Aircrew Operator’s and Maintenance Manual: Tarot 650

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1. Introduction

The Tarot 650 is a commercial hobby type UAS commonly used for photography and recreational use, and provides a stable platform for aerial photography. This document describes operating and maintenance procedures developed with the help of the University of Nevada AirCTEMPs instrument center. This document is intended for AirCTEMPs aircrew familiar with the operations and maintenance of the Tarot 650. The following Turbo Ace documents provide supplemental and more detailed information: Tarot 650 User’s Manual and the NAZA-M LITE GPS User’s Manual.

1.1 Performance Specifications

**Aircraft**
- Weight (including battery): 2180g
- Max. Payload: 1500g (battery weight dependent)
- Optimal Payload: 1130g
- Max yaw (angular velocity): 200°/s
- Max tilt angle: 35°
- Max flight speed: 15m/s
- Max flight altitude A.G.L.: 122m (FAA regulations, Geofenced)
- Flight time: 40min (assuming 22000mAh)

**Radio Control**
- Frequency: 2.4GHz
- Operating Temperature: -10.0°C - 50.0°C
- Working Voltage Range: 7.2V – 22.2V
- Work Amperage: 40A nominal with 70A max spike

**Drone LiPo Battery**
- Type: Lithium Polymer
- Weight: ~2500g
- mAh: 22000
- Vdc: 14.8 (6 cell)
2. Operation Checklists

2.1 Tarot 650 Pre-Mission Checklist
   ___ Flight Log, Registration, Manual, Check lists, Com Radios
   ___ NOTAM?
   ___ Prefetch imager of flight location for waypoint planning
   ___ Log Book Check. Firmware matches version in maintenance log?
   ___ Mission Planner Version matches maintenance log?
   ___ Airframe: no cracks or separations
   ___ Folding arms in good condition
   ___ Arm retention clips in good condition
   ___ Motors free and no roughness; only slight detent
   ___ Motor Airframe and Accessory screws tight
   ___ Battery Velcro support straps in good condition
   ___ Propellers, spares in good condition, tightened
   ___ Gimbal guards in place (when applicable)
   ___ Batteries half charge (3.85V) for transport, or full charge if mission imminent
   ___ Battery chargers (LiPo battery, controller battery, laptop battery, transmitter)
   ___ Control switches, sticks
   ___ Primary and backup laptop check and map(s) Pre-fetched
   ___ Primary and spare USB cables
   ___ Sony A5100 Camera functional (batteries, SD cards...)
   ___ Multispectral checklist (when applicable)
   ___ SD card(s) cleared
   ___ Transmitter Calibrated?

2.2 Preflight Checklist
Registration, Manual, Log, Com Radios

Craft
Airframe and Hardware Check

43
Gimbal
Propellers
Battery
Camera
VHF Radio
Center of Gravity
Gyro
Motors
Camera SD Card
Take off Pad
Locks removed and gimbal free (if necessary)
No nicks, cracks, on correct motors (cw, ccw)
Strapped and secured
Mounted, secured
On, tuned to local ATC
Check. If off, re-adjust battery
Calibrated
Free, slight detent
Installed
Placed

**Control**

Sticks
Controller
Laptop
Antenna
Full and smooth
Display Check
Attached, screen clean
45 degrees

### 2.3 Power Up Checklist

Control
Laptop
Video Monitor
Tx
Connection Established
GPS lock
Data Channel
Compass
Home Point
Take off Area
On
On
On
Check
Check. Wait 2-3 minutes after power up
Check and set
Calibrate if new location
Establish
Clear for 10m

### 2.4 Takeoff and Hover

Taking off Home Point
GPS fix
Gyro, Controls
Video Link
Telemetry Data Collection
Tx Range Check
Arm Trigger
Flight Mode Switch
Flight Mode
Camera Gimbal
Camera
Check (auto created by Mission Planner)
>6 satellites. HDOP < 2.0m
All axis check
Check (if applicable)
Check
Operation at 175ft
Armed (Solid Red)
Check
“Hover”
Check
Start
Take off
Attitude
Climb
Mission

Ascend to 20m
Check all axes
To Mission Altitude
Initialize (when applicable)

2.5 Landing and Shut Down

Camera
Landing Area
Motors
Battery and Flight Time
Flight Battery

Stop
Clear for 10m
Stopped
Recorded
Power Off

2.6 Post Flight

Flight Battery
Control
Motors
Gimbal
Airframe and Hardware.
Camera SD card.
Battery status and Flight Time
Aircraft Telemetry Logs

Off (too hot?)
Off, throttle down
Check and remove propellers
Install locks, remove camera
Check
Removed and mission labeled. Backup and transfer data
Logged and Recorded
Backed up and downloaded
3. Lost Link Procedures

3.1 Tarot 650 Lost Link Protocol
Turbo Tarot 650 signal loss protocol, or fail-safe protocol, is initiated if control signal is interrupted or lost. This will initiate a return to home function. If signal is lost, the failsafe will initiate.

3.2 Taranis X9D Radio Failsafe Procedure
An automatic failsafe procedure is programmed into the TAROT 650, so that in the event of controller signal loss, the “Return Home” feature is automatically enabled. Ardupilot Failsafe Webpage for steps on how to configure this feature.

Failsafe should trigger when:
- RC transmitter is turned off
- UAS travels beyond RC transmitter range (500 – 700m)
- RC receiver power loss
- Physical connection between flight controller and receiver is broken.

When Failsafe triggered:
- If vehicle is not armed, nothing will happen
- If armed, motors will disarm immediately if UAS is on ground or pilots has throttle set to zero in a stabilize or acro mode
- If has GPS lock, RTL feature will be initialized (within 2 meters of home position)
- If has no GPS lock, UAS will land.

Failsafe clears before landing, UAS will stay in the current flight mode. You will have to manually return to desired flight mode, or let failsafe complete is process.

3.3 Home Point Establishment
The PIC shall access the flight course to determine if terrain or obstacles are within the course area. If there are any terrain or obstacles, PIC must be aware that the return to home, though automatically established at startup if using Mission Planner software, function will not automatically avoid these features. The Turbo Ace flight controller does not provide a means of programming a remote lost link landing point.

3.4 Fly-Away
The Turbo Ace flight controller failsafe mode is to land immediately or return to home. Because of this fly-away is unlikely to occur providing that proper start up procedures are followed and the craft is not launched before GPS satellite acquisition has occurred and home point has been established.

In the event of a suspected fly-away the craft should be monitored, after abovementioned attempts to correct the errant flight have been attempted, and if it
appears the craft is not responding to controls, or does not appear to be following fail safe mode of land immediately or return. ATC shall be notified of the last position and altitude and heading of the craft, and of the approximate flight time remaining.

3.5 Recovery
All reasonable efforts shall be made by the flight crew to recover lost aircraft, with crew safety a priority.

3.6 Imminent Crash
If all attempt to regain control fail and a crash is Imminent. PIC is to first: attempt to, if at all possible, steer the UAS away from bystanders and other field workers. Second: audibly communicate to any nearby workers or bystanders of the imminent crash, forcing all nearby personnel and bystanders to keep their eyes on the UAS if possible.
4. Maintenance

4.1 Introduction
Because the Tarot 650 is powered by electric motors and lithium polymer batteries, and the manufacture Turbo Ace does not have a specified TBO or specified periodic maintenance, AirCTEMPs conducts physical inspection of craft pre- and post-flight and post-mission for any mechanical defects or indication of ware or aging of the airframe and components. Since flights are of a duration of approximately 25-30 minutes, because of battery capacity, problems with propulsion motors such as indications of bearing ware should be evident on inspection and initial power up. Also because of the short duration of flight, motors have a low likelihood to fail catastrophically during flight. Because this is a multi-rotor VTOL craft and does not have control surfaces, there are no moving parts or actuators other than the flight motors that require inspection or for ware or function. The lithium polymer battery life expectancy is dependent on charge and discharge rates and storage practices, and have an unpredictable life expectancy. To predict battery replacement interval, the voltage of each battery shall be recorded in a battery log along with the flight time and the percent battery remaining as indicated on the laptop display.

4.2 Inspection and Maintenance Procedures
UNR AirCTEMPs Tarot 650 is to be inspected by the PIC pre- and post-flight- and pre- and post-mission by the AirCTEMPs Technician.

Pre- and Post-mission Inspection

_____ Static Start Up
Remove gimbal locks. Remove propellers or secure aircraft landing gear to test bench. Start aircraft and ensure indicator lights and annunciators are functioning. Arm motors and listen for uniform idle operation.

_____ Control
Test control sticks for correct motor response. Test function of controller switches, and sticks.

_____ Firmware
Check last firmware update in log book and confirm firmware is current version. Update as needed.

_____ Airframe
Airframe has no cracks or separation. Replace airframe shell or other components if cracks are detected. Shell separation may be due to miss alignment and may snap into
place with slight pressure. Confirm that shell separation is not due to missing or loose screws or hardware, and replace any damaged components.

_____ Motors

Motors free and no roughness. Inspect motors visually for any debris between rotor and stator. Place propeller on motor and spin with finger to confirm motors turn freely with slight detent due to motor magnets. Any grinding, ticking or squeaking sound may indicate debris in the motor or worn bearing. Clean or replace motor as necessary.

_____ Propellers

Inspect primary propellers and spares for cracks chips or nicks. Replace cracked or chipped propellers. Small nicks may be sanded or burnished, however it is advisable to replace rotors with even slight defects.

_____ Gimbal

Inspect gimbal for free movement and put guards in place. GoPro for storage and transportation (post mission).

_____ Batteries

Confirm batteries are at half charge for long term storage or full charge if mission is imminent.

Check batteries for bloating. This in an indication of a failing LiPo battery. If battery shell is bloated, replace as soon as possible and do not continue use.

_____ Laptop

Check laptop for current Mission Planner/software updates. Ensure it is current.

_____ Accessories

Check flight, controller and laptop battery chargers cables and connectors.

_____ Test Flight

Schedule test flight if control systems, propulsion motors or airframe components have been replaced, or if firmware has been upgraded.