REPUBLIC OF TURKIYE
MINISTRY OF NATIONAL EDUCATION
The General Directorate
of Technical and Vocational Education

16th INTERNATIONAL MoNE ROBOT CONTEST

RC AIR PLANE ROBOT CATEGORY COMPETITION RULES

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1. AIM

Unmanned aerial vehicles (UAV) are used nowadays in many fields. Although aerial imaging and mapping are most common applications of drone, there are various applications too such as small size transportation, fire fighting, defence industry, first aid and live saving etc.

Technological revolutions are jumping times which increase level of developments and prosperities of countries. We can give steam engine, invention of car and plane, atomic engery, computer and space Technologies, industrial robots for these jumping moments on the timeline of history. We are working hard to follow these technolohical developments in our country. Nowadays jumping time in technology is UAV technologies. It is seen how UAVs support country’s defence because of successful implementations in military fieds. Because of these reasons, there are a lot of studies and R&D researchs in many countries and products in market.

Aim of this competition which high school and university students can participate in, is to increase the culture of producing and using UAV in our country. While doing so, it is intended to make young people combine technology with entertainment and increase their skills and knowledge. This competition hereby will contribute to the development of the human resources that our country will need in the near future both for the use of UAV (pilot) and for the production of UAV.

2. SCOPE

Types of UAV can be basically divided into 3 groups which are fixed wing, rotary wing and hybrid.

UAVs which have fixed and nonmoving wings are generally called fixed wings. Planes are considered in this group. Staying in air is depends on continously body movements. Thrust are provided by propellers driven by electrical motor or internal combustion engine. Some models have jet engine or electrical fan-jet to reach high rotations. Thrust are applied vertically. Location of propellers in electrical models can be placed at front (a), wings(b) , body (c) and back side (d) as shown in figure-1.

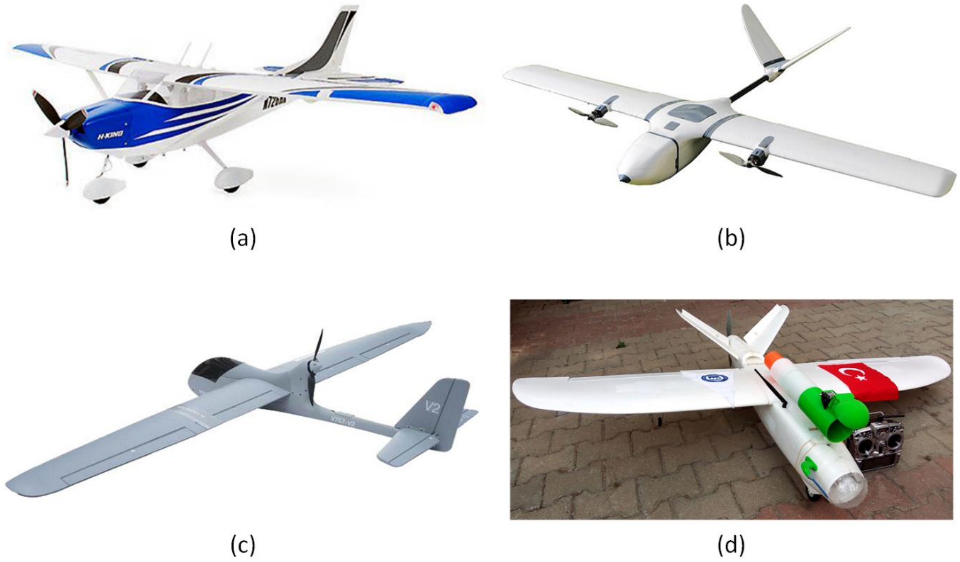

Figure-1: Fixed wings UAV pictures

It should also be noted that each fixed wing design has advantages and disadvantages over the other. A large part of the design and production of fixed-wing UAVs is mechanically oriented. The production costs of these single-engine vehicles are low compared to other UAV models. Although they require large areas for take-off and landing, their flight range is quite high.

UAVs which have propellers driven by motors placed vertically and keep the body at certain altitute are called rotary wings. These vehicles that have one,two,four,six and eight propellers are named respectively helicopter, tricopter, quadcopter (quadrotor) ,hexacopte and octocopter that all are latin words . Because body is fixed while wings are rotating , it is not necessary to move continously as fixed wings . Thus, rotary wings can do take off or landing at smaller area and their movements in air are more controlled because of their structures. Planning (balance of weight,load, battery) and skills in electronics are more important to produce rotary wings. Production cost of rotary wings is higher beacuse of expensive electronics parts such as motor and driver depens on number of propellers. Their flight range is short. Rotary wings UAVs which have different kind of propellers are shown at figure-2.

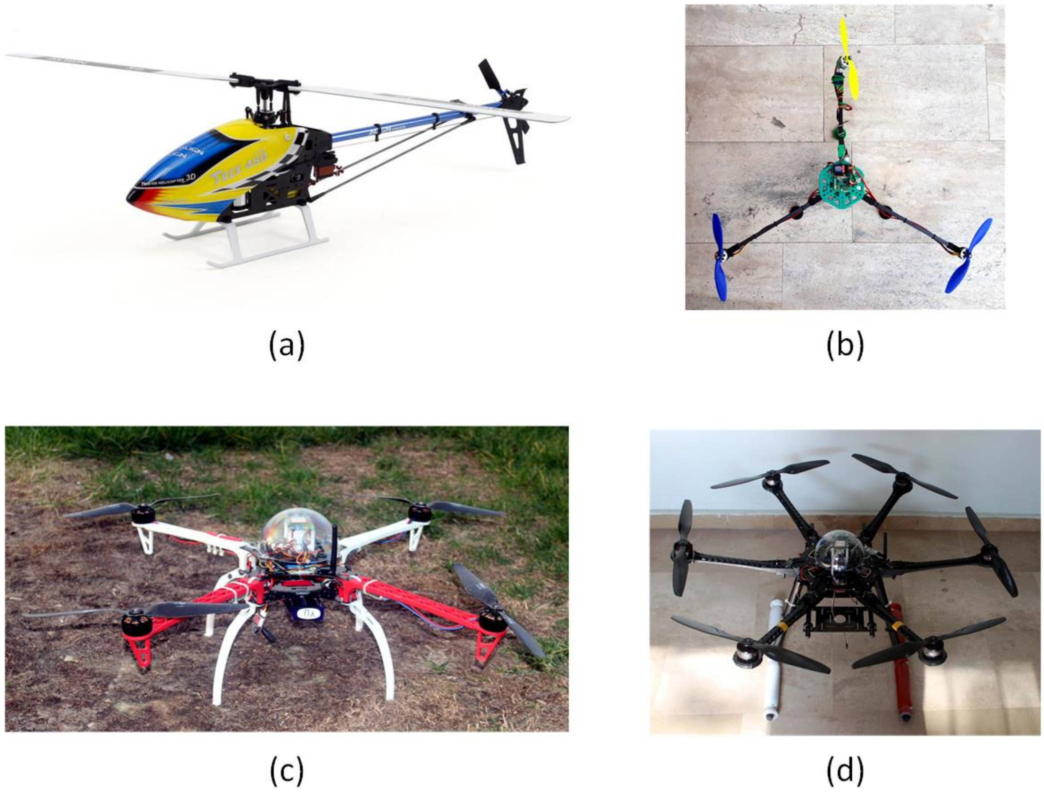

Figure-2. Rotary wings UAV pictures: Helicopter (a),Tricopter (b) , Quadcopter (c) , Hexacopter (d)

Hybrid designs are combination of fixed wing’s advantage which is long range and rotary wing’s advantage which is take-off / landing at small area. This hybrid UAV type, also called VTOL (Vertical Take Off Landing) in English, will be the manned and unmanned aerial vehicle design of the future. In principle, hybrid UAVs have both rotary propeller blades that allow the vehicle to take off and land vertically, and fixed wings attached to the fuselage that allow the vehicle to hover. There are various hybrid designs and studies in this area are still ongoing. Some designs have a propeller only on the vertical axis and the vehicle returns to the horizontal axis after vertical take-off. Some designs have propellers both on the vertical axis, as in rotary-wing UAVs, and on the horizontal axis, as in fixed-wing UAVs. In some designs, the propellers on the vertical axis change direction after take-off and return to the horizontal axis. Different kinds of hybrid UAV designs are shown at figure-3.

Figure 3: Hybrid UAV designs produced by differents companies.

In the Unmanned Aerial Vehicle RC Fixed Wing category, fixed wing UAVs with low production costs, open to development and offering design flexibility were preferred. These UAVs provide a suitable platform for competitors to add their own designs and interpretations and produce them in a unique way. The fixed-wing UAVs shown in Figure 4 were preferred because they are suitable for innovative designs and local production, have low production and material procurement costs, and are open to continuous development.

Figure 4: Sample UAV RC Fixed Wing Images

In the RC Fixed Wing category, a race will be organized in an open area within the scope of the rules detailed below. While determining the rules, the rules of international and national UAV racing leagues (e.g. TEKNOFEST, SESA, etc.) were taken into consideration. In this way, the ground has been prepared for a team competing as an amateur in the Unmanned Aerial Vehicle category to be able to participate professionally in national and international races by obtaining a license in the future.

3. BASIC INFORMATION ABOUT DRONES

The sample components that make up the UAV that will participate in the competition and the technical specifications to be complied with are as follows:

3.1. FLIGHT SIMULATOR SOFTWARE

When the UAV is on the ground, a flight plan is set via the ground station. This flight plan includes information such as which way the aircraft will go, which direction it will turn, and how high it will go. The prepared flight plan is loaded into the flight card and the UAV is made ready for flight and taken into the air. While the UAV is in the air, the autonomous flight card calculates the position, direction, speed and altitude of the UAV by means of the sensors on it and the sensors attached to it, and compares them with the information entered in the flight plan, and flies the UAV according to the information entered in the flight plan. Various applications can be used as ground stations, such as Q ground control or Mission planner. Various calibrations and settings of the UAV are done via ground stations. Flight plan preparation and loading of the flight plan to the card is done via the ground station. Telemetry modules provide communication between the UAV and the ground station. We can see the position of the UAV in the air, the direction and speed of the UAV through the ground station thanks to the gps module to be installed externally on the card. There are various autonomous flight modes, such as FBWA and Auto modes. FBWA mode allows the UAV to fly in an assisted manner, the flight card restricts the turns that the aircraft can make. Auto mode flies the UAV according to the information entered in the flight plan. The UAV flies completely autonomously, turns and accelerates autonomously.

3.2. BODY

The body of an Unmanned Aerial Vehicle (UAV) is usually made of various materials. These materials include FOAM (Styrofoam), BALSA, COMPOSITE (fiberglass), CARBON or PLA (with 3D printers). Which material is preferred should be determined depending on the specific characteristics and intended use of the designed UAV.

Figure 5: Some UAV made from different materials

- **FOAM (Styrofoam Foam):** It is a light, cheap and easy to process material. It enables the UAV to be produced quickly and economically. However, its durability is lower than other materials, so it is more suitable for light and low-speed flights only.

- **BALSA:** It is a light, flexible and durable material. It can be well machined and easily shaped. However, BALSA material requires mostly manual labor and production costs can be higher than other materials.

- **COMPOSITE (Fiberglass):** It is a high strength and lightweight material. It is frequently used in UAV bodies due to its durability and aerodynamic properties. However, composite material is more difficult to process and its production cost is higher than others.

- **CARBON:** It is an extremely lightweight and high-strength material. Therefore, it is preferred for fast and high-performance UAVs. However, carbon material is quite expensive and difficult to process

- **PLA (with 3D Printers):** Can be easily produced with 3D printers and provides design flexibility. PLA material is lightweight and durable, but is not recommended for high-speed and high-altitude flights.

Which material is preferred may vary depending on the UAV's design requirements, performance expectations, cost factors and usage scenarios. For example, FOAM or PLA may be preferred if lightness and economy are important while CARBON or COMPOSITE materials may be more suitable if durability and high performance are needed.

3.3 MOTOR

The number of brushless motors or fan motors to be used in the UAV is limited to 2, and there are no size, KV rotation speed and operating voltage limitations on the motors to be used. Teams can choose any motor that meets their needs. This flexibility gives UAV designers the freedom to choose the most suitable motor from a variety of motor options. In this way, the engine that best suits the design requirements and performance objectives can be selected and the efficiency, reliability and performance of the UAV can be improved. Factors to consider when selecting an engine include flight expectations, payloads to be carried, speed requirements and energy efficiency.

Figure 6 : Sample UAV motors

3.4. MOTOR DRIVER (ESC)

Motor drives (electronic speed controllers) that can drive 10-80A current with the power to support the current of the motor to be used in the UAV can be preferred. These drives receive the RC control signal through an optical isolator (optocoupler) so that interference from the supply voltage does not interfere with the operation of the drive and maintains the motor rotation speed more stable.

Figure 7 : Sample UAV motor drivers

3.5 FLIGHT CONTROLLER

Off-the-shelf controllers with 8-bit or 32-bit based processors (compatible with PIXHAWK, APM, CUAV, etc.) can be used, as well as personal design flight controllers using MEMs sensors (3-axis gyro, 3-axis accelerometer, 3-axis magnetic compass).

Figure 8 : Sample UAV autonomous flight controllers

3.6 POWER MODULE AND POWER SUPPLY

The UAV provides the power it needs from Li-PO batteries that provide high discharge current. In UAVs without a flight controller, equipment other than the engine is provided from the signal output of the ESC. In UAVs with a flight controller, it is necessary to use a 'PIXHAWK POWER MODULE' or a similar power reduction module. This module takes the power required for the engine from the battery and transfers it directly to the engine without reducing it at all, while reducing the voltage and amperage to other equipment.

Figure 9: LiPo battery and power distribution module

3.7. REMOTE CONTROL

To avoid interference with other UAVs, 2.4GHz frequency hopping transceiver modules with at least 6 channels should be used. In order for the remote control to work in harmony with the training simulator, it is recommended to choose among professional models with a trainer connection socket on the back. Thanks to a single professional remote control to be purchased, different vehicles can be controlled with a single remote control by purchasing an additional RC receiver in the future, professional remote controls can store the settings of at least 16 different vehicles separately, for these reasons, the remote control is a basic device (fixture) and it is recommended to prefer good brand models.

Figure 10: RC remote control types

3.8 FLYING CAMERA, SCREEN, FIRST PERSON VIEW (FPV):

First Person View is a video transmit systems which let the pilot feels as he/she was on board. It makes controlling air vehicle easy. FPV set consists of a camera transmitter, 7/21 receiver,antenna set and LDC screen or goggle. You can buy each equipments seperately. There are some models which are combination of camera and transmitter or screen/goggle and receiver on the market. In particular, when choosing a screen or glasses with a receiver, models with two separate receivers (diversity) should be preferred in order to get a clear image. When choosing a camera, it is recommended to choose a model with a high quality image sensor, low image resolution and minimum illumination value, and if possible, a transmitter and the ability to record simultaneously to an SD card. FPV is not compulsory in the competition. If you decided to use,you should use the models that can broadcast in 40 channels, using only the band 5.8GHz. and support racing bands (Band R: 5658, 5695, 5732, 5769, 5806, 5843, 5880, 5917) to prevent conflict with other drones.

Figure 11:FPV system

3.9 OSD (ON SCREEN DISPLAY) MODULE

It is a module to show data such as battery voltage, current, slope of air vehicle etc. that measured by sensors and flight controller on the view of camera. So user can see all parameters real-time on the screen. It is not compulsory in the competition.

Figure 12:OSD modules

3.10 PROPELLER

It should has proper size which motor can drive and proper lenght which prevent collision with others wings. While selecting motor, there are some informations about which size of propellers efficiently work with it in its datasheet.

Figure 13: sample propellers

3.11 Battery Alarm (Lipo Alarm)

It is a small electronic module which shows battery cell voltage and warns with voice alarm when battery voltage is lower than 3,7V

Figure 14: Sample LiPo battery alarm.

3.12 LiPo Safe Bag

Fireproof safe bag should be used to prevent any explosion and all batteries should be kept and charged in this bag.

Figure 15: Sample safe bag.

3.14 Mechanic assembly

Special liquid solutions (locktite etc) or fiber nuts must be used to prevent loosening of nuts,bolts and screws during the flight. Before the competition, your drone will be checked.

Electric-Electronic Assembly

Heat shrink tube must be used for connection of cables and connectors, never seen any of electric wire without isolated. When drone drops down or hit to somewhere , cables which are not fixed to drone’s body or not isolated may cause a fire. Because of this reason, fixing cables/wires by using heat shrink tubes and cable ties will be examined during techical check before the competition. The team that does not comply with even one of these rules cannot compete.

4. TASK

Task is to make 4 laps in the air and leave 2 balls on indicated points.

4.1. EXECUTION OF THE TASK

The teams will make a total of 4 laps in the air after taking off to perform the mission. The mission mechanism of the UAVs must be unique, but the ball to be dropped by all teams is the same. The UAV will drop the 1st ball in the area indicated in blue on the runway in the 2nd round, and the 2nd ball in the area indicated in red on the runway in the 3rd round.

- The UAV must take one more turn after dropping its 2nd ball in turn 3 and then land. In case of passing, they will lose the point.

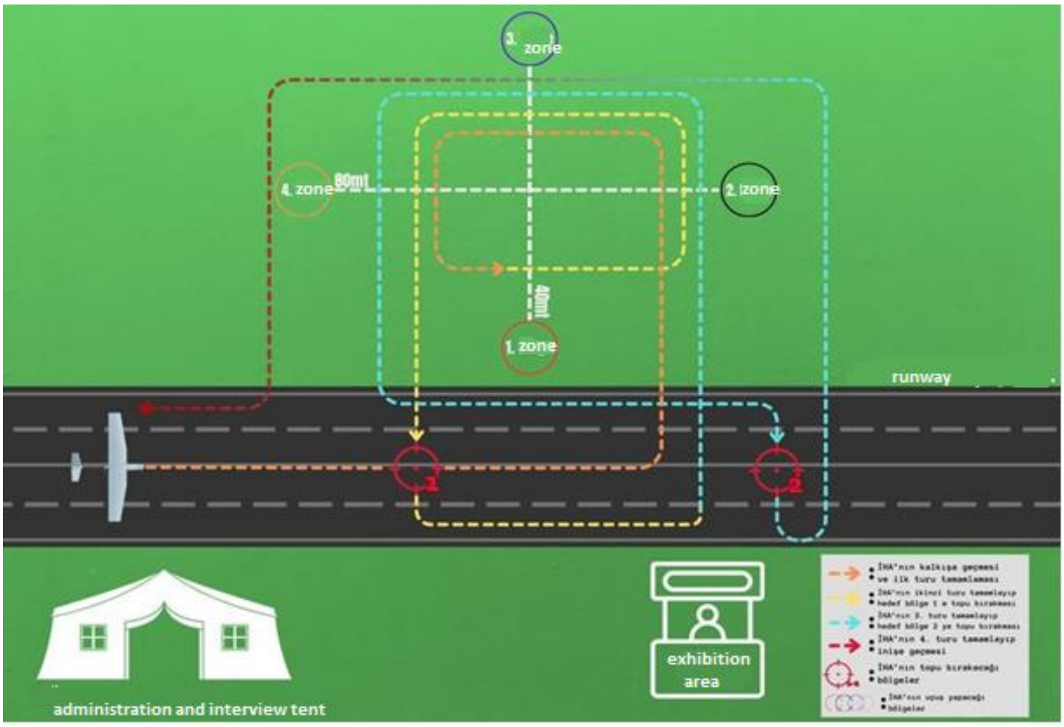

Figure 16: Task flow

OBJECTIVES

Know-How: The engineering skill, quality-oriented approach, functionality, effort and seriousness that the team demonstrates during the design process are indicators of know-how. It includes the technical skills and expertise related to the design, production and performance of the UAV.

Experience: The experience gained in the competition helps the team to be more successful in future projects.

Opportunity: Participation in competitions provides teams with the opportunity to establish collaborations with each other and with the private sector. Teams can access technology transfer and collaboration opportunities by establishing industrial partnerships through competitions.

Motivation: Participation in the competition and the awards received provide motivation to the teams and create a desire to participate in various competitions.

Team Awareness: Interdisciplinary work involves sustainability, social responsibility and ethics. These gains include the ability to succeed together, ensuring sustainability, process discipline, honesty, openness and transparency, and benevolence

5.1. EXPECTED FEATURES OF DEVELOPED UAV

Domestic parts: The developed UAV is expected to be produced with domestic capabilities. (For example, the use of indigenous hardware, software or both.)

- The design of the UAV must be indigenous.
- Production of the UAV using domestic capabilities.

Innovation: An innovative UAV is one that includes new hardware, software, auxiliary equipment or design. For example;

Using a different engine or adapting the type of engine used in another field to the UAV.

Feeding the UAV through a different power source.

Using or designing a different flight control board.

Designing a unique airframe and or mission mechanism.

Affordability: The fact that the developed UAV can perform its mission with less cost is an indicator of economy, but the efficiency and capabilities of the aircraft should not be limited while ensuring economy.

Ease Production: Ease of production is an indicator of the effectiveness and sustainability of the developed UAV in the production process.

The design and production of the UAV should be as simple and easy to use as possible.

Assembly time should be simple and efficient.

Parts should be easily accessible and easily replaceable.

Stability: The developed UAV is expected to perform a stable flight during take-off, during the mission and during landing.

Capability: The capability criterion is evaluated according to the following aspects;

The UAV must be able to effectively fulfill the specified tasks.

The UAV's ability to successfully complete missions with a specified degree of difficulty is an indication of its capability.

The UAV's speed, maneuverability, payload capacity, precision, accuracy and other performance characteristics determine its overall capability.

The UAV's ability to fulfill the specified tasks quickly, reliably and effectively indicates its high capability.

Autonomy: The UAV's autonomous flight capability scores higher than manual flights with remote control, and this criterion is often a decisive factor in the successful completion of the mission.

The reliability and accuracy of autonomous flight systems are critical to the UAV's successful mission accomplishment. The ability of the UAV to follow the specified targets and routes, to change course when necessary during the mission and to make effective decisions is an indicator of autonomy capability

Mission Accomplishment: Even if the UAV has a high capability, it is expected to successfully complete the prescribed mission. The UAV's completion of the specified missions in accordance with the targeted success criteria is an indicator of mission success.

*****The developed UAV is expected to include all the above-mentioned aspects. Otherwise, teams will receive missing points in the scoring.**

6. GENERAL RULES

The competition rules are as follows:

6.1. Each team must strictly follow the rules set by the race committee and the referee's warnings. Teams found to have violated the rules will be excluded from the competition.

6.2. The race committee may have the race repeated as it deems appropriate.

6.3. Teams can make all their appeals according to the rules of the general "Application Guide".

6.4. Each team may have a maximum of two students, one pilot and one observer (co-pilot).

6.5. UAVs cannot be controlled by watching through FPV goggles or LCD screen.

6.6. The observer will carry out the tasks of placing the UAV at the starting point with the referee's instructions, taking coordinates from the competition area, visually following the UAV by standing next to the pilot during the competition and providing all kinds of support by giving voice commands (co-pilot) when necessary.

6.8. The first 30 teams with the highest score from the video submission are invited to the competition.

6.9. On the first day of the competition, all teams are scored by the technical committee according to section 5.1 of the specifications. This scoring constitutes 50% of the team's score in the semi-final and final. The team that gets full points from the technical committee gets 50 points. The points received at this stage will also be used in the final stage.

6.10. The score to be obtained from the flight and flight task will be added to the score obtained from the technical committee to determine the 6 teams that will remain in the final stage. A team can get 50 points from technical control, 20 points from flight, 10 points from autonomous flight and 20 points from mission.

6.11. Each of the 30 teams has the right to fly 2 times in the mission area. The highest score from the 2 flights is used for the ranking of the final stage.

6.12. Each team that qualifies for the final stage gets 2 more flights. With the sum of the highest score obtained from the flights and the score given by the Technical Committee, the award-winning teams of the final stage are announced.

6.13. The flight order in the competitions will be determined by lot.

6.14. Before each flight, the UAV of the teams will be technically checked to determine whether it is suitable for flight. Teams that are not fit for flight have the right to pass 1 time, teams that are still not fit for flight after using this right are considered to have given up their flight rights respectively. Since each team has 2 flight rights, teams deemed unfit for flight 3 times will be disqualified.

6.15. Teams invited to the competition area according to the draw order must take their places in the technical control section within 15 minutes. Each team has 1 flight postponement right. After the postponement, the team's flight order is assigned to the end of the list.

6.16. Teams that use their right to postpone the flight and do not show up for the technical control even though it is their turn will be disqualified from the competition.

6.17. Teams that pass the technical control are given 15 minutes to start their flight. Teams that do not start their flight at the end of the time limit will be penalized 1 point for every 2 minutes of delay. Teams whose delay time exceeds 30 minutes will lose their flight rights. (It should be noted that each team has 2 flight rights).

6.18. Flight and task points are awarded according to the total duration of the flight and the fulfillment of the tasks.

6.19. Autonomous or semi-autonomous flight will bring 10 additional points for the teams.

6.20. In the competition that will be realized out of 100 points; the flight has 20 points and the task has 20 points.
6.21. In order for the flight to be considered complete, the UAV must make an undamaged landing after a stable flight without leaving the designated area.
6.22. UAVs that go out of the area during the flight are detected by the markers waiting at the borders of the flight area. For each violation after the first violation, 1 point will be deducted. Teams with 6 warnings will be asked to land their UAVs and their flight rights will be terminated.
6.23. In order for the mission to be considered complete, the balls released from the mission mechanism are expected to hit the predetermined targets marked in the competition area before the flight. The first point of contact of the balls on the ground is considered as hitting the target. The officials who are near the target determine the hit with the flags in their hands and notify the scoring committee. A ball falling within 1 square meter of the target is considered to have hit the target. Each hit of the target is worth 10 points. Teams that fail to hit the target do not receive mission points.

7. TECHNICAL SPECIFICATION OF UNMANNED AREA VEHICLES

7.1. The wingspan of the Unmanned Aerial Vehicle that can participate in the competition must have a maximum wingspan of 1500 mm and an end-to-end length of 1500 mm. In the technical control to be carried out before the competition, it is checked whether the UAV complies with the specified dimensions.
7.2. The weight of the UAV must be maximum 5 kg including the battery and all other equipment. The UAV will be weighed during the pre-competition technical controls.
7.3. Teams that fail to pass the technical controls for various reasons may complete their deficiencies during the qualifying rounds and re-enter the queue to compete. Teams that do not pass the technical controls will not be allowed to compete after the start of the second stage races is announced.
7.4. The propeller diameter that can be used in UAVs can be selected according to the needs of the UAV, there are no restrictions
7.5. UAV bodies must be individually designed. UAVs and teams that are found to be completely ready-made will be excluded from the competition.
7.6. Each team will carry out the mechanical and electrical-electronic assembly of the UAV itself. In addition, the installation and settings of the flight controller software will also be done by the team itself. Each team will fill in the technical report template in the form of a Word file to be downloaded from the competition website and convert it into PDF format after having it approved by their advisors and school administrators. Teams will upload the technical report in PDF format to the relevant section of the

competition website by the specified date. Teams that do not upload the report to the system on time will not be allowed to compete. Technical reports will not be accepted in printed form or by hand with a USB stick.
7.7. Teams must keep their LiPo batteries in a fireproof battery bag (LiPo safe bag). Teams without a fireproof battery bag will not be registered.

8.SAFETY PRECAUTIONS

8.1. A switch or button on the controller will be set to make the UAV active/passive (arm/disarm). This feature will be checked before the competition, and the UAV and its team will be excluded from the competition if this feature does not work.
8.2. When the control connection with the UAV is lost, the vehicle will land automatically (radio failsafe). The presence of this feature will be checked by the referees before the competition. UAVs without this feature will be excluded from the competition.
8.3. When the UAV goes beyond the boundaries of the competition area or the field of view, the UAV will be disarmed by the pilot when the referee gives instructions.
8.4. UAVs are equipped with LiPo or derivative batteries capable of delivering high current. These batteries are chemically unstable and can easily explode. Each team must have a sufficient number and size of fireproof battery bags (LiPo safe bags) to carry their batteries.
8.5. The plugs on the UAV where LiPo or derivative batteries are inserted shall be placed in such a way that they can be removed by the referee when necessary. This will ensure that the battery can be easily removed from the UAV in case of emergency. This should be taken into consideration in the design and assembly of the UAV.
8.6. Teams will be allocated a special test area within the competition area to test their UAVs. Referees in this test area will organize the test flights. Teams found flying outside the test area (corridor, garden, etc.) will be warned and the team will be given 2 penalty points for each warning. If necessary, at the discretion of the referees, the UAV and its team will be excluded from the competition.

9. GENERAL RULES OF THE COMPETITION

- The flight order of the teams is determined by lot. It is announced before the competition. Teams cannot object to the grouping and flight order.
- It is the responsibility of the team to provide all kinds of materials and equipment to be used for the mission to be performed.
- Teams consist of 2 students and 1 advisor teacher.

- All registered teams must undergo technical control before the flight.
- Since it is planned to complete the scoring in areas such as Technical Control, Design Ergonomics, Innovation, Localization, etc. to be held after registration on the first day of the competitions, teams must have completed all preparations in advance.
- In the technical control, the UAV is checked by experts in the field in terms of weight components, structural strength, mechanical movement ability and safety of electronic equipment.
- Teams that are successful in the technical control are prohibited from disassembling or replacing parts of the UAV before the flight in terms of flight safety.
- It is the teams' responsibility to follow the flight sequence. Reasons of 'not being ready' or 'not passing the technical control' are not accepted,
- Teams taken to the "Queue Waiting Tents" wait in readiness by attaching their propellers after the final checks of their vehicles. It is at the discretion of the relevant referee to consider the readiness of the teams in the queue waiting tent instead of the ranking when calling them to the track. No objection is accepted.
- When there is a possibility that the flights may not be completed due to weather conditions or other reasons that may occur during the competitions, another team may prepare in a part of the area by taking necessary security measures. Those who are in a position to disturb the other team due to reasons such as signal interference or visual pollution from the teams in the queue must notify the coordinator on the first day of the competitions. Otherwise, no excuse will be accepted.
- In order to prevent loss of time, the teams whose turn is approaching during non-flight hours should make preparations such as taking coordinates from the area and placing/forming the auxiliary platforms needed. Announcements can be made to announce the times when preparatory work can be done. It is the teams' responsibility to follow the announcements.
- It is essential for teams to perform their flights within the specified area. It is forbidden to go outside the specified area for security reasons.
- If the UAV crosses into the buffer zone, the referee may request the flight to be stopped if he/she feels a danger for safety. In this case, the vehicle will be switched to FAIL-SAFE mode and asked to land safely.

- The maximum flight altitude in competitions is 120 meters. However, for the sake of safety and accurate observation, it is recommended that flights do not exceed this height.
- Teams cannot fly with harmful biological, chemical, etc. substances that may endanger human health and safety in the competition areas.

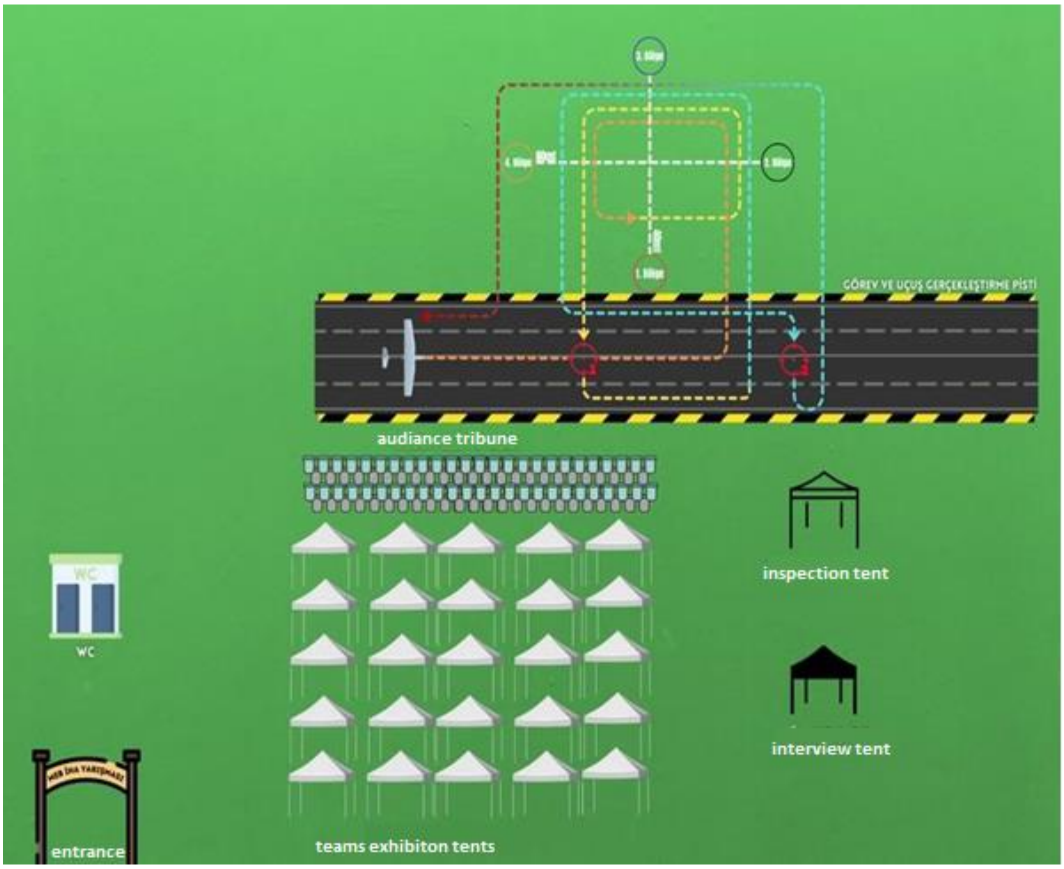

Figure 17: Activity Map