



Category D1 Challenge Booklet 2022

Organised by:



Supported by:



Partners:



SAFMC 2022 CAT D CHALLENGE BOOKLET CHANGE LOG

Version	Release Date	Description
1.0	22 Nov 2022	Official challenge booklet release

SAFMC 2022 COMPETITION SCHEDULE

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

** The competition schedule is subject to changes in accordance with the latest MOE guidelines for COVID-19. Any changes will be updated on the SAFMC Website and Facebook. Registered participants will be informed via their registered email address.*

CONTENTS

SINGAPORE AMAZING FLYING MACHINE COMPETITION 2022	5
1. INTRODUCTION.....	Error! Bookmark not defined.
2. CATEGORIES.....	Error! Bookmark not defined.
3. GENERAL SAFMC 2022 RULES	Error! Bookmark not defined.
4. FORMAT OF COMPETITION.....	Error! Bookmark not defined.
4.1 PRESENTATION	Error! Bookmark not defined.
4.2 CHALLENGE	Error! Bookmark not defined.
5. CATEGORY D1 AWARDS	10
5.1 CHAMPIONSHIP AWARD	10
5.2 JUDGES' COMMENDATION	10
5.3 PRIZES	11
6. CATEGORY D1 MISSION.....	12
6.1 CATEGORY D1 CHALLENGE (Connect 5).....	12
6.2 PENALTIES	23
7. SCORING	24
7.1 AERIAL PLATFORM FACTOR (A).....	25
7.2 CREATIVITY FACTOR (C).....	26
7.3 LEARNING JOURNEY AND INSIGHT (L)	26
7.4 TEAM CHALLENGE VIDEO (V).....	27
7.5 MISSION ACCOMPLISHED FACTOR (M).....	27
8. FLOW OF EVENTS.....	28
8.1 PRESENTATION SEGMENT	28
8.2 TEAM CHALLENGE VIDEO.....	29
8.3 COMPETITION SEGMENT	30
8.4 KEY POINTS TO NOTE	31
9. TECHNICAL RULES & REGULATIONS.....	34
9.1 AVIONICS SYSTEM	34
9.2 BATTERY.....	34
9.3 REMOTE CONTROL (RC) RADIO	35
9.4 DATALINK / VIDEOLINK / OTHER WIRELESS LINK TYPES	35
9.5 CAAS REGULATIONS	37
10. PANDEMIC RESTRICTIONS	38
ANNEX.....	39
Payload for Cat D1 Competition	39
Payload Well for Cat D1 Competition	39
QR Codes.....	40

SINGAPORE AMAZING FLYING MACHINE COMPETITION 2022

1. INTRODUCTION

In celebration of DSO National Laboratories' (DSO) 50th Anniversary in 2022, SAFMC is enhanced in both challenges and prizes [CAT D & E] to allow students to push the boundaries of innovation by designing and creating extraordinary flying machines. The event is organised by DSO and Science Centre Singapore, and supported by Ministry of Defence (MINDEF). Open to all schools and participants, this annual competition promises a fun-filled learning journey with special talks, workshops and live demonstrations.

2. CATEGORIES

CATEGORY A – PAPER PLANES (*Primary Schools*)

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

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

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

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

Category B will be open to a maximum number of 150 registered teams.

Design and build small unpowered bungee-launched gliders to achieve the farthest and most precise flight.

CATEGORY C – RADIO CONTROL FLIGHT / FIRST PERSON VIEW (FPV) FLIGHT (NOVICE, ADVANCED)

Category C1: Radio Control Flight - Fixed Wing (*Secondary Schools / Integrated Programme / Junior Colleges / Institute of Technical Education*)

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

Design and build a small remote-controlled fixed-wing air platform to navigate an obstacle course.

Category C2: FPV Flight – Novice (*All Schools*)

Each team should consist of ONE (1) to TWO (2) members.

Bring, or design and build, a ducted (shielded propeller) FPV drone to compete in an obstacle course.

Category C3: FPV Flight – Advanced (*All Schools*)

Each team should consist of ONE (1) member.

Bring, or design and build, an FPV drone to compete in an obstacle course.

[ENHANCED] CATEGORY D – SEMI-AUTONOMOUS / AUTONOMOUS

(*Polytechnics / Universities*)

Category D1: Semi-Autonomous

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

Design and build up to three semi-autonomous small air platforms, controlled using wearables, to perform a multitude of tasks in an indoor course.

Category D2: Autonomous

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

Design and build three autonomous small air platforms to collaboratively perform a multitude of tasks in an indoor course.

[ENHANCED] CATEGORY E – SWARM (*Open to Public*)

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

Bring, or design and build, a swarm of TEN (10) to TWENTY-FIVE (25) drones to compete in an obstacle course.

3. GENERAL SAFMC 2022 RULES

- **The deadline for registration is 18 February 2022.**
- Participants registered under a school must be a full-time student at the point of competition.
- Home-schooled participants and teams consisting of participants from different schools should be registered as “Independent teams”.
- Participants will be notified upon successful registration within two weeks of the registration deadline. The decisions made by the SAFMC organising committee are

final, and are subjected to the competition schedule and availability of logistics support.

- Each person can only participate in one team within a category. However, the person can participate as a member in different categories, i.e. a person can be a member of a team in Category B and another team in Category C but the person cannot be a member of two teams in Category B.
- Teams are allowed to take part in categories beyond the specified educational level, i.e. Primary school students are allowed to take part in Category B, C, D or E. Secondary school students are allowed to take part in Category C, D or E.
- Participants of Category C1 are also eligible to register for either Category C2 or C3 but not both.
- Participants of Category C2 are not eligible to participate in Category C3 and vice versa.
- Participants of Category D1 are also eligible to participate in Category D2 and vice versa.
- Members and family members of the organising committee are not allowed to participate in the SAFMC.
- The organisers reserve the right to amend the rules and regulations. In the event of changes, all teams will be informed at least **FOUR (4)** weeks prior to the start of the competition.
- Prizes will be issued to the Team Manager.
- A safety perimeter net will be set up at the competition field for Categories B, C, D, and E. There will be a top net approximately **EIGHT (8) meters** above the ground, which will limit the maximum flight altitude of flying machines. During the challenge attempts, teams are strongly encouraged to fly their aircraft away from the netting to avoid accidental entanglement.
- The organisers of SAFMC 2022 will not be held responsible for any damage to or the loss of any flying machine(s) throughout the entire competition.
- Participants are responsible for the safe flying of their flying machine(s) for the duration of the entire competition. The organisers reserve the right to ground the flying machine(s) of any team at any point in the competition.

- For queries regarding the competition, please send an email with the title stating the category in question (e.g.: [CAT D2] - Clarification about task locations) to the following email address: SAFMC@science.edu.sg

4. FORMAT OF COMPETITION

Once the teams have confirmed their registration for the competition, they are expected to start work on the different aspects of the competition, which consists of the Challenge and the Presentation.

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

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

4.1 PRESENTATION

The teams will be allocated a specific time slot to showcase their flying machine on a virtual platform. Teams will present their flying machine design and learning journey in this competition to a panel of judges. These teams will be assessed for a number of awards.

The presentation plays an integral part for teams who wish to vie for the SAFMC Championship Award. Teams that do not show their flying machines for the virtual presentation may be disqualified immediately. The requirements for the Presentation Segment will be detailed in Section 8.

The Chief Referee or Judge for each category reserves the right to deduct points if the flying machines used in the Challenge is drastically different from the flying machine presented at the Presentation.

4.2 CHALLENGE

The physical competition will be conducted in accordance with Safe Management Measures (SMM) guidelines, which will be announced closer to the competition.

For the Challenge, teams are to design, build and fly their flying machines to overcome various challenges for the different SAFMC categories. The Challenge consists of: a Team Video Challenge submission, and the actual in-venue flight on Competition Day.

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

On the Competition Day, tables will be provided within the main competition hall for teams to work on their flying machines. Alternatively, teams may be assigned a designated area instead.

Teams should expect the following during the Competition Day:

- Only registered team members of the participating teams can enter the playing field and team booths/holding areas.
- Teams are expected to fully comply with safety rules. Failure to comply with safety rules after the initial warning will result in immediate disqualification and potential blacklisting from the competition. The organizer will also not be responsible for any injuries or mishaps if any participant has disregarded the safety rules.
- No trials will be allowed in the flying area unless specified by the officials.
- The participants will acknowledge that there will be variations in environmental conditions between teams, despite best efforts to control them
- For all Category C, D, and E participants, all aircraft and their transmitting devices must be presented to SAFMC officials for inspection upon arrival.
- For all Category C, D, and E participants, no video transmitting devices, including spares, should be powered on in the competition hall unless specified by the officials. Teams may request from the Chief Referee or the Category D1 Technical Chairperson to perform power-on checks.
- Additional rules and regulations specific to Category D1 are detailed in Sections 8 and 9. Participants will acknowledge that they have read the rules.

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. Awards may not be given out if the teams do not meet the minimum standard determined by the SAFMC organising committee, or if there are insufficient participants for each category.

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

The list of awards for Cat D1 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 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 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 D, but there may not be a winner for this award.

5.3 PRIZES

CATEGORY D				
Awards	Medals	Trophy	Cash Prize	Remarks
*Cat D1 <u>Semi-Autonomous</u> Championship Award	✓	✓	\$4,000	
Cat D1 <u>Semi-Autonomous</u> 1 st Runner Up	✓		\$3,000	
Cat D1 <u>Semi-Autonomous</u> 2 nd Runner Up	✓		\$2,000	3 rd and 4 th runners up will receive medals <u>only</u>
Cat D Judge's Commendation	✓		\$500	Up to two teams (in the whole Cat D) can win this award

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

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

6. CATEGORY D1 MISSION

Category D1: Teams are required to design a system of **UP TO THREE (3)** small flying machines, where the system is controlled through intuitive means with the use of wearable devices. The flying machines are to be piloted by a single designated Pilot, with obstacle avoidance sensors and aids to assist the Pilot. The system of flying machines can consist of customized or commercial off-the-shelf product (COTS product) that is capable of semi-autonomous or fully autonomous flight, and need not be homogeneous.

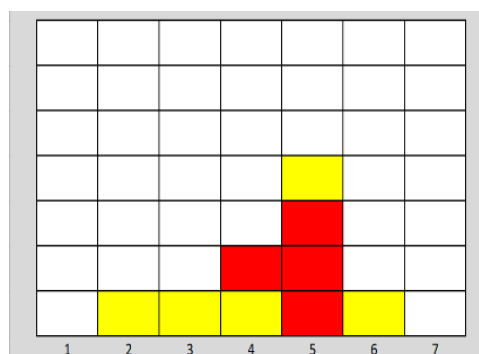
The detailed descriptions of the competition field, available mission tasks, as well as the scoring criteria are found in [Section 6](#). Teams are advised to read through these sections in detail to develop a strategy and identify key design requirements, before designing the flying machine to execute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

6.1 CATEGORY D1 CHALLENGE (CONNECT 5)

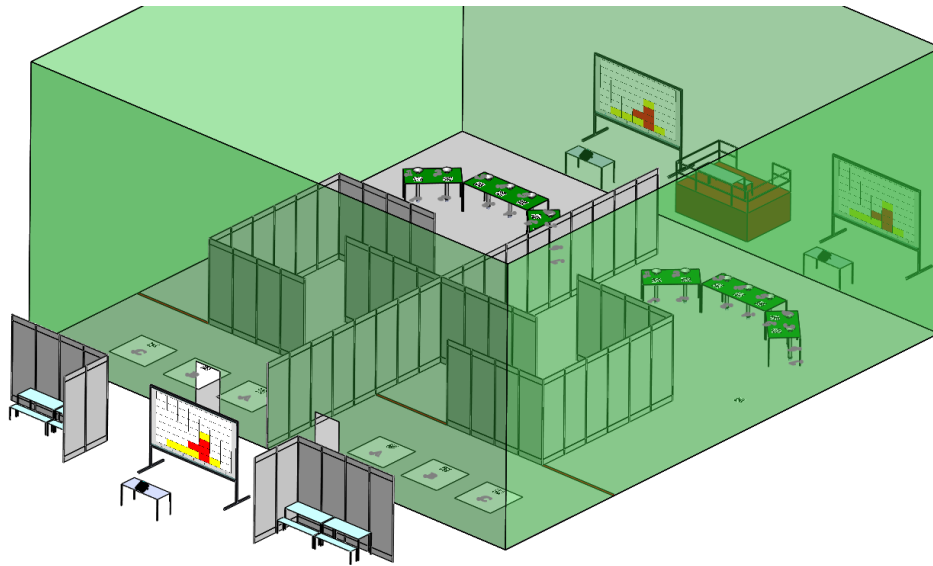
Category D1 requires its participating teams to design a system of flying machines that can pick up and release a small magnetic payload, and can be controlled using intuitive control through the use of wearable devices. Two teams will race against each other through a maze obstacle, playing the “Connect 5” game by the precise and strategic dropping of their payloads.

6.1.1 COMPETITION SETUP

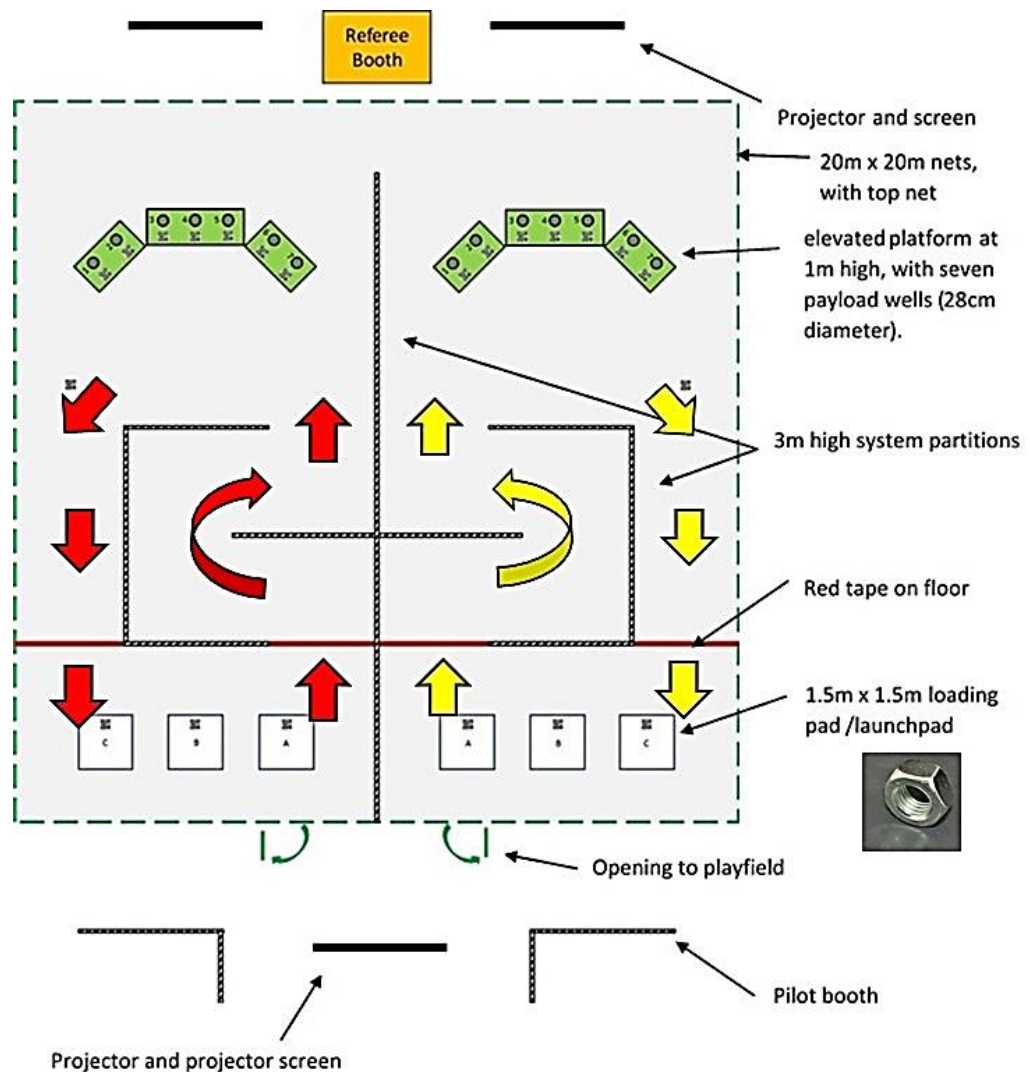
The competition set-up for Category D1, and a plan-view schematic are shown on the next page. The entire playing field is divided along its length by system partitions to allow two teams to compete in real-time. The progress of the Connect 5 game, as depicted in an example on the right, will be shown concurrently on the three projector screens during gameplay.



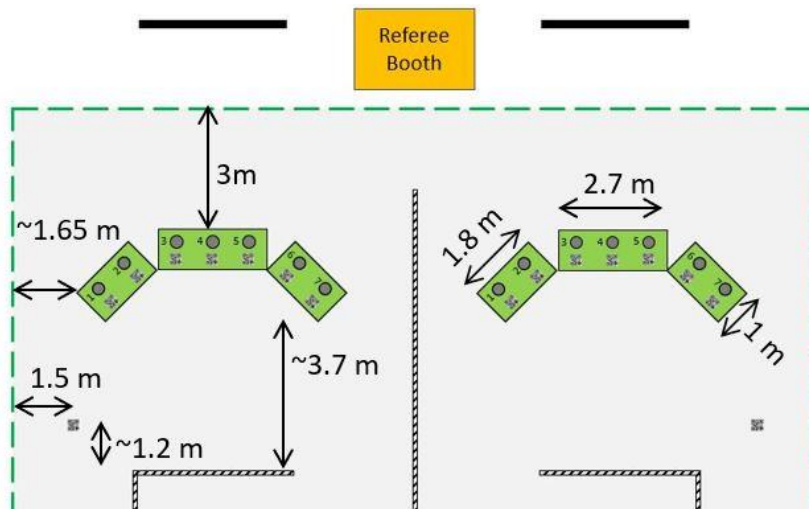
3D View of Playfield



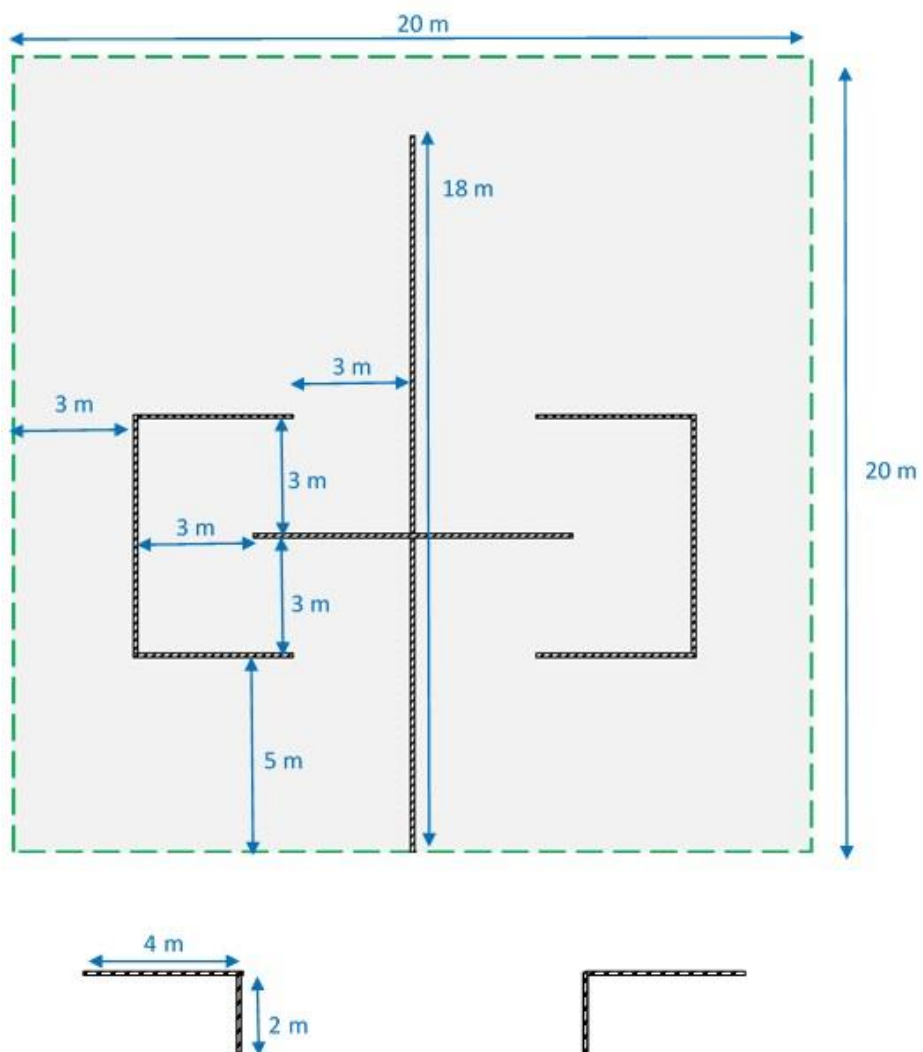
Plan View of Playfield (red and yellow arrows depict general gameplay)



Dimensions of Elevated Platforms at Drop-Zone

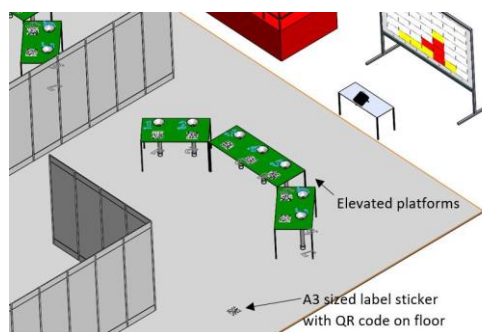
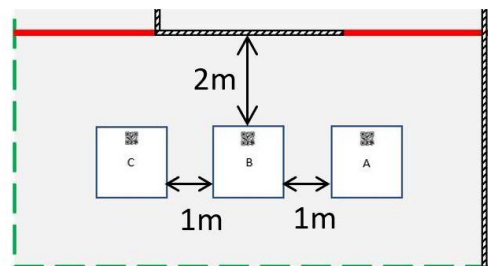
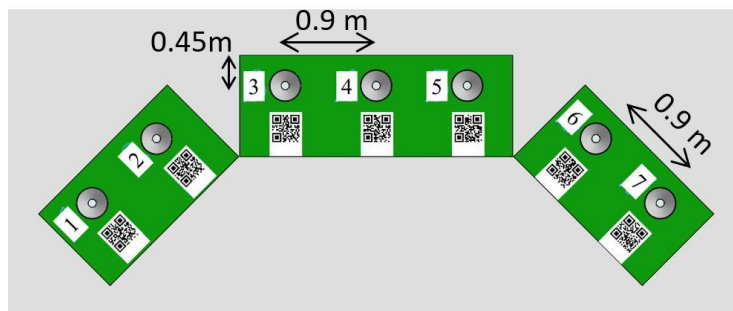


Dimensions of Maze Structure and Pilot Booths



QR CODES

With each QR code printed on an A3 sized label sticker, 11 of them would be deployed on each side of the playfield to aid participants. There would be 3 at the launchpads, 7 on the elevated platforms at the drop-zone, and 1 on the floor near the exit of the drop-zone. Please refer to ANNEX for the QR codes.



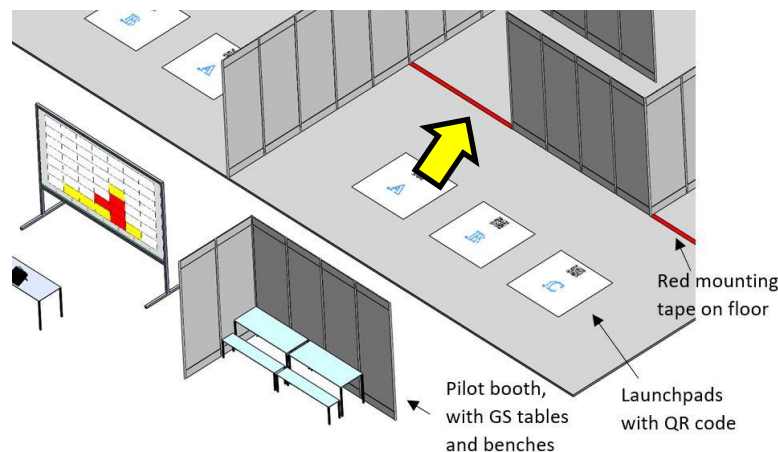
ITEM	LOCATION	DESCRIPTION OF QR CODE
1	LEFT SIDE, WELL 1	LEFT 1
2	LEFT SIDE, WELL 2	LEFT 2
3	LEFT SIDE, WELL 3	LEFT 3
4	LEFT SIDE, WELL 4	LEFT 4
5	LEFT SIDE, WELL 5	LEFT 5
6	LEFT SIDE, WELL 6	LEFT 6
7	LEFT SIDE, WELL 7	LEFT 7
8	LEFT SIDE, BEFORE EXIT OF DROP ZONE	LEFT EXIT
9	LEFT SIDE, LAUNCHPAD A (NEAREST TO PLAYFIELD ENTRANCE)	LEFT PAD A
10	LEFT SIDE, LAUNCHPAD B IN MIDDLE)	LEFT PAD B
11	LEFT SIDE, LAUNCHPAD C (FURTHEST FROM PLAYFIELD ENTRANCE)	LEFT PAD C
12	RIGHT SIDE, WELL 1	RIGHT 1
13	RIGHT SIDE, WELL 2	RIGHT 2
14	RIGHT SIDE, WELL 3	RIGHT 3
15	RIGHT SIDE, WELL 4	RIGHT 4
16	RIGHT SIDE, WELL 5	RIGHT 5
17	RIGHT SIDE, WELL 6	RIGHT 6
18	RIGHT SIDE, WELL 7	RIGHT 7
19	RIGHT SIDE, BEFORE EXIT OF DROP ZONE	RIGHT EXIT
20	RIGHT SIDE, LAUNCHPAD A (NEAREST TO PLAYFIELD ENTRANCE)	RIGHT PAD A
21	RIGHT SIDE, LAUNCHPAD B IN MIDDLE)	RIGHT PAD B
22	RIGHT SIDE, LAUNCHPAD C (FURTHEST FROM PLAYFIELD ENTRANCE)	RIGHT PAD C

6.1.2 MISSION TASKS

The category D1 is divided into two stages, the regular and knockoff stages. The top 8 teams (by score) from the regular stage will move into the knockoff stage. The mission is to pick up and drop off the greatest number of payloads and be the fastest team to form a row of 5, in the vertical, horizontal, or diagonal direction, for their team.

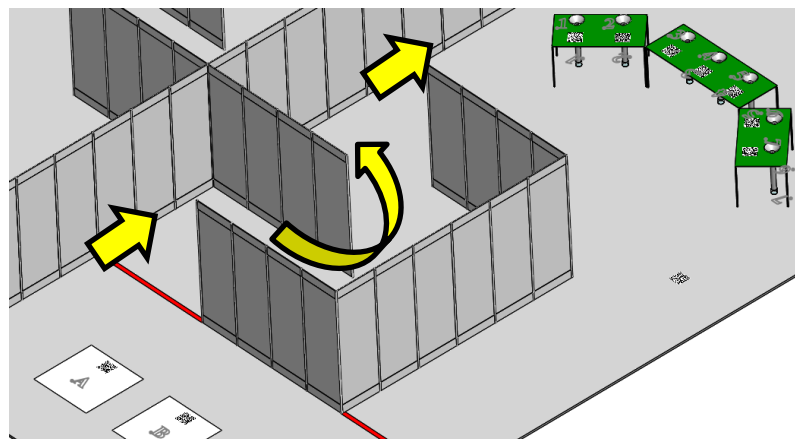
Start Point

Teams will be provided with standardised payloads (M14 hexagon nut made of carbon steel and weighing 22-23g) on the competition day. Details of the payload can be found in the [ANNEX](#). Teams would be given 15 minutes set-up time to prepare their pilot booth and launchpads. Each launchpad will only house a single drone pre-loaded with a payload. Competitive gameplay will automatically start at the end of set-up time.



Task 1: Navigate through the Maze

Controlling the drone(s) using wearable devices, the pilot will command the drone(s) to take off, fly and navigate through the maze to the drop zone.

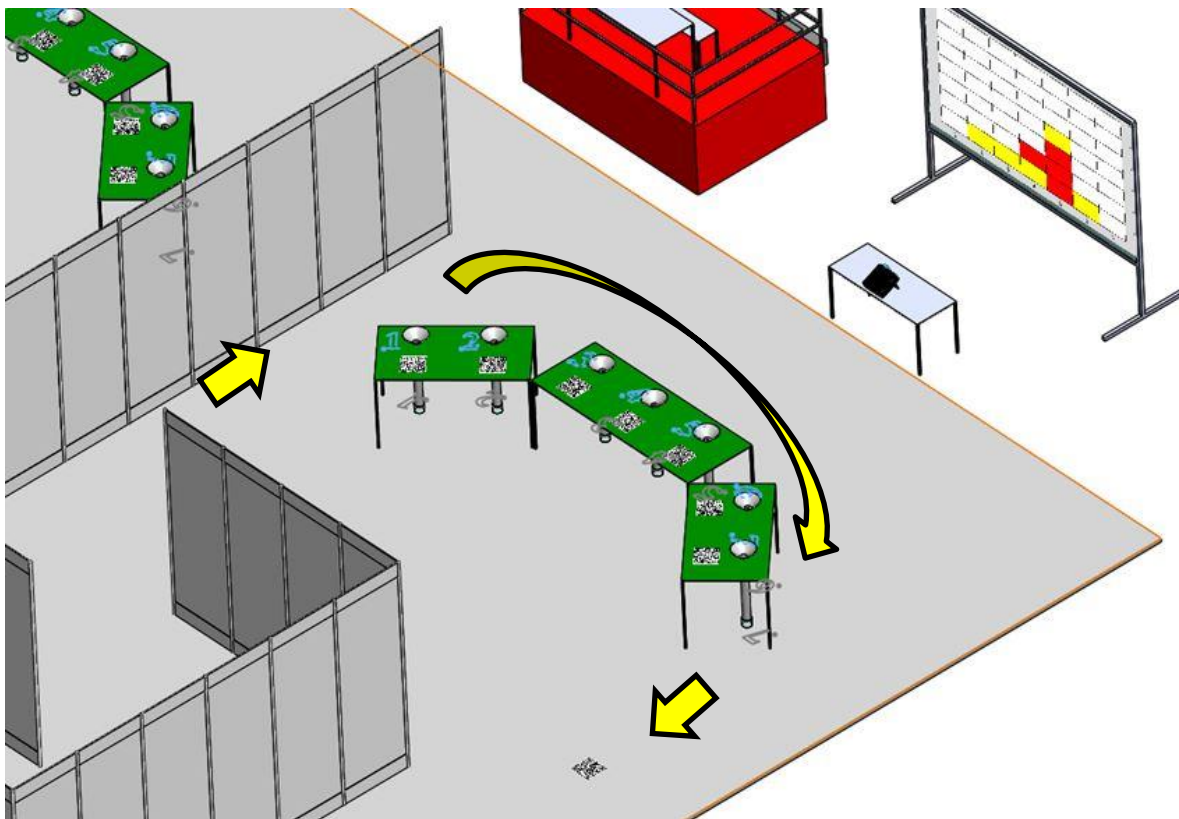


Task 2: Releasing Payloads at Drop-Zone

Having sight of the progress of the Connect 5 game on the projector screen, the pilot will command the drone(s) to navigate to its desired payload wells (funnel with an opening of 28cm diameter). Details can be found in the [ANNEX.](#)). The drone(s) will drop their payload(s) into the desired wells before leaving the drop-zone.



A successful drop of a payload into the payload well will see a coloured rectangle added to the respective Connect 5 column starting from the bottom. If the same column was contested by both teams, the first payload that reaches the bottom of the payload well will claim the bottom-most available spot in that column.

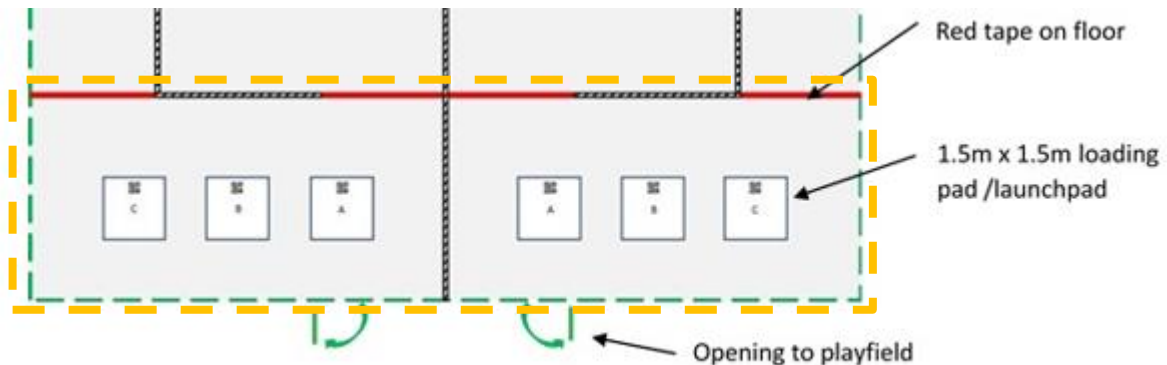


Task 3: Reloading of Payload

Each team will control their drone(s) to fly back to the launchpad(s) / loading pad(s) to retrieve one payload per drone. Teams are allowed to use any method to pick up the payload without direct human interaction. After retrieval of payload(s), the drone(s) can proceed with navigating through the maze to repeat the tasks.

Note: Refilling of Payload on the Launchpad(s)

Teams may place payload onto the launchpad (1 payload per launchpad) at any time when there are no airborne aircraft within the safety zone. Depicted as the dashed orange box below, the **safety zone** is the area around the launchpads that is bounded by the red safety line and the nets. No person is allowed to go in if there are any airborne drone(s) within this area.



6.1.3 MISSION RULES

- Teams can use up to three (3) small flying machines.
- Each flying machine must weigh less than 2kg, and measure less than 1m in any direction (includes maximum diameter of propeller circles).
- Pilots are allowed to fly their aircraft 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 must not leave any markings or traces for the next race.
- On the competition day, each team will have **only ONE (1)** attempt per race. Each team will have a **fixed duration of 15 minutes of mission time** to compete in the playing field.
- There will be allocated playing fields for the two teams, separated by system partitions. In the event that **any part** of the team's aircraft crosses to the other team's playing field, the offending team will be disqualified for the race.
- Teams that are competing against each other can decide the side of the field that they want, or to flip a coin.
- Both teams will then be given **15 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.

- 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

- 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 competition match is ongoing
- 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 are any airborne aircraft during this time. Offending teams will be disqualified.
- Once the 15 minutes of set-up time are up, the mission time will automatically start. Any drones that were 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.
- Teams are to control their flying machine(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 are not allowed. For any use of touchscreens, teams are to write in, explain and check with the Category D1 Technical Chairperson.
- Teams are not allowed to repair/troubleshoot during the race. Any aircraft that malfunction during the game will be considered to be taken out of the race. The team may continue the race with their remaining flying machine, if any, if it was deemed safe by the Chief Referee or Category D1 Technical Chairperson. In the case where all the flying machines in one of the team is taken out of the game, the opponent has to continue to attempt to win the game. In the event that the

opponent's flying machine system is also inoperable or if the mission time is up, the scores up to that point will be considered.

- Teams are allowed to change flight batteries during the game, but only if the aircraft has landed at the launchpad and there are no other airborne aircraft in the safety zone.
- The first payload for each drone is preloaded. No loading of the payload by hand onto the aircraft is allowed for subsequent payloads. The team must fly to the loading area to pick up their payload.
- Teams may place payload to the launch pad when there are no airborne aircraft within the safety zone. If there is any person still at the loading area, the aircraft must wait beyond the safety line until the loading area is clear before entering.
- The first team that has their payload dropped and reached the bottom of the payload well will claim the bottom-most spot in the corresponding column.
- In the event that the payload does not fall completely into the well or have bounced out, it will not be counted.
- There is no limit to the number of drones in the wells' area. The operator has to be careful of the drones hitting each other when attempting to drop the payloads into the wells.
- Once the payload is dropped or released under any circumstances outside of the safety zone, teams are **NOT allowed** to retrieve the dropped payload with their aircraft. They are required to fly back to the launchpads to pick up a new piece of payload.
- Teams are allowed to use pre-made attachments to carry the payloads as long as it is within the MTOW and the integrity of the payloads are preserved. Any ground aids or attachments that help in the picking and release of payloads will be allowed with the following conditions:
 - 1) Removable (no damage or marks on the take-off pad after removal)
 - 2) A size no more than 150mm (L) by 150mm (W) by 100mm (H)
 - 3) Must not be delivered together with the payloads.
- No modification of the payloads itself of any kind is allowed. Note that only the payload can be in the payload wells or on the raised platform. This means that any payload attachments or mechanisms must not be delivered along with the payload.

- To qualify for the number of drones used multiplier, the operator has to fly all the drones together from the take-off point towards the payload area and each drone has to drop their payload in the wells' area at least once (regardless if it scored).
- 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.
- Teams with inoperable aircraft are allowed to repair in between races. In the event that the aircraft is deemed incapable of flight, a new identical copy of the aircraft can be used for the next race. There will be no restriction on the number of spare aircrafts the team can prepare so long as the aircraft is replaced by another aircraft of the same design, at the discretion of the Chief Referee or Category D1 Technical Chairperson.
- In case of doubt, the Chief Referee or the Category D1 Technical Chairperson has the final decision.

6.1.4 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 50% 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	1 x multiplier / drone
Successfully pick up payload	1 / payload
Successfully drop payload in wells	1 x multiplier / payload
First to connect 5	40

The multiplier is computed based on the number of drones that drop the payload according to the rules:

Number of drones	Multiplier
1	1x
2	1.3x
3	1.5x

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 (50%). This will be followed by the 2nd team with 40%, 3rd with 30%, 4th with 25%, 5th to 8th with 20%, and the others 15% each.

6.2 PENALTIES

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

6.2.1 LIST OF MISSION PENALTIES:

S/N	DESCRIPTION	PENALTY
1	Exceeding the 15 minutes setup time for D1.	Mission time will start regardless.
2	Use of external markers/hardware outside of the playing field and pilot booths.	Referee's discretion or <u>disqualification</u>
3	No additional Internal markers/hardware within the playing field	Referee's discretion or <u>disqualification</u>
4	Interrupting the competition by potentially interfering with other competitors, e.g. switching on your platform's VTX, transmitters, etc.	Referee's discretion or <u>disqualification</u>
5	Aircraft crossing into opposing team's playing field.	Referee's discretion or <u>disqualification</u>
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 <u>disqualification</u>
7	Any ground aids used to help in the picking of payloads are <ol style="list-style-type: none">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 D Judges, while the Mission (M) factor will be computed from the highest attained score from the challenge attempts.

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

The weightage of the scoring components is listed as follows:

Segment	Factor	Weightage
Presentation	Aerial Platform	10%
	Creativity	10%
	Learning Journey and Insight	10%
Competition	Team Challenge Video	20%
	Mission	50%
	Total	100%

For both **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 10% weightage to the overall score.

Lower points would be given for wholesale usage of COTS products with little or without modification. If COTS product is used, teams are to explain the choice of COTS products and any modifications.

1) 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
- Explanations on how the wearable device operates

4) Software design, in particular describing how their proposed semi-autonomous / autonomous concept using wearable devices will work.

- Explanation of flight control strategy
- Explanation of autonomy strategy
- Explanation of design incorporating wearable devices

7.2 CREATIVITY FACTOR (C)

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

Examples of innovative approaches may include:

- More intuitive and refreshing methods of controlling the platform / camera to ease pilot workload and reduce human error
- Augmenting the video feed with real-time navigation data to improve situational awareness
- Non-conventional ideas and methods to achieve mission task(s)
- Innovative mechanisms for payload delivery
- The uniqueness of the wearables used

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
- Explanations on how the type of wearable device is decided, compared to other choices considered

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 20% weightage to the overall score.

- 1) Flight-worthiness
- Aircraft must be shown to perform stable, sustained flight
 - Video of how the operator controls the drone(s) movement using wearable devices, with movements such as forward, backward, up, down, left and right.
- 2) Mission-readiness
- Aircraft is shown to be able to fulfil mission requirements.
 - Payload mechanisms and on-board sensor suite.
 - The picking up and dropping of the payload must be shown clearly.
- 3) Creativity
- Resourcefulness in re-creating competition layout to showcase similar mission requirements.

7.5 MISSION ACCOMPLISHED 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 50% weightage to the overall score.

8. FLOW OF EVENTS

8.1 PRESENTATION SEGMENT

Teams will deliver their presentation to a panel of judges, on a virtual teleconference platform like Zoom. They will share about their flying machine and semi-autonomous system. For CAT D1, the presentation is currently tentatively scheduled for **17 March 2022**.

D1 teams will be given a maximum of **TEN (10)** minutes for this segment. **FIVE (5)** minutes are allocated for the team presentation, and another **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) Show an isometric and 3-view of the system of flying machines
- 2) Show the wearable devices used for the control of the flying machines
- 3) Show the actual flying machines during the presentation.
- 4) Teams are to prepare presentation in slides format that caters to a larger audience. The presentation material is to be submitted by **11 March 2022, 2359hrs** to SAFMC@science.edu.sg with title subject: “[CAT D1] - [Team Name] - Presentation Material”

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 D1] - [Team Name] – Challenge Video” before the deadline. The deadline for submission is **11 March 2022, 2359hrs**. Video should be uploaded before the deadline, and any re-upload of the video detected past the deadline may result in **penalization** or **disqualification**. You may write in to the SAFMC 2022 Committee to request for a re-upload of the Team Video if necessary.

The submitted video should adhere to the following guidelines:

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

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

8.3 COMPETITION SEGMENT

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

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

- 2.8 The platform must demonstrate failsafe capability in the event of a loss of link between the RC transmitter and the RC receiver on the aircraft. The failsafe check procedure is as follows:
- (a) All propellers and releasable payloads are to be removed from the platform.
 - (b) Flight motors will be armed and throttled up.
 - (c) While the motors are still spinning in the same flight mode, the RC transmitter will be switched off to simulate a link loss.
 - (d) All motors should come to a **complete stop immediately**. The aircraft should not attempt a hover / controlled descent / to return home.
- 3) For D1, each race will last for **FIFTEEN (15)** minutes. The mission time will end when the mission time is up, or when a Connect 5 is formed either horizontally, vertically, diagonally, or when the aircraft from both teams are unable to continue the mission.
- 4) A SAFMC official will be with the pilot or operator during the attempt. The official may give instructions to the pilot depending on the behaviour of the flying machine (e.g. to land immediately if the aircraft appears to be uncontrollable). The pilot is to **comply immediately** with all such instructions, which may include the activation of the failsafe to ground the aircraft.
- 5) At the end of each attempt, the radio control transmitter, datalink transceiver, video receiver and any other wireless device for the flying machine must be switched off.
- 6) After the completion of the first attempt, teams are advised to return to their respective team booth before their next attempt. The team is allowed to repair or make legal modifications to the flying machine in preparation for the next attempt.

8.4 KEY POINTS TO NOTE

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

- a. Only up to 3 members of the participating team are allowed to be inside the playing field at any one time, when NO aircraft is airborne within the safety zone. In the event of reloading payloads on the loading pad, the referee will ensure that the drone(s) has left the safety zone, or have stopped and is hovering at the red safety line before team members can enter. All team members have to vacate their playing field before their drone(s) can enter the safety zone.
 - b. No outside communication or assistance from the audience / spectators is allowed at any point. No headphones or earpieces are allowed to be worn by the pilot. Teams who flout this rule may be **disqualified**. Communication amongst teammates is allowed.
 - c. For Category D1, during the whole attempt, the pilot will have to remain in the pilot box, supervised by a referee.
 - d. All other teammates are required to remain outside of the playing field and be behind the safety net when the aircraft is airborne.
 - e. Team members may enter the field to collect their aircraft, or to change batteries **after** it has landed and propellers stop spinning. Entry into the playing field is only allowed upon confirmation with SAFMC officials.
- 2) Multiple video receivers and transmitters are allowed, but the team must stay within their allocated RaceBand frequencies only.
 - 3) No radio control transmitters, datalink transmitters and video transmitters and receivers are to be switched on within the competition hall, unless permitted to do so in the holding area or playing field. All repairs / maintenance / troubleshooting of their drone(s) can be done when the team is not competing. However, they are **NOT ALLOWED** to switch on their VTX when other teams are flying in the competition. Non-compliance may lead to **disqualification**.
 - 4) There will be a charging space allocated for D1 teams only to charge their batteries. Teams will have to bring their own charger/charging equipment should they plan to charge their batteries. At any point, there **MUST** be at least **ONE (1)** team member overseeing the charging. Failure to do so will result in **disqualification**.

- 5) Teams shall make sure that their designated representatives are contactable and should arrive at least **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:

- Off-the-shelf products and components are allowed in the competition.
- For safety considerations, the total weight of each flying machine **cannot exceed 2.0kg**.
- Each platform **should not exceed 1 m** in any direction (this measurement includes the maximum diameter of the propeller circles).
- Participants are only allowed to use **UP TO THREE (3)** flying machines for each mission attempt. Back-up aircraft that are similar to the primary aircraft may only be used in the event the primary aircraft has been determined to be incapable of flight for the subsequent attempts.
- The flying machine must transmit video back to the ground station and/or pilot.
- Only electric-based flight propulsion is allowed. Both brushed and brushless motors are allowed. No modifications to the motors are allowed.
- No internal combustion or gasoline engines are allowed.
- No tethering or umbilical wires to the aircraft are allowed during flight.
- For safety considerations, the platform must be able to perform full RC manual pilot over-ride and RC failsafe on demand.

9.1 AVIONICS SYSTEM

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

9.2 BATTERY

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

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

9.3 REMOTE CONTROL (RC) RADIO

1) Based on the Singapore Spectrum Management Handbook (Chapter 7, Issue 1 Rev 2.9, July 2017) from Infocomm Media Development Authority (IMDA) Singapore for short range devices, the following R/C frequency ranges are allocated for RC cameras / toys / miscellaneous devices:

- 26.96 – 27.28 MHz \leq 100mW Effective Radiation Power (ERP)
- 34.995 – 35.225 MHz \leq 100mW ERP
- 40.665 – 40.695 MHz \leq 500mW ERP
- 40.77 – 40.83 MHz \leq 500mW ERP
- 72.13 – 72.21 MHz \leq 500mW ERP

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

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

2) In any mode of flight, the team must be able to demonstrate the failsafe capability in their RC transmitter. All electric motors should come to a complete stop when failsafe is activated **and** when there is a loss of link between the RC transmitter and the RC receiver on the aircraft. Please refer to Point 2.8 in Section 8.2 for details on the failsafe check.

3) Please refer to the *Singapore Spectrum Management Handbook* on IMDA website for more details on the spectrum allocation and for the latest approved range of frequencies.

9.4 DATALINK / VIDEOLINK / OTHER WIRELESS LINK TYPES

1) The following frequencies are approved by IMDA for radio telemetry:

- 433.05 - 434.79 MHz \leq 10mW ERP
- 866 - 869 MHz \leq 500mW ERP
- 920 - 925 \leq 2000mW ERP

2) Wireless Wi-Fi routers will be allowed in this competition. Participants may choose to bring their own wireless routers.

- 3) Setup of external wireless device/s for purpose of performing autonomous flight is allowed. However, teams can only turn on their wireless routers and transmitters during the setup and flight phases (same restriction as R/C transmitters).
- 4) The following frequencies are approved by IMDA for wireless data communications / video transmitters / LAN:
 - 72.080, 72.200, 72.400, 72.600 MHz \leq 1000mW ERP
 - 158.275 / 162.875 MHz \leq 1000mW ERP
 - 158.325 / 162.925 MHz \leq 1000mW ERP
 - 453.7250 / 458.7250 MHz \leq 1000mW ERP
 - 453.7375 / 458.7375 MHz \leq 1000mW ERP
 - 453.7500 / 458.7500 MHz \leq 1000mW ERP
 - 453.7625 / 458.7625 MHz \leq 1000mW ERP
 - 2.4000GHz - 2.4835GHz \leq 200mW Equivalent Isotropically Radiated Power (EIRP)
 - 10.500 – 10.550 GHz \leq 117dB μ V/m @ 10m
 - 24.000 – 24.250 GHz \leq 100mW EIRP
 - 5.725GHz – 5.850 GHz \leq 4000mW EIRP
 - 5.150GHz - 5.350GHz \leq 200mW EIRP
 - 5.470GHz - 5.725GHz \leq 1000mW EIRP
 - 57 – 66 GHz \leq 10W EIRP
- 5) Please refer to the *Singapore Spectrum Management Handbook* on IMDA website for more details on the spectrum allocation and for the latest approved range of frequencies.

9.5 CAAS REGULATIONS

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

10. PANDEMIC RESTRICTIONS

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

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

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

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

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

ANNEX

PAYLOAD FOR CAT D1 COMPETITION

Payload Description	SAMPLE PICTURES
<p>CAT D1 payload:</p> <ul style="list-style-type: none"> - M14 hexagon nut - made of carbon steel - weight of 22-23g <div style="text-align: center;"> <p>Dimensions in mm</p> </div> <p>Possible vendor to buy from: Yong Seng Screws Pte Ltd 3, #01-04, Ang Mo Kio Industrial Park 2A, 568050</p>	

PAYLOAD WELL FOR CAT D1 COMPETITION

Description	SAMPLE PICTURES
<p>The payload well is where teams will attempt to use their drone(s) to drop the payloads into. At the top of the payload well is a stainless steel funnel with an inlet of 28cm diameter and an outlet of 8cm diameter.</p> <p>Link to buy: https://www.lazada.sg/products/thickening-stainless-steel-big-funnel-extra-large-caliber-funnel-industrial-gas-filling-material-large-mail-i1839602213-s9800981210.html</p>	

QR CODES



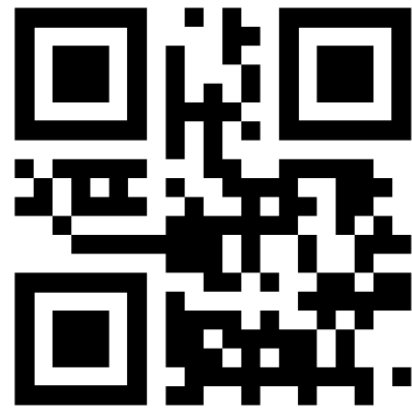
LEFT 1



RIGHT 1



LEFT 2



RIGHT 2



LEFT 3



RIGHT 3



LEFT 4



RIGHT 4



LEFT 5



RIGHT 5



LEFT 6



RIGHT 6



LEFT 7



RIGHT 7



LEFT EXIT



RIGHT EXIT



LEFT PAD A



RIGHT PAD A



LEFT PAD B



RIGHT PAD B



LEFT PAD C



RIGHT PAD C