



# Category D2 Challenge Booklet 2022

Organised by:



Supported by:



Partners:



## SAFMC 2022 CAT D2 CHALLENGE BOOKLET CHANGE LOG

Version	Release Date	Description
1.0	22 Nov 2021	Official challenge booklet release
1.1	08 Dec 2021	Modified maximum aircraft size

## 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 to 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 .....	5
1. INTRODUCTION.....	5
2. CATEGORIES.....	5
3. GENERAL SAFMC 2022 RULES .....	6
4. FORMAT OF COMPETITION.....	8
4.1 PRESENTATION .....	8
4.2 CHALLENGE .....	8
5. CATEGORY D2 AWARDS .....	10
5.1 CHAMPIONSHIP AWARD .....	10
5.2 JUDGES' COMMENDATION .....	10
5.3 PRIZES .....	11
6. CATEGORY D2 MISSION.....	12
6.1 CATEGORY D2 CHALLENGE (AUTONOMOUS MISSIONS) .....	12
6.2 PENALTIES .....	21
7. SCORING .....	22
7.1 AERIAL PLATFORM FACTOR (A) .....	23
7.2 CREATIVITY FACTOR (C).....	24
7.3 LEARNING JOURNEY AND INSIGHT (L) .....	24
7.4 TEAM CHALLENGE VIDEO (V).....	24
7.5 MISSION ACCOMPLISHED FACTOR (M).....	25
8. FLOW OF EVENTS.....	26
8.1 PRESENTATION SEGMENT .....	26
8.2 TEAM CHALLENGE VIDEO.....	27
8.3 COMPETITION SEGMENT .....	28
8.4 KEY POINTS TO NOTE .....	29
9. TECHNICAL RULES & REGULATIONS.....	31
9.1 AVIONICS SYSTEM .....	31
9.2 BATTERY.....	31
9.3 REMOTE CONTROL (RC) RADIO .....	32
9.4 DATALINK / VIDEOLINK / OTHER WIRELESS LINK TYPES .....	32
9.5 CAAS REGULATIONS .....	34
10. PANDEMIC RESTRICTIONS .....	35

# SINGAPORE AMAZING FLYING MACHINE COMPETITION 2022

## 1. INTRODUCTION

In celebration of DSO National Laboratories' (DSO) 50<sup>th</sup> 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.

**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 at least two 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 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 of 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 D2] - Clarification about task locations) to the following email address: [SAFMC@science.edu.sg](mailto: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 the mission tasks in a 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 organizer will also not be responsible for any injuries 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, D and E participants, all aircraft and their transmitting devices must be presented to SAFMC officials for inspection upon arrival.
- For all Category C, D and E 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 D2 Technical Chairperson to perform power-on checks.
- Additional rules and regulations specific to Category D2 are detailed in Sections 8 and 9. Participants will acknowledge that they have read the rules.

## 5. CATEGORY D2 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.

The list of awards for Cat D2 is listed in the subsequent sections.

### 5.1 CHAMPIONSHIP AWARD

This is the pinnacle award any team can win, and is bestowed on the team that achieves the highest total score across all areas. For D2, there will be **THREE (3)** championship awards: a winner and **TWO (2)** runners-up. The scoring and weightage can be found in Section 7.

### 5.2 JUDGES' COMMENDATION

This award is given out to Category D2 teams exhibiting a high quality in design and/or performance, but did not win the Championship Award or the runners-up prizes. Teams that have won any of the Top 3 prizes will not be considered for the Judge's Commendation Prizes. Overall scores may be taken into consideration for this award. Up to **TWO (2)** awards may be given for the whole Category D, but there may not be a winner for this award.

## 5.3 PRIZES

CATEGORY D				
Awards	Medals	Trophy	Cash Prize	Remarks
*Cat D2 <b><u>Autonomous</u></b> Championship Award	✓	✓	\$10,000	
Cat D2 <b><u>Autonomous</u></b> 1 <sup>st</sup> Runner Up	✓		\$7,500	
Cat D2 <b><u>Autonomous</u></b> 2 <sup>nd</sup> Runner Up	✓		\$5,000	3 <sup>rd</sup> and 4 <sup>th</sup> runners up will receive medals <b><u>only</u></b>
Cat D Judge's Commendation	✓		\$500	Up to two teams (in the whole Cat D) can win this award

\* **SPECIAL NOTE:** The Championship Award may not be given out if none of the top 3 teams meet the minimum standard determined by the organisers or if there are insufficient participants for each category. The SAFMC organising committee will have the **final** say and the decision made is **final**.

\*\* **PANDEMIC RESTRICTIONS:** The Awards and Prizes are subject to change in case of pandemic restrictions preventing SAFMC 2022 from being held in-venue.

## **6. CATEGORY D2 MISSION**

Category D2: Teams are required to design, or enhance commercial off-the-shelf products (COTS product), and build a system of at least **TWO (2)** small flying machine that is capable of fully autonomous flight. The drones need not be homogeneous. Such operations often involve a suite of integrated systems instead of a standalone machine. Due to the challenging nature of fully autonomous indoor flight, external aids such as visual markers or take-off / landing systems are allowed, subject to technical requirements detailed below in Section 6. A Safety Pilot for remote control takeover in case of flight emergency is required, but the main operation and control must not be from a remote controller.

The detailed descriptions of the competition field, available mission tasks, as well as the scoring criteria are found in Section 6. Teams are advised to read through these sections in detail to develop a strategy and identify key design requirements, before designing the flying machine to execute the mission. The technical rules for the flying machine are found in Section 9.

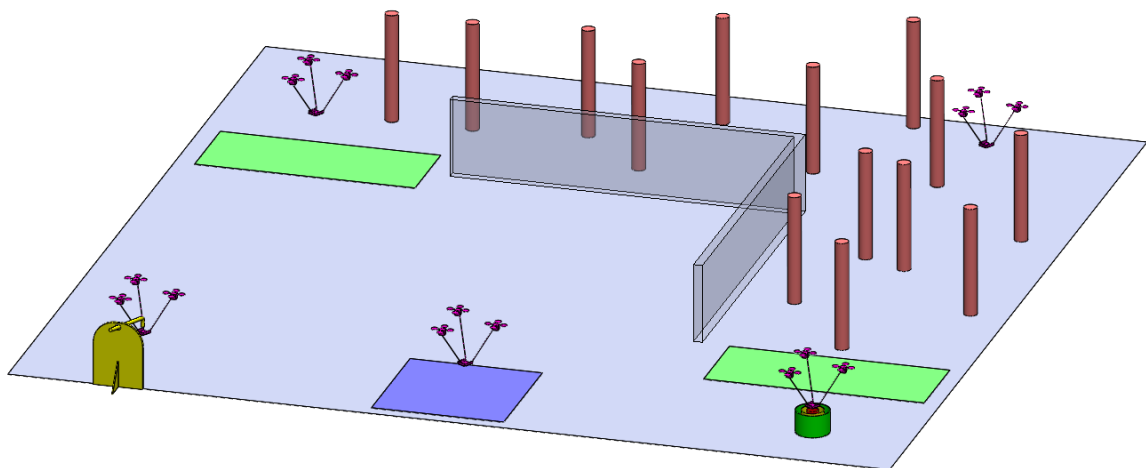
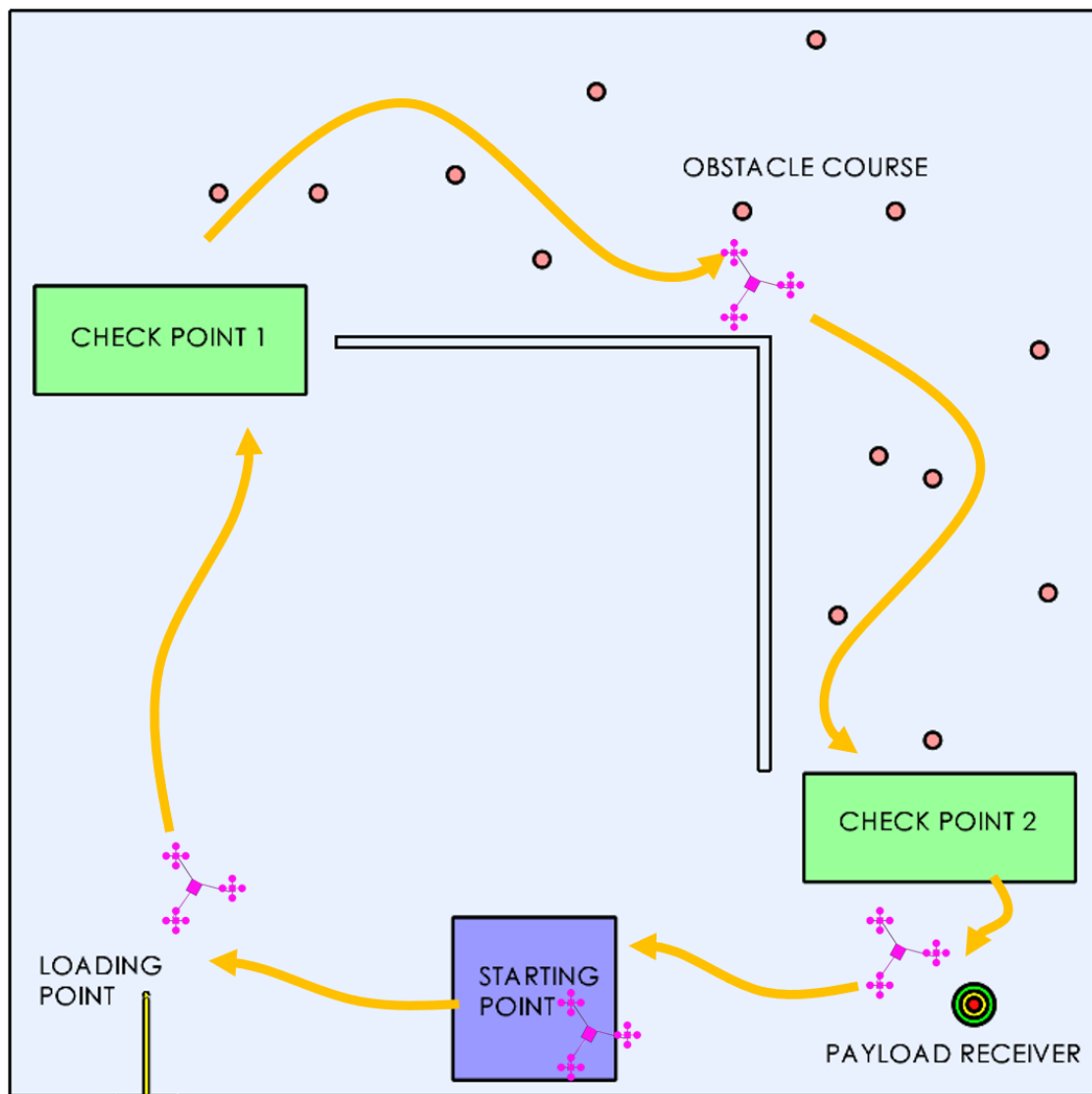
### **6.1 CATEGORY D2 CHALLENGE (AUTONOMOUS MISSIONS)**

**Category D2** requires its participating teams to perform various missions with a fully autonomous aerial robots that work dynamically and collaboratively for a resupply delivery operation. The team with the highest number of points accrued for successful missions wins the competition.

The flying machine should also possess various sensors, and/or mechanisms to complete a variety of tasks in a complex environment without inputs from the operator.

## 6.1.1 COMPETITION SETUP

The playfield and key dimensions are shown in Figure 1.



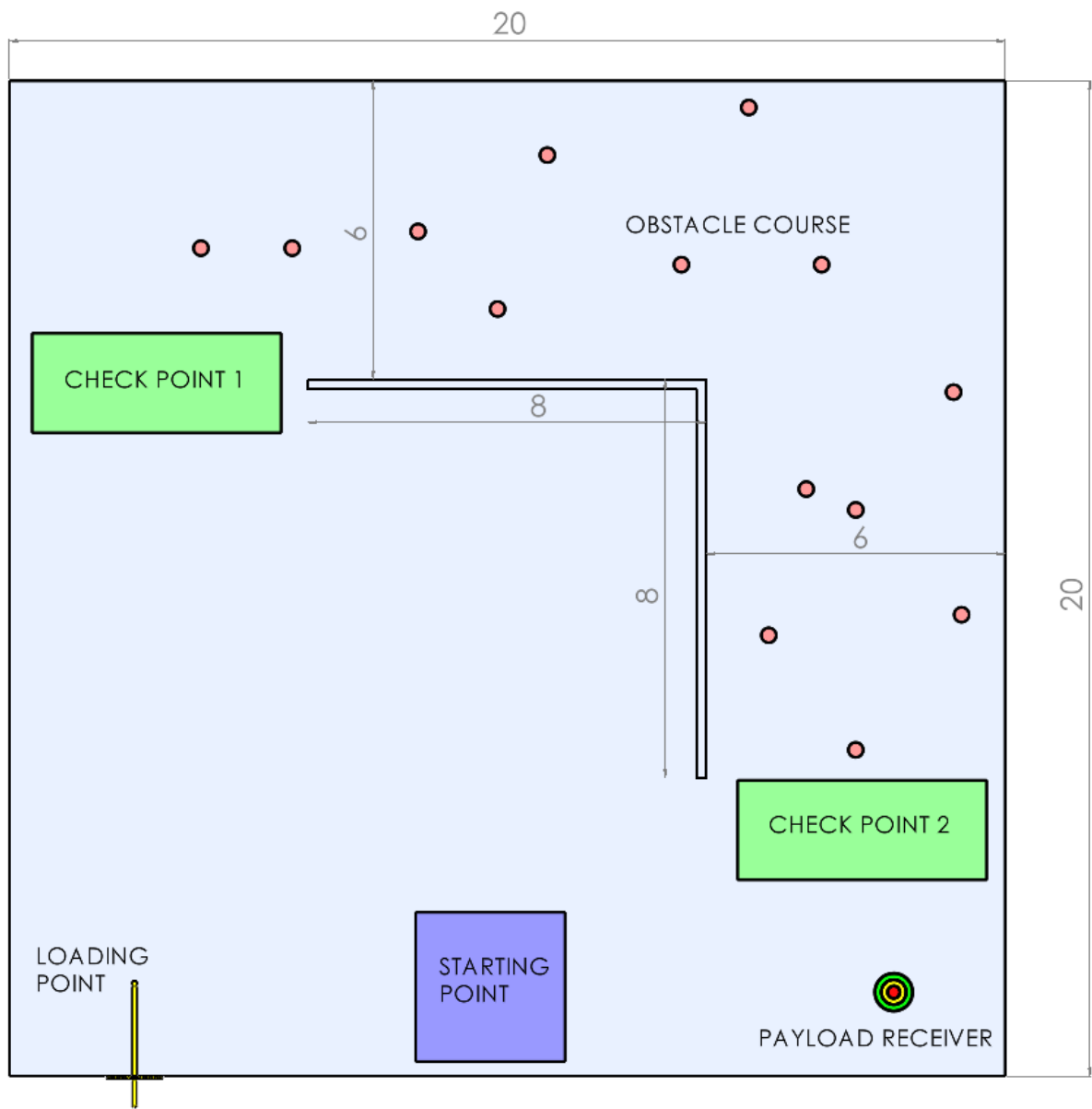


Figure 1: Playfield key dimensions (units in meters)

## 6.1.2 MISSION TASKS

This is a resupply delivery mission. The drones have to collect the payload, navigate static obstacles, and deliver the payload to the receiver. The goal is to deliver as many payloads as possible within the given time, using the provided carrier.

### Start Point

Teams start the mission with 9 payloads pre-loaded in the carrier. Teams may choose to go to the loading point to get more payloads, or head straight to Check Point 1 (CP1). Points will be awarded per payload in the carrier at CP1. Payloads will be typical rubber bouncy balls ( $37\pm 5\text{mm}$  diameter,  $40\pm 5\text{g}$  mass).



Figure 2: Example of rubber bouncy balls



Figure 3: Example of payload carrier – an A4 paper tray

### Mission 1: Collect Payload

The aircrafts position themselves with the given carrier to receive more payloads if they want to – this step is optional, and teams can choose to head straight to the next checkpoint. Payloads will be manually dispensed by the team via a loading tube. The tube can be freely maneuvered by the team from outside the playfield. Teams may choose to land the aircrafts to receive the payloads if they choose to do so.

Points will be awarded per payload in the carrier at CP1.

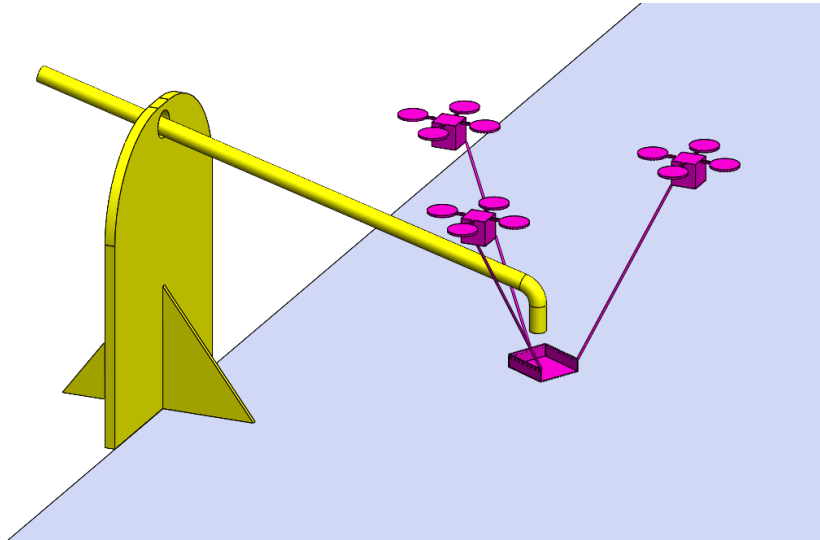


Figure 4: Drones receiving payload from the dispensing tube

### **Mission 2: Forested Terrain**

The aircrafts navigate through the obstacle course with the carrier and payload.

Points will be awarded per payload in the carrier at Check Point 2 (CP2).

There will be no penalty for collisions with pillars.

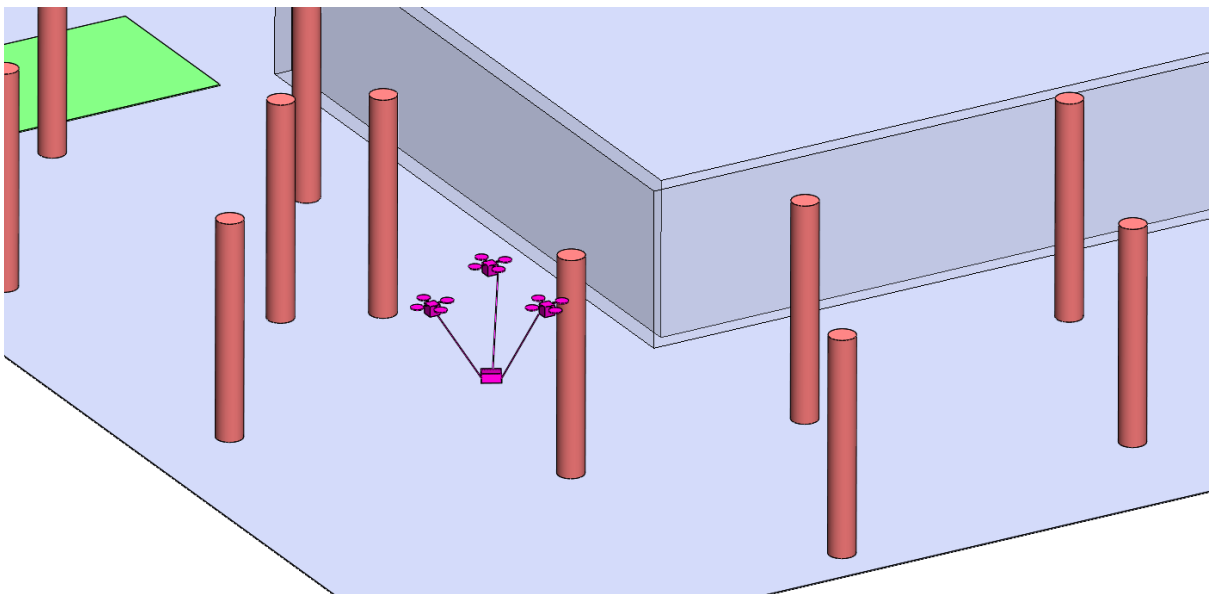


Figure 5: Drones navigating the obstacle course. Pillars ~2.5 m tall, 30 cm diameter.  
Colour and position not representative of actual pillars



### Mission 3: Deliver Payload

The aircrafts now navigate to the Payload Receiver to accurately drop the payloads into the collection point.

Points will be awarded per payload successfully delivered into the payload receiver. The receiver will be filled with 3cm of sand to prevent balls from bouncing out. There will be no penalty if the aircrafts or carrier touches the receiver.

The team should then attempt to repeat the course as many times as possible to earn more points.

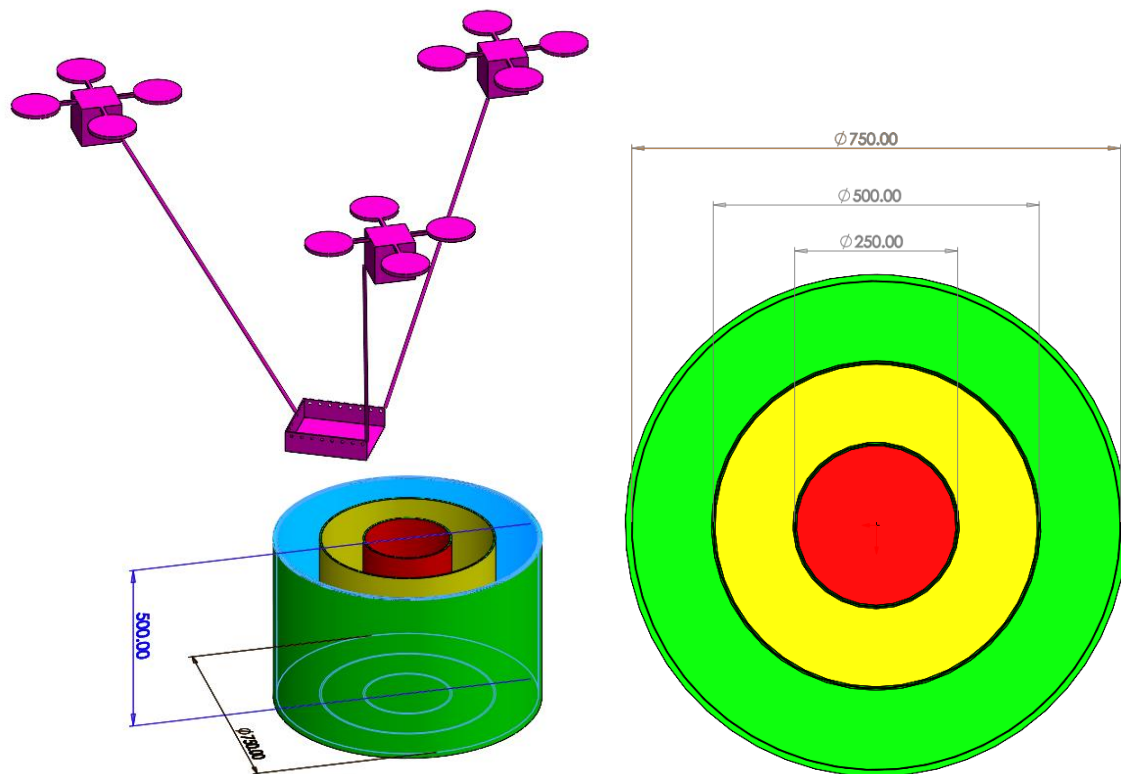


Figure 6: Drones above the payload receiver (left). Top view and dimensions of receiver (right).

### Option to Re-Attempt

Teams will be granted a total of 2 attempts.

At the end of the mission time, teams may choose to re-attempt the mission. If so, they will have another 15 minutes for preparation and 15 minutes for mission.

The attempt with the highest score obtained will be counted for the overall score.

### 6.1.3 MISSION RULES

- Teams must use at least 2 flying machines.
- Each flying machine must weigh less than 2kg, and measure less than 750mm from propeller tip to propeller tip.
- On the competition day each team will have a **fixed duration of 15 minutes of mission time** to complete the tasks in the playing field.
- Every team will also be given **15 minutes of setup time** prior to the mission start time. During this time, teams are allowed into the playing field to do any necessary setup and calibration. Teams are permitted to power-on and launch the aircraft during the setup time, provided that nobody is inside the playing field. Furthermore, no one is to enter the playing field while the aircraft is airborne, or the offending team will be disqualified.
- Once the 15 minutes of setup time are up, the mission time will automatically start. The mission time will continue to run throughout and will **not** be paused in the event of any landing, maintenance or repair works, etc.
- Teams will be granted a total of 2 or 3 attempts, to be determined by the organising committee at a later date.
- For each of the re-attempts, the team will have another 15 minutes for preparation and 15 minutes for mission.
- The attempt with the highest score obtained will be counted for the overall score.
- Missions must be attempted in order. Teams cannot skip missions.
- For payloads to be counted for scoring at CP1 and CP2, the carrier must enter the air space directly above the demarcated area on the ground. Cameras will be placed at each check point in case of dispute of whether carrier was above the CP or not.
- The maximum height of any aircraft cannot exceed 2m during any mission.
- If the aircraft loses all payload during the mission, the teams may choose to restart from the start point. Best scores at previously reached CPs for that round will not be saved.
- In the event that the team needs to repair/troubleshoot the aircraft, they are required (if possible) to land the aircraft as soon as possible. All repairs/troubleshooting should be done either on the take-off and landing pads or outside of the playing field.

- Teams are allowed to change flight batteries during the game, but only if all the aircraft has landed.
- Any ground aids or external markers used for navigation and guidance of the aircraft have to be easily removable without damaging or leaving visible traces on the ground. These markers must be placed within the playing field only.
- Participants may modify the provided carrier by removing material only (i.e. can cut, drill, and bend, but no glue).
- Fasteners used to connect the carrier to the aircraft cannot interfere with the payload.
- Payload can only contact the carrier. It cannot touch any fasteners or cables.
- The drone-to-carrier connection can be of any length, rigid or flexible. It cannot come into contact with payloads.
- All parts of the flying machines including the carrier trays must not touch the floor other than at the designated take-off, landing pad, and payload receiver.
- Back-up flying machines that are **similar** to the original flying machines may only be used in the event of the primary aircraft being determined to be incapable of flight for the remaining time left for the attempt, at the discretion of the Chief Referee or Category D2 Technical Chairperson.
- Teams are encouraged to have a safety pilot, to take over control of the aircraft in order to avoid a crash. The safety pilot may follow the aircraft (line-of-sight) from the edge of the field; however, he/she may not communicate in any way with the Ground Control Station operator.
- There should be no command switches made by the safety pilot at any point except to avoid a crash or during an emergency. In case of any take-over or command given via the remote control by the safety pilot, the aircraft will have to restart the mission from a position determined by the Chief Referee.
- The safety pilot needs to inform and demonstrate to the referees that the aircraft is in computer-in-control (CIC) mode before take-off. Once airborne, no directional command inputs is allowed as the aircraft is required to be fully-autonomous. The Chief Referee or Category D2 Technical Chairperson has the authority to determine what is considered to be fully autonomous.
- In case of doubt, the Chief Referee or the Category D2 Technical Chairperson has the final decision.

## 6.1.4 MISSION SCORING

The points awarded for completing each task is listed in the table below. The referees will make all scoring decisions and their decision is **final**. For arbitrary cases, the Chief Referee will have the **final** say.

	No. Points
Points per payload in <u>Carrier</u> at <b>CHECK POINT 1</b>	1
Points per payload in <u>Carrier</u> at <b>CHECK POINT 2</b>	2
Points per payload in <b>PAYLOAD RECEIVER RED CENTER RING</b> at end of time limit	3
Points per payload in <b>PAYLOAD RECEIVER YELLOW RING</b> at end of time limit	2
Points per payload in <b>PAYLOAD RECEIVER OUTER MOST GREEN RING</b> at end of time limit	1
Collisions with Static Obstacles	<p>There will be no penalty for collisions with the pillars unless the pillars are knocked down.</p> <p>If the pillars are knocked over, 2 points will be deducted and there will be a short safety pause at the end of the course to re-stand the pillars as quickly as possible.</p>

## 6.2 PENALTIES

The sum of penalties will be deducted from points acquired in the mission attempt to give a final mission score. The referees will make all scoring decisions and their decision is **final**. For arbitrary cases, the Chief Referee will have the **final** say. Further correspondence will not be entertained.

### 6.2.1 LIST OF MISSION PENALTIES:

S/N	DESCRIPTION	PENALTY
1	Exceeding the 15 minutes setup time for D2.	Mission time will start regardless.
2	Knocking over pillars during the missions	-2 points for each pillar, safety restoration time
3	Use of external markers outside of the playing field.	Referee's discretion or <b><u>disqualification</u></b>
4	Internal markers within the playing field unable to be removed or leave a mark after being removed.	Referee's discretion or <b><u>disqualification</u></b>
5	Interrupting the competition by potentially interfering with other competitors, e.g. switching on your platform's VTX, transmitters, etc.	Referee's discretion or <b><u>disqualification</u></b>
8	Attempting to subvert competition rules or gain an unfair advantage over other teams, e.g. receiving assistance from spectators, etc.	Referee's discretion or <b><u>disqualification</u></b>
9	Any ground aids used to help in the picking of payloads are <ol style="list-style-type: none"><li>1) Unable to be removed or damaged the take-off pad after removal</li><li>2) Having a size more than 150mm (L) by 150mm (W) by 50mm (H)</li><li>3) Delivered together with the payloads. (i.e. left remaining on the grid squares)</li></ol>	Referee's discretion or <b><u>disqualification</u></b>

## 7. SCORING

There are a total of **FIVE (5)** scoring components for the competition, namely: Aerial Platform (**A**), Creativity (**C**), Learning Journey (**L**), Team Challenge Video (**V**), and Mission (**M**). The first four components (A, C, L, and V) will be assessed by our Category D Judges, while the Mission (M) factor will be computed from the highest attained score from the challenge attempts.

Scores will be awarded relative to the performance of other teams. Further details on the scoring components can be found below.

The weightage of the scoring components is listed as follows:

<b>Segment</b>	<b>Factor</b>	<b>Weightage</b>
<b>Presentation</b>	Aerial Platform	10%
	Creativity	10%
	Learning Journey and Insight	10%
<b>Competition</b>	Team Challenge Video	10%
	Mission	60%
	<b>Total</b>	<b>100%</b>

For both **CAT D2** the total score (**T**) is computed as:

$$T = A + C + L + V + M$$

## 7.1 AERIAL PLATFORM FACTOR (A)

The **Aerial Platform Factor (A)** will be awarded based on the ability of the teams to demonstrate a comprehensive understanding of the following areas and apply them when designing and constructing their flying machine. It carries a 10% weightage to the overall score.

### 1) Mechanical design

- Quality of fabrication, workmanship, materials used
- Platform weight optimisation
- Lower points for usage of commercial off the shelf products
- Design factors affecting platform's flight stability, and payload carrier stability

### 2) Electronics design

- Power / Battery sizing to meet mission objectives
- Explanation of choice of sensor suite for the given environment
- Explanation of choice of embedded computer / microprocessor
- Neatness of harnessing and aesthetics

### 3) Software design, in particular describing how their proposed semi-autonomous / autonomous concept will work.

- Explanation of flight control strategy
- Explanation of autonomy strategy

## 7.2 CREATIVITY FACTOR (C)

The **Creativity Factor (C)** is a measure of the team's creativity in the design of their flying machine and control interface, or any sub-system which aids in their mission strategy. It is not mandatory to adopt unique concepts, but teams that do so will score higher for this factor. It carries a 10% weightage to the overall score.

Examples of innovative approaches may include:

- Non-conventional ideas and methods to achieve mission task(s)
- Innovative mechanisms for payload delivery
- Innovative choice of sensors
- Innovative algorithms.

## 7.3 LEARNING JOURNEY AND INSIGHT (L)

The **Learning Journey and Insight Factor (L)** is related to quality and content of the presentation. It carries a 10% weightage to the overall score.

### 1) Learning Journey

- Challenges faced and overcame
- Solutions explored and iterations to get to the final product
- Team is able to explain the rationale behind design choices and major decision
- Key takeaways from the experience

### 2) Delivery

- Speakers are clear and concise
- Speakers are able to answer questions smoothly

### 3) Teamwork

- Presentation should highlight the work of all the team members, and how they have contributed and cooperated to the team

### 4) Fun

- Should be able to capture the attention of the judges
- The judges should enjoy your presentation

## 7.4 TEAM CHALLENGE VIDEO (V)



The **Team Challenge Video (V)** scores provide a proof-of-flight insight into how the aircraft performs. It carries a 10% weightage to the overall score.

1) Flight-worthiness

- Aircrafts must display ability to perform stable, sustained flight while carrying a payload together

2) Mission-readiness

- Aircrafts must display ability to avoid static obstacles
- Aircrafts must display ability to manipulate the payload carrier to unload payloads

## 7.5 MISSION ACCOMPLISHED FACTOR (M)

The points attained in the actual missions will determine the team's **Mission Factor (M)** score. Please refer to [Section 6](#) for the mission scoring and penalties. This carries a 60% weightage to the overall score.

Since the missions can be repeated as many times as possible within the time limit, there is no fixed maximum number of game points attainable. As such, the overall Mission Factor score will be the team's game points as a percentage of the highest achieved game points.

For example, if the highest points attained by any team is 120 and Team A gets 90 points, Team A's Mission Factor score will be  $\frac{90}{120} * 60 = 45$ .

## 8. FLOW OF EVENTS

### 8.1 PRESENTATION SEGMENT

Teams will deliver their presentation to a panel of judges, on a virtual teleconference platform like Zoom. They will share about their flying machine and autonomous system. For CAT D2, the presentation is currently tentatively scheduled for **17 March 2022**.

D2 teams will instead be given a maximum of **15** minutes for this segment. **10** minutes are allocated for the team presentation, and **5** minutes for Questions & Answers.

Please refer to Section 7 for scoring factors for the presentation component.

During the presentation segment, teams are required to:

- 1) Show an isometric and 3-view of the system of flying machine
- 2) Show the actual flying machines during the presentation.
- 3) Teams are to prepare presentation in slides format that caters to a larger audience. The presentation material is to be submitted by **11 March 2022, 2359hrs** to [SAFMC@science.edu.sg](mailto:SAFMC@science.edu.sg) with title subject: “[CAT D2] - [Team Name] - Presentation Material”

## 8.2 TEAM CHALLENGE VIDEO

Teams are to submit **1** Team Challenge Video to the SAFMC committee. The video length should be no longer than **10** minutes, and should include the key components as stated in Section 7.

Videos should be uploaded to Youtube and set as “Unlisted”. The link to the video should be sent to [SAFMC@science.edu.sg](mailto:SAFMC@science.edu.sg) with title subject: “[CAT D2] - [Team Name] – Challenge Video” before the deadline. The deadline for submission is **11 March 2022, 2359hrs**. Video should be uploaded before the deadline, and any re-upload of the video detected past the deadline may result in **penalization** or **disqualification**. You may write in to the SAFMC 2022 Committee to request for a re-upload of the Team Video if necessary.

The submitted video should adhere to the following guidelines:

- 1) Animations are **NOT** allowed.
- 2) Computer-aided simulations are **NOT** allowed.
- 3) Video must **NOT** be produced by a professional, or with professional assistance.
- 4) No offensive images or audio
- 5) Narration and/or subtitles are allowed.
- 6) All videos must be original work conceived and created by the participants. No copyright materials (images, music, etc.) may be used in the video unless the participants own the copyright or have a license to use the material in the video.
- 7) If the participants have gained formal permission to use any copyright materials (images, music, etc.) under terms and conditions stipulated by the copyright owners, acknowledgements/credits must be included at the end of the video.
- 8) The use of logos including known commercial brands, institutional crests or trademarks, unless integral to the project, is not allowed.
- 9) Ownership of the underlying intellectual property of the video remains with the participant(s) of the individual/team project, with the following exception:
  - a. Participant(s) grant the organiser the right to use, distribute and display their videos without further compensation or notification to the participant(s).

- b. Participant(s) grant the organiser the right to use their images and videos for publicity and advertising without further compensation or notification to the participant(s).

### 8.3 COMPETITION SEGMENT

Teams are expected to comply with the following during the competition segment:

- 1) Upon arrival, and at the designated reporting time, all teams shall proceed to the reporting point for allocation of their team booth as well as the competition schedule for their teams.
- 2) At the allocated competition schedule, the team shall report to the safety inspection point. A SAFMC official will check the flying machine for any violation of the category rules and regulations. Teams who do not pass the inspection will **not be allowed** to fly their machine in the challenge mission, and may face **immediate disqualification** from the competition. The inspection will include, but is not limited to, the following checks:
  - 2.1 The maximum take-off weight (MTOW) of the each of the drone should not exceed **2.0kg**.
  - 2.2 The mass of the carrier and carrier-attachment structures (i.e. fasteners, cables, rods, linkages) will not be counted.
  - 2.3 Each drone **should not exceed 0.5m** in any direction (this measurement includes the maximum diameter of the propeller circles).
  - 2.4 RC / datalink / video link transmitter and receiver are operating on allowed frequencies. VTX used must be able to broadcast in the Raceband channels listed in Section 9.
  - 2.5 Electrical harnessing should be appropriately insulated and should not be chafed or broken. No exposed wires and connectors are permitted.
  - 2.6 All major assemblies and critical components must be securely fastened to the flying machine; loose items should be tied down and kept away from the propellers.
  - 2.7 For platforms operating on autonomous modes, the teams are to demonstrate the complete manual pilot override on-demand via RC.

- 2.8 The platform must demonstrate failsafe capability in the event of a loss of link between the RC transmitter and the RC receiver on the aircraft. The failsafe check procedure is as follows:
- (a) All propellers and releasable payloads are to be removed from the platform.
  - (b) Flight motors will be armed and throttled up.
  - (c) While the motors are still spinning in the same flight mode, the RC transmitter will be switched off to simulate a link loss.
  - (d) All motors should come to a **complete stop immediately**. The aircraft should not attempt a hover / controlled descent / to return home.
- 3) Each team is then granted up to **15** minutes to set up and calibrate their autonomous system inside the playing field and a total of **15** minutes to complete the mission. Once the mission time limit is up, no further points will be awarded for the tasks and the pilot will have to land their aircraft immediately.
- 4) A SAFMC official will be with the pilot or operator during the attempt. The official may give instructions to the pilot depending on the behaviour of the flying machine (e.g. to land immediately if the aircraft appears to be uncontrollable). The pilot is to **comply immediately** with all such instructions, which may include the activation of the failsafe to ground the aircraft.
- 5) At the end of each attempt, the radio control transmitter, datalink transceiver, video receiver and any other wireless device for the flying machine must be switched off.
- 6) After the completion of the first attempt, teams are advised to return to their respective team booth before their next attempt. The team is allowed to repair or make legal modifications to the flying machine in preparation for the next attempt.

## 8.4 KEY POINTS TO NOTE

- 1) Rules for personnel movement and communication during the setup time and the mission attempt are dictated in the following points:

- a. Only up to 3 members of the participating team are allowed to be inside the playing field at any one time, when the aircraft is not airborne.
  - b. No outside communication or assistance from the audience / spectators is allowed at any point. No headphones or earpieces are allowed to be worn by the pilot. Teams who flout this rule may be **disqualified**. Communication amongst teammates is allowed.
  - c. Team members are allowed to follow the system from outside the playing field to observe the platform for safety purposes as a safety pilot, and may contact the team if unexpected behaviours or if an emergency occurs.
  - d. All persons are required to remain outside of the playing field and be behind the safety net when the aircraft is airborne.
  - e. Team members may enter the field to collect their aircraft, or to bring it out of the playing field to modify or repair (including changing batteries) **after** it has landed and propellers stop spinning. Entry into the playing field is only allowed upon confirmation with SAFMC officials.
- 2) Multiple video **receivers** are allowed. Only **ONE (1)** video transmitter is allowed for each aircraft.
  - 3) No radio control transmitters, datalink transmitters and video transmitters and receivers are to be switched on within the competition hall, unless permitted to do so in the holding area or playing field. All repairs / maintenance / troubleshooting should be down in Raceband channel 8 with VTX set to either 25mW or pit-stop mode. Non-compliance may lead to **disqualification**.
  - 4) There will be a charging space allocated for teams to charge their batteries. Teams will have to bring their own charger/charging equipment should they plan to charge their batteries. At any point, there **MUST** be at least ONE (1) team member overseeing the charging. Failure to do so will result in disqualification.
  - 5) Teams shall make sure that their designated representatives are contactable and should arrive at least **10** minutes before any allocated timing. Latecomers may have their mission times shortened or may be **disqualified**.

## 9. TECHNICAL RULES & REGULATIONS

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

- Off-the-shelf products and components are allowed in the competition.
- For safety considerations, the total weight of each flying machine **cannot exceed 2.0kg**.
- Each platform **should not exceed 0.5 m** in any direction (this measurement includes the maximum diameter of the propeller circles).
- Back-up aircrafts that are similar to the primary aircraft may only be used in the event the primary aircraft has been determined to be incapable of flight for the remainder of the attempt.
- Only electric-based flight propulsion is allowed. Both brushed and brushless motors are allowed. No modifications to the motors are allowed.
- No internal combustion or gasoline engines are allowed.
- No tethering or umbilical wires to the aircraft are allowed during flight.
- External aids such as markers, indicators etc. will be allowed **only** in the playing field, and can only be placed during the set up time.
- For safety considerations, the platform must be able to perform full RC manual pilot over-ride and RC failsafe on demand.

### 9.1 AVIONICS SYSTEM

There is no limit on the number of inertial measurement units (IMUs), flight controllers (FCs), and other electronics used in the flying machine.

### 9.2 BATTERY

There is no limit on the number of batteries used, in series or parallel. Participants should size their batteries and aircraft appropriately for the respective mission. Lithium-Polymer (LiPo) batteries are preferred.

Batteries must be properly strapped or locked onto the aircraft before launch.

### 9.3 REMOTE CONTROL (RC) 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 RC 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

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

- 29.700 - 30.000 MHz  $\leq$  500mW ERP
- 26.96 - 27.28 MHz  $\leq$  500mW ERP

2) 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 2.8 in Section 8.2 for details on the failsafe check.

3) 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

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 $\mu$ 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.

## 9.5 CAAS REGULATIONS

- 1) Participants are to ensure that they have registered their aircraft if the weight exceeds 250g.
- 2) For educational purposes, if the total weight of the aircraft exceeds 1.5kg, but is less than 7kg, a UA Basic Training Certificate or a UA Pilot License is required.
- 3) Please refer to the *UA Regulatory Requirements* on the CAAS Website for more details on Unmanned Aircraft regulations.

## 10. PANDEMIC RESTRICTIONS

In the event where pandemic restrictions result in SAFMC 2022 being unable to be held in a physical venue, the following changes will be made:

- 1) As there will be no physical competition on-site, the Mission Factor component of scoring will be based solely on the Team Challenge Video submitted.
- 2) The Team Challenge Video will be scored by the Judges.
- 3) The segment weightages will be as follows:

<b>Segment</b>	<b>Factor</b>	<b>Weightage</b>
<b>Presentation</b>	<b>Aerial Platform</b>	20%
	<b>Creativity</b>	20%
	<b>Learning Journey and Insight</b>	20%
<b>Competition</b>	<b>Team Challenge Video</b>	40%

- 4) Team presentations will be held via Zoom. Presentation details will be communicated to participating teams accordingly. Teams will still need to submit their presentation slides to the SAFMC 2022 Committee before the deadline mentioned in Section 7.
- 5) Video submissions by each participating team will result in team members being automatically awarded a Certificate of Participation for SAFMC 2022.
- 6) Awards and Prizes as listed in Section 5 may be changed and modified at the discretion of the SAFMC 2022 Committee.
- 7) Ensure that the team member's names and contact details are accurate and updated, in order to receive timely updates from the SAFMC 2022 Committee.

The SAFMC 2022 Committee will follow all mandated Safe Management Measures as laid out by the Ministry of Health and Ministry of Education. The safety and health of our participants and event organisers are of paramount importance.