Category C1
Challenge Booklet 2023

Organised by:

DSO NATIONAL LABORATORIES

SCIENCE CENTRE singapore

Supported by:

MINDEF SINGAPORE

Partners:

DSTA Defence Science & Technology Agency

THE AIR FORCE ABOVE ALL

ST Engineering Aerospace

SP Singapore Polytechnic

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NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

NUS National University of Singapore

SINGAPORE YOUTH FLYING CLUB

FLIGHTSCIENCE AERO LABORATORIES

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SAFMC 2023 CAT C1 CHALLENGE BOOKLET CHANGE LOG

Version	Release Date	Description
1.0	16 Nov 2022	Official challenge booklet release

SAFMC 2023 COMPETITION SCHEDULE

Date*	Event	Platform/Venue
20 - 29 March 2023	Presentation	Challenge day
20 – 29 March 2023	Category Challenges	Science Centre Singapore
1 April 2023	Awards Presentation Ceremony	Science Centre Singapore

* *The competition schedule is subject to changes in accordance with the latest MOE guidelines for COVID-19. Any changes will be updated on the SAFMC Website and Facebook. Registered participants will be informed via their registered email address*.

CONTENTS

SINGAPORE AMAZING FLYING MACHINE COMPETITION 2023

1. INTRODUCTION

Singapore Amazing Flying Machine Competition (SAFMC) is an exciting and unique event organised by DSO National Laboratories and Science Centre Singapore, and supported by Ministry of Defence (MINDEF). Open to all schools and participants who are keen to explore the science behind flight and create their very own flying machines, this annual competition promises a fun-filled learning journey with special talks, workshops and live demonstrations.

2. CATEGORIES

CATEGORY A – PAPER PLANES *(Primary Schools)*

Each team should consist of TWO (2) to THREE (3) members.

Design and fold paper planes to achieve the longest, farthest or most unique flight.

CATEGORY B – UNPOWERED GLIDERS *(Secondary Schools / Integrated Programme)*

Each team should consist of TWO (2) to FIVE (5) members.

Category B will be open to a maximum number of 150 registered teams.

Design and build small unpowered bungee-launched gliders to achieve the farthest and most precise flight.

CATEGORY C – RADIO CONTROL FLIGHT / FIRST PERSON VIEW (FPV) FLIGHT (NOVICE, ADVANCED)

Category C1: Radio Control Flight - Fixed Wing *(Secondary Schools / Integrated Programme / Junior Colleges / Institute of Technical Education)*

Each team should consist of TWO (2) to FIVE (5) members.

Design and build a small remote-controlled fixed-wing air platform to navigate an obstacle course.

Category C2: FPV Flight – Novice *(All Schools)*

Each team should consist of ONE (1) to TWO (2) members.

Bring, or design and build, a ducted (shielded propeller) FPV drone to compete in an obstacle course.

Category C3: FPV Flight – Advanced *(All Schools)*

Each team should consist of ONE (1) member.

Bring, or design and build, a FPV drone to compete in an obstacle course.

CATEGORY D – SEMI-AUTONOMOUS / AUTONOMOUS (Polytechnics / Universities)

Category D1: Semi-Autonomous

Each team should consist of TWO (2) to FIVE (5) members.

Design and build up to three semi-autonomous small air platforms, controlled using wearables, to perform a multitude of tasks in an indoor course.

Category D2: Autonomous

Each team should consist of TWO (2) to FIVE (5) members.

Design and build three autonomous small air platforms to collaboratively perform a multitude of tasks in an indoor course.

CATEGORY E – SWARM (Open to Public)

Each team should consist of TWO (2) to TEN (10) members.

Bring, or design and build, a swarm of TEN (10) to TWENTY-FIVE (25) drones to compete in a search-and-rescue mission.

3. GENERAL SAFMC 2023 RULES

- **The deadline for registration is 24 February 2023.**
- Participants registered under a school must be full-time students at the point of competition.
- Home-schooled participants and teams consisting of participants from different schools should be registered as “Independent teams”.
- Participants will be notified upon successful registration within two weeks of the registration deadline. The decisions made by the SAFMC organising committee

are final, and subjected to the competition schedule and availability of logistics support.

- Each person can only participate in one team within a category. However, the person can participate as a member in different categories, i.e. a person can be a member of a team in Category B and another team in Category C but the person cannot be a member for two teams in Category B.
- Teams are allowed to take part in categories beyond the specified educational level, i.e. Primary school students are allowed to take part in Category B, C, D or E. Secondary school students are allowed to take part in Category C, D or E.
- Participants of Category C1 are also eligible to register for either Category C2 or C3 but not both.
- Participants of Category C2 are not eligible to participate in Category C3 and vice versa.
- Participants of Category D1 are also eligible to participate in Category D2 and vice versa.
- Members and family members of the organising committee are not allowed to participate in the SAFMC.
- The organisers reserve the right to amend the rules and regulations. In the event of changes, all teams will be informed at least **FOUR (4)** weeks prior to the start of the competition.
- Prizes will be issued to the Team Manager.
- A safety perimeter net will be set up at the competition field for Categories B, C, D, and E. There will be a top net approximately **EIGHT (8) meters** above the ground, which will limit the maximum flight altitude of flying machines. During the challenge attempts, teams are strongly encouraged to fly their aircraft away from the netting to avoid accidental entanglement.
- The organisers of SAFMC 2023 will not be held responsible for any damage to or the loss of any flying machine(s) throughout the entire competition.
- Participants are responsible for the safe flying of their flying machine(s) for the duration of the entire competition. The organisers reserve the right to ground the flying machine(s) of any team at any point in the competition.

- For queries regarding the competition, please send an email with the title stating the category in question *(e.g.: [CAT C1] - Clarification about task locations)* to the following email address: SAFMC@science.edu.sg

4. FORMAT OF COMPETITION

Once the teams have confirmed their registration for the competition, they are expected to start work on the different aspects of the competition, which comprise the Challenge and the Presentation.

4.1 PRESENTATION

The teams will be allocated a specific time slot to give a presentation on their flying machine. Teams will present their flying machine design and learning journey in this competition to a panel of judges. The teams will be assessed for a number of awards.

The presentation plays an integral part for teams who wish to compete for the SAFMC Championship Award. Teams that do not bring their flying machines for the presentation will be disqualified immediately. Depending on the category, there may be additional requirements for the presentation segment. The requirements for the Presentation Segment will be detailed in Section 8.1.

The Chief Referee or Judge for each category reserves the right to deduct points if the flying machines used in the Challenge are drastically different from the flying machine presented at the Presentation.

4.2 CHALLENGE

The physical competition will be conducted in accordance with Safe Management Measures (SMM) guidelines, which will be announced closer to the competition.

For the Challenge, teams are to design, build and fly their flying machines to overcome various challenges for the different SAFMC categories. The challenge comprises a physical presentation (subject to SMM guidelines) and an actual in-venue flight on scheduled competition day.

On the competition day, teams shall proceed to the presentation segment followed by the competition segment.

Teams should expect the following during the competition day:

- Only registered team members of the participating teams can enter the playing field and team booths/holding areas.
- Teams are expected to fully comply with safety rules. Failure to comply with safety rules after the initial warning will result in immediate disqualification and potential blacklisting from the competition. The organiser will also not be responsible for any injuries or mishaps if any participant has disregarded the safety rules.
- For all Category C1 participants, all aircraft and their transmitting devices must be presented to SAFMC officials for inspection at the registration counter.
- **NO trials** will be allowed in the flying area unless specified by the officials. Teams **must surrender** their transmitters to SAFMC officials at the Reporting Point for the competition.
- For all Category C1 participants, **NO video transmitting devices** including spares should be powered on in the competition hall unless specified by the officials. Teams may request from the Chief Referee or the Category C1 Technical Chairperson to perform power-on checks.
- The participants will acknowledge that there will be variations in environmental conditions between teams, despite best efforts to control them
- Additional rules and regulations specific to Category C1 are detailed in Sections 8 and 9. Participants will acknowledge that they have read the rules.

5. CATEGORY C1 AWARDS

Award winners will be selected based on the presentation scores and performance on the competition day.

There is no limit to the number of awards that a team can win, but there may not be a winner for every award. Awards may not be given out if the teams do not meet the minimum standard determined by the SAFMC organising committee, or if there are insufficient participants for each category.

All scoring decisions made by the judges are **final**. For arbitrary cases, the organising committee will have the **final** say.

CHAMPIONSHIP AWARD

This is the pinnacle award that any team can win. It is bestowed on the team that embodies the spirit of SAFMC. Teams are considered for the Championship Award based on their overall excellence and total learning experience during the course of the competition.

Award	Weightage
Creativity & Theory of Flight	15%
Presentation	30%
Performance	55%
Total	**100%**

THE BEST PERFORMANCE AWARD

This is awarded to the team that attains the highest score in the challenge. The best score attained among the two attempts shall be taken as the final score for the mission. The time taken for each attempt to complete all the tasks will be taken into consideration if there is a tie-in score.

THE MOST CREATIVE AND THEORY OF FLIGHT AWARD

For the team that shows the most innovative and original design in their remote-controlled fixed wing or kite platform and demonstrates a sound understanding and application of aerodynamic design principles.

Criteria	Areas of Consideration
Creativity	Unique Design or Strategy Flair and Appearance Functionality
Aerodynamic	Aerodynamics of the design Control & Stability

THE BEST PRESENTATION AWARD

For the teams that best exhibit creativity, fluency, confidence and flair in the presentation on their team's work, and demonstrates that "WOW" factor during the interview sessions.

Criteria	Areas of Consideration
Presentation	Fluency Confidence Flair

6. CATEGORY C1 CHALLENGE

The team is expected to design and build its own radio-controlled fixed-wing plane or kite plane to fly and manoeuvre through a series of obstacles.

COMPETITION SETUP

Figures 1 and 2 show the competition setup for Category C1. The designated take-off/landing area is 3m x 4m.

The fixed-wing or kite plane must take off from the designated take-off/landing area and land on the designated take-off/landing area after completion of the flying. Refer to Section 7.2 for the scoring for each task completed.

The team will challenge the flying circuit by navigating the fixed-wing plane or kite plane through a series of obstacles as follows:

Mission (Two (2) attempts only)

a. Take-off or hand launched from the designated take-off/landing area. The plane can take off in any orientation.

b. Challenge is to perform as many rounds of flying through the two loops in sequence in the flying circuit (Loop A followed by Loop B).

c. Points shall be awarded for every completed round of flying through Loop A and B in sequence. (Up to 15 rounds).

d. Successfully touch down onto the designated landing area.

e. Time taken for the completion of each attempt will be recorded if the total time is less than the stipulated time of **THREE (3) minutes.**

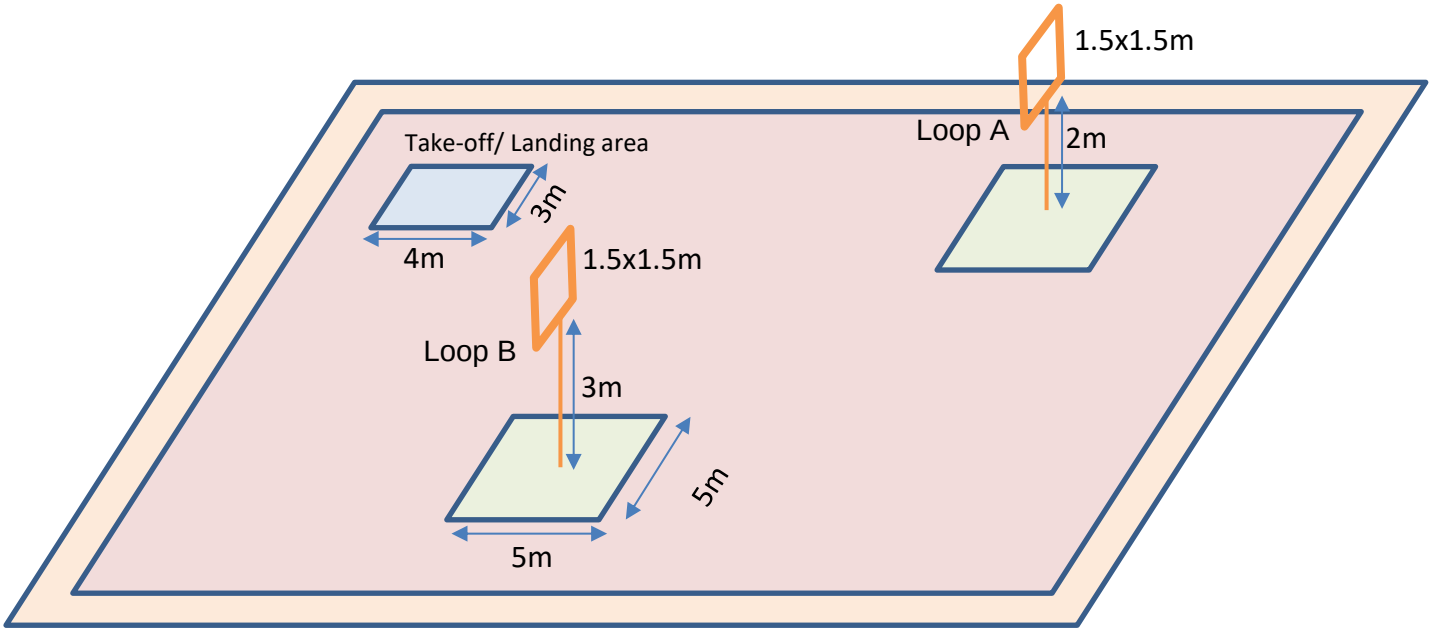

Figure 1 Competition Setup of Category C1

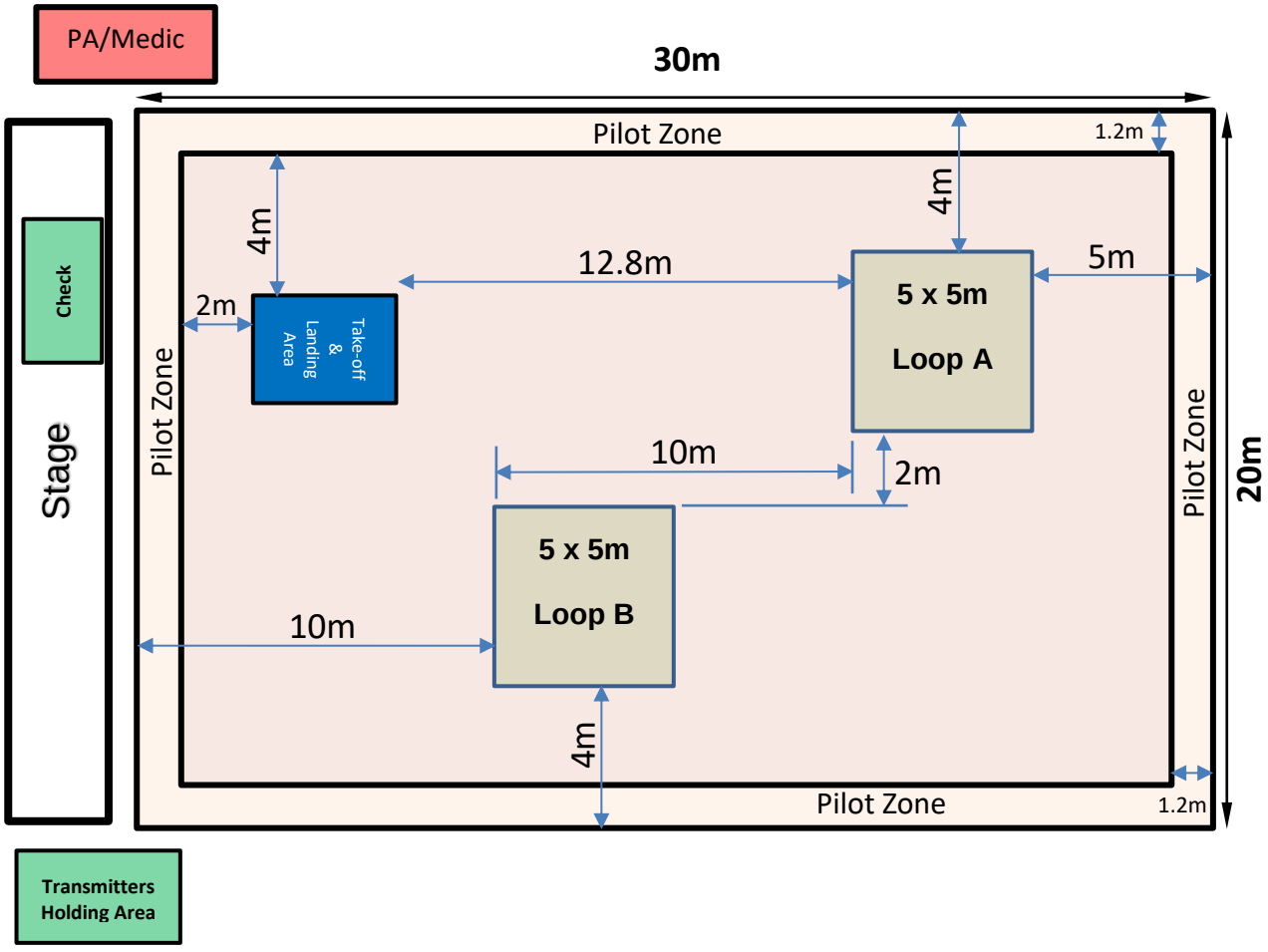

Figure 2 Competition Setup of Category C1 (Plan View)

7. SCORING

PRESENTATION SEGMENT (40 POINTS)

For each team, a specific time slot shall be allocated to them to present their flying machine during the scheduled date of presentation. Teams shall present to judges the work they have done for this competition. The team shall be assessed for a number of awards.

Each team is given only **TEN (10)** minutes [**FIVE (5)** minutes for presentation, **FIVE (5)** minutes for Questions & Answers].

Each team shall be allowed a **maximum of TWO (2) A1-size posters** as a visual aid for their presentation. A **short video clip is required** to showcase the flying machine able to fly along the border of the badminton court for **at least 30 seconds**.

A laptop or tablet can be used as the tech platform to showcase the short video clip during the presentation. The team shall bring their own laptop or tablet. **NO setup time shall be allocated and is expected to load and be ready for presentation before entering the presentation room**.

The judging criteria for the presentation are as follows:

Criteria	Areas of Consideration
Creativity	**Uniqueness in Appearance** - Originality in the design of flying machine - One of its kind design - Visually different, distinct, or appealing **Design Process** - Rationale and consideration of other ideas - Design Inspiration **Integration** - Unique joining techniques **Functionality** - Workable flying machines - Flight safely

Theory of Flight	**Aerodynamics** - Understanding the overall science of flight - Wing Design Consideration **Control & Stability** - Mechanism to operate a flying machine surface for level flight **Flight** - Airworthiness check **Design and Integration** - Knowledge of structural design
Presentation	**Creativity** - "WOW" Presentation - Short video clip to showcase their flying machine's capability for at least 30 seconds **Fluency** - Time management and presentation sequence - Poster Design **Confidence** - Technical Knowledge - Savviness **Flair** - Showmanship
Aesthetic	Most artistically decorated flying machine

COMPETITION SEGMENT

Scores shall be awarded to the team based on the sum of all points allocated to tasks successfully completed by the flying machine during the flying circuit in the mission. There are two attempts for the mission and the best score among the two attempts shall be taken as the final score. The time taken for each attempt to complete all the tasks will be taken into consideration if there is a tie-in score.

Flying Tasks	Allocated Points
<u>Taking-off</u> a. Proper roll take-off from the designated Take-off/landing area, or b. Hand Launch from designated take-off/landing area	5 points 3 points
Number of completed rounds through the 2 loops in sequence (e.g. Loop A followed by Loop B)	3 points per cycle (a maximum of 15 cycles)
Proper landing (touched down) onto the designated take-off/landing area	5 points
Final Score	**55 Points (Max)**

The referees make all scoring decisions, and their decision is **FINAL**. For arbitrary cases, the Chief Referee will have the **FINAL** say.

8. <u>FLOW OF EVENTS</u>

PRESENTATION SEGMENT

1. All teams shall be ready and report 15 minutes before their designated timeslot.
2. Every team shall be ushered to the respective room for their presentation.

COMPETITION SEGMENT

1. After the completion of the presentation, the team shall proceed to the Reporting Point to surrender their remote control (R/C) transmitter of the flying machine which shall be placed in a box provided by SAFMC to be quarantined at the storage point.

2. At the allocated competition schedule, the team shall report to the Inspection Point. An inspector shall check the flying machine for any violation of the category rules and regulations. Refer to Section 9 for more details provided. The box with the R/C transmitter shall be handed over to the team if the inspection is successful. After inspection, the flying machine shall be quarantined in a Holding Area prior to the mission attempt.
3. At the Holding Area, the SAFMC referee will hand over the R/C transmitter back to the team for preparation while waiting for your turn for the competition.
4. Prior to the start of the mission, the team shall demonstrate to the SAFMC referee the Failsafe capability to qualify for the competition.
5. Each team is given a total of **Two (2) minutes** to set up their flying machine inside the flying arena. In the event that the team is not ready to take off after **TWO (2) minutes**, the team shall be asked to leave the flying arena. The team shall be given one more chance to execute the attempt, failing which they are deemed to have scored **ZERO** for that attempt.
6. The team is required to complete a mission and shall be given **TWO (2)** attempts.
    a. Points will be awarded according to Section 7.2.
    b. There shall be no penalty if the plane touches the ground or hit any object as long as the flying machine can continue its mission.
    c. During the mission, **Only two (2) members** are allowed in the flying arena - the pilot and one assistant.
    d. If the first attempt failed, the team shall be given **THREE (3)** minutes for repair or preparation if the mission cannot continue for the second attempt. During this time, the next team will proceed on their first attempt.
7. The team is given **THREE (3)** minutes to complete each attempt. The start of the attempt is defined as the flying machine performing a rolling take-off from the runway or anywhere inside the flying arena. The completion of an attempt is described when the flying machine:
    a. lands back on the designated take-off and landing area when it completed the mission, or
    b. touches the floor of the flying arena and could not take-off or hand-launch again, or
    c. land outside the flying arena, or
    d. hits the safety net or barrier and could not resume flight, or

e. exceeds **THREE (3)** minutes of flight time.

8. During the recovery of the damaged or crashed flying machine, only the assistant is allowed to enter the flying arena to recover the flying machine. However, the pilot is **not allowed to enter the flying arena**.
9. Once the time is up, the pilot shall land the flying machine regardless of whether they have completed the circuit. If the total flight time taken is less than 3 minutes, then the total time will be recorded and can be used for consideration in the event of a tie situation.
10. At the end of the mission, the R/C transmitter of the flying machine must be switched off immediately. The team shall return the empty box to the organiser and vacate the competition area immediately.

9. TECHNICAL RULES & REGULATIONS

GENERAL RULES

Each team consists of **TWO (2) to FIVE (5)** students.

Each team is to design and build a radio-controlled flying machine based on the following guidelines:

1. Most parts of the fixed-wing plane or kite plane must be fabricated by the teams. **No kits or off-the-shelf flying models** are allowed.
2. The fixed-wing or kite plane must be radio-controlled by off-the-shelf radio systems.
3. **No internal combustion or gasoline engines** shall be allowed. Only an electric-driven flying machine is allowed.
4. Both brush and brushless motors are allowed. **No modification to the motors** is allowed.
5. Each participating team shall be allowed to bring up to **TWO (2) IDENTICAL fixed-wing planes or kite planes** into the competition hall.

RULES ON FIXED-WING PLANE OR KITE PLANE

Teams with interesting designs that may potentially infringe the written rules are strongly encouraged to send enquiry email with pictures and descriptions to SAFMC@science.edu.sg with the title **"[CAT C1] - Enquiries on Rules".**

PHYSICAL

- **No Vertical Take-off Landing (VTOL) flying machine** is allowed for the Cat C1 competition.
- **No balloon and airship designs** are allowed, including gaseous substances lighter than air flying machines.
- All flying machines must either conduct rolling take-off or hand-launched at the designated take-off/landing area on the flying arena.
- The flying machine **must not exceed a maximum all-up weight (AUW) of 250 grams**.

BATTERY

- There is no limit on the number of batteries used, in series or parallel.
- Only Lithium Polymer (Li-Po), Nickel Metal Hydride (Ni-MH) or Nickel Cadmium (Ni-Cd) batteries are allowed.
- **No charging** is allowed after entering the competition hall.

SPEED CONTROLLER

- Only Electronic Speed Controller (ESC) is allowed.

SERVO

- Only standard R/C servos are allowed. There is no limit on the number of servos used.

REMOTE CONTROL (R/C) RADIO

Based on the Singapore Spectrum Management Handbook (Chapter 7, Issue 1 Rev 2.9, July 2017) from Infocomm Media Development Authority (IMDA) Singapore for short-range devices, the following R/C frequency ranges are allocated for R/C cameras/toys/miscellaneous devices:

- 26.96 – 27.28 MHz ≤ 100mW Effective Radiation Power (ERP)
- 34.995 – 35.225 MHz ≤ 100mW ERP
- 40.665 – 40.695 MHz ≤ 500mW ERP
- 40.77 – 40.83 MHz ≤ 500mW ERP
- 72.13 – 72.21 MHz ≤ 500mW ERP

The following R/C frequency ranges are allocated for R/C aircraft and gliders:

- 29.700 - 30.000 MHz ≤ 500mW ERP
- 26.96 - 27.28 MHz ≤ 500mW ERP

The organiser understands the proliferation of 2.4 GHz R/C systems and will allow its use for this competition. However, the organiser shall bear no responsibility for any loss of control of the flying machine due to radio frequency interference. The team is advised to conduct a radio control range check prior to flight.

In any mode of flight, the team must be able to demonstrate the failsafe capability of their R/C transmitter. All electric motors should come to a complete stop when the failsafe is activated **AND** when there is a loss of link between the R/C transmitter and the R/C receiver on the aircraft. Please refer to Section 8.2 for details on the failsafe check.

Please refer to the *Singapore Spectrum Management Handbook* on the IMDA website for more details on the spectrum allocation and the latest approved range of frequencies.

DATALINK / VIDEOLINK / OTHER WIRELESS LINK TYPES

The following frequencies are approved by IMDA for radio telemetry:

- 433.05 - 434.79 MHz ≤ 10mW ERP
- 866 - 869 MHz ≤ 500mW ERP
- 920 - 925 ≤ 2000mW ERP

Wireless Wi-Fi routers will be allowed in this competition. Participants may choose to bring their own wireless routers.

Setup of external wireless device/s for purpose of performing the autonomous flight is allowed. However, teams can only turn on their wireless routers and transmitters during the setup and flight phases (same restriction as R/C transmitters).

The following frequencies are approved by IMDA for wireless data communications/video transmitters/LAN:

- 72.080, 72.200, 72.400, 72.600 MHz ≤ 1000mW ERP
- 158.275 / 162.875 MHz ≤ 1000mW ERP
- 158.325 / 162.925 MHz ≤ 1000mW ERP
- 453.7250 / 458.7250 MHz ≤ 1000mW ERP
- 453.7375 / 458.7375 MHz ≤ 1000mW ERP
- 453.7500 / 458.7500 MHz ≤ 1000mW ERP
- 453.7625 / 458.7625 MHz ≤ 1000mW ERP
- 2.4000GHz - 2.4835GHz ≤ 200mW Equivalent Isotropically Radiated Power (EIRP)
- 10.500 – 10.550 GHz ≤ 117dBµV/m @ 10m
- 24.000 – 24.250 GHz ≤ 100mW EIRP
- 5.725GHz – 5.850 GHz ≤ 4000mW EIRP
- 5.150GHz - 5.350GHz ≤ 200mW EIRP
- 5.470GHz - 5.725GHz ≤ 1000mW EIRP
- 57 – 66 GHz ≤ 10W EIRP

Please refer to the *Singapore Spectrum Management Handbook* on the IMDA website for more details on the spectrum allocation and the latest approved range of frequencies.