Category D1

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

SP Singapore Polytechnic

NYP NANYANG POLYTECHNIC

REPUBLIC POLYTECHNIC DISCOVER. TRANSFORM. ACHIEVE

NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

NUS National University of Singapore

SINGAPORE YOUTH FLYING CLUB Takes You To Greater Heights

FLIGHTSCIENCE AERO LABORATORIES

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SAFMC 2024 CAT D1 CHALLENGE BOOKLET CHANGE LOG

Version	Release Date	Description
1.0	22 Sep 2023	Official challenge booklet release

SAFMC 2024 COMPETITION SCHEDULE

Date	Event	Platform/Venue
1 March 2024	Team Challenge video submission	Email
20 March- 2 April 2024	Presentation and Challenges	Science Centre Singapore
6 April 2024	Awards Presentation Ceremony	To be Announced

CONTENTS

SINGAPORE AMAZING FLYING MACHINE COMPETITION 2024

1. INTRODUCTION

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

2. CATEGORIES

CATEGORY A – PAPER PLANES *(Primary Schools)*

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

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

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

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

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 – MAN-MACHINE TEAMING / MULTI-MACHINE TEAMING

Category D1: Man-Machine Teaming *(Polytechnics / Universities)*

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

Design and build UP TO THREE (3) semi-autonomous small air platforms, controlled using wearables, to perform a multitude of tasks in an indoor course.

Category D2: Multi-Machine Teaming *(Polytechnics / Universities)*

Each team should consist of TWO (2) to EIGHT (8) members.

Design and build TWO (2) to FOUR (4) autonomous small air platforms to collaboratively perform a multitude of tasks in an indoor course.

CATEGORY E – SWARM *(Open to Public)*

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

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

3. GENERAL SAFMC RULES

1. The deadline for registration is **16 February 2024**.
2. Participants registered under a school must be a full-time student at the point of competition.
3. Home-schooled participants and teams consisting of participants from different schools should be registered as “Independent teams”.
4. 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.
5. 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.
6. 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.
7. Participants of Category C1 are also eligible to register for either Category C2 or C3 but not both.
8. Participants of Category C2 are not eligible to participate in Category C3 and vice versa.
9. Participants of Category D1 are also eligible to participate in Category D2 and vice versa.
10. Members and family members of the organising committee are not allowed to participate in the SAFMC.

11. 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.
12. Prizes will be issued to the Team Manager.
13. Prizes may not be given out if the minimum standard is not met or if there are insufficient participants. The SAFMC organising committee will have the final say and the decision made is final.
14. A safety perimeter net will be set up at the competition field for Categories A, B, C, D, and E. There will be a top net **SIX (6) metres** above the ground, which will limit the maximum flight altitude of flying machines. During the challenge attempts, teams are strongly encouraged to fly their flying machine(s) away from the netting to avoid accidental entanglement.
15. The organisers of SAFMC 2024 will not be held responsible for any damage to or the loss of any flying machine(s) throughout the entire competition.
16. 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.
17. 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 registrations 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 2024 Awards Presentation Ceremony.

4.1. PRESENTATION

The teams will be allocated a specific time slot to showcase their flying machine physically during their challenge day. 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 compete for the SAFMC Championship Award. Teams that do not show their flying machines during the 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 are drastically different from the flying machine presented at the Presentation.

4.2. CHALLENGE

Teams are to design, build and fly their flying machines to overcome various challenges for the different SAFMC categories. The Challenge constitutes the actual in-venue flight on the competition day. For Categories D1, D2 and E, it will also consist of a team video challenge.

The team video challenge serves as a prelude to the team's aircraft capabilities and flightworthiness. 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:

1. Only registered team members of the participating teams can enter the team booths/holding areas.
2. Only members of the participating team can be allowed to be at the pilot booths and inside the playing field.
3. 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 not be responsible for any injuries or mishaps if any participant has disregarded the safety rules.
4. No trials will be allowed in the flying area unless specified by the officials.
5. The participants will acknowledge that there will be variations in environmental conditions between teams, despite best efforts to control them.
6. For all Category C, D and E participants, all aircraft and their transmitting devices must be presented to SAFMC officials for inspection upon arrival.
7. 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 Technical Chairperson to perform power-on checks.

5. CATEGORY D1 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.

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

The list of awards for Cat D1 is listed in the subsequent sections.

5.1. CHAMPIONSHIP AWARD

This is the pinnacle award any local team can win, and is bestowed on the team that achieves the highest total score across all areas. For category D1, 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. BEST INTERNATIONAL TEAM AWARD

This award is given to the best international team in CAT D1. The SAFMC Organising Committee recognises that international teams can bring a wide spectrum of unique designs and innovations and would like to award the best international team in this category if the minimum standard is met.

5.3. JUDGES' COMMENDATION

This award is given out to Category D1 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 D1.

5.4. PRIZES

CATEGORY D1				
Awards	**Medals**	**Trophy**	**Cash Prize**	**Remarks**
Cat D1 Championship Award	✓	✓	$4,000	
Cat D1 1st Runner Up	✓		$3,000	
Cat D1 2nd Runner Up	✓		$2,000	3rd and 4th runners up will receive medals **only**
Best International Team Award	✓	✓	$4,000	
Cat D1 Judge's Commendation	✓		$500	Up to two teams can win this award

6. CATEGORY D1 MISSION

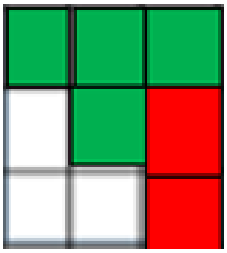
Teams are required to design a system of **UP TO THREE (3)** small drones, where the system is controlled through intuitive means with the use of **wearable technologies**. The drones are to be piloted by a single designated pilot through a course designed with a series of obstacles. The system of drones can consist of customised or Commercial-Off-The-Shelf (COTS) product that is capable of semi-autonomous or fully autonomous flight and need not be homogeneous.

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 drones to execute the mission. The technical rules for the flying machine are found in Section 9.

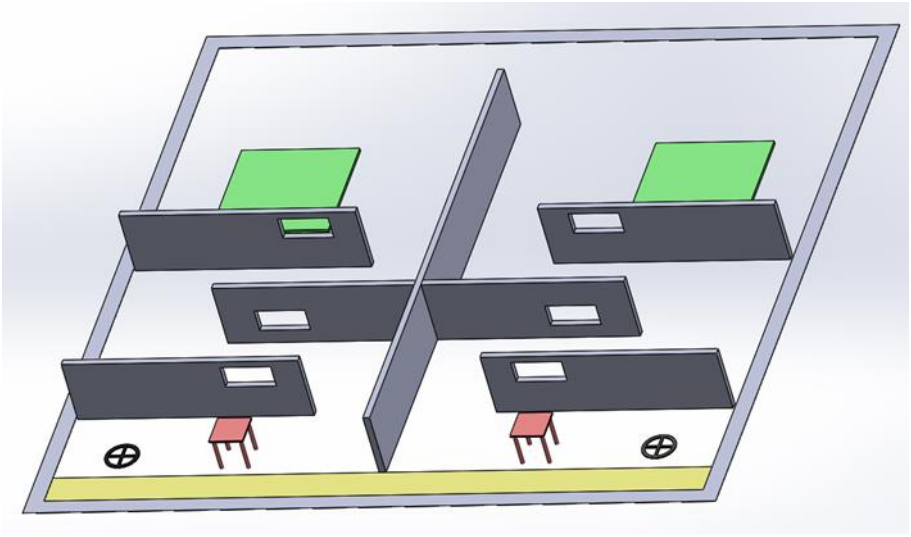
6.1. CATEGORY D1 CHALLENGE (TIC-TAC-TOE)

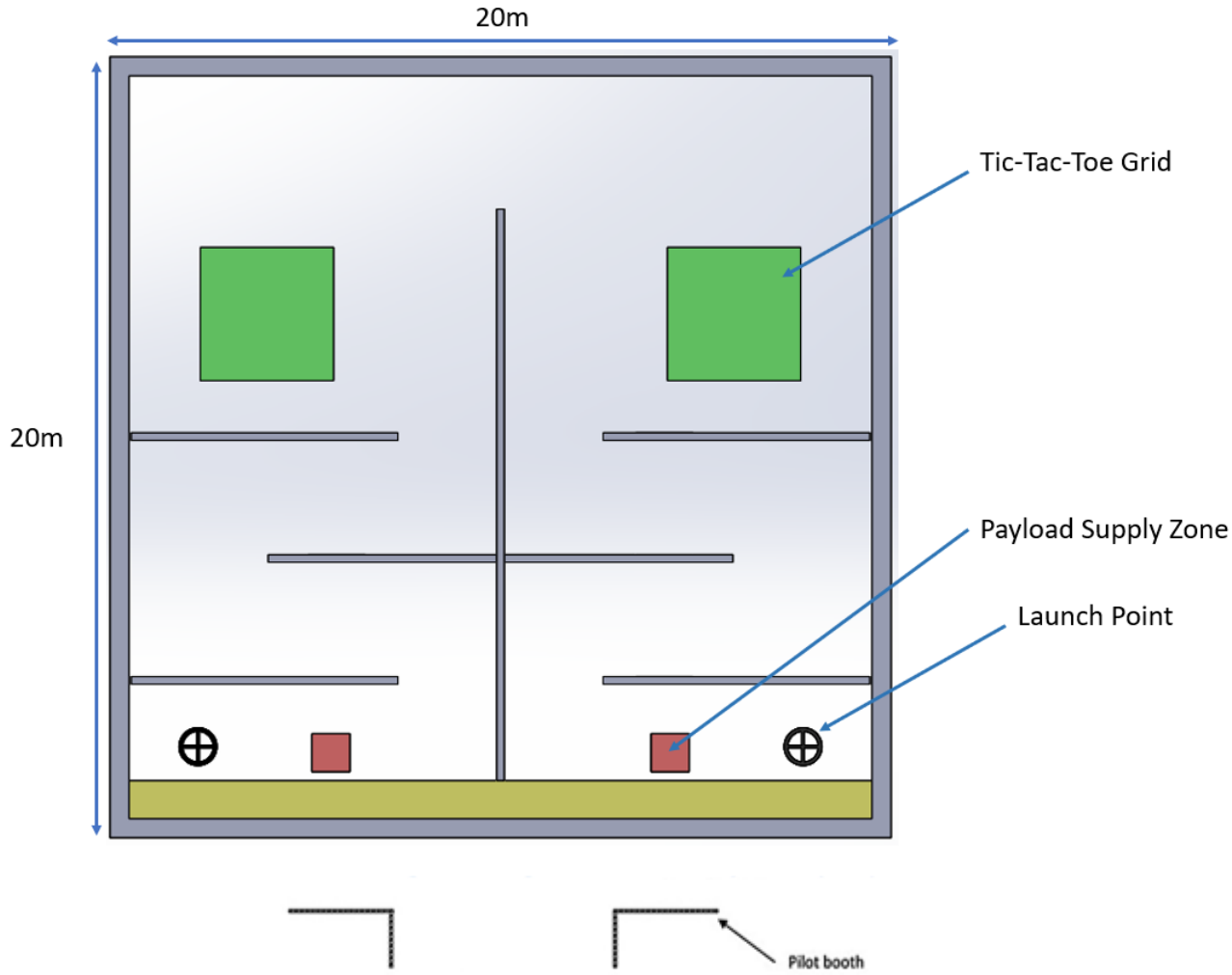
Category D1 participating teams are required to design a system of drones that can pick up and release a payload. The drones must be controlled through motion gestures using wearable devices. Two teams will race against each other through a series of obstacles, followed by playing the “Tic-Tac-Toe” game via the precise and strategic dropping of their payloads.

The competition set-up and a plan-view schematic are shown on the next page. The entire playing field is divided along its length by a wall to allow two teams to compete in real-time. The progress of the Tic-Tac-Toe game, as depicted in an example on the right, will be seen on the LED boards which are on the ground inside the competition zone, and will light up in green or red for each team depending on their allocated colour.

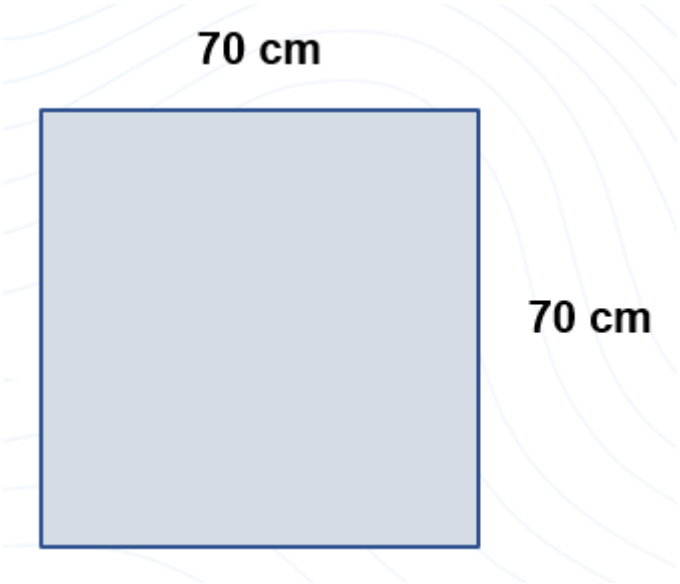


Plan View of Playfield

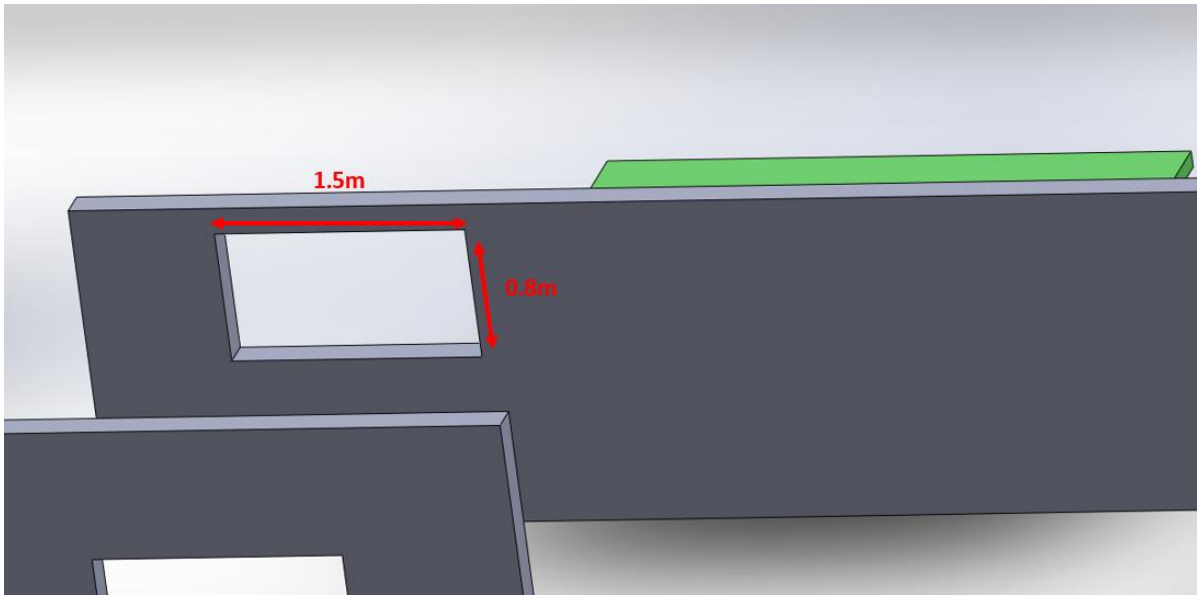




Dimensions of Each Grid on LED floorboard at Drop-Zone



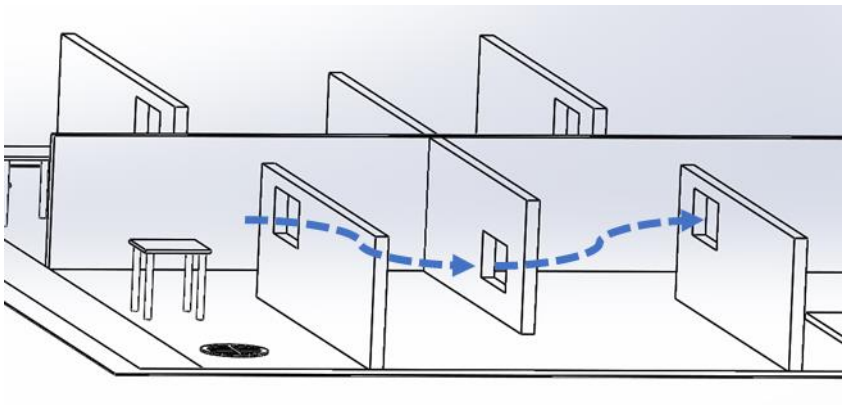
As illustrated in the plan view of the playing field, the maze consists of three walls, each with a window sized 1.5m by 0.8m. Pilots may choose to fly their drones in a zig-zag path around the walls or fly through the windows for a direct path to the Tic-Tac-Toe grids.

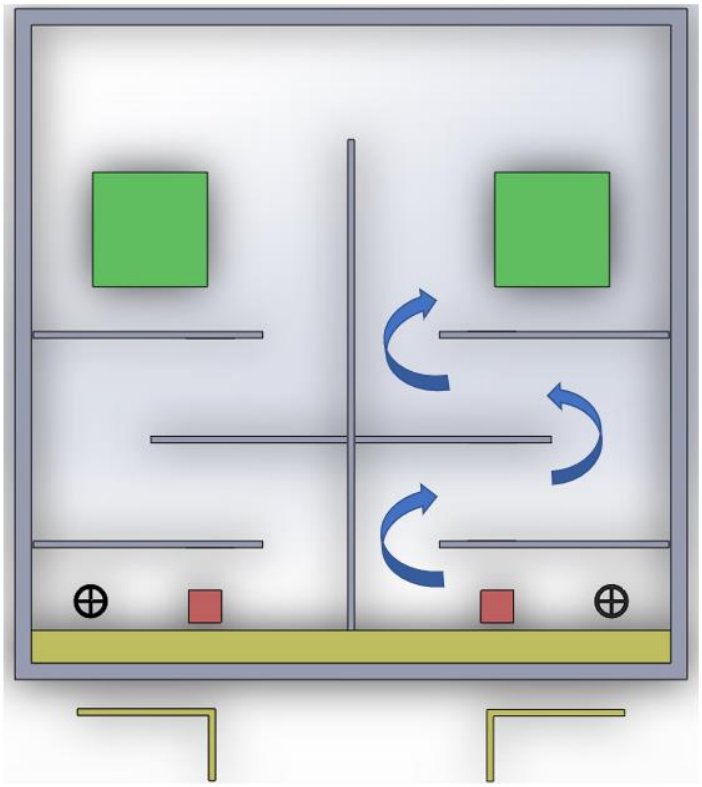


6.2. MISSION TASKS

Task 1: Navigate through the Maze (blue arrows depict general gameplay)

With each drone pre-loaded with its respective payload, teams are to control the drone(s) using wearable devices. The pilot will command the drone(s) to take off, fly and navigate through the winding course to the drop zone. Two possible routes are shown; either flying around the walls or through the windows in the walls.





Task 2: Releasing Payloads at Drop-Zone

Having sight of the progress of the Tic-Tac-Toe game on the LED floorboards, the pilot will command the drone(s) to navigate to its desired grid. The drone(s) will drop their payload(s) into the desired grids from the air before leaving the drop-zone.

A successful drop of a payload into the drop zone will see the respective grid light up in red/green according to the team's allocated colour. If the same grid was contested by both teams, the payload that lands and touches the grid first will claim that grid for the team.

Task 3: Reloading of Payload

Each team will control their drone(s) to fly back to the launchpad(s) / loading pad(s) via the winding course or through the windows in the walls to retrieve one payload per drone. Teams are allowed to use any method to pick up the payload, but without direct human interaction. After retrieval of payload(s), the drone(s) can proceed to navigate through the maze and repeat the tasks.

6.3. MISSION RULES

Flight

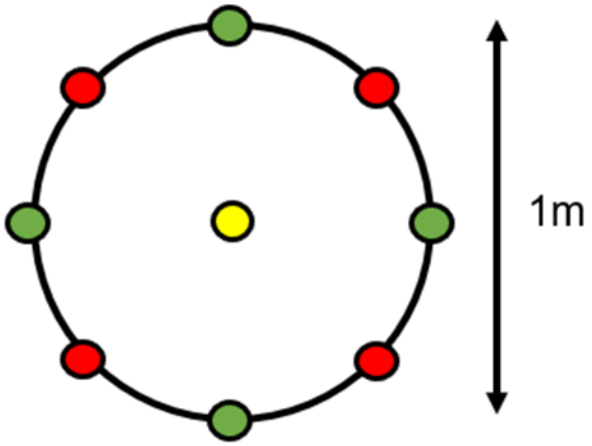
1. Teams can use UP TO THREE (3) small drones.
2. Each drone must weigh less than 2kg, and measure less than 1m in any direction (includes maximum diameter of propeller circles).
3. Teams are to control their drone(s) using wearable devices, which are items that are either worn around the body, such as hands (like gloves) and arm/wrists. Motion controllers that senses movement using a piece of equipment placed on the floor/table are also allowed. **Devices/equipment that requires hand grip such as joysticks/thumbsticks are strictly prohibited.** In case of any doubt, the Chief Referee and/or the Category D1 Technical Chairperson has the final decision. For any use of touchscreens, teams are to write in, explain and check with the Category D1 Technical Chairperson on the permissibility of this form of control.
4. Pilots are allowed to fly their drone(s) using remote sensors (video or otherwise). The pilot will be confined to the pilot box and will not have line of sight to the aircraft. Any ground aids used for positional awareness must not leave any markings or traces for the next race.
5. The drone(s) can may fly through the maze together.
6. Other than the launchpads, the drone(s) are not allowed to be in persistent contact with the floor or platform.
7. Drone(s) cannot fly over the walls.

Payload Pickup and Carriage

1. Teams will be provided with standardised payloads (85g beanbag with 1 metal clip) on the competition day.

2. Teams may choose to use only the metal clip or bring any removable attachment(s) to assist with the pick-up of the payload. However, the attachment(s) must be removable from the payload without causing any damage to it.

3. During the setup phase, teams will be provided with 9 payloads, 4 red, 4 green and 1 yellow (wildcard payload). Teams are to arrange the red and green payloads along the perimeter of a 1m diameter circle in alternate colours as shown, with the yellow beanbag in the centre. Once the setup phase has ended, the referee will assign each team a colour (red or green), and teams will only score points using beanbags of their team colour. The yellow beanbag may be used in the event the team requires a 5th tile in the tic-tac-toe game and will represent the colour of the team.



4. After the setup phase, teams are not allowed to adjust the positions of the beanbags.

5. Each team is free to determine its own payload pick-up strategy, as long as no human intervention is required. The payload may be placed on a structure (e.g. to erect the bean bag) but the payload's lowest point must not be more than 1 inch off the ground. The structure must be stationary. The structure must be easily removable with no damages to the launchpad after.
6. Articulating ground aids can only be used if:
    a. When stowed away, their dimensions are within 150mm x 150mm x 100mm.
    b. They adhere to previous bullet point regarding the <1 inch off the ground restriction.
    c. The base of the structure be stationary on the launchpad.
7. Each drone is permitted to pick up its payload without landing. Propellers can remain spinning if the drone touches the launchpad to pick up the payload. No direct human physical intervention is allowed when loading the payload.
8. Payload modification is strictly NOT ALLOWED. This means that any payload attachments or mechanisms must not be delivered along with the payload.

Payload Release

1. There are no restrictions on the number of drones entering the drop zone.
2. Each payload must be released while the drone is in the air.
3. If the payload is released when the drone has landed, it will not count as a valid drop.
4. Once the payload is dropped or released under any circumstances outside of the payload supply zone, teams are NOT allowed to

retrieve the dropped payload with their drone(s). They are required to fly the drone back to the launchpads to pick up a new payload.

5. Teams are allowed to use pre-made attachments to carry the payloads as long as it is within the maximum take-off weight (MTOW) and the integrity of all payloads are preserved. Any ground aids or attachments that help in the picking and release of payloads will be allowed with the following conditions:
    a. Removable (no damage or marks on the take-off pad after removal)
    b. A size no more than 150mm (L) by 150mm (W) by 100mm (H)
    c. Must not be delivered together with the payloads.
6. If the payload does not land cleanly within a grid, it is up to the referee's discretion to determine the intended grid.
7. If both teams release their payload on the same grid at the same time, it will be up to the referee's discretion to determine which payload touched the surface first.

<u>Safety and Admin</u>

1. Each team should consist of TWO (2) to FIVE (5) members.
2. All drones must follow CAAS regulations (e.g. CAAS registration sticker must be visible on drone). Any disregard for CAAS regulations will result in disqualification.
3. All drones must be inspected by designated event staff 30mins before the team's competition slot.
4. Teams are allowed to change flight batteries during the game only if the drone has landed on the launch pad AND there are no other airborne drones within the safety zone both playfields.

5. There will be a charging space allocated to charge flight 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.
6. The drone(s) can only take-off when there are no people within their side of the playfield.
7. If any drone(s) malfunction or crash, no disruption to the match is allowed. Teams are only able to retrieve their malfunction/crashed drone(s) after match ends. No troubleshooting of drone(s) is allowed during the match.
8. In the case where all the drones in one of the teams are taken out of the game, the opponent has to continue to attempt to win the game. In the event that all the opponent's drones are also inoperable or if the mission time is up, the scores up to that point will be considered.
9. On the competition day, each team will have **only ONE (1)** attempt per race. Each team will have a **fixed duration of 10 minutes of mission time** to compete in the playing field.
10. There will be allocated playing fields for the two teams, separated by system partitions. If **any part** of the team's aircraft crosses to the other team's playing field, the offending team will be disqualified for the race.
11. Teams that are competing against each other can decide the side of the field that they want, or to flip a coin.
12. Both teams will then be given **10 minutes of set-up time** prior to the mission start time. During this time, teams are allowed to set up their pilot booth and launchpads. No additional markers and/or

hardware is allowed inside or outside of the playfield except at the pilot booths.

13. Each competing team will be allocated half of RaceBand frequencies (either Ch1 to Ch 4, or Ch 5 to Ch 8).

	Frequency (MHz)							
Band	Ch1	Ch 2	Ch 3	Ch 4	Ch 5	Ch 6	Ch 7	Ch 8
Raceband	5658	5695	5732	5769	5806	5843	5880	5917

14. Teams are required to set their video transmitter (VTX) to broadcast at their allocated RaceBand frequencies. Other teams (not competing) are not allowed to turn on their VTX when a race is ongoing.

15. Teams are permitted to power on their drone(s) and VTX for testing during the set-up time but are not allowed to fly out of the safety zone. No one is to be in the playfield while there is any airborne drone during this time. Offending teams will be disqualified.

16. Once the 10 minutes of set-up time is up, the mission time will automatically start. Any drones that are not at the launchpad will have to return to the launchpad first before any action will be recorded. The mission time will continue to run throughout and will **not** be paused in the event of any landing, maintenance or repair works, etc.

17. To qualify for the multiplier for number of drones used, the operator has to fly all the drones together from the take-off point towards the payload area and each drone must drop their payload in the release zone at least once (regardless if it scored).

18. The radio transmitter must have an emergency switch to terminate the operation of all the drones, and teams are required to demonstrate this during inspection.
19. Teams with inoperable drone(s) are allowed to repair in between races. If the drone is deemed incapable of flight, a new identical copy of the drone can be used for the next race. There will be no restriction on the number of spare drones the team can prepare so long as the drone is replaced by another drone of the same design, at the discretion of the Chief Referee or Category D1 Technical Chairperson.
20. In case of doubt, the Chief Referee or the Category D1 Technical Chairperson has the final decision.

6.4. MISSION SCORING

The referees will make all scoring decisions and their decision is **final**. For arbitrary cases, the Chief Referee will have the **final** say. Mission scores take up 40% of the total Championship Score.

There are two stages in the competition, the regular and knockoff stages. In the regular stage, teams will be playing in a league with round-robin format. The number of leagues and teams in each league will depend on the number of participating teams.

In regular stages, points will be given according to the following table:

Task	Points
Successfully take off	1 / drone
Successfully flown to the drop zone, pick up a payload	1 / payload

Successfully fly to drop zone and drop payload onto grid	2 x multiplier / payload
Win / Draw / Lose	5 / 2 / 0

Beanbags must be dropped on an unoccupied grid to be considered a successful drop.

To be considered a draw, teams must have successfully dropped at least 3 beanbags on the grid.

To qualify for the multiplier, all drones must navigate through the maze together with payload, and each drone must drop their payload at least once on the drop zone.:

Number of drones	Multiplier
1	1x
2	1.5x
3	2x

The best 8 teams will proceed to the knockoff stage, where the teams will be grouped in a snake format. (i.e. 1st team vs 8th team, 2nd team vs 7th team, and so on). Teams will be awarded 20 points for each win.

At the end of the competition, the points accumulated by the teams will be summed up (including the knockoff stages). The team with the highest number of points will receive the full mission score (40%). This will be followed by the 2nd team with 35%, 3rd with 30%, 4th with 25%, 5th to 8th with 20%, and the others 15% each.

6.5. 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.

LIST OF MISSION PENALTIES

S/N	DESCRIPTION	PENALTY
1	Exceeding the 10 minutes setup time for D1.	Mission time will start regardless.
2	Use of external markers/hardware outside of the playing field and pilot booths.	Referee's discretion or **disqualification**
3	No additional Internal markers/hardware within the playing field	Referee's discretion or **disqualification**
4	Interrupting the competition by potentially interfering with other competitors, e.g. switching on your drone's VTX, transmitters, etc.	Referee's discretion or **disqualification**
5	Drone crossing into opposing team's playing field.	Referee's discretion or **disqualification**
6	Attempting to subvert competition rules or gain an unfair advantage over other teams, e.g. receiving assistance from spectators, etc.	Referee's discretion or **disqualification**

7	Any ground aids used to help in the picking of payloads are 1. Having a size more than 150mm (L) by 150mm (W) by 100mm (H) 2. Delivered together with the payloads. (i.e. left remaining on the payload wells or elevated platforms in the drop-zone)	Referee's discretion or **<u>disqualification</u>**

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 D1 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:

Segment	**Factor**	**Weightage**
Presentation	**A**erial Platform	20%
	Creativity	20%
	Learning Journey and Insight	10%
Competition	Team Challenge **V**ideo	10%
	Mission	40%
	Total	***100%***

For **CAT D1** 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 20% weightage to the overall score.

No points will be deducted for wholesale usage of COTS products with little or without modifications

1. Platform Choice
    a. If a COTS product is used, teams are to explain:
        - Choice of COTS products
        - Modifications to COTS products, if any are made
    b. For custom-built drones, teams are to explain:
        - Aerodynamic Design
        - Centre of gravity placement
        - Design factors affecting platform's flight stability, responsiveness, and controllability
        - Sizing for lift / thrust
2. Mechanical Design
    - Quality of fabrication, workmanship, materials used
    - Platform weight optimisation
    - Lower points for usage of commercial off the shelf products
3. 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

7.2. CREATIVITY FACTOR (C)

The Creativity Factor (C) is based on:

1. what type of wearable technology is used and how it is integrated with the flight control to tackle the obstacle course
2. how the payload is carried and how successful payload release/retrieval is achieved

The above two criteria carry a 20% weightage to the total score. Teams are to explain in detail about the above during the presentation.

Teams are also encouraged to utilise and present unique concepts which capitalize on the usage of wearable technology to enhance semi-autonomous drones.

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. Time management
    - Finishing within the allotted time, with enough time allocated for each segment

2. Delivery

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

3. Content

- Information presented is relevant to the flying machine and the team's project progress
- Team is able to explain the rationale behind design choices and major decision
- Team is able to express what they have learnt through the process and their learning journey

4. Teamwork

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

5. 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

- Aircraft must be shown to perform stable, sustained flight

- Video of drone(s) performing roll/pitch/yaw/ascending and descending upon input by pilot through the use of wearable technology

2. Mission-readiness

- Demonstrate that drone(s) is/are shown to be able to fulfil mission requirements; fly a route while carrying a payload and when the drone is hovering at a fixed point, able to release the payload successfully.
- Explain the on-board sensor suite for each unique drone used in the challenge

3. Creativity

- How the wearable tech is worn on the user? Ease of putting on and removing once worn
- Delivery of video (i.e. how it is filmed/presented)

7.5. MISSION FACTOR (M)

The mission attempt scores will form the **Mission Factor (M)** score. Please refer to Section 6 for the mission scoring and penalties. This carries a 40% weightage to the overall score.

8. FLOW OF EVENTS

8.1. PRESENTATION SEGMENT

Teams will deliver their presentation to a panel of judges in person during the challenge day.

Teams will be given a maximum of **FIFTEEN (15)** minutes for this segment. **TEN (10)** minutes are allocated for the team presentation, and **FIVE (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) Bring each unique aircraft used during the presentation

2) Teams are to prepare **TWO (2) A0** posters.

8.2. TEAM CHALLENGE VIDEO

Teams are to submit **ONE (1)** Team Challenge Video to the SAFMC committee. The video length should be no longer than **TEN (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 with title subject: "[CAT E] - [Team Name] – Challenge Video" before the deadline. The deadline for submission is **1 March 2024, 2359hrs**. Video should be uploaded before the deadline, and any re-upload of the video detected past the deadline may result in **penalisation** or **disqualification**. You may write in to the SAFMC 2024 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. Teams are to arrive at their designated reporting time.

2. At the allocated competition schedule, the team shall report to the safety inspection point. A SAFMC official will check the aircraft for any violation of the category rules and regulations. Teams who do not pass the inspection will **not** be allowed to fly their aircraft in the challenge mission, and may face **immediate disqualification** from the competition. The inspection will include, but is not limited to, the following checks:

   a. The maximum take-off weight (MTOW) and size of the aircraft.

   b. RC / datalink / video link transmitter and receiver are operating on allowed frequencies.

   c. Electrical harnessing should be appropriately insulated and should not be chafed or broken. No exposed wires and connectors are permitted.

   d. All major assemblies and critical components must be securely fastened to the aircraft; loose items should be tied down and kept away from the propellers.

   e. For aircraft operating on semi-autonomous / autonomous modes, it should allow complete manual pilot override on-demand via RC or GCS.

   f. The aircraft must demonstrate failsafe capability in the event of a loss of link between the RC/GCS and the aircraft. The failsafe check procedure is as follows:

      (1) All propellers and releasable payloads are to be removed from the aircraft.

      (2) Aircraft will be armed.

      (3) Throttle will be applied to spin the motors. While the motors are still spinning in the same flight mode, the

Wi-Fi router(s) will be switched off to simulate a link loss.

(4) All motors should come to a **complete stop immediately**. The aircraft should not attempt a hover / controlled descent / to return home.

g. A SAFMC official will be with the operator during the mission attempt. The official may give instructions to the operator depending on the behaviour of the aircraft (e.g. to land immediately if the aircraft appears to be uncontrollable). The operator is to comply immediately with all such instructions, which may include the activation of the failsafe to ground the aircraft.

h. The aircraft must demonstrate failsafe capability upon operator command. The failsafe check procedure is as follows:

(1) All propellers and releasable payloads are to be removed from the platform.

(2) Flight motors will be armed and throttled up.

(3) While the motors are still spinning in the same flight mode, the operator must be able to activate a kill-switch.

(4) All motors should come to a **complete stop immediately**. The aircraft should not attempt a hover / controlled descent / to return home.

i. Failsafe capability for the DJI Tello drones will be the OEM default failsafe logic. Any tampering or modifying of the OEM failsafe logic (unless it meets regulation 2e, 2f, and 2h), will result in a disqualification. Tello drones are exempt from regulation 2e, 2f, and 2h, because:

(1) The Tello SDK does not allow for the expected failsafe behaviour to be configured.

(2) DJI Tello drones do not allow motors to function when propellers are removed.

j. At the end of each mission attempt, the radio control transmitter, datalink transceiver, video receiver and any other wireless device for the flying machine must be switched off.

8.4. KEY POINTS TO NOTE

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

1. Only members of the participating team are allowed to be inside the playing field at any one time, when the aircraft is not airborne.
2. 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 operator/pilot. Teams who flout this rule may be **disqualified**. Communication amongst teammates is allowed.
3. All teammates are required to remain outside of the playing field and be behind the safety net when the aircraft is airborne.
4. 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 all aircrafts have been disarmed. Entry into the playing field is only allowed upon confirmation with SAFMC officials.
5. Multiple video **receivers** are allowed. Only **ONE (1)** video transmitter is allowed for each aircraft.

6. 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 done in Raceband channel 8 with VTX set to either 25mW or pit-stop mode. Non-compliance may lead to **disqualification**.
7. 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**.
8. Teams shall make sure that their designated representatives are contactable and should arrive at least **TEN (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:

1. Off-the-shelf products and components are allowed in the competition.
2. For safety considerations, the total weight of the flying machine **cannot exceed 2 kg.**
3. The platform **should not exceed 100 cm** in any direction (this measurement includes the maximum diameter of the propeller circles).

4. Teams can bring similar backup aircraft to replace any aircraft that has become incapable of flight. No changing of aircraft during runs is allowed. Teams can only change aircraft between runs.
5. Only electric-based flight propulsion is allowed. Both brushed and brushless motors are allowed. No modification to the motors is allowed.
6. No internal combustion or gasoline engines are allowed.
7. No tethering or umbilical wires to the aircraft are allowed during flight.
8. External aids such as markers, indicators etc. will be allowed **only** in the playing field, and can only be placed when there are no platforms flying.

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 aircraft.

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

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 RC frequency ranges are allocated for RC cameras / toys / miscellaneous devices:

1. 26.96 – 27.28 MHz ≤ 100mW Effective Radiation Power (ERP)
2. 34.995 – 35.225 MHz ≤ 100mW ERP
3. 40.665 – 40.695 MHz ≤ 500mW ERP
4. 40.77 – 40.83 MHz ≤ 500mW ERP
5. 72.13 – 72.21 MHz ≤ 500mW ERP

The following RC frequency ranges are allocated for RC aircraft:

1. 29.700 - 30.000 MHz ≤ 500mW ERP
2. 26.96 - 27.28 MHz ≤ 500mW ERP

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 **or** when there is a loss of link between the RC transmitter and the RC receiver on the aircraft. Please refer to Point 2(f) and Point 2(h) in Section 8.3 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:

1. 433.05 - 434.79 MHz ≤ 10mW ERP

2. 866 - 869 MHz ≤ 500mW ERP
3. 920 - 925 ≤ 2000mW ERP

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

Setup of external wireless device(s) is allowed. However, teams can only turn on their wireless routers and transmitters during the setup and flight phases (same restriction as RC transmitters).

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

1. 72.080, 72.200, 72.400, 72.600 MHz ≤ 1000mW ERP
2. 158.275 / 162.875 MHz ≤ 1000mW ERP
3. 158.325 / 162.925 MHz ≤ 1000mW ERP
4. 453.7250 / 458.7250 MHz ≤ 1000mW ERP
5. 453.7375 / 458.7375 MHz ≤ 1000mW ERP
6. 453.7500 / 458.7500 MHz ≤ 1000mW ERP
7. 453.7625 / 458.7625 MHz ≤ 1000mW ERP
8. 2.4000GHz - 2.4835GHz ≤ 200mW Equivalent Isotropically Radiated Power (EIRP)
9. 10.500 – 10.550 GHz ≤ 117dBμV/m @ 10m
10. 24.000 – 24.250 GHz ≤ 100mW EIRP
11. 5.725GHz – 5.850 GHz ≤ 4000mW EIRP
12. 5.150GHz - 5.350GHz ≤ 200mW EIRP
13. 5.470GHz - 5.725GHz ≤ 1000mW EIRP
14. 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.

9.5. CAAS REGULATIONS

Participants are to ensure that they have registered their aircraft if the weight exceeds 250g.

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.

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 2024 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. Team presentations will be held via Zoom. Presentation details will be communicated to participating teams accordingly.
4. Awards and Prizes as listed in Section 5 may be changed and modified at the discretion of the SAFMC 2024 Committee.
5. Ensure that the team members' names and contact details are accurate and updated, in order to receive timely updates from the SAFMC 2024 Committee.

The SAFMC 2024 Committee will follow all mandated Safe Management Measures as laid out by the Ministry of Health and Ministry of Education.