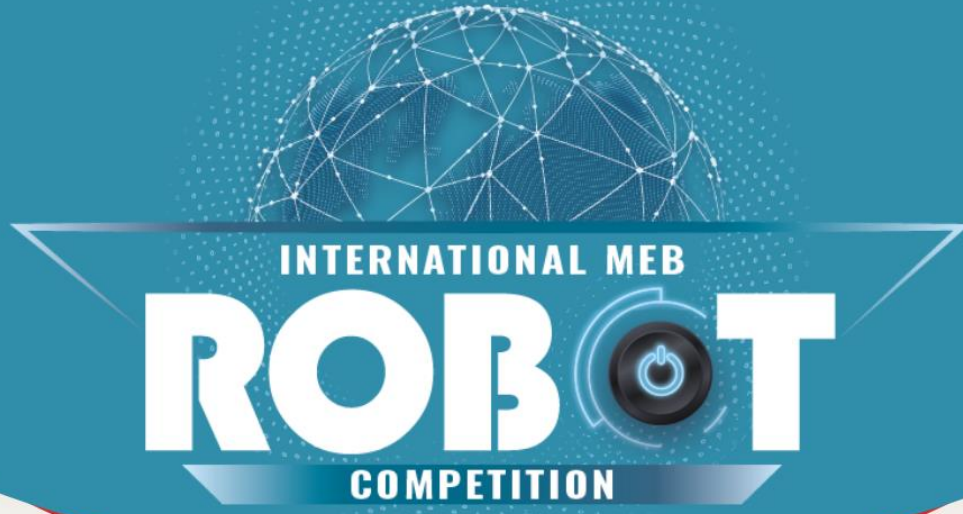




DIRECTORATE GENERAL OF
VOCATIONAL AND
TECHNICAL EDUCATION



TÜBİTAK



17th INTERNATIONAL MEB ROBOT COMPETITION

MINI DRONE (UAV) CATEGORY GUIDE

2025

Education, Technology, Production from Roots to the Future



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MINI UAV CATEGORY GUIDE

1. PURPOSE

Unmanned Aerial Vehicles (UAVs) are used in various fields today. Although aerial imaging and mapping are among the most common applications, UAVs are also utilized in small-scale cargo transportation, firefighting, defense industry, first aid, and life-saving operations.

Technological breakthroughs are events that act as a "booster" to enhance a nation's level of development and the well-being of its citizens. Historical technological breakthroughs include the steam engine, automobile and aircraft production, atomic energy, computers, space technology, and industrial robots. The technological breakthrough of today is UAV technology. Successful military applications have demonstrated how UAVs can contribute to national defense. As a result, many countries are conducting R&D activities in this field and bringing their UAV products to market.

The purpose of this competition, which is open to high school and university students, is to foster a culture of UAV manufacturing and operation in our country. While doing so, it aims to encourage young people to combine technology with entertainment and enhance their knowledge and skills. In this way, the competition will also contribute to developing the human resources necessary for both UAV operation (piloting) and UAV production in the near future.

2. SCOPE

As a fundamental structure, UAVs can be classified into three groups: fixed-wing, rotary-wing, and hybrid. UAVs with stationary and fixed wings that keep the vehicle airborne are generally referred to as fixed-wing UAVs. Airplanes fall into this category. The ability of fixed-wing UAVs to remain in the air depends on the continuous movement of their fuselage. The propulsion force required for this movement is generated by liquid-fueled internal combustion engines or propellers driven by electric motors. In some models, high-speed liquid-fueled turbines (jet) or electric fans (fanjet) are used. The propulsion force is applied perpendicular to the direction of gravity. In electric motor-powered models, the propeller

position can typically be at the front (a), on the wings (b), on top of the fuselage (c), or at the very rear of the fuselage (d), as shown in Figure 1.

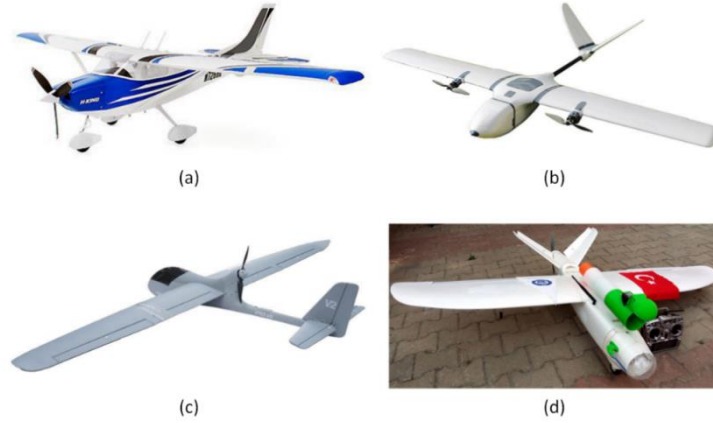


Figure 1. Fixed-wing UAV configurations: front-mounted motor (a), wing-mounted motors (b), top-mounted motor (c), and rear-thrust propulsion (d).

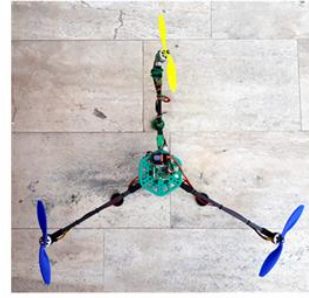
Each fixed-wing design has its own advantages and disadvantages compared to others. The design and production of fixed-wing UAVs are largely mechanical in nature. These vehicles, which are generally single-engine, have lower production costs compared to other UAV models. Although they require large areas for takeoff and landing, their flight range is significantly high.

UAVs that stay airborne by continuously rotating propeller blades in the direction opposite to gravity are called rotary-wing UAVs. Based on the number of propellers, these vehicles are named helicopter, tricopter, quadcopter (quadrotor), hexacopter, and octocopter, respectively, following their Latin-rooted terminology. In rotary-wing UAVs, the fuselage remains stationary while the propellers rotate, eliminating the necessity for constant movement like in fixed-wing UAVs. This allows rotary-wing UAVs to have more controlled aerial movement, enabling them to hover in place and take off and land in very small areas.

The design and production of rotary-wing UAVs mainly involve electronic craftsmanship and planning, including weight distribution and battery balance. Due to the increasing number of motors and electronic components like motor drivers as the number of propellers grows, production costs are significantly higher. Additionally, their flight range is much shorter. Figure 2 illustrates various rotary-wing UAVs with different numbers of propellers.



(a)



(b)



(c)



(d)

Figure 2. Rotary-Wing UAV Configurations: Single-rotor helicopter (a), three-rotor tricopter (b), four-rotor quadcopter (c), and six-rotor hexacopter (d).

Another design type that is becoming increasingly popular and widespread is hybrid UAVs. In hybrid UAV design, the long-range capability of fixed-wing UAVs is combined with the vertical takeoff and landing (VTOL) capability of rotary-wing UAVs. This hybrid UAV type, also known as VTOL (Vertical Take-Off and Landing), is expected to shape the future of both manned and unmanned aerial vehicle designs.

In principle, hybrid UAVs are equipped with both rotary propellers that enable vertical takeoff and landing and fixed wings attached to the fuselage that allow gliding in the air. Various design approaches exist for this UAV model, and research and development efforts on different configurations are still ongoing.

In some designs, the vehicle has propellers only on the vertical axis, and after vertical takeoff, it transitions to horizontal flight. In other designs, the UAV features both vertical-axis propellers (similar to rotary-wing UAVs) and horizontal-axis propellers (like fixed-wing UAVs). In certain models, the vertical-axis propellers change direction after takeoff and

transition into horizontal flight mode. Figure 3 illustrates various hybrid UAV designs developed by different companies.



Figure 3. Hybrid UAV Designs Developed by Different Companies.

In the mini UAV category, it has been deemed appropriate to include rotary-wing "Mini UAVs" (racer drones) due to their high maneuverability and ability to take off and land in small areas. As shown in Figure 4, these Mini UAVs are preferred because of their small physical dimensions, lower production and procurement costs, and reduced risk of damage or causing damage in case of a crash.



Figure 4. Example Mini UAV Image

The Mini UAV category competition will be held in an open area in accordance with the rules detailed below. When establishing the rules, both international and national Mini UAV racing leagues (e.g., TDL – Tech Drone League, FPV Drone Racers Sports Club, etc.) were taken into

consideration. This ensures that a team competing as an amateur in the Mini UAV category can later obtain a license and participate professionally in national and international competitions.

3. BASIC INFORMATION ABOUT MINI UAVs

The example components that make up the Mini UAVs participating in the competition and the required technical specifications are as follows:

3.1. Flight Simulator Software

Enthusiasts eager to fly UAVs might assume they can operate their aircraft immediately upon purchase. In fact, beginners often opt for a cheaper UAV, expecting minimal losses in case of a crash. However, regardless of the purchase price, if there is no prior flight experience, it is highly likely that the UAV will crash (suffer structural damage) and become unusable on the first flight. Beyond financial loss, such an experience can discourage enthusiasm for UAV piloting.

A critical aspect that new UAV pilots often overlook is the necessity of controlling the UAV from a fixed position. This concept can be illustrated with an example: a car driver sits in the front seat and directly perceives directional inputs from the steering wheel. When the wheel is turned right, the car moves right, and the driver's perspective aligns naturally with the motion. However, in remote-controlled vehicles, the pilot remains stationary. When a model vehicle is moving away from the operator, a right turn command will make the vehicle turn right. Conversely, when the same vehicle is facing the pilot and moving toward them, a right turn command will cause the vehicle to turn left from the pilot's perspective. This continuous change in directional perception depending on orientation is one of the biggest challenges in model UAV operation, requiring dedicated orientation training. The most effective and cost-efficient way to acquire this training is through simulator software.

A common feature among professional flight simulator software used for UAV piloting is that they are controlled via remote transmitters, just like real UAVs. Unlike video games, they do not use keyboards, mice, or joysticks. This allows pilots to familiarize themselves with the remote control they will use for actual flights and see their responses in the simulator environment. The simulator also enhances hand-eye coordination and controller handling

skills. For these reasons, it is mandatory for UAV pilots competing in this event to undergo training in a simulator environment.



Figure 5. Example of a Flight Simulator Software and its Accessories

Older generation remote controllers often feature a dedicated trainer port designed for flight training. These ports are usually 3.5mm mono headphone jacks. The connection between the controller and the computer is established using a USB dongle, which is typically provided with simulator software. It is advisable to select a simulator package that includes both a USB adapter and connection cables. (Tip: Relevant search keywords in online search engines: “rc flight simulator”, “6 in 1 flight simulator”, “FPV Drone simulator”, “Uncrashed FPV”, “VelociDrone”, “PhoenixRC”.)

New-generation remote controllers now feature a USB port for direct connection to a computer. This eliminates the need for additional adapters, allowing seamless connectivity with a simple mini-USB cable.

With advancements in internet software technology, simulators specifically designed for racing drones have become available via online platforms. These web-based simulators also support remote controllers connected to the computer. Examples of such online simulators include:

- <https://www.velocidrone.com>
- https://store.steampowered.com/app/1682970/Uncrashed__FPV_Drone_Simulator/

3.2. Frame

The frame of a Mini UAV must support four motors (Quadrotor) and can be made of carbon fiber or fiberglass. Ready-made frames from 220mm and 250mm series (or similar) are

allowed. Alternatively, custom-designed frames made using 3D printing, FR4 (printed circuit board material), or wood are also permitted.

(Tip: Relevant search keywords in online search engines: “quad frame 250”, “racer frame”, “5 inch FPV Drone Frame”.)



Figure 6. Example Quadrotor Frames

3.3. Motor

Brushless DC motors with a diameter of 18-24mm and an operating voltage range of 2-6S (8.4-25.2V) can be used. (Tip: Relevant search keywords in online search engines: “brushless DC 22”, “brushless DC racer”, “FPV Drone Motor”, “brushless 2205”, “brushless 2207”.)



Figure 7. Example UAV Motors

3.4. Electronic Speed Controller (ESC)

The electronic speed controllers (ESCs) used in the UAV must be capable of handling current loads between 10-80A and must utilize optocouplers to isolate the control signals from power noise, ensuring stable motor operation. ESCs should be OPTO models, meaning they do not include a built-in Battery Eliminator Circuit (BEC) to reduce electrical interference.

ESCs with an operating voltage of 2-6S (7.4-22.2V) are recommended. For flight controllers that come as preassembled stacks, 4-in-1 ESCs can be used. (Tip: Relevant search keywords in online search engines: “30A ESC OPTO”, “BLHeli ESC”, “4-in-1 ESC”, “micro ESC”.)



Figure 8. Example UAV ESC Modules

3.5. Flight Controller

Flight controllers should be based on 32-bit processors and support various MEMS sensors, such as: 3-axis gyroscope, 3-axis accelerometer, 3-axis magnetometer

Prebuilt flight controllers such as Pixracer, HGLR Zeus F722, Naze32, Mamba F405 Mk2, X-Racer, SP3 and similar models are allowed. Custom flight controllers using MEMS sensors are also permitted. (Tip: Relevant search keywords in online search engines: “Pixracer”, “Mamba F4 Mk2”, “Rush Blade F722+60A Stack”, “HGLR Zeus F7”, “SP F4”.)



Figure 9. Example Flight Controllers

3.6. Power Distributor and Power Supply

The power distribution board (PDB) is used to distribute current from the battery to the motor controllers. The battery eliminator circuit (BEC), on the other hand, steps down the battery voltage (typically between 10-14V) to supply power to the flight controller and other onboard electronics. Some models feature dual BECs, providing 5V for the flight controller and peripherals and 12V for the FPV camera system. Additionally, certain models include current sensors (low-ohm resistors) to measure the current drawn from the battery. There are also 2-in-1 models that integrate both PDB and BEC in a single unit. In some models, a 3-

in-1 version includes an On-Screen Display (OSD) module, which is further explained in section 3.9. For UAVs using 4-in-1 ESCs, an external PDB/BEC is not required, as the flight controller already has built-in voltage regulators. (Tip: Relevant search keywords for online searches: “PDB”, “BEC”, “PDB BEC”, “PDB BEC 2-in-1”, “PDB BEC OSD”, “PDB BEC OSD 3-in-1”, “current sensor”). “current sensor”)

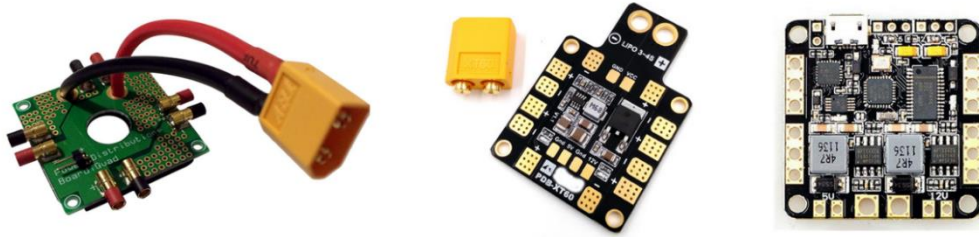


Figure 10. Example Power Distribution Boards

3.7. Remote Control

To prevent signal interference with other UAVs, a remote control system with at least 6 channels and operating on the 2.4GHz frequency band with frequency-hopping technology must be used. For compatibility with flight simulators, it is recommended to select a professional-grade transmitter that features a trainer port on the back. A high-quality remote control is an essential investment, as a single professional transmitter can be used to control multiple UAVs by simply changing the receiver. Advanced models also allow storing configurations for at least 16 different aircraft. (Tip: Relevant search keywords in online search engines: “Boxer Radio Controller”, “Taranis RC Control”, “Pocket ELRS”, “T-Pro RC Controller”).)



Figure 11. Example Remote Controllers from Various Brands

3.8. Pilot Camera, Display, and Goggles (FPV)

The First Person View (FPV) system allows the pilot to perceive the flight experience as if they were on board the UAV. This system significantly enhances navigation and control of the aircraft. The FPV setup typically consists of a camera, transmitter (VTX), receiver (VRX), antenna set, and a display device (LCD screen or goggles). Each component of the FPV system can be purchased separately and combined, but modern integrated models are also available, where the camera and transmitter or the receiver and display are built into a single unit. When choosing receiver-equipped screens or goggles, models with dual receivers (diversity) should be preferred to ensure a clear and uninterrupted video signal. These models feature an automatic switching circuit, which selects the best quality video feed from the available receivers. For camera selection, it is recommended to choose models with a high-quality image sensor, high resolution, low minimum illumination (lux) value, and built-in transmitter with DVR capability for simultaneous recording on an SD card.

Most FPV systems use analog video transmission, which, despite having lower image quality and susceptibility to interference, provides near-zero latency. This ensures that pilots can react to the UAV's movements without delay, making analog FPV systems still widely popular. Analog transmissions typically operate on the 5.8 GHz frequency band. To prevent signal interference during drone races, specific race frequency channels (Band R: 5658, 5695, 5732, 5769, 5806, 5843, 5880, 5917) have been designated. When purchasing an FPV system, it is recommended to choose a model that supports 5.8 GHz frequency and 40-50 channels for better compatibility. Recently, digital FPV systems with ultra-low latency (as low as 10 ms) have been developed. These systems provide superior image clarity, and some models can transmit both video and control signals simultaneously. Additionally, certain digital FPV goggles allow users to connect an analog module to receive analog VTX signals. (Tip: Relevant search keywords for online searches: "FPV LCD", "FPV goggles", "diversity LCD", "diversity goggles", "FPV camera").

The HDZero Event VRX is a high-resolution digital video receiver designed for FPV drone racing. It receives video signals from HDZero video transmitters, delivering clear and detailed footage through FPV goggles or screens. The HDZero system ensures low-latency transmission, digital noise reduction, and stable signal quality, making it ideal for

competitive racing. Thanks to these features, the HDZero Event VRX provides a smooth and uninterrupted viewing experience for both pilots and spectators. It also supports live streaming and DVR recording, making it a valuable tool for event organizers. Due to its high-definition video capabilities, HDZero technology is becoming increasingly popular in modern FPV racing.



Figure 12. Example FPV Cameras



Figure 13. Example FPV Screens and Goggles

3.9. On-Screen Display (OSD) Module

The On-Screen Display (OSD) module overlays flight data—such as battery voltage, current draw, aircraft tilt, and other sensor readings—onto the FPV camera feed. It functions similarly to how TVs display volume levels when adjusted at home. This allows FPV pilots to monitor critical flight information in real-time without needing additional external screens or telemetry setups. Most VTX units used in conjunction with flight controllers come with built-in OSD functionality. For these setups, purchasing an external OSD module is unnecessary. However, for systems without integrated OSD, an external module can be added for enhanced monitoring. OSD is not a mandatory component, but it greatly improves

situational awareness during flight. (Tip: Relevant search keywords for online searches: “mini OSD”, “Minim OSD”).

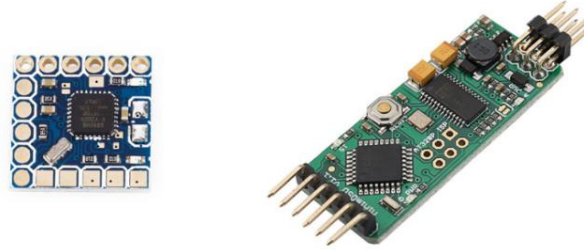


Figure 14. Example OSD Modules

3.10. Propellers

The propellers used in UAVs must be appropriately sized to ensure compatibility with the motor’s power and to prevent collisions between blades. The specifications of a motor will indicate the optimal propeller dimensions for efficient operation.

Based on these specifications, suitable propellers should have:

- A diameter of 4-7 inches
- A pitch of 4-5 inches (e.g., a propeller labeled 6045 is 6 inches in diameter and advances 4.5 inches per full rotation)
- Two-blade or three-blade configurations

Propellers must be purchased in clockwise (CW) and counterclockwise (CCW) pairs to ensure balanced thrust distribution. Propellers are one of the most frequently replaced components in a UAV. Therefore, having spare sets is highly recommended. Even with brand-new propellers, balancing is necessary to prevent vibrations, similar to how car wheels require balancing. Properly balanced propellers contribute to:

- Reduced battery consumption
- Increased motor bearing lifespan

(Tip: Relevant search keywords in online search engines: “5x4.5 prop”, “6045 prop”, “5147-3 prop”, “5045 3 blade”.)



Figure 15. Example Propellers

3.11. Battery

Lithium Polymer (LiPo) batteries are commonly used in UAVs due to their high instantaneous discharge capability, a result of their chemically unstable structure. LiPo batteries consist of multiple series-connected cells, and the required number of cells depends on the desired voltage. Each LiPo cell operates within a safe voltage range of 3.5V (empty) to 4.2V (fully charged). If a cell's voltage falls outside this range, it may become permanently damaged. For long-term storage, LiPo cells should be maintained at 3.85V per cell to prevent degradation. Many chargers include a storage mode for this purpose. This is crucial since batteries are often stored between competition seasons.

Series (S) Rating: The number of series-connected cells determines the battery's voltage. A 3S battery consists of three cells, meaning: 10.5V is empty, 12.6V is fully charged.

Capacity (mAh): Indicates how much energy the battery can store. A 2200mAh battery can supply 2200mA for one hour or 44A for approximately three minutes.

Charge Rate (C Rating): Defines the maximum safe charging current. A 1C charge rate means a battery should be charged at a current equal to its capacity (e.g., a 3000mAh battery should not exceed 3A during charging).

Discharge Rate (C Rating): Indicates the maximum instantaneous discharge current. A 1500mAh 120C battery can discharge 180A ($1.5\text{Ah} \times 120$).

Since racing UAVs prioritize low weight, their batteries have lower capacity but higher voltage (S) and discharge (C) ratings. Typical racing UAV batteries have: 1000-2000mAh capacity, 3-6S voltage range, 60-120C discharge rates

LiPo batteries require balancing to ensure all cells are charged evenly. Chargers achieve this by: Measuring the voltage of each cell, Discharging overcharged cells to match the others.

This is why LiPo batteries include both main power leads (+ and -) and a balance lead with (S + 1) wires (e.g., a 3S battery has a 4-wire balance connector).

Finally, when purchasing a LiPo battery, consider its connector type. Racing UAVs commonly use T-plug or XT60 connectors.

(Tip: Relevant search keywords in online search engines: “120C drone battery”, “1500 mAh 90C LiPo”, “1300 mAh 4S 120C LiPo”.)



Figure 16. Example LiPo Batteries

3.12. Battery Alarm (LiPo Alarm) and UAV Finder

A LiPo alarm is a small electronic module that connects to the battery's balance lead and displays the individual cell voltages. It emits an audible warning when the voltage of any cell drops below a set threshold during flight. The threshold voltage is adjustable and is typically set above 3.5V (e.g., 3.7V) to ensure a safe landing before the battery is fully drained.

Additionally, a UAV finder is a self-powered electronic module that activates when it detects a signal loss from the remote controller for a certain duration. Once triggered, it emits a loud alarm, helping locate a crashed UAV in the field.

(Tip: Relevant search keywords in online search engines: “LiPo alarm”, “Finder buzzer”, “Battery alarm”.)



Figure 17. Example Battery Alarm and Finder

3.13. Battery Safety Transport Case (LiPo Safe Bag)

LiPo batteries pose a fire risk, and to prevent accidents, they should be stored and charged inside a fireproof bag. These specially designed LiPo-safe bags protect against explosions and fires, ensuring safe transport and charging of the batteries. (Tip: Relevant search keywords in online search engines: “Fireproof LiPo bag”, “LiPo safe bag”, “LiPo guard”).



Figure 18. Example LiPo Safety Bags

3.14. Mechanical Assembly

To prevent screws and bolts from loosening during flight, thread-locking compounds (e.g., Loctite) must be used. During pre-race technical inspections, officials will check whether these compounds have been applied.

3.15. Electrical and Electronic Assembly

Shrink tubing will be used for cable and connector connections, and no exposed electrical wires will be visible. Cables will be secured to the UAV body with cable ties. Exposed and unsecured (dangling) cables pose a fire hazard if they come into contact with each other when the UAV crashes or hits an obstacle. In Figure 19, a fire extinguisher is being used to intervene in a UAV that caught fire during a fall in the competition area. Therefore, during the pre-competition technical inspection, it will be checked whether cable ties have been used to secure cables with shrink tubing, ensuring no exposed wires remain. Any team failing to comply with even one of these rules will not be allowed to participate in the competition.



Figure 19. Intervention of Judges on a Mini UAV that Caught Fire in the Competition Area Due to a Previous Fall.

3.16. Electrical-Electronic Liquid Protection

UAVs must be resistant to adverse weather conditions. To operate in weather conditions with a risk of rain, snow, etc., it is important to coat the electronics of the devices. Coating is not mandatory, and flights can still be performed without it, but this poses a risk. The electronics should be coated with waterproof solutions to protect them from water. These solutions are applied to the exposed electronic surfaces using a brush or stick to form a layer, which is then dried either by waiting, depending on the type of solution, or using UV light. Care should be taken not to apply the solution to the barometer or buttons, and the inner parts of the connectors should also be avoided. Teams using open PCBs for flight control boards and ESCs should pay special attention to this. Detailed application instructions and videos can be found on many platforms. (Tip: Use keywords such as “FPV Waterproof Silicone Coating,” “OscarLiang-Waterproofing FPV Drone Electronics,” “Silicone Conformal Coating” in search engines.)



Figure 20. Example of Electronic Liquid Protection.

4. COMPETITION AREA

1. Sample images of the competition venue are as shown in Figures 21, 22, 23, and 24:

[Google Earth link](#)



Figure 21. Images from the Competition Area #1.



Figure 22. Images from the Competition Area #2.



Figure 23. Images from the Competition Area #3.



Figure 24. Images from the Competition Area #4.

2. The competition environment and layout are as follows

The detailed layout plan will be published on our website as an announcement after the site inspection. Please follow the announcements.

Figure 25. General Layout Plan of the Competition Area.

3. In the competitor tents (or area) shown in the general layout plan in Figure 25, competitors will be able to make final adjustments, additions, checks, and modifications to their mini UAVs. Additionally, 220VAC power outlets will be available for charging batteries in the same area. Competitors may also use the practice area, as seen in the layout plan, for flight tests, provided they follow the order. Technical inspections will be carried out in the judge tents (or area). For safety, the areas for spectators, competitors, and judges will be enclosed with netting.
4. The competition obstacles will be inflatable types and/or made of neon LED lights, and the arrangement of the obstacles and course layout will be announced before the races. Figure 26 shows the dimensions of the inflatable obstacles, Figures 27-30 show images of the inflatable obstacles, Figure 31 shows a representative image of the tunnel used in the Erzurum competition, and Figure 32 shows the technical drawing of the tunnel. Additionally, there may be sail flag-shaped obstacles in the competition area, as represented in Figure 33.

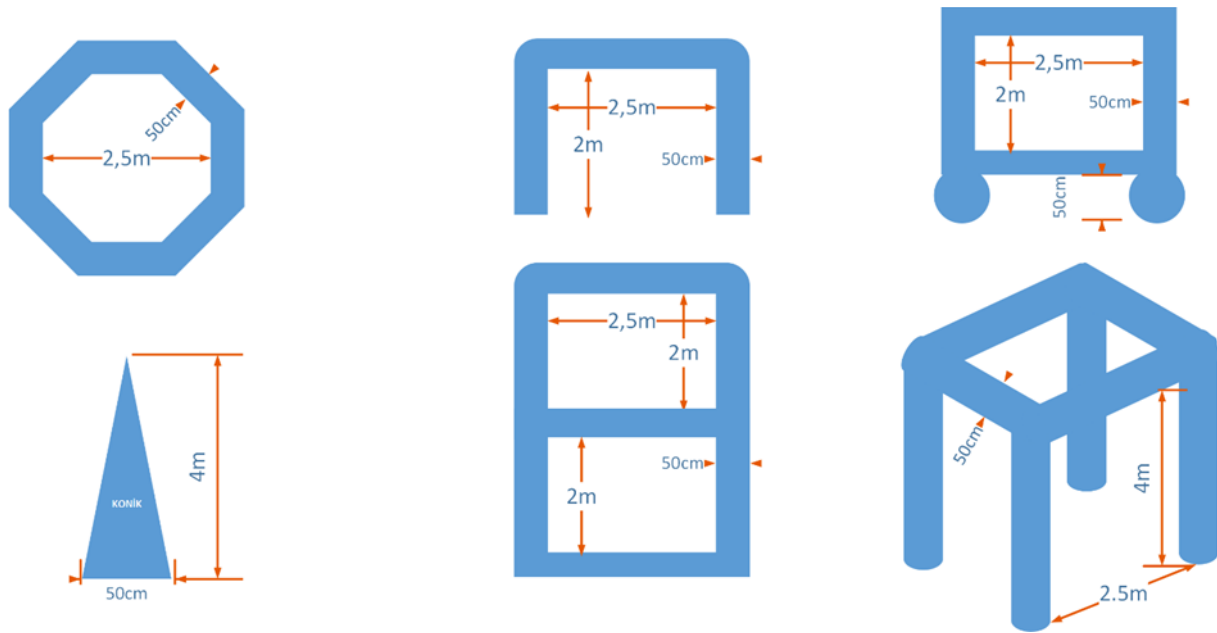


Figure 26. Dimensions of the Inflatable Obstacles.



Figure 27. Inflatable Obstacle Image #1.



Figure 28. Inflatable Obstacle Image #2.



Figure 29. Inflatable Obstacle Image #3.



Figure 30. Inflatable Obstacle Image #4.



Figure 31. Representative Tunnel Image.

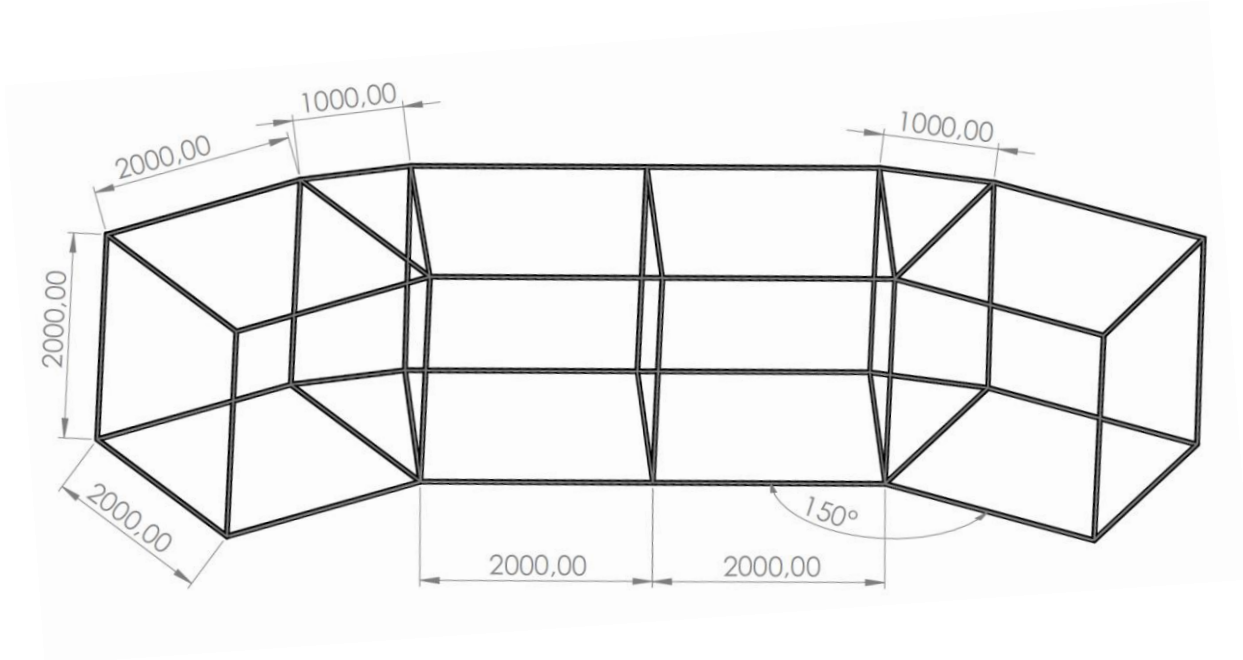


Figure 32. Technical Drawings and Dimensions of the Tunnel.



Figure 33. Representative Image of a Sail Flag-Shaped Obstacle.

5. For sample images of the Mini UAV competition held outdoors in 2022 in Şanlıurfa province as part of the 14th International MEB Robotics Competition, [click here](#)
6. The competition area image, including indoor obstacles from the 2023 competition in Bursa province as part of the 15th International MEB Robotics Competition, is shown in Figure 34.



Figure 34. Competition Area Image from the 2023 Bursa Competition, Including Indoor Obstacles.

7. For sample images of the Mini UAV competition held in an indoor sports hall in Bursa in 2023 as part of the 15th International MEB Robotics Competition, [click here](#).
8. Before the competition, the race course, created in the [UNCRASHED FPV Drone Simulator](#) environment, will be shared with the competitors. Competitors can either obtain the drone simulator software themselves or, if possible, use the simulator set up at the competition venue to prepare for the course.

5. COMPETITION RULES

For competition applications and general rules, please follow the application guide and updates published on the website <https://robot.meb.gov.tr/>. The competition committee may modify the competition rules according to technical and application requirements when necessary. The most up-to-date rules will be published on the competition website. (Please check the version number on the cover page.)

1. Each team must strictly adhere to the rules set by the competition committee and the referee warnings. Teams found violating the rules will be disqualified.
2. The competition committee may, at its discretion, order a re-run of the competition.
3. Teams can make all objections based on the general "Application Guide" rules.
4. Each team may have at least two members: one pilot and one observer (co-pilot).
5. Each team can bring up to 4 Mini UAVs for the competition. All Mini UAVs must be registered separately and receive a QR code label.
6. A pilot can only compete for one team. If a pilot competes for more than one team, all teams for which the pilot competes will be disqualified.
7. During the competition, the pilot must control their Mini UAV using their FPV goggles or LCD screen. Mini UAVs without FPV video transmission systems will not be allowed to compete. The competition committee will not provide cameras/goggles/screens.
8. The observer will assist the pilot by following the Mini UAV and performing tasks such as placing it at the starting point, removing it from the competition area, and providing voice commands as needed (co-pilot).
9. The competition will be organized in three stages, with a total of 5 rounds, as shown in Figure 35. In the first stage, qualifying rounds will be held. In the second stage, elimination rounds, quarter-finals, semi-finals, and in the third stage, the final stage will take place.

STAGE 1.**ROUND 1: Qualifying**

- Each team participating in the competition first takes part in the qualification rounds.
- The competition order for Round 1 is determined by a draw.
- Each team completes laps on the track either alone or alongside multiple teams.
- The fastest lap time completed within 4 minutes is recorded as the "Round 1 Lap Time."
- During Round 1, each team has a maximum of two attempts (chances) in the qualification rounds.

STAGE 2.**ROUND 2: Elimination**

- The 32 teams with the best lap times in the qualification rounds (shortest "Round 1 Lap Time") can advance to the elimination rounds.
- Teams compete on the track in groups of four, completing three laps each.
- The total time of these three laps is recorded as the "Round 2 Lap Time."
- A total of $32/4 = 8$ groups are formed.
- The teams in each group are determined through a seeded draw.
- The starting positions of the teams within each group are assigned based on their qualification round rankings.

ROUND 3: Quarter Final

- In the elimination rounds, the top 2 teams from each group (shortest "Round 2 Lap Time") can advance to the quarter-finals, making a total of $2 \times 8 = 16$ teams.
- Teams compete on the track in groups of four, completing three laps each.
- The total time of these three laps is recorded as the "Round 3 Lap Time."
- A total of $16/4 = 4$ groups are formed.
- The teams in each group are determined through a seeded draw.
- The starting positions of the teams within each group are assigned based on their Round 2 lap times.

ROUND 4: Semi Final

- In the quarter-final rounds, the top 2 teams from each group (shortest "Round 3 Lap Time") can advance to the semi-finals, making a total of $2 \times 4 = 8$ teams.
- Teams compete on the track in groups of four, completing three laps each.
- The total time of these three laps is recorded as the "Round 4 Lap Time."
- A total of $8/4 = 2$ groups are formed.
- The teams in each group are determined through a seeded draw.
- The starting positions of the teams within each group are assigned based on their Round 3 lap times.

STAGE 3.**ROUND 5: Final**

- In the semi-final rounds, the top 2 teams from each group (shortest "Round 4 Lap Time") can advance to the finals, making a total of $2 \times 2 = 4$ teams.
- Teams compete on the track in a single group of four, completing three laps each.
- The total time of these three laps is recorded.
- The final races continue until one team wins twice (maximum of 5 races).
- The team that wins twice is crowned the competition champion.
- The second, third, and fourth-place teams are determined based on their cumulative total time across all final races.
- In case of a time tie, a tie-breaker race is conducted. The starting positions of the teams in the final races are determined based on their Round 4 lap times.

Figure 35. Competition Plan.

10. Each team has a maximum of two attempts to participate in the qualifying rounds.
(The number of qualifying round attempts may be adjusted by the competition committee depending on the number of participants.)
11. The best time (based on completing the course in the shortest time) obtained by a team in the qualifying rounds will be accepted as the team's qualifying round result.
12. Teams that do not complete all their attempts before the announcement of the end of the qualifying rounds will lose their remaining attempts.
13. The order in which teams participate in the qualifying rounds will be determined by a draw before the competition. Teams will be notified of their video broadcast channel and competition times. Teams that fail to report to the technical inspection tent when called by announcement will lose their first attempt in the qualifying rounds.
14. In the second stage elimination rounds, the two teams with the best results in their groups will qualify for the quarter-finals.
15. In the quarter-finals, the two teams with the best results in their groups will qualify for the semi-finals.
16. In the semi-finals, the two teams with the best results in their groups will qualify for the finals.
17. In the final race, the four teams with the best results in the semi-finals will compete.
18. At the start of every race, the referees will check if the competitors' video transmission systems are operating on the correct channel and power. Then, the Mini UAV's first start (ARM) will be checked to ensure the remote controls are functioning. Teams that experience issues with the video transmission system or ARM control will be given time to fix the issue before the race begins. After this period, teams with unresolved technical issues will be considered as having used their first attempt. In all races in the second stage, teams that cannot resolve their issues during the technical break will be eliminated, and the remaining teams will compete.

19. The starting time for each team will be determined by a special electronic lap timer when the team passes the first obstacle (1st obstacle). The lap time for each team will be calculated electronically by the timer as they pass subsequent checkpoints.

The lap timer starts by detecting signals from the video transmitters (VTX) on the Mini UAVs. In some cases, the lap timer may fail to detect the first pass of a Mini UAV. In such cases, the timer will not start, and the race must be restarted. The referees will check whether all UAVs' first passes are detected by the lap timer. If the pass of any team is not detected, the race will be restarted.

20. Each team will have a referee assigned to them. The referee will monitor the team through a screen. The image that the pilot sees through their goggles/screen will be displayed on the referee's screen. These images will also be recorded with a DVR device, allowing the referee to check whether the team is following the correct order of obstacles and abiding by the rules. A time penalty may be given if the team fails to comply.

21. Each team will compete with their own video transmitter (VTX) and goggles. The VTX modules used by the teams must support the standard 48-channel analog racing band. The transmission power must be set to a maximum of 25 mW. Only one analog VTX transmission will be allowed from each Mini UAV. Teams detected using more than one VTX transmission will have their second VTX module turned off within a short time by the referees. Teams violating this rule may be disqualified. If a team causes interference (signal jamming) with other teams' transmissions, they will be disqualified unless they fix the issue.

22. Each competitor will be assigned a transmission channel by the referees before the competition. Competitors will bring their VTX modules and FPV goggles to the channel designated by the referees. In the final check before the competition, a special measurement device will be used to check if a team is broadcasting on more than one VTX, if the VTX power is within limits, and if the channel is correct. Teams who fail to comply with the rules will need to adjust their Mini UAVs accordingly. If not, they may be disqualified at the referee's discretion.

23. The VTXs used on the Mini UAVs must support the R band channels: R1: 5658 MHz, R2: 5695 MHz, R7: 5880 MHz, R8: 5917 MHz. Teams that arrive without adjusting to their assigned channel and band will not be allowed to compete.
24. The HDzero system will be used, which is compatible with both analog and HD video transmission systems used in previous years.
25. In the final checks before the race, if any team's transmission interferes with the images or control signals of other teams, the team causing the interference will lose their flight rights.
26. Mini UAVs that crash into obstacles, collide with other UAVs, or fall due to individual errors during the race, and suffer damage to their video transmission systems, will be allowed to continue the race if they can take off again. The time spent on the ground will be included in the race time, and the competition time will not stop for the team. Any Mini UAV that cannot take off for any reason will be considered out of the race.
27. Any unsafe practice or behavior identified by the referees, such as flying dangerously near spectators, flying outside the designated area, or unsportsmanlike conduct that negatively impacts another user, will result in disqualification.
28. Unauthorized entry into the competition area is prohibited. In case of any incident (such as UAV crashing, malfunction, battery depletion, etc.), entry into the competition area will only be allowed with referee permission. Any violation will result in disqualification.
29. If any unsportsmanlike conduct or inappropriate cheering occurs, the individual(s) responsible, if identified from their school, will result in a 20-second time penalty for all teams from that school in this category.
30. Teams that skip or pass obstacles in the wrong order will be given a 10-second penalty for each error, as determined by the referees. A maximum of 5 obstacles can be skipped or missed (with penalties) in any stage. Skipping more than 5 obstacles will result in disqualification. (Penalties for some obstacles may differ depending on the referee's decision.)

6. TECHNICAL SPECIFICATIONS OF MINI UAVs

The technical specifications of the UAVs competing in the Mini UAV category within the scope of the International MEB Robot Competition are as follows:

NOTE: To prevent arming issues during takeoff, teams are advised to set the minimum arm angle parameter in their flight control software (e.g., Betaflight) to 60 degrees or higher.

1. The motor-to-motor diagonal distance of the Mini UAV must be between 180-270 mm. The UAV must completely fit within a 240 mm × 240 mm square (excluding propellers). During pre-race technical inspections, UAVs will be checked for compliance with this requirement. Figure 36 shows an example Mini UAV fitting inside the required frame.



Figure 36. Example Mini UAV fitting inside the required square frame (12/05/2018, SİVAS).

2. The total weight of the Mini UAV, including the battery and all components, must be between 400 and 1000 grams. Technical inspections before the race will include weighing the UAV.
3. Teams failing to meet technical inspection requirements will lose their race rights if they do not resolve their issues before the competition starts.
4. The propeller diameter must be between 4 inches and 6 inches.

5. The Mini UAV must have a single VTX module capable of broadcasting on the analog race band with a maximum power output of 25 mW. Teams are responsible for providing their own VTX modules, FPV goggles, or LCD screens.
6. To enhance visibility for other FPV pilots and spectators, Mini UAVs must be equipped with visible LED lighting. Teams can choose the number, color, and pattern of LEDs as they wish. However, the lighting must be sufficient to ensure the UAV is visible in low-light conditions. An example of a Mini UAV with visible LEDs is shown in Figure 37.



Figure 37. Example Mini UAV with visible LED lighting.

7. The airframe type must be a Quadrotor (Quadcopter - 4 motors).
8. UAV frames can be custom-designed or commercially available prebuilt frames. However, fully preassembled UAVs or kits (RTF, ARF) are not allowed. Teams found using such UAVs will be disqualified.
9. Teams must assemble their UAVs themselves, including mechanical, electrical, and electronic components. Additionally, flight controller software must be installed and configured by the team.
10. Teams must store and transport their LiPo batteries in fireproof battery bags (LiPo safe bags). Teams without fireproof battery bags will not be allowed to participate.
11. Autonomous flight is not allowed.

12. The competition will be held in open areas, and weather conditions (rain, snow, etc.) will not lead to race cancellations. Teams must use equipment suitable for such conditions.

7. VIDEO UPLOAD AND PRODUCTION REPORT RULES

Each team must download the technical report template from the competition website, complete it, and upload it to the designated section of the website by the specified deadline. Printed reports or USB submissions will not be accepted. All teams must record a video of their Mini UAV and upload it to an online video platform.

The video should showcase:

- The Mini UAV's design and technical specifications
- The manufacturing process
- The pilot's flight capabilities

The video link must also be included in the production report. Teams that fail to submit their reports and videos on time or fail to meet content requirements will not be allowed to compete.

7.1. Video Upload Platform

- The video must be uploaded to an online video platform such as YouTube or Vimeo.
- The platform choice is free, but the video must not be password-protected.
- The video does not need to be publicly available, but the link must be accessible.

7.2. Video Content:

- **Introduction:** The first 5 seconds of the video must clearly display the Mini UAV's name and the name or logo of the participating school.
 - This information must be clearly visible at the beginning of the video.
 - A brief introduction and photo of team members may be included in the video.
- **Technical Specifications:** The Mini UAV's specifications (motor type, battery capacity, weight, dimensions, etc.) must be presented both verbally and visually.

- **Manufacturing Process:** The video must include photos or video footage of the Mini UAV's design and production stages, showing a step-by-step process.
- **Pilot's Flight Capabilities:** The video must include test flight footage demonstrating the pilot's ability to fly with FPV goggles and without FPV goggles. Both types of flights must be shown separately, with clear start and end points.

7.3. Technical Requirements

- **Video Quality:** The video must be at least 720p resolution. Low-quality videos will not be accepted.
- **Playback Speed:** The video must be recorded at normal speed, without fast-forwarding or slow motion.
- **Video Duration:** There is no specific time limit, but the video should be informative and engaging.

7.4. Video Link and Production Report

- The video link must be included in the production report.
- Teams must ensure that the embedded video link is correct and functional.

7.5. Example Video:

- A sample video link will be provided in future announcements. Teams must follow the competition website and updates. Ensure that all content is prepared completely and accurately.

7.6. Video Content and Report Consistency:

- The video content must match the technical specifications and flight tests mentioned in the production report.
- Both the video and the report must provide consistent and accurate information about the UAV.

8. SAFETY MEASURES

The following safety measures apply to both teams and UAVs. Failure to comply will result in disqualification.

1. A switch or button on the transmitter must be configured to arm/disarm the Mini UAV. This feature will be inspected before the competition. UAVs without a functional arm/disarm system will not pass technical inspections.
2. If the Mini UAV loses signal with the transmitter, it must immediately cut motor power and descend (drop feature). This feature will be checked before the competition. UAVs without this failsafe will not pass inspection.
3. If a Mini UAV leaves the competition area or pilot's line of sight, the pilot must immediately disarm the UAV upon referee instruction.
4. LiPo batteries are chemically unstable and can explode under improper handling. Teams must have a sufficient number of fireproof battery bags (LiPo safe bags).
 - If a team leaves batteries exposed or charges them unsafely, they will be penalized with a 20-second penalty per violation.
5. Battery connectors (plugs) must be easily removable by referees in case of an emergency. This must be considered during UAV design and assembly. Referees will inspect this during technical checks.
6. A designated test area will be provided for UAV testing. Teams found flying outside this area (hallways, gardens, etc.) will receive a 30-second penalty per violation. If necessary, referees may disqualify the team.

9. CONTACT

Participants must submit their inquiries through the <https://robot.meb.gov.tr/> system by selecting the appropriate category under the information menu. Questions submitted outside the designated category will not be answered. Teams are responsible for reading the competition guide thoroughly, as it already addresses most inquiries. Reading the guide carefully can prevent unnecessary questions.