UAV Challenge
Medical Express 2016

Competition Rules

Version: **4**
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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.

Flight operations during the UAV Challenge Medical Express will be governed by, in order of priority, the UAV Challenge Medical Express Operations Manual and the UAV Challenge Medical Express rules (this document). In the event of an unlikely inconsistency that impacts teams in an uneven way, the judges will take this into consideration.

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 Medical Express 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 Medical Express. Competitors are encouraged to alert the organisers if they find inconsistencies or loopholes in these rules.

Revision Record

Version 1

- Initial Release

Version 2

- Section 1.1: Updated figure 1
- Section 1.2.1: Added that the combined *Geofence* will have no more than 18 vertices
- Section 1.2.1: Added that the coordinates will be provided in a KMZ file
- Section 1.2.2: Updated that the base location does have a prepared runway
- Sections 1.2.2: Changed the *Base Geofence* shape to a square
- Sections 1.2.4: Changed the *Remote Landing Site* shape to a square
- Sections 1.2.2 & 1.2.4: Added that teams may define their own *Geofence* shapes within the prescribed *Base* and *Remote Landing Site* Geofences
- Section 3.2.2: Specified the situational awareness format as NMEA sentences
- Section 4.2: Added that the Team Communicator must be one of the team members that will enter the *Base* during the mission
- Section 4.2: Added that the Team Communicator must wear a high visibility vest during the mission
- Section 6.1: Scheduled dates of Deliverable 3 and the Event changed to be later by 1 week, including intermediate dates
- Section 6.3: Added that the event location will be the Dalby Model Aero Club

Version 3

- Section 1.1 and Section 1.2.3: Changed navigational distances to be in units of nautical miles instead of kilometres as required by Section 3.3.3 of these rules. Direct distance now stated as between 5.4 and 6.5 nautical miles, and flight path length now stated as between 11 and 16 nautical miles
- Section 1.1: Update Figure 1 to ensure all Geofence boundaries in the example are greater than 250m from the flightpath
- Section 5.3: Corrected incorrectly stated max points for the mission performance
- Appendix A: Added the D2 compliance statement

Version 4

- Section 1.5.2: Updated that the base location does have a prepared runway for landing

Glossary

Arming Switch	A switch on the retrieval aircraft that indicates the aircraft may autonomously takeoff one minute from arming.
Base	The bounded area of ground operations for the teams and where all aircraft must launch and recover
Base Geofence	The *Geofence* bounded area surrounding the Base
Base Controller	The member of the organising personnel in charge of the Base area.
CASA Designated Coordinator	The member of the UAV Challenge Technical Committee regarded by CASA as the coordinator of UAV Challenge air operations
E-Stop	A latching button that is red in colour with a yellow surrounding disk that de-energizes all aircraft propulsion and actuation systems.
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 Geofence boundary.
Geofence	A specified boundary in the airspace that must not be crossed by a competing unmanned aircraft.
Joe's Reported Location	The reported GPS location of Outback Joe as reported from his mobile phone
Range Safety Coordinator	The member of the organising personnel in charge of the range (the flight areas outside the *Base*).
Remote Landing Point	The resting location of a team's landed UAV within the *Remote Landing Site*
Remote Landing Site	The *Geofence* bounded area around *Outback Joe's Location*
Retrieval Aircraft	The unmanned aircraft that lands at the *Remote Landing Point*
Sample	A bottle containing a small amount of Outback Joe's blood.
Support Aircraft	The unmanned aircraft that does not land at the *Remote Landing Point* but is used to support the *Retrieval Aircraft* in some way.
Transit Corridor	The *Geofence* bounded area for flights between the *Base*
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 an 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, and returning medical samples, to and from critically ill patients in the Australian Outback.

1.1 Overview

Outback Joe is at his property in remote Queensland, Australia and has been feeling unwell. He has had a remote consultation with his doctor using video conferencing, and his doctor has requested some blood tests be done as soon as possible. Joe is well prepared, has a home sample taking kit, and has taken his blood sample. The challenge is now to get the blood sample to the lab. Joe's property is very remote and to make matters worse, it has been cut off by floodwaters.

Teams are invited to attempt to retrieve a blood sample from the remote Outback Joe and return it to base where medical staff will be waiting to analyse it. Teams must deploy unmanned aircraft to Joe's location, and then return a sample bottle from him utilising a remote landing and takeoff site close to him. They must complete all of this within one hour. The aircraft deployed must be capable of precisely finding Joe at the *Remote Landing Site*, which will be located approximately 5.4 to 6.5 nautical miles (as the crow flies) from a small Australian Outback township. Teams must not fly above 1500ft AGL at anytime during the mission.

Figure 1: An example layout for the Geofence areas of the Medical Express competition. Note that this figure is an example and does NOT show the actual Transit Corridor or Remote Landing Site.

1.2 Finding Outback Joe

1.2.1 Planning

The GPS coordinates from Joe's phone (referred to as *Joe's Reported Location*) will be given to the teams, but they must take into account that the reported location will only have an accuracy of + or -100m.

The event location is specified in Section 6.3.

The coordinates of *Joe's Reported Location*, the vertices of the *Base Geofence*, *Remote Landing Site* and *Transit Corridor* and intermediate waypoints that aircraft must pass through will be given to teams at the commencement of the Event. These coordinates will be provided in a KMZ file.

The aircraft must at all times during the mission remain within the mission *Geofence*, which is a combination of the 3 *Geofence* boundaries described in sections 1.2.2, 1.2.3 and 1.2.4 below. When the *Geofence* boundaries are combined they will form an irregular polygon with no more than 18 vertices.

1.2.2 Launch from the Base

Teams will launch their aircraft from the *Base*, which will be located on the edge of the township. Teams will be given time to prepare and setup for the takeoff. Launching from the *Base* may be autonomous or manual. The area at the *Base* for the takeoff will be limited but there will be a prepared grass runway available.

Surrounding the *Base* will be the *Base Geofence*, which will be a 1 kilometre square. Teams may define their own *Base Geofence* boundary of another shape, such as a circle, provided it fits entirely within the square. Aircraft must automatically engage their *Flight Termination System* if they breach the *Geofence*.

1.2.3 Transit to the Remote Landing Site

The competition aircraft must fly through a defined airspace *Transit Corridor* to the *Remote Landing Site*. The corridor will **not be** a straight corridor from the *Base* to the *Remote Landing Site*, but may include some intermediate waypoints that must be passed through. The total length of the flight path through the *Transit Corridor* will be less than 16 nautical miles but greater than 11 nautical miles. The *Transit Corridor* boundary will be at least 250m from any waypoint in the *Transit Corridor*. The layout of waypoints within the *Transit Corridor* may result in aircraft backtracking.

The boundary of the *Transit Corridor* will be treated as a *Geofence*. Aircraft must automatically engage their *Flight Termination System* if they breach the *Geofence*.

1.2.4 Arriving at the Remote Landing Site

On reaching the end of the *Transit Corridor*, aircraft will enter the *Remote Landing Site*. The *Remote Landing Site* is defined as the area around Outback Joe and will be a 1 kilometre square centred on *Joe's Reported Location*.

The boundary of the *Remote Landing Site* is to be treated as a *Geofence*. Teams may define their own *Remote Landing Site Geofence* boundary of another shape, such as a circle, provided it fits entirely within the standard square *Remote Landing Site*. Aircraft must automatically engage their *Flight Termination System* if they breach the *Geofence*.

1.2.5 Locating Outback Joe

The aircraft at the *Remote Landing Site* must then more precisely locate Outback Joe in order to avoid hitting him on landing. Joe will be standing or sitting within 100m of *Joe's Reported Location*. He will not be wearing bright coloured clothes, but his passion for blue jeans is life-long and teams can be confident that he will be wearing a pair. He will also be wearing his Akubra hat.

1.3 Remote Landing

1.3.1 Determining where to land

Once Outback Joe has been precisely located, the team's aircraft must land at the *Remote Landing Site*. The area around the *Remote Landing Site* will be largely cluttered and will impede low glideslope landings. It is expected that the aircraft will have a method of assessing the *Remote Landing Site*, and that the assessment produced, combined with the precise location of Outback Joe, will assist the aircraft determine where to land. The aircraft must land at least 30m away from Outback Joe (as per CASA regulations) but not further than 80m from him.

1.3.2 Remote autonomous landing

The landing manoeuvre must be fully autonomous in nature. At no time must the aircraft come within 30m of Outback Joe – who will remain stationary during the landing phase. The location of the landed aircraft will be referred to as the *Remote Landing Point*. Upon landing, the aircraft must automatically remove power from any propellers making it safe for Joe to approach. If the aircraft does come within 30m of Outback Joe, including at its final landing position, the mission will be declared over and aircraft will be deactivated and removed from the *Remote Landing Site*.

1.4 Sample placement and remote takeoff

1.4.1 Insertion of the sample bottle

One minute after the aircraft has been observed to remove power from its propellers, Outback Joe will walk over and place a small blood sample bottle into the aircraft. Teams must have an easily accessible *Storage Compartment* on their aircraft that is easy to open and close. The container will allow storage of a cylindrical container that is 20mm in diameter, 100mm in length and of a weight of no more than 100g.

1.4.2 Command to takeoff

Outback Joe will activate the *Arming Switch* and will return to his original location so that he is clear of the aircraft.

1.4.3 Remote autonomous takeoff

The aircraft will then autonomously takeoff - after a period of at least one minute from when Outback Joe armed the aircraft for the takeoff. The aircraft must stay at least 30m from Outback Joe (who will be back at his original location) during the takeoff manoeuvre and must exit the *Remote Landing Site* into the *Transit Corridor*.

1.5 Return to Base

1.5.1 Transit to the Base

The aircraft must fly within the *Transit Corridor*, flying through the intermediate waypoints in reverse order of the trip to Outback Joe, and back to the *Base*.

1.5.2 Landing at the Base

Landing may be autonomous or manual. The area at the *Base* for the landing will be limited but there will be a prepared grass runway available. The mission clock will be stopped at the time of the last of the team's aircraft landing.

1.5.3 Pack up

Teams will be given time to pack up their aircraft and associated ground stations, and any other equipment associated with their operation at the *Base*.

1.6 Unmanned Aircraft

All aircraft must comply with Section 3 of these rules.

Teams are allowed to have a maximum of two aircraft for the mission and hence only two aircraft can be airborne at any time. Only one of those aircraft may land at the *Remote Landing Site*. The aircraft that lands at the *Remote Landing Site* will be referred to as the *Retrieval Aircraft*. The second aircraft may assist the *Retrieval Aircraft* in some way, and will be referred to as a *Support Aircraft*. Both aircraft must remain within all defined boundaries at all times and both aircraft must have automatic *Geofence* crossing flight termination systems. Neither aircraft may fly above 1500ft AGL at any time during the mission.

1.7 Timing

90 minutes is allowed for the entire mission. This is broken down as follows:

- Set up at the *Base* and launch: 15 mins
- Off-Base time (the clock stops on the final landing at the *Base*): 60 mins
- Recovery and pack up at the *Base*: 15 mins

Point penalties will be incurred for having an aircraft flying past the stipulated main mission time limit.

The setup, recovery and pack up periods may be run in parallel to other team operations (to be determined by the scrutineers and judges).

Teams may be asked to "hold" at the end of their set up phase if another team has not yet returned from the mission area (i.e. only aircraft from a single team will be in the air at one time). Teams must receive approval from the *Base Controller* (or relayed via a *Judge* or *Range Marshall*) prior to launch. Any delays in authorising the launch due to other airspace users will not be counted as part of the time limit.

Variations in set up and recovery can be made at the *Judges'* discretion. However, the stipulated maximum mission time will be strictly enforced.

Teams may be required to hold while their aircraft is airborne for operational requirements such as separation management with other manned or unmanned airspace users operating outside the competition. These holds will not be included in the team's mission time. The *Judges* may make additional time adjustments to ensure fairness, taking into account such matters as establishing and exiting holding patterns. Teams must make endurance data available to the *Range Safety Coordinator* and at the time of request the team shall advise any implications of the requested hold or if the circumstances change during the requested hold.

1.8 Flying order

The order of flying for the UAV Challenge Medical Express competition will be determined by drawing team names out of a hat. All teams shall be ready to fly from the beginning of each competition day, as there will be no allocated launch time. The team next in the order of flying will be given a 15 minute notification of when their "Set up and launch" time commences. The teams will be transferred to the *Base* area in batches to maintain schedule efficiency.

If a team cannot meet the order of flying as detailed above, or elects to go to the back of the queue, then they will deemed to have competed in the UAV Challenge Medical Express for the purposes of deciding a winner. If no takeoff or launch has been attempted the team will be given another opportunity to compete if time and opportunity permits after all other teams have had an opportunity to compete. Additional days will not be activated for these teams.

1.9 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 25kts** at the *Base*, or
- it is raining or it is considered likely that rain will occur within the mission time allocation.

Adverse weather time has been built into the schedule.

If in the unlikely event that it is impossible to have all teams fly in the competition during the event days (including the adverse weather time) due to adverse weather, the competition will be declared incomplete and no prizes or prize money awarded. The organisers will do all they can to have all teams that pass scrutineering compete.

In addition to the competition rules, it is up to the teams to decide if they are safe and capable of performing the mission given the prevailing weather conditions.

1.10 Criteria for a Completed Mission

The *mission* is deemed complete if all of the following criteria are achieved:

- An aircraft does not cross a *Geofence* boundary.
- An aircraft lands autonomously within 80m of Outback Joe, but not closer than 30m.
- An aircraft takes off autonomously from the *Remote Landing Point* with the *Sample.*
- An aircraft lands at the *Base* carrying the intact *Sample*.
- All aircraft land back at the *Base* intact within the allocated mission time.

2 Rewards

2.1 The Prize

The team to achieve the highest points total and have also completed the *mission*, and after the competition is complete, will be declared the winner.

UAV Challenge Medical Express Winner	AU$ 50,000

In the case of a tie on points the following count back system will be implemented:

1. Team that landed closest to Outback Joe wins.
2. Team with the shortest mission time wins.
3. If there is still a tie, joint winners will be declared and the prize money will be equally split among the winning teams.

2.2 Rod Walker Trophy

The team achieving the highest points total, whether or not they have completed the *mission*, will be awarded the Rod Walker Trophy, presented in memory of Professor Rod Walker, co-founder of the UAV Challenge.

2.3 Incentive Awards

In the case that no team is successful at completing the *mission* the UAV Challenge Organisers may choose to award incentive prizes based on the team points totals. Likely awards would be:

The highest points scoring team	AU$ 10,000
The second highest points scoring team	AU$ 5,000

2.4 Airmanship Award

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

Airmanship Award	AU$ 1,000

3 The Unmanned Systems and their Operation

3.1 Aircraft Requirements

3.1.1 General requirements

Aircraft taking part in the UAV Challenge Medical Express will be subject to the following requirements and limitations.

Each aircraft:

1. Must not be a commercial off-the-shelf complete system (i.e., aircraft with all avionics, sensors and ground mapping processing systems that would result in completion of the mission already integrated);
2. May have an airframe and on-board systems can be commercial off-the-shelf or custom made;
3. Must be capable of *autonomous* flight;
4. Must be free flying (not tethered);
5. Must have a maximum gross weight (MTOW) of less than 100 kg (rotary) or 150kg (fixed wing) as per CASR101, noting that for platforms that are neither purely fixed wing or purely rotary the lower 100kg limit will apply;
6. Each aircraft must have continuous telemetry radio communication with the *UAV Controller* who will be located at the *Base.*
7. Must have an easily accessible E-Stop to render the aircraft deactivated.
8. Must have an external visual indication of state (armed, inert, disarmed). If the colour red is used it shall always indicate armed. If the colour green is used it shall always indicate disarmed.

The *retrieval aircraft*:

1. Must have an *arming Switch*. This *Arming Switch* will be in a readily visible, easily accessible location. The activation of the *Arming Switch* will indicate that the aircraft may autonomously takeoff no earlier than one minute from arming.

3.1.2 Combined aircraft

One aircraft is allowed to carry another. It is permissible to launch a single combined aircraft from the *Base* and have the aircraft split into two free flying aircraft during the mission. Mid-air docking is also allowed.

3.1.3 The Geofence

All aircraft must implement automatic (on-board) detection of crossing a *Geofence* boundary.

Note: The term "Geofence" includes both horizontal and upper vertical boundaries.

Aircraft MUST AUTOMATICALLY activate flight termination settings on crossing a *Geofence* boundary in all operating modes (no ground interaction can be involved). The autopilot is allowed to detect the *Geofence* boundary crossing and activate the flight termination system, or the *Geofence* boundary crossing can be detected external (but on-board) to the autopilot with activation of the flight termination system, or incorporated into a flight termination system.

Autopilots capable of self-monitoring and activating failsafe termination states upon lockup or failure are also acceptable devices for implementing failsafe states. Note that self-capability of an Autopilot does not replace the additional failsafe device required by these rules.

3.1.4 Flight Termination System

All aircraft must include a flight termination system with the following conditions:

- The system must be on-board the aircraft and it's function must not be dependant on the correct function of other on-board systems (implying separate power supply, processor, etc.).
- The system must be able to command the motors or actuators, OVERRIDING any other on-board system, to close the throttle on any propulsion system and set any control surfaces to cause the aircraft to descend near vertically to the ground.
- Flight termination must be able to be activated from the ground by the *UAV Controller* at the command of the judges or *Range Safety Coordinator*.
- Flight termination must activate in all instances (and control modes – Autonomous and Manual) when the flight termination criteria have been met, regardless of the previous or current state conditions of the aircraft.
- Once flight termination has been activated it may not be overridden by any means. This includes all modes, Autonomous and Manual.

3.1.5 Flight Termination Method

The flight termination method will vary depending on the aircraft type. In all instance the throttle or power to any propulsion system must be closed, and any control surfaces set to cause the aircraft to descend near vertically to the ground.

The flight termination servo positions for pure fixed-wing aircraft are:

- Throttle closed;
- Full up elevator;
- Full right rudder;
- Full down on the right aileron;
- Full up on the left aileron; and
- Full flaps down (if applicable).

The flight termination servo positions for pure rotary-wing aircraft is to close the throttle.

Teams may choose to implement a flight termination method that will slow the descent of the aircraft to the ground, such as a parachute system.

Regardless of the termination method used teams must conduct analysis of the maximum distance their air vehicle could reach outside the *Geofence*, if the flight termination system was activated at the *Geofence*, and the air vehicle was travelling at maximum velocity and maximum altitude. This analysis should include:

- Analysis of the rate of descent after termination is activated.
- Analysis of the impact of wind and rate of descent data to gauge maximum drift distance.
- Details on how the system is triggered and activated.
- Consideration of different modes of flight (eg hovering or forward flight) for transitioning aircraft

It is not mandatory to conduct flight tests of the termination system but teams must demonstrate a good understanding of how their aircraft will perform in the event of a flight termination. If flight-testing is conducted it is acceptable that the data be gathered on a proxy aircraft of similar size and weight.

In the case of lighter than air aircraft, strategies should be included that detail how the aircraft can be brought to ground in the case of failure.

3.1.6 Criteria for Flight Termination

It is the intention to keep aircraft that are capable of flight in the air as long as they maintain the required level of acceptable safety. As soon as the acceptable level of safety cannot be assured, flight termination must be activated.

The following events must result in immediate activation of the flight termination system:

- The aircraft crossing the *Geofence*;
- Failure or "lock up" of any processor and/or hardware implementing the *Geofence* crossing detection;
- If the aircraft is deemed to be out of control by the judges and/or range safety personnel;
- As requested by the judges and/or range safety personnel.

Additionally, the following events must result in immediate activation of flight termination when under autopilot control:

- Failure or "lock up" of the autopilot;

Teams may introduce additional criteria for flight termination in response to their Safety Case.

3.2 Unmanned System Requirements

3.2.1 UAV Controller Override

Systems may include a capability where the aircraft can be changed from autonomous flight to a manually flown radio mode when operating in normal visual/control range of the safety pilot who is located at the *Base*. Flight in the *Transit Corridor* and *Remote Landing Site* must be autonomous, except when conducting a recovery due to an in flight failure or emergency with approval from judges and/or range safety personnel, as detailed in the teams Deliverable 3 Safety Case.

3.2.2 Situational Awareness

Teams must have a ground control station that provides a graphical display of waypoints and aircraft current location.

Teams are required to provide a data feed from their ground station reporting their aircrafts' location, heading and speed to the *range safety coordinator*. There must be a separate output for each aircraft if the team is using 2 aircraft. The specific data format required is:

- NMEA 0183 serial output
- RS232, 4800 baud, 8 data bits, 1 stop bit, no parity
- Male DB9 connector
- GPGGA and GPRMC sentences
- Update rate of 1 Hz

Teams may use adapters such as USB to RS232 serial adapters to provide the output connection and if doing so must provide their own adapters.

This requirement is mandatory and will be tested during the safety inspections. Failure to provide a working data feed will result in failing the safety inspection.

3.2.3 Radio equipment

Teams are permitted to use any combination of frequencies as long as they comply with Australian Communications and Media Authority (ACMA) regulations (see Section 7.5 for more information).

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

3.3 Operational Requirements

3.3.1 Location of infrastructure

Team infrastructure cannot be located outside the *Base* operation area. Remote computer equipment such as servers may not be used and all processing must occur either on the aircraft or on the GCS computers within the *Base*.

3.3.2 Altimetry

All altitudes will be given as Feet Above Mean Sea Level (AMSL) or Feet Above Ground Level (AGL). If the reference is not stated it will be assumed as AMSL.

AMSL altitudes will be measured and reported as pressure altitudes as per aviation standards and will use QNH. Technical Committee will provide QNH on request, based on standard aeronautical references. Autopilots may use GPS altitude for altitude reference, but the remote pilot shall know and report the aircrafts pressure altitude. The vertical boundary for the UAV Challenge is a pressure altitude AMSL.

3.3.3 Aeronautics

All documents and operations in the UAV Challenge will comply with the following sections of the Aeronautical Information Publication (AIP) Australia, which is published by the Aeronautical Information Service (AIS), Airservices Australia. (http://www.airservicesaustralia.com/aip/current/aip/general.pdf):

- General 2.1.1 “Units of Measure”, and
- General 2.1.3.1 “Geodetic Reference Datum”

This means that teams MUST use the following units in all documentation and verbal communication with the judges, scrutineers and range marshalls at the event:

Distances used in navigation	nautical miles (NM) and tenths
Short distances	metres
Altitudes, elevations and heights	feet
Horizontal speed, including wind speed	knots
Vertical speed	feet per minute
Wind direction for runway operations	degrees magnetic
Wind direction except for runway operations	degrees true
Visibility	kilometres or metres
Altimeter setting	hectopascals
Weight	Kilograms

For example, if a team member is asked by the judges at the UAV Challenge event, “what is the current altitude of your aircraft?” the team member must reply in units of feet. Consistency with these aeronautical units (and the international standard) is critical to safe operation of unmanned aircraft in areas with manned aviation.

The tolerance for overflight of the waypoints listed in this document is ±50 metres.

Aircraft fly on airspeed, not ground speed (which is what GPS provides). Ground Speed may be reported, however the Technical Committee will be looking for an understanding as to how teams will maintain their aircraft within its airspeed envelop. This should be included in Deliverable 2.

Note: As the risk of stall increases (by not being aware of airspeed and/or managing the stall margin) so too does the risk to people and property on the ground. While there is not a requirement to determine and document a flight envelope for the UAV Challenge, sound aeronautics and airmanship requires an understanding of the limitations (boundaries of capability) of the Unmanned Aircraft System (UAS). Another area to consider is an understanding of wind limits and control power of the UAS. Many small unmanned aircraft are tested in light wind conditions and then flown in higher winds beyond the aircrafts ability to maintain control and/or navigation, again increasing risk.

While the UAV Challenge will move towards the adoption of the International Civil Aviation Organisation (ICAO) and Civil Aviation Safety Authority (CASA) standard UAS acronyms, many now superseded acronyms will continue to be used due to branding (i.e. UAV Challenge) or to avoid confusion and maintain continuity with previous rule releases.

3.3.4 Flights after an In Flight Failure or Unintended Recovery

If an aircraft recovers to an area outside of the competition *Base,* other than a controlled landing of the *Retrieval Aircraft* within the *Remote Landing Site*, it will not be allowed to make further flights in the UAV Challenge.

If an aircraft is recovered to within the competition *Base* the UAV Challenge scrutineering team will examine it. This activity will be undertaken in allocated mission time. The CASA Designated Coordinator, in consultation with the UAV Challenge Head Scrutineer and the UAV Challenge Technical Committee, will make a decision as to whether the aircraft can be repaired and further flights attempted. Any repairs will need to be scrutineered before flight. The UAV Challenge Technical Committee may decide to adjust the remaining mission time to account for delays in bringing the necessary people together for he reviews.

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; air vehicle safety inspections; UAV controller override capability; flight termination mode; range marshals observing the aircraft and airspace and a proven history of safe flight operations.

Teams will provide safety documentation with increasing levels of detail as the competition progresses, through the three deliverable documents (D1, D2 and D3).

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

Teams based outside Australia should ensure that they comply with local regulations when testing for the UAV Challenge.

The UAV Challenge Committee may disqualify a team that they deem to pose an unreasonable safety hazard to people, infrastructure, and other airspace users.

Aircraft are not to intentionally overfly any building within the *Base, Transit Corridor*, and *Remote Landing Site*. Besides being standard aviation practice, this will limit risk exposure in the event of an aircraft failure.

Judges may require a team to return the aircraft to the *Base* or to activate Flight Termination if they believe (either through direct observation or via information from event staff) safety to be compromised or the aircraft is unfit or unlikely to maintain safe operations.

3.4.2 Safety inspections

All aircraft and ground-based equipment will undergo rigorous safety evaluations leading up to the UAV Challenge Medical Express event. Physical inspections will occur during the scutineering and competition days. These inspections must be passed before the aircraft will be permitted to fly. All decisions by the Technical Committee in relation to airworthiness are final.

Safety inspections at the event may 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 electronic wiring
  - Controls move as expected
  - Payload general integrity
- UAV Controller overrides;
- Radio spectrum frequency compliance;
- Radio range checks with motors off and on;
- Flight termination system tested;
- Geofence system tested;
- Aircraft will be weighed to ensure they fall within the weight restrictions;
- Video evidence and flight logs of flight tests demonstrating safe operations;
- Proficiency of team members with respects to operation of UAV software & equipment, communications and procedures.
- Flight demonstration.

The aircraft used for the mission MUST be the aircraft subjected to the safety inspections.

3.4.3 Safety Case

It is the UAV Challenge Technical Committee's intent to only be proscriptive in essential safety requirements, this being the flight termination system and the requirement to activate the flight termination system on Geofence crossing, failure of critical functions, or on command by the judges. To support this, teams are required to submit a safety case as part of the Deliverable 3 requirements. The objective of this Safety Case is to convince the UAV Challenge Technical Committee that the team has identified risks, abnormal, and emergency conditions and put in place sufficient technology and procedures to provide an acceptable level of safety. The two hazards to be addressed are risks relating to:

- Ground Impact where the Entities of Value are: people, property, livestock, and crops; and
- Mid-Air Collision where the Entities of Value are: other airspace users.

Failure to provide a satisfactory Safety Case will be sufficient grounds for a team to be excluded from the competition.

If two aircraft are used they may be combined into a single flying platform. If this is planned then teams must treat the combined aircraft as a separate aircraft for the safety case, implying that they will need to consider three aircraft types (two individual and one combined) when outlining safety and compliance. Innovative solutions are encouraged but should be checked with the Technical Committee to ensure they remain within the rules and the spirit of the competition.

3.4.4 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.

3.4.5 Pyrotechnic Mechanisms

If a team chooses to use pyrotechnic mechanism (for example for deployment of a parachute for a flight termination system) then additional safety mechanisms must be implemented.

A safe/arm system shall be implemented for any pyrotechnic mechanisms. This shall consist of a minimum of a safe/arm plugs whereby when the system is 'safe' the pyrotechnic ignition system shall be:

1. Physically disconnected from the initiating electronics
2. Electrically shorted to reduce the chance of accidental firing due to electromagnetic interference.

Additionally:

1. The safe plug shall be coloured GREEN
2. The arm plug shall be coloured RED
3. The safe/arm plug shall be clearly visible, accessible and replaceable from the exterior of the aircraft without the need to remove hatches covers etc.
4. The safe/arm plug system should allow external testing of continuity of initiating devices (such as electric matches) to determine if the system has been activated.

No objects shall be dropped from the Aircraft as a consequence of the activation of the pyrotechnic mechanism.

The pyrotechnic devices used must conform to all relevant legislation and a team member must hold any licenses required as a consequence of manufacturing transporting and using the pyrotechnic system.

Only commercial propellants and initiating devices are to be used in the system.

Teams using pyrotechnics shall provide an operations and safety manual for their pyrotechnic system as an appendix to Deliverable 2.

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 to the *Base* during a mission.

4.2 Team Roles

Team Communicator: Each team must nominate a Team Communicator. That person will be the main point of contact between the Judges and safety personnel during the event and must be one of the team members who will enter the *Base* during the mission. The Team Communicator will be required to wear a high visibility vest during the mission. A vest will be provided to the Team Communicator for the duration of the mission, although they may alternatively provide their own.

UAV Controllers: Each team will nominate one team member as the *UAV Controller* for each of their aircraft. If a team uses two aircraft, they must have two *UAV Controllers* (one for each aircraft). If a team utilises a combined aircraft where one aircraft carries another the team must nominate which *UAV Controller* will be in command of the combined aircraft.

4.3 Sharing of equipment between teams

Teams may not share airframes. Teams may share avionics, piece parts and ancillary equipment. If an airframe 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 and model.

Sharing of equipment is 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 UAV Challenge Medical Express.

4.4 Cooperation between teams

Teams are allowed and encouraged to share experiences, data, and lessons learnt as part of the UAV Challenge. The cooperation may be to all teams, or a sub-group of teams. It is expected that individual teams will develop their own unique implementation, solutions and documentation. It is recognised that some hardware and software (code and algorithms) may be replicated and it would be viewed as a professional courtesy to acknowledge the source.

Compliance with the rule relating to originality of a team's work is still required as "shared", "common", "joint", "re-used", or "copied" documentation will not be accepted. The Technical Committee is required to assess each team for safety and proficiency in order to authorise flight and the Deliverables are a significant component of that assessment. The Deliverables shall demonstrate the teams understanding of their system. Any doubt as to compliance or system understanding in any Deliverables with large sections of copied, common, or similar work or wording will be awarded a "No Go" result.

Given that the UAV Challenge Medical Express is a competition there is no obligation for a team to cooperate with other teams. If a team chooses to cooperate with other teams then by default that teams forgoes any ability to make claims on overall placing and prizes awarded even if their contribution plays a significant role in another

team's success. Teams shall compete individually and independently in the UAV Challenge Medical Express regardless of the level of cooperation. Teams are not allowed to enter arrangements to share claims on overall placement or prizes.

"Industrial Espionage" or theft of ideas, hardware (design or physical), or software (code or algorithm) (i.e., where a team has elected not to cooperate with other teams, or has only cooperated on specific items) will not be tolerated.

Teams adjudicated to have broken specifics or the spirit of this Section and its restrictions will be asked to show cause as to why they should not be disqualified, and subsequently disqualified if the show cause was not deemed satisfactory.

An individual may only be a member of a single team at any time. They may change teams up until the beginning of the event, but they will have no claim on overall placing and prizes awarded to any previous teams they belonged to.

4.5 Loss of Team Members

In the case that a team's designated UAV GCS Controller or safety pilot is unable to fly the aircraft on the competition or scrutineering day for any reason (such as sickness), then the judges have the discretion to allow another suitably qualified and competition eligible person to take their place. Other team members who perform roles that are part of the normal flight operations will also need to demonstrate proficiency in that role before being allowed to perform the covering role.

4.6 Fatigue management of personnel

The nature of the UAV Challenge Medical Express schedule is such that personnel are usually required at the *Base* at sunrise, and will work up until sunset. There may be a number of evening functions scheduled. It is highly likely that personnel and team members will work in excess of 12 hours each day. No formal restriction will be placed on required hours of sleep. Each individual will be expected to manage their fatigue level and ensuring they can conduct their duties efficiently, effectively, and safely. The *CASA Designated Coordinator* and *Range Safety Coordinator* are authorised to replace event personnel if they appear fatigued. The *CASA Designated Coordinator* and *Range Safety Coordinator* are authorised to suspend a team's operation at the UAV Challenge Medical Express event if safety is compromised by fatigue or other circumstances.

4.7 Smoking, Drugs and Alcohol Policy

The UAV Challenge Medical Express is a non-smoking event. Event staff, teams or visitors who wish to smoke must leave the area of the UAV Challenge Medical Express event if they wish to smoke.

The UAV Challenge Medical Express is a drug free event. Alcohol must not be consumed at the *Base* or staging areas, or by event participants within the CASA NOTAMed area during the competition times (typically from first light until 6pm).

Competitors are advised not to consume alcohol within 6 hours prior to performing their duties or activities relating to the UAV Challenge Medical Express. Anyone reporting for competition showing evidence of being under the influence of drugs or alcohol will not be authorised to continue their activities. No random drug or alcohol tests will be performed by the event, however under existing aviation legislation and regulations CASA have the right to conduct random drug and alcohol testing.

5 Qualification and Judging

5.1 Eligibility

The UAV Challenge Medical Express is open to worldwide entrants – university students, privateers and hobbyists. Companies will be permitted to enter at the discretion of the UAV Challenge Medical Express Technical Committee provided they are shown to be participating in the spirit of the competition, have a passion for low-cost civilian applications and are not using unaffordable and ultimately unrealistic technology for the civilian market. Teams will be assessed for their eligibility to enter this category on application.

Employees of organisations who are official sponsors, supporters or organising partners of the UAV Challenge Medical Express are permitted to enter the Challenge **but will not be eligible to win any prize money**. Exceptions to this rule may be made for junior or casual employees of such organisations. Such entrants will be assessed for their eligibility to win prize money on application. Entrants must declare to the UAV Challenge Medical Express Technical Committee any employment relationship with an official sponsor, supporter or organising partner before arrival at the event.

Teams considering entering the UAV Challenge should take into account the tight timelines of the Deliverable documentation stages and the final Go decision (qualification) to attend the event. Teams from a limit number of countries have struggled in the past to obtain travel visas in time to attend the event (after they have qualified). Teams should be aware of any current visa restrictions or visa processing delays impacting the ability of citizens of their country to travel to Australia.

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 D2 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 Qualification process (the Deliverables)

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 five assessment elements. The first three are qualifying assessment elements. Some elements are scored and contribute to the final team score, while others are simple Go/No-go decision points within the competition.

The five assessment elements are as follows:

- Technical Report (Deliverable 1): no points - go/no-go
- Technical Report and video (Deliverable 2): max 15 points and go/no-go decision
- Flight Record (Deliverable 3): no points - go/no-go decision
- Team Interview: max 15 points
- Mission Performance: max 150 points

Each element is a prerequisite before progressing onto the next. All decisions by the Technical Committee and Judges are final.

5.3.1 Short Technical Report (Deliverable 1)

Each Team is required to electronically submit a Short Technical Report (max 6 pages) in PDF format that describes the proposed system design and management of risks. The UAV Challenge organisers want to know how the team plans to complete the mission and how they will minimise risk and operate as safely as possible.

The technical report must address the following:

1. Overall design of the UAV system(s) including
    a. The preliminary design of the flight termination system
    b. The preliminary design of the Geofence System
2. Description of how the UAVs will be employed to complete the Mission
3. A Risk Assessment
4. Risk Management including:
    a. The proposed strategies in response to failures such as loss of data link, loss of GPS and loss of engine power

Deliverable 1 should demonstrate understanding and compliance with the UAV Challenge Medical Express rules by describing a system that complies with the rules and explaining how it will meet the safety requirements set out in the rules. The document should refer to the rules where applicable rather than "cut and paste" of large sections. While a detailed description of the platform/s is interesting, it should not be at the expense of ensuring that the Technical Committee can assess compliance and safety.

This is a go/no-go checkpoint. If the organisers are not convinced that the team is complying with the rules the decision will be "no-go" and the team will be informed that they can no longer take part in the 2016 UAV Challenge Medical Express competition. The UAV Challenge Technical Committee reserves the right to allow a team to progress if they believe the technical and safety requirements have been met and that there are exceptional or mitigating circumstances.

5.3.2 Technical Report and Video (Deliverable 2)

Deliverable 2 is the main Technical Deliverable and is to include as much detail as required to assess safety and compliance, within the page limit. If these rules have requested information or detail and have not stated a specific deliverable then it is to be assumed that it should be included in Deliverable 2.

Each Team is required to electronically submit a Technical Report in PDF format and a flight demonstration video via an on-line video sharing service (e.g. YouTube).

The technical report must use the following headings and be no longer than 23 pages:

1. Title page (1 page)
2. Table of Contents (1 page)
3. Statement of Originality and Accuracy – see Appendix B (1 page)
4. Compliance Statement – see Appendix A (3 pages)
5. Executive Summary (1 page)
6. Introduction and Design Approach (1 page)
7. Landing site analysis strategy (1 page) including
    a. Details of how the team intends to locate Outback Joe
    b. Details of how the team intends to determine a suitable landing location
8. System Design (4 pages) including
    a. A system diagram
    b. aeronautical requirements
    c. flight termination system design, state machine diagrams and transitions
    d. analysis of the flight termination method
    e. Geofence system design

    f. radio equipment and frequencies to be used and relevant licences
9. Risk Assessment (3 pages) including
    a. An update of the Deliverable 1 risk assessment accounting for design changes
    b. An assessment of the risks associated with autonomously taking off and landing
10. Risk Management (4 pages) including
    a. Details of how the system will respond to failures including loss of data link, loss of GPS, lock-up or failure of autopilot and lock-up or failure of GCS, and loss of engine power.
    b. The team's Fuel or Li-Po battery management (if used)
    c. How the team will manage other risks identified in the risk assessment
11. Flight Test Results and Discussion (2 pages)
12. Conclusions (1 page)

No appendices are allowed other than those describing pyrotechnics as specified in Section 3.4.5.

Deliverable 2 should demonstrate understanding and compliance to the UAV Challenge Medical Express rules, and should refer to the rules where applicable. A "cut and paste" of the relevant section will not be considered as having understood and complied with that section. Ensure that compliance is clearly stated and if non-compliant a clear justification statement is required.

The report and video will be assessed as shown in Table 1 below:

D2 - Technical Report and Video (total of 15 Points)	
Scoring Components	**Max Points**
Executive Summary	1
Design approach and Strategies	2
Risk Assessment and Management	4
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 (23 pages)	MINUS 2 points per page

Table 1 Deliverable 2 Scoring

The video must show:

- the Team's *Retrieval Aircraft* autonomously landing and taking off, and
- the Team's pre-flight set up and checks.

Note that the movie MUST show the actual aircraft the team intends to use in the competition.

This is a go/no-go checkpoint. If the organisers are not convinced that the team is complying with the rules, the decision will be "no-go" and the team will be informed that they can no longer take part in the 2016 UAV Challenge Medical Express competition. The UAV Challenge Technical Committee reserves the right to allow a team to progress if they believe the technical and safety requirements have been met and that there are exceptional or mitigating circumstances.

Note to Teams: If requested by CASA, the UAV Challenge organisers will make available copies of Deliverable 2 to them as part of the compliance information for the UAV Challenge Medical Express event.

D2 and multiple aircraft missions

If a team is using two aircraft to complete the mission then reference to both those aircraft must be made in the Deliverable 2 document.

5.3.3 Autonomous Flight Record (Deliverable 3)

All activities undertaken to comply with this sub-section must comply with CASA (if in Australia) and other appropriate regulations for your country of operation.

Overview of Deliverable 3

All teams must provide documentary evidence of five hours of autonomous flight for each aircraft used in the mission. The five hours do not include the time taken to tune the autopilot. It is preferable that all five hours is accumulated on the total system that will be operated during the UAV Challenge Medical Express event, however consideration will be given due to incidents during preparation. An equivalence case will be required to demonstrate that the accumulated experience is relevant. Where equivalence is claimed, a minimum of one hour of autonomous flight on the system to be used at the UAV Challenge Medical Express event must be documented.

The five hours must have at least one flight with duration in excess of 30 minutes and one flight with a total track length of greater than 11 nautical miles.

If components, systems or airframes are replaced by identical components, systems or airframes equivalence will be automatic and only a functional checkout will be required. The one-hour requirement is waived; a functional test flight is a requirement.

If the airframe or system has significant changes, it is expected that evidence be provided related to the airframe and system to be operated during the UAV Challenge Medical Express event.

If multiple aircraft are being used then this requirement applies to both aircraft. However, if a combined aircraft is being used and a short flight duration *Retrieval Aircraft* is being deployed at the *Remote Landing Site* and re-docked in the air to the *Support Aircraft* for the return trip to the *Base*, then the 5 hour requirement only applies to the combined (docked) aircraft. If the retrieval aircraft is deployed at the *Remote Landing Site* but has to fly back on its own to the *Base*, then the 5 hour requirement must be met for the *Retrieval Aircraft* and the *Support Aircraft*.

While this deliverable is primarily a Go/No-Go point, the UAV Challenge Technical Committee reserves the right to allow a team to progress if they believe the technical and safety requirements have been met and that there are exceptional or mitigating circumstances.

Deliverable 3 Requirements

Deliverable 3 must include the safety case as described in Section 3.4.3.

The following evidence of autonomous flight for each aircraft must be provided for Deliverable 3:

- A digital copy of the flight log book
- A GPS telemetry log of a single flight in excess of 30 minutes duration
- A video of not more than 5 minutes runtime showing the aircraft during autonomous flight and the operational ground station
- 10 or more static images showing the ground station, aircraft and team members during flight operations from a number of flights.

As part of Deliverable 3 teams must provide the following information for each RF transmitter in their aircraft or ground station:

- Transmission frequency
- Transmitter power
- Transmitter antenna gain
- Calculated Effective Isotropic Radiated Power (EIRP)
- Any radio spectrum licences the team has obtained and needs to use during the challenge

Deliverable 3 must provide the following aircraft details regarding each aircraft and its flight performance:

- Maximum airspeed (i.e. at full throttle)
- Cruise airspeed (i.e. most fuel efficient)
- Endurance at maximum airspeed
- Endurance at cruise airspeed
- Maximum take-off weight
- Competition take-off weight
- Dimensions of the aircraft
- Identifying marks (if any)
- Aircraft plan form and configuration (to help range marshalls identify the aircraft while it is flying)

This information can be updated on arrival at the event.

If a combined aircraft arrangement is being used where one aircraft is carrying another, then three sets of aircraft details will be required. One set for the combined aircraft and one each for the separate aircraft (when undocked).

5.3.4 Top twenty (20) only to qualify

The competition can only support a maximum of twenty teams at the event. If more than twenty teams are given an initial Go decision at the Deliverable 3 stage, the teams will be ranked using their Deliverable 2 score. The twenty teams with the highest scores will be invited to the UAV Challenge Medical Express event and will be deemed to have qualified.

5.4 Event judging

5.4.1 Team Interview

The judges will interview teams during the event (prior to flying) in order to assess their approach to safety and the features of their system. Teams can be expected to answers questions from the Judges relating to:

- their approach to safety,
- system design,
- what they have learned from the process, and
- unique or innovative features and safety approaches.

The answers to the Judges' questions will be assessed as shown in Table 2 below:

Team Interview Questions (total of 15 Points)	
Scoring Components	**Max Points**
Safety Approach	5
System Design	3
Learnings from the development process	3
Unique or innovative features	4

Table 2 Team Interview Scoring

5.4.2 Mission Performance (Flying)

The mission performance will be assessed as shown in Table 3 below:

Mission Performance (total of 150 Points)	
Scoring Components	**Max Points**

Mission Performance (total of 150 Points)	
Scoring Components	**Max Points**
Pre-flight checks, team communication and organisation, and demonstration of good judgement (airmanship)	10
Autonomous takeoff from the *Base* of at least one aircraft (yes/no)	10
Precise location estimation of Outback Joe (within 10m)	20
Autonomous Landing at *Remote Landing Site* (yes/no)	25
Autonomous Landing at *Remote Landing Site* within 80m of Joe but not closer than 30m	Points = (80-d)/2, where d is distance in m from Outback Joe (max points 25, min 0)
Autonomous takeoff from the Remote Landing Site with blood sample (yes/no)	10
Return of the blood sample to the *Base* (yes/no)	40
Autonomous landing at the *Base* (yes/no)	10
Time penalty	Minus 2 point for each minute over the hour
Crossing a Geofence Boundary	Disqualified

Table 3 Mission Performance Scoring

6 Schedule and Event Location

6.1 Schedule

Table 4 below sets forth the overall competition schedule.

Activity	Date
Team Registration and Deliverable 1: Flight Safety Review (short Technical Report) A short technical report (Section 5.3.1) on the UAV design concept and proposed safety methodology must be provided.	At the latest: 2nd September 2015 at 5pm AEST
Deliverable 2: Flight Readiness Review (Technical Report and Video) - A technical report must be provided. The underlying objective of this report is to convince the Technical Committee that the team has developed a reliable and safe system, along with the appropriate operating procedures. A video must be supplied that includes a flight demonstration of an autonomous landing.	At the latest: 13th April 2016 at 5pm AEST
Deliverable 3: Autonomous Flight Record - Documentary evidence must be provided that details a minimum of five (5) hours of autonomous flight. This deliverable may include an equivalency case when the five hours has been accumulated across different systems.	At the latest: 10th August 2016 at 5pm AEST
Final "Go/No-Go" and qualification announcements Final approval to participate in the 2016 UAV Challenge Medical Express 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. If more than 20 teams achieve a Go decision then teams will be ranked on points scored for the Deliverable 2 document and the top twenty teams only will qualify.	17th August 2016
CASA Application Update The Technical Committee are to submit an update to CASA advising them of the names of the participants for inclusion in the airspace approvals for the UAV Challenge Medical Express event.	31st August 2016
Team Insurance Deadline Teams must provide documentation illustrating their insurance coverage. More details of insurance requirements and options will be posted on the UAV Challenge website. Teams that have not submitted this documentation by this date may be disqualified from the competition.	7th September 2016
UAV Challenge event - Orientation, Safety Briefing, Scrutineering, Team Interview and competition flights. Includes weather contingency	27th to 30th September 2016

Table 4 UAV Challenge Medical Express 2016 Schedule

6.2 Optional Early Delivery of Documentation

The organisers understand that some teams would like to receive a “Go” or “No Go” decision earlier than detailed above. The assessment process for Deliverable 1 and 2 documents prevents any early notifications and as such early delivery can be made but will not impact the processing and notification schedule. For Deliverable 3, being a compliance milestone can be submitted earlier than detailed above and the Technical Committee will endeavour to assess them as soon as possible and send notification. However, multiple attempts at achieving the “Go” decision will not be allowed, unless the Technical Committee formally requests additional information or clarification.

6.3 Event Location

The UAV Challenge Medical Express 2016 event will be held at the Dalby Model Aero Club, 743 Cecil Plains Road, Dalby, Queensland, Australia. This will be the location of the *Base*.

7 Discussion and Recommendations to Teams

7.1 The UAV Challenge Objective

7.1.1 Background

The first UAV Challenge was called the UAV Challenge Outback Rescue and involved teams undertaking a realistic search and rescue mission. The event took place from an open airport (with manned aircraft operating in concert with the competition's unmanned aircraft), in a relatively remote location, with hot and windy weather and a requirement of a long transit flight to the search area. That Challenge mission took seven years and six events to complete. Four teams completed the mission task in 2014 with a fifth team coming close. With the successful completion of the initial mission, it was time to consider a new mission that would push the boundaries of what low-cost civilian unmanned aircraft could achieve.

7.1.2 The mission and its aims

This Challenge is called the ***UAV Challenge Medical Express*** and will require teams to go beyond search and rescue and perform the more challenging task of automated sample return from an unknown remote location. The mission has been designed to extend the state-of-the-art in the following areas that will ultimately benefit the low-cost civilian unmanned aircraft industry:

- Improved search algorithms (that can locate a person that is standing and is wearing normal clothes – i.e. a non-high visibility shirt).
- Cheap and reliable ground-to-ground communications (between a GCS and a remotely landed unmanned aircraft) over a distance of at least 5.4 nautical miles.
- Unmanned aircraft that can transit long distances and land and take off in a constrained area that is surrounded by obstacles. New hybrid platforms that are neither pure fixed-winged aircraft nor pure multi-rotors are likely to be required to complete the mission.
- Fully automatic takeoff and landing systems that can operate in a remote location – not only at the GCS end.
- On-board situational awareness of remote landing locations that are largely unknown to aircraft operators before a mission commences.

The UAV Challenge Medical Express will provide valuable experience to all who enter, in the design, construction and operation of UAVs. This experience will help create a future generation of aerospace professionals - all focused on the fastest growing component of the international aerospace industry.

7.2 Soft Geofence

It is recommended but not mandatory that teams implement a "soft Geofence" inside the actual *Geofence* boundaries, set up that when crossed the aircraft commences a manoeuvre that will reduce the possibility of an actual *Geofence* boundary crossing and the subsequent mandatory activation of the "hard *Geofence*". The *Geofence* boundary-crossing requirement described in this section is non-negotiable regardless of the "soft *Geofence*" implementation, and will be subject to scrutineering.

The UAV Challenge Technical Committee does not intend detailing implementation or performance requirements for the "soft *Geofence*", leaving it entirely to the individual teams to consider. The intention for inclusion is to explore a means of reducing the potential activations of the "hard *Geofence*" and to keep aircraft in the air as long as it is safe to do so.

The following notes are offered for consideration:

- It is accepted that the autonomy may already be trying as hard as it can to follow the tracks defined in the mission and they may not be any options to "try harder" to avoid the “hard *Geofence*”.
- The activation of the “soft *Geofence*” may trigger the use of more aggressive or different control laws.
- The activation of the “soft *Geofence*” may alert the *UAV Controller* that incorrect waypoints have been entered or generated allowing changes to be made and thus avoiding the “hard *Geofence*”.
- If optionally in manual mode (at the *Base*), the activation of the “soft *Geofence*” may alert the *UAV Controller* as to proximity of the “hard *Geofence*” prompting a suitable manoeuvre.
- In manual mode, the activation of the “soft *Geofence*” may switch the aircraft to autonomous mode to follow a flight path that avoids the “hard *Geofence*”. This design will need to be declared in Deliverable 2.

7.3 Guidance Material for Deliverable 3

Over the history of the UAV Challenge competitions it has become clear that the probability of a successful mission is related to the team’s level of experience in autonomous operations and sufficient autonomous flight time to tune the autopilot and understand the systems. It is recommended but not mandatory that each team should aim to obtain at least ten hours of autonomous flight time (not including autopilot tuning flights), with at least one flight of one-hour duration. It would be expected that multiple flights be undertaken in excess of 30 minutes.

Each team should conduct testing of their command and control (C2), payload and RC override data links, including loss of data link actions.

Flights should be conducted in a range of wind conditions.

7.4 Definition and Levels of Autonomy

7.4.1 Definition

There is currently no widely accepted definition of autonomy and levels for unmanned aircraft. In the context of the UAV Challenge Medical Express there are two types of autonomous operations:

7.4.2 Type 1 Autonomy – Remotely Piloted Aircraft Systems (RPAS)

Type 1 Autonomy is the level of autonomy implemented by “waypoint following” autopilots, where the remote pilot does not directly control the aircraft control surfaces (such as aileron, elevator, rudder, elevons, etc.). The remote pilot continuously monitors the progress of the unmanned aircraft and the remote pilot can alter the waypoint positions, sequencing of waypoints, and command altitude and speed changes.

7.4.3 Type 2 Autonomy – Function Activation without Remote Pilot Intervention

Type 2 Autonomy is where specific functionality on a remote aircraft is activated by the sensing of specific conditions and without intervention from the remote pilot.

7.5 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 for the UAV Challenge Medical Express.

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

Appendix A. Deliverable 2 Compliance Statement

Each team is required to submit a Compliance Statement addressing the competition rules and requirements as part of their Deliverable 2. The aim of the Deliverable 2 Compliance Statement is to provide a checklist like template to each team to ensure that essential rules and requirements have been addressed and documented in Deliverable 2 prior to submission.

Team Name:

We declare that this report and the entry that it describes complies with the rules of the 2016 UAV Challenge, and that we enter with the intention of competing in the spirit of the challenge. Specifically we declare that our entry is compliant with the following topics and provide reference to within our Deliverable 2 document were our method of compliance is described:

Rules Reference	Topic	Compliance	Deliverable 2 Reference
Mandatory / Essential *Non-compliance in this section will result in a No-Go finding unless there are significant and/or extenuating circumstances. Please read the rules in detail. If using two aircraft ensure both aircraft are considered and Deliverable 2 references are provided for each aircraft if necessary.*			
1.6	Maximum of two aircraft for the mission	□ Compliant	
3.1.1	Must not be a commercial off-the-shelf complete system	□ Retrieval aircraft Compliant □ Support aircraft Compliant	
3.1.1	Must be capable of autonomous flight	□ Retrieval aircraft Compliant □ Support aircraft Compliant	
3.1.1	Must have a maximum gross weight of less than 100 kg (rotary) or 150kg (fixed wing)	□ Retrieval aircraft Compliant □ Support aircraft Compliant	
3.1.1	Must have continuous telemetry radio communication with the UAV Controller	□ Retrieval aircraft Compliant □ Support aircraft Compliant	
3.1.1	Must have an easily accessible E-Stop to render the aircraft deactivated	□ Retrieval aircraft Compliant □ Support aircraft Compliant	
3.1.1	Must have an external visual indication of state (armed, inert, disarmed)	□ Retrieval aircraft Compliant □ Support aircraft Compliant	
3.1.1	Must have an arming switch	□ Retrieval aircraft Compliant	
3.1.3	Must implement automatic (on-board) detection of crossing a Geofence boundary	□ Retrieval aircraft Compliant □ Support aircraft Compliant	
3.1.4	Must include a flight termination system meeting all conditions	□ Retrieval aircraft Compliant □ Support aircraft Compliant	
3.1.5 & 5.3.2	Flight termination method described and analysis provided of maximum distance outside Geofence	□ Retrieval aircraft Compliant □ Support aircraft Compliant	
3.1.6	All criteria for flight termination must result in immediate activation of flight termination	□ Retrieval aircraft Compliant □ Support aircraft Compliant	
3.2.1	Flight in the Transit Corridor and Remote Landing Site must be autonomous	□ Retrieval aircraft Compliant □ Support aircraft Compliant	

Rules Reference	Topic	Compliance	Deliverable 2 Reference
3.2.2	Must have a ground control station that provides a graphical display	□ Retrieval aircraft Compliant □ Support aircraft Compliant	
3.2.2	Must provide an NMEA data feed from the ground station	□ Retrieval aircraft Compliant □ Support aircraft Compliant	
3.2.3	Communication equipment must comply with ACMA regulations	□ Compliant	
3.3.2 & 5.3.2	AMSL altitudes will be measured and reported as pressure altitudes	□ Compliant	
3.3.3 & 5.3.2	Correct aeronautical units used	□ Compliant	
3.3.3	Description of how aircraft will be maintained within its airspeed envelope	□ Retrieval aircraft Compliant □ Support aircraft Compliant	
3.4.5	Pyrotechnic mechanisms have safety mechanism implemented and safety manual provided	□ Compliant □ Not Applicable	
5.2	Disclosure of sponsors and funding sources	□ Compliant	
5.3.2	Statement of originality and accuracy included	□ Compliant	
5.3.2	Executive summary provided	□ Compliant	
5.3.2	Introduction and design approach provided	□ Compliant	
5.3.2	Landing site analysis strategy provided	□ Compliant	
5.3.2	System Diagram provided	□ Compliant	
5.3.2	Flight termination system design, state machine diagrams and transitions provided	□ Compliant	
5.3.2	Geofence system design provided	□ Compliant	
5.3.2	Radio frequencies to be used and relevant licences provided	□ Compliant	
5.3.2	Updated risk assessment provided	□ Compliant	
5.3.2	Assessment of the risks associated with autonomously taking off and landing provided	□ Compliant	
5.3.2	Risk Management provided	□ Compliant	
5.3.2	Details of the system response to loss of data link provided	□ Compliant	
5.3.2	Details of the system response to loss of GPS provided	□ Compliant	
5.3.2	Details of the system response to lock-up or failure of autopilot provided	□ Compliant	
5.3.2	Details of the system response to lock-up or failure of the GCS provided	□ Compliant	
5.3.2	Details of the system response to loss of engine power provided	□ Compliant	
5.3.2	Details of fuel and/or battery management provided	□ Compliant	
5.3.2	Details of the management of other risks provided	□ Compliant	
5.3.2	Flight tests results provided	□ Compliant	
5.3.2	Conclusions provided	□ Compliant	
5.3.2	Video provided showing the retrieval aircraft autonomously landing and taking off	□ Compliant	

Rules Reference	Topic	Compliance	Deliverable 2 Reference
5.3.2	Video provided showing the teams pre-flight set up and checks	□ Compliant	
Highly Desirable			
7.2	"Soft Geofence"	□ Implemented □ Not Implemented	
5.3.2	Deliverable 2: Max 23 pages.	□ Compliant □ Non-Compliant	

Additional Information:

Date:
Signed by a team representative, on behalf of all team members:
Printed Name:

Appendix B. Statement of Originality and Accuracy

All Deliverable 2 documents should include a statement of originality and accuracy. This should be on a page by itself after the table of contents and should contain the following words:

> *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 is 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.*

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

Teams that have previously competed may submit materials that are still applicable, valid, and current from previous deliverables. This material shall be identified and acknowledged as being applicable, valid, and current.