Institution of MECHANICAL ENGINEERS

PROPELLAIR 2020

Rulebook

Propellair 20

What's Inside

Comprising of missions and tasks to be be performed during the competition and sets of rules to be considered to ensure a fair competition.

Contents

1. INTRODUCTION

Have you ever wanted to experience the thrill of flying aero planes without leaving the ground? If so, Radio Controlled (R/C) flying might just be the pastime for you. The hobby has grown by leaps and bounds in recent years, and with drones and other unmanned aircraft becoming the talk of the day, the era of RC planes is fast approaching. For those interested in a taste of remote aviation, NED University brings you this thrilling competition. In this competition, the participants must design, fabricate and fly an electric-powered/engine powered aircraft. The aircraft should be such as to be able to perform various aerobatic maneuvers and capable to carry a designated payload.

The competition is aimed to engage University Undergraduate teams in the design, construction, development and demonstration of a Radio Controlled Aircraft.

The Event is focused on:

- Providing an opportunity to the students to learn practical aerospace engineering skills for industry.
- Providing a challenge to the students in innovative airframe design and the systems engineering of a complex system, requiring them to follow an industry-recognized engineering development lifecycle (design, development, and demonstration) against a demanding mission requirement.
- Providing an opportunity to the students to develop and demonstrate team working, leadership and commercial skills as well as technical competence.
- Enhancing employment opportunities in the sector.

2. COMPETITION OVERVIEW

2.1 MISSION

Teams are required to prepare their radio control aircraft (see sec: 4) to complete two missions:

- Perform maneuvers as described in section 8.1
- Complete a successful flight with **two external payloads** as described in section 8.2
- Perform autonomous maneuvers as described in section 8.3 for **bonus points.**
- Perform banner towing as described in section 8.4 for **bonus points.**

2.2 ENGINEERING CHALLENGES

- The Challenge has been designed to give students exposure to a number of disciplines that they will need in their engineering careers which are:
- A methodical system engineering approach to identify the requirements, selection of the concept with a design to meet those requirements and then test to confirm that the actual system meets the requirements in practice.
- An elegant and efficient design solution, supported by an appropriate depth of analysis and modelling.
- Innovation in the approach to solve the engineering challenges.
- Due consideration of the safety and airworthiness requirements which shall be addressed from the early concept stage right through into the flying demonstration.
- Appreciation of the practical engineering issues and sound design principles essential for a successful, robust and reliable aircraft; e.g. adequate strength and stiffness of key structural components, alignment of control rods/mountings, servos specified appropriately for the control loads, consideration given to maintenance and ease of repair in the field.
- Construction quality, paying attention to good aerospace practice for such details as the connection of control linkages, use of locknuts, security of wiring and connections, the resilience of the airframe and undercarriage.

- Good planning and team-working; organizing the team to divide up roles and responsibilities. Good communication and planning will be essential to achieve a successful competitive entry, on time and properly tested prior to the demonstration event.

2.3 JUDGMENT CRITERIA

Students must design, document, fabricate and demonstrate the aircraft that they determine as best capable of achieving the highest score on the specified mission profile(s). The overall team score is a combination of the Report, Presentation, Question/Answer, MCQ based test and Flight scores. The team with the highest overall team score will be declared as the winner.

Grading of the complete event will be as follows:

Report (see sec: 5.1)	50 points
Presentation, Question/Answer and MCQ Test (see sec: 6.0 & 7.0)	50 points
Flying	120 points

- During the event, if it is found that the aircraft of any team is ready-made or pilot-made, the judges will have the right to disqualify that team.
- Teams are required to submit photos and videos of aircraft manufacturing, along with the submission of the final report.

2.4 BEST DESIGN

- If the design is non-conventional; e.g. tapered wings, under cambered airfoil, cylindrical fuselage, etc. then you will be granted additional points.
- Your team will be granted additional points if your design ends up being the most economical among all.

3. ELIGIBILITY AND TEAM STRUCTURE

- All team members (except for a pre-approved pilot) must be full-time undergraduate students from any University/Institute of Pakistan.
- Each team can consist of a minimum of **3** and maximum of **6** students (excluding pilot).
- Registration Fee is **3500 RS only** per team.

Teams may accept sponsorship in the form of funds or materials and components from commercial organizations. However; **all design analysis and fabrication up to the entry of the competition is the sole responsibility of the team members.**

4. AIRCRAFT REQUIREMENT

4.1 DESIGN REQUIREMENTS

Teams are required to design the aircraft and must justify the selected parameters for their design. However, the aircraft must follow below mentioned requirements:

4.1.1 WEIGHT LIMIT

- Total flying weight without payload must not exceed **3500 grams.**
- Exceeding the weight will cause a deduction of 10 points per 100 grams.

4.1.2 NON-TRADITIONAL DESIGN CHALLENGE

- Teams with traditional design will face **penalty** of 25 points.
- In order to avoid penalty, they are required to change either fuselage, wing .
- Traditional design means a plane that has rectangular wings, rectangular or square fuselage and conventional tail configuration.

4.2 GENERAL REQUIREMENTS

- The aircraft must not be a rotary wing or lighter-than-air aircraft.
- No structure/components should be dropped from the aircraft during flight.
- All aircraft must be propeller driven and electric powered/engine powered with an unmodified over-the-counter model electric motor/engine. Teams may use multiple motors and/or propellers. The

aircraft may be direct drive or with gear or belt reduction.

- No form of externally assisted take-off is allowed.
- Electric motors may be any commercial brush or brushless.
- For safety, each aircraft will use a commercially produced propeller. 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.
- Must use over the counter NiCad, NiMH or LiPo batteries. For safety, battery packs must have shrink-wrap or other protection overall electrical contact points. All battery disconnects must be "fully insulated" style connectors.
- Motors and batteries may be limited in the current draw by means of a fuse in the line from the positive battery terminal to the motor controller. It is the responsibility of each team to properly size the fuse to protect the battery, motor and controller against overcurrent from any source.
    - Fuse(s) must be located such that no propulsion system component: a motor; motor controller; or the battery may see more current than the stated limit (fuse value).
    - The fuse must be placed in the positive (+) lead from the battery and should be as close to the battery(s) as feasible.
    - Only ATO or blade style fuses must be used.
- No ready-made kits are allowed. Aircrafts built by ready-made kits will be disqualified.
- Elastic bands are not acceptable as self-locking mechanisms. Additionally, pins or other alignment features must be self-aligning. So, positioning or aligning of features by the ground crew member during deployment of surfaces or features to the flight condition is allowed.

4.3 SAFETY REQUIREMENTS

All aircrafts will undergo a safety inspection by a designated Competition Safety Inspector prior to being allowed to make any competition flight. All decisions of the safety inspector are final. Safety inspections will include the following as a minimum.

4.3.1 PHYSICAL INSPECTION OF AIRCRAFT TO ENSURE STRUCTURAL INTEGRITY

- Verify all components adequately secured to aircraft. Verify all fasteners are tight and have either

safety wire, Loctite (fluid) or Nylon Locknuts. Clevises on flight controls must have an appropriate safety device to prevent disengagement in flight.

- Verify propeller structural and attachment integrity.
- Visual inspection of all electrical wiring to assure adequate wire gauges and connect or sinuse.
- Radio range check.
- Verify all controls move in proper sense.

4.3.2 RADIO FAIL-SAFE CHECK

All aircraft radios must have a fail-safe mode that is automatically selected during the loss of transmit signal. The fail-safe will be demonstrated on the ground by switching off the transmit radio. During the fail-safe, the aircraft receiver must select:

a) Throttle closed

b) Full up the elevator

c) Full left rudder

d) Full right (or left) aileron

e) Full Flaps down (if so equipped)

Note: The radio Fail Safe provisions will be strictly enforced.

4.3.3 STRUCTURAL VERIFICATION

All aircraft will be lifted with one lift point at each wing tip to verify adequate wing strength and to check for C.G location. Teams must mark the expected C.G locations on the exterior of the aircraft fuselage. Special provisions will be made at the time of the competition for aircraft whose C.G does not fall within the wing tip chord.

If any aircraft shows an unsafe maneuver, intentionally or unintentionally, then the judges have the right to cancel all the flying marks and would not be allowed for any further flying attempts.

In addition to the above-mentioned condition if any activity of the team member or the pilot is unsafe; the team would be disqualified.

All structural components of an aircraft must remain intact and rigid after giving full-throttle on the ground.

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5. TECHNICAL REPORT

Reports must be submitted on or before time otherwise 05 points per day will be deducted from the final scoring. Teams must submit 3 hard copies and a soft copy; only hard copies will be used for judging. No editing will be allowed once the report has been submitted. Teams that fail to provide the report will not be eligible to fly their aircraft on the event day.

5.1 REPORT FORMAT

Reports must include the following details:

5.1.1 MANAGEMENT SUMMARY (10 points)

- Provide the description of the team along with their responsibilities.
- Provide a Gantt chart.

5.1.2 DESIGN SPECIFICATIONS (15 points)

- Provide complete details of your design.
- Show each step of the design process.
- Detail design of each component must be provided.

5.1.3 CAD DRAWING AND CFD (10 points)

- Detailed CAD model of every component (2D and 3D).
- CFD analysis of airfoil to obtain C_L and $C_{d.}$

5.1.4 FABRICATION DETAILS (10 points)

- A complete description of the fabrication process.
- Materials used.
- Manufacturing process.

5.1.5 THRUST PRODUCING DEVICE (05 points)

- Provide detail characteristics of the thrust producing device used e.g. Engine, Motor and Propeller, etc.
- Calculation of thrust to weight ratio.

6. E-TEST

E-test will be conducted prior to the event day to assess the knowledge of aircraft and aerodynamics of participants. There will be **20 MCQs** in the test with **negative marking of ¼ on each wrong answer**. All members of the team will appear in it separately.

7. PRESENTATION AND QUESTION/ANSWER SESSION

- All teams are required to prepare a maximum 6-minutes presentation in which minimum three members have to give presentation and others must be physically present with them. The aim is to explain how you utilized time, your journey, your innovation and the methods you adopted. (Schedule will be commenced to the registered team soon)
- All teams are required to be prepared for the debriefing session.
- In this debriefing session, the judges will test the knowledge of students regarding aerodynamics and their fabricated aircraft.
- Any team which misses debriefing session will miss marks for this activity. A debriefing session is a very important activity that will provide the physical and theoretical judgment of the design to fly.

E-test	20 points
Presentation & Question/Answer	30 points
Total	50 points

8. MISSION SPECIFICATIONS

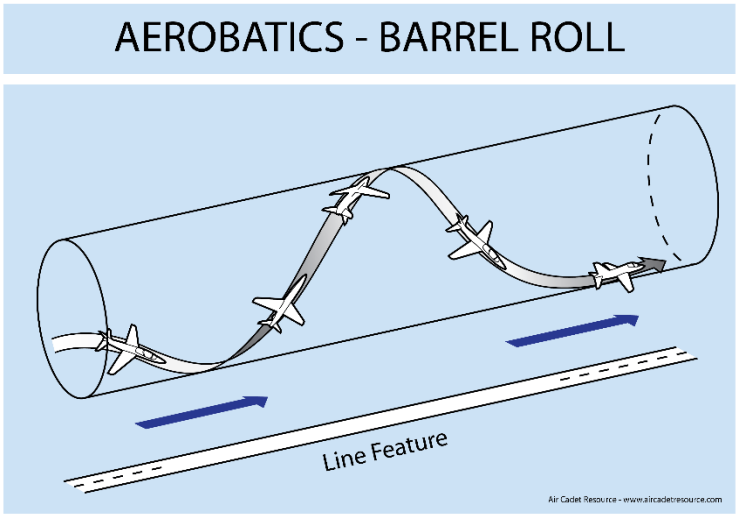
There are total two compulsory missions and the maximum number of attempts is 1 for each mission (It may be changed on competition day based on the number of entries, weather and field conditions.)
The decision of taking 2nd attempt is up to the team if they want to take it or not. However, if a team opts for 2nd attempt, the score of 2nd attempt will be counted whether it is better or worse than the previous attempt.

It is a general requirement for **both** the missions that aircraft should takeoff within the prescribed runway limit. **Exceeding the limit will result in a penalty of points as follows:**

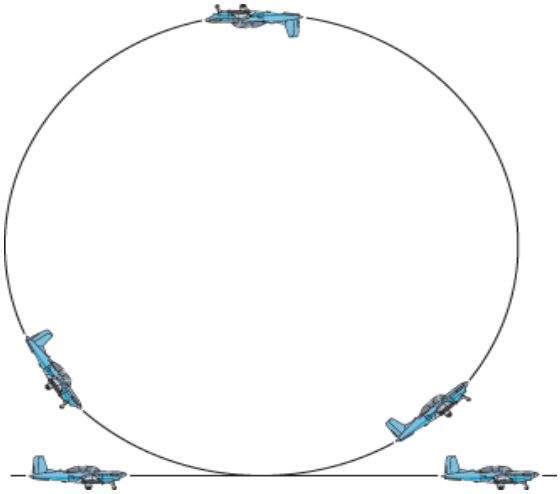
Takeoff distance	Points deduction
Less than 40 feet	0
Less than 50 feet	2
Less than 60 feet	4
More than 60 feet	8

8.1 MISSION 1

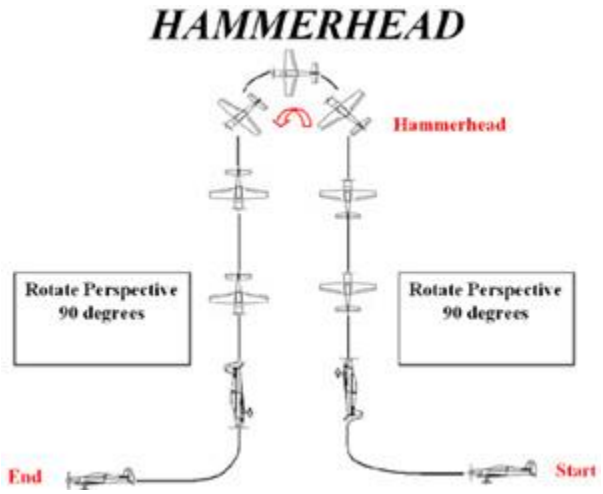
8.1.1 BARREL ROLL



8.1.2 VERTICAL LOOP



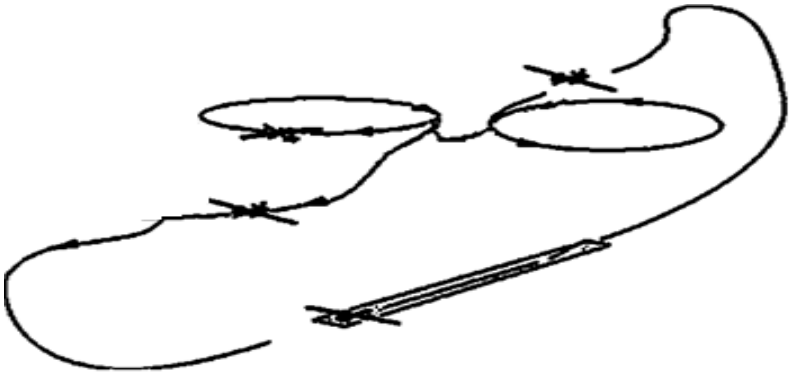
8.1.3 HAMMERHEAD



- These aerobatic maneuvers must be performed in the order as mentioned above.
- The maximum flight time for the 1st mission will be **4 minutes** after which penalty would be applied.
- Maximum Score: **70 Points**

8.2 MISSION 2

- Second round will be performed with the external payloads.
- In the Payload flight, the aircraft will take-off and first fly 2 different laps. One lap means that the aircraft must complete a 360-degree turn.
    a) Lap1 =360 left
    b) Lap2 =360 right



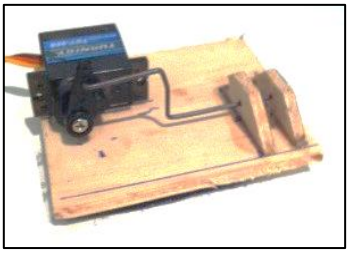
- All the aircrafts must be capable of carrying **2 payloads of 155 ±5 grams each** which could be carried externally. After performing above two loops, the aircraft will proceed for payload drops in the specified drop zones. The payload drop mechanism must be servo-operated and activated by remote control.
- Then the aircraft without engine off will perform Immelmann turn followed by barrel roll.
- The maximum flight time to complete the 2nd mission will be **4.5 minutes** after which penalty will be applied.
- Maximum Score: **50 Points.**

8.2.1 PAYLOAD DESCRIPTION

- Teams are required to prepare **two payloads by themselves** each of which weighs **155 ± 5 grams.**
- Payload can be of any appropriate shape and size. An example of a payload made of PVC pipe is shown in the figure.

- Participants can decide to attach the payload either at the belly or near the wing tips.
- Payload must be secured in place to ensure that it does not jerk around during flight.
- Payload must be colored or such stickers should be used which makes it easily visible when dropped on the target.

8.2.2 PAYLOAD DROP MECHANISM

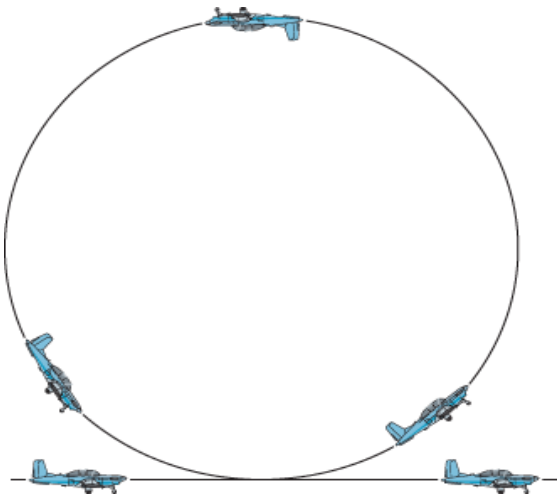


- The payload drop mechanism must be servo-operated and activated by remote control. An example is shown in the figure.
- Any plane whose mechanism is not secure won't be allowed to perform Mission 2.

8.3 MISSION 3 (Optional)

Mission 3 should be performed using automation, which should include the use of different microcontrollers e.g. Raspberry pi 2, or Arduino and Pixhawk. The teams using automation for mission 3 will get 35 marks as bonus on their score for mission 3, decided by the judges

8.3.1 VERTICAL LOOP

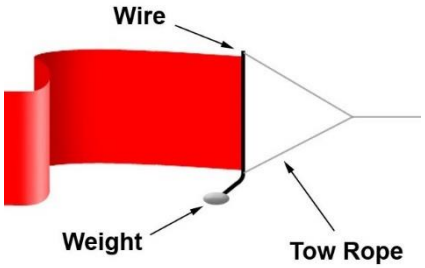


8.4 MISSION 4 (Optional)

8.4.1 BANNER TOWING

There will be two banners which includes

- A large banner of 30-inches in length and height of 10-inches from which a team can get 35 points bonuses.
- A small banner of 15-inches in length and height of 5-inch from which a team can get a bonus of 15 points bonuses.
- The banner must remain in the vertical orientation during flight.
- The banner will be provided by IMechE NED Student Chapter, the teams should have an proper attachment point of string of banner on the aircraft.



9. FLIGHT LINE ORDER

- A flight order list will be generated and posted at the beginning of flying.
- There will be two staging box positions 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 number comes up you will miss your opportunity for the flight.
- Electing to enter one of the staging box positions on your turn will constitute using a flight attempt
- If you choose to leave the staging box for any reason, you will forfeit that flight attempt.
- If you go to the flight line and are not able to begin your takeoff when instructed, you will forfeit that flight attempt.

Note: We will not call teams to the staging box; it is the team's responsibility to monitor the progress of the Competition and decide when they need to get ready to enter an open spot in the staging box. A Competition official will be available to help teams in entering the staging box area. If you miss your flying attempt 5 marks would be deducted from flying score.

10. Deadlines

Report Submission	**One week before Flight Day**
Test Flight Video	**4 days before Flight Day**
Flight Day (Tentative)	**Last Week of June**

11. Questions/Comments

Questions regarding the Competition, schedules or rules interpretation may be sent to us by e-mail mentioning team name and personal name.

For any questions, contact one of us:

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