Aeronautical Society of South Africa

2017 Aerospace Challenge

Draft Rules

14th October 2017

Version 1.0

Introduction

The goal of the 2017 Aerospace Challenge is for the teams to conceptualise, design, construct and fly model aircraft in two different categories. The **Inter-University Challenge** and **Open Challenge** are for designs that are radio-controlled, capable of taking off under its own power and flying as fast as possible over a short course, the **Inter-School Challenge** is for 500 mm span model gliders to compete.

- All competitors entering the **Inter-University Challenge** must be currently registered full time students at a SA university.
- Anybody, **especially corporates**, may enter the **Open Challenge**

The same rules apply to both of these categories.

- The **Inter-school Challenge** will be flown on the same day between the flights of the pylon racing models. Separate rules will be added to these rules in a later version of this document.

This is intended to be **a fun competition** with the intention of encouraging interest in both aviation and aeronautics amongst all hence entry not being limited to only pupils and students.

Inter-University Challenge and Open Challenge

General Rules

The competition is open to any individuals or teams consisting of up to **seven** competitors.

A **maximum** of **three** models is allowed per team (or a **maximum** of **two** models per individual) provided that they differ noticeably in geometry.

While anybody may enter as a team member, only a **SAMAA approved solo pilot** may fly the models at the competition. The pilot should preferably be one of the team members.

Organiser-furnished pilots may be available to fly the models for the **Inter-University Challenge** and **Inter-school Challenge** teams. Please make your request **at least two weeks** before the competition.

Building assistance from members outside of the team is permitted.

The models will be scrutineered before the event for compliance with the model rules and specifications.

Any team/individual whose model does not comply with the rules will be allowed a chance to modify the model before attempting to pass scrutineering.

Any model that is judged to be inherently unsafe to competitors or spectators may be disqualified at the judges' discretion.

The use of propellers that are not commercially available or in a manner for which they weren't intended may result in the model being disqualified on safety grounds at the judges' discretion.

Remote control of the model must be provided on a **SAMAA approved frequency** and with an ICASA approved transmitter.

Transmitters transmitting on the 2.4GHz frequency are encouraged.

Radio equipment required is to be sourced by the teams/individual.

Any team/individual not entering in the spirit of the competition may, at the judges' discretion, be disqualified.

Model Rules and Specifications:

All models shall use the same (unmodified) electric motor – the E-flight Park 450. (http://www.e-fliterc.com/Products/Default.aspx?ProdID=EFLM1400) available from many hobby shops. Some universities will have these available from the previous competitions.

The power source is limited to a **3 cell Lithium Polymer (LiPo) battery** of sufficient capacity for the required tasks.

The **minimum** span of the model shall be **1000 mm** measured in a straight line at right angles to the fuselage in plan view from left wing tip to right wing tip.

There is no fuselage length limitation.

Any model entered in the competition must be an **original design, no major components from existing model aircraft such as wings, fuselage or tails are permitted**.

Use of standard model aircraft hardware such as engine mounts, control horns, and landing gear is allowed.

Designs are limited to **fixed winged** aircraft configurations only and the model must fly largely on the aerodynamic effects of its wing(s).

The mass of the model may not be altered during take-off or flight.

Geometry changes on the model (flaps, wing sweep etc.) are allowed providing it is brought about by remote control.

The fuselage, wing and tails may be constructed of any material.

The flight batteries may be replaced or recharged between attempts.

Repairs to the models are permitted at all times during the competition – bring super glue!

Flight Rules

The flight consists of a four leg pylon race. All models are to take off from the ground and within **30 seconds** of motor start enter and fly, in a controlled manner and as fast as possible, four lengths of the pylon course of 150 m, turning at each end (i.e. 600 m in total).

The models are timed from their first entry into the course or at the end of the 30 seconds from motor start, whichever is the earlier.

A late entry into the pylon course incurs no other penalty than the additional time recorded from the 30 second mark.

The model must be landed within **one minute** of completing the course.

All turns in the course **shall be directed away** from the spectator side of the course. Any turns in the course towards the spectators **will result in a zero score** for that flight. This is an important safety rule.

Any object falling from the model during the take-off, flight or landing may disqualify the attempt.

Flight Scoring

The objective is to fly the course in the shortest time.

At least **three attempts** at flying the course (time allowing) will be permitted per model.

The fastest time in each category will be awarded 100 points and the remainder of the team's/individual's flight scores calculated on a pro rata basis.

The highest two scores of the three attempts will form the basis for the official **flight score** for each team/individual.

Overall Scores

The various Challenge winners will be the team/individual that has the highest **score.**

In the event of a tie, the teams/individuals shall enter a winner-takes-all fly off task.

Venue and times

The venue for the event is still under discussion. The safety briefing will take at 08h45 and the first flights taking place at 09h00.

Contacts:

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Aeronautical Society of South Africa

2017 Aerospace Challenge

Inter-University Challenge and Open Challenge

Official Entry Form

Category name: ____

Team/individual name: ______________________________________

University/School/ Company name: ___________________________

Team members: (Pilot) ____________________________ __________ (SAMAA no.)

(2) ____________________________ __________

(3) ____________________________ __________

(4) ____________________________ __________

(5) ____________________________ __________

(6) ____________________________ __________

(7) ____________________________ __________

Number of models entered: ______

Transmitter frequencies: ____________ ____________ ____________

Contact e-mail address for team manager: ____________________________

Contact cell phone number for team manager: __________________________

We agree to abide by the rules of the 2017 Aerospace Challenge:

Signed (team manager – on behalf of the team): __________________________

Date: __________________________

Please complete, sign, scan and e-mail this entry form to John Monk at jsmonk@csir.co.za.
Entries officially close at midnight on Wednesday the 11th of October 2017.

Version 1.0

Design tips – for the aerodynamicists amongst you

The intention behind these rules is for the model designer to understand that there is an optimal design model that will fly the fastest around the course with the prescribed motor. The aerodynamic compromises required for that optimal design come from choosing a design that will be fast (low overall drag) in the straight sections of the course and will lose a minimal amount of energy in the turns (low induced drag).

The electric motor has been purposefully chosen to provide enough power for a well designed aircraft to fly relatively fast around the course and for a not-so-well designed aircraft to still be able to complete the course in a reasonable time. A more powerful motor would decrease the difference between a good design and a not-so-good design.

Hint: Design a light weight, low drag aeroplane.

The aircraft overall configuration is up to the designer to choose.

I will lay out three basic design approaches that can be followed – none of these are cast in stone and in all cases the approach can be modified and improved with careful thought. The first approach focusses just on designing for the pylon course and will require a basic understanding of aircraft design and the effect of aspect ratio on drag. The second approach will require the use of some aerodynamic analysis tools to more accurately predict and hence improve the performance of the model. The third approach requires some software coding to simulate the whole task from initial climb to the completion of the task to assist in the optimisation of the design. Optimally the motor/propeller modelling should be included in the simulation.

Design approach 1

The ultimate goal is to reduce the energy loss due to drag in flight throughout the course to a minimum and maximising the use of the motor power.

(Hint: The general rule for all these approaches is to reduce the mass of the model as much as is safely possible as this will typically reduce the drag at any speed.

During the flying of the pylon course, the aerofoil will be operating at two opposite ends of its lift coefficient range. In the straight legs the model will (hopefully) be flying fast and the aerofoil will be operating at a low lift coefficient. During the turns the aerofoil will be operating at a higher lift coefficient to minimise the turn radius and hence time outside the course. Too high a lift coefficient though and the energy loss due to drag will be too high, too low a lift coefficient and the turn radius and time outside the pylon course will penalise your flight time.

The model's drag can be broken down fundamentally into two components, lift independent drag (Cd_0) and lift dependent drag or "induced drag" (Cd_i). Lift independent drag (Cd_0) is a function of the skin area and smoothness, how well the design is streamlined and how few bits are hanging out in the breeze. Induced drag (Cd_i) is largely a function of aspect ratio, that is wingspan divided by mean aerodynamic chord (very similar to average chord). It is important to understand that a higher aspect ratio wing will produce less induced drag in the turns than a low aspect ratio wing.

(Hint: Look up these terms on-line for a deeper understanding of the concepts)

Having learned that, your design approach could be something along these lines.

1. Assume an aircraft with a given span (equal to or greater than 1200 mm) and aspect ratio – from this you can determine your wing area.
2. Assume an overall drag coefficient (Cd_0) of the model, say 0.020.
3. Assume a realistic flying mass (you work this one out) and a reasonable top speed (start with 25-30 m/s) and calculate the lift coefficient in the straight legs of the pylon course.
4. Choose an aerofoil from the UIUC database (Google it) whose low drag range extends down to that lift coefficient and preferably slightly lower.
5. Now taking 80% of the maximum lift coefficient (the **wing** maximum lift coefficient is always less than the aerofoil's **2D** maximum lift coefficient), calculate the turn radius you can achieve and the time to turn through 180 degrees.
6. Calculate the induced drag in the turn.
7. Take a time weighted average of the drags and record your answer.
8. Now adjust your span, aspect ratio and choice of aerofoil selection to minimise the drag.

Do a sanity check on your results!

Design Approach 2

In the previous method, the drag was estimated very roughly to obtain a "ballpark' figure. To improve your accuracy you can use tools such as XFOIL or XFLR5 to design and analyse your wing and more importantly predict the **actual** drag based on Reynolds number effects etc.

XFLR5 will also allow you to check that at high angles of attack the local lift coefficient outboard on the wing does not exceed those values inboard as that can cause a tip stall when turning tightly. If they do, you can increase the chord width at your tips, twist the wing tips downwards (adding "washout") or reduce the sweep, if you have any.

Design approach 3

Using the same estimation tools, model the flight from take-off through the climb phase (typically at a lower speed) and then through the pylon race. The modelling of the electric motor and propeller combination is important here and there are a few software tools on the internet that can help (PropCalc, MotorCalc, etc.). You should now optimise your design altering the wing geometry, span, aspect ratio, twist, aerofoil choice and propeller type. You can add other parameters if you wish such as flap settings etc.

Good luck with your designs and we hope to see you on the 14^{th} of October!