



IMAV 2018 Competition Rules Indoor & Outdoor Events

V4.0 – 12th November 2018

* Note that rules are subject to minor revisions and updates

Introduction

The indoor and outdoor competitions are set up to test the following capabilities:

- Aircraft efficiency;
- innovative design;
- Small size and light weight;
- Autonomy and image processing;
- Stability in turbulence; and,
- Multi-MAV cooperation.

General

Australian Media and Communication Authority (ACMA) allows use of the following frequency bands:

Table 1 Available Frequency Bands

Frequency range	EIRP (Fixed frequency)	EIRP (Frequency modulated) *
915-928MHz	3mW (0.003W)	1W
2.4 – 2.4835 GHz	10mW (0.01W)	1W
5.725 – 5.875 GHz	25mW (0.025W)	1W

**Must be used for telemetry or telecommunication. For video transmitters, refer to the fixed frequency power limits*

Important notes:

433MHz and 868MHz are **not permitted** for use in Australia.

Operation of FPV equipment in the 960 – 1215MHz range is **strictly prohibited**. This band is utilised by Aeronautical Radio Navigation Services, which includes aircraft collision avoidance radar systems.

Failure to abide by the boundaries and frequencies will result in penalty and immediate disqualification.

Safety

To comply with Australian Drone regulations:

- The maximum take-off weight of any MAVs must not exceed 2 kg;
- The legal maximum altitude is 400ft (approx. 120m) Above Ground Level (AGL). The maximum altitude during the competition is 30m;
- Aircraft must stay inside the designated flight areas. If a MAV leaves the designated flight area, it should either land or return to the flight area immediately;
- Please ensure safe working practice while working on MAVs.
- Please see this link for further details: www.casa.gov.au/modelaircraft

Location

The event is held from the 17th – 23rd of November in Bundoora, VIC, Australia, and will consist of 3 competition days, 2 practise days, and 2 conference days.

Indoor Event

The indoor event will be held at the RMIT Bundoora East Campus, approximately 20 km from Melbourne city centre. You can reach Bundoora on the 86 Tram line, which leaves from Bourke St in the city centre – the trip takes about an hour, and Bundoora is the last stop (Stop 76). Please note that RMIT Bundoora has both an East and West Campus; the East campus is on the right-hand side as you exit the tram.

Address:

RMIT Bundoora East Campus,
Plenty Road,
Bundoora VIC

Map:

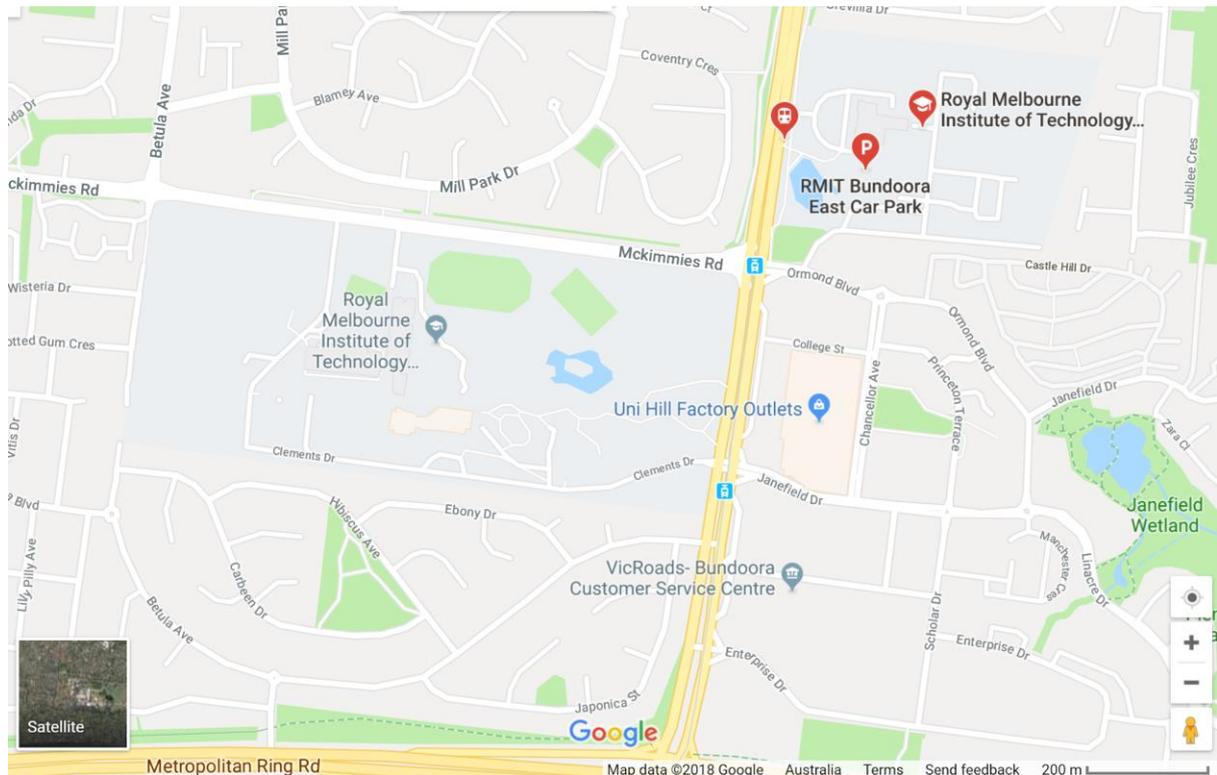


Figure 1 Map of Bundoora

Outdoor Event

The outdoor event will be held at Greensborough Model Aircraft Club (GMAC), approximately 20 minutes' drive north from RMIT Bundoora East Campus. Buses have been arranged to and from the outdoor event from the RMIT Bundoora east campus. Pick up times is 8.00am and drop off time is 5.30pm on the outdoor event day (19th November).

Address:

Greensborough Model Aircraft Club,
Yan Yean Rd,

Yarrambat VIC

Map:

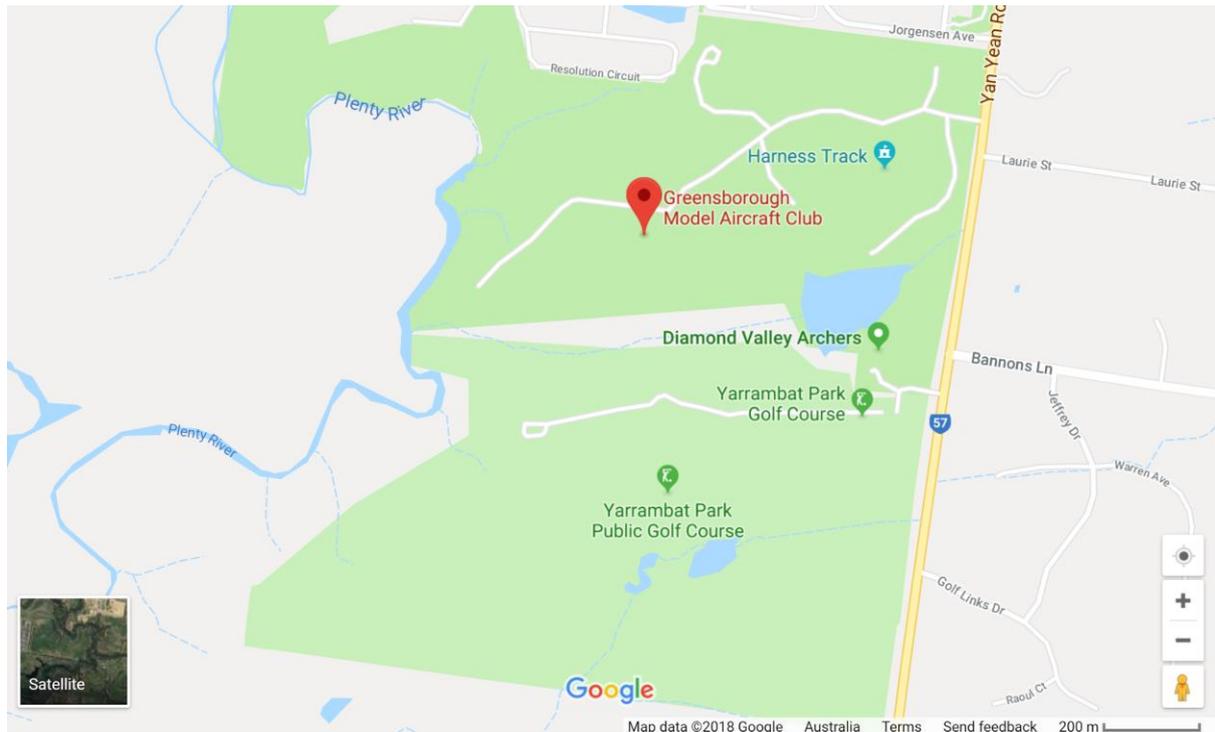


Figure 2 Map of Greensborough Model Aircraft Club

Scoring

The final score will depend on the success of each mission element (E = mission element score), the level of autonomy for each mission element (A), the mass factor (M), the power factor (W), the “in-a-row” factor (I), and a presentation made by the team during the mission (P). Awards will be determined using the following formula:

$$Score = P \times W \times M \sum_i E_i I_i A_i$$

Where:

P = Presentation Factor

E = Element Score

I = In-a-row Factor

A = Autonomy Level

M = Mass Factor

W = Power Factor

Presentation factor (P)

The team is rewarded when a team member presents the tasks and actions currently performed. The goal is to make the demonstration of each team more lively and accessible to the public. Video feedback of the ground station is possible, and is strongly recommended (we can accommodate both standard VGA cable and analogue video).

The presentation factor will be determined according to the description of:

- The MAV system and its design;
- The initial plan to perform the mission elements;
- The tasks actually performed; and,
- The level of autonomy of each task / MAV.
- The presentation factor scales to a maximum of an additional 10% of the final score (P from 1 to 1.1).

In-a-Row Factor (I)

The in-a-row factor rewards sequential completion of successive tasks (one after another). The multiplier starts counting after the first mission element is completed (take-off and landing are not included). The in-a-row factor can only be counted from the take-off pad/zone. Multipliers are given in the following table:

Table 2: Factors for successive challenge completion

Successive Challenge Completions	Factor
1	1.0
2	1.2
3	1.4
4 (max. available)	1.6

Level of Autonomy

Table 3: Factors for Varying Levels of Autonomy

Level of Autonomy	Factor
Video based control: control of the MAV through an FPV system.	1
Autonomous flight control: the navigation is completely autonomous, but the operator is controlling the mission and payload	5
Autonomous target detection: navigation is manual, but the detection and processing of targets is automatic	5
Fully autonomous control of both navigation and target detection.	10
Using external aids, such as visual markers.	-2 (not a multiplier, negative 2 for each marker. Capped at -20)

Mass Factor (M)

This year there will be a mass factor allocated to each MAV, rather than a size factor, defined as follows:

$$M = \frac{1000}{MAV\ Mass\ (Grams)}$$

*Note: This is done to not unfairly penalize fixed wing and alternative MAVs. Lighter than air craft will but limited to maximum points (multiplier of 1).

Power Factor (W)

A power factor will also be applied to each competing MAV, to encourage alternative energy sources and lower capacity batteries.

$$W = \frac{10}{Total\ Battery\ Capacity\ (W.h)}$$

*Note: For alternative power supply (eg. Solar) the multiplier will be capped at 1/10

Indoor Course

*Note: diagram is not to scale, obstacles are representative only and may not be configured in these exact locations during the competition.

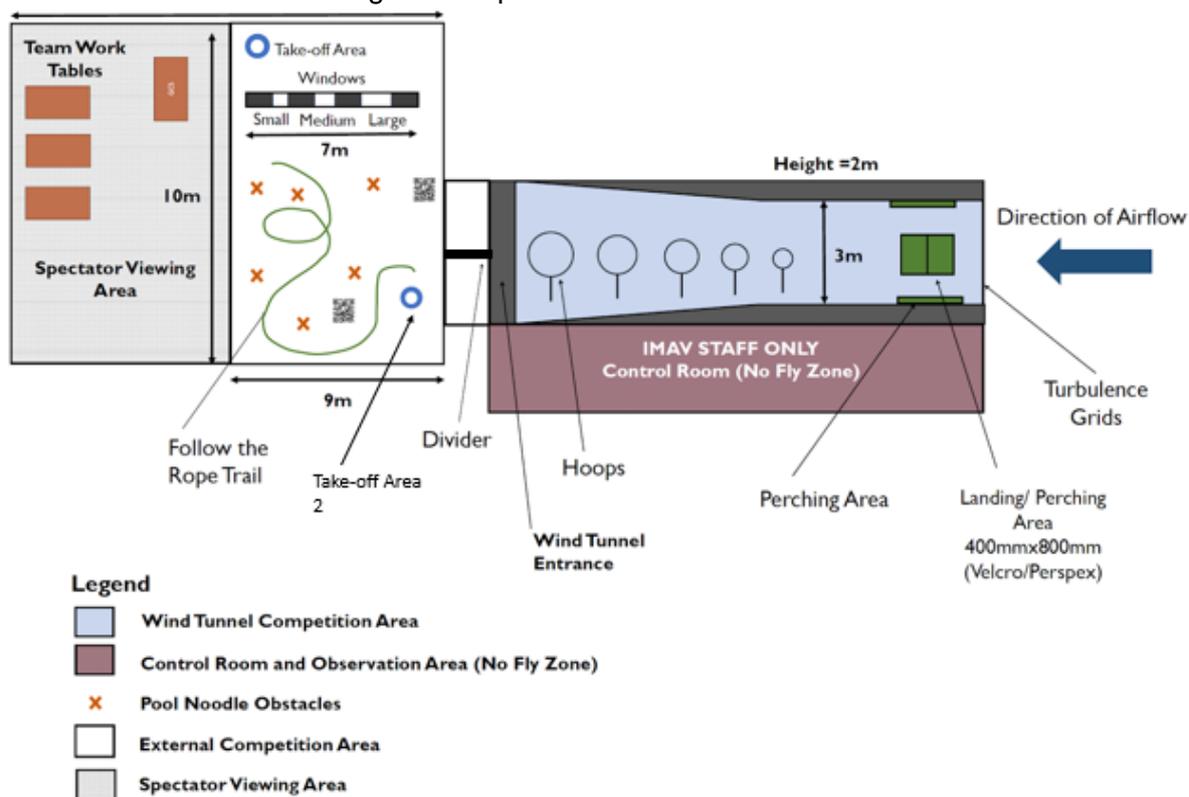


Figure 3: Indoor Challenge Layout

Indoor Competition Rules

- 1-pilot per MAV is required;
- All flying MAVs need to stay within the designated flight area;
- All MAVs will be checked before flight and must be airworthy;
- At least one team member must maintain visual line-of-sight contact with their aircraft. For the wind tunnel challenge, one member of the team is allowed inside the Wind Tunnel Control Room during the flight;
- Only the competing team may have their radio equipment on during the competition;
- Teams may only fly during their allotted slot;
- Teams must present all aircraft for scrutineering;
- All batteries must have a means of monitoring the voltage to prevent cells dropping too low and becoming a hazard. They must also have appropriate storage when not in use, or charging (for example, LiPo safe bags);
- Teams are responsible for their own aircraft, and are liable for any accidents caused;
- The main ground station screen has to be shared via a VGA output (to a projector or screen delivered by the venue);
- A human pilot must be able to take manual control of the MAV at all times in case of an emergency;
- Instructions given by IMAV staff should be followed without argument;
- Decisions made by the IMAV judging panel are final;
- The “Wild Card” may only be used to pause the competition time slot once. When all other teams have competed, remaining time from the first attempt may be used to complete the course (time permitting).

Failure to adhere to these rules may result in penalty or disqualification.

Indoor Mission Brief

Teams are allocated 15 minutes to attempt the course, with the option to “pause” their time once by using their “Wild Card”. The indoor event consists of several challenges, culminating in a wind-tunnel challenge focusing on stability in turbulence. Teams must attempt to complete as many of these challenges as possible to achieve the maximum number of points. Points will be deducted if any part of the aircraft touches an obstacle that is not the take-off and landing pad, including the ground.

Take-off

- Take-off from the designated platform.

Window Challenge

- Three different sized windows will be available for teams to choose.
- Points range according to the size of the window (smaller windows are worth more points).
- Small window
 - Square
 - (W)0.5m x (H)0.5m
- Medium window
 - Rectangular

- (W)1.0m x (H)1.5m
- Large window
 - Rectangular
 - (W)1.5m x (H)1.5m

*Note: pictures of the windows will be available soon.

Pole Navigation and Follow the Rope

- Poles will be arranged in a random pattern that the aircraft(s) **MUST** navigate through (cannot go above pole height to clear all obstacles). The poles will be pool noodles similar to the material of the hoops used in the wind tunnel. (Exact dimensions TBA)
- A rope will pass through the pole area (high contrast against the floor) representing the preferred path through the section.
- The MAV must follow the rope all the way to the end. Points for following the rope are awarded in sections. The rope is divided into 4 sections.

QR Code Translation

- QR code(s) will be visible at the end of the pole area.
- QR code(s) must be translated to English words and displayed to the judging panel.
- One QR code contains information pertaining to the next challenge. The QR code will either state 'RIGHT' or 'LEFT', the team needs to use this information to enter the wind tunnel on the right or left side of the wind tunnel. Additional points are awarded if the MAV is able to incorporate the information from the QR code into its decision-making for entry to the wind tunnel (see next mission element for more details).

Take-off / Landing Zone

- A second take-off/landing area will be provided at the end of the rope and poles section, but before the entry to the wind tunnel.
- If your team chooses to use this as a take-off pad, you can only proceed to the wind tunnel challenges (see the next two sections); you cannot return to previous elements.
- If your team chooses to use this as a landing pad, it will not count as a "crash" landing, but this ends your "in-a-row" counter. No points are awarded for landing here.

Wind Tunnel Entry

- The door to the wind tunnel diffuser chamber will be open, with a divider down the middle. The entrance is split into left and right sections. Points are awarded for entering the wind tunnel section through either right or left sections.
 - One QR code (from the previous challenge) will translate to "LEFT" or "RIGHT" (upper-case text). If the MAV is able to use this information to choose the correct side to enter the wind tunnel, additional points are awarded
- For this element, teams may choose 1 of 3 wind speeds:
 - No wind - 0 km/h
 - Low wind - 24 km/h
 - High wind - 30 km/h

More points are awarded for higher wind speeds. Wind speed may not be changed once the MAV has entered the wind tunnel area (it may be changed before additional attempts). Wind speed must be set before take-off.

Turbulent Wind Tunnel Test Section with Hoops

- The wind tunnel test section will contain 5 hoops of different sizes, starting with largest, and getting smaller. The MAV is challenged to fly through each of these hoops, with points awarded for each hoop flown through.
- Hoops are not perfectly round and so nominal dimensions are as follows;
 - Extra-Large hoop (1400 x 1270)
 - Large hoop (1030 x 1200)
 - Medium hoop (800 x 880)
 - Small hoop (590 x 620)
 - Extra-small hoop (360 x 400)



Figure 4: Wind Tunnel Challenge Section

Landing/Perching

- Landing takes place in the wind tunnel on a choice of landing pads. The landing pads are situated close to the turbulence grids at the foremost part of the test section (farthest from the MAV entry point).
- Landing/perching pads in the wind tunnel are half velcro (white) and half perspex (red) ((0.5m x 0.8m). Note that the soft side of the velcro will be used in the wind tunnel. Points are awarded according to material.
- The same landing pad will be placed at each landing location. Landing location is either floor, ceiling, or wall, with the most points being awarded for the wall.
- The MAV will finish the course by successfully landing on one of the pads and remaining there for 10 seconds.
- This mission element needs to be conducted at the same speed chosen as the previous wind tunnel element.

Indoor Competition Scoring

Mission Element	Description	Points
Take-off	Successful take-off from take-off platform	2
	Points deducted for each obstacle/ground hit	-2 each for a min. of -50 pts.
Window Challenge	Large window Medium window Small window	10 20 30
Poles Navigation and Follow the Rope	Successfully make it through poles area Points awarded for each section of the rope followed accurately	+10 +10 (max. 50 pts)
QR Code Reading	Successful QR code translation	+5 (each)
Wind Tunnel Entry	Entry to tunnel Correct side of tunnel entered (as named in QR code) <i>Wind speed:</i> No wind in tunnel Low wind in tunnel High wind in tunnel	2 +5 0 5 10 (max. 17 pts)
Passing through hoops	Extra Large Hoop Large hoop Medium Hoop Small hoop Extra Small hoop <i>Wind speed:</i> No wind in tunnel Low wind in tunnel High wind in tunnel	+1 +5 +10 +15 +40 0 5 10 (max. 81 pts)
Landing/perching	<i>Location:</i> Floor Side Wall Ceiling <i>Material:</i> Perspex (smooth) Velcro <i>Wind speed:</i> No wind in tunnel Low wind in tunnel High wind in tunnel	5 20 10 20 10 0 5 10

- All batteries must have a means of monitoring the voltage. They must also have appropriate storage when not in use, or charging (e.g. LiPo safe bags).
- Teams are always responsible for their aircraft, and are liable for any accidents their aircraft may cause.
- The main ground station screen has to be shared via a VGA output (to a projector or screen delivered by the organisation)
- A human safety pilot must be able to take over the aircraft at all times in case of an emergency.
- Instructions given by the IMAV staff and field marshalls shall be followed without argument.
- If you wish to leave pilot zone you must be with a marshal for safety purposes. The area is prone to snakes and other dangerous wildlife.
- Decisions made by the IMAV judges are final.
- With respect to the previous search and rescue mission element, a live video feed needs to be sent back to the ground control station. Due to the nature of terrain, teams will not have line of sight signal from the take-off and landing area to the river and therefore will require a video feed relay back to the ground control station.
- **Per Australian regulation, You must maintain radio communication with your MAV(s) during operation.**

Failure to adhere to these rules may result in penalty or disqualification.

Outdoor Mission Brief

Teams are allocated a 20-minute time slot. The mission elements for the outdoor event are as follows:

Take-off

- Two take-off zones are available – one for rotorcraft, and a second one for aircraft requiring a runway.
- Teams must use the designated take-off areas.
- Maximum points are awarded for automatic take-off; manual take-offs will result in a points penalty.

Treasure hunt (metal detection)

- Underground gas pipelines can be hazardous, and detection and location of metal pipelines is often necessary for surveying, maintenance, and construction purposes. This mission element challenges teams to detect hidden metal objects. Details:
 - An 8m x 8m area will contain 4 identical hidden metal discs, the objective is to identify the location of the metal discs. Points will be awarded for each disc found;
 - Metal disc specifications: 40cm diameter, 2cm thick;
 - Discs will be hidden under organic material (leaves and other plant materials).

Mapping

- Teams will generate a 2D or 3D map of the specified area.

- Additional points are awarded for:
 - Identifying any of up to three 44 Gallon drums with red coverings (dimensions 584mm diameter, 876mm height)
 - Identifying the green crocodile hidden in the bush (dimensions ???)



Figure 6: Crocodile toy hidden in the undergrowth



Figure 7: 44 Gallon drum with red covering

Search and Rescue

- Search for an injured firefighter in the bush, and deliver a first aid kit. You are provided with the injured firefighter's last known location when you commence the challenge. You know he is within a 15m radius of this point (he is injured and can't move far). Points will be allocated for:

- Navigating through the environment (you will not be able to see the firefighter from above the tree line)
- Detecting the firefighter and relaying his location to judges;
- Delivering a first aid kit to within 1 m of the firefighter;
- If you cannot detect the firefighter, deliver the first aid kit to the last known location provided. Otherwise demonstrate the payload drop elsewhere for minimum points.



Figure 8: Injured survivor of a dropbear attack



Figure 9: First-aid kit to be used

Trafalgar first-aid kit mini. Only one kit (12cm x 9cm x 2.5cm, 150 grams) needs to be carried by the aircraft.

Landing

- If the MAV lands in the designated precision landing area (fixed wing or rotorcraft), maximum points will be awarded. Fewer points are awarded for normal landing elsewhere.

Outdoor Competition Scoring

The scoring of each element is as follows:

Mission Element	Description	Points
Take-off	Successful take-off from designated area	2
Treasure hunt (metal detection)	Correct location found of each disc Bonus points for all 4 disks located	+2 +2 (max. 10 pts)
Mapping	Map created Classify each hazard Location of each hazard	+10 +5 +5 (max. 50 pts)
Search and Rescue	Navigating through the forest Detect Firefighter Provide firefighter's location to judges <i>Payload Drop:</i>	+10 +5 +10

	Deliver the first aid kit to the firefighter Deliver the first aid kit to last-known location Successful payload drop demonstration	10 3 1 (max. 35 pts)
Landing	Precision landing in specified fixed wing or multi-rotor areas. Controlled landing in specified fixed wing or multi-rotor areas. Controlled landing outside all landing areas	10 5 1
Video Relay	Video from aircraft relayed to ground station for viewing by spectators	+10

Novelty Events

Co-operative Carry (Outdoor)

- The co-operative carry will require teams to carry a single bucket (purchased from [Bunnings](#)). The bucket is half filled with water, and has cut-outs to encourage spillage unless the MAVs are very stable. Points will be deducted for the amount of water spilled.
- The objective of this event is to deliver water from one location to a drop-off point located 24m away.
- Teams may choose how to attach the bucket to their MAV. For this event we want to encourage using multiple, smaller MAVs, and the scoring is representative of this.
- The scoring for this event uses Equation 1, except the In-a-row Factor is replaced by a Number-of-MAVs Factor (e.g. two MAVs is a 2.0 multiplier, four MAVs is 4.0 multiplier);
- MAVs cannot be attached to one another. MAVs should only be attached to the bucket.



Figure 10: The bucket that will be used for the stability challenge

Novelty Events Scoring

Novelty Events	Description	Points
Cooperative Carry	Multiplier for Number-of-MAVs used to carry bucket Take-off safely and hover while carrying bucket Travelling towards drop off location while carrying bucket Successful landing of MAVs and bucket at designated location Spilling out 250 grams of water	*N-MAVs +10 + 5 per meter +10 -10
Silent MAV	The entrant with the lowest average sound pressure level wins the challenge.	-

Silent MAV Contest (Indoor)

- The silent MAV contest requires the MAV to carry a 500g payload for 5 minutes;
- The aircraft will have the average Sound Pressure Level (SPL dBA) measured over the course of 30 seconds, taken during the final minute of the hover challenge;
- The entrant will be notified when the measuring time starts;
- The entrant with the lowest average SPL wins the challenge.
- The flight space (see figures below) is 3m wide x 3m long x 4.5m tall (up to the ceiling). Drawings are provided below.
- The area has 1 wall of plaster (standard room), with the additional 3 walls made from a net.
- The entrant may hover anywhere within the flight space, provided both the craft and payload are off the floor and out of ground effect. The MAV must not touch any of the walls or ceiling during the flight.
- The sound pressure level meter is mounted on a tripod at the centre of the net face farthest from the wall, at a height of 1m from the ground.
- The maximum MAV dimension allowed in any direction is 1000mm (e.g. measured from prop-tip to prop-tip)
- The maximum take-off weight is limited to 2 kg, including the payload.
- The payload is a standard pizza box (measurements: 340mm, 340mm, 45mm) weighing 500g.
- The payload may be attached to your MAV in any fashion; however, the bottom of the payload must be at least 0.5m off the ground.

- Should the craft come in contact with the walls and the net during the 30 second measurement period, any noise caused by the contact will be included in the noise measurement.

