Category D2

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

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SINGAPORE YOUTH FLYING CLUB Takes You To Greater Heights

FLIGHTSCIENCE AERO LABORATORIES

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SAFMC 2024 CAT D2 CHALLENGE BOOKLET CHANGE LOG

Version	Release Date	Description
1.0	22 Sept 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 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 7.

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 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:

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 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.

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 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 category 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 D2.

5.3. PRIZES

CATEGORY D2				
Awards	**Medals**	**Trophy**	**Cash Prize**	**Remarks**
Cat D2 Championship Award	✓	✓	$10,000	
Cat D2 1st Runner Up	✓		$7,500	
Cat D2 2nd Runner Up	✓		$5,000	3rd and 4th runners up will receive medals **only**
Cat D2 Judge's Commendation	✓		$500	Up to two teams can win this award

6. CATEGORY D2 MISSION

Teams are required to design and build **TWO (2) to FOUR (4)** autonomous small drones to collaboratively perform a multitude of tasks in an indoor course. The drones need be homogeneous. The drones should also possess various sensors, and/or mechanisms to complete a variety of tasks in a complex environment without inputs from the operator.

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 tasks, as well as the scoring criteria are found in the following sections. Teams are advised to read through these sections in detail to develop a strategy and identify key design requirements, before designing the drone to execute the mission. The technical rules for the drone are found in Section 9.

6.1. CHALLENGE TASKS

The challenge requires its participating teams to perform various tasks with fully autonomous drones that work dynamically and collaboratively for a package delivery operation.

The challenge comprises of package deliveries to 6 victims within the play area with different priorities. The challenge is split into 2 segments: Setup and Mission. Teams are allowed to deliver the packages to victims in any order, within the allotted mission time.

The challenge ends when packages are delivered to all 6 victims or the allocated time is up.

6.2. ARENA SPECIFICATIONS

6.2.1 PLAY FIELD

The dimensions for the play field are shown in Figure 1, Figure 2.[1] The safety area is approximately 20m x 20m.[1]

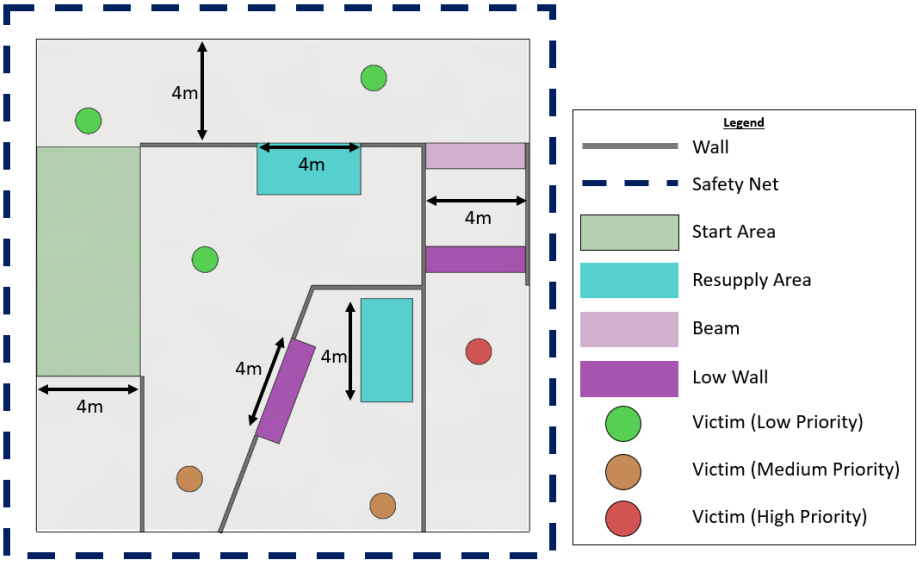

Figure 1 Top View of Play Field (metres)

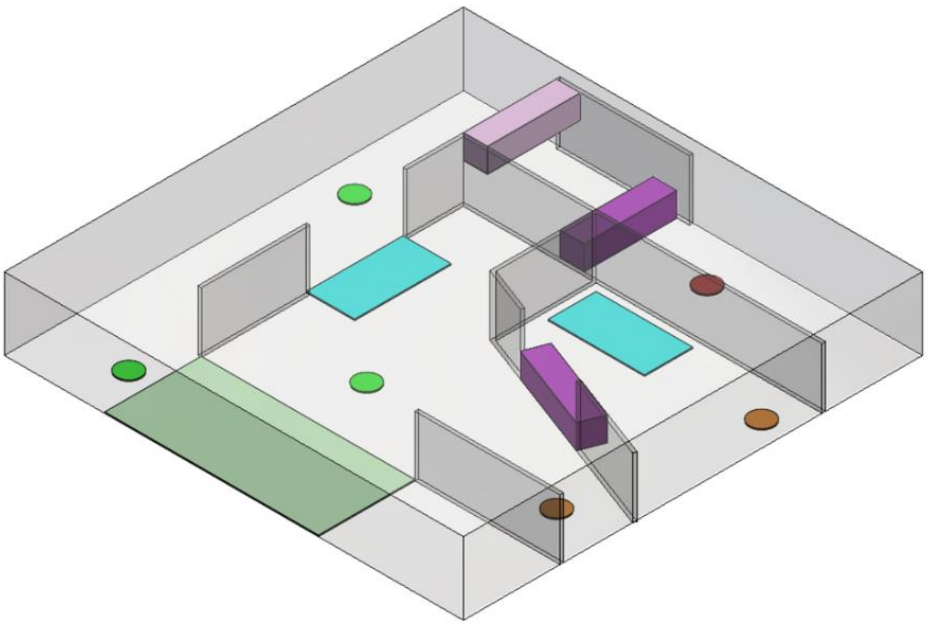

Figure 2 Isometric View of Challenge Arena

[1] subject to change without prior knowledge and may vary on the actual day.

6.2.2 OBSTACLES

Visualizations for obstacles that may be encountered, such as beam and low wall, can be found in Figure 3 and Figure 4.[1]

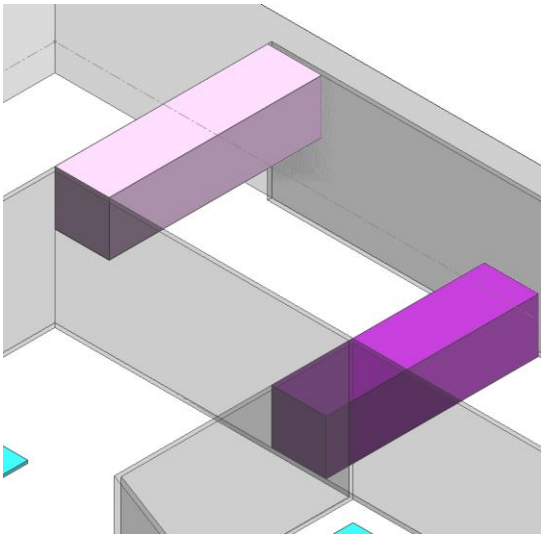

Figure 3 Beam Obstacle

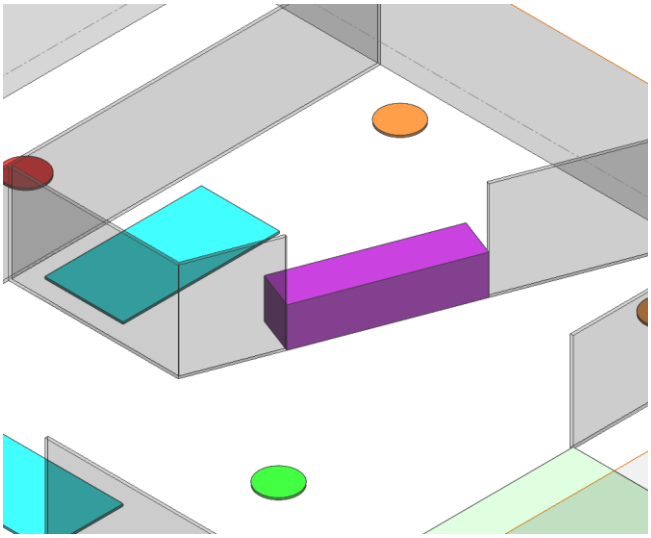

Figure 4 Low Wall Obstacle

Dimensions for beam and low wall can be seen in Figure 5 and Figure 6, respectively.[1]

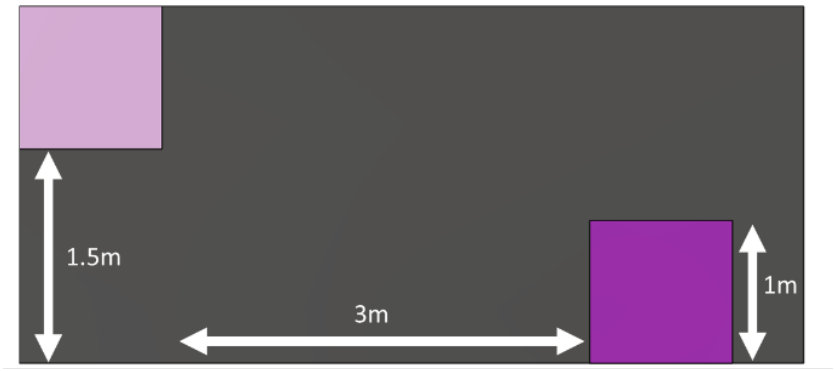

Figure 5 Beam Obstacle Dimensions

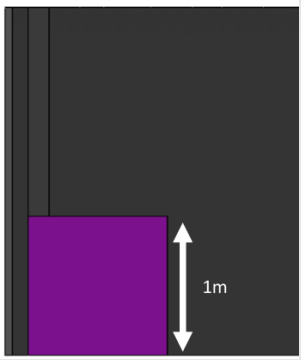

Figure 6 Low Wall Dimensions

6.2.3 VICTIM, RESUPPLY AREA AND START AREA

Dimensions for victim, resupply areas and start area can be found in Figure 7, Figure 8 and Figure 9, respectively.[1] There are 3 priority levels

of the victims – low, medium and high. The priority levels will be denoted by colour.

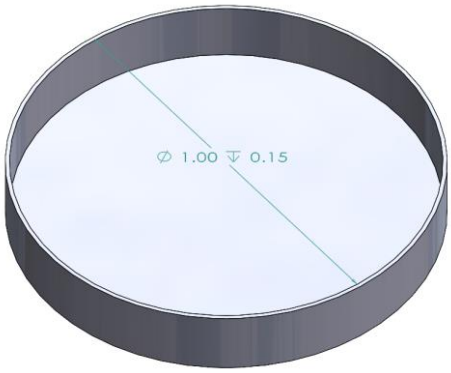

Figure 7 Victim Dimensions in Metres

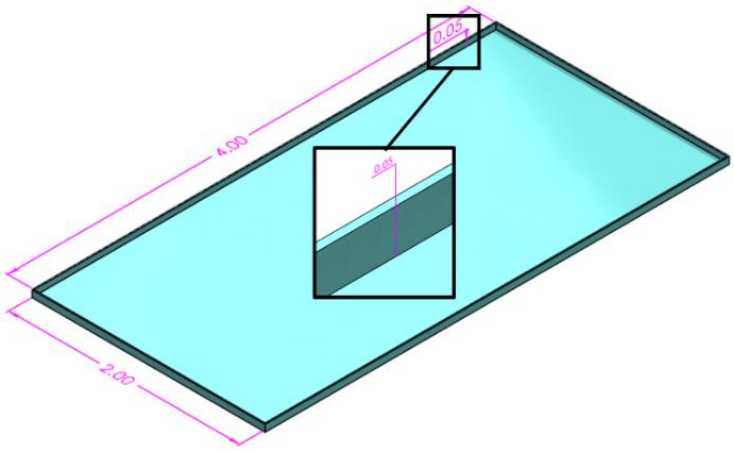

Figure 8 Resupply Area Dimensions in Metres

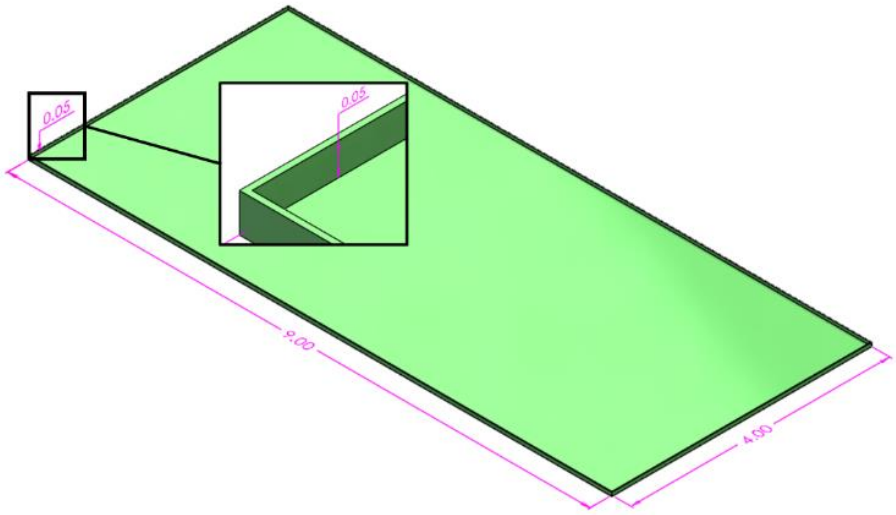

Figure 9 Start Area Dimensions in Metres

6.3. SETUP SEGMENT

Teams are to setup their drone system and external aids at the start of this segment. The drone system consists of the drones and carrier.

If the drone system takes off with a package within the allotted setup time, points will be awarded, as stated in Section 6.5 and the mission segment will start immediately. The remaining time from the setup segment will not be reallocated to the mission segment.

If the drone system has yet to take off at the end of the setup time, the mission segment will start immediately. No time extension will be given.

6.4. MISSION SEGMENT

Starting the Mission

Teams start the mission with 1 package, pre-loaded in a carrier of the drone system at the Start Area. Autonomous pickup is not allowed for the first pickup. The package will be a standard resizable container, obtainable via IKEA.[2] Without modifications, the weight of this package is 150g (±10%). To complete the challenge, Teams are encouraged to prepare at least 6 such packages. Teams may choose to modify the packages to suit their carrier. Additionally, to encourage teams to develop a system which can handle heavier loads, more points will be awarded for teams that choose to increase the weight of the package[3]. More details regarding awarding of extra points may be found in Section 6.5.

Figure 10 Package Template[2]

[2] Link to purchase: KACKLA Extendable box, white, 25-38x9 cm - IKEA
[3] Materials to increase the weight of the package will be provided on the actual day

In the mission segment, there are three main sequences that shall be performed as listed below:

1. Delivery
2. Pickup
3. Release/ Drop

Typical Package Delivery Sequence

The drone system is to take off with a package at the start area or resupply area. Teams are encouraged to design a drone system that can pick up a package autonomously to earn higher points. Manual loading of package onto the drone system is allowed[4].

The drone system, with the package, will then navigate to one of the victims to release the package autonomously, within the victim area.

Points will be awarded according to the following:

1. Pickup method (Manual loading or Autonomous pickup) and;
2. Victim's priority level.

More details regarding awarding of points may be found in Section 6.5.

After the package has been released, the drone system is to fly to a resupply area or start area to retrieve the next package.

[4] Subject to safety procedure as set by the SAFMC committee

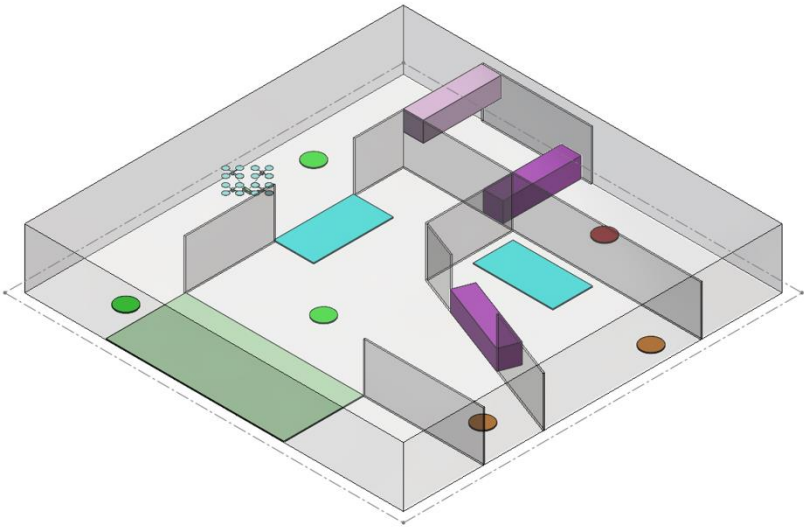

Figure 11: Drone system delivering package in play area

Pickup Sequence

The package may be manually loaded, or picked up autonomously, by the drone system at the start area or resupply area for the 2nd pickup onwards. The drone system with the package will then take off and leave the start area or resupply area.

Points will be awarded when the package leaves the start area or resupply area without touching wall boundaries of the area.

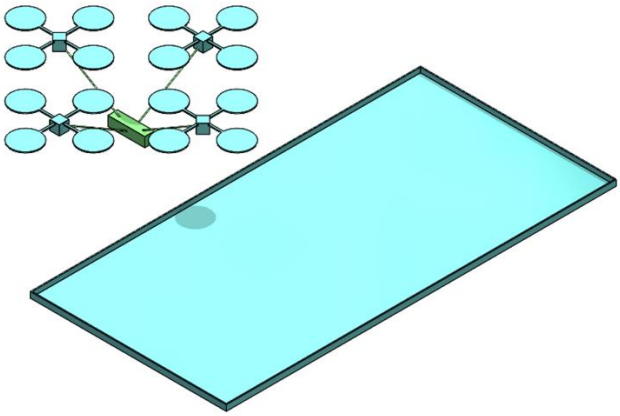

Figure 12: Drone system above resupply area

Drop / Release Sequence

Drone system is to drop/ release the package autonomously within the wall boundaries of the victim area.

Points will be awarded if the package is touching the base floor of the victim within the wall boundaries after the challenge ends.

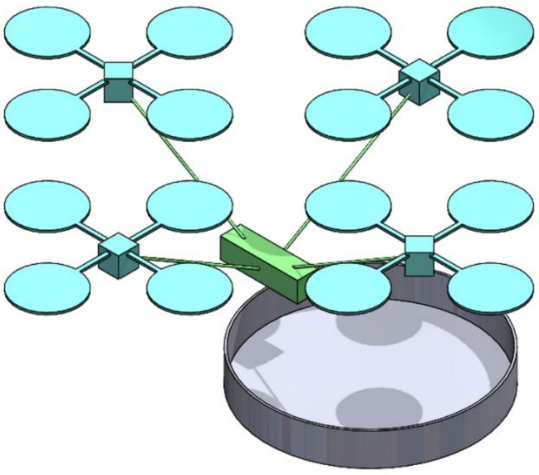

Figure 13 Drones above the victim

6.5. MISSION SCORING

As described in Section 6.3 and Section 6.4, there are several tasks or sequences to be performed during the challenge.

Teams that are successful in completing these will be awarded points. 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.

Criteria	**Point**
Start Mission before setup time expires	5
Points per unique, successful autonomous package pickup	50
Points per unique, manual package load	2
Points per package in **low priority victim** (Only one package per victim is counted)	30
Points per package in **medium priority victim** (Only one package per victim is counted)	100
Points per package in **high priority victim** (Only one package per victim is counted)	150

Points are awarded for both autonomous and manual pickup tasks. Up to 6 packages are eligible for points from either pickup task. Regardless of the way it was picked up, each package is eligible for points coming from either task, once. This means that if the same package is retrieved multiple times, additional points will not be awarded.

For counting of delivery points, only the package which gives the highest score will be counted.

6.5.1 POINT MULTIPLIERS

To encourage teams to design systems which can bear heavier loads, teams will be given point multipliers for successful pickups and deliveries if the package has a higher weight.[5]

To verify this, the weight of the package will be recorded twice – before the challenge starts and after the challenge ends. The point multiplier for both pickup and delivery tasks will be given based on the weight recorded after the challenge. A table showing how the multipliers are awarded can be found in the table below.

Criteria	Multiplier
Package weight < 150 grams	0.0
150 grams ≤ Package weight < 200 grams	1.0
200 grams ≤ Package weight < 400 grams	1.2
Package weight ≥ 400grams	1.4

6.5.2 TIE BREAKER

Tie breakers will be decided by priority of first victim which receives a package followed by the time taken to perform that delivery. This will be recorded during the mission time.

6.5.3 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

[5] materials will be provided by the committee on the actual day

decisions and their decision is **final**. For arbitrary cases, the Chief Referee will have the **final** say. Further correspondence will not be entertained.

S/N	DESCRIPTION	PENALTY
1	Exceeding the 15 minutes setup time for D2.	Mission time will start regardless.
2	Use of external markers outside of the playing field.	Referee's discretion or disqualification
3	Internal markers within the playing field unable to be removed or leave a mark after being removed.	Referee's discretion or **disqualification**
4	Interrupting the competition by potentially interfering with other competitors, e.g. switching on your platform's VTX, transmitters, etc.	Referee's discretion or **disqualification**
5	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**
8	Any navigation aids used to help in the picking of packages are: 1) Unable to be removed or damage the take-off pad after removal 2) Having a size more than 150mm (L) by 150mm (W) by 50mm (H) 3) Delivered together with the packages. (i.e. left remaining on the grid squares)	Referee's discretion or **disqualification**

6.6. MISSION RULES

General

1. On the competition day each team will have **a fixed duration of 75 minutes of challenge time** to complete the tasks in the playing field.
2. The allotted 75 minutes is **inclusive of 15 minutes setup time**.
3. Teams will be granted **a single attempt**. Any additional attempts will be granted at the discretion of the judges/organising committee.
4. The mission time will continue to run throughout and will not be paused in the event of any landing, maintenance, or repair works, etc.
5. In the event that the team needs to repair/troubleshoot the drone system, they are required (if possible) to land the drone system as soon as possible. All repairs/troubleshooting should be done either on the start area, resupply area or outside of the playing field. However, if any drone is taken out of the playing field, the drone system, in its last state before landing, must be relocated at the start area.
6. Teams are allowed to change flight batteries during the challenge, but only if the drone system returns to the start area or resupply area.[6]
7. All packages must be placed in their respective areas prior to the start of the mission. Additional packages are **not allowed** to be placed after the mission starts.
8. Teams are allowed to relocate the drone system to the start area during the mission at the committee's discretion. If the drone system loses the package in flight and the team wishes to relocate,

[6] Teams are to follow safety procedure as defined in **Section 6.6**.

teams shall place the package back at its original location.[4] However, points will not be awarded for subsequent pickups of that specific package.

9. In case of doubt, the Chief Referee or the Category D Technical Chairperson has the final decision.

Flight

1. The maximum height of the drone system cannot exceed 2.5m during any mission.
2. The package must be attached to at least 2 (drones) of the drone system at all times except when the package is within wall boundaries of the victim zones, start area or resupply areas.
3. The package must not touch the floor except when the package is within the wall boundaries of start area, resupply areas, or victim zones.
4. The carrier must be attached to the drone system at all times except when the package is within wall boundaries of the victim zones, start area or resupply areas.
5. The carrier must not touch the floor except when the package is within the wall boundaries of start area, resupply areas, or victim zones.
6. Drones must not touch on the floor except when the package is within the wall boundaries of start area, resupply areas, or victim zones.

Points

1. For packages to be eligible for scoring points for delivery to a victim, it must be within the inner boundaries of the victim and touching the base of the victim zone. The package must be released/dropped by

the drone system. No points are given for manually uploading of the package. This will be verified by the referee/judge.

2. Points for successful delivery will be counted only after mission time. If there are multiple packages delivered to the same victim, only the package which gives the highest score will be counted.

Safety

1. Teams must ensure that there is no one in the arena when the drone system is airborne.
2. Teams should have a safety pilot, to take over control of the drone in order to avoid a crash. The safety pilot may follow the drone (line-of-sight) from the edge of the field outside the safety net. However, the pilot may not communicate in any way with the ground control station operator.
3. 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 team will have to relocate the drone system from a position determined by the Chief Referee.
4. The safety pilot needs to inform and demonstrate to the referees that the drone is in computer-in-control (CIC) mode before take-off. Once airborne, no directional command inputs are allowed as the drones are 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.

6.7. PLAY AREA SAFETY ALERT

During the challenge, teams who require entry into the play area are to follow this sequence of events:

1. Notify the Chief Referee prior to disarming the drone system,
2. Disarm the drone system and
3. Enter the play area at the Chief Referee’s discretion.

Upon entry into the play area, the **Play Area Safety Alert** will be enforced. Note that mission time will not be paused during the alert.

During the alert, teams are not allowed to interact with any equipment that commands the drone system. In addition, the drone system must be powered off and the batteries shall be disconnected at the earliest time.

To resume the mission, teams are to ensure that all members have left the play area. Upon confirmation, teams are to notify the Chief Referee. At the Chief Referee’s discretion, teams will be allowed to connect the batteries and arm the drone system and the **Play Area Safety Alert** will be lifted. Teams may resume the mission after the alert has been lifted.

7. SCORING

There are a total of **FIVE (5)** scoring components for the competition, namely: Aerial Platform **(A)**, Strategy **(S)**, Learning Journey **(L)**, Team Challenge Video **(V),** and Mission **(M)**. The first four components (A, S, L, and V) will be assessed by our Category D2 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	22.5%
	Strategy	22.5%
	Learning Journey and Insight	5%
Competition	Team Challenge **V**ideo	10%
	Mission	40%
	Total	***100%***

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

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

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 22.5% 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 package 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 autonomous concept will work.
    - Explanation of flight control strategy
    - Explanation of autonomy strategy

7.2. STRATEGY FACTOR (S)

The **Strategy Factor (S)** is a measure of the team's creativity in the design of their system setup workflow, drones and control interfaces, 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 22.5% weightage to the overall score.

Examples of innovative approaches may include:

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

7.3. LEARNING JOURNEY AND INSIGHT FACTOR (L)

The **Learning Journey and Insight Factor (L)** is related to quality and content of the presentation. It carries a 5% weightage to the overall score.

4. 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
5. Delivery
    - Speakers are clear and concise
    - Speakers are able to answer questions smoothly
6. Teamwork
    - Presentation should highlight the work of all the team members, and how they have contributed and cooperated with the team
7. Fun
    - Should be able to capture the attention of the judges
    - The judges should enjoy your presentation

7.4. TEAM CHALLENGE VIDEO FACTOR (V)

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

1. Flight-worthiness
    - Drones must display their ability to perform stable, sustained flight while carrying a package together
2. Mission-readiness
    - Drones must display their ability to avoid static obstacles
    - Drones must display their ability to manipulate the package carrier to unload packages

7.5. MISSION FACTOR (M)

The points obtained during the mission will determine the team's **Mission Factor (M)** score. Please refer Section 6.5 for the mission scoring, point multiplier 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 ONE (1) presentation in the form of 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 D2] - [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 solution 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 2.5kg.**
3. The platform **cannot not exceed 75cm** in any direction (this measurement includes the maximum diameter of the propeller circles).
4. Participants are only allowed to use between to TWO (2) TO FOUR (4) flying machines for each mission attempt. Teams can bring similar backup aircraft to replace any aircraft that has become incapable of flight. No additional time will be given to replace the aircraft.
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. For safety considerations, the platform must be able to perform full RC manual pilot override and RC failsafe on demand.
10. Any external aids used have to be easily removable without damaging or leaving visible traces on the ground. These markers

must be placed within the playing field only. They must have a size no more than 150mm (L) by 150mm (W) by 50mm (H)

11. All flying machines entered into the competition must be homogeneous.[7]

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

[7] A group of homogeneous items shares similar specifications. To be homogeneous, each flying machine must have similar weight and dimensions. The size and weight of the remaining drones shall not deviate ± 20% from the baseline drone

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.