# Board 380: REU Site on UAV Technologies: Exposing Participants to Multidisciplinary Environment

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# REU Site on UAV Technologies: Exposing Participants to Multidisciplinary Environment


## Abstract

This paper discusses the multidisciplinary environment that the participants of the REU Program are exposed to at California State Polytechnic University, Pomona (Cal Poly Pomona). The REU Program titled "Research Experience for Undergraduates in UAV Technologies" has been funded by the NSF's EEC Program. The main goal of the Program is to increase undergraduate students' participation and interest in research on unmanned aerial vehicles (UAV) technologies. The current focus of the UAV research at Cal Poly Pomona is the increased autonomy of UAVs, collaboration between and autonomous coordination of multiple UAVs, autonomous coordination between UAVs and unmanned ground vehicles (UGVs), and widespread application of UAVs including fire detection, suppression, and monitoring, search & rescue, and package delivery. These projects require knowledge and skills in multiple disciplines including Aerospace, Electrical & Computer, and Mechanical Engineering and Computer Science.

The paper discusses how the involvement in multidisciplinary projects has helped the participants learn other disciplines, acquire new knowledge and skills, and pursue industry career or further studies in these areas. The participants are mentored and supervised by an interdisciplinary team of faculty members from several Engineering and Computer Science departments. In addition, participants work in a team environment, which provides additional avenue for them to learn other disciplines from each other. The team environment has also helped the participants acquire group working, time management, and leadership skills. This approach has been found to effectively engage students in learning and acquiring new knowledge and skills. Results of the participant and faculty mentor surveys will be presented along with the evidence of the participants pursuing career in the areas that require multidisciplinary knowledge and skills.


## Introduction

The goal of this REU Site is to provide research experience to undergraduates and expose them to state-of-the-art in the area of UAV technologies in a multidisciplinary environment. The research focus of the REU Site is increased autonomy of UAVs, collaboration between and autonomous coordination between multiple UAVs, autonomous coordination between UAVs and unmanned ground vehicles (UGVs), and widespread application of UAVs including search & rescue, fire detection, suppression, & monitoring, autonomous package delivery, remote sensing, and precision agriculture. These projects require knowledge and skills in multiple disciplines including Aerospace, Electrical & Computer, and Mechanical Engineering and Computer Science.

The Program has so far hosted a 55 participants from an applicant pool of 499 from across the country since summer of 2017 including 11 participants from Community Colleges. The goal of the Program was also to encourage Community College students to transfer to 4-year institutions for B.S. degrees in STEM disciplines. Selected students were from Aerospace Engineering,

Electrical and Computer Engineering, Mechanical Engineering, and Computer Science disciplines.

The participants were mentored by an interdisciplinary team of faculty members. The students were exposed to a wide range of disciplines such as UAV Flight Dynamics and Control, Obstacle Detection and Avoidance, Guidance, Navigation, and Control, Computer Vision, Artificial Intelligence, Modeling & Simulation, and Flight Testing. Students learned fundamental skills in engineering, computer science, and mathematics, and were trained to use computational tools needed to engage in multidisciplinary UAV research. Most of the participants who have already graduated have joined aerospace companies or Government organization and are working in UAV technologies or related areas including Lockheed Martin Corporation and Northrop Grumman Corporation. Some of the Participants were also accepted for summer internship positions at companies or corporations that are heavily involved in UAV research and development.

**Figure 1. Participants of 2022 Summer REU Program.**

Figures 2 and 3 show the multidisciplinary teams of students working on various projects in the UAV Lab during summer of 2022.

**Figure 3. Some Participants of 2022 Summer REU Program working in the UAV Lab along with High School and Community College Students.**

**Figure 3. A Multidisciplinary Team of Students working on a novel e-VTOL project.**

The Participants learn to design and build UAVs, do instrumentation, systems integration, and flight testing of developed algorithms. Figure 4 shows a team of students preparing their UAVs for flight test in a flying field.

**Figure 4. A Multidisciplinary Team of Students Preparing their UAVs for Flight Test in a Flying Field.**

Figure 5 shows students testing fire suppressant dropping system from their UAV. A multidisciplinary team of students worked on collaboration between multiple UAVs for fire detection and suppression. They used a different UAV to detect fire and fire location before sharing that information with the fire suppressant UAV.

**Figure 5. A Multidisciplinary Team of Students Preparing their UAVs for Flight Test in a Flying Field.**

## Evaluation of Outcomes

The REU Program has been found to be very effective in providing the participants learn other disciplines, acquire new knowledge and skills, and pursue industry career or further studies in the area of UAV autonomy and their applications [1, 2]. The program outcomes were evaluated by an external evaluator. Findings from external evaluation and faculty mentor feedback are discussed below.

### 1. Development of New Skills and Knowledge

The involvement of students in the REU Program in a multidisciplinary environment has helped students learn, by means of hands-on learning, other disciplines that are not taught in classroom settings of individual disciplines. Students are exposed to the state-of-the-art in UAV technologies and industrial trends. For example, students from Aerospace Engineering major have learned or have opportunity to learn computer programming, computer vision, electronics, avionics system, communication, etc. This is also evidenced by a number of Aerospace Engineering majors getting employment for the industry careers that have traditionally required Computer Science or Electrical & Electronics Engineering graduates. Some of the sample responses from the Participants on the acquisition of multidisciplinary knowledge and skills are: 1) "I was able to learn how to teach myself as well as take into account different people's disciplines and their perspectives in the problem"; 2) "I have learned how to collaborate with different people who are not in my field" ; 3) "It helped me develop new learning skills such as python programming language and simulations"; 4) "I was able to learn skills in areas different from my field of knowledge"; 5) "I got a lot of experience working outside of my comfort zone and learning new things. This gives me confidence that I can learn something new independently in the workforce. It also gave me confidence working on complicated tasks that are outside of my major of aerospace engineering" and 6) "This UAV Program not only influenced my knowledge on UAVs, but it also introduced me to learning new skills, artificial intelligence, and team building."

### 2. Increased Ability to Apply Multidisciplinary Knowledge to Real-World Problems

Involvement in the project has increased the students' ability to apply the newly acquired knowledge and skills to the real-world problems that require multidisciplinary knowledge and skills. The students have been successful in identifying, formulating, and solving multidisciplinary problems. The students have also been successful in designing and conducting experiments to test their multidisciplinary work and in collecting and interpreting the experimental data. This is evidenced by the successful testing of developed methods and techniques including flight testing. Some of the sample responses from the Participants on the ability to apply multidisciplinary knowledge and skills to real-world problems are: 1) "I think the best aspect was the collaborative effort to address real-world issues" and 2) "The best aspect of the UAV program is learning and using different programs to collaboratively accomplish a flight mission. Several participants have presented their multidisciplinary work on real-world problems at student and professional conferences [3-8].

### 3. Increased Readiness for Industry Career

The students involved in the REU Program project have shown increased readiness for industry career. The participants' career in industry or academia is an important indicator of the success of the Program. Most of the participants who have already graduated have joined aerospace companies or Government organization and are working in UAV technologies or related areas or are pursuing graduate studies. Some of the sample responses from the Participants on the increased career readiness are: 1) "I was pushed into a new environment which required me to multitask and focus on learning new things. It was a struggle, but I am glad I was able to learn different programs needed for industry"; 2) It was difficult and I struggled a little but pushed through. In the end I feel accomplished and better prepared for a higher level of professionalism"; 3) "I am now considering working with UAVs after graduation"; 4) "I will definitely be bringing these experiences with me in my future career"; 5) "The program boosted my programming skills significantly. I learned C++ and hardware interfacing. This played a large role in gaining skills that help me in my career today"; 6) "The UAV REU helped me obtain a job by building a foundation on the concepts of guidance navigation and control"; and 7) "The UAV REU has certainly been a strong contributing factor in my path to my current position. Much of my current work is an elaboration of the principles I discovered during the REU Program."

## Conclusion

The REU Program has enabled students to acquire new knowledge and skills and apply the newly acquired knowledge and skills to real-world problems. They have learned to design, build, simulate, perform instrumentation and system integration, and/or test the developed methods and algorithms in a multidisciplinary environment. This has resulted in improved readiness for careers that require multidisciplinary knowledge and skills.

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