

Project Summary

Unmanned Aircraft Systems operations Technician Education program (UASTEP) is a comprehensive three year project aimed at developing educational and career pathways at the community college level in order to prepare students to succeed as employees or entrepreneurs in the high growth UAS industry. The project team will develop new academic programs and curriculum at two community colleges within the San Diego region, host professional development workshops for educators, cultivate students' business and workplace competencies, and host summer academies as well as outreach events to excite students about UAS educational and career pathways. To maximize the impact of the project's activities, the best practices for adopting the new Palomar UAS programs at Southwestern College will be documented and disseminated in publications, in order to help other colleges understand the process of adopting UASTEP's curriculum. The project will involve college faculty members, industry professionals, and veterans in creating industry-specific UAS courses. The project team will also recruit two cohorts of STEM and Career Technical Education faculty members to create short UAS-related lessons in two professional development workshops. The project team members' prior successes on NSF-funded projects showed that these activities can lead to the introduction and integration of emerging technology across disciplines.

UASTEP partners include primarily Palomar College and Southwestern College, and partner high school districts and universities. The partners have a long history of successful collaboration, and have cooperated on community outreach, program development, and course articulation in a number of prior grant projects. The project's other partners include NSF funded initiatives such as the National GeoTech Center, GeoTEd-UAS, UASTECC, as well as industry and nonprofit partners such as the USGS, SlantRange, ESRI, URISA, Fallbrook Land Conservancy, Escondido Creek Conservancy, CompassRose GIS, San Diego Gas and Electric, City of San Marcos, Navy Naval Air Systems Command, and the San Diego Regional Economic Development Corporation. These partners will help with project outreach and dissemination, partake on the project's Advisory Committee, and/or provide internships to students.

Intellectual merit:

UAS labor market studies conducted nationally (AUVSI), regionally (San Diego Business Chamber), and locally (Palomar UAS Advisory Committee) confirmed that UAS will be a huge driver of job and economic growth. Specifically, the UAS industry is already well established in the San Diego region thanks to major employers such as General Atomics and Northrop Grumman. Nonetheless, the San Diego Business Chamber predicted a shortage of UAS operations technicians in the region, and called for the development of UAS technical education programs to preserve San Diego's leadership in the UAS sector. In addition to preparing skilled operations technicians, the business and workplace competencies emphasized in our project will also spur interest in UAS startups offering services in fields such as GIS, construction inspection, and filmmaking.

Broader impacts:

While the main goal of the project is to prepare skilled operations technicians for the regional UAS workforce, this interdisciplinary project will foster interest in UAS among faculty members and students from different fields across different educational levels. The project's curriculum, outreach events, and summer academies will target underrepresented groups. For example, the project will participate in outreach events on military bases and develop curriculum in consultation with veterans with UAS background, in order to create accelerated educational and career pathways for veterans. The Massive Open Online Course (MOOC) developed from this project will provide broad societal benefits by educating the public on the safe and novel applications of UAS, thus fostering a responsible culture for UAS operations and building excitement around UAS careers.

Unmanned Aircraft System operations Technician Education Program (UASTEP)

The UASTEP will build on successful NSF-ATE projects previously funded at Palomar College and Southwestern College. The program was modeled after and expanded upon currently funded projects such as GeoTed-UAS (NSF DUE#1601614) with the Virginia Space Grant Consortium and UASTEC (NSF DUE#1601785) at Del Mar College. Prior NSF support at Palomar College and Southwestern College developed academic programs in geospatial technologies (GST), and courses in areas such as geographic information systems (GIS) and remote sensing (RS). Some of the GST courses developed with previous NSF support will be integrated in the UASTEP.

Results from prior support:

Palomar College: In 2010, Palomar College was awarded the “Advancing Geospatial Technology Pathways at Palomar College” grant by the NSF-ATE program (ATE-DUE #1003341; \$413,081; 8/1/2010 to 7/31/2014; PI: Wing Cheung). Broader Impacts for DUE#1003341: The professional development workshops of this project introduced GST to non-GST instructors from 24 different disciplines, who integrated GST into their classes and disseminated their products in publications (e.g. CSU Geospatial Review) and conferences (e.g. American Association of Geographers Annual Meeting). Eighty nine GST students performed service learning projects for 32 unique community organizations, addressing community concerns such as food insecurity (Feeding America), invasive species monitoring (California Department of Fish and Wildlife), and emergency preparedness (The American Red Cross). These service learning projects not only helped students develop technical and workplace competencies, but also fostered professional connections that resulted in internships and job opportunities. The project also impacted underrepresented groups by hosting and participating in 31 outreach events hosted by programs such as Encuentros Leadership and GEAR UP. Moreover, the courses developed by the program were offered at three local high schools through concurrent enrollment agreements. Intellectual Merit of DUE#1003341: The project team developed seven new GST courses, and three new programs in the GST program to serve students with different educational objectives (Certificate of Achievement, Associate’s Degree, and Bachelor’s Degree Pathway with Marshall University). It also hosted six professional development workshops for educators that served a total of 80 faculty members. Two Palomar students were selected annually to present at the ATE PI Conference in Washington D.C., and one student was featured among the ten student success stories on ATE Central (*ATE Student Success Stories: Su’s Story, 2012*).

National Geospatial Technology Center of Excellence (GeoTech Center): In 2013, a consortium of two-year colleges was awarded the “GeoTech Center: Innovation in Geospatial Information Science and Technology Education” grant by the NSF-ATE program (NSF-ATE#1304591; \$2,976,294; 6/6/2013 to 5/31/2017; PI: Vincent DiNoto). Broader Impacts for DUE#1304591: The GeoTech Center has disseminated effective models and pedagogic approaches to GST instruction. By developing different learning models, instructional materials, virtual learning environments, and a community of practice of GST students, educators, and practitioners, the GeoTech Center has improved student and educator access to quality GST academic courses and pathways to careers in GST. Wing Cheung of Palomar College participated as a senior project staff member on this grant. He hosted two workshops annually for students and GIS industry professionals covering topics including open-source GIS, pre-incident GIS planning, and public safety applications of GIS. He also co-developed one model course titled “Data Acquisition and Database Management” complete with lecture materials and lab activities for the GeoTech set of model courses based on the Department of Labor/GeoTech Geospatial Technology Competency Model (GTCM). Moreover, he published articles on topics including Hi-accuracy GIS data capture (*Cheung, 2016*) and GIS Service Learning (*Cheung, 2015*), gave webinars on 3D WebGIS visualizations, and co-hosted Unmanned Aircraft Systems (UAS) workshops as well as presented on UAS-GIS integration at venues such as the annual

GeoEd Conference and ESRI Educational User Conference. Southwestern College under the leadership of Ken Yanow participated as a Co-PI on this grant. Professor Yanow developed two model courses, including the “Geospatial Awareness Course” and “An Introduction to Remote Sensing”. He also leads annual 3-day teacher-training workshops on the campus of San Diego State University. Professor Yanow is on the GeoTech Center leadership team, and works to develop GeoTech Center agendas and priorities. He also creates and publishes a monthly GeoTech Center newsletter. Intellectual Merit of DUE#1304591: The nature of an evolving GST industry presents challenges when educators seek to prepare a national workforce, especially with respect to competency requirements. The GeoTech Center helped address this challenge by providing workforce analysis, professional development opportunities, and industry relevant curriculum and resources. The model courses developed by the project team have been widely disseminated at conferences and over the web, and have been adopted by a number of institutions across the country. The conferences, workshops, and webinars hosted by the GeoTech Center has spurred the academic and professional communities’ interest in a number of innovations in GIS, including UAS, open source GIS software, and WebGIS.

Project overview:

The activities in the UASTEP are modeled after previously funded NSF initiatives such as the GeoTech Center and GeoTED, and will be revised regularly to reflect the workforce needs identified by currently funded NSF projects such as UASTEC and GeoTED-UAS (e.g. UAS Developing a Curriculum [DACUM] Analysis). The overarching goal of this project is to develop educational and career pathways at community colleges that will prepare students to succeed as employees or entrepreneurs in the ever-expanding UAS field. A number of reports prepared by government agencies and private foundations have pointed to the explosive growth in demand for commercial UAS operators, especially given that the FAA recently (August, 2016) relaxed its rules for commercial UAS operators. Therefore, community colleges within regions with demonstrable UAS workforce demands, must develop new programs and courses in response to these new developments, and meet the needs of employers who already seek employees proficient in UAS operations. In this project, a strong emphasis will be placed on fostering sustainable partnerships between community colleges, industry partners, and 4-year universities and high schools. Palomar College will lead and administer this project, but the courses and programs developed at Palomar will also be adopted by Southwestern College, not only to expand the project’s reach to southern parts of San Diego County, but also to document best practices in adopting a model UAS program at other 2-year colleges. As detailed in the proposal narrative, activities such as community outreach, dual enrollment and articulated courses, professional development workshops for educators, and summer academies for students will also be implemented throughout the project in order to excite students about UAS career pathways while promoting a culture of responsible UAS operation in the region.

Project Team:

Palomar College, with its 8 locations in San Marcos (main campus), Camp Pendleton, Escondido, Fallbrook, Mt. Carmel, Pauma, and Ramona, serves a diverse student population including military veterans and rural populations. Palomar is federally designated as a Hispanic Serving Institution with a large underserved student population: 34.6% (11,794) of Palomar’s student population is Hispanic, 41% (14,000) receive financial aid, and 4.4% (1,493) are veterans (*Palomar College Institutional Research and Planning Office, 2016*). The Palomar Community College District service area covers the northern and eastern parts of San Diego County. Aside from major UAS employers such as Camp Pendleton, Northrop Grumman, and General Atomics, medium to small UAS-related employers such as San Diego Gas and Electric (SDG&E), 5D Robotics, SlantRange, and various local government entities can also be found in the region. Past NSF support has enabled the GST program to expand

from a 5 course Certificate of Proficiency into an Associate's Degree along with pathways into a B.S. or B.A. degree program in Geography. Given that remote sensors (e.g. on satellites or UAS) have been a major source of spatial data for GST applications, the integration of UAS into the GST programs is a logical next step. In addition to GST, this project will also integrate UAS into the College's existing programs in Engineering, Graphic Communications, Business, and Construction Inspection. The professional development workshops for educators will also produce short lessons that will introduce students from various Science, Technology, Engineering, and Mathematics (STEM) and Career Technical Education (CTE) disciplines to UAS. Moreover, the project team will leverage its relationships with industry partners in the private, governmental, and nonprofit sectors to provide students with internships and service learning opportunities. The outreach activities, industry partnerships, and inter-campus collaborations (e.g. dual enrollment, articulation) will provide students with clear pathways and excite students about UAS careers, thereby growing and diversifying the regional UAS workforce and student population.

Wing Cheung (PI) will lead Palomar College's participation in the project and oversee the creation of the UAS Associate's Degree and Certificate of Achievement programs at the College. He will also be developing courses and revising existing GIS curriculum for the new programs. Wing is an Associate Professor of Geography, and the program coordinator for the GIS Associate's Degree and Certificate programs. He also co-developed the 5 course Certificate of Proficiency in UAS at Palomar College. He is a member of the Academy of Model Aeronautics, and holds a FAA Part 107 Remote Pilot Certificate with a sUAS rating. He has two years of experience flying various models of UAS manually and autonomously. The UAS data that he has collected have been integrated into his introductory GIS course. He has given presentations and co-hosted workshops on UAS at conferences such as the ESRI Educational User Conference and the GeoEd Conference sponsored by the NSF funded GeoTech Center. Wing has extensive experience with curriculum and program development, GIS instruction, and community outreach activities with GIS and UAS. As an example, he has developed service learning partnerships with community organizations such as the Audubon Society, where GIS and remote sensing students gathered GPS field data to map distinct ecosystems and study the spread of native cattails within the Buena Vista Lagoon.

Sean Figg (Co-PI) is an Assistant Professor as well as the Geology Associate's Degree program coordinator at Palomar College. He holds a FAA Part 107 Remote Pilot Certificate with a sUAS rating. Sean's academic and research experience are in the fields of geochemistry and geochronology. Sean has experience teaching at all levels of education, including K-12, Community College, and University. He has developed lesson plans, re-developed much of the Geology program at Palomar College, and coordinated the Palomar STEM Summer Academy for high school students. In the classroom, he constantly utilizes active learning strategies, and introduces students to new technologies such as Layered Earth Simulation software, Cross-polar Trinocular Microscope, and GIS. He holds a Certificate in GIS that has aided his research and geologic field mapping. He is a strong believer in using emerging technologies in field work, and has introduced his students to the techniques and applications of GPS and GIS in his field courses. He has participated in professional development workshops on UAS and GIS hosted by the GeoTech Center and ESRI, where he developed lessons and activities to further integrate emerging technologies in his courses.

Mark Bealo (Co-PI) is a Professor of Graphic Communications at Palomar College, and the primary instructor and curriculum developer for the introductory and advanced Digital Imaging with UAS classes currently offered at the College. His UAS courses cover topics such as building a digital imaging UAS platform, operating commercial UAS for agriculture, underwater, surveying and mapping as well as scripted film making and photography purposes. He has extensive experience as both a pilot and camera operator with UAS since early 2013. Mark is a regular participant in UAS

related trade shows and conferences, such as the GeoTech UAS Workshop and the Commercial UAS Expo. In particular, after speaking with attendees at the UAS Educator Summit in February 2016, he realized that the UAS related programs at many 4-year universities are still in early planning stages, and lagged behind the progress at Palomar College. Mark co-developed the UAS Certificate of Proficiency program at Palomar College. He is frequently called upon to consult in matters related to UAS applications in industry, research, and education. He has assisted members of the California State Government GIS User Group, the State Chancellor's Office, Sempra Energy, Shelby Motorsports, and local film makers in the operation of UAS. Mark also developed the curriculum for the UAS portion of the Palomar STEM Summer Academy.

Southwestern College (SWC): SWC is located in Chula Vista, CA, which is 12 miles south of the City of San Diego and eight miles north of the U.S.-Mexico International Border. The College serves approximately 380,000 residents within the SWC District, which encompasses the communities of the southern urban section of San Diego County. Almost 62% of the nearly 380,000 people living in the SWC District are from ethnic minority groups. Over 44% of the population is Hispanic, 11.8% are Asian or Pacific Islander, and 5.4% are African-American. SWC is the 3rd highest Associate's Degree producer in the nation for Hispanic students. It is the only public institution of higher education in southern San Diego County with an enrollment of over 19,000 students. Of the more than 1,100 community colleges nationwide, SWC consistently places in the top 100 in the number of Associate's Degrees conferred. SWC offers two certificate tracks in geospatial technologies (GST). Track 1 is designed for continuing students seeking a higher degree, who could benefit from a GST toolset for their career. Track 2 is designed for students seeking an entry-level position as GST technician. As with Palomar College, Southwestern College will leverage its existing GST coursework (such as Introduction to Remote Sensing, and Introduction to Image Analysis) for a new UAS program. In addition, Southwestern College will work with its local high school district, Sweetwater Union High School District (SUHSD), to explore opportunities for dual enrollment courses (see Letter of Support). SWC will also work with the U.S. Navy Naval Air Systems Command (NAVAIR) and other UASTEP partners to develop a student sUAS competition (i.e. sUAS Challenge) as one of the outreach activities for this project (see Letter of Support).

Kenneth Yanow (Co-PI) has been a Professor of Geographical Sciences at SWC for the past 16 years, and directs the GST program at SWC. He also teaches Physical Geography, Earth Science, GIScience, Remote Sensing, and Image Analysis. He received his Bachelor's Degree from UC Santa Barbara in Physics, and two Master degrees (Astronomy and Geography) from San Diego State University. Ken is an Associate Director for the NSF-funded GeoTech Center. He has been involved in researching best practices for the recruitment and retention of both traditional and underserved student populations into GST courses and programs, the development and promotion of a general education course in GST, and the exploration and vetting of core competencies for the GST profession. Ken has extensive experience in curriculum development, and has led annual GST professional development workshops for educators for the past seven years.

Advisory Committee: The project team will develop a UAS Advisory Committee consisting of industry professionals and representatives from project partners. While we anticipate that a majority of our members will be current UAS users, we also recruited members who see themselves as future users of UAS. Members will guide regional workforce assessment, review materials from our courses and workshops, as well as suggest internship, service learning, and employment opportunities for students. The following organizations have committed to serving on the committee and more partners will be recruited throughout the project period.

UASTEP Advisory Committee Members				
ESRI	National University	Vista Unified School District	GeoTED-UAS	CompassRose GIS
City of San Marcos	UC-Irvine	Sweetwater Union School District	UASTEC	U.S. Geological Survey (USGS)
SlantRange	UC-San Diego (UCSD)	Urban and Regional Information Systems Association (URISA)	GeoTech	San Diego Gas and Electric
Navy Naval Air Systems Command	San Diego State University	San Diego Regional Economic Development Corporation	Fallbrook Land Conservancy	Escondido Creek Conservancy

Motivating Rationale

Why sUAS¹ Now? The FAA defines “small unmanned aircraft system (sUAS) [as one] that includes the unmanned aircraft itself and its associated elements that are required for safe operation, such as communication links and components that control the aircraft.” They generally “weigh less than 55 pounds, including everything that is onboard or otherwise attached to the aircraft...and are operated without the possibility of direct human intervention from within or on the aircraft.” (*Operation and Certification of Small Unmanned Aircraft Systems, 2016*) sUAS can be operated manually by a pilot or programmed to operate autonomously in a data collection mission. Although the FAA has long permitted hobbyists and recreational users to fly sUAS without special exemptions or pilot licenses under Section 336 (*Operation and Certification of Small Unmanned Aircraft Systems, 2016; 14 CFR 101*), commercial operators (educational users included) have been subjected to much stricter guidelines until the recent passage of FAA’s Part 107 rule (*Operation and Certification of Small Unmanned Aircraft Systems, 2016; 14 CFR 107*). In contrast to the previous requirements for commercial operators (i.e. FAA’s Section 333 exemption), the Part 107 rule no longer requires sUAS operators to hold a pilot’s license, or complete a highly technical application that can take upwards of 5-7 months to obtain the FAA’s approval (*UAV Coach, 2016*). Instead, under the Part 107 rule, sUAS operators will now only need to pass an initial aeronautical knowledge test and a security background check conducted by the TSA (*FAA, 2016a*). This relaxation of rules for commercial and educational operators of sUAS has been considered a major development for the sUAS industry, and has been welcomed by members from industry as well as decision makers who expect these new regulations “to harness new innovations safely, to spur job growth, advance critical scientific research and save lives” (*FAA, 2016a*). In fact, Michael Drobac, executive director of the Small UAV Coalition, argued that the passage of Part 107 “is that big moment where we are ushering in technology. To this point it has only been a concept or the art of the possible, and now we are saying it is not only possible, but now it is legal and we are open for business” (*Cardoza, 2016*). In quantitative terms, one industry estimate pointed out that sUAS can create more than 100,000 jobs and generate economic impact of \$82 billion in the US by 2025 (*AUVSI, 2013*). A similar industry estimate from the Teal Group found that “the production of combat, commercial, and consumer drones will triple over the next 10 years to \$93 billion” (*Schneiderman, 2014*). Meanwhile, the commercial UAS market alone is expected to undergo “a compounded annual growth rate of 109.31 percent between 2014 and 2020” (*Schneiderman, 2014*). As the UAS industry expands, California ranks as the state to gain the most in terms of job creations (18,161) and positive economic impact (\$14,372 million) (*AUVSI, 2013*).

Until the recent passage of the Part 107 rule by the FAA, the Section 333 exemption process has been the main venue leveraged by commercial operators to conduct UAS flights in the nation’s airspace (*FAA, 2016b*). By analyzing the 5,521 petitions for exemptions that have been approved by the FAA between September 2014 and August 2016, we can see that California is the state with the

¹The specific class of UAS targeted in this proposal are sUAS since they weigh less than 55 pounds but over 0.55 pounds. For this reason, the terms UAS and sUAS are used interchangeably in this proposal.

most exemptions (639), and most petitioners (4,742) are small businesses with revenues less than \$1 million and less than 10 employees (3,635) (AUVSI, 2016). According to Schneiderman (2014), “drones have become a significant opportunity for entrepreneurs...By June 2015, UAS startups had raised \$172 million in venture financing.”

In a more detailed analysis of the first 1,000 Section 333 exemptions, AUVSI noted that the top six use cases for UAS in California are 1) Aerial Photography, 2) Real Estate, 3) Aerial Survey, 4) Film and TV, 5) Agriculture, and 6) Construction (AUVSI, 2105). From these statistics, one can see that California is a major market and producer of UAS technology, while entrepreneurs and small startup businesses are poised to become major driving forces in this emerging field.

Why sUAS in San Diego County? sUAS is expected to have enormous impacts on the nation’s job market and economy, and California has been one of the major drivers of this trend as reflected in industry projections of expected job growth and economic gain within the state (AUVSI, 2013). As the second largest county in the State (3.3 million people) (United States Census Bureau, 2015), San Diego County is a major contributor to the UAS industry in the state and the nation. In fact, Reno (2013) has branded “San Diego, the undisputed drone capital of America.” This is in part due to the county being the home of the world’s two leading UAS manufacturers, which are General Atomics Aeronautical Systems and Northrop Grumman. Moreover, Northrop Grumman has designated its facility in Rancho Bernardo, San Diego as its Unmanned Systems Center of Excellence since 2013, which further solidifies San Diego’s position as the hotbed of UAS technology (San Diego Regional Economic Development Corporation, 2013; Northrop Grumman Corporation, 2013). One industry report estimated that the direct, indirect, and induced impacts of UAS contracts in the military sector generated 7,135 jobs, \$590 million in wages, and \$2.3 billion in total economic output per year in the San Diego region (North San Diego Business Chamber, 2012). Beyond military and defense applications of UAS, the commercial applications of UAS have also seen dramatic growth in the region thanks to small startup companies such as SlantRange (10 employees, \$5 million in a first round of venture capital funding), which concentrates not on drone manufacturing and production, but rather the production of drone sensors and drone data analytics for agricultural applications (Freeman, 2016). Other examples of UAS startups in San Diego include SkySafe (\$3 million in seed funding), which was founded in 2015 with the goal of keeping restricted airspace (i.e. stadiums, airports, prisons) safe by disabling intrusive rogue drones (Brown, 2016). Another example is the Carlsbad/San Diego-based 5D Robotics (\$5.5 million in seed funding), which focuses on the development of high precision automated navigation technology for UAS in mapping and inspection applications (Bigelow, 2016). This project is committed to working with industry partners, and has already secured commitments from organizations including SlantRange, San Diego Gas and Electric, CompassRose GIS, City of San Marcos, San Diego State University, and the U.S. Geological Survey (USGS) to provide internships for students (see Letter of Support).

Despite the importance of the UAS industry in the San Diego economy, a report released by the North San Diego Business Chamber and National University System Institute for Policy Research concluded that the UAS industry’s “role and importance in the local economy and employment base seem underappreciated” (North San Diego Business Chamber, 2012; P.3). Specifically, the report noted the shortage of comprehensive UAS technical education programs at universities such as UCSD and San Diego State University, and urged educational institutions to focus on UAS education in order to preserve San Diego’s leadership role in the industry. In fact, industry leaders such as Bob Cassidy, Senior Director of Operations at ViaSat, have openly said that “community colleges and other educational institutions should take a hands-on approach to engage students and get them interested in the field [by] showing them how...drones operate” (Horn, 2014). Thus, we believe that this proposed project will not only create new academic pathways for students interested in employment and startup opportunities in the UAS field, but will also respond to industry demand for

qualified and experienced UAS technicians and operators, which in turn will ensure the region's economic prosperity given the growing importance of UAS in the public and commercial sectors.

Why UAS Operations Technician Certificate and Degree? UAS technology is not a new development as it has been used for military applications as early as the 1920's, as practice targets for anti-aircraft artillery units (Blom, 2010). In contrast to early UAS, modern UAS have longer operational duration and range, more precise control, and require less maintenance thanks to advances in navigational, battery, and communication link technologies. In particular, UAS in the form of multi-rotors (e.g. quadcopters) or fixed wing aircraft has emerged as a critical tool in a variety of fields, such as aerial reconnaissance, surveying and mapping, filming, search and rescue, environmental monitoring, pipeline and construction inspection, crop management, disaster management, and geophysical surveys (Quinn et al., 2016; Unmanned Aerial Vehicle Systems Association, 2016).

Based on the project team's review of UAS job posts and labor statistics as well as consultation with industry partners on the Advisory Committee, we have determined that there is a need for qualified UAS operations technicians in the region. We have adopted the UAS operations technician definition proposed by the GeoTED-UAS Project: "A UAS operations technician is defined as one who is knowledgeable in the safe and legal operation and flight of a UAS which includes mission planning, flight operation, data collection, data post-processing and analysis using GIS, remote sensing image processing software, and other processing tools and techniques." We believe that the above definition is comprehensive and reflective of the general industry needs. In particular, our UAS Advisory Committee members emphasized the need for students to be aware of safety and legal guidelines regulating UAS, stressed that students should practice flight operation using simulators prior to field operations, and requested that students be knowledgeable in troubleshooting data collection issues and post-processing procedures. The UAS operations technician is different from large UAS maintenance technicians or large UAS pilots in two major ways. First, the UAS operations technician will not operate nor maintain large UAS (aircraft 55lbs and over). Second, the UAS operations technician is an integrative occupation with skills in all aspects of UAS operation before, during, and after flight, whereas the large UAS maintenance technician may primarily focus on hardware and maintenance (but not flight or post processing), and the large UAS pilot may focus on UAS flight (but not pre-flight maintenance or post processing).

Similar to other technical fields (e.g. Engineering, GIS), technician level positions typically require two year degrees or some sort of post-secondary certificate (State University of New York-Canton, 2016). As industry representatives have expressed a desire for hands-on training of UAS operations technicians in applied settings, community colleges are poised to provide this type of training given their focus on skill development and technical education. The coursework and certificate program that will be created by this project will complement a variety of existing degree programs at Palomar College and Southwestern College, such as GIS, Graphic Communications, Construction Inspection, and Business. Meanwhile, the Associate's Degree option will provide students with a stand-alone credential for those who wish to gain immediate employment in the UAS industry. For students wishing to continue their education at a 4-year institution, the project team will articulate courses in the Palomar UAS Associate's Degree and Certificate programs with institutions such as University of California-San Diego (UCSD) and National University, in order to create educational pathways to certificate and Bachelor's Degree programs in Business Administration.

Palomar College and Southwestern College have decided to partner on this project because they serve different parts of the county. While Palomar College serves the northern and eastern parts of the county, Southwestern College serves the southern and western parts of the county. Both institutions are federally designated as Hispanic Serving Institutions, and serve a large number of military service members. In comparison to the Southwestern Community College District which serves a primarily urban population, the relatively larger Palomar Community College District

consists of relatively rural communities in the eastern part of the district (e.g. Valley Center, Fallbrook, Julian), military installations in the northern part (i.e. Camp Pendleton), and major defense contractors like Northrup Grumman and General Atomics in the southern part of the district (e.g. Poway, Rancho Bernardo). Between the two institutions, we believe that we can serve the needs of UAS industry in the entire San Diego County region. The diverse industries present in the two districts can spur diverse curriculum and innovations that can be transferrable to various community colleges around the country with distinct regional needs.

Goals, Objectives, and Deliverables

The overarching goal of the UASTEP (Unmanned Aircraft System operations Technician Education Program) is to develop educational and career pathways at community colleges that will prepare students to succeed as employees or entrepreneurs in the ever-expanding UAS field. Specifically, graduates will receive the technical skills and discipline-specific knowledge needed to become a safe and responsible commercial UAS operator or a small UAS startup businesses owner (e.g. UAS consultant to construction firms, UAS consultant to municipalities) (see Logic Model in Appendix 0).

Goal 1: Program and Curriculum Development and Improvement: Based upon preliminary research conducted using local market data and feedback from the Advisory Committee, we have developed a tentative course of study for the Certificate of Achievement and Associate's Degree in UAS technology (Table 1). Within the State of California, 2-year colleges can propose a 12-18 unit Certificate of Achievement, and students who complete the colleges' general education and graduation requirements in addition to the courses required by the Certificate of Achievement can receive an Associate's Degree in that discipline. The proposed programs (Certificate of Achievement and Associate's Degree) will leverage existing courses at Palomar College and SWC, as well as courses that will require significant revisions or entirely new courses.

In year 1, the project team will begin to develop or revise courses needed for the certificate/degree program. Each course will be developed either solely by PI/Co-PI of the project, or co-developed with a content expert from a specific academic department (e.g. Engineering, Construction Inspection) or industry (e.g. U.S. Marine Corps, SDG&E) (see Appendix 1 for a list of content expert consultants who have committed to this effort). The content expert will provide discipline specific knowledge and resources, while the assigned PI/Co-PI will review case studies and work with content experts to integrate UAS into the courses. Moreover, the project team will request content experts to include the new courses in the existing certificate/degree programs in their home academic departments (e.g. Engineering A.S., Construction Inspection A.S.). We anticipate that three to four courses will be developed by the end of each project year, with the entire proposed certificate/degree program being offered by the end of year 3 or earlier (depending on the speed of the program approval process at the institutional and state levels). The syllabi and resources developed for each course will be validated by members of the UAS Advisory Committee. The proposed curriculum will be modified as needed based on the findings from the DACUM analysis currently being undertaken by the ATE-funded GeoTED-UAS project.

In year 2, Co-PI Ken Yanow will propose new curriculum at Southwestern College (SWC) by adopting the curriculum that has been developed at Palomar College (see Letter of Support). The process will continue until the end of the project period resulting in a new UAS Certificate program being implemented at SWC. The project team will focus on student interest and scheduling in order to reduce the duplication of efforts (e.g. not offer low enrollment classes at the same time at Palomar and SWC), and to create synergetic relationships between the two institutions. Moreover, the successes and challenges in adopting the Palomar UAS curriculum and program at Southwestern College will be documented and published as a case study (to be completed at the end of year 3). The

case study can help other 2-year colleges anticipate the benefits and challenges in adopting the Palomar UAS curriculum and programs at their own institutions.

We will explore dual enrollment opportunities with Vista Unified School District’s Junior Air Force ROTC program (see Letter of Support) and Sweetwater Union High School District (see Letter of Support) to offer course(s) from the UAS program at high schools. This can enhance high school students’ interest in UAS careers and develop academic pathways between high schools and colleges.

Three additional highlights of the proposed program are (1) the development of a Massive Open Online Course (MOOC) on UAS safety and applications, (2) the internship course, and (3) a course co-developed with active and former military pilots (see Appendix 1) that is designed to transition UAS operators in the military to the civilian sector. First, the MOOC will be offered as a noncredit course for free to the general public, and will be a co-requisite for the Introduction to Digital Imaging with UAS course that is in the certificate/degree program. In this MOOC, students will receive an overview of the legal regulations governing the use of UAS in different contexts (e.g. recreational, public, commercial), and also learn about the applications of UAS in various industries. This MOOC will not only help promote a culture of responsible UAS operation by educating the general public about FAA regulations, but can also enhance the public’s interest in UAS related careers as well as the UAS programs at Palomar College and Southwestern College. Second, the internship course will give students hands-on experience in UAS operations in the real-world. A number of industry partners from the private, public, and non-profit sectors have already committed to offering UAS-related internships and service learning opportunities to students from our program (see Letter of Support). These internships will synergistically benefit our students and industry partners, by enabling students to build professional connections and strengthen their workplace competencies, while providing our industry partners with assistance in UAS operations or UAS application testing. Third, the “Civilian and Commercial UAS Operations for Veterans” course will be developed with veterans from the U.S. Navy (see Letter of Support from SDG&E) and the U.S. Marine Corps (see Appendix 1). It will highlight the regulatory differences between military and commercial UAS operations, as well as the functional differences between military and commercial UAS equipment. We believe that this course will help accelerate the transition of veterans with UAS experience into the public and commercial UAS workforce.

Table 1. Tentative course of study for the Certificate/Associate’s Degree in UAS technology

Required Courses (All Required)	Elective Courses (Pick 2)
Introduction to drone safety and applications (MOOC)*	Elements of Marketing in Science and Technology*^
Introduction to Digital Imaging with UAS	UAS Videography
Advanced Digital Imaging with UAS and Project Management	Civilian and Commercial UAS Operations for Veterans*
Groundschool for UAS*~	Construction Inspection with UAS*
GIS~	Intro. to Electrical and Computer Engineering*~
Remote Sensing (RS) and UAS*	GIS and Mapping with UAS*
Small Business Entrepreneurship*^	
Internship*	

*Courses that need to be developed or require significant revision to integrate UAS; ^Courses to be articulated with UCSD extension and National University; ~Courses to be considered for dual enrollment with high schools.

Objective 1.1: Develop courses that are aligned with the UAS Advisory Committee’s recommendations, DACUM (GeoTed-UAS), and FAA regulations to be offered at Palomar College and Southwestern College.

Objective 1.2: Establish Certificate and Associate's Degree in UAS technology at Palomar College and Southwestern College.

Objective 1.3: Document the process as well as best practices in adopting the Palomar College UAS curriculum and program at Southwestern College.

Objective 1.4: Explore opportunities for offering classes online to reduce duplication of efforts among partner colleges, and increase access for underserved (veteran, rural) student populations.

Objective 1.5: Investigate opportunities to offer dual enrollment courses at high schools.

Objective 1.6: Investigate opportunities to articulate courses with UCSD Extension's certificate program in Business Management specializing in Entrepreneurship and National University's Bachelor's Degree program in Business Administration concentrating in Entrepreneurship (see Goal 3 for details).

Deliverables will include (1) 10 new courses or existing courses that require significant revisions to integrate UAS, (2) Certificate/Degree programs in UAS technology with curriculum description, course syllabi, and instructional resources, (3) publication documenting best practices for adopting the Palomar College UAS curriculum and program at other 2-year colleges, and (4) materials describing educational pathways between high schools (dual enrollment courses), Palomar College and SWC (UAS certificate and degree programs), and universities (articulated courses).

Goal 2: Professional Development for Educators: In order to enhance the understanding of emerging technologies like UAS among STEM as well as Career Technical Education (CTE) instructors, we will provide annual workshops and follow-up mentoring designed to introduce participants to the operation, capabilities, and applications of UAS. The project team will build on the GeoTech Center's faculty professional development model and provide two workshops (one in year 2, and one in year 3) for educators. Each workshop will last two consecutive weekends. Participants will spend the first weekend learning to operate UAS safely (1st Friday) and gathering primary or secondary UAS data (1st Saturday), then spend the second weekend learning about ArcGIS online (2nd Friday), and writing a short lesson with the UAS data that they have acquired (2nd Saturday). Participants will receive mentoring in the forms of virtual communication and site visits until the end of the project.

The project team will recruit and select 15 STEM and CTE faculty members from Palomar College and Southwestern College for each workshop. Participants' gender, ethnicity, discipline, and experience will be considered in order to ensure a diverse group of faculty participants in the workshops. Other key selection criteria of workshop participants include their experience and interest in UAS and GIS, intended plan for implementing UAS in their classes, and proof of administrative support. We will recruit instructors from our high school and university partners if space permits.

The workshop's main goal is to conduct "in-reach" (i.e. attract current Palomar and SWC students who are undecided majors to the UAS program, or attract students from other majors to pursue the UAS certificate concurrently with their majors) by promoting UAS technologies among different disciplines within Palomar College and Southwestern College. The workshops will also foster interdepartmental and inter-institutional collaborations among faculty members. These collaborations in conjunction with ongoing mentoring from the project team can result in long term benefits as shown in GeoTech Center's workshops. Examples of these benefits include the sharing of instructional resources, the development of course articulation partnerships, and the exchange of expertise and assistance necessary to complete the deliverable (i.e. short lesson) for the workshop.

In order to maximize the visibility and dissemination of the short lessons developed in the workshop, participants will be asked to submit their lessons to ESRI's popular SpatiaLABS repository, which has a national audience (see Letter of Support) and will serve as a mechanism for preserving and archiving the lessons produced by this project. Moreover, this project will pay for participants' registration to the annual ESRI Educational User Conference, the premier educational conference in the GIS field, should they decide to present their lessons at said conference.

The first workshop will be held in Fall 2018 at Palomar College, and the second workshop will take place during Fall 2019 at Southwestern College. The project will be responsible for the cost of meals, supplies, data, and resources. Each participant will receive a \$700 stipend after successfully submitting their lessons to the SpatialLABS repository by the end of the school year (Spring 2018, Spring 2019).

Objective 2.1: Develop and offer two annual workshops for STEM and CTE faculty members.

Objective 2.2: Mentor faculty members on lesson development during and after workshops.

Objective 2.3: Encourage faculty members to present their UAS lessons at the ESRI Educational User Conference, and require them to post their lessons on the SpatialLABS repository.

Deliverables will include at least 20 SpatialLABS lessons focused on the application of UAS in various STEM and CTE fields, as well as ongoing mentoring for workshop participants.

Goal 3: Strengthening Business and Workplace Competencies: In an effort to provide students with business and workplace competencies (i.e. “soft skills”) demanded by employers, and the necessary knowledge to start or join small startup companies that are dominating the commercial and civilian UAS sector, we will partner with UCSD Extension and National University to develop curriculum that will introduce students to entrepreneurial skills, business plans, marketing strategies, as well as workplace competencies such as professionalism, initiative, and integrity. These competencies have been previously identified by the GeoTech Center’s Designing a Curriculum (DACUM) analysis and included in the Department of Labor’s Geospatial Technology Competency Model (GTCM). These competencies are applicable across different high technology industries, and will inform the development of business courses included in the UAS Degree and Certificate programs. The courses will be co-developed by a collaboration of Palomar, National University, and UCSD Extension business faculty members, articulated across the institutions, and integrated into the UAS Degree and Certificate programs as well as the new Entrepreneurship program being developed at Palomar. This provides new educational pathways to 4-year universities for students with an interest in UAS business management.

Objective 3.1: Develop two courses (Small Business Entrepreneurship, Elements of Marketing in Science and Technology) in business and entrepreneurial skills.

Objective 3.2: Request local economic investment organizations (e.g. San Diego Regional Economic Development Corporation, see Letter of Support) to validate the developed courses.

Objective 3.3: Courses will be articulated between Palomar College, National University, and UCSD Extension, and will be integrated into the new UAS programs and Entrepreneurship program.

Objective 3.4: Develop sample educational plans for students interested in taking advantage of the educational pathways to UCSD Extension or National University.

Deliverables will include (1) two new industry-validated business courses, (2) new articulation agreements between Palomar College, National University, and UCSD Extension, and (3) educational plans for UAS students interested in the educational pathways to UCSD Extension or National University.

Goal 4: Student Outreach and Summer Academies: This project goal consists of two major components: (1) student outreach, and (2) student summer academies. Both components are designed to excite students, parents, and community members about the responsible use of UAS for recreational, commercial, public, and academic research applications.

In addition to producing brochures and launching social media campaigns (e.g. Facebook page, LinkedIn group, Google group, Instagram) to promote the UAS courses and programs at Palomar College and Southwestern College, the project team will collaborate with community partners to hold a student UAS competition (i.e. sUAS Challenge) and participate in outreach

activities throughout San Diego County. Besides participating in local events such as GIS Day or Earth Science Week at Palomar College and SWC, the project team will participate in outreach activities that are aimed at underserved populations (i.e. first generation, minority, veteran, and female students) around the county (e.g. STEM in your Backyard, Encuentros Leadership Conference, Earth Day at Camp Pendleton, Girl Tech Conference and EXPO). The project team has extensive experience participating and presenting at the aforementioned events, and believes that a combination of hands-on activities and demonstrations at such events is crucial in exciting underrepresented populations about the UAS educational and career pathways.

In an effort to attract high school students to the UAS educational pathways at Palomar and Southwestern College, we will develop a 6-day summer academy for students. The students will be recruited from high schools (and community colleges, if space permits) within San Diego County, and recruitment efforts will especially target members of underserved populations. The project-based summer academy will be held at Palomar College, and structured as a conservation-focused (e.g. mapping forest fire scars and recovery) service learning project developed by the project team, researchers from the University of California-Irvine (UCI), and our community partners (i.e. Escondido Creek Conservancy, Fallbrook Land Conservancy) (see Letter of Support). The academy will introduce students to UAS safety and operations with simulators (Day1), autonomous and manual flights (Day2), field data collection with UAS (Day3), image processing and accuracy assessment (Day4), data presentation and GIS story maps (Day5), and student presentation and guest speaker (Day6). The output from the academy will be presented to community partners and parents on the last day of the academy. The involvement of engineering researchers from UCI who are utilizing UAS in their research and instruction is designed to inspire students to consider additional academic and career pathways related to UAS. The academy will take place in June 2018, June 2019, and June 2020.

Objective 4.1. Market programs and host or participate in outreach activities and student competitions targeted at underserved student populations.

Objective 4.2. Develop and implement 6-day student summer academy annually.

Deliverables will include at least three community (e.g. [STEM in your Backyard](#)) and campus outreach events per year targeting underserved student populations, and three summer academies for students over the span of the project.

Management Plan and Responsibilities of Personnel

Palomar College will lead the project, and Wing Cheung (PI) will provide overall fiscal and administrative oversight with the help of a dedicated administrative staff. Each member of the project team will (co-)lead one of the four main goals of the project. Specifically, PI Cheung and Co-PI Yanow will co-lead Goal 1 in Program and Curriculum Development and Improvement and Goal 3 in Strengthening Business and Workplace Competencies; Co-PI Figg will lead Goal 2 in Professional Development Workshops for Educators; and Co-PI Bealo and Consultant Schubert will co-lead Goal 4 in Student Outreach and Summer Academies. Please see Table 2, project timetable, for the detailed allocation of project activities among project team members.

Plan for Sustainability

The project's advisory committee and industry partners have already expressed interest in assisting with curriculum development and offering internships for students. These are no-cost items that will be sustained beyond the life of the grant project. Similarly, the curriculum and programs that are developed from the grant will be institutionalized as was done in the previously NSF-funded projects at Palomar College and SWC. The same goes for dual enrollment courses at local high schools as well as articulated courses at UCSD Extension and National University. Depending on the reception of the short lessons produced from the educator workshops, we will consider monetizing the lessons

in order to fund future workshops. While the student academies will be offered free of charge for the duration of the grant in order to pilot and publicize the academies, we believe that parents and students will be willing to pay a modest registration fee beyond the grant period once the academies have been established in the community. Meanwhile, other sources of funding such as student equity funds and Perkins funds will fund outreach and equipment upgrades after the end of the grant period. Moreover, senior administrators at Palomar and Southwestern College (see Letter of Support) have committed to replacing the hardware (e.g. computers) associated with the UAS program beyond the project period. Building on the project team members' successes and experience in previously NSF-funded projects, the UASTEP project is committed to developing sustainable career and educational pathways for students, hosting workshops and academies for educators and students, and ultimately exciting and preparing students to join the UAS workforce as operations technicians with strong business and entrepreneurial competencies.

Table 2. UASTEP Management Plan and Timetable (Requested start date of July 2017)

Year 1 Fall [F17]	Year 1 Spring [S18]	Year 1 Summer [Su18]	Year 2 Fall [F18]	Year 2 Spring [S19]	Year 2 Summer [Su19]	Year 3 Fall [F19]	Year 3 Spring [S20]	Year 3 Summer [Su20]
Develop and implement 4 courses at Palomar with content experts: MOOC [KY], Groundschool [SF,*,~], Entrepreneurship [MB,*,~], RS [WC,*]			Develop and implement 3 courses at Palomar with content experts: Engineering [WC,*,~], Marketing [MB,*,~], Internship [MB,SF]			Develop and implement 3 courses at Palomar with content experts: GIS w/UAS [WC], UAS for Veterans [SF,*], Construction Inspection [MB,*]		
			Adopt UAS courses at Southwestern [KY]					
			Develop and implement programs at Palomar and Southwestern [WC,KY]					
						Produce case study on best practices in curriculum and program adoption [KY]		
	Explore dual enrollment with high schools [KY,WC,~]							
	Create articulation agreements with UCSD Extension and National University [MB,WC,~]							
		Develop & recruit for educator workshop [KY,SF]	Host educator workshop [SF,MB]	Publish and present short lessons [SF]	Develop & recruit for educator workshop [KY,SF]	Host educator workshop [SF,MB]	Publish and present short lessons [SF]	
			Mentor educators [ALL]					
Competit- ion [KY]	Outreach [WC]	Outreach [MB]	Competit- ion [KY]	Outreach [WC]	Outreach [MB]	Competit- ion [KY]	Outreach [WC]	Outreach [MB]
	Plan, recruit for student academy [WC,MB, JS]	Host student academy [MB,WC, JS]		Plan, recruit for student academy [JS,MB, WC]	Host student academy [MB,WC, JS]		Plan, recruit for student academy [MB,WC, JS]	Host student academy [MB,WC, JS]

WC-Cheung, KY-Yanow, SF-Figg, MB-Bealo, JS-Schubert, *Content Experts [see Appendix 1 for content expert details], ~High School, UCSD Extension, and National University partners. Refer to Table 1 for full course titles.

Dissemination Plan

This project will contribute to the intellectual merit and broader participation in UAS education and workforce development by disseminating the products and resources from the project at the local, regional, state, and national levels. The UAS courses and pathways will be disseminated through the

project's website, press releases at Palomar College and SWC, and other NSF-funded projects and centers (see Letter of Support). The project team and educators from the weekend workshops will present at the NSF ATE PI Conference, the ESRI Educational User Conference, the American Association of Geographers Meeting, the GeoTech Center's Annual GeoEd Conference, Urban Regional Information Systems Association (URISA)'s CalGIS Conference, and other regional conferences. ESRI will disseminate the lessons produced by our educator workshop participants at no-cost through its SpatiaLABS repository, which has a national audience from various grade levels. Project materials such as program brochures and educational pathway pamphlets will be distributed at in-reach events at Palomar College and Southwestern College (STEM Day, GIS Day) as well as outreach events in the community (STEM in your Backyard, Girl Tech Conference and EXPO, Earth Day at Camp Pendleton) in addition to professional conferences. The project team has experience organizing and presenting at the aforementioned conferences and events. The case study article on the best practices of UAS curriculum and program adoption will be submitted to open-access peer reviewed journals such as Journal of Technology Education or publications such as Directions Magazine in order to maximize reach and impact. The project team will also leverage its connection with the San Diego Regional Economic Development Corporation and URISA to promote the UAS program to incumbent working professionals and recruit new industry partners.

Evaluation Plan

The independent evaluation of this project will be conducted by Candiya Mann, Senior Research Manager at Washington State University. Mann serves as the evaluator for several ATE Centers, in addition to NSF ITEST and IUSE projects and other federal, state, and community projects.

The UASTEP evaluation is based on the vision, mission, and goals set forth in this proposal (see Logic Model in Appendix 0). The evaluation will address project impacts among students, faculty, employers, and the home institutions. Analysis will be conducted using the Statistical Package for the Social Sciences (SPSS) for the quantitative data and thematic analysis of the qualitative data. SPSS analysis will include descriptive statistics of the survey data and tests of pre-post changes in Self-Assessment Tool scores.

The evaluation will provide both formative and summative evaluations (Table 3). Formative assessments will be aimed at improving the effectiveness of project implementation. A summative evaluation report at the end of the grant will examine the effectiveness of project strategies and will provide an overall assessment of how well the project has met its goals.

Conclusion

The increasing accessibility and growing capability of UAS technologies has created an unprecedented opportunity for industries that demand high resolution and timely imagery data. Many employers (e.g. SDG&E, SlantRange) in the San Diego region have already integrated UAS into their workflows, and many more are interested in doing so in the near future. In response to the need for quality UAS educational programs and skilled UAS operations technicians in the region, the UASTEP seeks to develop educational and career pathways at 2-year colleges that will prepare students to succeed as employees or entrepreneurs in the ever-expanding UAS field. By collaborating with partners from the community, industry, high schools, universities, and the military, the project team will develop courses, academic programs, internships, educational pathways, workshops, academies, and outreach activities (especially targeting underserved populations such as women, minorities, and veterans) to educate the general public, faculty, and students about UAS concepts, applications, and career opportunities. Ultimately, UASTEP aims to not only excite the region about UAS educational and career pathways while preparing skilled UAS operations technicians, but also hopes to serve as a model and resource for 2-year institutions wishing to develop similar programs in the emerging field of UAS technology.

Table 3: Evaluation Questions & Data Sources

Evaluation Questions	Data Sources
Goal 1: Program and Curriculum Development / Improvement	
<ul style="list-style-type: none"> To what extent does UASTEP develop and implement the courses and UAS certificate/degree program in the two colleges? How well do the courses align with employer expectations? What factors facilitate and/or hinder implementation? How does student performance change on student learning outcomes (SLOs) and how do student perceptions of UAS careers change throughout the courses? To what extent do the new courses impact non-UAS (e.g., construction inspection) programs, faculty, and students? How do interns and internship hosts characterize students' level of preparation for the internships and growth through the internships? 	<p>Interviews/surveys of program advisory board members (employers)/students/instructors/veterans/PIs/interns/internship hosts/non-UAS program heads and instructors implementing the UAS courses in their disciplines, comparison of student performance on pre-post knowledge tests, implementation data review (# courses developed/implemented, # students declaring UAS major, enrollment/retention/completion data), document review (syllabi, course materials, program approval records, white paper).</p>
Goal 2: Professional Development	
<ul style="list-style-type: none"> To what extent do the workshop participants increase their knowledge and skills due to the workshops and mentoring? To what extent do the participants implement what they learned at the workshops? Do students meet the SLOs of the lessons developed in the workshops? How do student perceptions of UAS careers change due to the lessons? To what extent are students in other disciplines recruited to complete UAS certificates? How do the workshops affect interdepartmental communication and collaboration? 	<p>Workshop participant pre-post knowledge tests, interviews/surveys of participants at end of training and annually thereafter, retrospective pre-post web surveys of students, implementation data review (# lessons uploaded to SpatialABS repository, # presented at ESRI Educational User Conference)</p>
Goal 3: Business and Workplace Competencies	
<ul style="list-style-type: none"> To what extent do students strengthen their business and entrepreneurial knowledge and skills through the courses? How do the courses affect students' perception of UAS careers? How do the courses affect students' inclination to start UAS-related businesses? To what extent do students take advantage of articulations to 4-year universities? 	<p>Comparison of student performance on pre-post knowledge tests, student surveys, implementation data review (# courses developed/implemented, enrollment/retention/ completion data, # dual enrollment students, # Junior Airforce ROTC students, # articulations, # students using articulation pathways)</p>
Goal 4: Student Outreach and Summer Academies	
<ul style="list-style-type: none"> To what extent do the outreach events and competition motivate students/families to seek information about the UAS program? To what extent do students gain knowledge and skills at the Summer Academies? How do the Academies influence students' perception of and inclination to pursue UAS careers? Do the Academies meet service learning partners' expectations? 	<p>Comparison of student performance on Academy pre-post knowledge tests and surveys, interviews of service learning partners, review of outreach event and competition documentation (sign-in sheets, # participants requesting follow-up information, # participants joining the UAS program Google group)</p>

References Cited

- ATE Student Success Stories: Su's Story*. Perf. Su Coy. *ATE Central*. National Science Foundation (DUE#1261744), 04 Dec. 2012. Web.
<https://atecentral.net/r20108/ate_student_success_stories_sus_story>.
- AUVSI (Association for Unmanned Vehicle Systems International). *Commercial UAS Exemptions by the Numbers*. Rep. AUVSI, 2016. Web.
- AUVSI (Association for Unmanned Vehicle Systems International). *The Economic Impact of Unmanned Aircraft Systems Integration in the United States*. Rep. AUVSI, Mar. 2013. Web.
- AUVSI (Association for Unmanned Vehicle Systems International). *The First 1,000 Commercial UAS Exemption*. Rep. AUVSI, 2015. Web.
- Bigelow, Bruce. "5D Robotics Raises \$5.5M to Commercialize Technology for Vehicles." *Xconomy* 4 Feb. 2016: n. pag. Web. <<http://www.xconomy.com/san-diego/2016/02/04/5d-robotics-raises-5-5m-to-commercialize-technology-for-vehicles/>>.
- Blom, John David. *Unmanned Aerial Systems: A Historical Perspective*. Fort Leavenworth: Combat Studies Institute, 2010. Print. Occasional Paper 37.
- Brown, Bob. "UAV Startups Focused on Management, Security, Big Data and More." *NetworkWorld* 21 Apr. 2016: n. pag. Web. <<http://www.networkworld.com/article/3060052/hardware/top-drone-startups-find-venture-capital-flying-their-way.html>>.
- Cardoza, Christina. "What Part 107 Means for the Drone Industry." *InterDrone*. N.p., 22 June 2016. Web.
- Cheung, Wing. "Want Your GIS Students to Excel as Pros? Try Service Learning!" *Directions Magazine*. Directions Media, 22 Apr. 2015. Web.
<<http://www.directionsmag.com/entry/want-your-gis-students-to-excel-as-pros-try-service-learning/439251>>.
- Cheung, Wing. "What Your Phone and a Garmin GLO Can Do for Education." *Directions Magazine*. Directions Media, 24 Feb. 2016. Web. <<http://www.directionsmag.com/entry/what-your-phone-and-a-garmin-glo-can-do-for-education/463015>>.
- FAA (Federal Aviation Administration). Department of Transportation. *DOT and FAA Finalize Rules for Small Unmanned Aircraft Systems*. N.p., 2016a. Web.
- FAA (Federal Aviation Administration). Department of Transportation. *Fly for Work/Business*. N.p., 2016b. Web.
- Freeman, Mike. "SlantRange Nets \$5 Million Investment." *The San Diego Union-Tribune* 28 Apr. 2016: n. pag. Print.
- Horn, Jonathan. "He Built a Drone, and Got the Job." *The San Diego Union-Tribune*. N.p., 3 Oct. 2014. Web.
- North San Diego Business Chamber. *Unmanned Aerial Vehicles: An Assessment of Their Impact on San Diego's Defense Company*. Rep. National University System, 2012. Web.
- Northrop Grumman Corporation. "Northrop Grumman Announces Centers of Excellence in Florida, California and New York." *Northrop Grumman News Release* (2013): n. pag. Web.
- Operation and Certification of Small Unmanned Aircraft Systems, § 14 CFR 101-107 *et seq.* (2016). Print.
- Palomar College. Institutional Research and Planning Office. *Student Demographics, Outcomes and Accountability*. N.p., 2016. Web.
- Quinn, Kenneth, Jennifer Trock, Graham Keithley, and Chris Leuchten. "Drones, SUAS and More: A Basic Guide for Unmanned Aircraft Terminology." N.p., 2016. Web.
- Reno, Jamie. "San Diego, Hub of the U.S. Drone Industry." *The Daily Beast*. N.p., 2013. Web.

San Diego Regional Economic Development Corporation. "Broad Coalition Seeking Designation as Center of Excellence for Unmanned Systems." Web log post. N.p., 2013. Web.

Schneiderman, Ron. "Drones Are a Big Job Opportunity; but for New Engineers, Not so Much." *IEEE JobStie*. N.p., 2014. Web.

State University of New York-Canton. "Who Is a Technician, Technologist or Engineer?" N.p., 2016. Web.

UAV Coach. *Drone Certification: A Step-by-Step Guide to FAA Part 107 for U.S. Commercial Drone Pilots*. New York City: UAV Coach, 2016. Web.

United States Census Bureau. *American FactFinder: Community Facts*. N.p.: n.p., 2015. Web.

Unmanned Aerial Vehicle Systems Association. "Civil and Commercial UAS Applications." N.p., 2016. Web.