Singapore Amazing Flying Machine Competition 2024

Category E

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

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NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

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SAFMC 2024 CAT E 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

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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 <u>final</u> 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 <u>cannot</u> be a member for two teams in Category B.

6. Teams are allowed to take part in categories <u>beyond</u> 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. <u>FORMAT OF COMPETITION</u>

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 <u>equal</u> 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. <u>PRESENTATION</u>

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 <u>Section 8</u>.

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. <u>CHALLENGE</u>

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 E 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 E 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 E, 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 E 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 E.

5.3.   <u>PRIZES</u>

CATEGORY E				
Awards	**Medals**	**Trophy**	**Cash Prize**	**Remarks**
Cat E Championship Award	✓	✓	$20,000	
Cat E 1st Runner Up	✓		$15,000	
Cat E 2nd Runner Up	✓		$10,000	3rd and 4th runners up will receive medals **only**
Cat E Judge's Commendation	✓		$1,000	Up to two teams can win this award

6.   CATEGORY E MISSION

Teams are required to design a system of **TEN (10) to TWENTY-FIVE (25)** drones to navigate through an indoor environment and search for victims, using either a centralised or de-centralised fully-autonomous control system. The system has to possess localisation, obstacle sensing and obstacle avoidance capabilities. The drones and localisation system can be customised or commercial off-the-shelf (COTS) products, and need not be homogenous.

The description of the mission tasks and scoring criteria will be detailed in Section 6 and Section 7. 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 drones can be found in Section 9.

6.1. MISSION TASKS

The mission requires the system of drones to collaboratively explore an indoor environment and search for victims.

The key phases of the mission are:

1.   **Take-off** within the Take-off Area
2.   **Search** for all victims as fast as possible
3.   **Rescue** victims by landing at the victims' positions
4.   **Land** all drones to end the mission

6.2. PLAYING FIELD

The layout of the playing field is shown below. The playing field is approximately 20 m x 20 m. It is surrounded by a perimeter wall on 3 sides,

and netting on all sides. The placement and number of victims shown are for illustration purposes only, and the walls are not drawn to scale.

Placement and number of victims for illustration purpose only
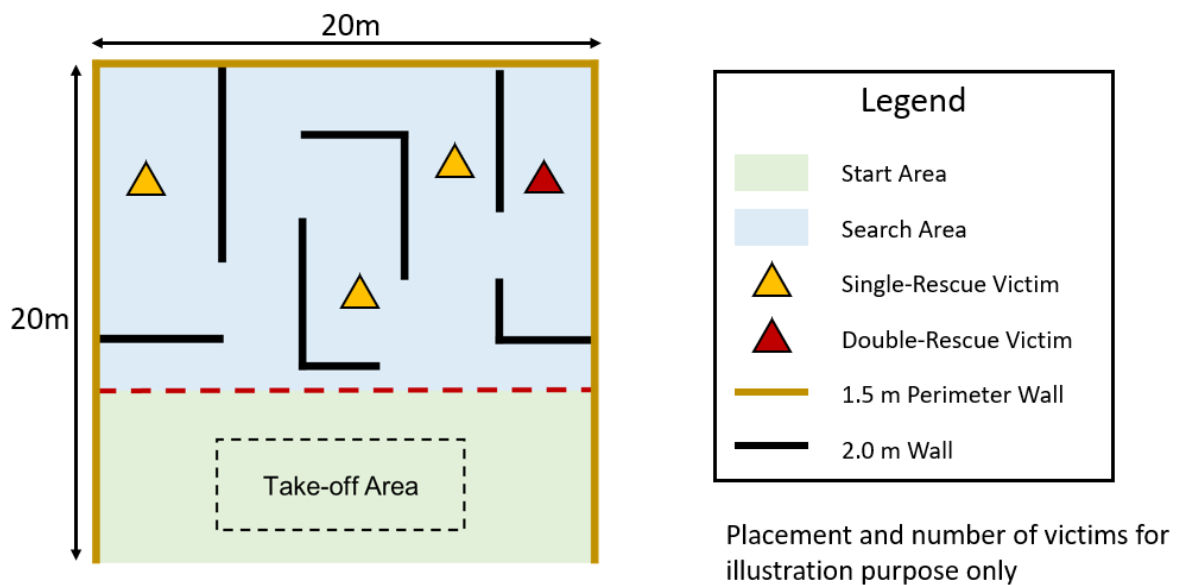
Dimensions of specific elements are listed below.

Take-off Area: 10 m x 4 m rectangle marked out on the ground.

Start Area & Search Area: The Start Area is approximately 20 m x 6 m. The Search Area is approximately 20 m x 14 m. The boundary between the two areas will be marked on the ground.

Walls: The perimeter walls are 1.5 m tall, while the internal walls are 2 m tall. The lengths of the walls are not given, but the layout will be as shown in the illustration above.

Corridors/ Doorways: Any corridors and doorways will be at least 3 m wide.

6.3. MISSION RULES

General

1. A minimum of TEN (10) and maximum of TWENTY-FIVE (25) drones are required to participate in each run.
2. Every team will be given 2 runs (i.e. 1 run during each mission time)
3. Teams will be given setup time prior to each mission time. The time is allocated as follows:

Setup (25 min)	Mission (10 min)	Setup (15 min)	Mission (10 min)

4. During the setup time, teams are allowed to take-off the drones for testing, but the drones must stay within the Start Area.
5. If teams complete their setup earlier, the remaining setup time will not be carried over to the mission time. In such cases, teams must inform the officials that they are ready to start the mission.
6. During mission time, teams may reset and re-attempt take-off as long as no drones have entered the Search Area.
7. A run starts when the first drone enters the Search Area. It ends when all drones have landed, or the mission time is exceeded, whichever is earlier.
8. Teams are not allowed to repair/troubleshoot the drones during the run. Any drones that malfunction during the run will be considered to be out for that run. The run may continue if the remaining drones are deemed safe.
9. Teams are allowed to repair their drones outside of runs. There is no restriction on the number of spare aircraft the team can prepare as long as they have passed the inspection.

10. The system must be fully-autonomous. Teams are not allowed to input commands during the run, other than to take-off or land the drones.

11. Drones are not allowed to be physically connected to each other (e.g. tied together).

12. Ground robots are not allowed to be used during the run.

13. Drones are not allowed to fly over walls. The maximum flight height is 1.4 m.

14. The netted playing area must be clear of persons when any drone is in flight, including any drone that takes off during the set-up time.

15. If any drones are powered on, persons entering the netted playing area must don the appropriate PPE, which will be provided.

16. Any navigation aids (e.g. ultra-wideband systems, fiducials) must be:
    a. Placed during setup time
    b. Placed within the perimeter walls
    c. Easily removable without leaving a mark
    d. Properly secured, e.g. will not topple over
    e. Cannot be secured to overhead structures
    f. Within the maximum base dimensions of 1 m x 1 m

17. A maximum of 10 navigation aids are allowed in the Search Area. Teams are allowed to enter the Search Area only during setup time, as the victims will be placed by the officials between setup and mission time.

18. There is no limit on the number of navigation aids within the Start Area.

Take-off

1. Drones are to take-off only within the demarcated Take-off Area.

2.   Each run has a maximum of 2 phases of simultaneous take-off. Simultaneous take-off is defined as having a group of drones take off together, where the last drone of the group takes off within 10 seconds after the first drone of the group takes off.

3.   The number of drones to take off simultaneously in each phase is up to the teams.

4.   Remaining drones that did not take off within those 2 phases are not allowed to take off. In the event that these drones enter the Search Area, any points scored by them will not be counted.

Search

1.   The actual number of victims and their positions will be unknown to the teams.

2.   There are 2 types of victims: single-rescue and double-rescue. Single-rescue victims require at least 1 drone to rescue it. Double-rescue victims require at least 2 drones to rescue it.

3.   Teams shall provide markers to be used as the victims. A total of 8 markers are required: 4 single-rescue victims, 4 double-rescue victims. The markers must be non-electronic, have a base of smaller than 30 cm x 30 cm, and with a maximum height of 1 m.

4.   The victims will be placed at least 1 m away from walls and the edge of the Search Area. There is a possibility that the victims placed may overlap with any navigation aids placed by the teams.

Rescue

1.   Upon finding a victim, rescue is simulated by having drone(s) land within 1 m of the victim. The drone(s) will remain there until the end of the mission.

2.   When measuring the distance between a drone and a victim, the start point of the measurement will be the position of the victim, as

set by the organising committee. The start point will remain the same even if the victim markers are dislodged (e.g. by drones flying over). Teams must indicate on each drone where the end point of the measurement will be, e.g. with a sticker or marking.

Landing

1. The swarm must decide when it has sufficiently searched the playing area, and end the mission by landing. Teams are also allowed to send a command to land the remaining drones.
2. If no victims were found, the team will receive a Did Not Finish (DNF) timing.

6.4. MISSION SCORING

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

Scoring Criteria	Points Awarded
Single-rescue victims rescued (at least 1 drone lands within 1 m of victim)	+10 for 1st rescuer
Double-rescue victims rescued (at least 2 drones land within 1 m of victim)	+5 for 1st rescuer +15 for 2nd rescuer
The highest score attained across the runs will be taken as the mission score. In the event that teams have the same total score, run time will be used to break ties. No points will be awarded for any additional rescuers.	

6.5. PENALTIES

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. The list of mission penalties is shown below.

S/N	DESCRIPTION	PENALTY
1	Exceeding the setup time	Mission time will start regardless. No additional mission time will be provided.
2	Use of external markers outside of the playing field.	Referee's discretion or **disqualification**
3	Internal markers within the playing field that are unable to be removed or leave a mark after being removed.	Referee's discretion or **disqualification**
4	Internal markers within the playing field that cause harm to persons or damage to structures, e.g. tripod stands toppling due to improper securing.	Referee's discretion or **disqualification**
5	Interrupting the competition by potentially interfering with other competitors, e.g. switching on your platform's VTX, transmitters, etc.	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.   SCORING

The scoring components for the competition are: Team Challenge Video (V), Team Live Presentation (P), and Mission (M). The first 2 components (V and P) will be assessed by our Category E 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:

Component	Weightage
Team Challenge **V**ideo	10%
Team Live **P**resentation • Strategy – 30% • Presentation Quality – 10%	40%
Mission	50%
Total	**100%**

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

$$T = V + P + M$$

7.1. <u>TEAM CHALLENGE VIDEO (V)</u>

The Team Challenge Video provides a proof-of-flight insight into how the aircraft performs before the competition day. The video should include:

1. Flight-worthiness

   - Aircraft must be shown to perform stable, sustained flight
   - At least 5 drones must be shown to take-off simultaneously

2. Mission-readiness

   - Explain the on-board sensor suite for each unique drone used in the challenge
   - At least 2 drones must be shown avoiding static obstacles
   - At least 2 drones must be shown to search a room containing at least 2 victims, and land next to them when detected

3. Creativity

   - Resourcefulness in re-creating competition layout to showcase similar mission requirements

7.2. <u>TEAM LIVE PRESENTATION (P)</u>

Teams should present their proposed strategy and learning outcomes.

Proposed Strategy

Teams are to explain how their drones, sub-systems, and swarm algorithms help in their mission strategy. These include:

1. Choice of sensor suite used to tackle the mission
2. Obstacle and collision avoidance method
3. Localisation method
4. Search strategy

5.   Method of communication between drones and ground control station (GCS)

6.   Any other algorithms used in completion of the mission

Teams are also encouraged to utilise and present unique concepts, which may include:

1.   Robust and intelligent methods of swarm control

2.   Effective utilisation of different kinds of drones in the swarm

3.   Unconventional ideas and methods to complete the mission

4.   Methods to reduce time taken to complete the mission

Learning Outcomes and Insights

Teams are to share about their experience preparing for the competition. These include:

1.   Challenges faced and lessons learnt

2.   Key decisions made during the design process and their rationale

7.3.   MISSION (M)

The challenge attempt scores on the competition day will form the **Mission (M)** score. Please refer to Section 6 for the mission scoring and penalties.

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 slides format.

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 <u>switched off</u> to simulate a link loss.

   (4) All motors should come to a **<u>complete stop immediately</u>**. The aircraft should <u>not</u> 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 <u>failsafe capability</u> 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 **<u>complete stop immediately</u>**. 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.   <u>KEY POINTS TO NOTE</u>

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 **<u>disqualified</u>**. 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 1.0kg.**

3.   The platform **should not exceed 30cm** in any direction (this measurement includes the maximum diameter of the propeller circles).

4.   Participants are only allowed to use up to **TWENTY-FIVE (25)** flying machines for each mission attempt. 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.   For safety considerations, the swarm must be able to stop the mission and power down.

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. <u>BATTERY</u>

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. <u>REMOTE CONTROL (RC) RADIO</u>

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 <u>**or**</u> 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. <u>DATALINK / VIDEOLINK / OTHER WIRELESS LINK TYPES</u>

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 <u>Section 5</u> 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.