Preliminary Design Review

Cambridge University Unmanned Air Systems Society

University of Cambridge

Team Members

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Sponsors

Cambridge University Engineers Association
Cambridge University Engineering Society
Student-led Projects and Industry Partnership (The Boeing Company, Marshall Aerospace and Defence Group, McLaren Technology Group)

1 Project Management

- project plan with main activities, lead times, and dependencies
- table summarising risks and their mitigation

2 Requirement Verification

	Requirement	Verification
Req. 1	MTOW of 6.9kg.	Weight budget supported by component and final assembly measurements.
Req. 2	Maximum 4 cell LiPo battery.	Voltage measurement.
Req. 3	Payload: Single First Aid Kit, one or more Buxton water bottles.	CAD of fuselage in combination with exact dimensions of payload, flight tests.
Req. 4	Completely autonomous operation.	Philip
Req. 5	Take off and landing within 30m	Basic performance calculations and tests.
Req. 6	All radio equipment must be licensed for use in the UK and have a minimum range of 1km. Radio equipment providing control of the UAS and for the FTS must be 'spread spectrum', and must operate on the 2.4GHz band.	Philip
Req. 7	The UAV must have a FTS which is either activated 5s after the uplink is lost or manually by the flight safety officer via the master controller, and 10s after the downlink is lost. The FTS will also be activated in the case of a geo fence breach.	Philip
Req. 8	The UAS should carry a camera system with target recognition capability to undertake target search.	Philip
Req. 9	The following telemetry must be available in flight: UAS position on moving map, local airspace, QFE, IAS.	Philip
Req. 10	The aircraft must allow for the fitting of a WBT-201 "G-Rays 2" GPS Tracker.	CAD of fuselage, using dimensions of tracker provided in rules document.
Req. 11	Batteries must be coloured brightly.	Visual inspection of batteries.
Req. 12	Carrying and dropping of payload on demand.	CAD of fuselage, flight tests.
Req. 13	The UAV should be as accurate as possible when delivering the payloads.	Usage of flaps for slow flying during payload drop.
Req. 14	Payload must remain intact during impact	Parachutes as speed retardation systems.
Req. 15	The aircraft should carry as much payload mass as possible.	Use of composite materials (CFRP, GFRP) for lightweight airframe design.
Req. 16	The UAV should navigate as accurately as possible.	Philip
Req. 17	The mission should be completed in under 10 min.	Performance calculations factoring in wind and expected distance covered, flight tests.

3 Performance Calculations

preliminary aerodynamic, structural, and peformance calculations supporting the initial sizing, basic stability and control calculations, and weight and balance estimate.

4 Cost Budget

Table XXX below gives a detailed list of *Commercial Off The Shelf (COTS)* components used in the UAV. As shown, the total sum is below the £1000 limit set out in the competition rules.

Component	*Retail Price* (£)
Teensy 3.6 Microcontroller	27.89
XBee 2.4 GHz Telemetry Transceiver	65.10
FrSky X8R Telemetry Receiver	23.94
Differential Pressure Sensor and Pitot Tube	41.77
Turnigy 16000mAh 4S LiPo Battery	15.03
Turnigy Aerodrive SK3 Brushless Motor	29.36
Turnigy Plush 60A ESC	28.21
Turnigy BMS-380MAX Servos (Total: 10)	134.70
Hitec HS-55 Servos (Total: 4)	40.48
DC-DC Converters (Total: 4)	80.04
Dr. MadThrust Wheels with Braking System	36.35
Electronic Components for Custom PCBs (e.g. Resistors, Capacitors, etc.)	27.13
Sensors for Custom PCBs (e.g. Absolute Pressure, IMU, GPS)	38.25
Total	**588.25**

Table 2: UAV COTS Components and Costs

Missing: e.g. materials, payload release mechanism parts, etc.

5 Safety

Safety Risks and Mitigation

Table XXX below gives a summary of major safety risks and their respective mitigations encountered in all stages of design, testing, and final mission deployment of the UAV.

ID	*Risk*	*Mitigation*
S1	Propeller blades	Safe distance from UAV before motors are armed and then started
S2	LiPo battery charging	Undertaken in fire-retardant LiPo charging box
S3	Loss of uplink/downlink connection	Flight termination system (FTS, see below)
S4	Faulty automatic control	Ability to switch to manual or initiate FTS via master controller
S5	UAV out-of-bounds or above height limit	Sensor feedback (GPS, pressure), position and alerts relayed to base-station
S6	Exceeding maximum airspeed	Pitot tube feedback limiting airspeed
S7	Payload delivery	Payload retardation system (see below)

Table 3: Risk and Corresponding Mitigation

RF Compliance

The data telemetry unit found in the UAV and base-station compromises a pair of *Digi XBee S2C 802.15.4* 2.4 GHz *Direct Sequence Spread Spectrum* transceivers. In addition to fulfilling the requirements of being 2.4 GHz and spread spectrum, they operate at a maximum of 6.3 mW transmit power. These units are also approved by the *European Telecommunications Standards Institute (ETSI)* for use in Europe. Thus, our UAV complies with the strict legal requirements in the UK for RF transmissions.

Flight Termination System (FTS)
The FTS onboard the UAV complies fully with the guidelines layed out in *Section 3.3.1* of the 2019 UAS Challenge Competition Rules. In particular,

- the FTS is selectable via the master controller using a two-way toggle switch,
- on activation the main control unit onboard the UAV sets the throttle to zero,
- the relevant control surfaces being set to initiate a gentle turn.
- Additionally, the FTS is initiated after 5 seconds lost uplink and initiated after 10 seconds lost downlink.

The control unit onboard the UAV has two separate countdown timers running (5s and 10s) which reset when data is received via the uplink and downlink respectively, as well as constantly monitoring the signal level of the master controller toggle switch, to determine when the FTS needs to be activated.

Payload Retardation System
To allow the payloads to be delivered intact without any harm to the deliverables themselves as well as to the environment, the payloads will be fitted with parachutes which shall deploy when the respective payload is released.

6 Design Description

- functional description, rationale for selection of systems (airframe, propulsion, flight controls, navigation & mission control, sensors, image processing, autonomy, payload carriage, fts) $->$ highlight innovative features
- diagram showing hte preliminary system architecture and data flowfor navigation and mission control, flight control, vision sensors
- overall layout & description with three-view scale drawing

7 Test Plan

short summary of any testing (flight testing, structural loads)