



Category C1 Challenge Booklet 2019

Organised by:



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SAFMC 2019 CAT C1 CHALLENGE BOOKLET CHANGE LOG

Version	Release Date	Description
1.0	30 Nov 2018	Official booklet release with challenge announcement.

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SINGAPORE AMAZING FLYING MACHINE COMPETITION 2019

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 students who want 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 accurate flight.

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

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

Design and build small unpowered gliders to be bungee-launched from designated launcher in a bid to fly the furthest.

CATEGORY C – RADIO CONTROL FLIGHT (*Secondary Schools / Integrated Programme / Junior Colleges / Institute of Technical Education*)

Category C1: Fixed Wing Radio Control Flight

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 – Tiny Whoop (*All Schools*)

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

Bring or design a FPV (first-person view) Tiny Whoop class drone to navigate an obstacle course.

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

Each team should consist of **ONE (1)** member.

Bring or design a FPV (first-person view) Micro class drone to navigate 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 a semi-autonomous small air platform to perform a multitude of tasks in an indoor open course.

Category D2: Autonomous

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

Design and build an autonomous small air platform to perform a multitude of tasks in an indoor open course.

CATEGORY E – UNCONVENTIONAL (*Open to Public*)

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

Design and build unconventional air platforms or showcase co-operative technology, and demonstrate its flight within a confined indoor area.

3. GENERAL SAFMC 2019 RULES

- **The deadline for the competition registration is 31 January 2019.**
- Participants registered under a school must be a full-time student at the point of competition.
- Home-schooled participants and teams consisting of students from different schools should register as “Independent teams”.
- Participants will be notified upon successful registration within two weeks of the registration deadline. The decision made by the SAFMC Organising Committee is final, and is subject to the availability of the competition schedule and logistics support.

- Each member 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 for 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 higher than their educational standard, 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.
- Members and family members of the organising committee are not allowed to participate in SAFMC.
- The organisers reserve the right to amend the rules and regulations. In the event of any change, all teams will be informed **FOUR (4)** weeks prior to the start of the competition.
- Prizes will be issued to the Team Manager.
- A safety net will be set up around the perimeter of 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 a safe distance from the netting to avoid accidental entanglement.
- The organisers of SAFMC 2019 will not be held responsible for any damage to, or the loss of, any flying machine(s) throughout the entire competition.
- All participants will be held responsible for the safe flying of their flying machine(s) throughout the entire competition. The organisers reserve the right to ground the flying machine(s) of any team.
- For any queries regarding the competition, please send an email with the title addressed to the relevant category (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, the Challenge and the Presentation (*excluding Category C2 and C3 which do not require presentation*).

Teams are encouraged to give equal attention to both the Challenge and the Presentation aspects of the competition.

The top team from each category will be bestowed with the championship award to be presented at the SAFMC 2019 Awards Presentation Ceremony.

4.1 PRESENTATION

During the presentation, teams will be allocated a specific time slot to present about their flying machine in ITE College Central. Teams will present their flying machine design and learning journey in this competition to a panel of judges. These teams will be assessed for a number of awards.

The presentation plays an integral part for teams who wish to vie 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 to the Presentation segment.

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

4.2 CHALLENGE

For the Challenge, teams (*except Category C2 and C3 which allow commercial off-the-shelf products*) are to design, build and fly their flying machines to overcome various challenges for different SAFMC categories.

For Category C, D and E participants, tables may be provided within the main competition hall for teams to work on their flying machines. Alternatively, teams may be assigned a designated area instead.

Teams should expect the following during the course of the competition:

- The competition hall will open at 8 am. Only registered team members of the participating teams can enter the competition hall from 8 am to 6 pm.
- As for spectators, there is a separate entrance to the spectators' viewing gallery and they are not permitted to enter the competition zone (playing field and team booths).
- No trial runs will be allowed in the flying area unless specified by the officials.
- For Category C1, D and E participants, all transmitting devices **must** be surrendered to SAFMC officials.
- For Category D and E participants, no video transmitting devices, including spares, should be powered on in the competition hall unless specified by the officials.
- For Category C1, D2 and E participants, no team is allowed to charge batteries within the competition hall. The team is required to bring sufficient batteries for all the missions.

5. CATEGORY C1 AWARDS

The judges make all scoring decisions and their decision is **final**. For arbitrary cases, the organising committee will have the **final** say.

5.1 THE CHAMPIONSHIP AWARD

This is the most prestigious 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
Performance	55%
Creativity	10%
Theory of Flight	20%
Presentation	15%
Total	100%

5.2 THE PERFORMANCE AWARD

For the team that attains the highest score in the challenge. The total score from the two scoring rounds will be used to vie for the award. In the event there is more than one team having the same highest score after the two scoring rounds, then the timing to complete the mission shall be taken into consideration.

5.3 THE MOST CREATIVE AWARD

For the team that shows the most innovative and original design in their remote-controlled fixed wing air platform.

Criteria	Areas of Consideration
Creativity	Unique Design or Strategy Flair and Appearance Functionality

5.4 THE THEORY OF FLIGHT AWARD

For the team that best demonstrates a sound understanding and appropriate application of aerodynamic design principles.

Criteria shading	Areas of Consideration
Aerodynamics	Aerodynamics Control & Stability Design and Integration

5.5 THE BEST PRESENTATION AWARD

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

Criteria	Areas of Consideration
Presentation	Fluency Confidence Flair

5.6 THE AESTHETIC AWARD

For the team whose flying machine is the most artistically decorated. As it does not contribute to flying qualities, it does not contribute to the scoring for the Championship Award.

5.7 MERIT AWARD

This award is given out to the teams exhibiting a high quality in Design and Performance. Overall scores will be taken into consideration for this Merit Award.

5.8 PRIZES

CATEGORY C1				
Awards	Medals	Trophy	Cash Prize	Remarks
Cat C1 Championship Award	✓	✓	\$ 1,500.00	
Cat C1 1st Runner Up	✓		\$ 1,000.00	
Cat C1 2nd Runner Up	✓		\$500.00	
Cat C1 Best Performance Award	✓		\$300.00	1st and 2nd Runner up will receive only Medals
Cat C1 Most Creative Award	✓		\$200.00	
Cat C1 Theory of Flight	✓		\$200.00	
Cat C Best Presentation Award	✓		\$200.00	
Cat C Aesthetic Award	✓		\$100.00	
Cat C Merit Award	Certificate of Merit will be given for teams exhibiting a high quality in design and performance.			

6. CATEGORY C1: FIXED WING RADIO CONTROL FLIGHT - CHALLENGE

6.1 CATEGORY C1 CHALLENGE

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

6.2 COMPETITION SETUP

Figure C1 and C2 below show the competition setup for Category C1. Both the taking-off and landing areas are 3 m x 4 m.

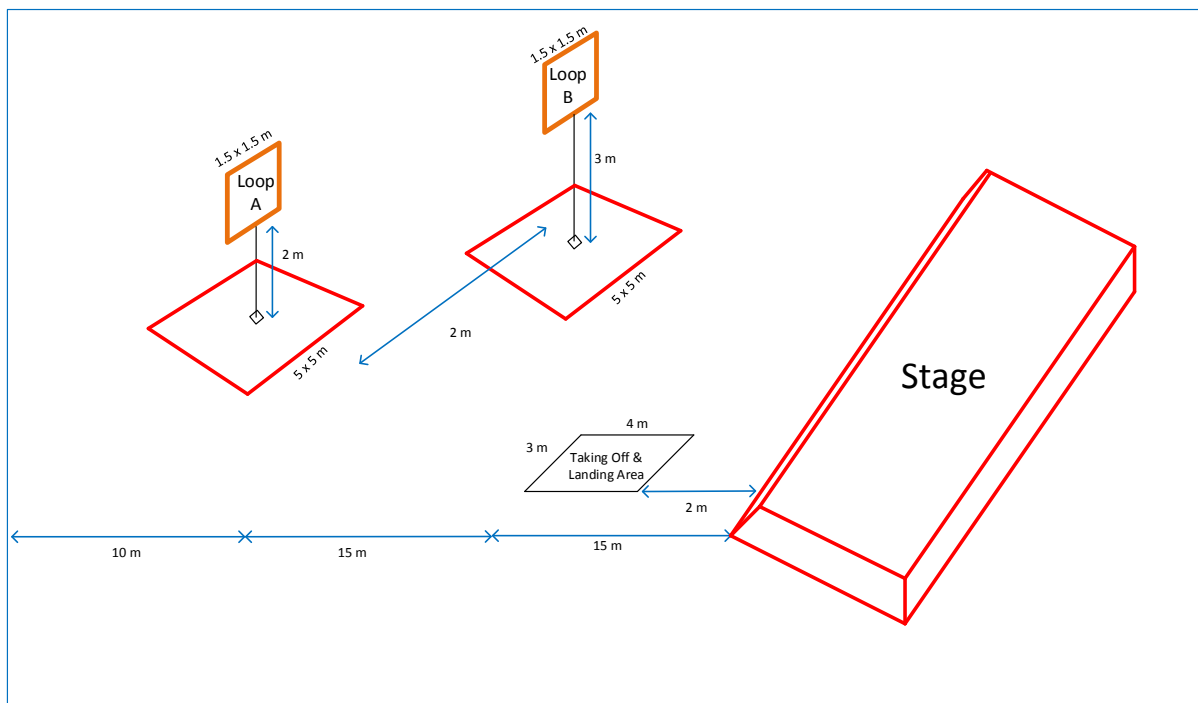


Figure C1: Competition Setup of Category C1

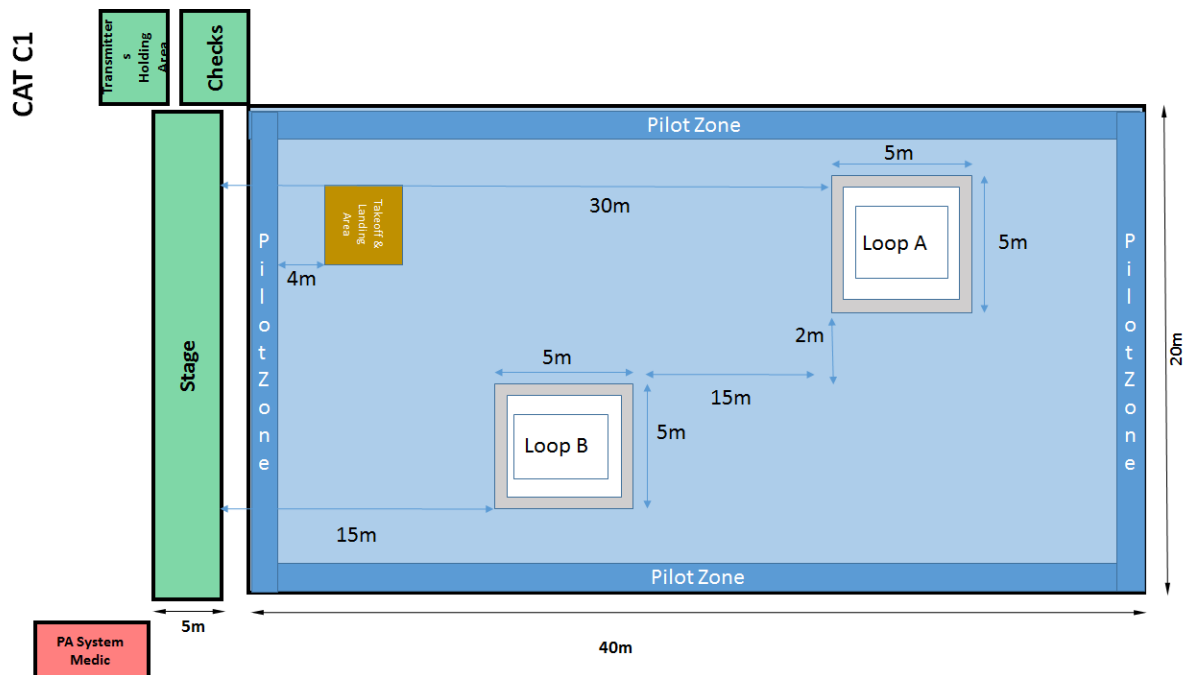


Figure C2: Competition Setup of Category C1 (Plan View)

The fixed wing plane or kite plane is required to perform the following mission.

1. Mission (2 attempts)

- a. Take off or hand launched from the designated taking-off 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 (Loop A followed by Loop B).
- c. Points will be awarded for every completed round of flying through Loop A and B in sequence (up to 15 rounds).
- d. Successful landing onto the designated landing area. The plane must reside in 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 3 minutes.

7. SCORING

7.1 PRESENTATION SEGMENT

Teams shall be allocated a specific time slot to present about their flying machine in ITE College Central. Teams shall present to a panel of judges the work they have done for this competition. These teams 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].

Presentations using laptops shall not be allowed. Each team is allowed a maximum of TWO (2) A1 size posters as visual aid for their presentation.

Laptops can **only** be used as the tech-platform to showcase **the flight ability** of Category C1 flying machines. The teams shall bring their own laptop. No setup time shall be allocated and the team is expected to load and prepare the presentation videos in the laptop before entering the presentation room.

There are 4 different awards arising from this presentation segment. They are:

- Most Creative Award
- Theory of Flight
- Best Presentation Award
- Aesthetic Award

Criteria	Areas of Consideration
Creativity	Uniqueness in Appearance <ul style="list-style-type: none">- Originality in the design of the flying machine- Being one of a kind in design- Visually different or distinct or appealing Function <ul style="list-style-type: none">- Proper working- Fly safe Design Process <ul style="list-style-type: none">- Has the team brainstormed other ideas?- What inspired your design? Integration <ul style="list-style-type: none">- Unique joining techniques

Criteria	Areas of Consideration
Theory of Flight	<p>Aerodynamics</p> <ul style="list-style-type: none"> - Understanding of science of flight - Wing Design Consideration <p>Control & Stability</p> <ul style="list-style-type: none"> - Mechanism to operate an flying machine surfaces for level flight <p>Flight</p> <ul style="list-style-type: none"> - Airworthiness check <p>Design and Integration</p> <ul style="list-style-type: none"> - Knowledge of structural design
Presentation	<p>Creativity</p> <ul style="list-style-type: none"> - WOW Presentation - Short video clip to show their model plane's flying capability <p>Fluency</p> <ul style="list-style-type: none"> - Time management and Presentation sequence - Poster Design <p>Confidence</p> <ul style="list-style-type: none"> - Technical Knowledge - Savviness <p>Flair</p> <ul style="list-style-type: none"> - Showmanship
Aesthetic	Most artistically decorated flying machine

7.2 COMPETITION SEGMENT

Scores awarded to the team shall be based on the sum of 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 better score from 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 scores.

Flying Tasks	Allocated Points
Mission (55 Points)	
Proper roll take-off from the designated taking-off area, or	5 points or
Hand Launch from designed taking-off area	3 points
Number of completed rounds through the loops in sequence (Loop A followed by Loop B)	3 point per cycle (a maximum of 15 cycles)
Proper landing onto the designated landing area	5 points
Time taken:	
Final Score	55 Points (Max)

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

8. COMPETITION DAY

8.1 PRESENTATION SEGMENT

1. All teams shall be informed of their reporting time for the presentation and they shall report to the Reporting Point 15 minutes earlier.
2. Every team shall be ushered to the respective room for their presentation.

8.2 COMPETITION SEGMENT

1. After completing their presentation, the team shall proceed to the Reporting Point to surrender their radio control transmitter of the flying machine, to be placed in a box provided by the SAFMC Organising Committee and quarantined at the Storage Point.
2. At the allocated competition schedule, the team shall report to the Inspection Point. A flying machine inspector shall check the flying machine for any violation with the category rules and regulations. The box with the transmitter shall be handed over to the team upon successful completion of the inspection. After inspection, the flying machine shall be quarantined at the Holding Area prior to the mission attempt.
3. At the Holding Area, as long as the frequency does not clash with the frequency of the flying machine inside the flying area, the SAFMC referee will hand over the transmitter back to the team to conduct Airworthiness and Failsafe check on the flying machine. The team is also given a total of **THREE (3)** minutes for the final adjustment on the flying machine prior to mission, after which the transmitter shall be switched off and be quarantined in the box again.
4. Prior to the mission, the radio control transmitter shall be handed back to the team. Each team is given a total of **ONE (1)** minute to set up their flying machine inside the flying area. In the event that the team is not ready to take off after one minute, the team shall be asked to leave the flying area. The team shall be given one more chance to execute the attempt, failing which they are deemed to have scored **zero** for that attempt.

5. Team must set up failsafe capability in the R/C transmitter. The team must inform Chief Referee of the location of the failsafe switch. When failsafe is activated, the electric motor shall automatically be switched off. The failsafe capability shall be demonstrated in the holding area prior to the actual flight.
6. The team is required to complete a mission and shall be given **TWO** attempts.
 - After the first attempt of the mission, the team shall be given **THREE (3)** minutes of preparation time before their second attempt. During this preparation time, the next team will proceed with their first attempt.
 - Teams are encouraged to fly their own flying machine.
 - 2 points shall be deducted if the plane takes off by hand launch.
 - There shall be no penalty if the plane touches the ground or hit any object.
 - Only two members are allowed in the flying arena, the pilot and one assistant cum repairman.
7. The team must re-launch at the location the plane falls and outside of the pole 5m x 5m parameters. If the plane falls inside the 5m x 5m parameters of the poles, the plane must be taken outside of the parameters for a re-launch.
8. The team is given **THREE (3)** minutes to complete each mission. The start of the mission is defined as the ability of the flying machine to perform rolling takeoff from the runway area or takeoff from anywhere inside the flying area. The completion of the attempt is defined as:
 - when the flying machine lands back on the runway, or
 - touches the floor of the flying field and could not take-off again or hand-launch again, or
 - hits the safety net or barrier and could not resume flight, or
 - exceeds **THREE(3)** minutes flight time.
9. Once the time limit is up, the pilot shall land their aircraft regardless of whether they have completed. Time taken to clear circuit shall be recorded for judges to decide a winner in the event of a tie.

10. **Simple and quick repairs** are allowed within the given mission. However, pilot is not allowed to repair the plane if it crashes in the flying arena. Penalty shall be implemented if pilot fail to observe the above rule.
11. At the end of each mission, the radio control transmitter of the flying machine must be switched off immediately, placed back into the box and surrendered to the SAFMC referee.

9. TECHNICAL RULES & REGULATIONS

9.1 GENERAL RULES

- Each team shall consist 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 plane or kite plane must be radio controlled by off-the-shelf radio systems.
 3. Only electric flight is allowed. Both brush and brushless motors are allowed. No modification to the motors is allowed.
 4. No internal combustion or gasoline engines shall be allowed.
 5. Teams are strongly encouraged to bring their fixed wing plane or kite plane during presentation and show a short video clip of their model plane flying capability. Teams are to submit **TWO (2)** photos of sized 4R during the presentation. Teams shall **NOT** be allowed to make major changes to their flying machine after the presentation. Non-compliance may lead to **VOID** of presentation.
 6. Each participating team shall be allowed to bring up to **TWO (2)** IDENTICAL fixed wing planes or kite plane into the competition hall.

9.2 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 Takeoff Landing (VTOL) flying machine is allowed.
- No balloon and airship design will be allowed. No gaseous substance lighter than air will be allowed.
- All flying machines must either conduct rolling takeoff or be hand launched at designated runway area on the flying field.
- Minimum Dimensions: Length (400mm) x Width (500mm)
- Maximum Dimension : Height (500mm)
- The flying machine must not exceed a maximum all-up weight (AUW) of 500 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 is allowed.

Speed Controller

- Only Electronic Speed Controller is allowed.

Servo

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

9.3 REMOTE CONTROL (R/C) RADIO

- 1) 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 \leq 100mW Effective Radiation Power (ERP)
 - 34.995 – 35.225 MHz \leq 100mW ERP
 - 40.665 – 40.695 MHz \leq 500mW ERP
 - 40.77 – 40.83 MHz \leq 500mW ERP
 - 72.13 – 72.21 MHz \leq 500mW ERP

- 2) The following R/C frequency ranges are allocated for R/C aircraft and gliders:
 - 26.96 - 27.28 MHz \leq 500mW ERP
 - 29.700 - 30.000 MHz \leq 500mW ERP

- 3) 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 responsibilities for any loss of control of flying machine due to radio frequency interference. The team is advised to conduct a radio control range check prior to flight.

- 4) In any mode of flight, the team must be able to demonstrate the failsafe capability in their R/C transmitter. All electric motors should come to a complete stop when 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.

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

9.4 DATALINK / VIDEO LINK / OTHER WIRELESS LINK TYPES

- 1) The following frequencies are approved by IMDA for radio telemetry:
 - 433.05 - 434.79 MHz \leq 10mW ERP
 - 866 - 869 MHz \leq 500mW ERP
 - 920 - 925 \leq 2000mW ERP

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

- 3) Setup of external wireless device/s for purpose of performing 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).

- 4) The following frequencies are approved by IMDA for wireless data communications / video transmitters / LAN:
 - 72.080, 72.200, 72.400, 72.600 MHz \leq 1000mW ERP
 - 158.275 / 162.875 MHz \leq 1000mW ERP
 - 158.325 / 162.925 MHz \leq 1000mW ERP
 - 453.7250 / 458.7250 MHz \leq 1000mW ERP
 - 453.7375 / 458.7375 MHz \leq 1000mW ERP
 - 453.7500 / 458.7500 MHz \leq 1000mW ERP
 - 453.7625 / 458.7625 MHz \leq 1000mW ERP
 - 2.4000GHz - 2.4835GHz \leq 200mW Equivalent Isotropically Radiated Power (EIRP)
 - 10.500 – 10.550 GHz \leq 117dB μ V/m @ 10m
 - 24.000 – 24.250 GHz \leq 100mW EIRP
 - 5.725GHz – 5.850 GHz \leq 4000mW EIRP
 - 5.150GHz - 5.350GHz \leq 200mW EIRP
 - 5.470GHz - 5.725GHz \leq 1000mW EIRP
 - 57 – 66 GHz \leq 10W EIRP

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