Category C1
Challenge Booklet 2022

Organised by:

DSO NATIONAL LABORATORIES

SCIENCE CENTRE singapore

Supported by:

MINDEF SINGAPORE

Partners:

DSTA Defence Science & Technology Agency

Republic of Singapore THE AIR FORCE ABOVE ALL

ST Engineering Aerospace

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SAFMC 2021 CAT C1 CHALLENGE BOOKLET CHANGE LOG

Version	Release Date	Description
1.0	22 Nov 2021	Official challenge booklet release

SAFMC 2022 COMPETITION SCHEDULE

Date*	Event	Platform/Venue
7-18 March 2022	Pre-Challenge Submission	Email
16-23 March 2022	Presentation	Teleconference
4-14 April 2022	Category Challenges	Singapore Expo
16 April 2022	Awards Presentation Ceremony	Singapore Expo

** 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 2022

1. INTRODUCTION

In celebration of DSO National Laboratories' (DSO) 50th Anniversary in 2022, SAFMC is enhanced in both challenges and prizes [CAT D & E] to allow students to push the boundaries of innovation by designing and creating extraordinary flying machines. The event is organised by DSO and Science Centre Singapore, and supported by Ministry of Defence (MINDEF). Open to all schools and participants, 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, an FPV drone to compete in an obstacle course.

[ENHANCED] 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.

[ENHANCED] 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 an obstacle course.

3. GENERAL SAFMC 2022 RULES

- **The deadline for registration is 18 February 2022.**
- Participants registered under a school must be a full-time student 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 are 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 2022 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 consists of the Challenge and the Presentation.

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

The top team from each category will be presented with the Championship Award at the SAFMC 2022 Awards Presentation Ceremony.

4.1 PRESENTATION

The teams will be allocated a specific time slot to showcase their flying machine on a virtual platform. 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 show their flying machines for the virtual presentation may be disqualified immediately. The requirements for the Presentation Segment will be detailed in Section 8.

The Chief Referee or Judge for each category reserves the right to deduct points if the flying machines used in the Challenge is 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 consists of: a Team Video Challenge submission, and the actual in-venue flight on Competition Day.

The Team Video Challenge serves as a prelude to the team's aircraft capabilities and flight-worthiness. The Competition Day allows teams to accomplish their missions in live capacity in front of an audience.

On the Competition Day, tables will 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 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 injures or mishaps if any participant has disregarded the safety rules.
- No trials will be allowed in the flying area unless specified by the officials.
- The participants will acknowledge that there will be variations in environmental conditions between teams, despite best efforts to control them
- For all Category C and D participants, all aircraft and their transmitting devices must be presented to SAFMC officials for inspection upon arrival.
- For all Category C and D 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.
- 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 either presentation scores, performance on the competition day, or a combination of both.

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.

5.1 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.

Scoring	Weightage
Proof of Flight/ Learning Journey	20%
Virtual Presentation	30%
Performance	50%
Total	**100%**

5.2 THE PERFORMANCE AWARD

This is awarded to 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 a tie in scores between teams, the mission completion timing shall be taken into consideration to determine the winner.

5.3 THE PROOF OF FLIGHT AND LEARNING JOURNEY AWARD

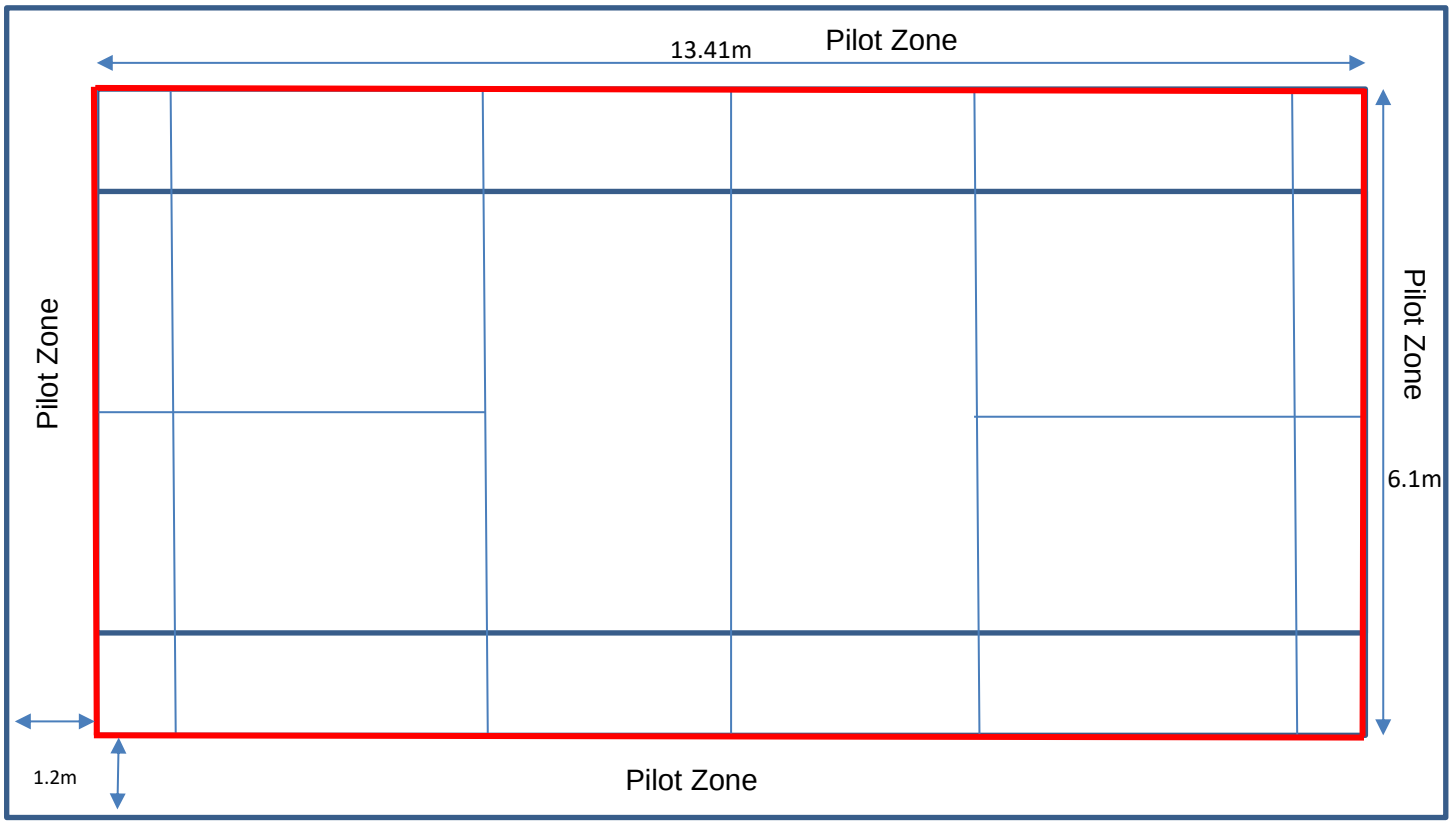

Figure 1 shows the Setup of the Proof of Flight using a badminton court or equivalent

The Proof of Flight Criteria

Record a **ONE (1) minute video** showing the fixed-wing plane or kite plane flying along the perimeter of the badminton court as shown in Figure 1 (or construct a perimeter of the same dimension with marking on each corner if no badminton court is available).

a. Take-off or hand launched the plane in any orientation.

b. Challenge is to fly the fixed-wing plane or kite plane along the border of the badminton court (outermost border indicated in red) for 1 minute.

c. Show time counter of the flight on video.

The Learning Journey Video

Record a **FIVE (5) minute video** showing the team's learning journey as they come up with the Design Process, Control and Stability to produce the most innovative and original design in their remote-controlled fixed-wing air or kite plane platform.

The Learning Journey Criteria

The team is able to develop the most innovative and original design in their remote-controlled fixed-wing air or kite plane platform.

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

The team is able to demonstrate a sound understanding and appropriate application of aerodynamic design principles.

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

Submissions:

Deadline: Proof of Flight and Learning Journey video is **17 Mar 2022**.

Submit video link to SAFMC@science.edu.sg

5.4 VIRTUAL PRESENTATION AWARD

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

5.5 PRIZES

CATEGORY D				
Awards	**Medals**	**Trophy**	**Cash Prize(s)**	**Remarks**
Cat C1 Championship Award	✓	✓	$ 1200	
Cat C1 1st Runner Up	✓		$ 800	
Cat C1 2nd Runner Up	✓		$400	
Cat C1 Best Performance Award	✓	✓	$500	1st and 2nd Runner up will receive **only** Medals
Cat C1 Virtual Presentation Award	✓	✓	$400	1st and 2nd Runner up will receive **only** Medals
Cat C1 Proof of Flight and Learning Journey Award	✓	✓	$200	1st and 2nd Runner up will receive **only** Medals

Note: Prizes are subjected to change due to the COVID-19 situation and if no satisfactory performance were presented.

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.

6.1 COMPETITION SETUP

Figure 2 and 3 below shows the competition setup for Category C1. The taking-off and landing areas are 3m x 4m.

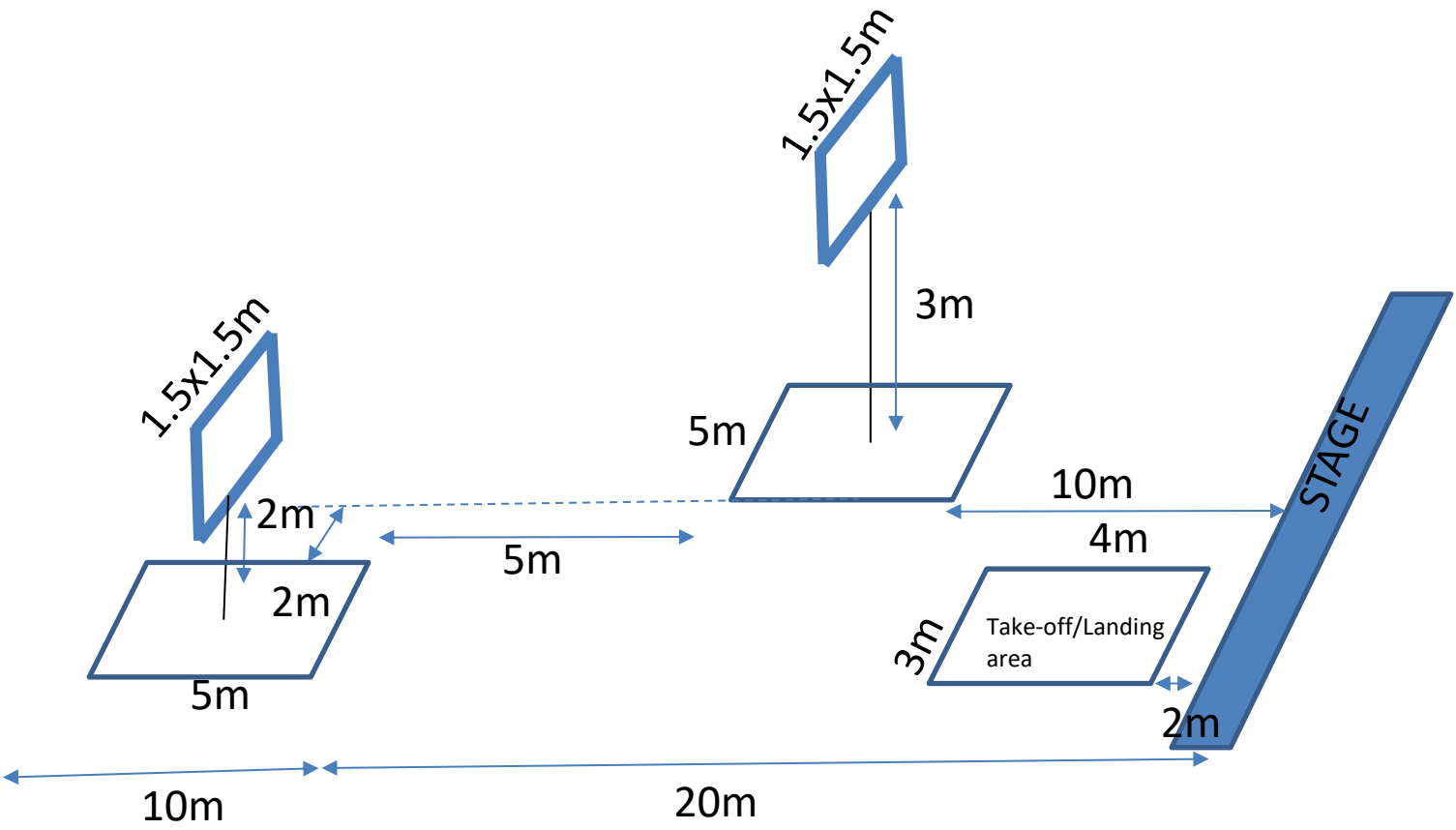

Figure 2: Competition Setup of Category C1

CAT C1

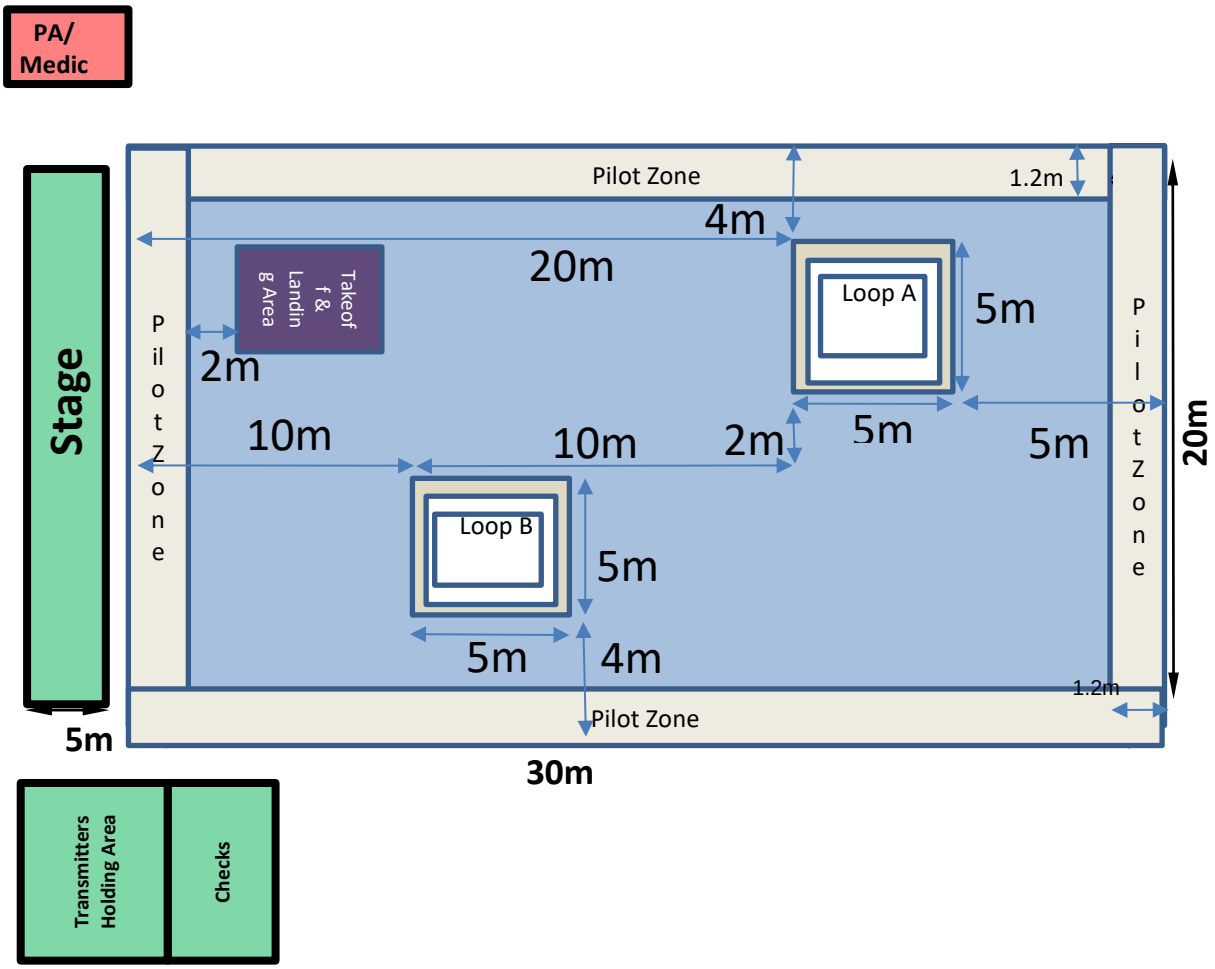

Figure 3 Competition Setup of Category C1 (Plan View)

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

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 shall 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 **THREE (3) minutes.**

7. SCORING

7.1 PROOF OF FLIGHT AND LEARNING JOURNEY SEGMENT (20 POINTS)

Criteria	Areas of Consideration
Proof of Flight	- Fixed-wing plane or kite plane is able to fly along the border of the badminton court for 1 minute
Learning Journey	**Design Process** - Has the team brainstormed other ideas? - Wing design consideration **Control & Stability** - Mechanism to operate a flying machine surfaces for level flight **Flight** - Airworthiness check **Design and Integration** - Knowledge of structural design

7.2 VIRTUAL PRESENTATION SEGMENT (30 POINTS)

Each Team is required to produce a **TEN (10) minute video** to showcase the work they have done for this competition to a panel of judges. Presentation to be conducted online using Zoom or Microsoft Teams.

Each team will be allowed a maximum of 10 slides for their presentation. The video camera must be turned on throughout the presentation.

The judging criteria for the Virtual Presentation as follows.

Criteria	Areas of Consideration
Creativity	**Uniqueness in Appearance** - Originality in the design of flying machine - Being the only one of its kind in design - Visually different or distinct or appealing **Function** - Proper working - Fly safe **Design Process** - Has the team brainstormed other ideas? - What inspired your design? **Integration** - Unique joining techniques
Theory of Flight	**Aerodynamics** - Understanding overall science of flight - Wing Design Consideration **Control & Stability** - Mechanism to operate a flying machine surfaces for level flight **Flight** - Airworthiness check **Design and Integration** - Knowledge of structural design
Presentation	**Creativity** - "WOW" Presentation - Short video clip to showcase their flying capability **Fluency** - Time management and presentation sequence - Poster Design **Confidence** - Technical Knowledge - Savviness **Flair** - Showmanship
Aesthetic	**Most artistically decorated flying machine**

7.3 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
Mission (50 Points)	
Proper roll take-off from the designated taking-off area, or	3 points or
Hand Launch from designated taking-off area	1 point
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	2 points
Time taken	Used to determine the winner in case of tie
Final Score	50 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. FLOW OF EVENTS

8.1 VIRTUAL PRESENTATION SEGMENT

All teams shall be informed of their reporting time for the virtual presentation.

8.2 COMPETITION SEGMENT

1. Upon registration and arrival to of the team, the team will go to a Reporting Point to surrender their radio control 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. A 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 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, as long as the frequency does not clash with 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. The team is also given a total of **THREE (3)** minutes for any final adjustments on the flying machine prior to mission, after which the transmitter shall be switched off and 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 (1) 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 setup failsafe capability in the R/C transmitter. The team must inform the 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 actual flight.

6. The team is required to complete a mission and shall be given **TWO** attempts.
    - After the first attempt, the team shall be given **THREE (3)** minutes for preparation before commencing on the second attempt. During this time, the next team will proceed on their first attempt.
    - Teams are encouraged to fly their own machine.
    - 2 points shall be deducted if the plane is launched by hand.
    - 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.
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 take-off from the runway area or take-off 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 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 is up, the pilot shall land their aircraft regardless of whether they have completed the circuit. Time taken to clear circuit shall be recorded as a yardstick for judges to decide a winner in the event of a tie-situation.

10. **Simple and quick repairs** are allowed within the given mission. In consideration of the time constraint, additional members not exceeding two are allowed to enter the arena to expedite the repair. 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 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 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. 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 Take-off 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 take-off or be hand launched at designated runway area on the flying field.
- 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 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

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 RC 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 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.

In any mode of flight, the team must be able to demonstrate the failsafe capability in their RC transmitter. All electric motors should come to a complete stop when failsafe is activated **AND** when there is a loss of link between the RC transmitter and the RC receiver on the aircraft. Please refer to Point 5 in Section 8.2 for details on the failsafe check.

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 / 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 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 IMDA website for more details on the spectrum allocation and for the latest approved range of frequencies.