UAV Challenge
Airborne Delivery 2017

Competition Rules

Version: 1
Date: 20 March 2017

NOTICE TO COMPETITORS

This document is subject to change by the UAV Challenge organisers. The current version of this document will be available from the UAV Challenge website, http://www.uavchallenge.org. Registered participants will be notified of any changes.

These rules have been designed to address safety and maintain an acceptable level of aviation rigour, while attempting to maintain a high level of "fair play", accessibility, and enjoyment. There is an expectation that teams will enter into the UAV Challenge with a desire to compete within the spirit of the Challenge and not to exploit loopholes for an unfair advantage. The UAV Challenge Technical Committee and judges reserve the right to take action against any team or individual that conducts themselves in a manner judged contrary to the intent and spirit of the UAV Challenge. Competitors are encouraged to alert the organisers if they find inconsistencies or loopholes in these rules.

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Revision Record

Version 1

Changes from 2016 include but are not limited to

- Section 1.3: Added new section on the Drop Target
- Section 1.6: Added new section on Delivery Timing
- Section 3.1.1: Added that if multiple radio links are used flight termination should be activated on the status of only the UAV Controller's radio
- Section 3.3.2: Changed wording from always requiring remote control to always requiring a radio control transmitter
- Section 3.3.3: Added new section explicitly permitting the use of ground control stations
- Section 5.4.1: Added mathematic modelling as a required heading in the technical report
- Section 5.5.1: Added mathematical modelling as a part of the oral presentation
- Section 5.5.2: Change bonus points for autonomous drop triggering to be a percentage of accuracy points instead of a fixed bonus
- Section 5.5.2: Changed drop scoring to be dependent on delivery timing
- Section 7.2: Added new discussion section on drop strategy
- Section 7.3: Added new discussion section on Mathematical Modelling

Glossary

Epipen	An auto-injector containing a measured dose of epinephrine for treating anaphylaxis
Drop Target	A marker placed on the field where the Medical Package must be delivered to
Flight Termination System	A mandated system on-board all competition unmanned aircraft that guarantees that an aircraft will not fly a significant distance outside a boundary.
Flying Zone	The area of the course in which all flying must occur
Impact Monitor	A device that will enable the judges to know if the medical package has experienced an acceleration larger enough that damage to the package may have occurred
Medical Package	A simulated Epipen containing an Impact Monitor that teams must drop
Mission Manager	The team member who may manually trigger the dropping of the medical package from the unmanned aircraft
No Fly Zone	The zone where aircraft may not fly that ensures a safe distance is maintained between a flying aircraft and people not involved in its operation
Range Safety Coordinator	The member of the organising personnel in charge of the flight range
Technical Committee	The committee of UAV Challenge organisers and industry experts that write these rules and manage the flight operations of the UAV Challenge
UAV Controller	The team member in command of the unmanned aircraft

1 The Mission

The goal of the UAV Challenge is to demonstrate the utility of Unmanned Airborne Vehicles (UAVs) for civilian applications, particularly in those applications that will save the lives of people in the future. In this competition, competitors will be required to develop a UAV that could save lives by quickly and cost effectively delivering medical supplies to critically ill patients in the Australian Outback.

1.1 Overview

Outback Joe has made an emergency mobile phone call to advise that he is suffering an allergic reaction and needs urgent medical assistance. Teams are invited to use an unmanned aircraft to quickly deliver an Epipen as close as possible to where Outback Joe needs it so that he can treat his anaphylaxis immediately while medical aid travels to reach him.

1.2 The Medical Package

Medical packages will be provided to each team for delivery on the day of the competition. The medical package will be an Epipen shaped device containing no actual medication and will have the following specifications:

1. Size equal to 152 mm x 31 mm x 23 mm
2. Weight of 60 grams

Note that these dimensions are slightly larger than an actual Epipen.

Figure 1 An Example Medical Package

The medical package could be damaged by the shock of hard impacts and so must be protected. Teams must take measures such as slowing the impact velocity of the package and/or cushioning the package from impacts.

The maximum acceleration the medical package can be subjected to is 75G. A points penalty will be incurred for each drop that exceeds this threshold (see Section 5.5.2).

Teams are permitted to install the medical package in a carrier that will be dropped with the package or otherwise make attachments to the package. The medical package must be easily removable from any carrier or attachments. Any carrier or attachments must minimise the hazard to people and property by not having sharp protrusions or points. The carrier or attachments may have features that improve the drop accuracy.

The team will be provided with 3 medical packages at the beginning of their mission time and it is these medical packages that must be dropped.

1.2.1 Impact Monitor

The medical package will contain a digital impact monitor that will record the accelerations that the medical package is subjected to during the flight and drop. This data will be inspected for each drop to determine if the maximum permitted acceleration has been exceeded.

The impact monitor will be an X200-4 USB Impact Accelerometer manufactured by Gulf Data Concepts. This device has a 3-axis accelerometer with a range of ±200g. The impact monitor will be configured to record data continuously at a sample rate of 200 Hz. The accelerations from all 3 axes will be vector summed to determine if the 75G limit has been exceeded at any time during the flight and drop.

Figure 2 The impact monitor installed in the medical package

A limited number of medical packages including the impact monitors will be made available for loan to competing schools and independent teams in the months prior to the flying event. Further details of this loan program will be available on the UAV Challenge website.

1.3 The Drop Target

Outback Joe does not wish to be hit by the dropped Medical Package so he has placed an easily visible target on the field where he wants the package delivered to. The target has the following specification:

- Flat 500 mm x 500 mm
- Black with a 250 mm x 250 mm white square in the centre
- A peg in the centre securing the target to the ground

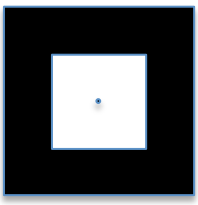

Figure 3 The Drop Target shape

Outback Joe will be waiting safely clear of the drop area, ready to retrieve the Medical Package.

1.4 Course Layout

The flying course, shown in Figure 4, is approximately 350 metres by 250 metres and consists of 2 zones:

1. The Flying Zone where all flying activities must occur
2. The No-Fly Zone where team aircraft are not allowed to fly

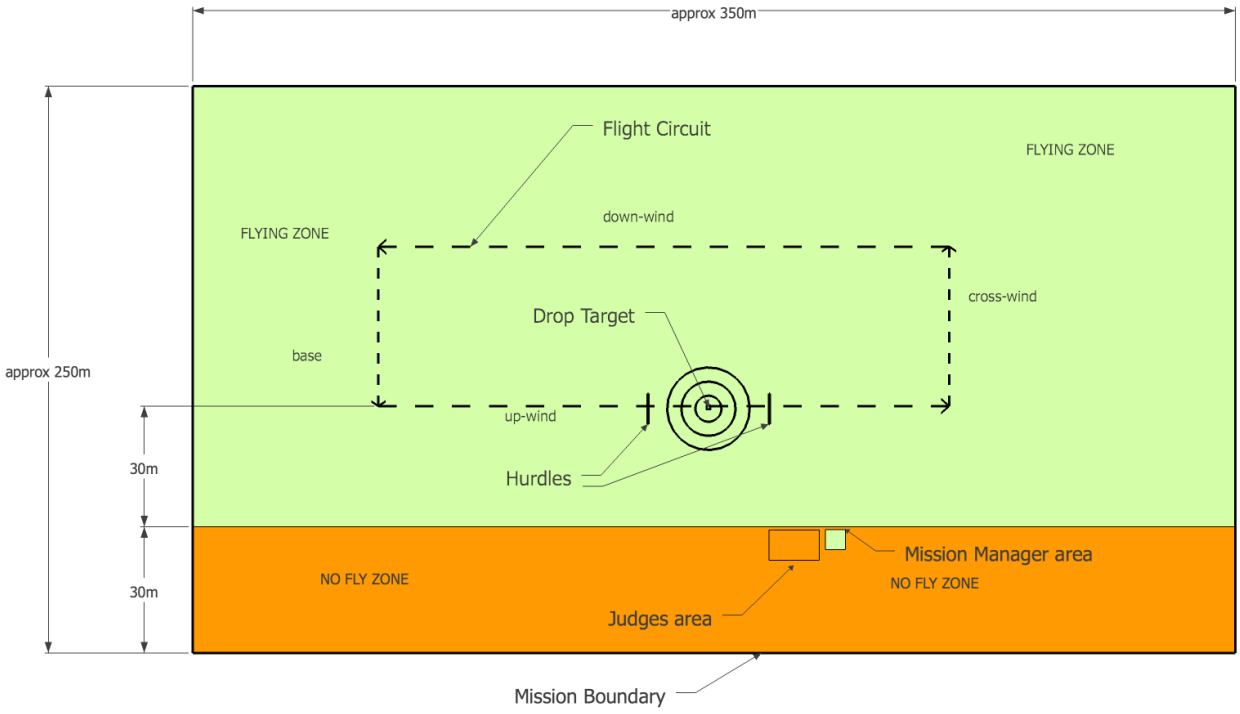

Figure 4 General Layout of the Airborne Delivery course

The Drop Target will be located within the Flying Zone, approximately 30 metres from the No-Fly zone boundary. Either side of the Drop Target will be hurdles, shown in Figure 5, that act as markers for the minimum permitted flying height.

The two hurdles have the following specifications:

1. Height of 4m
2. Width of 3 m
3. Open hurdles
4. Consist of 80mm x 80mm right angle aluminium, with 50mm wide Class 1 reflective yellow tape on the top surface of the horizontal beam

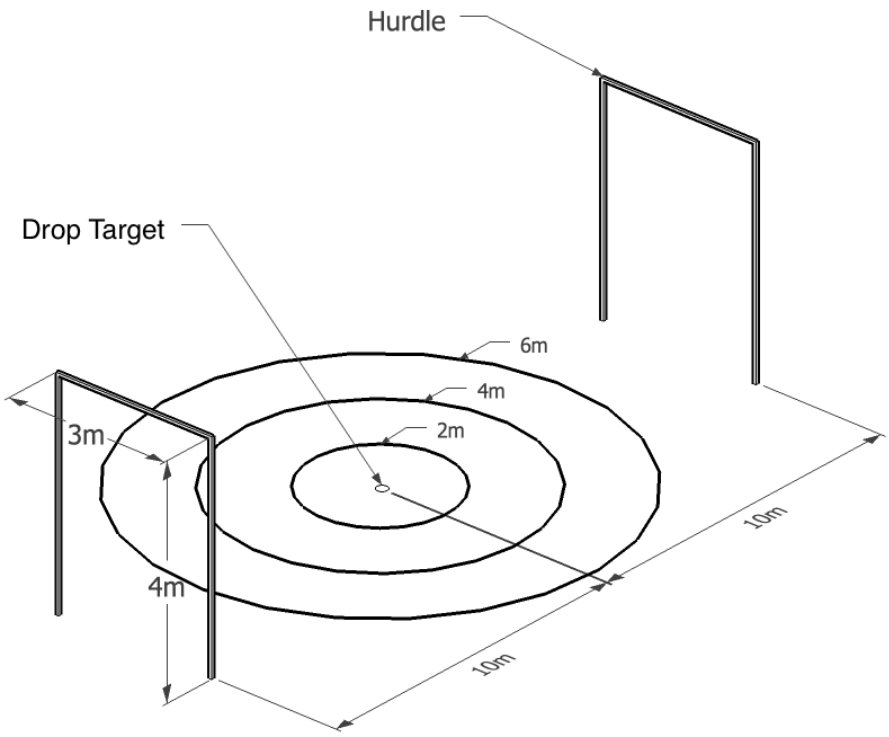

Figure 5 Dimensions of the hurdles

1.5 Delivering the Package

The medical packages must be dropped from the team's unmanned aircraft and come to rest as close as possible to the Drop Target. A human operator, known as the UAV Controller, will be in command of the aircraft.

The aircraft must fly such that it will pass directly overhead the two hurdles that are laid out on the course. Whilst flying between the hurdles, the aircraft must at all times remain above the height of the top of the hurdles but must not fly higher than 200 feet.

Each package delivery must occur within 3 passes over the hurdles. Following the drop the UAV Controller can perform as many additional circuits or passes as desired before landing

the aircraft, so long as it is within the time limit for the competition and the aircraft remains within the flying zone. The UAV Controller can launch and recover the aircraft as many times as desired within these constraints also. The UAV Controller can move around the course as required in order to fly the aircraft in a safe manner.

The aircraft may carry more than 1 medical package at a time and is not required to land between package deliveries.

1.6 Delivery Timing

Outback Joe is desperately ill so time is of the essence. The longer it takes to deliver the medical package the higher his expectation of accuracy.

The time taken for the aircraft to travel between the two hurdles will be measured by an electronic system on the ground and contribute to scoring (see Section 5.5.2). The longer the time spent between the hurdles the higher the required drop accuracy.

1.7 Drop Triggering

The dropping of the medical package can be triggered either:

1. Remotely by the Mission Manager
2. Autonomously by systems on board the aircraft.

Teams must select which drop triggering method they will use prior to the competition and include reference to their choice in their technical report and oral presentation.

1.7.1 Remote Controlled Drop Triggering

A human operator, known as the Mission Manager, may control the delivery of the supply package. The Mission Manager and associated equipment must be located within the Mission Manager's enclosure at all times during the mission. The Mission Manager's enclosure will be barricaded around the sides towards the flying area, covered from the top for safety and will be 2m x 2m or greater in area. The Mission Manager will NOT be able to see the Drop Target or the aircraft during the flying element of the competition and will NOT be able to communicate with the UAV Controller while the aircraft is airborne during the Primary Mission.

The Mission Manager must control the delivery mechanism independently of the UAV Controller. The UAV Controller and the Mission Manager will act independently and without communication while the aircraft is airborne.

1.7.2 Autonomous Drop Triggering

The delivery of the supply package may be triggered automatically by systems on board the aircraft. No interaction between the team members and the automatic triggering system is to occur while the aircraft is airborne. The only connections between the automatic dropping system and the remote control equipment should be the power supply and an input to arm the system.

As the drop is triggered automatically by systems on board the aircraft there is no mission manager and therefore no restriction on communications between team members during the flying competition.

All equipment that will be used to communicate with or configure systems on board the aircraft during the execution of the mission must be inside the mission boundary.

1.7.3 Changing drop method

In the event of technical difficulties, teams selecting automatic drop triggering can downgrade to manual drop triggering. This declaration must be when the team registers upon arrival at the event.

1.8 Mission Duration

A total time of 20 minutes will be provided for each team in the UAV Challenge Airborne Delivery. This includes walking onto the field, set-up, launch, the mission, landing, recovery, pack-up and exiting the field. The judges will indicate when the timer starts and team can then enter the mission area.

Teams must complete their mission and leave the field within the 20 minutes time period. A points penalty will be applied for time over the 20 minutes and any drops after 25 minutes will not be counted.

2 Rewards

High school students may enter the competition without the approval of their schools and be entitled to the full cash prize themselves, however they must do all the work in their own time (not school time) and obtain insurance themselves.

If project work is conducted in school time with school resources and costs subsidised by the school, prize money will be awarded directly to the school.

If teams are tied for a prize the prize money for the positions they hold will be combined and shared equally between the teams. e.g. If two teams are tied for first place the prize money for first-place and runner-up will be equally shared between those two teams.

2.1 Airborne Delivery Award

The teams with the highest points totals as described in Section 5 who flew at the competition and dropped at least one package which scored points will be awarded the following prizes:

1. First Place AUD$ 5,000
2. Second Place AUD$ 2,000
3. Third Place AUD$ 1,000

2.2 Rookies Award

The team that consists entirely of rookies (team members who have never competed at the UAV Challenge before) with the highest points total as described in Section 5 who flew at the competition and dropped at least one package which scored points will be awarded the following prize:

First Placed Rookie Team AUD$ 2,000

2.3 Airmanship Award

The airmanship award trophy will be presented to an individual who in the judges' opinion has displayed the best airmanship during the competition.

3 The Unmanned System and its Operation

3.1 Aircraft Requirements

All aircraft entered will be subject to the following requirements and limitations:

1. Must use an electric propulsion system;
2. Must be untethered and free flying;
3. Gross takeoff weight must not exceed 7 kg;
4. Must have continuous radio communication with the *UAV Controller*; and
5. Platform and on-board systems can be commercial off the shelf or custom made.

3.1.1 Flight Termination Behaviour

All teams must implement a safe flight termination behaviour for their aircraft. Specifically, teams must use radio receiver(s) that are capable of reverting to pre-defined failsafe values when radio communications are lost from the UAV Controller's radio transmitter. If for any reason the aircraft appears to be out of control during the competition or during practice flights, the UAV Controller must turn off their transmitter, and invoke the flight termination mode.

If teams use more than one radio link to their aircraft Flight Termination must always be activated when radio communications are lost from the UAV Controller's radio transmitter regardless of the status of the other radio links.

The flight termination servo positions (programmed into the radio receiver) for fixed-wing aircraft and rotary-wing aircraft is to close the throttle.

In the case of lighter than air aircraft, strategies should be developed that ensure that the aircraft can be brought to ground in the case of failure, noting maximum crosswinds and the estimated maximum distances that the vehicle could exceed the mission boundary.

3.1.2 Alternate Flight Termination Systems

If a team wishes to use an alternate Flight Termination Method, such as a parachute, then the details of such a system must be outlined in the Technical Report. It is up to the team to convince the judges that the alternate system is safe.

3.1.3 Criteria for Flight Termination

The Range Safety Coordinator or judges can demand that the flight be terminated if they deem that the aircraft is out of control.

The UAV Controller must comply without delay or argument.

3.2 Unmanned System Requirements

3.2.1 Radio equipment

Teams are permitted to use any combination of frequencies as long as they comply with Australian Communications and Media Authority (ACMA) regulations.

Teams must present any radio licences that they may have obtained and need to use during the UAV Challenge Airborne Delivery to the scrutineers during scrutineering.

3.3 Operational Requirements

3.3.1 Take-off and landing

Teams must be capable of executing take-off and landing from a rough mown grass runway.

3.3.2 Conduct of the UAV Controller

The UAV Controller is responsible for launching and recovering the aircraft and the safe piloting of the aircraft once it is airborne. At all times while the aircraft is airborne the UAV Controller must have a handheld radio control transmitter for the aircraft and be able to activate flight termination mode in accordance with Section 3.1.1.

The UAV Controller must control the aircraft such that it remains in the flying zone as shown in Figure 4. Spotters on the course will determine if the aircraft flies outside the flying zone.

Airspace incursion procedures:

- *Flying into the No-Fly Zone:* If the aircraft is deemed to have flown into the no-fly zone then the Range Safety Officer will direct the UAV Controller to land the aircraft without delay. The Range Safety Officer is responsible for the safe operations of the event. Upon landing the aircraft the Range Safety Officer will direct the team to vacate the field and their mission will be declared over. The no-fly zone is designed to protect the general public, organisers and teams.
- *Exiting the Flying Zone*: If the aircraft is deemed to have flown outside the flying zone (excluding the no-fly zone) then the Range Safety Officer will direct the UAV Controller to land the aircraft without delay. Upon landing the aircraft the Range Safety Officer will give a verbal warning to the UAV Controller. The clock will remain running throughout this process. The UAV Controller is allowed two warnings. If the flying zone is breached a third time, the Range Safety Officer will direct the UAV Controller to land the aircraft and to vacate the field and their mission time will be declared over.

The UAV Controller must adhere to the flight circuit procedures that will be provided at the competition.

3.3.3 Ground Control Station

Teams may utilise a ground control station to support their UAV Controller. A team member other than the UAV Controller must operate the ground control station. If performing remote controlled drop triggering the ground control station cannot be located with the mission manager.

3.3.4 Measuring the Target's Location

During their flight scrutineering or during their designated mission time, teams are permitted to measure the Drop Target's location, for example with a GPS.

A metal peg will be driven into the ground in the centre of the Drop Target and serve as the point from which distance measurements will be taken for scoring.

3.3.5 Adverse Weather

Postponement of the competition due to adverse weather conditions will be at the judges' discretion. Flying will be delayed if the 10-minute average wind speed exceeds 15kts. An adverse weather day has been built into the schedule.

In the event that all teams do not have the opportunity to fly due to adverse weather the points from the team's technical report and oral presentation will determine the winners.

3.4 Safety Requirements

3.4.1 Challenge Safety

Safety is a priority for the UAV Challenge, and the rules contained in this document have been put in place with safety in mind. The safety mechanisms that have been put in place include: ensuring compliance with CASR101 (where applicable); air vehicle safety inspections and structural verification; UAV Controller override capability; flight termination mode; and a proven history of safe flight operations.

Entrants are reminded that during their research and development phase, all test flying must comply with the relevant CASA regulations.

3.4.2 Flight Demonstration

All teams will be required to conduct a scrutineering flight demonstrating (but not limited to) the following:

- The team's ability to safely launch the aircraft,
- The UAV Controller's piloting competency (Section 3.4.3), and
- The aircraft's suitability for competition.

These flights also provide teams with an opportunity to familiarise themselves with the flight area. The circuit to be flown will typically be the same as the mission circuit, but full details will be given to the teams at the time of their scrutineering flight.

3.4.3 Piloting Proficiency

All Pilots will be required to demonstrate a competency in the following areas of airmanship, regardless if they hold an MAAA pilots rating for powered RC model aircraft. A scrutineering flight will take place with flight boundaries similar to a typical model aircraft field. Before qualifying to fly in the competition, each team pilot will be asked to perform the following routines and functions:

- Please note - **emphasis is on the pilot to demonstrate a high degree of control of his / her aircraft***.
- Demonstrate a take-off from a grass runway into a head or crosswind, with safe transition into a rectangular circuit at a height of 200ft above ground level (AGL).

- Perform rectangular flight circuits in both clockwise and anti-clockwise directions, maintaining constant altitude in transacts and corners.
- Demonstrate minimal deviation (less than ± 30ft) in altitude.
- Typical height for the demonstrated circuits will be 200ft AGL. Each circuit leg should be no less than 200ft in length.
- Corners should be concise 90° angles and clearly demonstrated again with no loss or change in altitude.
- Demonstrate a horizontal figure of 8, with large clearly defined circular parts of the '8', whilst maintaining constant altitude. The radius of the circle should be no less than 100ft and have clearly defined transitions from one half of the 8 to the other half.
- Demonstrate a simulated landing circuit including; clearly defined crosswind, downwind and base legs, ending in a landing approach a landing into the wind** and an aborted landing i.e. go around.

At any time, during any flights, the flight may be terminated by the organisers. In such an event, pilots should immediately follow the instructions given to them at that time, taking into account safety. Remember Aviate, Navigate then Communicate.

*Pilots will be flying in front of crowds of spectators, including judges, marshals and event personnel. This can be an extremely nervous situation. It is highly recommended that pilots practice for such conditions.
**No downwind landings will be permitted or requested, except in emergency situations.

3.4.4 Safety inspections

Prior to conducting any competition flights all aircraft and ground-based controlling equipment will undergo rigorous safety evaluations referred to as scrutineering. Static scrutineering will occur initially and these inspections must be passed before the aircraft will be permitted to fly. All decisions by the organising committee in relation to airworthiness are final.

Static safety inspections will include (but not be limited to) the following:

- Structural verification of the aircraft to ensure structural integrity including,
    - Components adequately secured and fasteners tightened
    - Propeller structure and attachment integrity
    - Inspection of all wiring
    - Controls move as expected
    - Payload general integrity
- Radio range checks with motor/s off and on;
- Flight termination behaviour tested (transmitter switched off);
- Aircraft may be weighed to ensure they fall within the weight restrictions;
- Video evidence and flight logs of flight tests demonstrating safe operations.
- Verifying that the aircraft being scrutineered matches the aircraft described in the submitted technical report

3.4.5 Practice Drop

If time permits, in conjunction with the scrutineering flights each team will be given the opportunity to conduct a single practice drop, including setup of their Mission Manager's equipment in the mission manager enclosure if performing remotely controlled drops.

3.4.6 Airmanship

Airmanship is a term widely used in the aviation industry. One of the better definitions can be found at http://www.auf.asn.au/students/airmanship.html, and it states:

> *Good airmanship is that indefinable something, perhaps just a state of mind, that separates the superior airman/airwoman from the average. It is not particularly a measure of skill or technique, nor is it just common sense. Rather, it is a measure of a person's awareness of the aircraft and its flight environment, and of her/his own capabilities and behavioural characteristics, combined with good judgement, wise decision-making, attention to detail and a high sense of self-discipline.*

Airmanship is the cornerstone of pilot competency. Competency has been defined as the combination of knowledge, skills and attitude required to perform a task well or to operate an aircraft safely — in all foreseeable situations.

The expectation of the UAV Challenge is that all teams exercise good airmanship. It is each team's responsibility to conduct their operations in a manner that they feel comfortable. If at any stage a team feels uncomfortable with the tempo of the operation, number of people in and around a given area, the weather conditions, readiness of their UAS, etc., they are invited to make their concerns known to officials and make appropriate requests. These requests will be assessed for compliance with the rules and the requirements, as well as the safe and efficient conduct of the event as a whole. While a decision not to proceed due to concerns is a difficult one to make, it is one that is often required in the aviation industry and is applauded as an example of good airmanship.

4 Teams and Personnel

4.1 Team size

There is no maximum limit to team size. However, no more than six members of a team will be allowed entry onto the flying field.

4.2 Team Roles

Team Communicator: Each team must nominate a Team Communicator. That person will be the main point of contact between the team and Judges during the event.

UAV Controller: The team member remotely controlling the unmanned aircraft.

Mission Manager: The team member remotely triggering the dropping of medical packages (not required if performing autonomous drop triggering).

4.3 Loss of Team Members

In the case that a team member in a designated role is unable to participate on the competition or scrutineering day for any reason (such as sickness, etc), then the judges have the discretion to allow another suitably qualified team member to take their place. The replacement must also be a current high-school student.

4.4 Sharing of equipment between teams

Teams may not share airframes.

Teams may share avionics, piece parts and ancillary equipment. If a part is swapped between teams, the aircraft must be re-scrutineered. Records should be kept of items that are exchanged, from both the perspective of the donor and the recipient, including serial numbers (where they exist), make, model, etc.

Sharing of equipment may not possible if two teams run consecutively due to timing issues.

The sharing provision exists to assist teams that may suffer equipment damage while travelling or at the event.

4.5 Footwear

All entrants are required to wear appropriate footwear, such as enclosed shoes, that will provide some protection to their feet while at the challenge. Bare feet, thongs or sandals are not appropriate and are not permitted. Teams members without the correct footwear will not be allowed onto the airfield or to work on the aircraft in the team preparation areas.

4.6 Sun Protection

Team members should consider the potential weather conditions at the challenge and bring appropriate equipment such as eye protection, sunscreen and wind resistant clothing.

4.7 Conduct at the Challenge

While competing in the Airborne Delivery Challenge team members should conduct themselves professionally with due attention to safety and their role in the competition. Specifically, team members must not be using mobile telephones while their team is conducting the flying component of the challenge.

The conduct of the team members is considered in the first scoring component of the challenge and if any team member is found during the flying component of the challenge to be using a telephone or other device unrelated to their role in the Challenge they will be required to leave the field.

5 Qualification and Judging

5.1 Eligibility

This category is open to high-school aged students from around the world.

Competitors over the age of 18 may be asked to provide evidence that they are currently attending high school or equivalent study.

It is expected that parents, teachers and other supporting adults will provide technical advice, mentoring and organisational assistance but it should be recognised that they are not members of the entering team. **The members of the team and not teachers or other supervising adults must therefore conduct the construction of aircraft and any repairs and modifications to aircraft or equipment**.

5.2 Team sponsors

Teams must advise the Organising Committee of their sponsors and the terms of the sponsorship. Full disclosure of sponsors and funding sources must be provided as part of the technical report. Sponsors should be aware that footage of a team's aircraft and team members could form part of official UAV Challenge video features and other promotional materials.

5.3 Liability and Insurance

It is necessary that competition flights be covered by appropriate Public Liability insurance and this insurance is the responsibility of the team operating each aircraft. Teams must advise the UAV Challenge Technical Committee of their insurance arrangements prior to arrival at the flying event. It is the responsibility of teams to determine if the existing insurance coverage of their school or flying association is relevant.

5.4 Qualification process

The UAV Challenge Technical Committee is responsible for determining compliance with the rules up to the point of qualification. At the event, the Judges are responsible for determining compliance with the rules. Note that at least one of the Judges will be a member of the Technical Committee.

There are three assessment elements that will each be scored and contribute to the total team score. The first element is also a qualifying element and teams must be awarded a "Go" decision for it before they can attend the competition event. All decisions by the Technical Committee and Judges are final.

The assessment elements are as follows:

- Technical Report and Video: max 15 points - go/no-go
- Oral Presentation: max 15 points
- Mission Performance: max 85 points
    - Bonus points for Autonomous Drop max 30 points

5.4.1 Technical Report and Video

Each Team is required to electronically submit a Technical Report in PDF format and a flight demonstration video in a common video format.

Refer to schedule for the due date for the report and video.

The technical report must use the following headings:

1. Executive Summary (1 page)
2. Introduction (1 page)
3. Design and Rationale (2 pages)
4. Mathematical Modelling (2 pages)
    a. how did Maths and Science help your design and/or mission strategy (see Section 7.3 for some background)
5. Risk Management (2 pages)
6. Flight Test Results and Discussion (2 pages)
7. Conclusions (1 page)

One page is also allowed for the title page and one for that table of contents (gives total maximum page count of 13). No appendices are allowed.

The video should contain footage of:

- The aircraft taking off
- The aircraft landing
- Releasing of the payload.

The primary purpose of the video is to demonstrate the flight worthiness of the aircraft and the ability to drop the payload and remain stable. Attention should be made to ensuring the payload drop is clear and easily identifiable.

The report and video will be assessed as follows:

Technical Report and Video (total of 15 Points)	
Scoring Components	**Max Points**
Executive Summary, Introduction and Conclusion	2
Design and Rationale and Mathematical Modelling	3
Risk Management	2
Flight test results and discussion	2
Quality of writing	2
Overall style/presentation	2
Overall quality of video	2
Late submissions	MINUS 5 points per day
Over page limit (13 pages)	MINUS 2 points per page

Table 1 Technical Report and Video Points

Teams must also submit a statement of originality as detailed in Appendix A with their technical report.

5.4.2 Modifications after Technical Report Submission

Minor modifications to the aircraft and systems will be allowed between the submission of the technical report and the day of competition, but these must be highlighted to the judges during the oral presentation and will be subject to the discretion of the scrutineers.

In the event of the necessity to rebuild a system between the submission of the technical report and the day of competition, the system used in the competition should be that described in the technical report subject to any minor modifications as in the preceding paragraph.

Major modifications such as a complete system redesign or usage of an aircraft of different design may result in reassessment of the technical report with those sections no longer relevant (potentially up to the entire report) being disregarded and no points scored.

5.4.3 Top twenty (20) only to qualify for the event

The UAV Challenge Airborne Delivery event can only support a maximum of twenty teams.

The twenty teams will qualify as follows:

1. The teams will be scored on their Technical Report and Videos.
2. The top scoring team from each school will be ranked against one another and the top twenty will qualify (note that a non-school based team will be counted as a "school")
3. If there are still not 20 teams the second-highest scoring teams from each school will ranked. The top schools from this list will qualify until the total of twenty teams is reached.
4. This process will continue with the third-highest scoring teams from each school, and so on until the 20-team quota for the event is reached.

5.5 Event judging

5.5.1 Oral Presentation

Each Team will deliver a presentation (not exceeding 10 minutes, plus 5 minutes of questions from the judges) highlighting:

- Their approach,
- System design,
- Mathematical Modelling: how did Maths and Science help your design and/or mission strategy (see Section 7.3 for some background)
- Any system changes since submission of the technical report,
- Expected performance and
- What they have learned from the process.

The presentation will be assessed as follows:

Presentation (total of 15 Points)	
Scoring Components	**Max Points**
Quality and clarity of the oral presentation	2
Quality and clarity of the presentation slides	2
Does the presentation convey the overall team's achievements	3
Unique features and safety approach	3
Ability to answer questions	5

Table 2 Oral Presentation Points

The presentation must include prepared presentation slides in one of the following common software file formats: MS PowerPoint, OpenOffice Impress and Adobe PDF. For other file types teams should consult with the event organisers before the event to confirm readability.

Teams MUST supply their presentation file at registration upon arrival at the flying event. Teams will still use their own laptop to conduct the presentation, but the presentation material cannot be modified after registration.

Each team will be allocated a presentation time when they register upon arrival at the Challenge flying event. Teams MUST be ready to present at their allocated time.

All presentations will finish at the end of the allocated time slot regardless of when they started. For example, if a team is 5 minutes late, they will only have 5 minutes to present.

Teams MUST supply their own laptop with the presentation loaded. Challenge organisers will provide a projector and screen.

The statement of originality as detailed in Appendix A that teams must supply with their technical report also applies to their oral presentation and presentation slides.

5.5.2 Mission Performance (Flying)

Points will be awarded based on the proximity of the dropped supply packages to the Drop Target and taking into account the time taken to travel between the hurdles when making the drop. A maximum of three drops are allowed and each drop will be scored. **The combined total scores of all valid drops will be used for the final score.**

Teams who utilise autonomous drop triggering will be awarded a points bonus for each point scoring drop.

Judges will consult the scrutineers and award points for scrutineering based on the team's preparedness for scrutineering (both static and flight scrutineering), their ability to answer technical questions by the scrutineers, the number of safety issues found during scrutineering and the quality of workmanship on the aircraft.

The mission performance will be assessed as follows:

Mission Performance (maximum of 115 Points)	
Scoring Components	**Max Points**
Scrutineering	5
Pre-flight checks, team communication and organisation, conduct and demonstration of good judgement (airmanship)	15
Quality of flight (safety, controllability and condition of the aircraft)	5
Accuracy and timing of 3 drops, measured from where they rest. For Time ≤ 3 seconds: • Drop Score = 20 – 2 x Distance For Time > 3 seconds and Time < 15 seconds: • Drop Score = 20 – 2 x Distance x Time ÷ 3 For Time ≥ 15 seconds: • Drop Score = 20 – 10 x Distance	3 x 20 points
Bonus points for each autonomously triggered drop that scores points	Plus 50% of accuracy and timing points
Penalties	
Penalty for exceeding the drop impact rating	Minus 50% of accuracy and timing points for that drop
Time penalty	Minus 10 points for each minute over 20 minutes on the field
Flying into the no-fly zone	Minus 30 points
Exiting the flying zone (excluding into the no-fly zone)	Minus 10 points per breach

Table 3 Mission Performance Points

5.6 Rule Infringements

In the event of a team being found to have infringed a rule the following penalties may be applied at the Judges' discretion:

1. The team may be disqualified
2. A maximum of 25 points per infringement may be deducted from the team's points total

If an infringement is found to be contrary to the spirit of the competition, giving the team a significant advantage or posing an unacceptable safety risk then disqualification is a likely outcome.

The most likely causes of infringements will be issues found during static scrutineering and in such cases teams will be given opportunity to rectify or resolve the issue and keep within the rules. At the judges' discretion teams will be given fair time to rectify the issue if possible without impacting on the UAV Challenge schedule or providing the team with unequal treatment.

6 Schedule and Event Location

6.1 Schedule

The table below sets forth the overall competition schedule.

Activity	Date
Team Registration Teams must register their intention to compete in the Airborne Delivery competition. Registration requirements will be posted to the UAV Challenge website.	At the latest: 26th July 2017 at 5pm AEST
Technical Report and Video *A technical report must be provided. The underlying objective of this report is to convince the organising committee that the team has developed a reliable and safe UAV system, along with the appropriate operating procedures.* *A video must also be supplied that includes a flight demonstration of the dropping mechanism that will deliver the payload.*	At the latest: 23rd August 2017 at 5pm AEST
"Go" "No-Go" Announcement of Teams *Final approval to participate in the UAV Challenge given to teams. The final approval to participate will be based on several aspects of the technical report, predominantly the demonstrated ability to operate within the competition safety standards.* *Successful teams must supply the UAV Challenge organisers with final team details. A form will be given to teams to fill in.*	30th August 2017
UAV Challenge Airborne Delivery event begins - Safety Briefing and Inspections, Team Presentations and Flight Scrutineering.	26th September 2017
Challenge Mission Flights - The competition Flights.	27th September 2017
Adverse Weather Day *An adverse weather day is allocated in case judges decide wind, rain or other adverse conditions interfere with the running of the competition.*	28th September 2017

Table 4 UAV Challenge Airborne Delivery 2017 Schedule

6.2 Event Location

The location for the UAV Challenge Airborne Delivery 2017 flying event is the Calvert Radio Aero Modellers Society flying field, Bourke's Road West, Calvert, approximately 25 km west of Ipswich, Queensland.

7 Discussion and Recommendations to Teams

7.1 RF Spectrum Compliance

The following information has been summarised from the official ACMA website (refer below) and correspondence with the Authority, on behalf of the UAV Challenge Technical Committee.

Please note that the following information should only be considered as GUIDELINES designed to assist competitors in understanding the issue of spectrum compliance. Each team should ensure they understand and comply with all relevant spectrum regulations prior to their Deliverable 2 submission.

The ACMA, Spectral Planning and Licensing

The Australian Communications and Media Authority (ACMA) are the Australian federal regulatory body responsible for radio-communications compliance and manage the access to the radiofrequency spectrum within Australia.

As an independent Statutory Authority to the Commonwealth of Australia, the ACMA manages the spectrum in accordance with the Radiocommunications Act 1992, as outlined by the Ministry of Communications, Information Technology and the Arts.

While the ACMA encourages competitiveness and self-regulation of the RF spectrum, spectral planning provides the overall Statutory framework for the allocation and administration of radiofrequency transmissions for different types of services, as granted under the Act. This is done to maximise the efficient use of the spectral resource and minimise interference of adjacent channels.

The Australian Radiofrequency Spectrum Plan (ARSF) is the latest spectrum plan used in Australia and is based upon the outcomes of the International Telecommunication Union (ITU) World Radiocommunication Conferences. As Australia is an obligatory member of the ITU, the ARSF must be drafted so that it takes into account the spectral allocations moved by the ITU.

The ARSF is used in conjunction with frequency and administrative band plans to structure the available RF spectrum for use within Australia.

In order to utilise the RF spectrum, a relevant licence must be obtained from the ACMA for anyone who makes use of a transmitter, as implied under the Act. The licensing of operators using RF devices falls under several different categories:

- Apparatus Licence – based on the type of service provided by the communication link.
- Spectrum Licence – based on the area the communication link is routed.
- Class Licence.

Both Apparatus and Spectrum Licences are issued on an individual basis and there are subsequent Licence fees incurred, as well as the need for direct consultation with the ACMA by the licensee over the terms and conditions of the Licence.

Class Licences cover designated parts of the spectrum set aside for shared access by the general populous. Users of devices under a Class Licence conform to a common set of conditions applicable to all users and do not need to register or pay the ACMA for the Licence.

Under the current regulatory framework, there are no "un-licensed" bands for RF communication purposes.

All radiofrequency bands are subject to frequency and power restrictions, as defined within the applicable Licence category. This includes Class Licences.

Class Licensing and the UAV Challenge

Class Licences are a common choice of Licence given the ease of their use and the wide range of readily-available communication devices that fall within the operational conditions of the various Licences.

Class Licences vary according to the type of services provisioned under the Licences, the bandwidth of frequencies each Licence is defined over and the maximum allowable transmitted power over that bandwidth.

As such, not all Class Licences are applicable for UAV operations from legal, technical and safety perspectives.

The Technical Committee has deemed the following Class Licences, or parts thereof, applicable to the UAV Challenge for competitors to use in their link budget designs:

- Radiocommunications (Low Interference Potential Devices) Class Licence 2000
- Radiocommunications (Radio-Controlled Models) Class Licence 2002

Guidelines for Using Class Licences

Competitors are entitled to use the aforementioned Class Licences for their radio links, on the provision that they act in accordance with the conditions defined under the Licence.

In general, this requires competitors to conform to:

- The class of transmitter specified by the Licence (e.g. Digital modulation, Frequency hopping).
- The maximum radiated power for that frequency band. This is usually expressed in Effective Isotropic Radiated Power (EIRP).

If competitors fail to meet the conditions specified by the Class Licence, they are no longer deemed to be acting in accordance with it. Unless competitors gain another type of Licence from the ACMA to do so, it is classified under the Act as an illegal activity.

The ACMA has stated to the Technical Committee that devices used under the Radio communications (Low Interference Potential Devices) Class Licence 2000 must be low

interference. They are within their right, should circumstantial evidence be provided, to turn off any transmitter causing potential interference and prevent further usage of the offending device.

ISM Frequencies

Several of the Industrial, Scientific and Medical (ISM) bands fall under the Radio communications (Low Interference Potential Devices) Class Licence 2000 and devices used for radio communication purposes across these frequency bands are subject to the provisions outlined by the Class Licence.

It should be noted that the frequency range for the 900MHz ISM band for Region 3 (Australia) is different to other parts of the world and competitors should take this into consideration when designing their system.

Furthermore, the ACMA warns that radio communication services operating over ISM frequencies cannot be afforded protection from interference caused by non-radio communication ISM applications. As such, the suitability of using ISM bands for radio applications should be assessed by competitors (refer NOTE § 3 of the LIPD Class Licence).

Final Note to Competitors on Spectrum Compliance

Spectrum compliance is an issue that the organisers of the UAV Challenge Medical Express take very seriously.

It is the responsibility of each team to ensure their UAV operations are spectrum compliant for the UAV Challenge Medical Express competition.

Details of frequency management at the event will be provided during competitor orientation and safety briefing.

Failure to comply with any of the rules may result in team disqualification or other appropriate penalties (at the judges' discretion).

For more information regarding spectrum planning, licensing and frequency allocation, please refer to the ACMA website available at:

www.acma.gov.au

7.2 Drop Strategy

In 2017 the time it takes the aircraft to travel between the hurdles will affect the drop score, with a longer time leading to a lower score for the same distance. An aircraft taking more time between the hurdles must therefore make a more accurate drop to get the same score as an aircraft taking less time.

This means teams can choose a strategy for their delivery system; such as fly through quickly and drop at the right time for the payload to land on target, or fly in and hover over the target and drop accurately when in the right spot, or a different strategy in-between.

This change was introduced because the majority of competition aircraft are now rotorcraft and it makes sense to let teams use the hovering capability during the drop if they want to, provided they also do a better job of dropping the payload on target.

When selecting their strategy, teams will have to consider their solution for deciding when to trigger the drop as well as their mechanism for protecting the payload from impact. Wind can have a big effect on the payload so having a payload that is easily blown may not be a good idea when flying slowly and requiring a very close drop to score good points. Teams can always adjust their strategy when it comes to their mission time in response to weather conditions.

7.3 Design and Mathematical Modelling – How did applied Maths and Science help ?

The development of system prototypes is a fundamental aspect of engineering design – from a design you build a prototype, and you test, tune and modify the prototype (and the design) iteratively until it works the way it's supposed to. This is an engineering workflow that is practiced in industry and it's also a workflow that teams entering the UAV challenge can practice.

But what happens before the prototype is built ? Or before a test is done ?

In the development of commercial products, the prototype development stage is preceded by a formal engineering design stage. Here, the application of Maths and Science is used to create "Mathematical models" that support/justify why certain design decisions were made. There is an old saying :

If we can understand a system, then we can model it.
If we can model it, we can predict it.
If we can predict it, we can make it better.

As a concrete example, ponder for a moment the following:
If you had a Mathematical model describing the relationship between an aircraft's speed and altitude, and the horizontal distance that a released package would travel.

- *How would a model like that be useful to you? Eg: Perhaps it would clarify the speed and altitude that the pilot needs to practice.*

To be clear, testing a design (or a strategy) with an actual prototype is essential … but what if a Mathematical model helped you focus on some very specific aspect of your design which in turn reduced the amount of "tuning/refinement" needed with the prototype.

So ?

Teams entering the UAV Challenge should present and report, on how some of the topics taught in Maths and Science were used to create "Mathematical models" that influenced their designs and strategies. Not every design decision needs the assistance of a "Mathematical Model", but there are no doubt many aspects of the design (and mission strategy) where Math modelling could be applied. Teams should reflect on their classroom lessons and look for the specific design tasks where those classroom lessons can be applied.

An example of how you could communicate this in your written report and oral presentation are to comment on the following:

1. What problem were you specifically trying to resolve?
2. What was the Mathematical model that you made to help solve your problem?
3. Where appropriate, how did your model compare with real behaviour observed/measured with your prototype?
4. By using this Mathematical model, what benefit did it have?
    a. Alternatively: if you had NOT used the Mathematical model … why would that have been bad?

Statement of Originality and Accuracy

Each team is required to submit a statement of originality as given below with their technical report, signed by each team member. It also relates to the oral presentation and accompanying slides.

> *We declare that this report is entirely the work of the team members listed below, and has not previously been submitted by us, or others for this challenge or any other similar event.*
>
> *We have acknowledged external material with appropriate references, quotes or notes to indicate its source.*
>
> *We declare that this report and presentation are an accurate record of activities carried out by us in preparing for this specific challenge. The events, data and other material contained within this report actually occurred and have been fully detailed.*
>
> *We declare that we Are/Are Not a rookie team consisting only of team members who have never competed at the UAV Challenge before.*

Please then list the names of **ALL team members**.