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INCORPORATING REAL LIFE DESIGN ACTIVITIES INTO THE AEROSPACE CURRICULUM

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ABSTRACT

Aerospace Engineering Department of the Middle East Technical University has long incorporated multidisciplinary design activities into its curriculum. Recently, it has embarked on a number of student aerospace vehicle development projects by the support of aerospace companies, such as Boeing, Turkish Aerospace Industries, Roketsan Missile Industries, as well as the international organization, Asia Pacific Space Cooperation Organization. These activities, and how the students are involved in these activities are presented and discussed.

INTRODUCTION

Aerospace Engineering Department of the Middle East Technical University (METU) is founded in 1981, to support the emerging aerospace engineering industry in Turkey. It is the top aerospace engineering department in the country. Currently, there are about 700 students enrolled in the undergraduate and graduate programs.

The department is accredited by Accreditation Board for Engineering and Technology (ABET) since 2007. The next review will start in 2021. To become eligible for accreditation, the Engineering Faculty has started a review of the undergraduate programs before 2000. As a result of this process, the courses of the aerospace engineering department were also reviewed and a capstone design course, as well as elective design courses are incorporated into the curriculum.

Recently, the students are invited and voluntarily involved in a number of real life design problems. The first one is the vertical takeoff and landing unmanned air vehicle competition, (VTOL-UAV), where both the students of the department, as well as students from other universities in Turkey has taken part. The second activity is the Asia Pacific Space Cooperation Organization's (APSCO) project to build small satellites by engineering students. The third activity is supported by the TUSAS Aerospace Industries (TAI) of Turkey to design, develop and build a very light weight category aircraft by the students of METU. Recently another Turkish aerospace company, Roketsan Inc., started another student project to design and build a small tactical unmanned vehicle by the METU students. This manuscript describes these activities and how they are incorporated into the curriculum.

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In the next section, the design aspect of the METU Aerospace Engineering Department undergraduate curriculum is described. It is followed by the description of the above activities. Lessons learned are given next, followed by the concluding remarks.

METU AEROSPACE ENGINEERING UNDERGRADUATE CURRICULUM

The undergraduate of the Aerospace Engineering Department has one mandatory capstone design course titled “AE451 Aeronautical Engineering Design I”. In this course, students learn about the conceptual design of aircraft, and carry out an aircraft design with a specified mission.

The curriculum requires that students also select another design course from the following list:

- AE446 Introduction to Helicopter Aerodynamics and Helicopter Design
- AE452 Aeronautical Engineering Design II
- AE462 Design of Aerospace Structures
- AE476 Space Vehicle Design

The students also carry out design activities in the above courses. Additionally, another elective course is also introduced to the curriculum recently, “AE4800 Aerospace Engineering Project”. Within this elective course, a student or a group of students may do a more involved design such as a design, build, fly activity for a competition, or carry out an individual research working with a particular professor. Thus, a student may do a project with different faculty members during the course. At end, all students submit their project reports, and present their work in front of other students and professors.

It may be observed from the course list above that, there are a number of courses, where the students will have the opportunity to learn design, and carry out projects under different topics.

REAL LIFE DESIGN PROJECTS

Currently, there are four real life design projects carried out by the the students in the department. These are listed and described under subheading below.

METU VTOL Unmanned Air Vehicle Competition

Boeing Turkey, under the Global Corporate Citizenship program offered to support activities in the Aerospace Engineering Department, back in 2016. It was offered by myself to held a student VTOL-UAV competition among university students. Using the budget provided, the organization expenses are carried out as well as a fixed stipend is given to the student teams to build their aircraft. The travel expenses of the students travelling from other cities were also covered.

The first competition was held in METU stadium on weekend of 11-12 November 2017.

Last year the second METU VTOL-UAV competition was held. The teams were requested to send their proposals by June 30. Of the 27 proposals received, 21 of them are accepted and teams are invited to the competition. However, the teams are also required to send their final reports two weeks prior to the competition. 13 teams turned in their final design reports and all are graded. Finally, the competition is held at an air field near Ankara on October 13-14, 2018 (Figure 1). 11 teams attended the competition, involving over 70 students. Two other professors from METU Aerospace Engineering (Dr. Ali Turker Kutay and Dr. Mustafa Percin) and one professor form Thailand (Dr. Chinnapat Thipyopas of Kasetsart University) were involved in the scientific organization of the competition. The referees were selected among the graduate research assistants, preferably among those whom had taken part in design, build, fly competitions before. Last years’ winner team was from Necmettin Erbakan University located in the city of Konya (Figure 2).

During the competition, other students and faculty from METU are also transported to the competition site to observe the competition.

Figure 1. Martyr First Lieutenant Gurcan Ulucan Airport, Temelli, Ankara.

Figure 2. Some of students that attended the METU VTOL 2018 competition.

We are repeating the competition as well this year (Figure 1). It will be held at the Temelli airport on October 19-20 2019 (Figure 3). This year 21 teams were invited to the competition. Similar to the last years' competition, the organizing committee is consisting of three professors from our department and the other professor from Thailand is also involved. This year we will support three members from the winning team to attend a conference in the USA, such as SciTech 2020.

Figure 3. VTOL aircraft competition banner.[2]

The activity has provided engineers working in a multidisciplinary environment. Some students of the METU-Aerospace completed their designs as a part of their design course. Many students from other universities are given a change to enhance their education by working in an interdisciplinary engineering groups, writing out design reports in English as well as building and flying a real life system such as a UAV.

Student Small Satellite Project

APSCO is an intergovernmental organization of eight member states where Turkey is also a member [3]. Space Technologies Research Institute of, The Scientific and Technological Research Council of Turkey (TUBITAK-SPACE)[4] () represents Turkey in APSCO. The Institute is located on the METU campus, very close to the Aerospace Engineering Department.

APSCO, about three years ago, decided to do a project involving the engineering students from member states. Under the Student Small Satellite Project, one microsatellite and two CubeSats were to be build. The mission of the satellites are depicted in Figure 4. Turkey, will lead the development of one three unit CubeSat, called SSS-2B, with contributions from other member states as well.

It was offered to METU to build the CubeSat together with its students. Since, there was not sufficient infrastructure in the department, it is decided to build the satellite using the infrastructure of TUBITAK-SPACE, located few hundred meters from the department, with the support of their engineers.

The preliminary design review of the SSS-2B CubeSat was held on April 16-24, 2018 in Ankara. The critical design review was successfully competed on 21-29 August 2019, in Beijing. The project is evolving with the involvement of METU students. It is a two-year project, expected to be completed by 2020.

In addition, numbers of summer camps to teach students satellite technologies were held. The second summer camp, lasted three weeks, was organized by myself at METU in August 2018. Four students from each of the member states as well as a mentor attended the summer camp. However, twelve students from METU were permitted to attended the summer camp activities, since they were not paid for travel and subsistence. This year's summer camp was on presenting hands on experiences on satellite subsystem manufacturing and testing. One professor from China and another professor from Iran lectured during the camp. The

[2] http://vtol.ae.metu.edu.tr/en/
[3] http://www.apsco.int/
[4] https://uzay.tubitak.gov.tr/en

remaining lectures were given by the METU professors and practicing engineers from TUBITAK-SPACE.

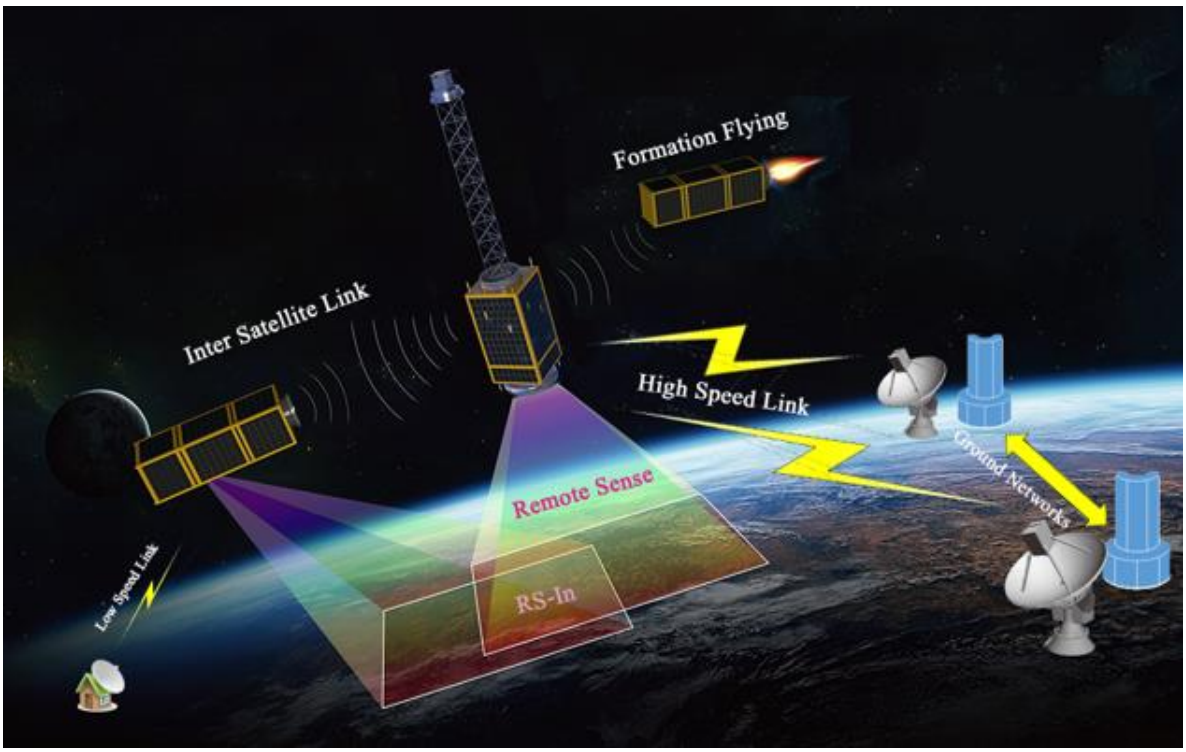

Figure 4. APSCO Student Small Satellite Project [5]

Additional summer camps are also being held within the scope of the project. A team of four undergraduate students attended to this year's summer camp from June 15 - August 2, 2019. Two of the students them from our department, one of them was from the electrical engineering department, and one student was from the University of Turkish Air League University. During the training, the teams were evaluated according to their project on designing a satellite control system for Earth observation mission, where the Turkish team ranked 2nd among 8 teams present.

So far about twenty METU students are involved in the SSS-2B project, as doing mission analysis or subsystem design in the design courses. During their design activities they frequently visit TUBITAK-SPACE, and work with the experts there. Burak Yaglioglu and Omer Atas were specifically assigned to the project by the institute. Most of them also completed their second summer practice activities at TUBITAK-SPACE.

Since these students have already got acquainted with the Institute's engineers, as well as have worked with them on the CubeSat project. Many recent graduates have already been employed by TUBITAK-SPACE.

Very Light Aircraft Design and Development Project

The very light aircraft project is initiated by TAI to educate the students from METU in the design and development of aircrafts. The necessity was clear to the TAI management, since the fresh out of school engineers they draft, spent the first few years learning the standards and procedures used in designing an aircraft. However, it is envisaged that, if engineers are introduced to the company activities as part of their curriculum, they will become productive much earlier in the company. Thus, it is proposed that the students will design a small, namely a very light weight category aircraft complying with the requirements of the EASA

[5] http://www.apsco.int/html/comp1/content/HandsTraining/2018-07-05/65-179-1.shtml

CS-VLA. The aircraft will be a two seater, less than 750 kg maximum take-off weight. A contract is signed between TAI and METU, in December 2017. Beside myself as the project manager the following professors have involved in the project: Dr. Altan Kayran, Dr. Dilek Funda Kurtuluş, Dr. İlkay Yavrucuk, Dr. Demirkan Çöker, Dr. Ercan Gürses and Dr. Yavuz Yaman from aerspace engineering department; Dr. Erhan İlhan Konukseven and Dr. Haluk Aksel from Mechanical Engineering Department; Dr. Kemal Leblebicioğlu and Dr. Ece Güran Schmidt from the Electical Engineer Department.

Figure 5. The Very Light Aircraft Project

The students are encouraged to work with designated TAI engineers. Over 80 students were and are currently active in the project. These students are also being paid, although a small amount from the project. Number of the students also competed their second summer practice at TAI last summer, working on the project, under the supervision of the TAI engineers as well. Students, according to their area, took design courses, and worked on their assigned topic at VLA project.

Project kick-off meeting was held on March 17, 2018. System Requirements Review (SRR) was completed on June 30, and Preliminary Design Review (PDR) was held on September 29, 2018. Prior to each of these meetings a report is sent to the customer, TAI, and a presentation is made by the students to the TAI engineers coming from different areas of expertise. Their criticisms are carefully recorded and addressed in the provided deadline.

A pre-CDR was carried out on May 4, 2019 at TAI facilities. The CDR is expected to be complete this fall. Afterwards the purchase of the aircraft parts and a prototype manufacturing, and test activities will be started.

The aircraft will be manufactured by TAI. The students will also be involved at this stage, in different capacities, at the shop floor, as well as during testing.

Because of the VLA project, TAI offers jobs to students as soon as they graduate. Some of them are even hired as engineering assistants during their final year. Most of those students graduated that has contributed to the project were already hired by TAI.

Recently we have been informed that the project was awarded the Best Academia-Industry Cooperation Project by the Turkish Council of Higher Education.

Small Tactical Unmanned Air Vehicle Design and Development Project

A similar student design project was also carried out by the Roketsan Missile Industries Inc. The project envisaged designing and building two small unmanned air vehicles for observation purposes. The air vehicles would be less than 7.5 kg in weight, and shall carry an observation payload. The duration of the project was eight months.

One of the vehicles would be catapult launched, whereas the other one should take-off and land vertically. Again about 20 students were engaged from aerospace engineering, mechanical engineering and electrical engineering departments. They were all senior level students. A total of eight faculty members from aerospace: Dr. Ozan Tekinalp (project manager), Dr. Dilek Funda Kurtulus, Dr. Nilay Sezer Uzol, Dr. Melin Sahin and Dr. Yavuz Yaman of aerospace engineering department; Dr. Alpay Ankarali and Dr. Kemal Lelebicioglu of electrical engineering department and Dr. Ender Cigeroglu of mechanical engineering department. The project milestones, SRR, PDR are completed. The CDR was held on July 10, 2019. Some subsystem engineering models are constructed and tested. Another subsystem that built and tested is the catapult subsystem. During CDR it is decided to build only the catapult launched UAV system at this time. It is flight test is expected to be carried out this Fall.

The students worked with Roketsan engineers, at the office provided for them in the company. They also worked with the faculty as well. As with other industry cooperation projects, most of the students have completed their undergraduate studies last spring, and hired by Roketsan,

LESSONS LEARNED

The main difficulty encountered in UAV competition was with the organization. Previously, UAV's with has less than 4 kg take-off mass were not regulated. Just for this reason, the takeoff mass of the competition vehicles was limited to 4 kg. Recently, regulation have changed and flying such vehicle required registration. Permission is also required from the Civil Aviation Authority to fly them at a certain area. Getting a permission is a lengthy process, which took almost six months and quite a bit of written correspondence.

In last year's competition we received support from Turkish Land Forces, specifically from the Land Forces Air Command to held the competition at the Martyr First Lieutenant Gurcan Ulucan Airport at Temelli. The competition was quite successful with eleven teams attending the competition. This year we have invited 22 teams to attend the competition.

If we are to become a developer in the UAV industry, we should offer support to education, as well as support to flight vehicle developers and provide areas for them to fly and test their vehicles.

Student small satellite project is as discussed above is an international project. We as METU offered to carry out the complete project in our department. However, the low budget offered for the project, and infrastructure available at the department prevented us from doing so. Finally, it is decided that the CubeSat is to be manufactured at TUBITAK-UZAY. However, students of the department, working in groups, has took part in the preliminary and the critical design phases of the project, with support from the practicing engineers of UZAY. This approach has been quite beneficial for the students and our undergraduate program.

We continue to benefit from APSCO activities. In October 2019, a group of students will be competing at the APSCOSat Contest at Northwestern Polytechnic University, Xi'an China. Overall, the project is quite successful and continues to add value to our education[6].

The Very Light Aircraft Project, supported by TAI has also been quite successful in supporting the design education activities in our department. The course design projects were selected from the activities of VLA Project. For example, the conceptual very light aircraft designs were carried out in the Aeronautical Engineering Design II course. An additional benefit was the support of the TAI engineers in the activities. However, the project is too long. It has already bean 18 months since the start of the projects. It is not possible to continue with the same group of students throughout the project, since some of them continuously graduate. Consequently, quite a number of students have graduated and employed by TAI. Thus we try to replace position of the graduates with new senior students with some mixed success. Similarly, the TAI engineers assigned to the project are continuously changing, and from time

[6] http://www.apscosatcontest.com/

to time TAI support is weakening. Thus, there is quite a bit of effort at the METU side to manage the project.

Another difficulty on the METU side was that not all of our professors contributed similarly. Those Professors offering a design course were more enthusiastic and consequently contributed more.

The Small Tactical UAV project was quite different from the TAI project. In this project students mainly worked with Roketsan engineers, and got support from the METU professors as needed. Their project activities are also counted as design work in the design classes. Again most of the students in the project, except a few, graduated in Spring of 2019, are employed by Roketsan. They continue working on the project, and it is expected that a maiden flight will be carried out this Fall. Similar to the VLA project, some of the professors involved in the project were less enthusiastic than others.

CONCLUSION

The student projects described above has been quite successful. As described above, these are educational projects to improve the quality of education by carrying out real life design activities, as well as getting students acquainted to means of doing engineering in industry.

We will continue pursuing such activities in the department to improve the quality of the education.

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