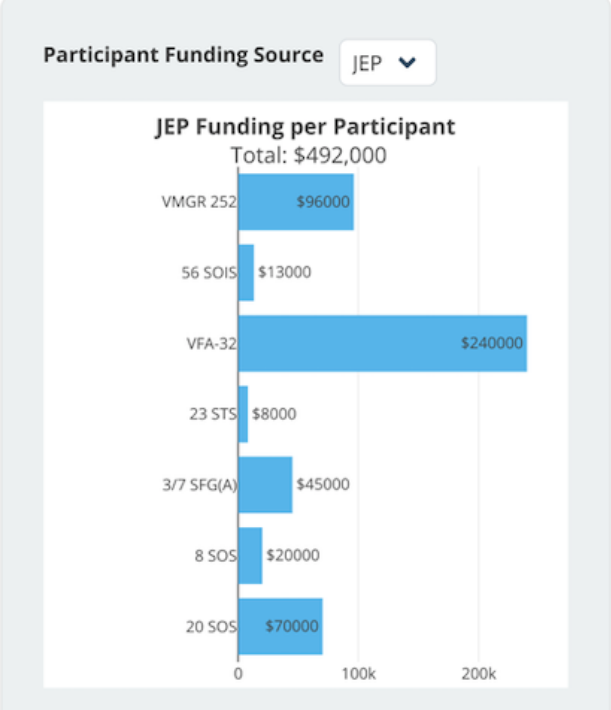
- Search pre-plans
- Decision making guidelines for where/when/how to search

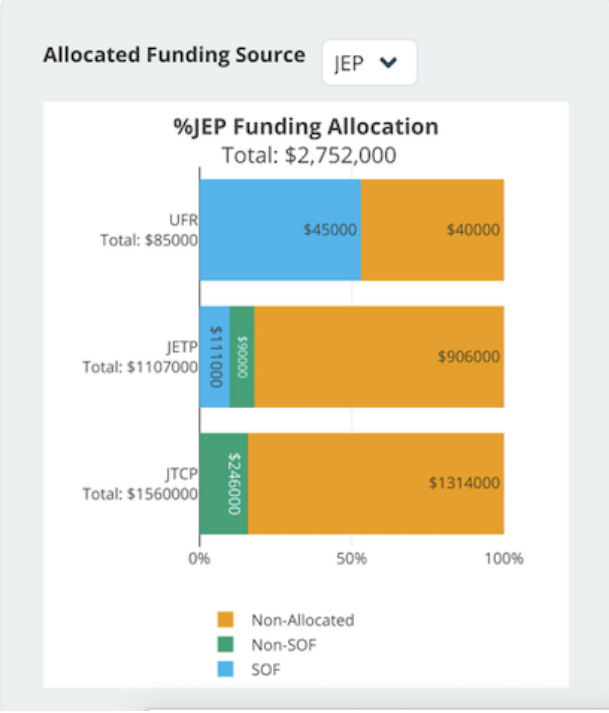
- Agreements and relationships with other SAR agencies
- How their agency organizes on scene
- Recent search missions
- A firm grounding in SAR terminology and employment techniques, practical SAR experience, basic arithmetic and calculator skills, an understanding of local SAR mission management requirements, and an open mind are essential.
- Download and review this case study prior to start of class.

ASSESS

After the exercise is complete, the data is already inputted and ready to be analyzed. All the metrics were set in the planning phase so the assessment on the five 'Ws' – who, what, when, where, and why to improve, and how to get it done are retrieved from this digital assessment.







Through the use of this commercially available cloud-based joint mission readiness exercise program, WOLF EVOLVE will provide an objective platform that educators can learn to develop, execute, and evaluate AISL exercises that address the priorities established by the National Science Foundation (NSF) Preparedness Goal for Advancing Informal STEM Learning (AISL) strategy documents, threat and hazard identification/risk assessment processes, capability assessments, and the results from previous exercises and real-world events. These priorities guide the overall direction of a progressive exercise program, where individual exercises are anchored to a common set of priorities or objectives and build toward an increasing level of complexity over time.

The subsequent year will add both more scenario templates for enhancing technical skills sets applied to real world use cases while analyzing lessons learned from the pilot to improve the mission planning gaming environment for ISL. Years 3-4 are geared toward developing machine learning to automate the enhancements of the cloud-based mission planning/gaming curriculum based on three criteria: 1) market demand of skills, 2) User feedback/performance 3) and Outreach to more ISL programs to the underserved communities. The Final Year will be again analysis of system's ability to provide links between student and mentor; its ability to teach new skills in a fun, realistic gaming environment; the student's ability to get internship placement and job entry.

ACKNOWLEDGEMENTS

We would like to thank the National UAV Training Center at Sinclair College in Ohio, and the NSF funded Center for Unmanned Aerial Systems (C-UAS) at Brigham Young University in Provo, Utah, as well as Subject Matter Expertise from Air Force Special Operations, and Engineering support from Visual Awareness Technologies & Consulting.

REFERENCES

1. Search is An Emergency, LaValla, et al, Emergency Response Institute Inc., 4th Edition, 1995, pp. 25-36.
2. Dennis Martin Search, National Park Service Chronological Narrative, Regional Director Southeast Region NPS, Sep. 26, 1969.
3. Kim Family Search Review, Oregon State Sheriff's Association, Jan. 2007.
4. Kayla Matthews, Collaborative Robotics Trends, June 4, 2019.