THEME: **MOTHER SHIP UAV**

Definitions

mother ship

: a large ship or spaceship that sends out swarms of boats or smaller spaceships to explore, do scientific research, etc.

swarm

: a large number of animate or inanimate things, i.e. UAVs, massed together and usually in motion.

FFD 2015 Rules

Scope of competition

Participating teams are going to control aerial vehicle to reach a target area on the flight arena and leave micro unmanned aerial vehicles (MAVs) over the area surrounded by a red line and return.

Student teams will design, fabricate, and demonstrate the flight capabilities of an unmanned, electric powered, radio controlled aerial vehicles that can best meet the specified mission profiles. The goal is a balanced design possessing good demonstrated flight handling qualities and practical and affordable manufacturing requirements while providing a high vehicle performance.

Questions may be addressed to the contest director at

ffd2015@hho.edu.tr

The winner, second and third of the competition will be awarded with prizes and a certificate of achievement. Cash prizes are 7000TL for 1st, 5000TL for 2nd and 3000TL for 3rd place.

Competition Category

Aerial vehicles must be radio-controlled, originally designed and constructed for this competition only. Autonomous, previously manufactured and modified types of vehicles are not allowed.

Judging

Teams must design, document, fabricate, and demonstrate the aerial vehicle they determine to be capable of achieving the highest score on the specified mission profile(s). Flight scores will be based on the demonstrated mission performance obtained during the contest.

Each team must also submit a written Design Report. A maximum of 100 points will be awarded for the team design report. Scores for the written reports will be announced at the beginning of the fly-off.

The overall team score is a combination of the design report, volume score, and flight scores. The team with the highest overall team score will be declared the winner.

All submitted reports are the property of Turkish Air Force Academy and may be published or reproduced at their discretion.

Contest Site

Host for the competition will be Hezarfen Airport, Istanbul, Turkey. You can check on historical weather conditions at www.accuweather.com or www.weatherunderground.com.

Transportation from Turkish Air Force Academy to Hezarfen Airport may be arranged for the teams on contest dates. Teams must declare their transportation demands by e-mail to the FFD Organizing Committee until **April 13, 2015**.

Teams are advised to check with their airlines on what materials they will be allowed on the plane to bring both to and from the contest site. Hazmat items like paints, thinners and glues may need to be purchased locally.

Team Requirements

Only high school, academy, college, university or institute teams' applications are accepted. All team members (except for a non-student pilot) must be full time students of the applicant schools. Teams may use a non-student member for the pilot if desired.

Team members may be updated/changed at any time during the contest period. Teams wishing a team member list update must submit an updated copy of the contest entry form with all fields fully filled (but only the team member information may be changed).

Each educational institution may submit several team entries. There is no restriction for the schools to submit a single entry. In addition, two or more schools may combine to submit a single entry.

Sponsorship

Teams may solicit and accept sponsorship in the form of funds or materials and components from commercial organizations. All design, analysis and fabrication of the contest entry is the sole responsibility of the team members.

Schedule

Preregistration for participation ends on **December 26, 2014**. Participating teams should finalize their registration and deliver their technical reports until **April 10, 2015**. The competition will be held on **08-10 May 2015** at Istanbul Hezarfen Airport,

Istanbul/Turkiye. Awards ceremony and closing cocktail will be held on May 10, 2015.

The FFD 2015 registration form is a MS-Word file and can be found on the contest web site. Registration forms must be submitted via e-mail to the contest administrator at ffd2015@hho.edu.tr by 5 pm local time (UTC+02:00 Istanbul) on **December 26, 2014**. Be sure to include the phone and fax numbers for your team advisor and at least one student contact so we may reach you in case of any last minute problems or changes. All teams are required to provide two point-of-contact e-mail addresses with their contest application, one of which must be the team's leader. **Incomplete entry forms will not be accepted** and will be returned for correction.

It is the team's responsibility to make sure the e-mail contact addresses they supply remain active during the entire period from entry to the close of the competition, as e-mail will be the primary means to provide information and updates. Don't use an internal team correspondence e-mail list server as your point of contact e-mail address. The Entry Name may not be changed once the registration form is submitted, but must be retained and used on all reports and correspondence during the competition year.

Design reports must arrive at the reports-ffd2015@hho.edu.tr email address by 5 pm local time (UTC+02:00 Istanbul) on **10 April 2015**. Electronic reports must be less than 15 MB in size (including encoding for e-mail transmission). Reports will be judged "as received"; no corrections/additions/page changes will be made by the organizers so check your reports carefully before sending them.

Submission of reports is electronic only (no hard copy required). Details are outlined in the report section at the bottom of this document. Only the electronic copies in PDF will be used for judging.

The contest is scheduled for **08-10 May 2015**. A detailed final schedule will be announced on the contest web site, and also e-mailed to the teams prior to the contest date. All teams should plan their travel considering the contest schedule.

All schedule deadlines are strictly enforced. Late entries will not be accepted. Late report submissions will not be judged. Teams who do not submit the required written reports will not be allowed to fly. It is the team's responsibility to assure that all deadlines are known, understood, and met.

Communications

The contest administration will maintain a worldwide web site containing the latest information regarding the contest schedules, rules, and participating teams. The contest web site is located at

http://www.hho.edu.tr/ffd2015

Questions regarding the contest, schedules, or rules interpretation may be sent to the contest administrator by e-mail at

ffd2015@hho.edu.tr

Questions received prior to the official entry submission date may not be answered directly. Official questions and answers received following the entry submission date will be posted to all teams by e-mail periodically.

Written reports should be in English language and sent electronically to the Chief of Scoring at

reports-ffd2015@hho.edu.tr

The FFD Organizing Committee address is (if needed)

International FFD 2015 Competition
Hava Harp Okulu, Dekanlık,
Havacılık ve Uzay Mühendisliği Bölümü
34149, Bakırköy, Istanbul, TURKIYE

Phone: +90 212 6632490 int. 4340/4341
Fax: +90 212 6628554

Aerial Vehicle Requirements - General

- The aerial vehicle may be of any configuration.
- No structure/components may be dropped from the aerial vehicle during flight (except mission requirements).
- No form of externally assisted take-off is allowed. All energy for take-off must come from the on-board propulsion battery pack(s).
- Must be propeller driven and electric powered with an unmodified over-the-counter model electric motor. May use multiple motors and/or propellers. May be direct drive or with gear or belt reduction.
- Motors may be any commercial brush or brushless electric motor.
- For safety, each aerial vehicle will use commercially produced propeller/blades. Must use a commercially available propeller hub/pitch mechanism. Teams may modify the propeller diameter by clipping the tip, and may paint the blades to balance the propeller. No other modifications to the propeller are allowed. Commercial ducted fan units are allowed. Propeller diameter/pitch can be changed for each flight attempt.
- Motors and batteries will be limited to a **maximum of 40 Amp** current draw by means of a 40 Amp fuse (per motor or battery pack) in the line from the positive battery terminal to the motor controller. Only ATO or blade style plastic fuses may be used.
- Lithium-ion polymer (LiPo) batteries are allowed. NiCad or NiMH batteries are also allowed. For safety, battery packs must have shrink-wrap or other protection over all electrical contact points. The individual cells must be commercially available, and the manufacturers label must be readable / documented (i.e. clear shrink wrap preferred). All battery disconnects must be "fully insulated" style connectors.
- Maximum propulsion battery pack weight is defined in the mission rules section. This battery pack **must** power propulsion systems only. Radio Rx and servos must be on a separate battery pack. Batteries may not be changed or charged during a mission flight period.
- The aerial vehicle must remain substantially the same as documented in the report (i.e. configuration change from biplane to flying wing is not allowed). You may make small modifications to the design to enhance flight performance after the

report submission. The three-view drawing must be inside the report and will be used to verify the flight article during tech inspection.

Aerial Vehicle Requirements - Safety

All vehicles will undergo a safety inspection by a designated contest safety inspector prior to being allowed to make any competition or non-competition (i.e. practice) flight. All decisions of the safety inspector are final.

Safety inspections will include the following as a minimum.

- Physical inspection of vehicle to insure structural integrity.

1. Verify all components adequately secured to vehicle. Verify all fasteners tight and have either safety wire, locktite (fluid) or nylock nuts. Clevises on flight controls must have an appropriate safety device to prevent their disengaging in flight.
2. Verify propeller structural and attachment integrity.
3. Visual inspection of all electronic wiring to assure adequate wire gauges and connectors in use.
4. Radio range check, motor off and motor on.
5. Verify all controls move in the proper sense.
6. Check general integrity of the payload system.

- Radio fail-safe check. All aerial vehicle radios must have a fail-safe mode that is automatically selected during loss of transmit signal. The fail-safe will be demonstrated on the ground by switching off the transmit radio. During fail-safe the aerial vehicle receiver must select (if so equipped):

Throttle closed
Full up elevator
Full right rudder
Full right (or left) aileron
Full flaps down

The radio Fail Safe provisions will be strictly enforced.

- "Safe" mode for all payload changes. The aerial vehicle Rx should always be powered on and the throttle verified to be "closed" before activating the motor arming switch. Fuses must be mounted on the **outside the aerial vehicle**, they can't be behind an access panel or door and must act as the "safeing" device.

- The aerial vehicle must be "safe" (arming fuse removed) any time the aerial vehicle is being manually moved, or while loading/unloading payload during the mission. The arming fuse must be removed anytime the aerial vehicle is in the hanger area.

Scoring

In the event that, due to time, weather, or facility limitations, it may not be possible to allow all teams to have the maximum number of flight attempts, the contest committee reserves the right to ration and/or schedule flights. The exact determination of how to ration flights will be made on the contest day based on the number of entries, weather, and field conditions.

Each team's overall score will be computed from their Written Report Score, Total Flight Score and Rated Aerial Vehicle Cost using the formula:

$$SCORE = \left[\frac{Written\ Report\ Score \times Total\ Flight\ Score}{RAC}\right]$$

The **Total Flight Score** is a composition of the individual mission flight scores (M1, M2, and M3) and is computed for each team using the following formula:

$$Total\ Flight\ Score = 0.3 \times M1 + 0.3 \times M2 + 0.4 \times M3$$

The **RAC** is a score based on maximum empty weight (**EW**) of the vehicle measured after each successful scoring flight (the payload removed):

$$RAC = EW_{MAX}$$

Any team which does not have a flight score will not be taken into consideration for the winner list.

Mission Task Matrix

General

- Battery pack(s) must weigh less than **3 kg.**
- Teams will be allowed a maximum of **5 flight attempts** or **4 successful scoring flights** whichever comes first.
- The team must bring all flight hardware to the assembly area. This includes the aerial vehicle, radio transmitter, safety fuse(s) and tools. If you forget something you must leave the assembly area and forfeit the flight attempt.
- All payloads must be secured sufficiently to assure no movement of payload elements or variation of aerial vehicle cg (center of gravity) during flight.
- Assembly/flight line crew is limited to 3 people (including the pilot).
- Scoring measurement units are m, kg, and seconds.
- All payload must be provided by the teams.
- MAV as payload must be a free-fly model being the configuration of either **conventional design** or **flying-wing design**. Examples to MAV designs are given in Figures 1&2. Teams must select one configuration and fabricate their own MAVs for the competition considering the limitations. Features of MAVs are defined below:
    - MAVs can be constructed of any means or materials; such as balsa, plywood, foam, composite or plastic; but, they must be structurally rigid and sustain damage during missions. Paper fold up models are not allowed.
    - Conventional MAVs must have wing, body and empennage sections. Flying-wing MAVs must have wing-body and vertical stabilizer sections. Other components are not compulsory.
    - There are some limitations of sizing for both MAV designs. Teams must **strictly** obey the limitations.
        - The wing span must be at least 22 cm for both configurations.
        - Height of the MAVs must be at least 5 cm (including the vertical stabilizer).
        - The length of the MAVs must be at least 15 cm.

- Each MAV must weigh at least 15 g. In order to adjust the c.g. location, any kind of weights like lead, coins, foldback clips, etc. can be added on the MAVs.
- Small add-ons of the payload release mechanism are allowed by no means of affecting the aerodynamics of the MAV.

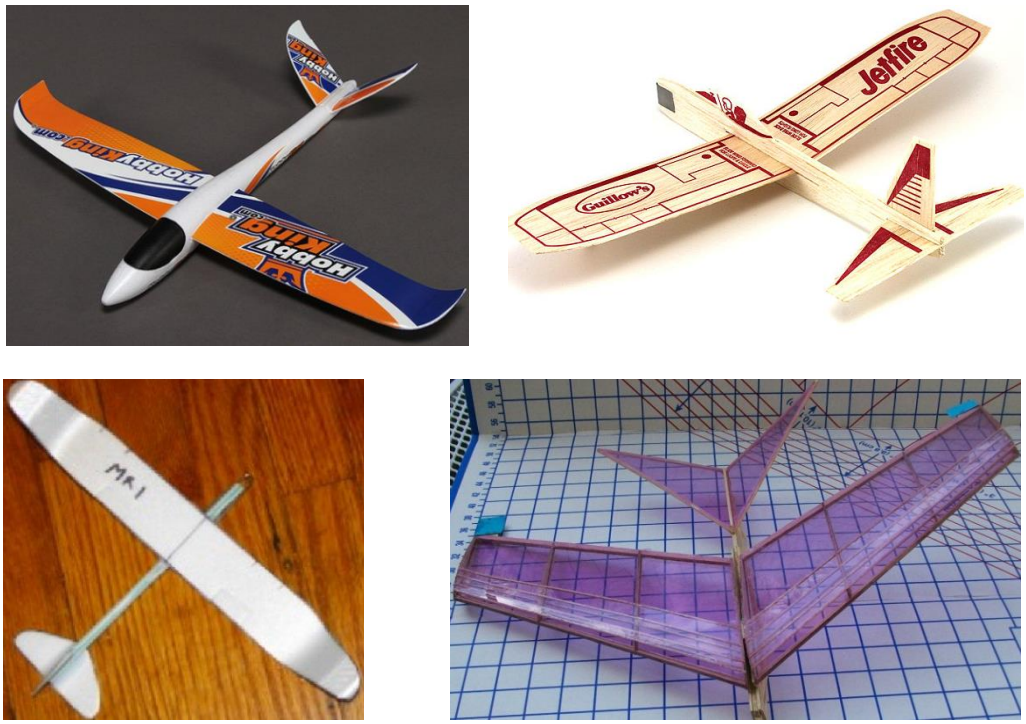

Figure 1. Some examples to conventional MAV design.

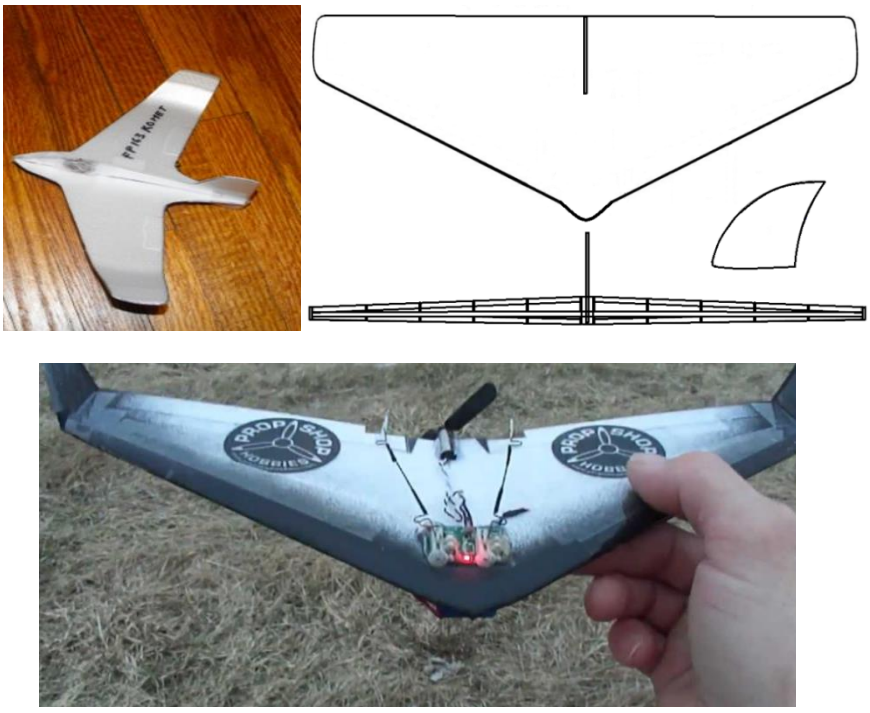

Figure 2. Some examples to flying-wing MAV design.

Mission Sequence

- The aerial vehicle will enter the assembly area with the payload of that mission uninstalled.
- After entering the assembly area the team will assemble and check their aerial vehicle prior to being called to the flight line.
- The assembly, payload loading and checkout must be completed in **less than 5 minutes.**
- The team may not work on the aerial vehicle after the assembly/loading/checkout time. The RC receiver should be able to be turned on externally or must be left on. Teams will not be allowed to re-open any compartment after 5 minutes to turn on the receiver.
- Only the assembly crew, pilot and pilot assistant may be in the staging area during the assembly. After the assembly is complete the assembly crew member may be swapped for a different flight line crew member.
- When called to the flight line the team must bring the aerial vehicle to the designated areas.
- Missions will be flown in order. A new mission cannot be flown until the team has obtained a successful score for the preceding mission(s).
- A repeat of a previously successful mission can be flown in any order.
- Total Flight Score will be the composition of the team's best score for each mission, Mission #1, Mission #2, and Mission #3.
- The aerial vehicles will be weighed each time after the team accomplishes a successful flight for that mission. The RAC will use a single weight value which will be the heaviest weight recorded on any successful flight attempt made by the team during the contest.
- Maximum take-off distance for all missions is **20 m**. All wheels must be off the runway, and remain off the runway by the marked take-off line.
- The aerial vehicle must complete a successful landing at the end of a mission for the mission to receive a score. A successful landing is outlined in the general mission specification section below.

Missions

- **Mission 1**

  - It includes a flight with 4-bottle payload.
  - The bottles are common type of 500 ml bottles of water. An example bottle illustration is given below in Figure 3.
  - Bottles must be carried internally and properly secured.
  - Take-off within the prescribed field length.
  - The flight pattern is given in Figure 4.
  - 3 Lap ferry flight.
  - Mission score : $\mathbf{M1 = 100 \times (T\_ref/T\_team)}$
  - **T_ref** is the lowest time recorded for any team that successfully completes the mission; **T_team** is the mission time recorded for that team.
  - Time starts when the throttle is advanced for the (first) take-off (or attempt).
  - A lap is complete when the aerial vehicle passes over the start/finish line in the air.
  - Must complete a successful landing to get a score.

Figure 3. An example for a bottle of water.

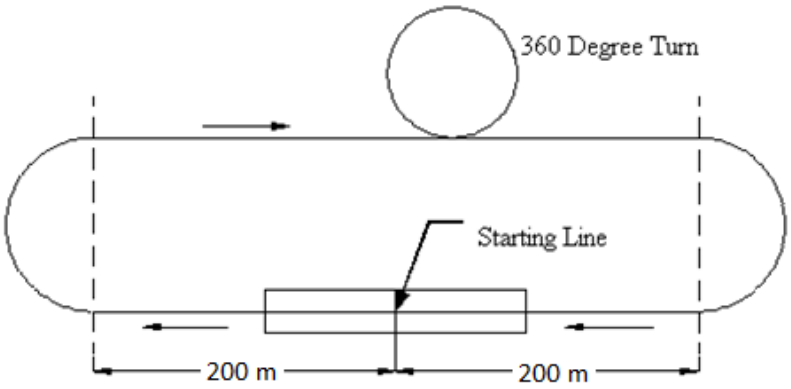

Figure 4. Flight pattern for Mission 1.

- **Mission 2**
  - 1 Lap payload flight. The flight pattern is given in Figure 5.
  - The payload must be released **safely** on each segment of the flight pattern inside the target area. No structure/components may be dropped from the UAV and MAVs during release.
  - The released MAVs should be freely flown and landed safely.
  - Mission score : $M2 = 100 \times R$
  - **R** is the scoring coefficient corresponding the number of successfully released MAVs. **For 3 MAVs R=1.5; for 2 MAVs R=1.0; for 1 MAV R=0.5; and for zero MAV R=0.1**
  - Must complete a successful landing to get a score.

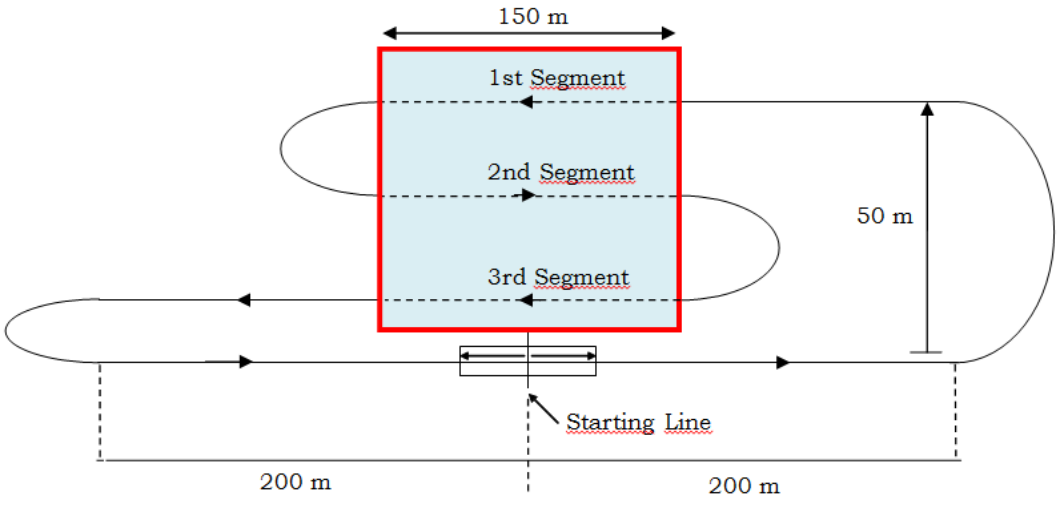

Figure 5. Flight pattern for Mission 2.

- **Mission 3**

  - It includes a flight loaded with MAVs and releasing them one after another **on the same segment** over the target area.
  - Before the flight attempt each team will declare the number of MAVs that they can carry and release. In order to get a mission score, teams must meet the required number at the end of the flight.
  - MAVs **must** be securely carried **inside** and/or **under** the aerial vehicle.
  - Take-off within the prescribed field length.
  - 3 Lap payload flight. The flight pattern is given in Figure 6.
  - The lap is completed when the aerial vehicle passes over the start/finish line while still in the air.
  - The payload must be same-type MAVs.
  - The payload will be released one after another on the **last Lap** of the flight pattern inside the target area.
  - The payload must be released **safely** on each segment of the flight pattern inside the target area. No structure/components may be dropped from the UAV and MAVs during release.
  - The released MAVs should be freely flown and landed safely.
  - Mission score : $\mathbf{M3 = 100 \times (N\_team/N\_ref)}$
  - **N_ref** is the biggest number of MAVs securely released over the target area recorded for any team that successfully completes Mission 3, and **N_team** is the number of MAVs securely released over the target area for that team from any mission attempt.
  - Must complete a successful landing to get a score.

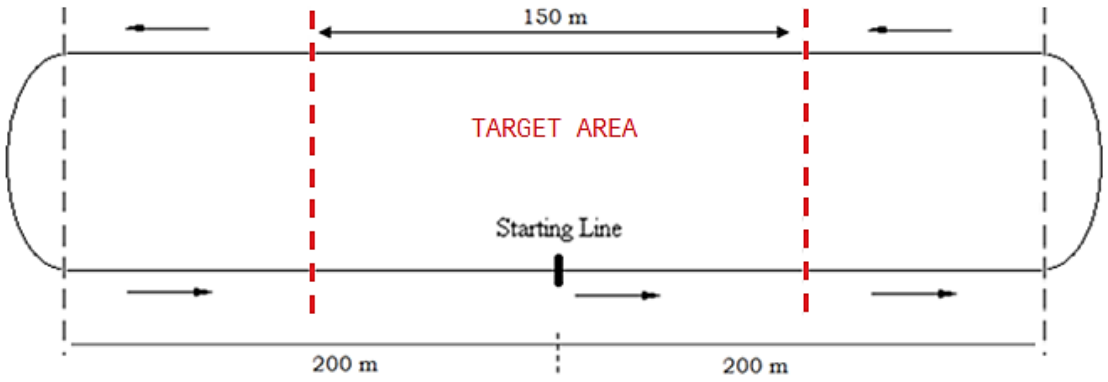

Figure 6. Flight pattern for Mission 3.

Flight line order

- A flight order list will be generated and posted at the beginning of flying. Teams will always rotate in this order. The flight order will be repeated continuously.
- Each team's position in the flight order will be determined from their written report score, highest report score goes first.
- Report scores will be available following the pilot briefing at the start of the contest.
- There will be staging box position near the flight line. While in the staging box teams can make any final preparations and checkout required prior to flight.

- If you are not in place in a staging box when your rotation number comes up you will miss your opportunity for that rotation. We will not call teams to the staging box, it is the team's responsibility to monitor the progress of the contest and decide when they need to get ready to enter an open spot in the staging box. A contest official will be available to help teams in entering the staging box area.
- Electing to enter staging box position on your turn in the rotation order will constitute using that flight turn. If you choose to leave the staging box for any reason or if you go to the flight line and are not able to begin your takeoff when instructed you may not attempt a flight until your turn comes up again in the rotation order.

General mission specification and notes

- The aerial vehicle propulsion system(s) must be "safe" (fuse removed) during any time when crew members are preparing/handling the aerial vehicle.
- Maximum flight support crew is: pilot, observer, and ground crew. Only the designated ground crew may load the aerial vehicle payload. Pilot and observer may be members of the ground crew, provided total ground crew size remains 3 people.
- Observer and all ground crew must be students. Only the pilot may be a non-student.
- The upwind turn will be made after passing the upwind marker. The downwind turn will be made after passing the downwind marker. Upwind and downwind markers will be 200 m from the starting line. Aerial vehicle must be "**straight and level**" when passing the turn marker before initiating a turn.
- Aerial vehicle must land on the paved portion of the runway. Aerial vehicle may "run-off" the runway during roll-out. Aerial vehicle may not "bounce" off the runway.
- After landing, aerial vehicle will return to the starting line as outlined in the individual mission specifications.
- Aerial vehicle obtaining **"significant" damage** during landing will not receive a score for that flight. Determination of "significant" is solely at the discretion of the Flight Line Judge.
- Flight altitude must be sufficient for safe terrain clearance and low enough to maintain good visual contact with the aerial vehicle. Decisions on safe flight altitude will be at the discretion of the Flight Line Judge and all rulings will be final.
- The released micro UAVs should be freely flown over the target area and landed safely. MAVs obtaining significant damage during landing may not receive a score for that flight.

Flight Course

The orientation (direction) of the flight course will be adjusted based on the prevailing winds as determined by the Flight Line Judge. The flight course will be positioned to maintain the greatest possible safety to personnel and facilities. The nominal flight courses are given in the Missions section.

Protest Procedure

Submitting a protest is a serious matter. Teams may submit a protest to the Contest Administration at any time during the competition. Protests may not be submitted after the conclusion of the competition. Protests must be submitted in writing and signed by the team advisor, designees are not allowed for protest submissions. If the team advisor is not present, he may FAX or email a signed

protest to the team for them to present. Protests may be posted for review at the decision of the administration.

Protests and penalties (up to disqualification from the contest for deliberate attempts to misinform officials, violate the contest rules, or safety infractions) will be decided by the Contest Administration. **The decision of the Contest Administration is final.**

Design Report

- Each team will submit a judged design report as outlined below and in the schedule section above.
- Reports must strictly adhere to the following requirements. Failure to meet requirements will result penalties that range from score reduction to elimination from the contest.
- Reports must have the School/Collage/University name (as listed on the original entry form, not team "nicknames") on the cover page. Reports missing this identification information will not be scored.
- Report PDF must be formatted as A4 (21 × 29.7 cm) pages. The drawing package may be A3 (29.7 × 42 cm) pages. A 10 point penalty will be given for the use of oversize paper.
- Absolute maximum page count for the report is **60 pages**, inclusive of all pages of any type including front cover, blank pages and A3 size drawing pages. Reports exceeding the maximum page count will be given a 10 point penalty for each additional page.
- Reports will be scored on a 100 point basis following the guidelines outlined below. All information used for scoring must be in the outlined sections, content that is out of sequence, including the drawing package, will be treated as missing and scored accordingly.
- All reports should be at least one and one half line spacing, 10-pt Arial font. Tables and figures should be clear and readable for the judges. Margins should be at least 2.5 cm on all sides. The reports will be judged on format and readability.
- All items requested below should be present, easy to locate and identify, well documented and in the correct section for full scoring.
- Examples of winning team design reports from prior contest years are posted on the contest website. Prior year reports may not reflect or meet the rules listed for the current year.
- Report scores will not be available prior to the contest weekend.
- Report scoring is based on the reports **as submitted**. Final proofing of the report prior to submission is strongly encouraged.

Design Report

All section scores will include format, completeness and readability.

1. Executive Summary **(10 points)**
   - Provide a summary description of your selected design and why it is the best solution to the specified mission requirements.
   - Describe your key mission requirements and design features keyed to those requirements.
   - Document the performance/capabilities of your system solution.

2. Management Summary **(5 points)**
   - Describe the organization of the design team.

- Provide a chart of design personnel and assignment areas.
- Provide a milestone chart showing planned and actual timing of the design/fabrication/testing processes.

3. Conceptual Design **(15 points)**
   - Describe mission requirements (problem statement).
   - Translate mission requirements into design requirements.
   - Review solution concepts/configurations considered.
   - Describe concept weighting, selection process and results.

4. Preliminary Design **(20 points)**
   - Describe design/analysis methodology.
   - Document design/sizing trades.
   - Describe/document mission model (capabilities and uncertainties).
   - Provide estimates of the aerial vehicle lift, drag and stability characteristics.
   - Provide estimates of the aerial vehicle mission performance.

5. Detail Design (**30 points** total. 15 points for discussion items, 15 points for drawing package)
   - Document dimensional parameters of final design.
   - Document structural characteristics/capabilities of final design.
   - Document systems and sub-systems design/component selection/integration/architecture.
   - Document Weight and Balance for final design. Must include a Weight & Balance table for the empty aerial vehicle and with each of the possible payloads.
   - Document flight performance parameters for final design.
   - Document mission performance for final design.
   - Drawing Package, 3-View drawing with dimensions.
   - Structural arrangement drawing.
   - Systems layout/location drawing.
   - Payload(s) accommodation drawing(s).

6. Manufacturing Plan and Processes **(5 points)**
   - Document the process selected for manufacture of major components and assemblies of the final design.
   - Detail the manufacturing processes investigated and the selection process/results.
   - Include a manufacturing milestone chart showing scheduled and actual event timings.

7. Testing Plan **(5 points)**
   - Detail testing objectives, schedules, and check-lists.

8. Performance Results **(10 points)**
   - Describe the demonstrated performance of key subsystems and compare it to predictions from Section 5. Explain any differences and improvements made.
   - Describe the demonstrated performance of your complete aerial vehicle solution and compare it to predictions from Section5. Explain any differences and improvements made.

Design Report Electronic Submission

Each team must provide an electronic copy of their final design report for the report judging as outlined below.

- Electronic copy must arrive at the **reports-ffd2015@hho.edu.tr** email by 5 pm local time (UTC+02:00 Istanbul) on **10 April 2015**.
- Electronic PDF report files must be named: "**FFD2015_[school name].pdf**".
- Electronic report must be a single file with all figures/drawings included in the proper report sequence in PDF format. (Free office and PDF file conversion programs are available on the Internet.)
- Electronic reports should have all figures compressed to print resolution to minimize file size.
- Electronic reports must be less than **15 MB** in size (including encoding for e-mail transmission).

Reports not following the name format or exceeding the file size will be rejected. We will notify the team only if the report arrives in the email INBOX. If the report is rejected by the email system for being too large we may not be able to send a notification of the problem to the team.