İZMİR INSTITUTE OF TECHNOLOGY

ELECTRICAL AND ELECTRONICS ENGINEERING DEPARTMENT

SUMMER PRACTICE REPORT

Name - Last Name	**:** Emre Nedim Hepsağ
Turkish Identification #	**:** 19243151332
Student #	250206012
Company Name	**:** Turkish Aerospace Industries, Inc.
Dates	**:** 12/08/2021 - 09/09/2021
Summer Practice #	**:** ☐ 1st ☒ 2nd

İZMİR

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İZMİR INSTITUTE OF TECHNOLOGY
FACULTY OF ENGINEERING
ELECTRICAL & ELECTRONICS ENGINEERING DEPARTMENT
SUMMER PRACTICE REPORT INNER COVER PAGE

Name – Last Name : Emre Nedim Hepsağ

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Student # : 250206012

COMPANY / FIRM

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Starting Date : 12/08/2021

Ending Date : 09/09/2021

SUPERVISOR AT COMPANY

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TUSAS Türk Havacılık ve Uzay Sanayii A.Ş.
Turkish Aerospace Industries, Inc.

1. We encourage our students to start writing internship reports during their internships. In this way, they will have the chance to do an internship in awareness of what is required of them.

2. Internship reports must be prepared in accordance with the regulations defined in this document. **Reports that do not comply with these conditions are not assessed and the internship of the student is considered to be unsuccessful.**

3. The reports must be in English and written with computer with your own words. Drawing should conform to acceptable engineering standards). There is no page limit for Appendix, however the other sections must not exceed 30 pages in total.

4. When sources or documents are used in the report from other resources such as internet, company sources, books, data sheets etc., they should be specified both in the text where they are used and in the **References** section. The reports must not consist of cut and paste parts from other sources. The whole report must written in student's own words. In mandatory cases, the tables and figures can be copied, but still must be cited in the text and referenced in the **References** section of the report. The students are responsible for knowing the contents of their reports. When necessary, the students may be invited to the oral exam and respond to the questions about the content of their reports.

5. Internship reports should provide information indicating that engineering activities complementary to the education received at the department have been performed at the company.

6. In the internship reports, the name and contact info of the supervisor must be clearly indicated and the signature and the firm stamp must exist.

7. The reports should be prepared and printed on **A4** size white papers in **1,5 line** spacings in **justified** paragraphs using **12 pt Times New Roman** fonts, with the **top, bottom, and right on 2.2 cm**, and **left on 3 cm**. Main headings are centered and written in capital boldface. Subtitles should be written in small letters and boldface. Drawings should conform to acceptable engineering standards.

8. Appendices may be added at the end of the internship reports if needed in a section named **Appendix**. The appendices are separated in the form of Appendix 1, Appendix 2, and these appendices, if any, are numbered in section number A.1, A.2. No unnecessary information and documents are put into the report and its annexes. There is no page limit for Appendix.

9. **Internship reports should be submitted in spiral bound or in filed form, and internship evaluation forms should be presented in closed envelops and approved form. Otherwise the reports will not be evaluated and the internship of the student will be considered as unsuccessful.**

EEE Department Internship Commission

I declare that I have prepared my internship report according to the regulations and notes above.

Student's Name and Last Name: Emre Nedim Hepsağ

Student's Signature: 

TABLE OF CONTENTS

1. DESCRIPTION OF THE COMPANY

I have done my internship at Turkish Aerospace Industries, Inc. at department of system System Integration and Test Engineering for 20 days. My aim was to learn how a system integration laboratory is designed and how it works. The company locates at Fethiye Mahallesi, Havacılık Bulvarı No:17 06980 Kahramankazan Ankara. Oğuz Han and Mert Kaya were responsible for system integration laboratories and the manager of the department is Lüfü Akçıl. President and the CEO of the company is Temel Kotil. There are 10320 employees: 44% of them are technicians, 33% are engineer, 9% are administrators and etc. There are six strategic business centers which are: structural group, aircraft group, helicopter group, unmanned aerial vehicle (UAV) systems group, space systems group and national combat aircraft (NCA) group [1]. Main areas of business are aviation and space industry.

Turkish Aerospace was established in 1973 under the Ministry of Industry and Technology. They aimed to meet the requirement of fighter aircraft of Turkish Air Force. After 2005, TAI and TUSAS united into a company called Turkish Aerospace Inc. [1].

2. INTRODUCTION

I can divide this internship into 3 sections. First three days were for general education. I attended presentations for orientation and some other topics of safety and security. In the second part, I started to learn about system integration laboratories and general knowledge of drones. I and my intern friend tried to write a code to automate some process on C# with UDP server-client implementation. Then, I started to learn PCB design with Altium and designed a board with it. Also, I learned about serial communication.

In the last part, a model plane with the name of extra 330sc was given to me and my intern friend. Initially, we made a lot of research about mechanics of a plane and how to program it with Pixhawk. It was challenging to us learn how build a plane almost from the very beginning in two weeks. We were lacking lots of equipment and materials. Hence, our challenge was finding ways to solve those problems with different methods. For example, we did not have wire extensions, splitters, and connectors. Hence, we produced our version of them. Additionally, our aircraft is designed for gasoline engine. However, we tried to turn it into work with an electric DC motor. Therefore, we designed extra metal sheet to be an equipment for DC motor. After configuring, assembling servos, we did our tests. We did taxi with our plane and send it to flight test.

3. WORKING SCHEDULE

From 12/08/2021 to 09/09/2021	
Week	**Task Description**
1.Week (2 days)	Orientation for interns Organizational culture and administrative regulations Security rules for interns Information security awareness Occupational health and safety Environmental awareness and environmental management system familiarization Energy efficiency awareness and energy management system familiarization
2.Week	Introduction to Anka and Aksungur system integration laboratories (SEL) Learning how an aircraft and a drone work, communicate with base Learning Visual Basic environment for C# Learning serial communication and UDP server-client implementation Automating configuration process by C# Learning CorelDraw and how to read and write documentation of a project Learning Altium and PCB design Observing how a testing process is being done
3.Week	Ending my PCB design and design rule checking Observing how a SEL is being debugged and fixed Learning serial communication protocols: I2C, SPI and UART Learning the environment of Microchip MPLAB X IDE Learning working principle of a drone and Extra 330SC 122” aircraft Learning what Pixhawk is and how to use it for a RC plane
4.Week (4 days)	Determining places to cut and scuff to place our servo motors, wires and horns Learning how to control rudder, elevator, and ailerons by RC transmitter Assembling horns and gluing them Assembling landing gears Figuring out supplying power to Pixhawk and servo motors Configurating and calibrating Pixhawk Building a stand for testing DC motor Doing little factory tour
5.Week (4 days)	Designing and manufacturing an equipment for DC motor to be further than body Measured our required cable length and manufactured servo motor extension cables and Y splitter cables Assembling servo motors and connecting them to the hinges with pushrods Testing servo motors Doing taxi and flight test

4. BODY OF THE REPORT

4.1) Orientation and training of safety and security

4.1.1) First three days, on 12th and 13th of August, of the internship were general training with presentations. First presentation was about orientation for interns then with the following presentations, we learned regulations, security rules, security awareness, health and safety, environmental awareness and environmental management systems and lastly energy efficiency awareness and energy management systems.

4.1.2) I did not need any extra information. I highly recommend other students to apply for this training because these topics are so crucial for any company to sustain wounding and damage at lowest level. Also, getting environmental awareness made me care my wastes and be more efficient person.

4.1.3) We as all 3rd term interns got trained about seven topis with presentations. This occurred in two days.

At first day, there was an orientation. I learned general history, departments and working system of TUSAS. Then, the next presentation was called “Organizational Culture and Administrative Regulation”. I learned culture of TUSAS and general regulations in the company. In the following presentation, I learned security rules for interns and what happens otherwise. Last presentation was about information security awareness and, I learned what the threats, weakness, cyber-attacks, information securities and ISO 270001 certificate are.

At second day, at the beginning of the day, there was a presentation called “Occupational Health and Safety”. I learned concerns about health and what to do to avoid situations which result in damage. The subsequent presentation was about environmental awareness and environmental management system familiarization. I learned essential things about environment, what TUSAS does for keeping environment clean and what I am supposed to do while doing internship. Then, I got trained for fire, how to extinguish it, what I am supposed to do in any emergency situation and built-in fire extinguishing systems. The last presentation is called “Energy Efficiency Awareness and Energy Management System Familiarization”. There was really important information about consuming and generating energy, energy efficiency, energy management systems and what energy is.

4.2) Programming an automation system for configuring Moxa NPort

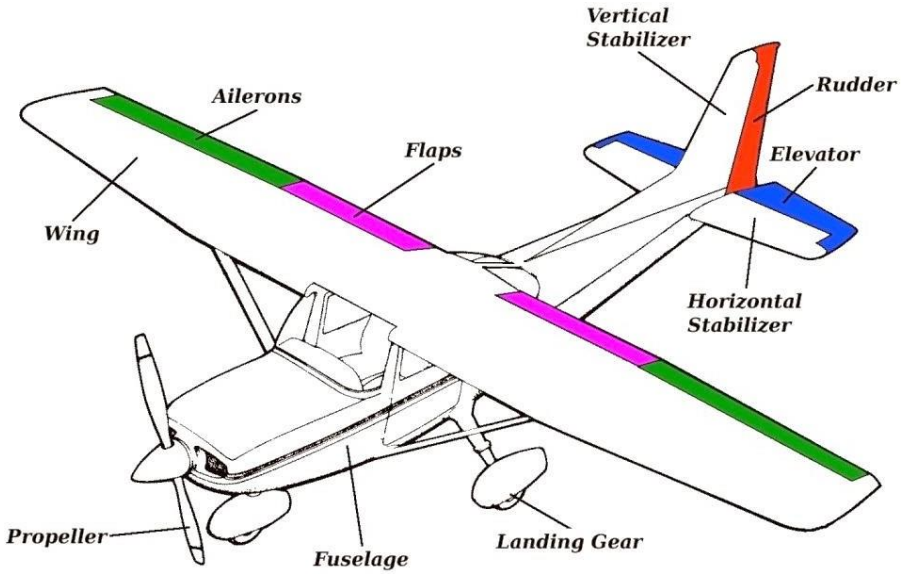
4.2.1) This project maintained for 2 days on 16th and 17th of August. Me and another intern in the same department tried to create a program to automatize the configuration process of Moxa NPort with UDP server-client implementation.

4.2.2) The lecture of introduction to programming helped me to figure out the system more easily. I had to learn object-oriented programming, C#, and visual basic environment as extra. I would recommend other student, who want to improve their programming skills and serial communication knowledge to try to solve this problem because you need to know lots of things from these areas which help you to develop these skills rapidly.

4.2.3) In two days, we had to code a program in C# to build a GUI to make cumbersome configuration process for Moxa NPort on WebGUI could be done with one button. First, I had to learn concept of object-oriented programming which C# uses. It is a programming paradigm which is based on object unlike C [2]. Then, to communicate Moxa NPort, we had to communicate with it on ethernet via UDP which is user datagram protocol and thanks to it we are able to transmit and receive data quickly with packets. After that, we started coding. First, we build whole program on C# and designed a nice looking GUI with visual studio, but after a while we realized that a library for the device is needed. Thus, we searched for it and found one. However, there was a problem which is that the library was written in C programming language. Hence, we had to implement C codes in C#. It was challenging to us to deal with this problem. Then, we succeeded to communicate with the device, but we realized that the library was missing for functions we needed. Therefore, we failed to build automation program.

While we are dealing with these, our mentor thought us about SEL (system integration laboratory): how they work, what are they for and brief introduction to the aircraft and their moving parts and mechanism such as aileron, rudder, and elevator at visual 1 (See Appendix). I learned how to control a drone and what controller affect what part of the aircraft. Additionally, this made me to figure out what part of plane affects the plane to be directed in which way on which axis by seeing. I also learned the communication systems in the drone, between base to drone and what the communication protocols are. These are being done by UBB (end connector) and UKB (flight control computer). Then I saw those hardware systems physically: connections, connector, devices etc. Also, I learned about the software part of the SEL because my department was also responsible for simulations and

management softwares running on it. I got familiar to use them and the control system made me understand the main principles of controlling a drone better.



Visual 1: Moving parts of a plane and names [3]

4.3) SEL design, PCB design and embedded systems

4.3.1) I dealt with these task for 5 days, from 18th of August to 24nd of August. I wanted to change my position to work with more on hardware systems. Thus, I started to learn these. First, I observed technical documentation of a SEL and tried to understand. Then, I learned PCB design with Altium by designing a board and learned MPlab platform from Microchip in short term.

4.3.2) Circuit analysis, electronics and introduction to programming lectures are related to this task. Except the technical knowledge, I needed to learn the programs and environments. These tasks are for students who mostly want to deal with hardware design and low-level programming because those force you to learn about electronics and C programming at register level.

4.3.3) At the beginning of this task, I opened a technical documentation of a SEL on CorelDRAW which is a software for vectoral graphical designs and in my scope, it was used for designing a SEL with descriptions and connections. First, it was hard to find out the meanings of the pages because there were many pages, more than 10, for one decent system.

However, after a while, I followed most of the lines and saw the logic behind it. After, I observed the built, real system of it to see if I really understand the documentation.

Then I started to learn PCB design with Altium because my department was planning to design their own PWM cards by themselves. Altium is a very developed electronic design automation software to design printed circuit boards and it is so common in hardware designing industry. I was familiar with PCB design with EAGLE EDA, but Altium was more complex software than EAGLE. Thus, I took time me to learn the processes. My first small project was to build my own Arduino board from scratch. First, I created my integrated library for Arduino components, such as Atmega328p and FT232R which is an UART interface. I designed their symbols and named their pin according to the datasheets. Then, I designed their footprints which is so crucial for a board because manufacturer build PCBs according to footprints. The wrong one would inhibit your board to be work properly. Thus, I created them carefully with fully dependent to the datasheet and I created their 3D models which is not important that much. Those process could be done by researching symbol and footprint files on internet, but they are not always correct. Hence, it was needed to do that on my own. After building my own reliable library, first thing to do was designing the schematics of it. After finishing the wiring process, I created my board and placed my components then routed. Sometimes I encountered problems because there are design rules and the DRC (Design Rule Check) system that finds my error. According to them, I changed the placement of the components and rerouted until I got no error. Lastly, I finished my board and created gerber formatted files to make it ready to be manufactured.

4.4) Serial communication protocols and introduction to embedded systems

4.4.1) In one day, on 25th of August, I started to learn embedded systems on MPLAB X IDE. However, due to the lack of debugging devices, I had to stop doing that task.

4.4.2) This task is normally related to Embedded Systems lecture at IYTE, but I could not get that lecture yet. Fortunately, Introduction to Programming lecture helped me to understand C codes easily. Thus, I needed to learn same basics of serial communications and embedded systems. I would recommend this task if the student likes to deal with both hardware and software.

4.4.3) First of all, I needed to learn serial communication protocols. That is why, I started to do research about I2C, SPI and UART. They were not hard to understand, so it did not take much time. After, to program my microchip brand microcontroller, I installed my environment which is MPLAB X IDE and related packages. There was a prewritten code from TUSAS for UART. I observed it and tried to understand. However, to program my own microcontroller, I needed a debugger, and it was not available at that time. Therefore, my task was ended at the end of the day.

4.5) Learning how a SEL work and testing processes

4.5.1) This observing and learning process took two days, on 26th and 27th of August. I witnessed the process of how to fix a bug on the SEL (System Integration Laboratory) and then I was introduced the testing protocol.

4.5.2) Debugging and testing processes reminded my lab sessions of any lecture and electronics design project. I was familiar with concepts of debugging and testing any product. I just did not know how the system know in detail. I would recommend this task who is capable of problem solving.

4.5.3) At the beginning of the day, I was informed that we need to update the software of a SEL. Therefore, we went the laboratory and started to update the softwares. While this was happening, I observed how an ANKA drone simulation work by trying it. I learned principles of flight computers, land computer and some peripherals. After that, we started to debug the system by trying most of the features. However, we encountered an error that we could not solve for hours. That was a great experience to see a real problem in the field. After long run of debugging operation, we finally solved the issue at the end of the day.

The next day, I requested a test engineer to show me the testing process. She was also running some test on that time. Therefore, she showed me step by step how to test a new equipment or new software by running in on a SEL. I leaned the mentality of testing which is that you have to think every possible situation to find a bug. So, the main purpose is to try to break the system to encounter with an error. Also, stability is one of the main concerns in this work.

4.6) Building a drone with only a frame and company tour

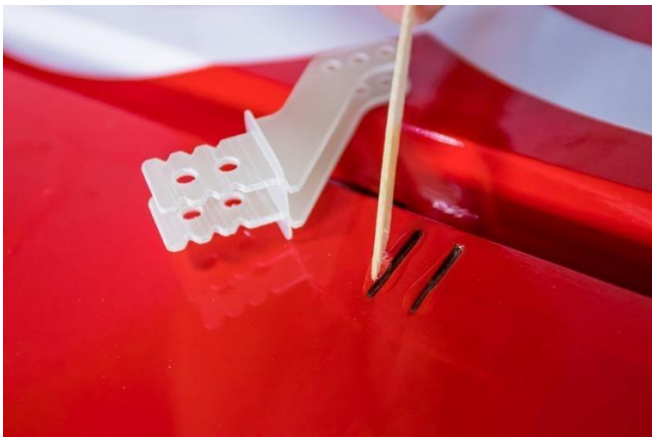
4.6.1) This was my longest term task which started on 31st of August and finished at the end of my interview on 9th of September. I tried to finish this project with another intern in the same department. That was quiet challenging to try to handle a drone almost from starch and it was very informative for me.

4.6.2) I had to use a lot of information from a lot of lecture of IYTE which are electronics design project, feedback control systems, circuit analysis and electronics. I also needed to learn mechanics of a drone as extra to safely finish this project. If somebody is enthusiastic to aircrafts and drones, I highly recommend this task because there were many challenges we had to solve and those helped me to grasp lots of concepts about planes.

4.6.3) First I want to mention about the company tour which I learned a lot of things about helicopters, aircrafts, and production line. We went the mounting line of Atak and Skorsky helicopter. The process was so similar to pipelining in digital system design which enlightened me about how important efficiency is. Also, I saw that, at every section, there are complicated assembling process and cablings. Then, in the next building, I learned the modification and modernization processes also why thy are being done. I also went into a modernized plane and I observed it. Next, we learned some about Havasoj plane. Lastly, we went Aksugur building and I learned why everything has a backup. Also, I was informed about interior mechanism of it.

After these all of these task, manager of our department gave me and another intern the project of drone. There is a RC Plane model called Extra 330SC 122” which is just a frame of this plane and which some accessories. We both did not have extensive knowledge about it and there was no manual or guide. Therefore, we started to do long research about RC planes and the mechanisms of them. After getting some sense of it by observing other RC plane’s mounting operation, we started to learn about Pixhawk the Cube Black which is a flight controller system similar to any single board computer but specified for drones and RC cars. We had to learn it to control our plane such as, throttle, aileron, rudder, elevator and DC motor of it. We figured out how to control them with RC transmitter by configuring Pixhawk on Mission Planner which is a software for controlling, calibrating and configurating Pixhawk.

After educating ourselves, we started to observe the plane. We had some problems. First of all, the plane was designed for gasoline engine, but we only had DC motor. Secondly, due to the lack of manual, we did not know where to cut and carve. It was hard because all of the plane is covered by plastic coating; every slot was hidden under it. After brainstorming to solving the problems, we started to determine the places we would cut and glued our horns similar to visual 2. Then we mounted the landing gears which was relatively straight forward.

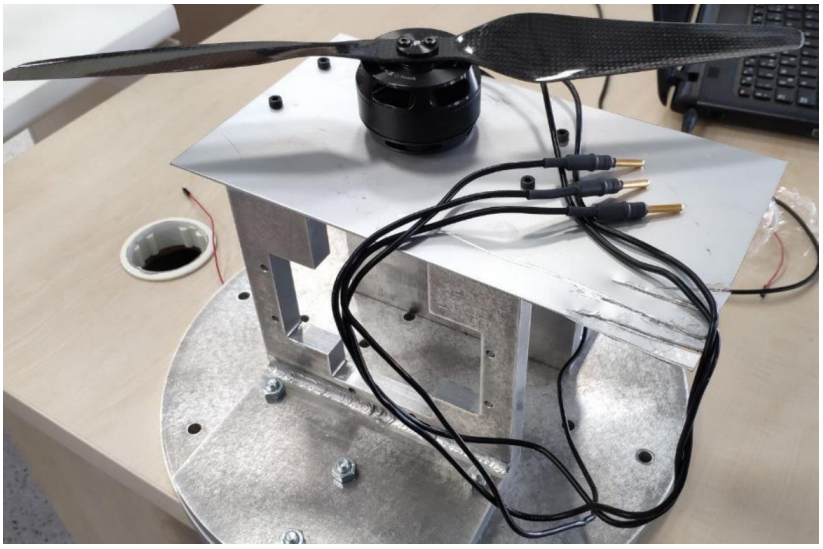


Visual 2: Cutting and gluing horns [4]

We were controlling moving part of the plane by servo motor. However, we had a problem to supplying power to them because Pixhawk can not do on its own. Therefore, we looked for the solution of this and we found out that the ESC (Electronic Speed Control) is able to supply 5V and 3A. This was adequate for relatively weak servo motors. However, we also had another problem, the ESC we have, T-motor T80A, did not have any connectors; it was just naked wire. Thus we had to produce some connectors. Therefore, we used power connectors, which are normally used for SELs just like at visual 3. It was a bit compelling to recrate a connector for personal usage but it worked well.

Visual 3: Produced connector of the ESC

After doing our essential connections, we had problem to control the DC motor. We tried to solve this problem and saw that we configurated our radio channel of the RC transmitter in a wrong way. After doing configuration and calibration, we could easily control our DC motor. This time the problem was observing the DC motor which is T-Motor U7 V2.0 420KV. Because the motor was so fast and powerful, we could not hold the motor while working. Thus, we designed a metal stand, drilled holes of an aluminum sheet and nailed it on a metal structure as seen in visual 4. After mounting it, we connected the propeller and did our tests. To feed the motor the motor we used 6S battery which is 22.2V. Also, to control Pixhawk without connecting it to a PC, we needed an eternal power supply except battery. Thus, we used a small dedicated power supply which is used for Moxa devices and it was 24V/5A.



Visual 4: Metal stand for DC motor

The next problem was again DC motor. To mount it, we had to take it forward because the nose of the plane was so far away for it. The propeller was staying inside and this was unacceptable. Hence, we had to design an attachment for it. We did a prototype with cardboard, measured and drawn it. To model it in 3D, we used Siemens NX which is a vectoral 3D graphics design CAD tool. We learned how to use it and modeled a metal sheet from it. Then, send it to manufacturing. The result was as seen in the visual 5.

Visual 5: Manufactured metal sheet

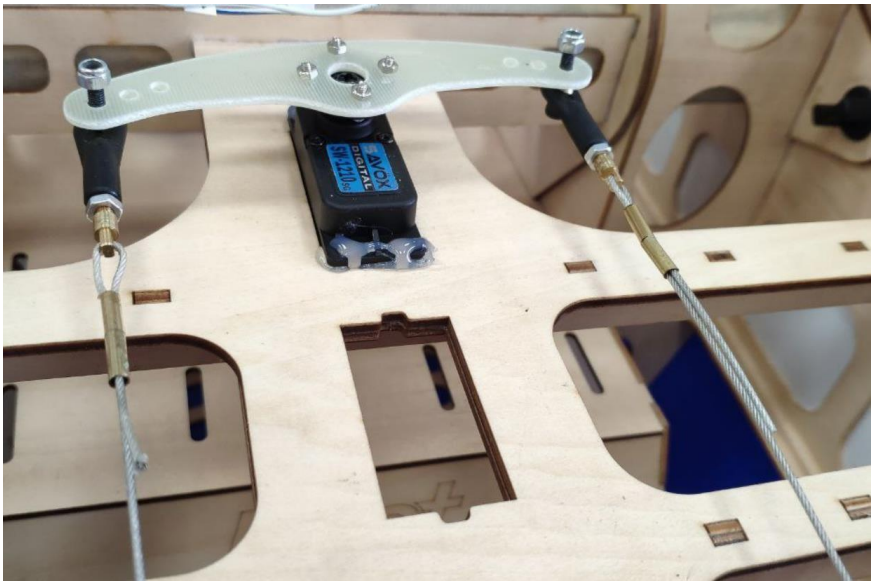
The next day, we got our 7 servo motors which are SW-1210SG and they are really powerful for our light plane. We determined the places we will put our servos. Four of them for ailerons, two of them for elevator and one for rudder. One of the serve motor on left aileron can be seen in visual 6. However, these ones are approximately 1 millimeter wider than standard ones. Thus, we sandpapered the sides. Also, the cable output was not meant for our slots. That is why, we also craved a little chunk for one side of them.

Visual 6: Inner servo motor of left aileron.

We were planning to connect all servos on the wings and elevator to the Pixhawk. However, the length of the built-in cable was just 15cm and we need 2 meters for elevator ones. Also, we needed to splice double servos on each wing because they are supposed to work with same PWM signal. We did not have any kind of those cables. Thus, we measured our needed lengths and produced our cables. Before connecting them, we centralized our servo motor by Arduino Mega and attached the hinges of them. Then, tested our each cables if they work with its own servo and cabled our plane.

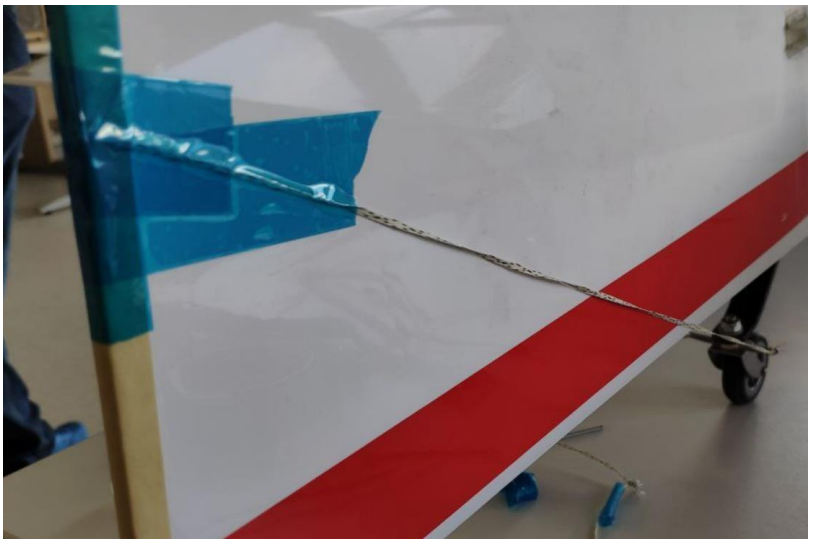
The next day, we connected hinges of the servos with the horns with pushrods. We had to adjust the length of each pushrods to be perfectly fit for each distance. After that, we applied hot glue to every servo motor not to come off easily while the plane is on air. We attached the cable of each elevator to a different pin to control them differently because they are supposed to be behave in reverse manner. Thus, we configured it on Mission Planner to act like that. Also, we were planning each elevator to go up and down in a synchronicity, but the Y splice cable made them reverse because the direction of the servos was reverse. We did not think that would happen. Thus, we produced different cable for every elevator and canceled the splitter. After that, we connected the metal ropes of the rudder to the inner servo which is 2 meters each as seen in visual 7 and visual 8. To control it properly, we adjusted the rope lengths. Finally, we connected everything at the end of the day and saw that right elevator was not working well but the day was over, so we delayed this problem to the next day.

Visual 7: One of the metal rope coming from rudder servo



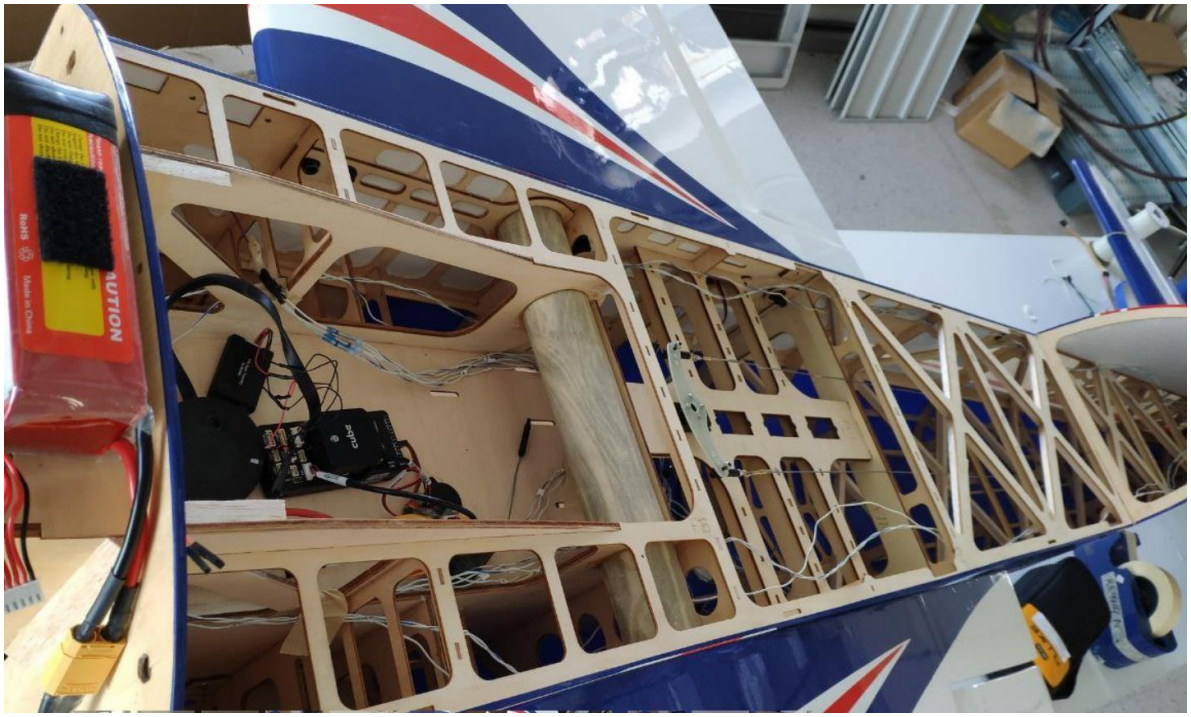
Visual 8: Servo which controls the rudder

At the beginning of the day, we fixed the elevator. We recognized that the cabling was wrong for only right elevator. It did not take much time to solve. There was a little wheel at the back of the plane which directs the plane by turning according to rudder. We were trying to connecting it to rudder by some ways but none of them worked appropriately. That day, we made up a solution with a rope and tape just like visual 9. It does not seem good but it works quiet well. Then, our cabling was so messy as seen in visual 10. Thus, we arranged them in a neat way like in visual 11. Lastly, we tested our ESC and servo motor how much current they draw under load; it was 1.5 ampere.



Visual 9: Rope and tape solution

Visual 10: Messy cabling



Visual 11: Arranged cabling

The next day we had few stuffs to be done. First, we fixed our components: Pixhawk, 6S battery, buzzer, telemetry, antenna, and ESC. We mounted our metal sheet in front of the plane and attached the nose of the plane with screws. The metal sheet and the cutting of the plane was not straight. Thus, it was hard to find the perfect symmetric balance due to the lack of reference point but is was being done thanks to the technicians of TUSAS. However, then we figured out that our propeller was not big enough; it was fifteen inches. Thus, we changed them with seventeen inches one, but now the problem is the connection kits of the propellers were not the same. So, we encountered with a problem to place the propeller. Then, we connected the DC motor to its slot and mounted it also and we tested if it works well; we saw that it creates good amount of thrust.

At the end of my internship, we did our last configurations and recalibrations before doing taxi which is plane movement while they are not flying. After doing every test and check, we send the plane to the test flight to pilot to drive the plane which was mostly designed and produced by me and another intern.

5. CONCLUSION

In these 20 days internship, I dealt with lots of works from different subjects. All of them thought me new things in a profound way because I tried them and saw them in real situations.

First of all, I tried to design an automation system with UDP client. Which made me learn about object orienting programming, C#, and visual studio. These are being commonly used in industry and thanks to this task now I know how to use them.

Secondly, I learned PCB design with Altium. Even though, I was familiar with PCB designing, due to professional and complex structure of Altium, I learned new designing techniques, information and strategies. The experience of designing my own Arduino card gave me the ability to create my own boar completely with just datasheets. Also, I worked on embedded systems and serial communication protocols. That invoked my low-level C knowledge and the protocols made to understand serial data transmission comprehensively.

Thirdly, to see the debugging process of a SEL and testing process widen my vision of what an electronical engineer does in the industry. Although, the concepts were similar to what I encounter as IYTE, real word problem are much more serious and requires attention.

Lastly, the RC plane project was the most educatory one among them because we tried to build a working RC plane almost from just a frame. From the beginning to end, I improved myself about electronics, mechanics, manufacturing, and problem solving. At first, I had no idea, but now I can build my own drone from scratch. The most informative part of this project was that all the time when we accomplish something, we came across new problem to solve and we devised about it very hard to do it at first shot. This is because, almost always we had one chance to solve the problem. Wrong one could just break the mechanism of the plane. That being on the verge psychology made me think more wisely. Now, I also know how to do a project properly step by step and I acquired massive amount of information about aviation and RC planes.

At the end of the internship, I can say that to build a real world project or to solve a real problem, I need to know lots of concepts from lots of areas. Thanks to IYTE, I am confident about electronic systems and also thanks to this training at TUSAS I gained lots of information from computer science, mechanical engineering, aircraft engineering and project management.

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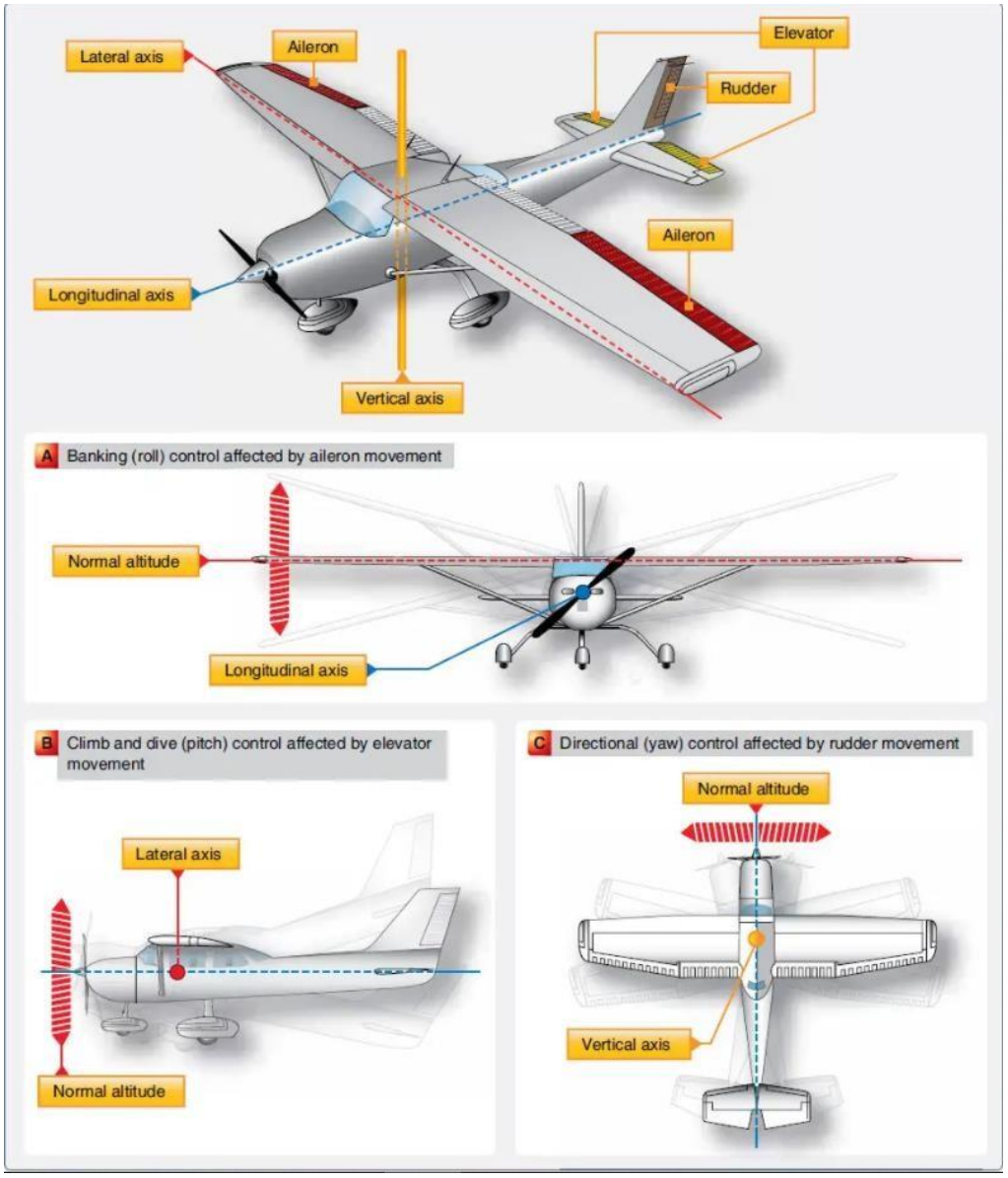
APPENDIX

Essential parts of a plane and functions of them

An aircraft can have lots of parts which have different purposes. However, some of them are more crucial than other. They are ailerons, rudder, and elevator. Ailerons are moving parts which states at the back of the wings. Main purpose of them is to roll the plane. In other words, rotate at longitudinal axis. Rudder posits vertically at the back of the tail, and it helps aircraft to rotate in vertical axis to push or pull the tail in a direction. Lastly, elevator is again at the back of the tail but horizontally. It makes to lift the nose of the plane up or push down or it turn the plane at lateral axis as seen in the visual 12 [5].



Visual 12: Plane parts and axis [6]