REPUBLIC OF TURKEY

MINISTRY OF NATIONAL EDUCATION

The General Directorate of Technical and Vocational Education

13. INTERNATIONAL MEB ROBOT CONTEST

UNMANNED AERIAL VEHICLES (UAV) (MINI DRONE)

CATEGORY RULES

2019 – SAMSUN

MINI DRONE CATEGORY RULES

1. AIM

Unmanned aerial vehicles (UAV) commonly known as Drone are used nowadays in many fields. Although aerial imaging and mapping are most common applications of drone ,there are various applications too such as transportation, fire fighting , 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 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.

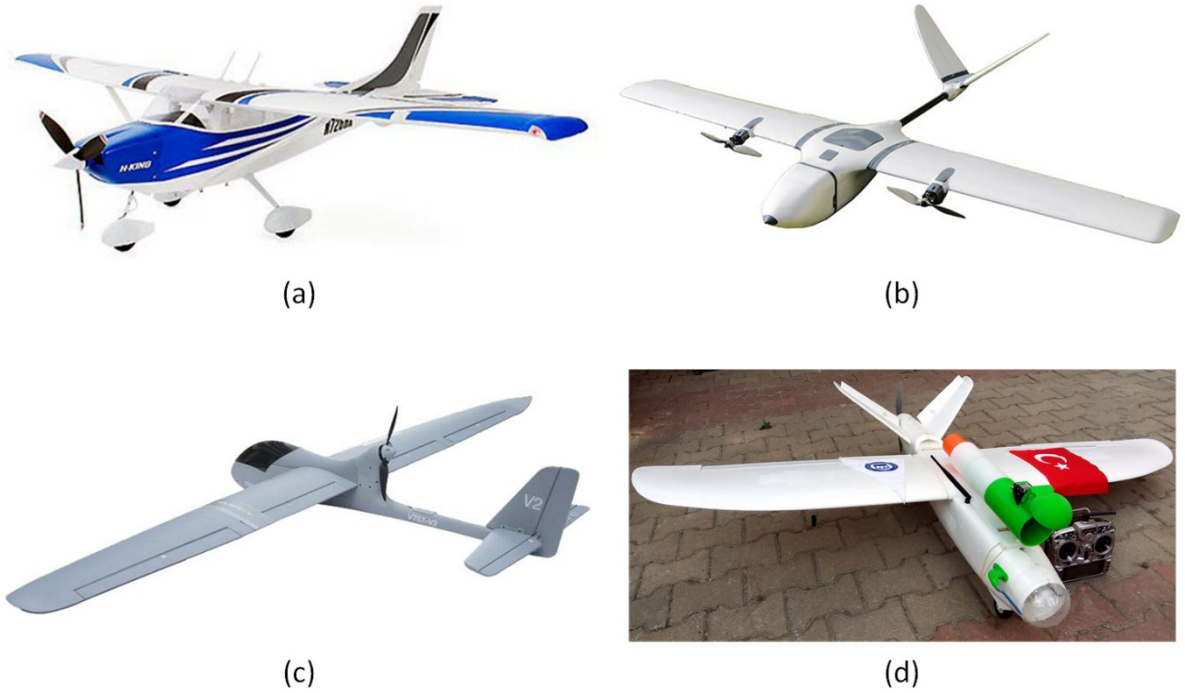


Figure-1: Fixed wings UAV pictures

Most of production and design process of fixed wings are mechanical works. Production cost of these vehicles which has usually single motor is relatively low. Their flight range is quite long, besides wide area is necessary to make them fly , take off and land.

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.

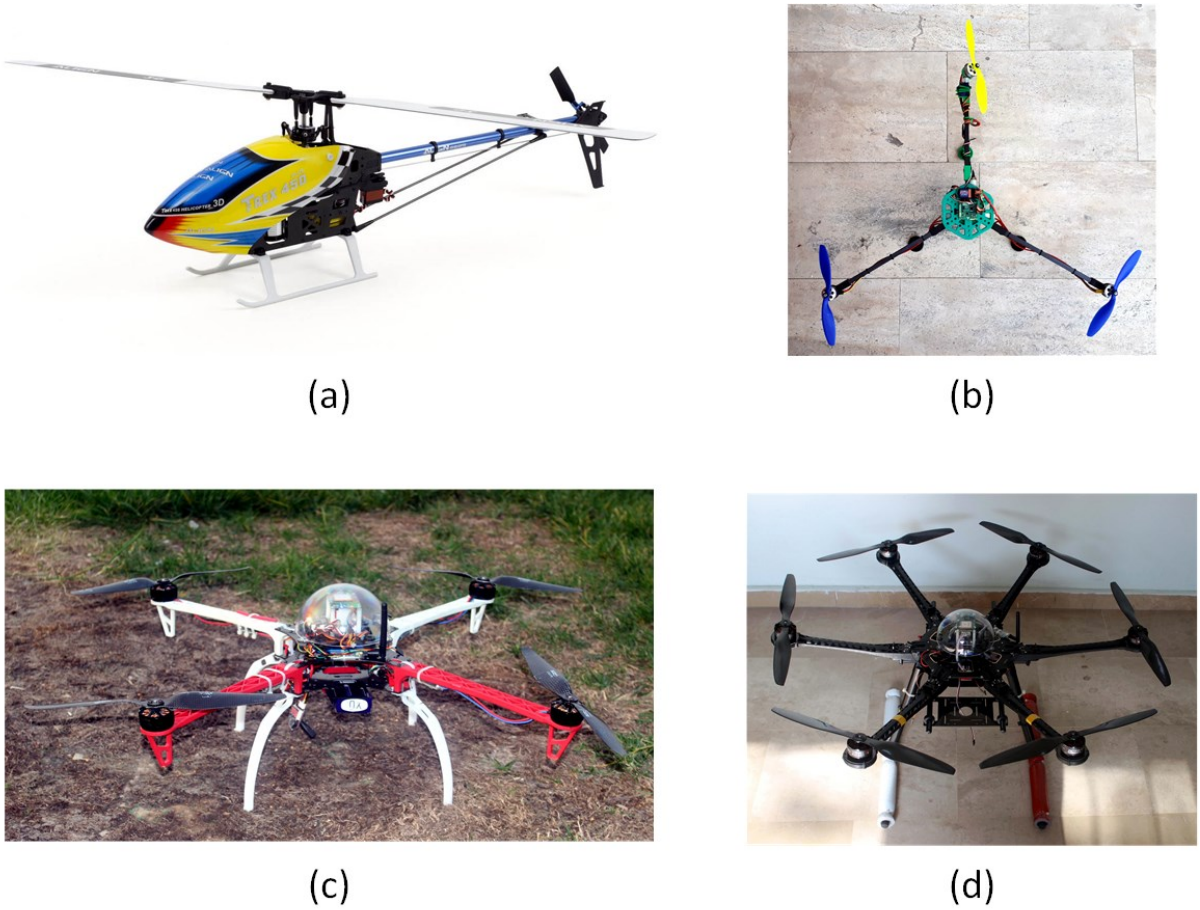


Figure-2. Rotary wings UAV pictures: Helicopter (a),Tricopter (b) , Quadcopter (c) , Hexacopter (d)

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. Therefore, it has both rotary wings and fixed wings. There are various hybrid designs and studies in this area are still ongoing. Different kinds of hybrid UAV designs are shown at figure-3.

Figure 3: Hybrid UAV designs produced by differents companies.

In this competition , Mini UAV (racer drone) which is kind of rotary wings either well control in air or need small area to take-off/landing will be raced. Mini UAV seen as a sample at figure 4 is preferred because they have small bodies, low cost maintenance and low possibilites to damage at moment of accidence. This competition will be task-based race given details at the followings as a category of INTERNATIONAL MEB ROBOT CONTEST.

Figure 4: Sample mini UAV picture (UAV MARMARA Yelkovan)

3. MINI DRONE SPECIFICATIONS

Flight Simulator Software: Beginners may have idea that fly drone right after buying. Even they prefer cheaper one to have minimum loss in case of accident. However, if there is no any flying experience, first flight big probably ends with an accident and drone becomes unusable. It causes the loss of passion about flying drone which is more important than financial loss.

The most important point for someone who just start flying drone is to control drone by standing a certain place. We can give an example for this issue : A driver sit inside the vehicle so driver's brain directly affected from vehicle's movements. When driver turn the steering right, vehicle turn right. There is no sensing error between driver's brain and physical movement. When using remote controlled toy car, driver is outside of car and stand on fixed place. While the car is moving away from driver, car turns right by right command of driver using remote controller. But, while the car is coming to driver , it happens vice versa. In this case, car turns left by right command of driver using remote controller. Sensing left/right of driver and car's movement always changes depens on car's direction. Drone pilots have same problem. Therefore , orientation trainings are required for beginners. Using simulator is the best and cheapest way to do this.

Professional simulator softwares provides USB dongle to connect PC. UAVs remote controller can connect PC via this dongle and it's cables.(There is a connection socket located back of remote

controller, usually this socket is 3,5mm but it may change according to brands). You can connect simulator software by this way. Thus, pilot can train on remote controller and get experience for its reactions. Pilot can increase his/her skills. Therefore , We strongly advice that pilots who will particate to this competition get training in the simulator. They can prefer flight simulator softwares that provide cables and dongle. (clue: keywords to search in internet “rc flight simulator”, “6 in 1 flight simulator”, “12 in 1 flight simulator”, “16 in 1 flight simulator”, “20 in 1 flight simulator”, “PhoenixRC”)

Figure5. Sample software for flight simulator and it’s equipments

3.1. Frame: Commercial bodies which support 3 or 4 motors and made by fiber/ fiber-carbon (220, 250 series, etc.) or special designed bodies made by using 3D printer ,FR4 (printed board) or wooden may be used.(clue: keywords to search in internet “quad frame 250”, “racer frame”, “tricopter racer frame”)

Figure 6. Sample bodies for drone.

3.2. Motor: Brushless DC motors which have 2.000-4.000KV rotation speeds, 11-22 series motor diameters, voltage 2-4S (7,4-14,8V) can be used. (clue: keywords to search in internet “brushless dc 18”, “brushless dc 22”, “brushless dc racer”, “2400KV”, “brushless 1104”, “brushless 1304”, “brushless 1804”, “brushless 1808”, “brushless 2205” , “brushless 2206”)

Figure 7. Sample motors.

3.3. Motor Driver (ESC): Motor drivers (electronic speed controller) which has voltage 2-4S(7,4-14,8V) and able to drive drone's motors current 10-30A and equipped with optocoupler to provide stable speed of motor, and prevent electronic noise caused by suppy voltage can be used. (clue: keywords to search in internet "30A esc opto", "blheli esc", "simon k esc", "micro esc")

Figure 8. Drone motor drivers.

3.4. Flight Controller: 8 bit or 32 bit microcontrollers (compatible with CC3D, PIXRACER, APM, NAZE, Cirus etc.) or special designed flight controllers using MEMs sensors (3 axis gyro, 3 axis accelaretion sensor, 3 axis magnetic compass) maybe used. (clue: keywords to search in internet "pixracer", "x-racer", "naze32", "SP F3", "apm", "SP F4")

Figure 9. sample controllers.

3.5. Power Distribution Board-PDB , Battery Eliminator Circuit-BEC

PDB distributes the current supplied from battery to the drivers. BEC decreases battery voltage (10-14V) and supplies voltage for flight controller and other hardware. Some models have two BECs , one is 5V for flight controller and peripheral circuits , one is 12V for FPV camera system. In addition, there are some models which have sensor (low value resistor) to measure battery current. Some models which are combination of both PDB and BEC are avaliable in the market. Also there are some models which are combination of PDB,BEC and OSD (On Screen display) explained in section-3

(clue: keywords to search in internet "pdb", "bec", "pdb bec" "pdc bec 2 in 1", "pdc bec osd", "pdc bec osd 3 in 1", " current sensor")

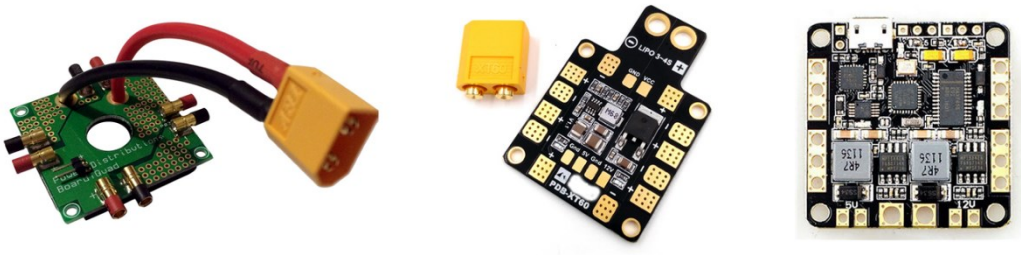


Figure 10: Sample power distributor,power supply pictures

3.6. **Remote control:** To prevent conflict with other drones, transceivers that have minimum 6 channels , 2.4GHz. should be used. It is adviced that you choose professional models which can work with simulator properly. By purchasing one professional remote control, you can control different kinds of devices with only one single remote control just buying extra RC receiver. Remote control is main device of drone systems , so it is strongly adviced that you choose good brands which can control minimum 16 devices.

Figure 11: sample remote controls

3.7. **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 drone easy. FPV set consists of a camera, transmitter, receiver,antenna 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. You should select camera which has receiver, high quality image sensor, low illumination value and SD memory 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. (clue: keywords to search in internet “fpv lcd”, “fpv goggle”, “diversity lcd”, “diversity goggle”,”fpv camera”)

Figure 12:Sample flying camera pictures

Figure 13: Sample headsets, goggle and lcd screens

3.8. On Screen Display - OSD : It is a module to show parameters such as battery voltage, slope of drone etc. on the view of camera like a volume bar appearing on TV screen when you increase TV volume. So user can see all parameters real-time on the screen. It is not compulsory in the competition. (clue: keywords to search in internet “mini osd”, “minim osd”)

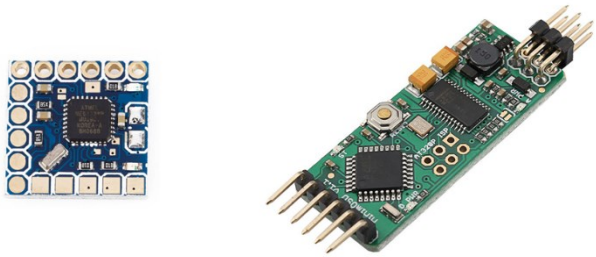


Figure 14:Sample OSD modules pictures

3.9. 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. By helping this informations, two or three blade props that have 4-5 inches screw pitch(linear distance when one revolution of prop)(for example: when 6045 written on prop, it means that prop lenght is 6 inch and screw pitch is 4,5inches), 5-7 inches radious can be selected. You shoud buy twin props , one has direction of CW, the other has direction of CCW. Props are most easly fragile equipment, so it is better to buy more. In addition, even you change them with new props , first you should adjust balance just like car’s wheels to prevent shaking. This balance adjusting contributes positively to both battery consumption and motor bearings life.

(clue: keywords to search in internet “5x4.5 prop”, “6045 prop”, “7038 prop” “6045 prop”, “5045 3 blade”)

Figure 15. sample propeller sets.

3.10. **Battery:** It may be Lityum polimer (LiPo), voltage 2-4S (7,4-14,8V), current capacity 45C but no limit in capacity(mAH). You can use battery which has capacity between 1.000mAH and 2.200mAH

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 (clue: keywords to search in internet “lipo alarm”, “mini lipo alarm”, “battery alarm”)

Figure 16. 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. (clue: keywords to search in internet “fireproof lipo”, “lipo safe bag”, “lipo guard”)

Figure 10. Sample safe bag.

3.13. **Drone Size:** Distance between diagonal motor axes must be between 180-260mm. Drone must fit inside a 230mm x 230mm square without its propellers. Before the competition, your drone will be checked.

3.14. **Flight weight:** Weight of drone must be between 450 and 1000gr. Include battery and other equipments. Before the competition, your drone will be checked.

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

3.16. **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. Drones which have cables not fixed will not be allowed to participate competition. This is a strike rule.

Figure 1. Image showing that judge was fighting with fire because drone crashed in flight zone.

4. SAFETY PRECAUTIONS

4.1. Safety measures for drones which will race in this competition are as the follows. Teams which violate safety rules will be disqualified.

4.2. Flying zone is a covered area which surrounded with safety net.

Figure 19 A picture from 12.MEB robot competition

4.3. A switch or button on the remote controller must be set for throttle cut. Before the competition, this button will be checked. If there is no button, team will not be allowed to compete.

4.4. UAVs can run by using LiPo or other types of batteries which have high current capacity. These batteries may explode easly because of their unstable chemical structures. It is compulsory that every team keep their batteries in fireproof safety bags. During the competition, if any team detected while keeping or charging the batteries without safety bag, it will be warned and penalty point will be given to this team.

4.5. Plugs to connect LiPo or other batteries should be placed on drone so that judge can easily plug in or out. Therefore batteries can be dismounted easily in case of emergency situation. It should be considered while designing drones.

4.6. A practice place will be reserved for teams to able to test their drones. A judge will stay in this practice area. If any team detected while practicing in any other places (such as halls, outside of venue etc.) , it will be warned and penalty point will be given to this team.

5. RULES

This rules is subject to change by the competition committee. (Any updates will be published in official web site. Please check it.)

5.1. Teams have to obey the rules and order of judges. Otherwise they will be disqualified.

5.2. Competition committee can decide to repeat the race when it is necessary.

5.3. Teams can object to decisions of judges by written document.

5.4. After the drone is placed on take-off area, timing will be started when drone taking off. Time will stop at the moment of all propellers stop after landing

5.5. After desk check, each team has 8 minutes to finish tasks. It includes preparation of drone and accomplish the flight. Drone will land by judge's announcement and time will be recorded as "flight time"

5.6. Each team has one technical break. Teams can make repairs to fix small damages such as breaking props, cables etc. Break is limited with 1 hour. When break time finishes, team will continue again from where it left (time and place) after all teams have competed.

5.7. In case drone becomes unable to flight because of crash to ground or net, chronometer will be stopped by judge. Pilot or rescue team will enter the flight zone and fix the drone. After that, race will continue from the place where judge shows. If drone is heavily damaged,team can request technical break explained in article 5.6

5.8. Pilot must be team member. There may be more than one pilot in the team.

5.9. Competition will be carried out with two stages. After all teams have competed, ranking list will be announced. %35 of teams from top of the list will have right to fly at final race. (if result number is fractional number, it will be rounded up. For example: 23,17=24). Scores of all teams will be calculated according to explanation given at article 6.4 for the second stage as a final race.

5.10. Commercial or special designed frames can be used but commercial drones or Drone Kits (RTF, ARF etc.) bought completely in market are not allowed. Such drones will be disqualifed.

5.11. Each team must assemble mechanic , electric and electronics parts of drone by own . In addition, they will also install flight software and make settings by themself .Teams will prepare "Drone Production Report " explained all steps of production process of their drones . Each team must dowload and fill the "Drone Production Report" from offical web page of competition. After that it should be uploaded as .pdf format. Teams which didn't upload their reports cannot participate in this competition.

5.12. LiPo safe bags will be checked. Teams which have no safe bags will not be registered.

5.13. At registration desk:

5.13.1 Before each entrance of flight zone, technical control will be performed. If drone cannot pass technical check, it can race later only after fixing

5.13.2 İHA'nın Safety measures of Drone will be checked. If drone cannot pass the safety check, it will be disqualified.

5.13.3 When drone is different than its specifications given at registation process and "design report" , team will be disqualified.

5.14. During the flight:

5.14.1 Entering flight zone without permission is prohibited. In case of unexpected situation (such as falling , breaking, battery discharge etc.) , competitor can enter the zone only if judge gives permission. Otherwise, team will get penalty point as it was explained in article 6.1

5.14.2 Drone pilot cannot go out of competitor zone. In case of each breach of this rule, penalty is given as it was explained in article-6.1

5.14.3 If any supporter of team acts inappropriate, all teams of supporters school in this category will get penalty points (unfair act) as it was explained in article 6.1.

5.14.4 There will be cameras at some different locations of flight zone to observe all flying moments of drones.

5.14.5 Objects placed in flight zone and their dimensions are shown at figure 20 :

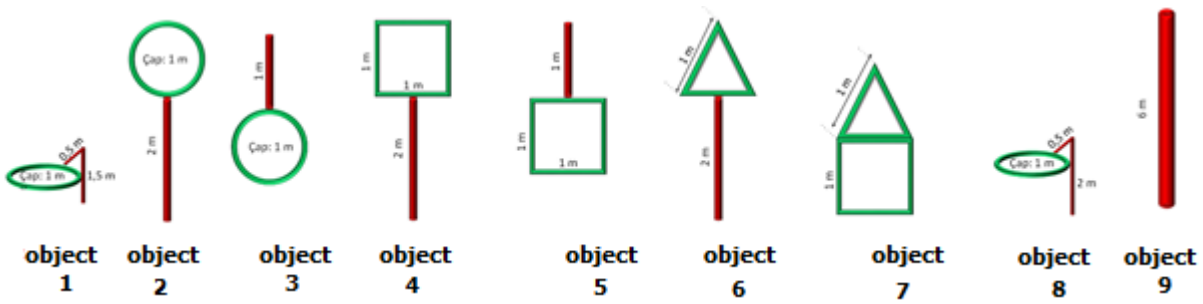


Figure 2. Objects placed in flight zone and their dimensions

5.14.6 Flight zone and flight route are shown at figure 21 (a) and (b):

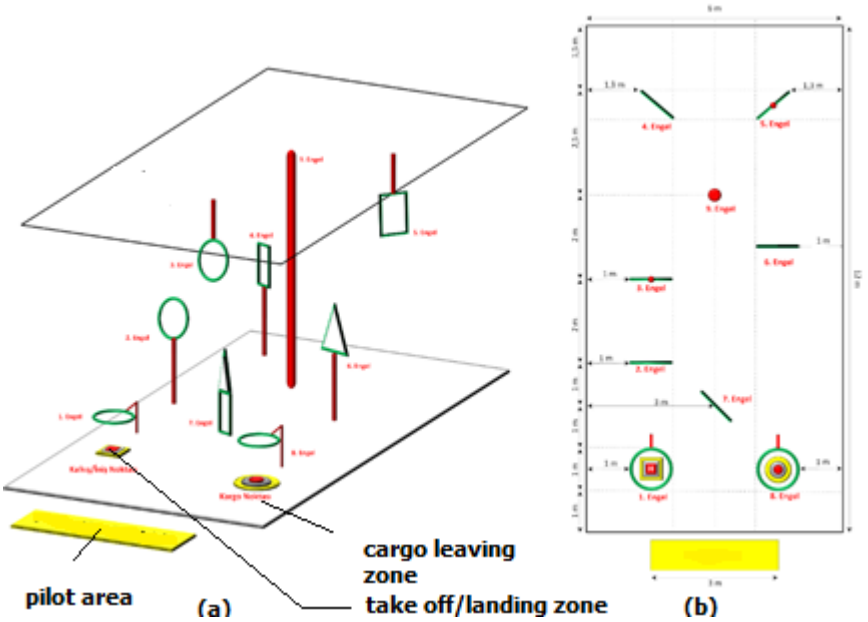


Figure3. Flight zone and route : general view (a), top view and object positions (b).

5.14.7 Competition will be carried out with two stage.In first tour, drone will take off from starting zone and follow the route explained in aticle 5.14.10 and lands into landing zone(same with take off zone). Teams which get right to participate final tour will add “Load Release System” on their drones for loads described in article 5.14.11. Drone will follow the route which will be announced just before final tour and release its load from air. After that, lands to take off/landing zone. The system for final tour might be already mounted even in first tour. It is not compulsory that this system is removable.

5.14.8 In final tour, a glass marble (ball) which has 2-3cm diameter will be used as a load. It will be provided for teams by organisation if they wish. “Load Release system” which is freely designed by teams will have capacity for 1 load. Load will be released into “Cargo Leaving Zone” as shown in figure 22.

5.14.9 Drone is placed into “starting zone”. Pilot stays inside of “pilot area” .When judge says “ready” , pilot starts the propellers up. (arming process). When judge says “start” , drone takes off and timing starts.

5.14.10 At first tour: After take off , drone completes the following tasks respectively:

- Task 1: pass through object-1 as it goes from down to up,
- Task 2: pass through object-2
- Task 3: pass through object -3
- Task 4: pass through object -4
- Task 5: pass through object -5
- Task 6: pass through object -6
- Task 7: First, drone pass through lower part (rectangle) of object 7 and pass through upper part of object 7 (triange). Passing directions not important.
- Task 8: turns around from object-9
- Task 9: pass through object-1 as it goes from up to down,
- Task 10: Landing.

5.14.11 Final Tour : Route in this part will be announced just before the starting. In final game, drone will be equipped with “load carry and release“ system. After take off , drone completes the following tasks respectively:

- Task 1: Drone will follow the route which was announced before starting,
- Task 2: Drove arrives above the object 8 and releases its load.(any part of drone won’t pass object 8. It is assumed that ring of object 8 was upper limit and load must pass through inside this ring. If load is not pass inside the ring , action will be invalid.)
- Task3: pass through object-1 as it goes from up to down,
- Task 4: Landing.

5.14.12 Drone that will be used for final tour shoud be the same drone used at first tour but added “load release system”. During technical checks before the competition, if any changes on basic properties (body,motor,esc, flight control unit etc) were determined , it will be the reason for disqualifying team.

5.14.13 Drone must follow the route which was determined by judges. Time will not be stopped without finishing the route.

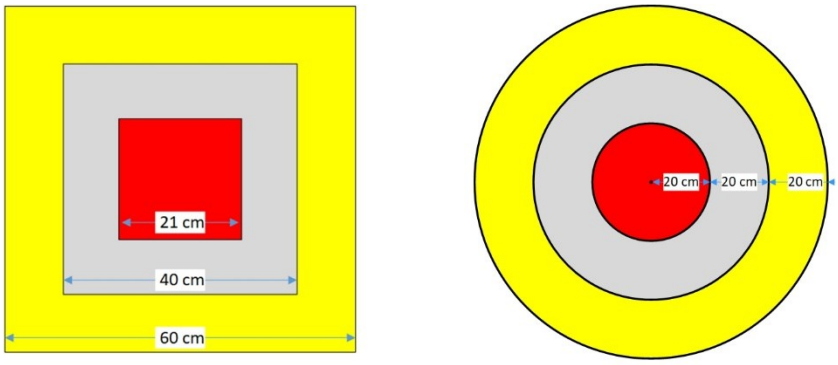
5.14.14 Drone finishes it’s flight without touching any material from it’s take off in flight zone. Penalty is given for each contact as it is explained at article 6.1

5.15 End of Flight:

5.15.1 When Drone lands and its props stop completely , judge stops the chronometer and says “time is up”. Only the judge’s chronometer will be taken into consideration while calculating time of drone.

5.15.2 "Landing zone" consists of nested 3 squares as it is shown at figure 22. Drone gets landing score according to these parts as it is expained in article 6.2. First, judge checks the position of drone from the top view. Minimum point of square on which any part of drone is considered to calculate it's landing score. Final decision belongs to judge.

5.15.3 For final tour: "Cargo leaving zone" consists of nested 3 circles as it is shown at figure 22. Cargo zone has walls to prevent load moving to another areas by rolling When penalties explained in article 6.1 occur, they effects general score.Team gets points according to place where the load remains stationary which is explained in article 6.3. Final decision belongs to judge.



(a) (b)

Figure 22. Top view of Landing zone (a) and Cargo leaving zone (b).

6. SCORE

6.1 Penalty scores:

- Each touching to any object in flight space: 3
- Crash to ground: 5
- If pilot lands the drone consciously while flying drone: 8
- If pilot go out of competitor field while flying drone: 10
- Skip the tasks (for each task): 10
- Entering fly zone without judge's permission:10
- General penalty point (for each penalty) :20
- Unfair act penalty point: 20

6.2 Scores for first tour will be calculated according to following table and formulas

Criterion	**Weight (%)**	**Calculation**
Drone weight	15	$\frac{Lightest\ Drone\ weight(g)}{Drone\ weight\ (g)}\ x\ 100$
Drone design and skill	20	Judge decision $0 - 100$

Flight point	55	$\frac{Shortest\ flight\ time(sec)}{Flight\ time\ (sec)}\ x\ 100$
Landing point	10	Red: 100, Gray: 80, Yellow: 50, Other:0

First tour score = (%15 x Drone weight) + (%20 x Drone design, skill and report) + (%55 x flight point) + (%10 x landing point) - penalties

6.3 Scoring for final tour

Criteria	**(%)**	**calculation**
Flight point	40	$\frac{shortest\ flight\ time(sn)}{flight\ time\ (sn)}\ x\ 100$
Cargo point	60	red: 100, gray: 80, yellow: 50, other:0

Score in final tour = (%40 x flight point) + (%60 x cargo point) - penalties

6.4 Calculating general score

General Score = (%40 x score in first tour) + (%60 x score in final tour)

1. CONTACTS

- Res.Assist. Dr.Barış DOĞAN, Marmara University , Faculty of Technology Mechatronics Engineering G002 Kadıköy ISTANBUL; baris@marmara.edu.tr
- Ünal SEVİM, MEB Atatürk Technical and Vocational High School - Industrial Automation Tech. Department, Odunpazarı ESKİŞEHİR; usevim@hotmail.com
- Dr. Mustafa Baha BAYRAM, MEB Battalgazi Technical and Vocational High School - Industrial Electric-Electronics Tech. Department , Mamak, ANKARA; bahabayram@hotmail.com