**The University Of Edinburgh**

**Airborne GeoSciences Facility (UoE-AG)**

**Flight Reference Card**

**Tarot 680 Pro**

**This FRC covers the following aircraft & purposes:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Type** | **Class** | **Aerial Work** | **Private / Internal** |
| Tarot 680 Pro | Multi-Rotor, < 7 kg | Yes\* | Yes |



*Tarot 680 Pro Hexacopter*

This document is a part of a combined Safety and Operations Manual for small enterprises that covers all of the appropriate aspects of UoE AG operations required to satisfy the requirements of the UK CAA Permission for Aerial Work using Small Unmanned Aircraft Systems (sUAS).

**Document Reference: OM-RPAS-Appendix 6a FRC Tarot 680 Pro**

**Revision: R1-1**

**This document is based on the FC template in OM-RPAS-Appendix 6 R1-1.**

*\* Subject to pilot qualification and CAA permissions, planned for summer- autumn 2016*

**Amendment Record**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Rev.** | **Date** | **Author** | **Comments** | **Signature (T. Wade)** |
| R0-1 | 20150828 | Tom Wade | Initial first draft of following major formatting revision |  |
| R0-2 | 20150925 | Tom Wade | Lipo Cell V corrected (Section 6)  Flight Mode summary added (new section 5) |  |
| R0-3 | 20160325 | Tom Wade | Updated normal procedures, pre-flight sections. Formatting of calls fonts. Added maintenance program section 6. |  |
| R1-1 | 201604132 | T Wade | Incorporate comments from A. Cunliffe to Normal procedures section  Added description of flight Modes.  Appendices Re-indexed from 7 to 6 |  |
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# Technical Data

|  |  |  |
| --- | --- | --- |
| Item | Tarot 680 Pro |  |
| Operators Name | UoE |  |
| Registered Keeper | UoE |  |
| Manufacturer Name | UoE |  |
| Airframe Make | Tarot 680 Pro |  |
| Airframe Model | - |  |
| Serial Number | UoE-AG-001 |  |
| LUASSTM Registration Number | TBC |  |
| Registration Number | TBC |  |
| Airframe Type | Multi-rotor |  |
| Span / Diameter (metres) | 0.68 less props |  |
| Un-laden Weight (kg) |  |  |
| Maximum Take-Off Mass (kg) |  |  |
| Propulsion Type | Electric |  |
| Number of Motors / Engines | 6 (Flat) |  |
| Motor / Engine Size |  |  |
| Motor KV |  |  |
| Flight Battery Type |  |  |
| Flight Battery Capacity | 2 x 14.8v, 8000mAh, 4s, 10C |  |
| Propeller Size |  |  |
| Flight Control System | 3DR Pixhawk |  |
| Flight Control Power Supply | Main flight battery via UBEC |  |
| Software / Firmware Version | Arducopter 3.2.1 |  |
| GPS Unit | Ublox LEA-6H |  |
| Transmitter Make and Model | Futaba T10J |  |
| Receiver Make and Model | Futaba R2008 |  |
| Aircraft Control Frequency and Power | 2.4 Ghz, 100mW |  |
| Ground Station Type | Active |  |
| Ground Station Make and Model | Dell Latitude E4300, Windows 7 |  |
| Ground Station Software | Mission Planner |  |
| Firmware / Software Version | 1.3.25 |  |
| Ground Station Link | USB Cable |  |
| Telemetry Link Make and Model | 3DR Radio V2 |  |
| Telemetry Link Frequency and Power | 433 Mhz, 6.3mW |  |
| Payload Link Make and Model | N/A |  |
| Payload Link Frequency and Power | N/A |  |

# Operating Limits and Conditions

|  |  |  |
| --- | --- | --- |
| Limitation | Tarot 680 Pro ‘Mercury’ |  |
| Operational Ceiling | 5000ft (Estimated) Above Mean Sea Level (AMSL) |  |
| Operational Endurance | 15 Minutes @ 4kg AUW (1300ft AMSL) |  |
| Maximum Outside Air Temperature | 35 °C |  |
| Minimum Outside Air Temperature | -5 °C |  |
| Maximum Permissible Wind Speed Including Gusts | 15Kts @ 0ft Above Ground Level (AGL) |  |
| Maximum Permissible Precipitation | None |  |
| Broadcast Frequency Signal Strength | 2.4 GHz @ 100mW  433 Mhz @ 6.8mW |  |

# Types of Operation

|  |  |  |
| --- | --- | --- |
| Operation Type |  | Comments |
| Category: |  |  |
| VLOS – Day | Yes |  |
| VLOS – Night | No |  |
| EVLOS - Day | No |  |
| EVLOS – Night | No |  |
| Aerial Work | Planned | Subject to pilot qualification and CAA permission, planned for autumn 2015 |
| Internal - Training & Currency | Yes |  |
| Internal - Trials / Development | Yes |  |
| Internal – Teaching | Yes |  |
| Internal – Research Grant Support | Yes |  |
|  |  |  |
| Data Acquisition: |  |  |
| Ortho-photography | Yes | Gimballed Sony A6000, Pixhawk controlled via IR / wired trigger |
| Laser range-finding | Yes | Lightware SF10/C, SF11/C, on above gimbal |
| Videography | Yes | Onboard SJ4000 action camera, non-gimballed, forward oblique |
| Oblique Photography | Yes | Onboard SJ4000 action camera, non-gimballed, forward oblique in still mode (internal intervalometer) |
| Multi-Spectral Imaging | Yes | Gimballed Micasense Sequoia multi-spectral camera |

# Performance Data

**Battery Endurance Vs Payload Performance**: 2 x 4S 8000 mAh

This section to be populated based on flight test data

**Battery Endurance Vs Wind-Speed Correction**

This section to be populated based on flight test data

# Flight Modes

|  |  |  |
| --- | --- | --- |
| Flight Mode | Switch Position(s) | Description |
| Stabilize | TBC | * ‘Manual’ flight, but self-levels the roll and pitch axis. * Pilot’s roll and pitch input control the lean angle of the copter. When the pilot releases the roll and pitch sticks the vehicle automatically levels itself. * Pilot will need to regularly input roll and pitch commands to keep the vehicle in place as it is pushed around by the wind. * Pilot’s yaw input controls the rate of change of the heading. When the pilot releases the yaw stick the vehicle will maintain it’s current heading. * Pilot’s throttle input controls the average motor speed meaning that constant adjustment of the throttle is required to maintain altitude. If the pilot puts the throttle completely down the motors will go to their minimum rate (MOT\_SPIN\_ARMED) and if the vehicle is flying it will lose attitude control and tumble. * The throttle sent to the motors is automatically adjusted based on the tilt angle of the vehicle (i.e. increased as the vehicle tilts over more) to reduce the compensation the pilot must do as the vehicle’s attitude changes. |
| Alt Hold | TBC | * When altitude hold mode (aka AltHold) is selected, the throttle is automatically controlled to maintain the current altitude. Roll, Pitch and yaw operate the same as in Stabilize mode meaning that the pilot directly controls the roll and pitch lean angles and the heading. * Automatic altitude hold is a feature of many other flight modes (Loiter, Sport, etc) so the information here pertains to those modes as well. * The pilot can control the climb or descent rate of the vehicle with the throttle stick. * If the throttle stick is in the middle (40% ~ 60%) the vehicle will maintain the current altitude. * Outside of the mid-throttle deadzone (i.e. below 40% or above 60%) the vehicle will descend or climb depending upon the deflection of the stick. When the stick is completely down the copter will descend at 2.5m/s and if at the very top it will climb by 2.5m/s. These speeds can be adjusted with the PILOT\_VELZ\_MAX parameter. * The size of the deadband can be adjusted with the THR\_DZ parameter (AC3.2 and higher only). This params value should be between “0” and “400” with “0” meaning no deadband. “100” would produce a deadband 10% above and below mid throttle (i.e. deadband extends from 40% to 60% throttle stick position). |
| Loiter | TBC | * Loiter Mode automatically attempts to maintain the current location, heading and altitude. The pilot may fly the copter in Loiter mode as if it were in manual. Releasing the sticks will continue to hold position. * Good GPS position, low magnetic interference on the compassand low vibrations are all important in achieving good loiter performance. * The pilot can control the copter’s position with the control sticks. * Horizontal location can be adjusted with the the Roll and Pitch control sticks with the default maximum horizontal speed being 5m/s (see Tuning section below on how to adjust this). When the pilot releases the sticks the copter will slow to a stop. * Altitude can be controlled with the Throttle control stick just as in AltHold mode * The heading can be set with the Yaw control stick |
| AUTO | TBC | * In Auto mode the copter will follow a pre-programmed mission script stored in the autopilot which is made up of navigation commands (i.e. waypoints) and “do” commands (i.e. commands that do not affect the location of the copter including triggering a camera shutter). * AUTO should be set-up as one of the Flight Modes on the flight mode switch. * If starting the mission while the copter is on the ground the pilot should ensure the throttle is down, then switch to the Auto flight mode, then raise the throttle. The moment that the throttle is raised above zero, the copter will begin the mission. * If starting the mission from the air the mission will begin from the first command the moment that the flight mode switch is moved to Auto. If the first command in the mission is a take-off command but the vehicle is already above the take-off command’s altitude the take-off command will be considered completed and the vehicle will move onto the next waypoint. * At any time the pilot can retake control from the autopilot by returning the flight mode switch to another flight mode such as Stabilize or Loiter. If the pilot then switches to AUTO again, the mission will restart from the first command. * During the mission the pilot’s roll, pitch and throttle inputs are ignored but the yaw can be overridden with the yaw stick. This allows the pilot to for example aim the nose of the copter (which might have a hard mounted camera on it) as the copter flies the mission. The autopilot will attempt to retake yaw control as the vehicle passes the next waypoint. * Missions should normally have an RTL as their final command to ensure the copter will return after the mission completes. Alternatively the final command could be a LAND with a different location. Without a final RTL or LAND command the copter will simply stop at the final waypoint and the pilot will need to retake control with the transmitter. * Remember that when using RTL, the copter will return to the “home” position which is the location where the copter was armed. * As the copter touches down at the end of the mission the pilot should move the throttle to zero at which point the autopilot will disarm the motors if it also believes that it has landed. |
| Land | TBC | * LAND Mode attempts to bring the copter straight down and has these features: * descends to 10m (or until the sonar senses something below the copter) using the regular Altitude Hold controller which will descend at the speed held in the WPNAV\_SPEED\_DN parameter which can be modified on the Mission Planner’s Config/Tuning > Copter Pids screen. * below 10m the copter should descend at the rate specified in the LAND\_SPEED parameter which defaults to 50cm/s. * Upon reaching the ground the copter will automatically shut-down the motors and disarm the copter if the pilot’s throttle is at minimum. * NOTE: The Copter will recognise that it has landed if the motors are at minimum but it’s climb rate remains between -20cm/s and +20cm/s for one second. It does not use the altitude to decide whether to shut off the motors except that the copter must also be below 10m above the home altitude. |
| RTL | TBC | * RTL mode (Return To Launch mode) navigates Copter from its current position to hover above the home position. The behavior of RTL mode can be controlled by several adjustable parameters. * When RTL mode is selected, the copter will return to the home location. The copter will first rise to RTL\_ALT before returning home or maintain the current altitude if the current altitude is higher than RTL\_ALT. The default value for RTL\_ALT is 15m. * RTL is a GPS-dependent move, so it is essential that GPS lock is acquired before attempting to use this mode. Before arming, ensure that the APM’s blue LED is solid and not blinking. For a GPS without compass, the LED will be solid blue when GPS lock is acquired. For the GPS+Compass module, the LED will be blinking blue when GPS is locked. * RTL will command the copter to return to the home position, meaning that it will return to the location where it was armed. Therefore, the home position is always supposed to be your copter’s actual GPS takeoff location, unobstructed and away from people. For Copter if you get GPS lock and then ARM your copter, the home position is the location the copter was in when it was armed. This means if you execute an RTL in Copter, it will return to the location where it was armed. |

# Maintenance Procedures

**Full System Check:**

1. Check all mechanical fasteners and fixings
2. Calibrate IMU
3. Calibrate compass system
4. GPS functionality check (ground)
5. Radio calibration / configuration & functionality check
6. Configuration / functionality check of additional sensors, including:
   1. Voltage and current sensors
   2. Laser altimeter / sonar
7. Functionality check of additional equipment, e.g. strobes etc.
8. Configuration / functionality check of camera / gimbal setup
9. Full flight test as below

**Full Flight Test:**

1. UAV able to hover for 1 min under manual control in STABILISED flight mode
2. UAV altitude stable in ALTITUDE HOLD mode (visual check)
3. UAV altitude stable in SIMPLE ALTITUDE HOLD mode and cardinal orientation hold (based on magnetic compass) as expected
4. UAV altitude and position stable in GPS controlled LOITER mode, no circling (‘toiled bowling’)
5. Automatic LAND mode works as expected
6. Automatic RETURN TO LAND mode works as expected
7. UAV able to successfully complete a simple three waypoint mission in AUTO flight mode
8. Agreement of ground control visual and audible signals with aircrafts behaviour throughout the above tests.
9. Telemetry and radio control signal strengths indicators checked for proportionality and a confirmation of a minimum control signal range of 500m (0.27 nm). This is tested by manually moving the UAV at intervals away from the ground station at ground level. Distances were verified with a digital laser range finder.
10. Agreement of flight controller based battery voltage monitoring with the separate on-board hardware battery monitors. Both are verified additionally with voltage readings from the charging stations before recharge.
11. Triggering and functioning of both low battery alarm systems (flight controller and on-board hardware monitors). Tested by raising alarm threshold into normal operating voltage.

**6 month / 20 Hr Checks:**

1. Inspect the airframe for any damage, unusual marks and tightness of fixings.
2. Inspect the motor mountings for correct tension.
3. Inspect propellers for condition, unusual marks, chips, cracks and tightness of fixings.
4. Inspect electrical wiring for condition, unusual marks or discolouration.
5. Inspect electrical terminal fittings and plugs for secure attachment and general condition.
6. Inspect attachment of all fittings such as flight controller, GPS antennae etc. for secure attachment
7. Inspect payload attachment points for condition and security of payload.
8. Inspect condition and function of all ancillary equipment such as transmitter, ground station etc.
9. Test all system battery packs for charge status and general condition.

**Re and Post flight Actions:**

See Normal Procedures Section below.

# Normal Procedures

|  |  |  |  |
| --- | --- | --- | --- |
| Procedure | Responsibility Delegated to | | Action Required |
| Embarkation Checks | PIC / GSC | | 1. UA Check / Pack 2. Spares Box Check / Pack 3. GCS Box Check / Pack 4. GSC laptop stand Check / Pack 5. Tx / radios Check / Pack 6. LiPos Check / charge / pack (Safe bags mandatory) 7. Fire Extinguisher x 2 Check / Pack 8. First Aid Kit Check / Pack - check 9. Telemetry / Wind Vane Pole Check / Pack 10. Job File Compile / Pack 11. Ground markers, signs Check / pack |
| On-Site Arrival Checks | PIC | | 1. On-Site Survey Form – Complete 2. Landing Site and alternate – select 3. Mark (delegate via GEC / Spotters if available) 4. Notifications – as required 5. Check job file, aircraft tech log etc, all docs, logs, insurance etc ok and in place 6. Unpack UA and RC equipment 7. Oversee cordon setup etc |
| GSC | | 1. Ground station – setup 2. Ground control points – direct / assist GEC / Task / Specialist / Spotters as required |
| GEC / Spotters | | 1. Set up cordon (see OM for procedure) 2. Check / assess public incursion risk and advise PIC 3. Select spotter positioning, confirm with PIC |
| OPERTAING SITE SETUP | | **TAROT 680 Pro** | |
| Radius: | | Minimum 3 m (based on probable GPS accuracy in event of failsafe autonomous RTL) | |
| Markings, Main Landing Zone: | | Where practical, circular marking with low-level ORANGE or YELLOW cone markers. | |
| Markings, Alternate Landing Zone: | | Where practical, circular marking with low-level WHITE cone markers. | |
| Markings, obstacles / avoids: | | If any small obstacles / unsuitable areas exist within or immediately around the designated landing zone, clearly mark with RED low-level cone or caution tape, as appropriate. | |
| Telemetry / Wind Pole: | | 3 – 4m height, minimum 10 m from marked landing zone, not in direction of operations (preferably to one side to maintain visibility to PIC) | |
| Fire Extinguishers: | | 1 lying flat immediately outside of marked landing zone  1 upright at base of GCS | |
| First Aid Kit: | | At base of GCS | |
| Cordon procedure: | | As per Operations Manual | |

|  |  |  |  |
| --- | --- | --- | --- |
| Procedure | Responsibility Delegated to | Action Required | |
| CHECK A  Daily check, upon move to new site, or payload change | PIC  (specific tasks may be delegated to GSC) | 1. Airframe | Unfold rotor arms and landing gear; check securely locked; check condition |
| 1. Payload / Gimbal | Attach; check security, install sensor system |
| 1. Canopy | Remove |
| 1. Main body | Check security of screws, hardware and components (flight controller, cables, UBECs etc.). Check electrical connections secure. |
| 1. Canopy | Replace, check nuts secure |
| 1. Motor mounts | Check security and level; check all screws |
| 1. Props | Attach, check security and condition |
| 1. GCS / UA | Connect USB (enables GPS Lock / warm-up) |
| 1. Once GPS Locked: | Check GPS, compass and IMU function & accuracy |
| 1. TX | ON |
| 1. Controls | Check (Mandatory Settings->Radio Calibration) |
| 1. Flight Modes | Check correct / selectable (Flight Modes page) |
| 1. Camera(s) | Calibrate (if required); sett; load into Gimbal; check control |
| 1. Balance | Check balance about centre rotor arms |
| 1. Records | Update as required. PIC must sign to confirm A Check complete. |

|  |  |  |  |
| --- | --- | --- | --- |
| Procedure | Responsibility Delegated to | Action Required | |
| CHECK B  Completed prior to EACH flight. | PIC  (specific tasks may be delegated to GSC) | **Part 1: General condition check and battery mounting** | |
| 1. Airframe | Check security & condition of canopy, main frame, rotor arms, motor mounts, props |
| 1. Payload | Change if required.  If changed, check security of attachment, control, calibration, aircraft balance, aircraft total mass. |
| 1. **Batteries** | Remove used batteries if fitted. Install fresh battery set but do not connect. Check physical condition of batteries.  DO NOT connect batteries to UA electrically at this time. |
| **Part 2: Mission Upload and Checking** | |
| 1. GCS / UA | Connected via USB (enables GPS Lock / warm-up) |
| 1. Battery Settings | Check (Optional Hardware>Battery Monitor mAh value) |
| 1. Geofence Settings | Check / Set |
| 1. Failsafe Settings | Check / Set (inc. RTL value) |
| 1. Mission | LOAD, write to UA |
| 1. MIS\_TOTAL parameter | Check (should match the # of wpts or # of wpts + 1) |
| 1. Parameters | Compare with valid reference parameter file |
|  |  |
| **Part 3: Battery Installation** |  |
| 1. UA / GCS USB link | DISCONNECT |
| 1. TX | Check ON |
| 1. Flight Mode | STABILIZE |
| 1. Batteries | Check security |
| 1. Battery Power Connectors | Connect |
| 1. Battery Monitors | Connect / Check set to 3.3V (top button) |
| 1. Battery Vs | Check (16.8 V for full charged) |
| 1. Cell Vs | Check (4.2 V fully charged; not more than 0.05 V difference) |
| **Part 4: Vital Actions** |  |
| 1. Camera Gimbal | Check response |
| 1. GCS / UA Telemetry | CONNECT / Check (connect at 57600 baud) |
| 1. MIS parameter | CHECK |
| 1. GPS Lock | CHECK (main flight screen) |
| 1. Hdop & Num Sats | CHECK (main flight screen; num says >=7, hdop < 2.5) |
| 1. Voltage / Charge | CHECK (should be close to batt. Monitors) |
| 1. Error Messages | CHECK None |
| 1. Records | Update as required |

|  |  |  |  |
| --- | --- | --- | --- |
| Procedure | Responsibility Delegated to | Action Required | |
| Take-Off | PIC | 1. UA Position | In launch/recovery area; facing away from crew |
| 1. Camera | ON |
| 1. Call | ***‘Ready for launch, check clear’*** |
| 1. Clear Area | Completion of a 360° visual sweep of the area (paying particular attention to airspace and public encroachments) await confirmation from GSC /GEC / Spotters |
| 1. TX | ON, all switches in correct position and control sticks as required |
| 1. Flight Mode | STABILIZE |
| 1. Safety Switch | Hold; light to SOLID RED (allows motor arming) |
| 1. Call | ***‘Arming’*** |
| 1. Throttle/Yaw | DOWN and RIGHT for FIVE seconds (loud single beep) |
| 1. Flight timer on TX | Start if avbl |
| 1. Rotors | Will start to rotate at low RPM |
| 1. Area | CHECK clear |
| 1. Call | ***‘Lifting’*** |
| 1. Throttle | Smoothly to 75%; UA will take-off |
| 1. Hover | Maintain 2 -3 m AGL |
| 1. Flight Mode | ALT HOLD; Check response |
| 1. Flight Mode | LOITER; Check response |
| 1. Flight Mode | AUTO (to fly pre-planned mission) |
| 1. UA | Monitor visually and via GCS |
| 1. Airspace | LOOKOUT for other aircraft |
|  |  |
| GSC | 1. On Hearing ‘Ready for Launch, Check Clear’ | Coordinate responses from any additional crew; visually check area clear; once confirmed, call *‘****Area Clear’*** to PIC |
| 1. On hearing ‘Arming’ | Note time, start independent timer, confirm armed status on GCS, call ***‘Roger, Armed’*** |
| 1. Monitor GCS | Confirm arming and flight mode selections via telemetry. Verbally confirm to PIC. |
| 1. Monitor airspace | Check clear of aircraft and ground hazards; take any reports from additional crew and pass on to PIC |
|  |  |
| GEC/Spotters | * Maintain visual lookout for public encroachments and airspace incursions * Communicate any required information to the GEC/GSC/PIC * Act, as directed by the GEC / GSC or PIC, to prevent public encroachment of the operating site where possible (note the limitations regarding the right to stop members of the public against their will!) | |

|  |  |  |
| --- | --- | --- |
| Procedure | Responsibility Delegated to | Action Required |
| In-flight | PIC | * Controls: Throttle 50% (40-60%) during AUTO flight * Maintain aircraft within Visual Line of Sight (max 500 metre horizontally, max 400 feet vertically). Maintain primary focus on the aircraft and immediate surroundings * Monitor (via GSC where appropriate) basic telemetry from aircraft when safe and appropriate * Maintain communications with the GSC at all times |
| GSC | * Monitor flight time elapsed, telemetry, flight battery voltage, satellites tracked, altitude etc. via the Ground Control Station (GSC) * Relay the above to the pilot-in-command, when safe to do so, via verbal call-outs (in particular, regular updates on flight time elapsed, battery voltage and progress within the flight plan. * Maintain visual lookout for public encroachments and airspace incursions * Communicate with any additional spotters or the GEC (if appointed) to coordinate response to any public encroachment |
| GEC | * Maintain visual lookout for public encroachments and airspace incursions * Reduce GSC workload by coordinating the response to any public encroachment, e.g. utilising additional spotters etc. where available * Communicate any required information to the GSC (or PIC if very urgent) |
| Task Specialist (if present) | * Maintain visual lookout for public encroachments and airspace incursions * Monitor any telemetry / read-outs from the payload to ensure correct function; inform the GSC (or PIC if very urgent) of any issues or malfunctions * Provide any control of the payload, if applicable, or coordinate with the GSC for payload control * Communicate any required information to the GSC (or PIC if very urgent) |
| Spotters | * Maintain visual lookout for public encroachments and airspace incursions * Communicate any required information to the GEC/GSC (or PIC if very urgent) * Act, as directed by the GEC / GSC or PIC, to prevent public encroachment of the operating site where possible (note the limitations regarding the right to stop members of the public against their will!) |

|  |  |  |  |
| --- | --- | --- | --- |
| Procedure | Responsibility Delegated to | Action Required | |
| Landing & Shutdown | PIC | 1. Call | ***‘Returning to land, check area clear’*** |
| 1. Payload | If reqd, stow payload for landing or instruct GSC / Task Specialist to do so |
| 1. UA position | Once area confirmed clear, relocate above landing zone |
| 1. Visual Check | Final check of landing site |
| 1. Call | ***‘Landing’*** |
| 1. Flight Mode | RTL or LAND; aircraft will descend at 1.5m/s then 0.5m/s |
| **When UA on Ground:** |  |
| 1. Throttle | 0% |
| 1. Flight Mode | STABILIZE |
| 1. UA | Disarm ( Hold throttle at minimum and rudder to the left for 2 seconds) |
| 1. Safety Switch | Press for ~ 5 seconds (red light flashes) |
| 1. Call | ***‘Landed, stop timing’*** |
| 1. TX flight Timer | Stop |
| 1. GCS / UA | Disconnect telemetry |
| 1. Battery Power Connectors | DISCONNECT |
| GSC | 1. Visual Check | On hearing intention to land, complete check of landing site (use GEC / spotters if available) and confirm to PIC (if not clear, direct to alternate) |
| 1. Payload | If reqd, assist PIC to stow payload for landing |
| 1. Navigation | If reqd, assist PIC to relocate UA using waypoint navigation |
| 1. Flight Modes | Confirm changes verbally |
| **When UA on Ground:** |  |
| 1. Timing | On hearing ‘ landed, stop timing’, note time and stop independent timer |
| 1. GCS | Assist PIC to disconnect telemetry |
| GEC / Spotters | * Maintain visual lookout for public encroachments and airspace incursions * Communicate any required information to the GEC/GSC (or PIC if very urgent) * Act, as directed by the GEC / GSC or PIC, to prevent public encroachment of the operating site where possible (note the limitations regarding the right to stop members of the public against their will!) | |

|  |  |  |
| --- | --- | --- |
| Procedure | Responsibility Delegated to | Action Required |
| Site Departure Checks | PIC | Provide any ATC end-of-action notifications  Ensure all UA and battery records updated  Pack UA  Oversee packing and clear up process  Ensure safe packing / handling of batteries  **CONDUCT DEBRIEF** – Complete ‘After Action Report’ on On-Site Form |
| GEC  / Spotters  (PIC / GSC if none available) | Ensure area cleared of all markers, GCPs, litter, signage etc  Assist PIC and GSC to pack / load UA and GCS hardware |
| GSC | Pack-up GCS hardware  Assist PIC packing UA  Back-up any retrieved logs/data if possible |

# ABNORMAL & EMERGENCY OPERATIONS

|  |  |  |
| --- | --- | --- |
| Emergency Type | Responsibility Delegated to | Action Required |
| Transmitter Failure  Frequency Interference | PIC | 1. Call ***‘RC Failure’*** 2. Confirm FAILSAFE RTL Activated (consult GSC if present)     If **YES:**   1. Call ***‘Fail Safe Activated, Aircraft Returning to Land*’** 2. Monitor aircraft progress visually and via telemetry   If **NO:**   1. Attempt to activate RTL via telemetry (via GSC) 2. If successful, Call ***‘Fail Safe Activated Via Control Station, Aircraft Returning to Land*’**, proceed as above 3. If unsuccessful, commence ‘Fly-Away’ procedure |
| GSC | 1. Upon hearing the call ***‘RC Failure’***, confirm FAILSAFE RTL Activated and advise PIC 2. Proceed as instructed by PIC 3. Once FAILSAFE RTL confirmed, ensure landing zone (i.e. point of arming) is clear of all persons |
| GSC / GEC / Spotters | 1. Upon hearing the call ***“Aircraft Returning to Land*”** ensure landing zone (i.e. point of arming) is clear of all persons |
| Loss of Propulsion  Motor or Propeller Failure  Aircraft Battery Failure | PIC | 1. Call ***“Motor Failure”*** 2. Assess if the aircraft is controllable   If sufficient control is maintained:   1. Proceed directly to either the landing site or alternate landing site whichever is closest (take advice from GSC if available) 2. Call ***‘Returning to Land’*** or ***‘Returning to land, Alternate’*** as appropriate   If control is compromised:   1. Attempt a controlled descent and landing in current location 2. Call ***‘Emergency landing NOW’*** |
| GSC | 1. Upon hearing the call ***“Motor Failure”*** identify the closest safe landing position to the aircraft and advise PIC 2. Clear any persons directly underneath or in the path of the aircraft to either the landing site or alternate landing as advised by the PIC landing call 3. Maintain visual contact with the aircraft once the area is clear. |
| GEC / Spotters | 1. Upon hearing the call ***“Motor Failure”*** immediately clear any persons directly underneath or in the path of the aircraft to either the landing site or alternate landing site as advised by the PIC landing call 2. Maintain visual contact with the aircraft once the area is clear. |

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| Emergency Type | Responsibility Delegated to | Action Required |
| Ground Control Station Failure | PIC | 1. Call / confirm ***“GCS Failure – Returning to Land”*** 2. Carry out the standard landing procedure.   NOTE: The aircraft is not in immediate danger but the ground station monitors crucial systems and therefore it is not advisable to fly without telemetry information. |
| GSC | 1. Upon noticing GCS failure, inform PIC ***“GCS Failure”*** 2. Attempt rectification, advise PIC if successful 3. Proceed as instructed by PIC (expect per normal landing procedure) |
| GSC / GEC / Spotters | 1. On hearing call ***“GCS Failure – Returning to Land”*** proceed as per normal landing procedure |
| Loss of GPS / GNSS Signal | PIC | 1. Call ***“Navigation Failure – Manual Control”*** 2. Flight Mode to STABILISE 3. Proceed directly to either the landing site or alternate landing site whichever is closest. 4. Call ***‘Returning to land’*** or ***‘Returning to Land, Alternate’*** as appropriate 5. If control is compromised try to execute a controlled descent; if so call **‘*Emergency landing NOW’*** |
| GSC | 1. Upon hearing the call ***“Nav Failure – Manual Control”*** identify the closest safe landing position to the aircraft and advise the PIC. 2. Clear any persons directly underneath or in the path of the aircraft to either the landing site or alternate landing site as advised by the PIC landing call 3. Maintain visual contact with the aircraft once the area is clear. |
| GEC / Spotters | 1. Clear any persons directly underneath or in the path of the aircraft to either the landing site or alternate landing site as advised by the PIC landing call 2. Maintain visual contact with the aircraft once the area is clear. |

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| Emergency Type | Responsibility Delegated to | Action Required |
| Public Encroachment | GEC / Spotter | 1. Call *“****Public Incursion, (location)”*** 2. Approach the member of the public asking them to follow you to safety as they are currently in an extremely dangerous situation. |
| GSC | 1. Upon identifying an encroachment from a member of the public or hearing the call *“Public incursion (location)”* advise the Pilot-In-Command. 2. Identify the nearest available landing site away from the encroachment and advise the PIC. 3. Once the PIC confirms they understand, if there is no spotter present dealing with the situation approach the member of the public asking them to follow you to safety as they are currently in an extremely dangerous situation. |
| PIC | 1. Immediately hold position and wait for further information. 2. The GSC will advise which the safest area to land 3. Confirm landing site selection 4. Proceed to confirmed landing site |
| Aircraft Incursions | GSC / GEC / Spotter | 1. Upon identifying an imminent aircraft incursion into the operating area call ***“Aircraft Incursion (relative location by clock code, using the line between PIC and the UA as the 12 o’clock reference), (relative height)’*** 2. Maintain visual contact with the approaching aircraft   If PIC confirms visual contact:   1. Monitor aircraft, UA and check ground environment below UA 2. Advise PIC of any immediate hazards below if present   If PIC does NOT make visual contact:   1. Advise on de-confliction action required (normally ‘***Descend NOW’***) |
| PIC | 1. Upon hearing call ‘Aircraft ….’, immediately search in direction indicated   **If visual contact made:**   1. Call ***‘Contact Aircraft…’*** 2. Hold position (Flight Mode LOITER) 3. Check beneath aircraft for hazards 4. Descend to 10ft AGL (Flight Mode LAND or STABILISE) |
| **Warning**  RAPID DESCENTS MAY INDUCE VRS AND LOSS OF CONTROL  **DO NOT** EXCEED MAXIMUM DESCENT RATE AS PER LIMITATIONS SECTION ABOVE UNLESS SITUATION CRITICAL AND AREA BELOW IS CONFIRMED TO BE CLEAR |
| 1. Once threat passed, resume planned mission if battery state sufficient (instruct GSC to check MIS-RESTART parameter = 0, then set Flight MODE AUTO), otherwise execute normal landing procedure   **If visual contact NOT made**   1. Call ***‘Looking’*** 2. Take avoiding action as advised by GSC / GEC / Spotter with visual contact |

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| Emergency Type | Responsibility Delegated to | Action Required |
| Fly Away Actions | PIC | 1. Call ***“Fly Away*”** so that the crew understand the situation. 2. Activate RETURN TO LAND mode via RC and telemetry (instruct GSC if applicable) in case communication is re-established 3. Maintain direct visual contact with the aircraft for as long as possible. 4. Note (or instruct GSC to note) last known altitude, speed, remaining battery endurance and heading / track from GCS or visual estimation if telemetry not available   **If visual contact with UA is lost, or if airspace / congested area incursion imminent:**   1. Contact the local air traffic control and local police using the contact numbers found on the SSA form within the job file to advise them of the situation.   **If the aircraft is seen to make contact with the ground or a structure:**   1. Execute the shutdown procedure and walk over to the crash site taking a fire extinguisher and camera. 2. Take photographs at the crash site, contact details and statements from anyone present and recover the aircraft. 3. Leave contact details for any property damaged as a result. |
| GSC | 1. Upon hearing ***“Fly Away”*** immediately monitor the aircraft telemetry data and make a note of the aircraft’s actual heading, speed and altitude. 2. On instruction from PIC, activate the RETURN TO LAND mode via telemetry. 3. Continue to monitor the telemetry data for as long as the connection remains and advise the PIC of the available information |
| GEC / Spotter | 1. Upon hearing ***“Fly Away”*** maintain direct visual contact with the aircraft for as long as possible and advise the Pilot-In-Command of an estimated heading. 2. If practical, check area under UA and attempt to keep public well clear |

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| Emergency Type | Responsibility Delegated to | Action Required |
| Pilot Incapacitation | PIC | **If possible:**   1. Upon feeling as though incapacitation is imminent activate RETURN TO LAND mode 2. Call ***‘Pilot Incapacitated – Returning to Land’*** |
| GSC | 1. Upon noticing the PIC has become incapacitated activate RETURN TO LAND mode via telemetry 2. Call ***‘Pilot Incapacitated – Returning to Land’*** 3. Ensure that the PIC is not in any imminent danger from a returning aircraft 4. Ensure that the landing site (where aircraft was armed) is clear of all persons; instruct GEC / spotters to assist as required 5. Call for the emergency services if required, or instruct GEC / spotters to do so if available 6. Once the aircraft lands and shuts down disconnect the flight battery. |
| GEC / Spotters | 1. Upon hearing call ***‘Pilot Incapacitated – Returning to Land’*** check primary landing site (RTL location) is clear of persons 2. Assist GSC as instructed |
| Fire (Ground Equipment) | All Crew | 1. Upon noticing fire call ***“Ground Fire”*** 2. If the fire is a Lithium Polymer battery fire do not try to extinguish, allow the battery to burn out and then extinguish any additional fires. 3. If the fire cannot easily be extinguished and increases in size call the emergency services. |
| Fire (Aircraft in Flight) | PIC | 1. Upon noticing / being made aware of an aircraft fire call / confirm *“****Aircraft Fire”*** 2. **I**dentify nearest safe landing site (take advice from GSC if available). 3. Proceed directly to nearest safe landing point. Call ***‘Emergency Landing’***, ***‘Emergency Landing, Alternate’***, or ***‘Emergency Landing NOW’***, etc. as appropriate 4. Upon landing shut down the motors. 5. Approach the aircraft (or instruct crew as appropriate) with a fire extinguisher and continue as per the Fire (Ground Equipment) procedure |
| GSC | 1. Upon identifying an aircraft fire call *“****Aircraft Fire”.*** 2. Immediately identify the nearest safe landing point and advise the PIC. 3. Once landed, approach the aircraft with a fire extinguisher and continue as per the Fire (Ground Equipment) procedure |
| GEC / Spotters | 1. Upon identifying an aircraft fire call *“****Aircraft Fire”.*** 2. Upon hearing *“****Aircraft Fire”*** *c*heck landing areas are clear of persons (PIC will call where aircraft will be landed) 3. Once landed treat the emergency as per the Fire (Ground Equipment) procedure. |

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| Emergency Type | Responsibility Delegated to | Action Required |
| UA exhibits poor or limited control  UA appears ‘bouncy’ or high unexpected vertical thrust  (Probable excessive vibration affecting accelerometers) | PIC | 1. Set Flight Mode to STABILISE 2. Call ***‘Limited Control’*** 3. Identify nearest safe landing site 4. Call ***‘Emergency landing’, ‘Emergency landing, Alternate’***, or ***‘Emergency Landing NOW’*** as appropriate 5. Proceed to land in STABILISE mode |
| GSC | 1. Upon hearing call *‘Limited Control’* check nearest safe landing site; advise PIC. 2. Once PIC has confirmed landing site, ensure that the landing site is clear of all persons; instruct GEC / spotters to assist as required |
| GEC / Spotters | 1. Once PIC has confirmed landing site, ensure that the landing site is clear of all persons; instruct GEC / spotters to assist as required 2. Assist PIC / GSC as instructed |
| UA ‘toilet bowling’ around waypoints or in LOITER  (probable magnetometer failure / interference) | PIC | 1. Set Flight Mode ALT HOLD 2. Call ***‘Navigation Failure’*** 3. Identify safe landing site (consult GSC if applicable) 4. Call ***‘Emergency landing’, ‘Emergency landing, Alternate’***, or ***‘Emergency Landing NOW’*** as appropriate 5. Proceed to land in STABILISE mode |
| GSC | 1. Upon hearing call *‘Navigation failure’* check nearest safe landing site; advise PIC. 2. Once PIC has confirmed landing site, ensure that the landing site is clear of all persons; instruct GEC / spotters to assist as required |
| GEC / Spotters | 1. Once PIC has confirmed landing site, ensure that the landing site is clear of all persons; instruct GEC / spotters to assist as required 2. Assist PIC / GSC as instructed |