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

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

Control

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

2.3 Power Up Checklist

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

2.4 Takeoff and Hover

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

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Take off	Ascend to 20m
Attitude	Check all axes
Climb	To Mission Altitude
Mission	Initialize (when applicable)

2.5 Landing and Shut Down

Camera	Stop
Landing Area	Clear for 10m
Motors	Stopped
Battery and Flight Time	Recorded
Flight Battery	Power Off

2.6 Post Flight

Flight Battery	Off (too hot?)
Control	Off, throttle down
Motors	Check and remove propellers
Gimbal	Install locks, remove camera
Airframe and Hardware.	Check
Camera SD card.	Removed and mission labeled. Backup and transfer data
Battery status and Flight Time	Logged and Recorded
Airfraft Telemetry Logs	Backed up and downloaded

3. Lost Link Procedures

3.1 Tarot 650 Lost Link Protocol

Turbo Taro 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 Taro**t** 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.