Flight Manual			
Pavaman Aviations Private Limited			
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Pavaman
Aviation

TEJA - M

INDEX

List of Figures

List of Tables

Disclaimer

Thank you for purchasing the TEJA-M, an advanced industrial drone developed by Pavaman Aviation Pvt. Ltd. This manual is designed to guide you through the safe and efficient operation of your TEJA-M drone. Please read and follow all instructions carefully. Disregarding the instructions provided in this manual may result in immediate UIN cancellation, voided warranty, and severe legal consequences.

Important Notices

NOTE: Draws attention to any special item not directly related to safety but is important or unusual.

CAUTION: Disregarding the following instructions leads to serious or long-term deterioration of flight safety.

WARNING: Disregarding the following instructions leads to an immediate or severe deterioration of flight safety and hazardous situations, including such resulting in personal injury or damage to property.

Critical Warning: Disregarding the following instructions may result in immediate UIN cancellation, voided warranty, and severe legal consequences.

1. Introduction

1.1. General Information

The TEJA-M stands as an innovative Remotely Piloted Aircraft System (RPAS), specifically engineered as a hexacopter for agricultural spraying applications. This rotorcraft boasts a robust and meticulously designed airframe coupled with cutting-edge electronics, making it a trailblazer in the realm of precision agriculture. Designed to revolutionize precision agriculture through efficient and targeted crop spraying, the TEJA-M not only prioritizes operational efficiency but also integrates a master-slave RC configuration for training. This setup allows for real-time control transfer between instructors and trainees, enhancing hands-on learning and safety in Remote Pilot Training Organizations (RPTOs).

UAS TYPE	Rotorcraft
UAS STRUCTURE	Hexacopter
UAS CLASS	Medium
UAS CATEGORY	Remotely Piloted Aircraft System (RPAS)
UAS APPLICATION	Agricultural Spraying with live monitoring and specialized training for RPTO usage
UAS GROUND CONTROL STATION	AeroGCS Green (Version - v1.39)
UAS PRIMARY TRANSMITTER	SIYI MK15
UAS BUDDY SYSTEM TRANSMITTER (Optional)	Skydroid T12

Table 1

Figure 1.1.1 : TEJA-M Unfolded

Figure 1.1.2: TEJA-M Folded

1.2. Purpose of Flight Manual

The TEJA-M Agriculture Drone Flight Manual is an essential document designed to provide pilots and users with comprehensive information to ensure the safe and efficient operation of the TEJA-M drone. This manual serves as a guide covering all aspects of drone operation, including take-off and landing procedures, flight operations, emergency procedures, and maintenance. It provides detailed instructions and performance data to help pilots understand the capabilities and limitations of the drone and how to use them effectively. By adhering to this manual, pilots and operators can ensure they have the necessary information to fly the drone safely, efficiently, and in compliance with regulations.

It serves as a reference guide for pilots and operators, providing them with the necessary information to fly the drone safely and efficiently.

1.3. Drone Make and Model

Manufacturer: Pavaman Aviation Private Limited

Model: TEJA-M Hexacopter

The TEJA-M is a state-of-the-art hexacopter designed for agricultural monitoring and spraying. It features robust construction, high-precision GPS, a stabilized camera, and multiple flight modes to support a variety of missions.

1.4. TEJA-M Specifications

Specification	**Details**
Dimensions	
Width Unfolded	2.037 meters
Height Unfolded	0.581 meters
Length Unfolded	1.844 meters
Weight	
Empty Weight	11.46 kg
Maximum Takeoff Weight (MTOW)	30.5 kg
Power	
Battery	Li-Ion 6s, 25200 mAh (two batteries in series)
Maximum Power Consumption	2380.29 W
Performance	
Maximum Flight Duration	● Endurance with maximum variable payload without dispensing: 12 minutes ● Endurance without variable payload: 25 minutes
Maximum Horizontal Speed	10 m/s
Maximum Ascend Speed	2.5 m/s
Maximum Descent Speed	0.5 m/s
Operating Temperature	-10°C to 50°C
Wind Resistance	Up to 6 m/s
Operating Voltage Range	36 V to 50.2 V

Table 2

1.5. Component List

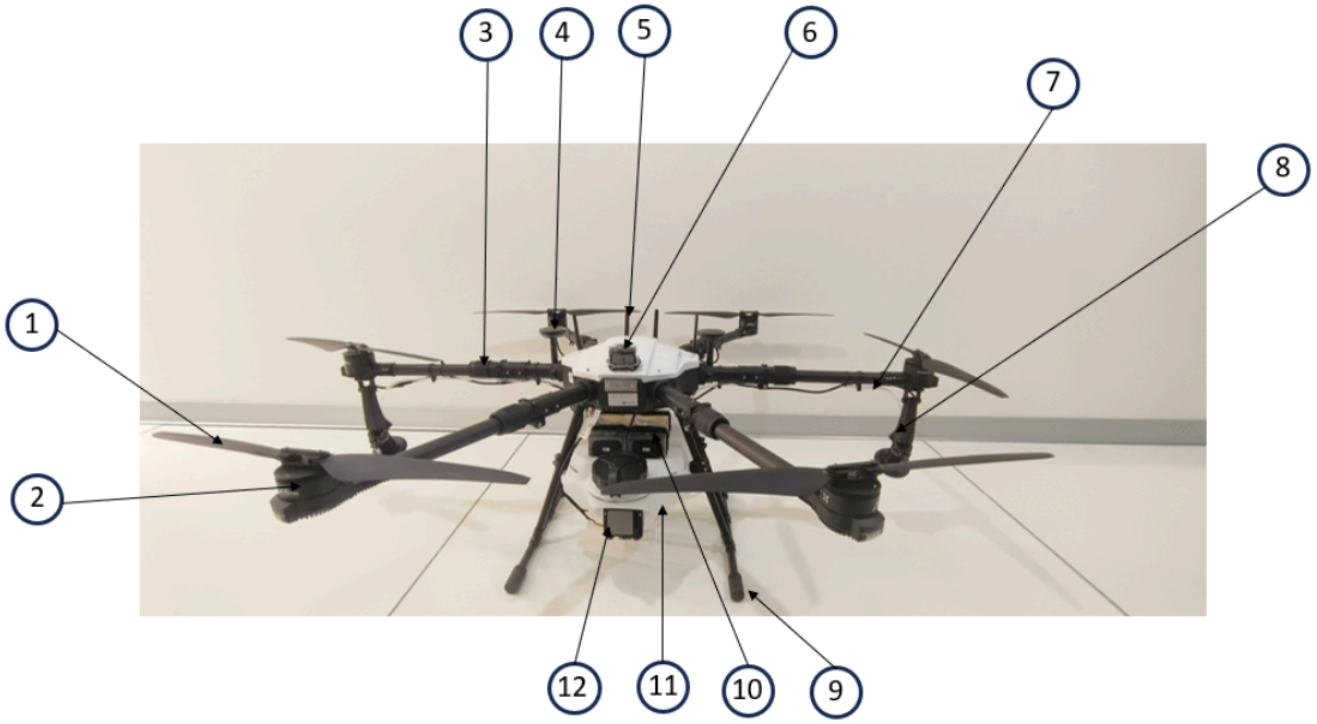


Figure 1.5.1: Component Nomenclature

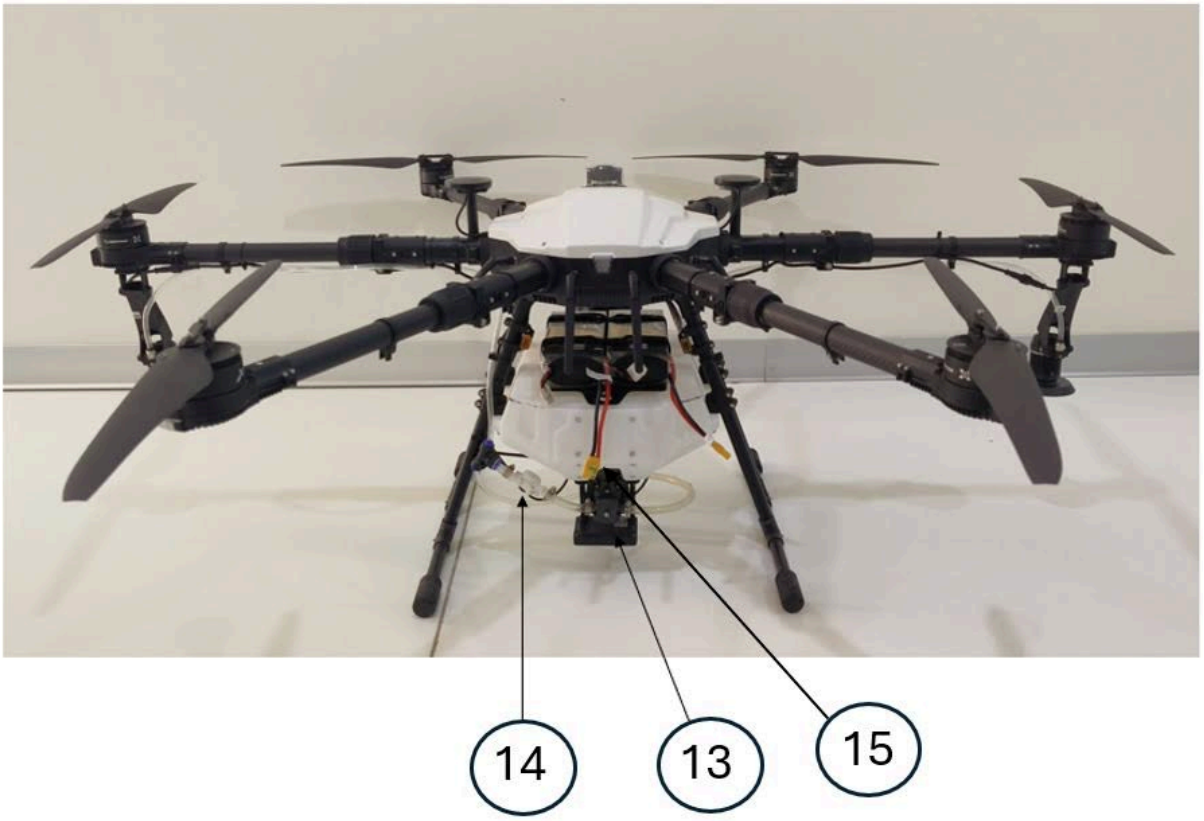


Figure 1.5.2: Component Nomenclature

Sr. No.	Component	Type of component	Quanti ty	Part Number	Description
1	Propellers	User removable	6	TEJA-PROP-0 01	High-efficiency propellers
2	Motor	Non user removable	6	TEJA-MOT-0 01	High-torque brushless motors
3	Hexacopter Airframe	Non user removable	1	TEJA-FRAM E-001	Carbon fiber reinforced airframe
4	GPS	Non user removable	2	TEJA-GPS-00 1	GPS modules for navigation
5	Antennae	Non user removable	4	TEJA-ANT-00 1	Communication antennae

6	Camera	Non user removable	1	TEJA-CAM-A8	A8 mini camera for live feed monitoring
7	Spraying Pipes	User removable	1 set	TEJA-SP-001	Pipes for liquid spraying
8	Centrifugal Nozzles	User removable	2	TEJA-NOZ-001	High-precision centrifugal nozzles
9	Landing Gears	Non user removable	2	TEJA-LG-001	Sturdy landing gears
10	Battery	User removable	2	TEJA-BAT-25200	Li-Ion 6s, 25200 mAh battery packs
11	Tank	Non user removable	1	TEJA-TANK-001	Liquid storage tank
12	Obstacle Avoidance Sensor	Non user removable	1	TEJA-OAS-001	Sensor for obstacle detection and avoidance
13	Terrain following sensor	Non user removable	1	TEJA-TFS-001	Terrain Following Sensor
14	Liquid Level Sensor	Non user removable	1	TEJA-LLS-001	Sensor for monitoring liquid levels in the tank
15	Pump	Non user removable	1	TEJA-PUMP-001	High-efficiency liquid pump

Table 3

Do not tamper with or attempt to remove non-user-removable components. Do not remove or tamper with void tapes. These are in place to ensure the integrity of the drone's components. Do not open the canopy. Unauthorized access to the drone's internal components can lead to serious malfunctions

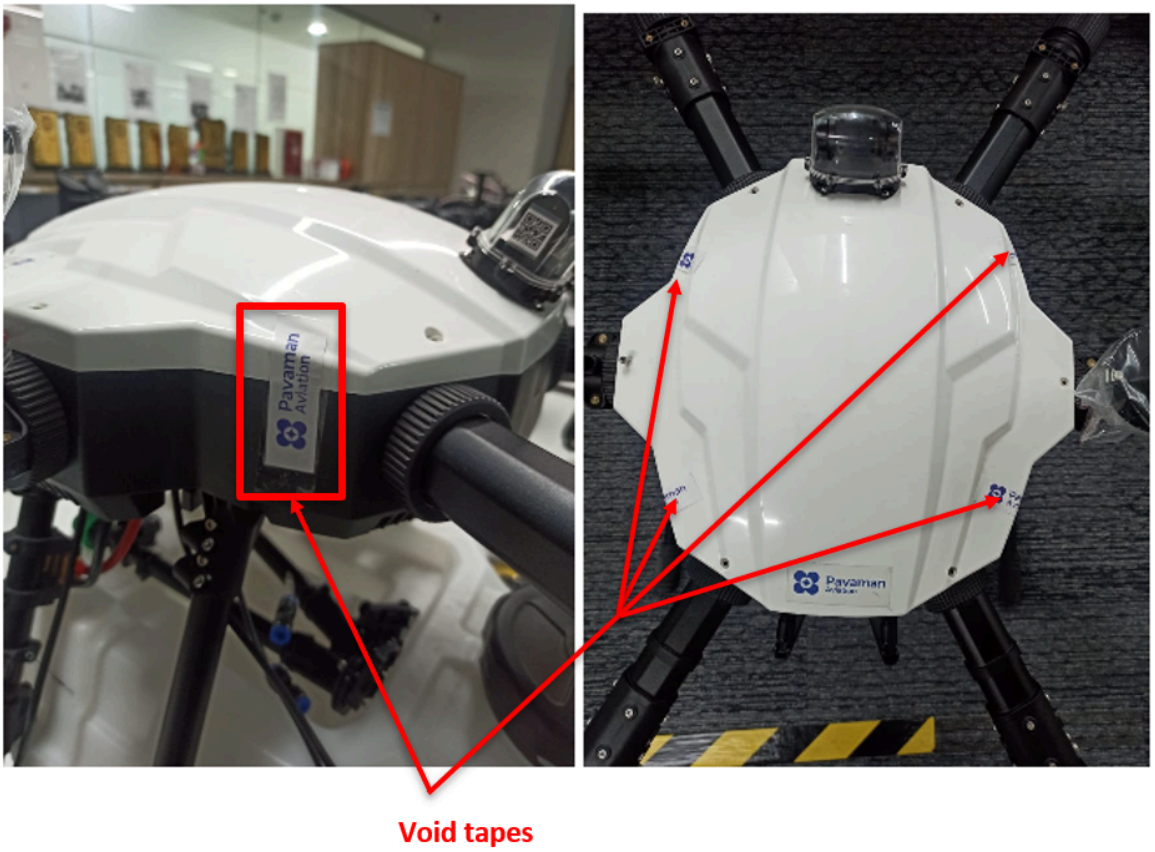


Figure 1.5.3: Void Tape

TEJA - M relies on GPS altitude readings for altitude control. The absence of barometric equipment in TEJA - M is a deliberate design choice tailored to its intended use for agricultural spraying during daylight hours with a restricted altitude ceiling and VLOS operations only. TEJA- M is not equipped with anti-collision strobe lights, as its design and functionality are optimized for daytime operations.

1.6. System Diagram

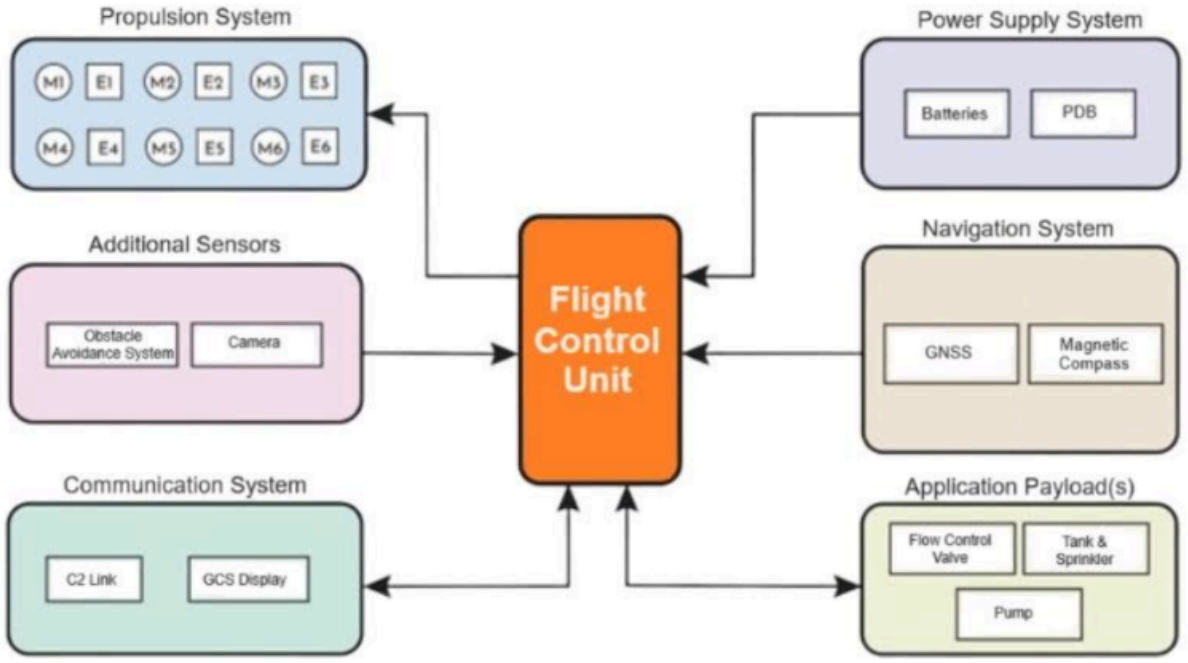


Figure 1.5.4: System Diagram

2. Safety Guidelines

2.1. Safety Protocols for Handling and Operating the Drone

1. Always follow the manufacturer's guidelines for operation and maintenance.
2. Keep a safe distance from the drone while it is in operation.
3. Wear appropriate safety gear (e.g., goggles, gloves) when handling the drone.

Never operate the drone near people, animals, or restricted areas.

Flight trial tests and Vibrational analysis confirms that the drone operates free from resonance and harmful vibrations, ensuring safe and reliable performance.

2.2. Protective Gear

- **Goggles:** Protects eyes from debris and bright sunlight.
- **Gloves:** Provides a better grip and protects hands from sharp edges.
- **Safety Vest:** Enhances visibility in operational areas.

2.3. Local Aviation Regulations

- Adhere to the maximum altitude and distance limits as specified by local authorities.
- Avoid flying in restricted areas such as airports and military zones.
- Obtain necessary permissions and licenses for commercial operations.

Links to Regulatory Bodies for More Detailed Information

- Drone Rules, 2021
- Airspace Map

3. Operational Limitations

Understanding the operational limitations of the TEJA-M drone is crucial for ensuring its safe and efficient use. This section outlines the key operational parameters, their specifications, and implications for flight performance.

3.1. Maximum Takeoff Weight

The maximum takeoff weight (MTOW) for the TEJA-M drone is 30.5 kg.

Implications on Flight:

- Exceeding the MTOW can significantly impair the drone's performance, leading to reduced maneuverability and increased power consumption.
- Overloading the drone may result in structural stress, potentially causing damage to the airframe and components.

Always ensure the combined weight of the drone, payload, and any additional equipment does not exceed the MTOW to maintain optimal performance and safety.

Do's:

- **Do** verify the total weight of the drone and payload before every flight.
- **Do** use a calibrated scale for accurate weight measurement.

Don'ts:

- **Don't** attempt to take off with a weight exceeding 30.5 kg.
- **Don't** ignore weight limitations for the sake of carrying additional payload.

3.2. Maximum Payload Weight

The maximum payload weight for the TEJA-M drone is 10 kg or 10 liters of water. The tank has a maximum capacity of 11 litres, but it is recommended to fill it only up to 10 litres until the marking shown in below image to allow 1 litres of space for frothing. This precaution ensures optimal performance and prevents spillage during operation. The user must not fill the tank beyond 10 litres, it may cause safety problems.

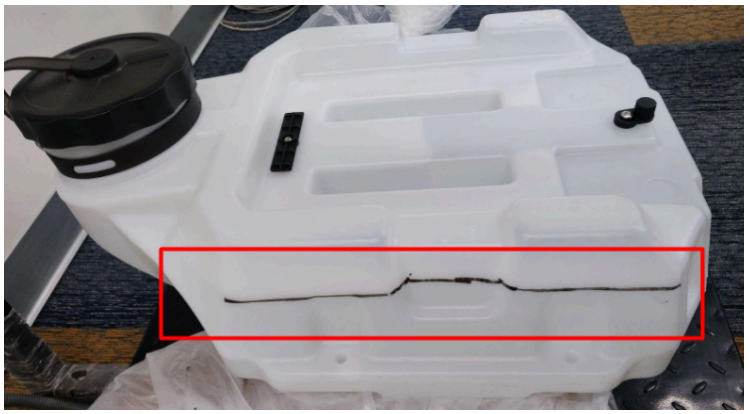


Figure 3.1 - Payload Tank limit

Impact on Performance:

- Payload weight directly affects the drone's flight duration, speed, and handling characteristics.
- Higher payload weights result in shorter flight times due to increased power consumption.

Balancing payload weight with mission requirements is essential to achieve the desired performance without compromising safety.

Do's:

- **Do** plan your mission according to the payload capacity.
- **Do** regularly check the payload attachment for security.

Don'ts:

- **Don't** exceed the 10 kg payload limit.
- **Don't** assume the drone can handle additional weight without testing.

TEJA-M is not equipped with SSR Transponder, Actuators, Servos, GSM, RFID, ADS-B, Barometric equipment with sub-scaling settings

3.3. Environmental Operating Conditions

Temperature Range:

- The TEJA-M drone is designed to operate in temperatures ranging from -10°C to 50°C.

Cold temperatures below -10° C will negatively impact the performance and endurance of the flight. The pilot must be aware and compensate during flight planning.

Wind Speed Limits:

- Maximum safe operational wind speed is 6 meters per second.
- High wind conditions can impair flight stability and control, requiring cautious operation and potentially limiting mission scope.

The pilot must be aware that a wind speed of 6 m/s as recorded on the ground may in fact be stronger as the altitude increases. The wind rating of 6 m/s does not distinguish between a constant wind speed and a gust. Pilots understand that flying the UAS in wind conditions greater than 6 m/s is at their own risk.

Humidity Considerations:

- The drone can operate in relative humidity levels up to 90%, but pilots should be aware of the potential for condensation and moisture ingress, especially in tropical environments.

Proper maintenance and storage are essential to prevent moisture damage.

Do's:

- **Do** check environmental conditions before each flight.
- **Do** operate the drone within the specified temperature and humidity range.

Don'ts:

- **Don't** fly the drone in adverse weather conditions without proper assessment.
- **Don't** ignore humidity and temperature warnings.

Understanding and adhering to these operational limitations ensures the safe and effective use of the TEJA-M drone. Operators should always consider these parameters during mission planning and execution to maximize performance and ensure compliance with regulatory requirements.

By following these guidelines, operators can ensure the longevity and reliability of the TEJA-M drone, while maintaining safety and legal compliance.

TEJA-M is not built for operation in rain, snow or in intensely-dusty conditions.

Do not operate the TEJA-M RPA during nighttime or in low-visibility conditions without proper lighting and permissions.

4. Operating Procedures

4.1. Turning ON/OFF the Transmitter and Connecting to Ground Control Station

Turning ON the Transmitter:

1. **Power Button Sequence:**
    - **Single Press:** Give a single press on the power button of the transmitter.
    - **Long Press:** Follow it with a long press on the power button until the transmitter powers up.

Figure 4.1.1: Power Button Sequence

2. **Confirmation:** The transmitter screen will light up, indicating it is powered on.

Connecting to Ground Control Station (GCS):

1. **Open GCS App:**
    - Click on the **Aero GCS Green** app on your device.
2. **Access Connection Menu:**
    - Once the app is open, locate and click on the **three dots symbol** at the top right corner of the screen.
    - From the menu that appears, select the "**Connect**" option.

Figure 4.1.2: Connecting GCS

3. **Select Communication Link:**
    - In the connection settings, click on the **communication link type drop-down menu** and choose **"Bluetooth."**

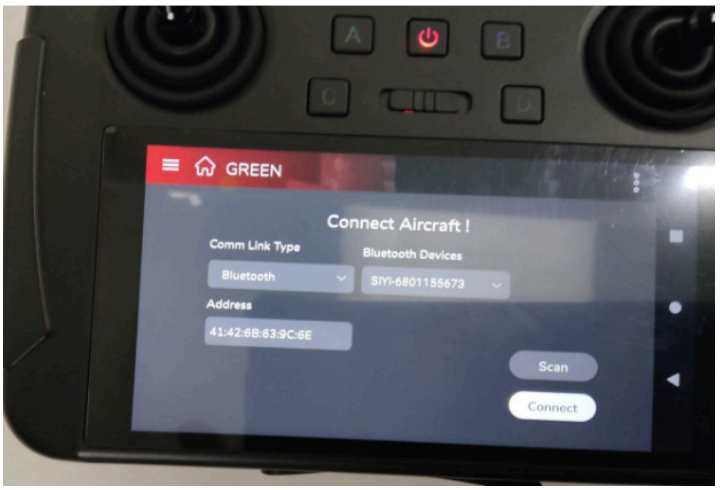


Figure 4.1.3: Selecting Communication Link

4. **Scan for Devices:**
    - Click on the **"Scan"** option to discover available Bluetooth devices.
5. **Select and Connect:**
    - From the list of devices, select the **"SIYI-6801155673"** Bluetooth device.
    - Click on the **"Connect"** button to establish a connection between the GCS and the drone.

6. **Confirmation of Connection:**
    - Once connected, the app should display a screen indicating the successful connection.

Figure 4.1.4: Visual Signal After Connection Successfully

Disconnecting and Turning OFF the Transmitter:

1. **Disconnecting the Drone:**
    - To disconnect the drone and RC, **disconnect the batteries**. This will terminate the communication link between the drone and the remote control (RC).
    - The RC may display a **red indicator**, indicating that the drone is disconnected.
2. **Turning OFF the RC:**
    - **Single Press:** Give a single press on the power button.
    - **Long Press:** Follow it with a long press until the transmitter powers down.

Figure 4.1.5: Turning Off the C2 link transmitter

Following these steps will help you properly turn ON and OFF the transmitter, establish a connection with the GCS using Bluetooth, and manage the communication link between the drone and the RC.

Always turn on the transmitter before connecting the drone's battery to avoid unexpected behavior.

Turning off the transmitter before disconnecting the drone's battery may result in loss of control.

4.2. Control And Communication

The TEJA - M hexacopter utilizes the SIYI MK15 communication system, offering advanced features for remote control and high-definition image transmission. The MK15 radio controller serves as a comprehensive and cost-effective solution, seamlessly integrating RC, video, data, and an Android system into one device.

The **TEJA-M Hexacopter** primarily utilizes the **MK15 Transmitter** for its communication and telemetry systems. This transmitter serves as the primary link for real-time control, data transmission, and operational feedback between the drone and the pilot.

In addition to the MK15 transmitter, the TEJA-M is equipped with a **T12 Transmitter and Receiver** system, which allows for the operation in **Buddy Mode** (Master/Slave configuration). This feature enables two pilots to share control of the drone, which is particularly useful for training and educational purposes, such as during Remote Pilot Training Organizations (RPTOs).

- **Primary Communication**: The MK15 transmitter is the primary system for controlling the TEJA-M and providing telemetry feedback.
- **Buddy Mode**: In Buddy Mode, the T12 system allows one pilot (slave) to control the drone while the second pilot (Master) can take over control if needed. This system is ideal for training scenarios, allowing an instructor to take control of the aircraft in case of emergencies or to guide the trainee in learning drone operation.
- **Control Switching**: The control of the drone can be switched between the MK15 and T12 transmitters, depending on the mode selected. While the T12 system can be used for training, the MK15 remains the primary telemetry and control interface.

This dual-communication setup enhances operational flexibility, making the TEJA-M suitable for both agricultural spraying operations and as a training platform for RPTOs.

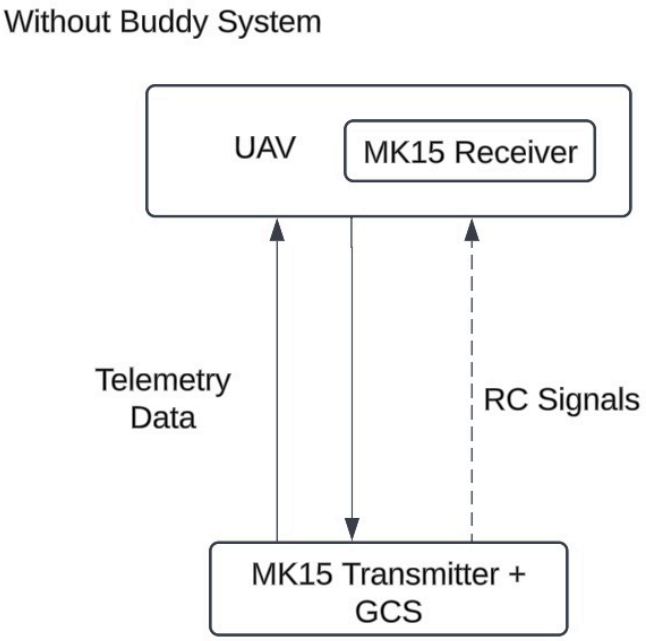


Figure 4.2.1: Communication link without Buddy system

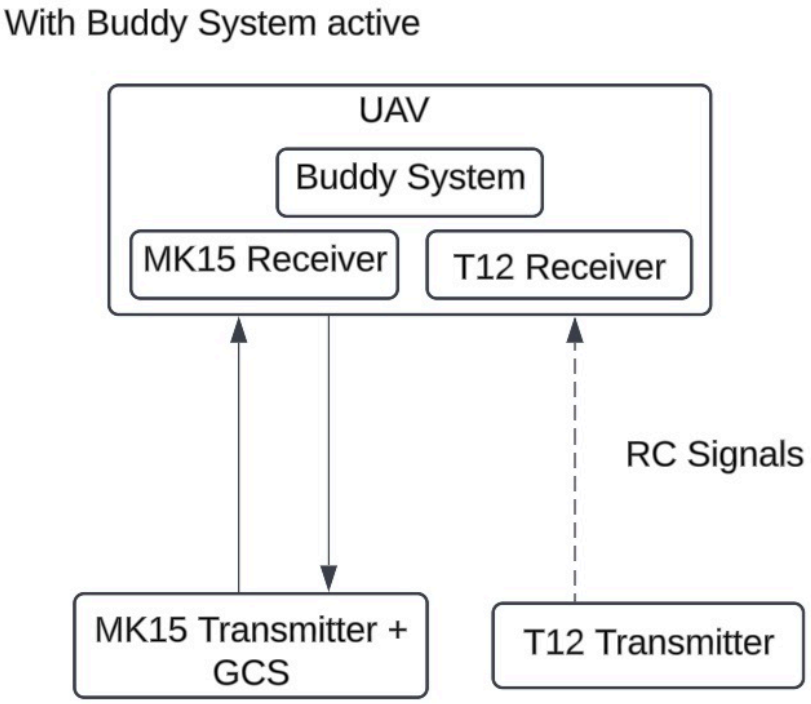


Figure 4.2.2: Communication link with Buddy system

4.2.1. Transmitter Nomenclature

Figure 4.2.3: C2 Link Transmitter Nomenclature

Figure 4.2.4: C2 Link Transmitter Nomenclature

Do not touch the antenna during operation. Doing so could interfere with transmission, causing a crash.

Do not carry or pull the transmitter by the antenna. The antenna wire could break and prevent transmission.

Figure 4.2.5: C2 Link Transmitter Nomenclature

Figure 4.2.6: C2 Link Transmitter Nomenclature

4.2.2. Button / Switch Types and Default Channel Definitions

MK15 remote controller comes with 13 physical channels and 16 communication channels in total. Communication channels 10 to 14 are also PWM channels 1 to 5 by default.

Channel No.	**Physical Channel Type**	**Default Mapping**
1	Roll	Joystick
2	Pitch	Joystick
3	Throttle	Joystick
4	Yaw	Joystick
5	Mode Switch	3-Stage Switch SA
6	Pump On/Off	3-Stage Switch SB
7	-	3-Stage Switch SC
8	Master/Slave	Button A
9	RTL	Button B

Table 4

4.2.3. Indicator Definition

The status indicators on MK15 remote controller and air unit use three different colors and different blinking frequencies to indicate the system's working or abnormal status.

4.2.3.1. Transmitter Indicator

🔴 Solid Red: No communication between transmitter and Air Unit.

🔴 Fast Red Blinks: The transmitter is binding to the Air Unit.

🔴 Slow Red Blinks: Firmware does not match.

🔴🔴🔴 Triple Red Blinks: Image transmission initialization failed.

🔴🔴🔴🔴 Four-time Red Blinks: The Transmitter requires calibration.

🔴🟢🔴🟢🔴 Red-Green-Red-Green-Red Blinks: Unexpected power off of MK15

4.2.4. RPA Manoeuvres

4.2.4.1. Arming/Take-off/Landing

- **Arming:** Perform a Combination Stick Command (CSC). The drone is armed.

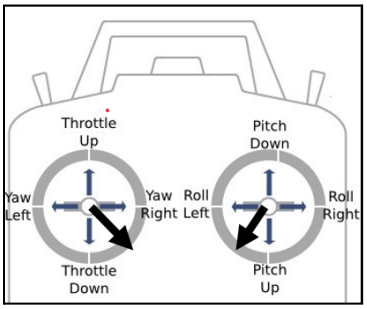


Figure 4.2.7 - RC Arming

- **Take-off:** Push the throttle stick up to take off.

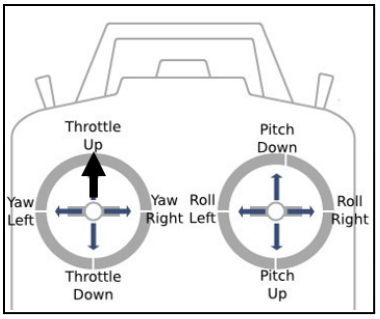


Figure 4.2.8 - RC take off

- **Landing:** To land, pull down on the throttle stick to descend until the aircraft touches the ground.

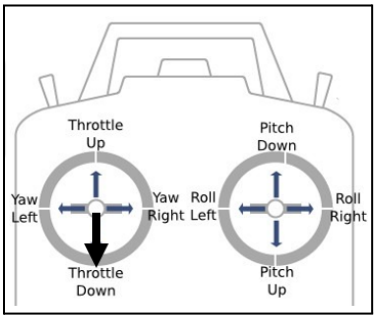


Figure 4.2.9 - RC Landing

- **Disarm**: Perform a Combination Stick Command (CSC). The drone is Disarmed.

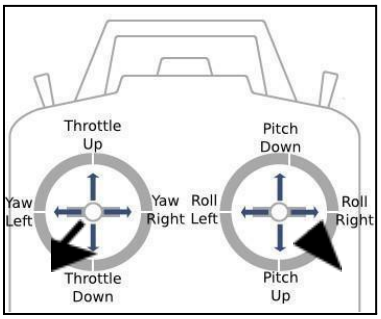


Figure 4.2.10 Disarming

4.2.4.2. Cruise / Maneuvering Flight

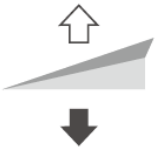
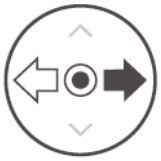
Remote Controller	Aircraft (Indicates nose direction)	Remarks
Left Stick 		Throttle Stick: Move the left stick vertically to control the elevation of the aircraft. Push up to ascend and push down to descend. Use the left stick to take off when the motors are spinning at an idle speed. The aircraft hovers in place if the stick is in the centre position. The further the stick is pushed away from the centre position, the faster the aircraft changes elevation.
Left Stick 		Yaw Stick: Move the left stick horizontally to control the heading of the aircraft. Push left to rotate the aircraft counter clockwise and push right to rotate clockwise. The aircraft hovers in place if the stick is in the centre position. The further the stick is pushed away from the centre position, the faster the aircraft rotates.
Right Stick 		Pitch Stick: Move the right stick vertically to control the pitch of the aircraft. Push up to fly forwards and press down to fly backward. The aircraft hovers in place if the stick is in the centre position. Push the stick further for a larger pitch angle and faster flight.
Right Stick 		Roll Stick: Move the right control stick Horizontally to control the roll of the aircraft. Push the stick left to fly left and right to fly right. The aircraft hovers in place if the stick is in the central position. Push the stick Further for a larger roll angle and faster flight.

Table 5

4.3. Standard Operating Procedure (SOP) for changing Speeds, Altitude, Range, Spray rate.

4.3.1. Flight parameters which user can change

The flight parameters which can be changed by the users but with a limit are

1. Speed (0 - 10 m/s)
2. Altitude (0-100m)
3. Range (0 - 1500m)
4. Spray Rate (0 - 100)

The objective of this SOP is to provide a step-by-step guide for the changing Speeds, altitude, range and Spray rate in the TEJA - M hexacopter used for agricultural spraying. Users can change the following parameters but with limits.

4.3.2. Procedure

Step 1: Select Flying Method -Automatic	

Step 2: Select Field Plot	
Step 3: Create Field Plot - Map	

Step 4: Add Point-Create Plot	
Step 5: Save Plot	


A
B
C
D
Add Point
Clear All
Save
Create Plan
Plot saved successfully
Obstacle
Plot


A
B
C
D
Add Point
Clear All
Save
Create Plan
AeroGCS GREEN
Do you want to use saved crop template for planning?
NO
YES
Obstacle
Plot

Step 6: Change Spray rate pressing symbols - in the left or + in the right or scrolling the center line.	
Step 7: Change Spray altitude pressing symbols - in the left or + in the right or scrolling the center line.	

Step 8: Change flight speed pressing symbols - in the left or + in the right or scrolling the center line.	
Step 9: Change Fence boundary pressing symbols - in the left or + in the right or scrolling the center line.	

Step 10:Save changes made	
Step 11: Upload the mission	

	
Step 12: Reviewing set parameters. The set parameters can be reviewed under the saved plan as shown above. Then start the mission.	

4.4. Battery Operation and Charging

Installation and Safety Precautions

Incorrect use can lead to serious fire, damage to your device, property damage, collateral damage, and serious injury. Read and follow all instructions carefully.

Do not use batteries other than recommended by Pavaman Aviation Private Limited

4.4.1. Battery Installation:

1. **Battery Tray:**
    - Place the set of batteries in the battery bay located on the tank.

Figure 4.3.1 - Battery Tray Location

2. **Battery Placement:**
    - Place the batteries as shown in image below and put straps on the battery

Figure 4.3.2 - Battery Placement

Ensure battery straps are securely tightened to prevent the battery from shifting during flight, which could lead to a loss of control.

3. **Connecting XT-90 Connectors:**
    - Connect the XT-90 connector of the drone with battery.

Figure 4.3.3- Connecting XT-90 Connectors

    - Listen for a single beep sound, indicating a proper connection.

The XT90 connectors prevent reverse connections and misalignment.

4.4.2. Pre-use Inspection:

1. **Damage Check:** Inspect the battery for any visible damage. Do not use it if damaged.
2. **Swelling Check:** Ensure the battery is not swollen. Do not use it if it is swollen.
3. **Leak Check:** Check for any electrolyte leakage. Do not use it if it is leaking.
4. **Connector Safety:** Avoid contact between connectors and metal or carbon fiber products to prevent short circuits.
5. **Temperature Safety:** Ensure the cell temperature does not exceed 50°C. Higher temperatures pose safety hazards.
6. **Power and Health Check:** Regularly monitor battery power and health.

4.4.3. Charging and Discharging:

1. **Noting Battery voltages:** The voltage is displayed in the battery charger. Battery voltages to be noted before charging and after charging and recorded in the battery log book.
2. **Monitoring:** Do not charge or discharge the battery without monitoring.
3. **Temperature Range:** Charge and discharge between 0°C to 40°C.
4. **Cold Environment Use:** Capacity drops sharply in cold environments. Fully charge the battery and keep it warm if operating between -10°C to 5°C. Avoid using below -10°C.
5. **Overcharging:** Never overcharge the battery.
6. **Short Circuit:** Never connect battery positive and negative terminals together.
7. **Polarity:** Ensure correct polarity connection to equipment.
8. **Over-discharge:** Avoid over-discharging to prevent battery damage and swelling.
9. **Electrolyte Safety:** Avoid contact with skin or eyes. Rinse immediately with water if contact occurs, and seek medical help if necessary.
10. **Disassembly:** Never disassemble the battery.

4.4.4. Charging

Recommended charging settings:

- No. of cell : 6
- Voltage : 22.2 V
- Current : 8 A Mode
- Charge / Balance Charge
- Battery type : LiPo

PC1080 Charger:

- Capable of balancing and charging 2 packs of 6 cell batteries simultaneously.
- Three modes: fast charge, balance charge, and storage.

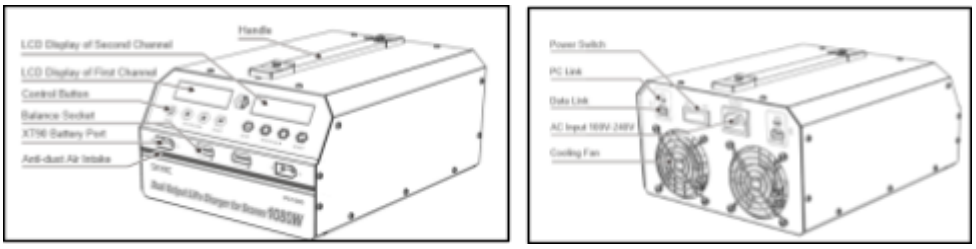


Figure 4.3.4 - Battery Charger

Features:

- Support charging 2 packs of 6S Li-ion batteries.
- Battery memorizing last charging current.
- Modes: fast charge, balance charge, storage.
- Safety: short circuit protection, reverse polarity protection, overheat protection.
- 2x16 LCD screen for real-time status display.
- Battery voltage meter and resistance meter.

Operational Steps:

1. **Power On:** Connect to the power source and turn on the switch. Listen for a beep sound and check the LCD screen.

Figure 4.3.5 - Charger Display

2. Parameter Settings:

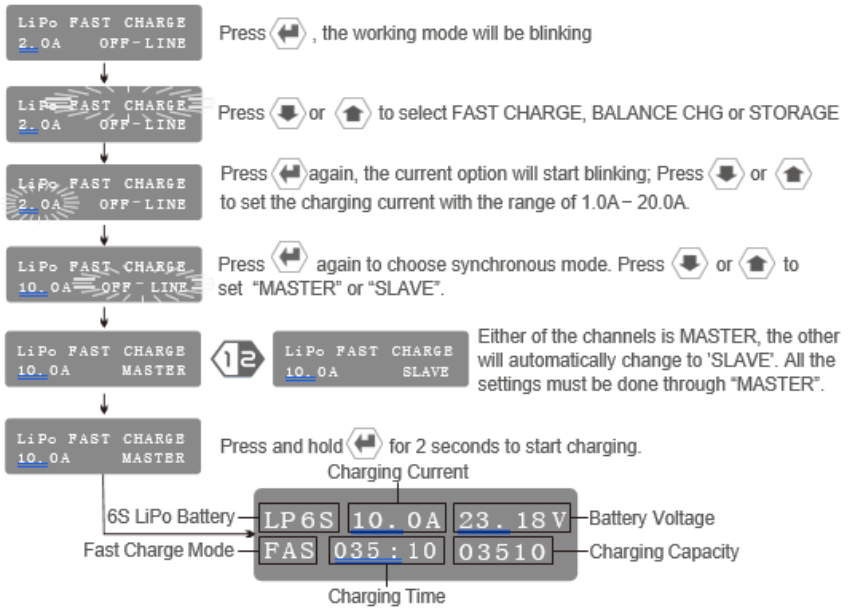


Figure 4.3.6- Parameter Settings:

3. **Battery Connection:** Connect batteries to the PC1080 charger as shown.

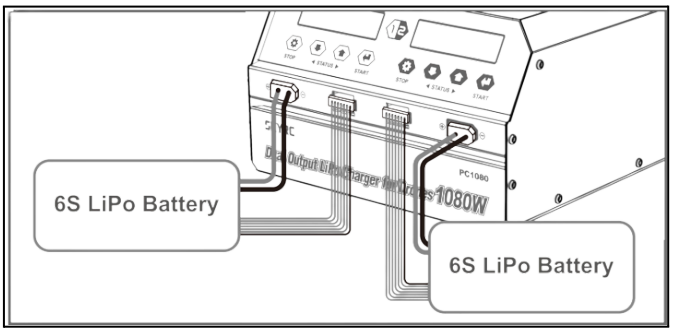


Figure 4.3.7 - Charging Operational Step

4. **Mode Change:** Change mode as shown below:

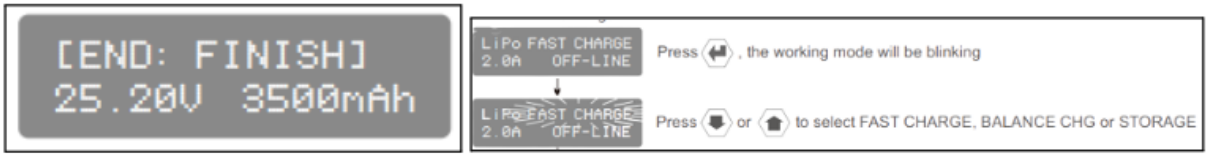


Figure 4.3.8 - Charging Finish Display

5. **Storage Mode**: If a Lithium battery is not used for a long time of more than a month, it's highly recommended to charge or discharge the battery with STORAGE mode so as to extend the battery life. If the battery voltage is higher, the charger will discharge the battery; if battery voltage is less, then the charger will charge the battery under STORAGE mode.

Battery Voltage Meter:

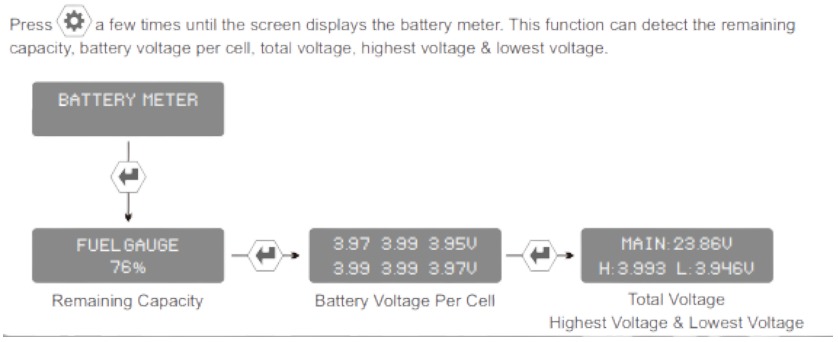


Figure 4.3.9 - Battery Voltage Meter:

Battery Resistance Meter:

Press a few times until the screen displays the battery resistance meter. This function can detect internal resistance per cell and total resistance. The lower the battery resistance is, the higher the battery performance will be. Internal resistance will increase after the battery is commonly used.

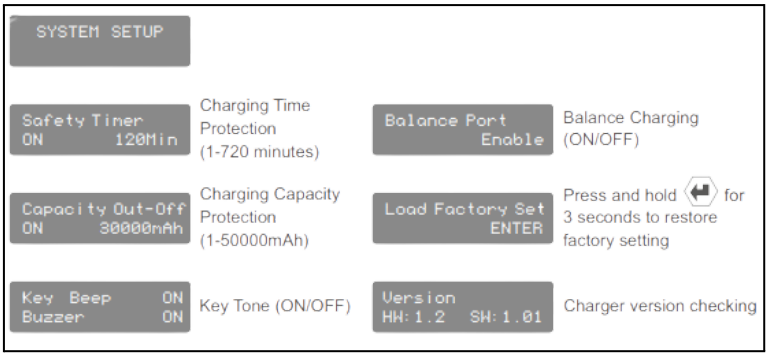


Figure 4.3.10 - Battery Resistance Meter

Specifications

- Input Voltage: 100-240V
- Output Power: 1080W (540W×2)
- Discharging Power: 50W×2
- Charging Current Range: 1.0-20.0A×2
- Balance Current: 1.2A Max.
- Battery Type: Li-Ion
- Battery Cell Count: 6S×2
- Charging Modes: Fast Charge/Balance Charge/Storage
- Size: 272×202×118.6mm
- Weight: 4.88kg

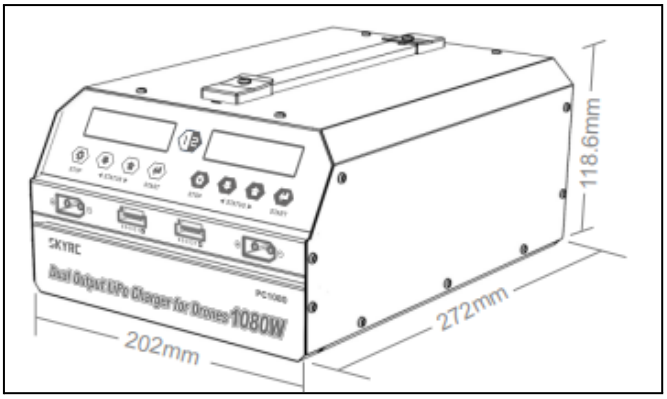


Figure 4.3.11 Charger dimension

4.4.5. Warnings and Safety Precautions

1. **Unattended Charging:** Never leave the charger unattended when connected.
2. **Malfunction:** Terminate the process immediately if any malfunction occurs.
3. **Environment:** Keep the charger away from dust, moisture, heat, direct sunlight, and vibration.
4. **Surface:** Place on a heat-resistant, non-flammable, non-conductive surface. Avoid placing on car seats, carpet, etc.
5. **Battery Types:** Never charge/discharge batteries that are:

- Different cell types or manufacturers.
- Already fully charged or slightly discharged.
- Non-rechargeable (Explosion hazard).
- Faulty or damaged.
- With integral charge circuits or protection circuits.
- Installed in other devices.

4.4.6. Battery Storage and Transportation

Guidelines:

1. **Humidity:** Avoid storing batteries in humid environments. Use LiPo Bags for a controlled environment.
2. **Fire Safety:** Keep batteries away from fire and heat sources.
3. **Child Safety:** Store batteries out of reach of children.
4. **Temperature:** Store at 25°C.
5. **Storage Space:** Ensure ample space to avoid squeezing batteries.
6. **Regular Checks:** Inspect storage every two weeks. Perform charge and discharge cycles to maintain stability.

Safe Storage Instructions:

1. **Storage locations:**·
   - There should be separate racks for keeping discharged batteries and charged batteries. These racks should be clearly marked for the respective use. Faulty batteries are not to be kept in the vicinity of serviceable batteries. Those are immediately disposed as per the disposal procedure.
   - The batteries should be placed by not touching each other. Nevertheless, 3-to-4-inch distance should be maintained while storing.

Figure 4.5.1 - Battery storage clearance

2. **Inspection:**

On every 90th day of storage:

1. **Visually inspect** the battery for swelling, corrosion, leaks, or connector damage.
2. **Measure total voltage** and **individual cell voltages** using a calibrated battery checker or smart charger.
3. Ensure the battery remains within the storage **voltage range** of **21.6V to 22.8V.**
4. Check cell balance: cells should be within **±0.03 V** of each other.
5. If the battery is to be reused, **charge to full** before deployment.
6. If the battery is **not being used**, adjust charge to **storage level** (approx. 3.80 V/cell).
7. **Update logbook** with inspection results and actions taken.

The battery should always be stored in a LiPo safe bag in order to maintain temperature and humidity.

Before storing in a LiPo safe bag, ensure that the LiPo safe bag is not damaged and has no cut or any other damage exposing the LiPo battery stored inside to the outside environment. In case the LiPo bag is damaged, dispose of the damaged lipo bag and use a new one.

The users should follow a separate battery log for each battery.

4.4.7. Decommissioning and Discarding Batteries:

- **Cycle Limit:** Decommission batteries after 384 cycles or if damaged/swollen.
- **Hazardous Chemistry:** Proper disposal to prevent fire and contamination.
- **Steps:**
    - Track cycles and monitor for damage.
    - Discharge in saltwater until voltage reaches zero.
    - Wear PPE during handling.
    - Return to manufacturer for disposal.

Strictly adhere to guidelines for safety and environmental responsibility.

4.5. Pre-flight Checklists

Detailed Pre-flight Checklist:

Step	Description	Tick Box
1	Inspect airframe for damage	☐
2	Check propellers for wear and secure attachment	☐
3	Ensure battery is fully charged and properly installed	☐
4	Verify all payloads are securely attached	☐
5	Check all fasteners of Primary structural elements mentioned in Annexure - 2 for looseness and integrity	☐
6	Inspection of critical components for in-service wear due to weathering effect and corrosions	☐
7	Power on the transmitter	☐
8	Connect the battery to the drone	☐
9	Perform a control surface check	☐
10	Confirm GPS lock and home point	☐
11	Satellite counts more than 10 sat	☐

12	HDOP value less than 1	☐

Table 6

The VDOP allowable is less than 2.5 normally. However the VDOP value is not viewed by the users in GCS. . Only Satellite counts and HDOP value can be monitored using GCS. The recommended value for Satellite count and HDOP value is mentioned in the above Table 6.

Do's and Don'ts:

- **Do's:**
  - **Do** complete the checklist before every flight.
  - **Do** verify each item thoroughly.
- **Don'ts:**
  - **Don't** skip any checklist items.
  - **Don't** start the flight if any issues are found.
  - **Don't** fly the drone if the sat count value is less than 10 and HDop value is more than 1.

Ensure that the flight plan avoids any HIRF areas and restricted airspace to prevent interference and maintain safety.

4.6. Payload Installation

Step-by-Step Installation Process:

1. **Check for the pump motor to be clear with the air blocks.**

Ensure the pump motor is free of obstructions to avoid malfunction during operation.

2. Check that the motor is tightly fitted.

A loosely fitted motor can lead to vibrations and potential detachment mid-flight.

3. Check that the nozzle rods are fitted properly.

Properly fitted nozzle rods ensure accurate spraying and effective payload delivery.

4. Check that the pipeline and pneumatic connectors are free from leaks. Refer to the maintenance manual for detailed SOP of leak check and its resolution.

Leaking connectors can lead to loss of chemicals and pose a safety hazard.

5. Check that the nozzle tips are free from debris.

Debris in nozzle tips can block the flow, reducing efficiency and accuracy.

6. Check that the water tank is filled up to the 10L mark.

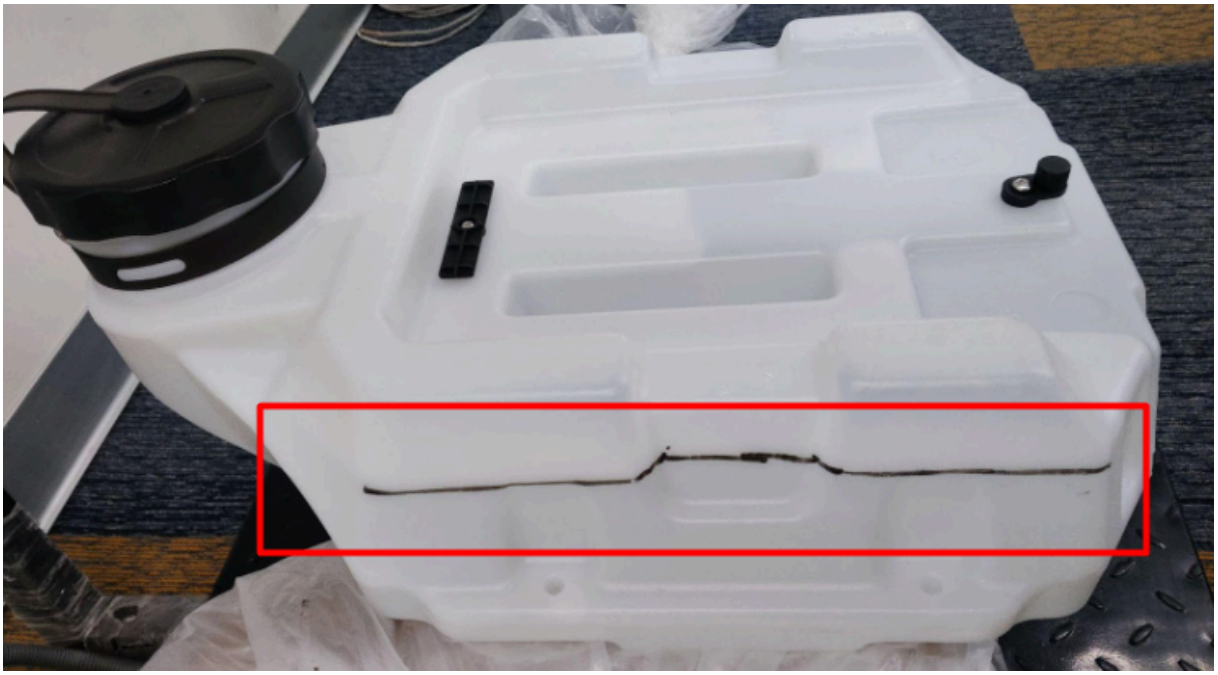


Figure 4.5.2 - Payload Tank limit

The maximum tank capacity is 11 litres. But the tank to be filled is 10 liters up to the mark. Under no circumstances, a tank should be filled beyond 10 litres marking.

Do's and Don'ts:

- **Do's:**
  - **Do** check all components for secure attachment.
  - **Do** ensure the water tank is filled correctly to avoid imbalance.
- **Don'ts:**
  - **Don't** operate the drone if any checks fail.
  - **Don't** skip any steps in the checklist.

4.7. Takeoff Procedures

As TEJA-M being a rotorcraft, it has the ability to vertically takeoff without any requirement of any special launching mechanism. Even though the following points must be kept in mind for safe flights.

Detailed Instructions for Safe Takeoff:

1. Position the drone on a flat, open surface free from obstacles.

Ensure the area is clear to avoid collisions during takeoff.

2. Turn on the transmitter and check for a stable connection with the drone.

A weak connection can lead to loss of control.

3. Perform the arming check to ensure all systems are functioning correctly.

When arming TEJA-M, ensure the throttle (left stick) is pulled all the way down before confirming. Failing to hold the throttle down will cause the aircraft to leap into the air once armed.

4. Gradually increase the throttle to lift the drone off the ground.

Avoid sudden throttle increases to prevent instability.

5. Maintain a steady ascent to a safe altitude before initiating flight maneuvers.

A steady ascent helps in maintaining control and stability.

4.8. Landing Procedures

As TEJA-M being a rotorcraft, it has the ability to vertically land without any requirement of any special landing mechanism. Even though the following points must be kept in mind for safe flights.

Safe Landing Techniques:

1. **Clear Landing Area:**
    - Perform a visual check of the area before initiating the descent.

Ensure the landing area is free of obstacles and people to prevent potential accidents.

2. **Controlled Descent:**
    - Monitor the drone’s alignment with the landing spot and keep it level.

Gradually decrease the throttle to maintain stability during descent.

3. **Align and Stabilize:**
    - Make minor adjustments to keep the drone steady and aligned with the landing area.

Misalignment during descent can cause the drone to tip over.

4. **Gentle Touchdown:**
    - Aim for a smooth and gentle touchdown to minimize impact.

Reduce the throttle gradually to avoid a hard landing.

5. **Power Down:**
    - Ensure the motors are completely off before handling the drone.

After touchdown, turn off the motors first, then the transmitter.

Additional Landing Guidelines:

- **DO:**
    - Always land the drone in an open space.
    - Always land the drone in the direction of the wind.
    - Perform a pre-landing check of the drone's batteries, propellers, and other components.
    - Check the weather conditions and avoid landing if the wind speed exceeds safe limits.
    - Maintain a safe distance from the drone during landing.

- Disarm and switch off the drone immediately after landing.

- **DON'T:**
  - Never attempt to land on uneven or unstable ground.
  - Never land the drone near people, animals, or buildings.
  - Never abruptly reduce throttle during descent.

The TEJA-M does not have a shock-absorbing mechanism in its landing gear. Exercise caution and controlled landing to prevent damage to the drone. Choose landing surfaces carefully, ensuring they are free from obstructions and suitable for the absence of a shock-absorbing system.

4.9. Geofencing Capability & Procedure

The TEJA-M has geofencing capability to enhance flight safety by preventing the RPA from entering restricted or hazardous areas.

Manual Setup Instructions:

- **Step 1:** Open the AeroGCS Green application and connect with the RC via Bluetooth or Serial. The UI will appear as shown below.
- **Step 2:** Click on "Start Here" to begin the setup process.
- **Step 3:** You will be redirected to a page where you can choose the manual mode of flying.
- **Step 4:** After clicking "Manual," you will see a square fence with green lines and yellow dots on the edges on your screen.
- **Step 5:** To update the fence, click on the yellow dots and move them as needed. You will receive a notification that the fence has been updated.

When to Set Up Geofence:

- **Before Every Flight:** Always set up a geofence to prevent the RPA from entering restricted or hazardous areas.
- **During Flight Planning:** Include geofence setup as part of the flight planning process to ensure compliance with local regulations and safety guidelines.

4.10. Sensor Operations

4.10.1. Liquid Level Sensor Operation

The liquid level sensor provides valuable information about the remaining liquid inside the tank, ensuring smooth and interruption-free drone operations.

Figure 4.9.1 - Liquid Level Sensor

Working of Liquid Level Sensor:

- **Monitoring Tank Levels:** The sensor continuously measures the liquid level within the tank.
- **Real-time Data Transmission:** It sends real-time data to the drone's flight controller.
- **User Accessibility:** The flight controller processes the data, making it accessible to users through telemetry or a ground control station.

Configuring through AeroGCS GREEN:

1. Set the auxiliary pin to Aux 3.
2. Reboot the drone, and the sensor initiates operation.

3. Navigate to AeroGCS GREEN:
    - Spray setting ==> Level sensor setting ==> Set the Auxiliary pin for the sensor's signal output.

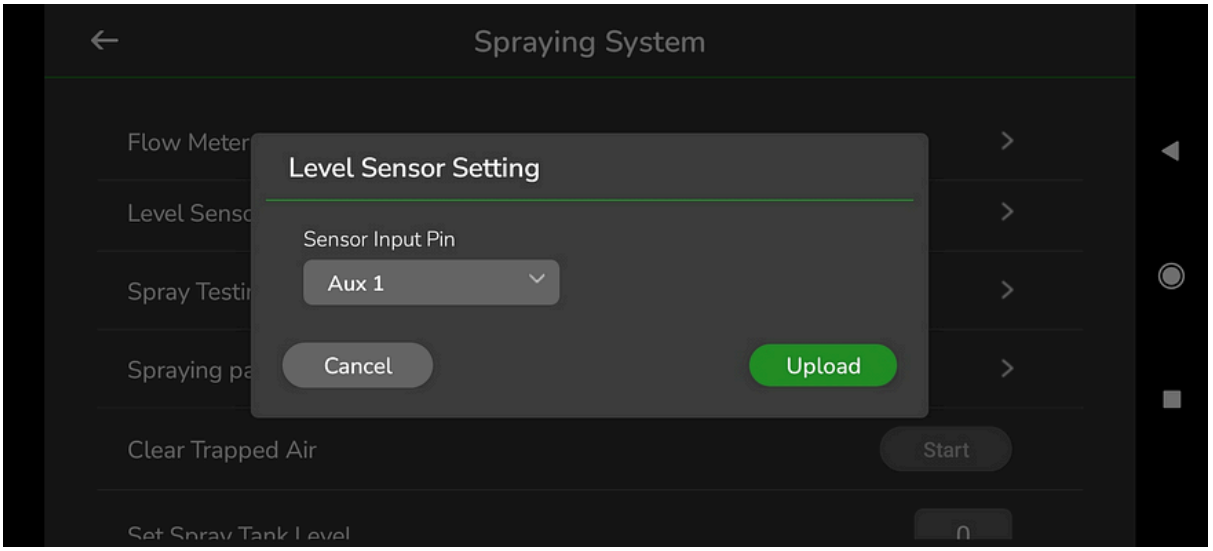


Figure 4.9.2 - Level Sensor Settings

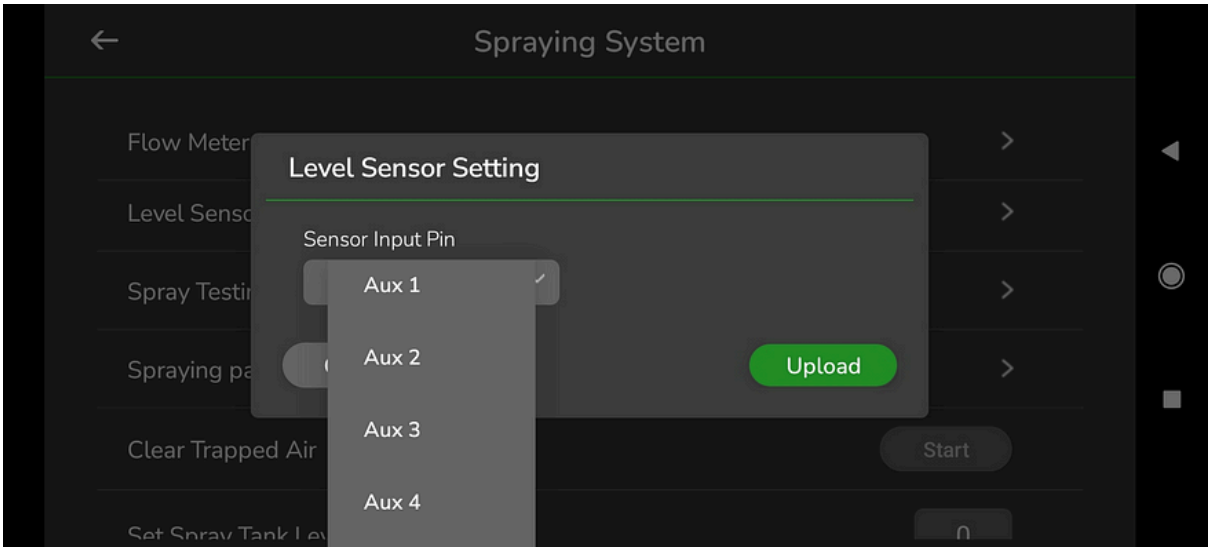


Figure 4.9.3 - Level Sensor Settings

Operation and Monitoring:

- When the tank is empty, the configured action (RTL/Hover) is triggered, and a "LUA: Tank Empty" message is displayed in the status.

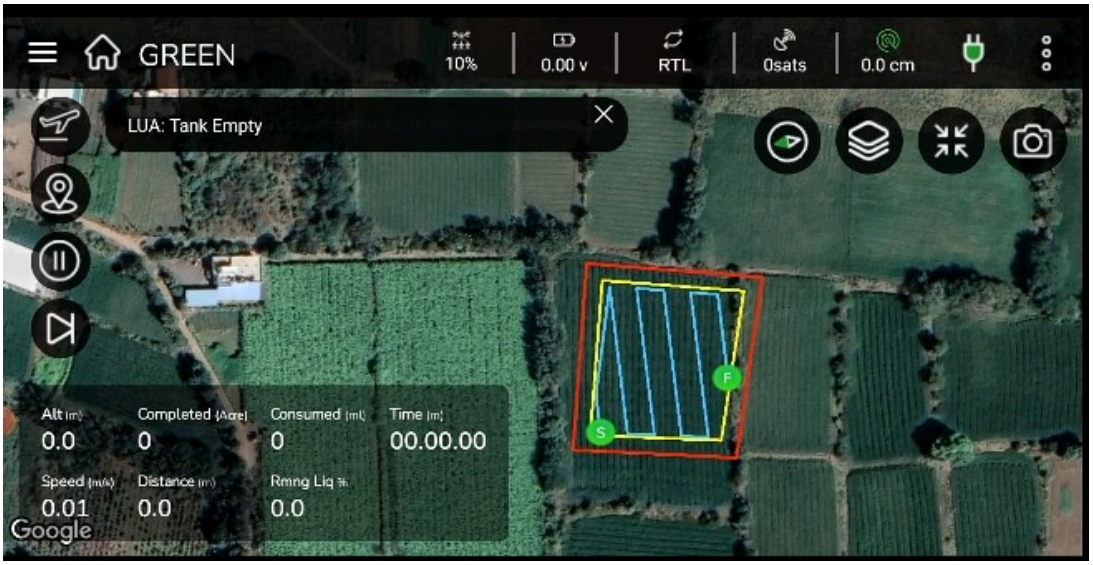


Figure 4.9.4 - AeroGCS GREEN Fly View

4.10.2. Flow Level Sensor Operation

The flow sensor plays a crucial role in regulating the liquid flow from the tank to the spray system.

Figure 4.9.5 - Flow Sensor

The TEJA-M drone is equipped with advanced sensing technologies to enhance its operational safety and adaptability to diverse environments. The following sensors contribute to obstacle avoidance and terrain following capabilities, ensuring a secure and efficient flight experience.

Working of Flow Level Sensor:

- **Measuring Flow Rate:** The sensor accurately measures the rate of liquid flow from the tank.
- **Adjusting Flow:** It allows for precise adjustment of the flow rate based on the liquid application requirements.
- **Connection to Flight Controller:** The flow sensor is connected to an available PWM input port on the drone's flight controller.

Configuration through AeroGCS GREEN:

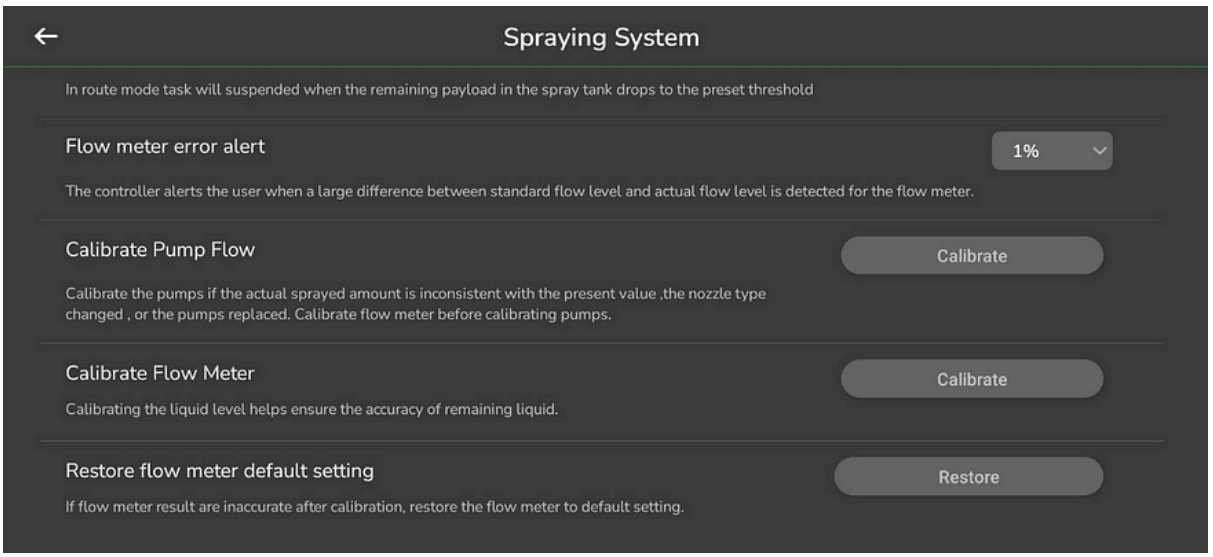


Figure 4.9.6 - Spraying system in AeroGCS GREEN

1. Spraying System Configuration:
    - Configurations include selecting the flow sensor type, flow input pin value, and specifying the fuel tank capacity in ml.
2. Clear Trapped Air:

- Ensure pump and drone are powered, and there is water in the tank to clear trapped air.

3. Restore Flow Meter Default Settings:
   - Allows users to restore all flow-related settings to default.

Flow Meter Settings:

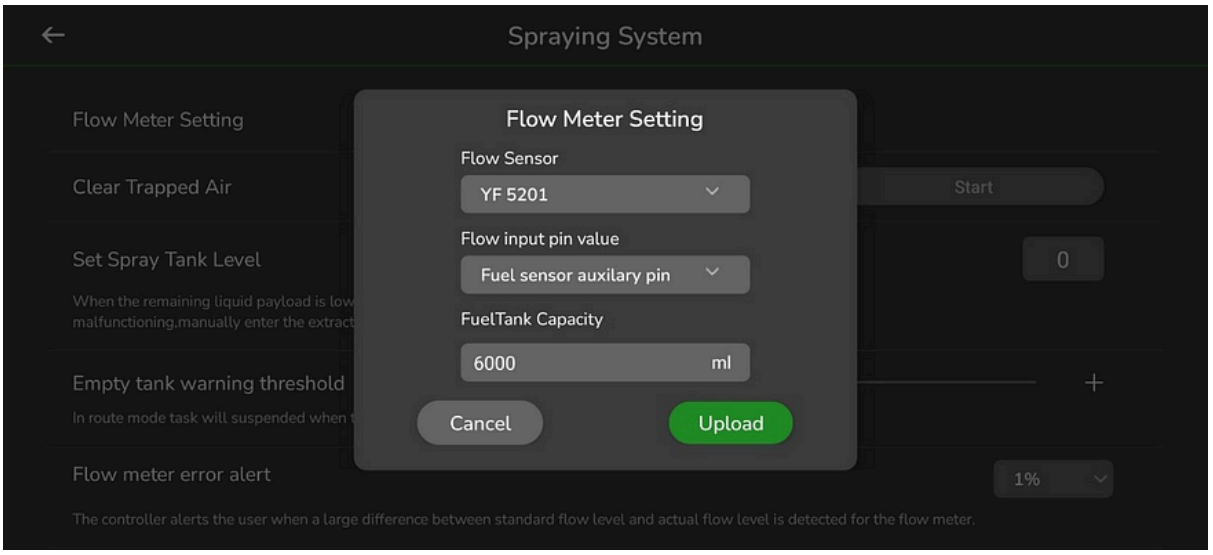


Figure 4.9.7 - Flow Meter Settings

- Flow Sensor:
  - User-selectable flow sensor type.
- Flow Input Pin Value:
  - User-selectable input pin value type.
- Fuel Tank Capacity:
  - User-entered liquid amount in ml.

Clear Trapped Air:

- Procedure:
    - Ensure the pump is on, the drone is powered, and there is water in the tank.

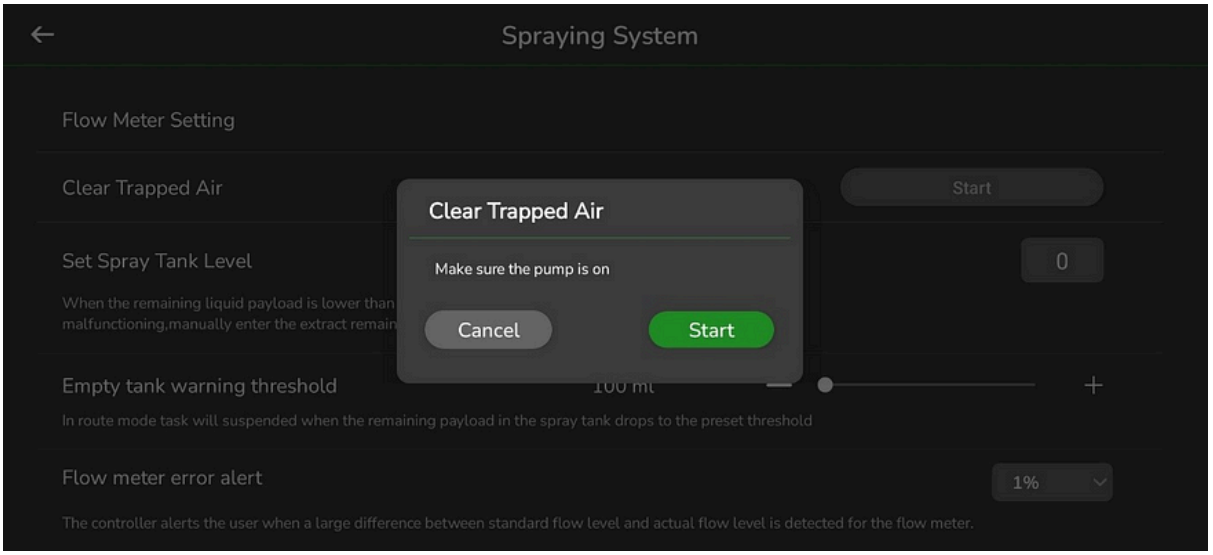


Figure 4.9.8 - Clear Trapped Air

Restore Flow Meter Default Setting:

- Option:
    - Users can restore default settings for all flow-related configurations.

Flow meters play a pivotal role in precise liquid application for spraying drones.

4.10.3. Obstacle Avoidance Sensor Operation (Optional Sensors)

The TEJA-M has obstacle avoidance capability to enhance flight safety by preventing the RPA from colliding with obstacles in the path.

The obstacle avoidance sensor is designed to detect obstacles within a range of 25 meters. In case of detection, the TEJA-M drone will promptly halt and maintain a safe distance of 10 meters from the obstacle. Detects obstacles within an azimuth width of ±15° and an elevation width of -5° to +3°.

Figure 4.9.9 - Obstacle Avoidance Sensor

Operating Instructions:

1. **Monitoring:** Continuously monitor the telemetry data for obstacle detection alerts.
2. **Manual Override:** Be prepared to manually navigate the drone if the obstacle avoidance system detects an obstacle.

4.10.4. Terrain Following Sensor Operation (Optional Sensors)

The TEJA-M drone, equipped with advanced terrain-following capabilities, ensures safe and efficient agricultural spraying operations over varying landscapes. It can detect maximum up to 25 meters of distance. This functionality enhances flight safety by adapting to changes in elevation. Below are the details of the terrain-following system:

Figure 4.9.10 - Terrain Following Sensor Operating Principle

1. **Manual Mode**

When the drone is flown manually using pilot inputs:

- **Activation Threshold**:
  - Terrain-following functionality activates only when the drone's altitude exceeds **5 meters**.
  - At lower altitudes, the system remains inactive to prevent errors during ground operations.
- **Response to Terrain Changes**:
  - If the terrain rises and the pilot does not adjust altitude, the drone will:

        - **Slow down automatically**.
    - After reaching the appropriate altitude, the drone resumes forward motion.

2. Auto Mode (Pre Planned Missions)

When operating in auto mode with a pre planned mission:

- **Safe Altitude Monitoring**:
    - The drone continuously monitors the distance between its altitude and the terrain below.
    - **Mission Suspension**:
        - The drone halts the mission and switches to **Loiter Mode**.
        - It prompts the operator for input, asking whether to resume the mission from the same point.
    - **Automatic Altitude Adjustment**:
        - The drone ascends slightly to maintain clearance from the terrain.
        - After adjustment, the drone remains in Loiter Mode until instructed by the operator.
- **Loiter Mode Functionality**:
    - In Loiter Mode, the drone maintains its position and altitude while awaiting further operator commands.

3. Operational Considerations

- **Mission Planning**:
    - Careful planning is essential to ensure the drone maintains safe terrain clearance.
    - Operators must consider terrain elevation changes and ensure the flight path avoids abrupt altitude variations.
- **Avoidance of Close Environments**:
    - **Top Clearance**: The drone's terrain-following sensor is downward-facing and does not detect obstacles above it.
    - When flying manually or planning missions, ensure there are no obstacles overhead, such as tree canopies, power lines, or structures.

Operator Guidelines

1. **Altitude Awareness**:
    - In manual mode, maintain an altitude greater than **5 meters** for terrain-following functionality to activate.
2. **Mission Preparation**:
    - While designing pre planned missions, avoid flight paths with sharp elevation changes to prevent unnecessary mission halts.
3. **Obstacle-Free Environment**:
    - Ensure a clear environment above the drone, particularly during spraying operations, as the system cannot detect upward obstacles

This terrain-following system significantly improves operational efficiency and safety by adapting to ground elevation changes and ensuring optimal clearance. Operators must adhere to the provided guidelines to maximize the benefits of this functionality while minimizing risks during agricultural spraying missions.

Figure 4.9.11 - Terrain Following Sensor

4.11. Post-flight Procedures

Steps to Take After Landing:

1. **Turn off the drone and transmitter.**

Ensure both the drone and transmitter are powered down to prevent accidental activation.

2. **Disconnect the battery from the drone.**
    - Disconnecting the battery prevents power surges and accidental starts.
3. **Inspect the drone for any damage or wear.**
    - Check for damages to avoid future malfunctions.
4. **Clean the drone and remove any debris.**
    - Regular cleaning ensures the longevity of the drone.
5. **Fill out the logbook with flight details and any observations.**
    - Accurate log entries help in tracking flight history and performance.
6. **Update the maintenance manual with any performed maintenance or noted issues.**
    - Documenting maintenance actions ensures proper record-keeping and regulatory compliance.
7. **Store the drone and components in a dry, safe place.**
    - Proper storage prevents damage and ensures readiness for next use.
8. **Check any looseness of PSE fasteners.**

Post-flight Checklist:

Task	Completed
Turn off drone and transmitter	Yes ( ) / No ( )
Disconnect battery	Yes ( ) / No ( )
Inspect for damage	Yes ( ) / No ( )
Clean the drone	Yes ( ) / No ( )
Fill out the logbook	Yes ( ) / No ( )
Update the maintenance manual	Yes ( ) / No ( )
Store properly	Yes ( ) / No ( )
Check Primary structural elements for looseness and integrity	Yes ( ) / No ( )
Inspection of critical components for in-service wear due to weathering effect and corrosions	Yes ( ) / No ( )

Table 7

Proper storage is essential to prolong the life of your drone.

Always clean the drone to prevent dust and debris from affecting its performance.

Failure to update the logbook and maintenance manual can result in undetected issues leading to potential flight safety hazards.

Ensure all post-flight procedures are meticulously followed to maintain the warranty and operational integrity of the TEJA-M drone.

5. Master/ Slave Modes for RPTO Training

5.1. Master-Slave Mode – Operational Procedure for RPTO Training

5.1.1. **Purpose:**

The purpose of this procedure is to define the use of **Master-Slave mode** during practical drone flying training in the Remote Pilot Training Organisation (RPTO). This ensures **safe, controlled, and effective** transfer of control between the instructor and the trainee, in compliance with DGCA regulations.

5.1.2. **Scope:**

This procedure applies to **all practical flight training sessions** conducted by the RPTO involving students undergoing training under **DGCA-approved RPTO courses** for Remotely Piloted Aircraft Systems (RPAS).

5.1.3. **Definitions:**

- **Master Controller:** The primary Remote Controller handled by the RPTO-certified Instructor (Remote Pilot Instructor - RPI).
- **Slave Controller:** The secondary Remote Controller operated by the Trainee (Student Remote Pilot).
- **Master-Slave Mode:** A training mode where control authority is shared between the Instructor and the Student with override capability for the Instructor at any time.

5.1.4. **Responsibilities:**

- **Instructor (Master):**
    - Retains **overall authority and responsibility** for the safety of the flight.
    - Provides continuous guidance and supervision.

- Shall intervene immediately in case of any unsafe actions or loss of control by the trainee.

- **Trainee (Slave):**
  - Operates the RPAS as per instructor guidance.
  - Shall yield control back to the instructor upon command or intervention.

5.1.5. Operational Guidelines:

1. **Pre-Flight Setup:**
   - Ensure that both the **Master and Slave controllers** are properly configured and paired with the RPAS.
   - Conduct a pre-flight briefing to explain the control-sharing protocol.
   - Verify the instructor's ability to override the slave control at all times.
2. **During Flight:**
   - The instructor may transfer control to the trainee for specific maneuvers or phases of flight.
   - Control transitions must be **clearly communicated** using predefined verbal commands (e.g., "You have control" / "I have control").
   - The instructor shall monitor trainee actions continuously.
3. **Emergency Override:**
   - The instructor must immediately take back control in the event of:
     - Incorrect maneuvering
     - Loss of situational awareness by the trainee
     - Any external hazard or emergency
4. **Post-Flight Review:**
   - Conduct a **debrief session** to review trainee performance and provide feedback.
   - Log the usage of Master-Slave mode in the flight training records.

5.1.6. **Safety and Compliance:**

- Mandatory use of Master-Slave mode for:
    - First-time trainees performing critical operations like takeoff, landing, and emergency procedures.
    - Practical flight assessments under supervision.
- This procedure aligns with **DGCA RPTO guidelines** and industry best practices for pilot training safety.

5.1.7. **Documentation:**

- Record of each Master-Slave training session shall be maintained in the trainee's logbook.
- Any instructor interventions during flights must be documented for training evaluation purposes.

5.2. How MASTER / Slave Mode works

The **TEJA-M Hexacopter** primarily utilizes the **MK15 Transmitter** for its communication and telemetry systems. This transmitter serves as the primary link for real-time control, data transmission, and operational feedback between the drone and the pilot.

In addition to the MK15 transmitter, the TEJA-M is equipped with a **T12 Transmitter and Receiver** system, which allows for the operation in **Buddy Mode** (Master/Slave configuration). This feature enables two pilots to share control of the drone, which is particularly useful for training and educational purposes, such as during Remote Pilot Training Organizations (RPTOs).

- **Primary Communication**: The MK15 transmitter is the primary system for controlling the TEJA-M and providing telemetry feedback.
- **Buddy Mode**: In Buddy Mode, the T12 system allows one pilot (slave/ student) to control the drone while the second pilot (Master/ Instructor) can take over control if needed. This system is ideal for training scenarios, allowing an instructor to take

control of the aircraft in case of emergencies or to guide the trainee in learning drone operation.

- **Control Switching**: The control of the drone can be switched between the MK15 and T12 transmitters, depending on the mode selected. While the T12 system can be used for training, the MK15 remains the primary telemetry and control interface.

This dual-communication setup enhances operational flexibility, making the UV suitable for both agricultural spraying operations and as a training platform for RPTOs.

1. **MK15 Receiver and Master MK 15 Transmitter**:
    - The **master receiver** serves as the **primary communication link** to the **Ground Control Station (GCS)**.
    - The **master** receiver connects as the GCS and handles all data transmission between the drone and the control station.
    - The **transmitter** allows the operator to regain full control of the aircraft by pressing the **A BUTTON** on the transmitter.
2. **T12 Receiver and Slave T12 Transmitter**:
    - The slave **receiver** receives basic **flight control commands** (pitch, roll, yaw, and throttle) from the Transmitter 2
    - It communicates only the RC (remote control) commands for flight control; it does not have direct access to the GCS, GCS remains connected solely to the receiver 1.

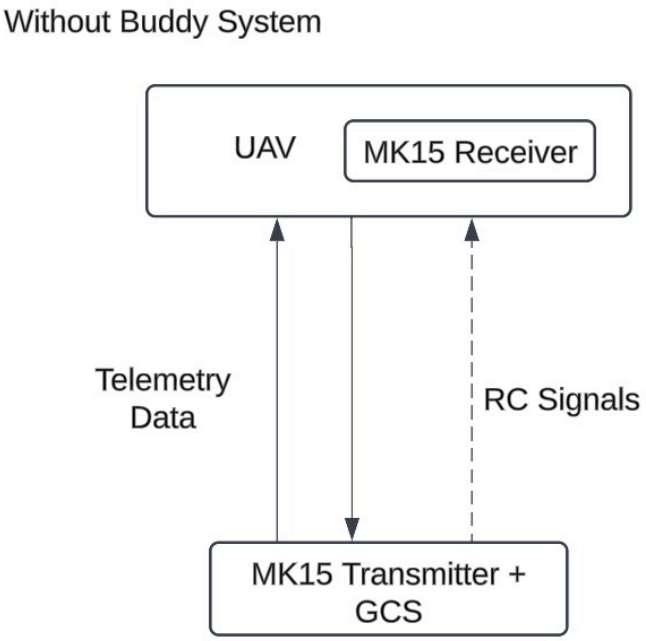


Figure 5.1.1: Communication link without Buddy System

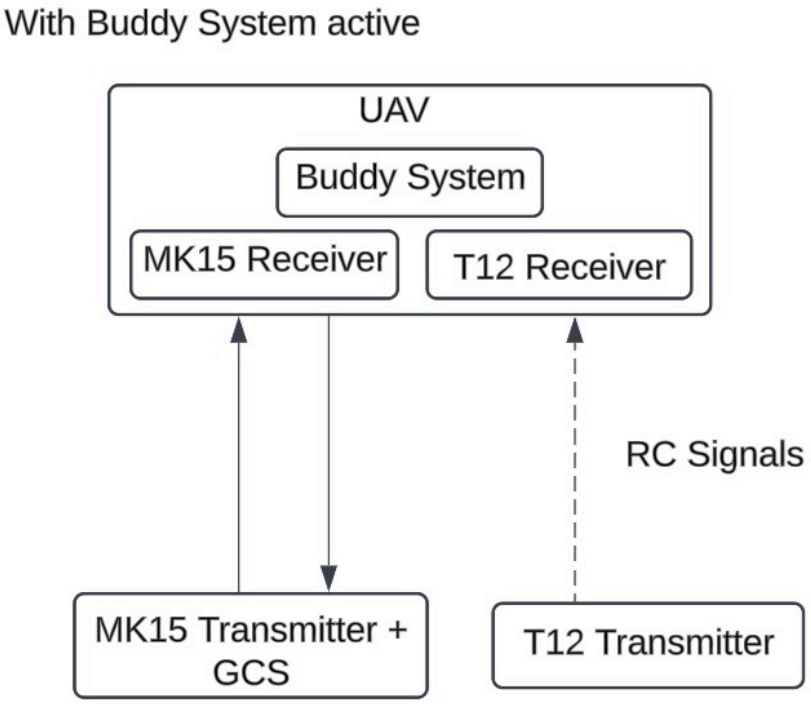


Figure 5.1.2: Communication link with Buddy System

5.3. Button / Switch Types and Default Channel Definitions

The MK15 remote controller comes with 13 physical channels and 16 communication channels in total. Communication channels 10 to 14 are also PWM channels 1 to 5 by default.

Channel No.	**Physical Channel Type**	**Default Mapping**
1	Roll	Joystick
2	Pitch	Joystick
3	Throttle	Joystick
4	Yaw	Joystick
5	Mode Switch	3-Stage Switch SA
6	Pump On/Off	3-Stage Switch SB
7	-	3-Stage Switch SC
8	Master/Slave	Button A
9	RTL	Button B

Table 8

5.4. Activation of Master to Slave Mode

To activate Master/Slave Mode, press the “A” button on the MK15 radio. The controls will shift to the T12 radio, making the MK15 the master and the T12 the slave. In Master Mode, the MK15 can take control to navigate obstacles by pressing the "A" button again.

Skydroid T12 Slave Transmitter

Siyi M15 Master Transmitter

Figure 5.1.3: Master and Slave transmitters with A button OFF

Figure 5.1.4: Master and Slave transmitters with A button ON

1. The control is always with Master Remote (MK 15 transmitter) whenever the Master is willing to give control to a student, A button to be switched ON. When the

auxiliary switch A in the Master transmitter is ON, the A switch glows, The control goes to Student/ Slave. Trainee/ Slave can control the drone.

2. When the auxiliary switch A in the Master transmitter is OFF, Master/ Instructor can control the drone.
3. The instructor must immediately take back control in the event of:
    a. Incorrect maneuvering
    b. Loss of situational awareness by the trainee
    c. Any external hazard or emergency

Fail safe scenarios while using buddy system:

Table 9

Sr. No.	Control with	Contingency	Action by UAV
1	Master	Master Fails	RTL
2	Master	Slave Fails	No action
3	Slave	Slave Fails	Radio fail safe warning comes on GCS and RTL is triggered. Master has the authority to resume control
4	Slave	Master Fails	Control remains with the slave.

Note: In the case of the buddy system, the same failsafe procedure will be displayed on the GCS, and the drone will trigger the failsafe in a manner similar to the actual failsafe with MK15.

6. Flight Operations

6.1. Flight Modes

1. **Loiter Mode:**

In Loiter Mode, the drone maintains its current position and altitude using GPS to stabilize. To activate Loiter Mode, push the button located on the top left of the RC in the upward direction. It is also useful during windy conditions to stabilize the drone.

- **Do:** Ensure GPS signal is strong (More than 10 sats) before engaging Loiter Mode.
- **Don't:** Activate Loiter Mode in areas with poor GPS coverage or high electromagnetic interference.

Engaging Loiter Mode in areas with poor GPS signal can result in drift or loss of control.

2. **Auto Mode:**

In Auto Mode, the drone autonomously follows a pre-programmed flight path and executes designated tasks. To activate Auto Mode, push the button located on the top left of the RC in the downward direction. Use Auto Mode for repetitive tasks like mapping or surveillance, where precision and consistency are critical. Ideal for long-distance flights where manual control would be impractical.

- **Do:** Double-check the pre-programmed flight path for obstacles.
- **Don't:** Change the flight path mid-mission without pausing the drone.

Ensure the pre-programmed flight path avoids restricted airspace and obstacles. Unauthorized flight paths can result in severe legal consequences.

3. Return to Launch (RTL):

The Return-to-Launch (RTL) mode ensures the TEJA-M drone autonomously returns to its home location, following a predefined sequence of actions. This mode offers safety redundancy by automatically engaging during critical events or when triggered manually by the operator.

Activation of RTL Mode

RTL mode in the TEJA-M can be triggered:

1. **Manually**: By pressing the **SC key** on the remote control.
2. **Battery Failsafe**: When the **first battery failsafe** activates at **42 V**.
3. **C2 Link Failsafe**: If the **command-and-control (C2) link** is lost.
4. **Fence Breach**: If the drone breaches the set geo-fence.
5. **Tank Failsafe**: If the **tank becomes empty** during agricultural operations.

RTL Procedure

- **Return Path**: Upon activation, the drone will return to the home location immediately, traveling at **5 m/s** and following the shortest path while maintaining its **current altitude**.
- **Hovering**: Once the drone reaches the home location, it will descend to **5 meters** altitude and hover, allowing the operator to either land the drone manually or await further commands.
- **Landing**: The operator can override the hover phase to initiate a smooth landing, or the drone can remain hovering until a pre-configured timeout or further input is received.

- **Do:** Configure RTL settings according to your operational environment.
- **Don't:** Rely solely on RTL in densely populated or obstructed areas.

RTL can be configured as per requirement. Contact Pavaman Aviation Private Limited for custom configurations.

4. **Land Mode:**

Land Mode is designed for automatic emergency landings, ensuring the drone safely reaches the ground when faced with critical system failures, such as battery depletion or sensor malfunction.

Activation Conditions:

- The drone will automatically enter **Land Mode** when:
    - **Critical Battery Voltage** is crossed.
    - **EKF Failure** is detected.

Features of Land Mode:

- **Descent**: The drone will attempt to bring itself straight down to the ground.
    - It will descend to a height of **10 meters** or until the **sonar** detects an object beneath the drone.
    - The descent rate is controlled by the regular **Altitude Hold** controller at a speed of **50 cm/s**.
- **Landing and Disarm**:
    - Upon reaching the ground, the drone will automatically **shut down the motors** and **disarm** if the pilot's throttle is set to minimum.

5. **Altitude**

As per design, the UAS can achieve a maximum altitude of 100 m Above Ground Level. But the spraying height from the crop is as per user requirement and generally above 5-10 m.

6.2. Fail Safe Procedures

6.2.1. C2 Data Link Failsafe:

The TEJA-M drone is equipped with a robust data link failsafe mechanism designed to ensure safe operations in the event of a loss of communication between the drone and the Ground Control Station (GCS). This section provides a detailed explanation of how the data link failsafe operates, its triggers, actions taken by the drone, and practical considerations for operators.

Conditions for Data Link Failsafe Activation

Datalink failsafe activates under the following conditions:

- **Loss of Communication:** Occurs when the connection between the drone and the GCS or RC is interrupted due to factors such as signal interference or hardware malfunction.

Actions Taken by the Drone

Upon activation of the data link failsafe, the TEJA-M drone initiates the following actions:

1. **Alert Generation:**
    - The GCS immediately displays a "Communication link loss, drone disconnected" message to alert the operator.
    - An auditory warning is also issued through the GCS speakers, notifying the pilot that the drone has lost connection.
2. **Failsafe Mode Activation:**
    - After a 10-second delay of lost connection, the drone automatically enters failsafe mode.
    - During this time, the drone ceases its current mission or flight path and prepares to execute the Return to Launch (RTL) procedure.
3. **Return to Launch (RTL) Procedure:**

- **Return Path:** Upon activation, the drone will return to the home location immediately, traveling at 5 m/s and following the shortest path while maintaining its current altitude.
- **Hovering**: Once the drone reaches the home location, it will descend to 5 meters altitude and hover, allowing the operator to either land the drone manually or await further commands.
- **Landing**: The operator can override the hover phase to initiate a smooth landing, or the drone can remain hovering until a pre-configured timeout or further input is received.

Practical Considerations and Best Practices

1. **Pre-Flight Checks:**
   - Ensure that the data link between the drone and GCS is stable and within operational range before flight.
   - Verify that all equipment, including antennas and connections, are securely fastened and functioning properly.
2. **Monitoring During Flight:**
   - Continuously monitor the GCS for any alerts or warnings related to data link connectivity.
   - Maintain visual line of sight with the drone to facilitate manual intervention if necessary.
3. **Environmental Factors:**
   - Consider environmental conditions such as electromagnetic interference and weather conditions that may affect datalink performance.
   - Plan flight operations accordingly to minimize risks associated with potential communication loss.

Visual and Audio Alerts

The TEJA-M drone employs visual and audio alerts to inform the operator of data link failsafe activation:

- **Visual Alert:** "Communication link loss, drone disconnected" message prominently displayed on the GCS screen.
- **Audio Alert:** Auditory warning broadcasted through the GCS speakers indicating "Drone disconnected."

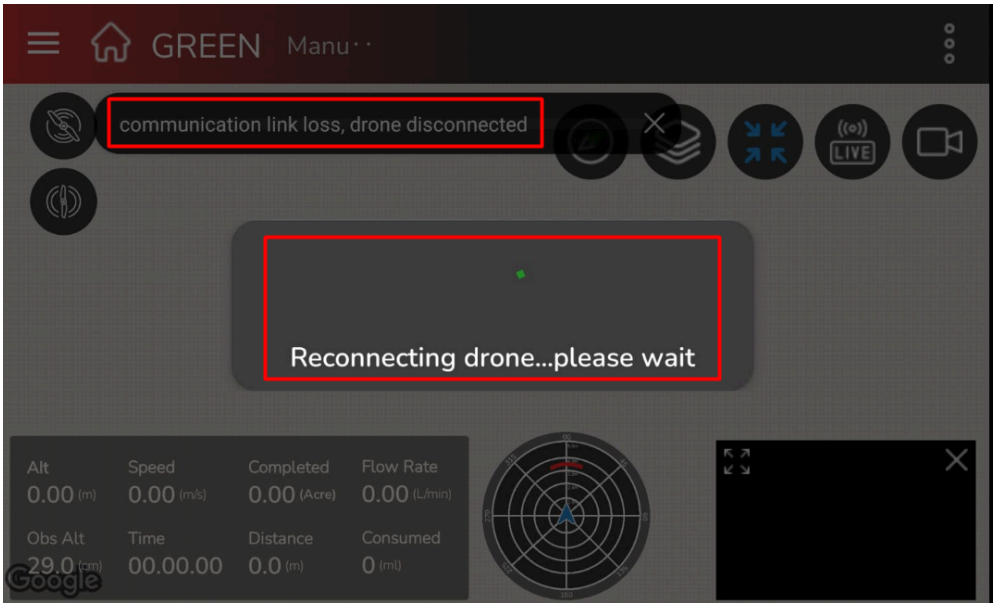


Figure 5.2.1 - Visual Alert

The data link failsafe mechanism in the TEJA-M drone is critical for maintaining safe operations by ensuring immediate response to communication disruptions between the drone and the GCS. By initiating the RTL procedure and providing clear alerts, the system enhances situational awareness and supports timely intervention to safeguard the drone and its surroundings.

Sr. No.	Control with	Contingency	Action by UAV
1	Master	Master Fails	RTL
2	Master	Slave Fails	No action
3	Slave	Slave Fails	Radio fail safe warning comes on GCS and RTL is triggered. Master has the authority to resume control
4	Slave	Master Fails	Control remains with the slave.

Note: In the case of the buddy system, the same failsafe procedure will be displayed on the GCS, and the drone will trigger the failsafe in a manner similar to the actual failsafe with MK15.

6.2.2. Geofence Breach**:**

The TEJA-M drone incorporates a geofence breach failsafe mechanism to prevent unauthorized flight outside predefined operational boundaries. This section details how the geofence failsafe operates, its triggers, actions taken by the drone, and practical guidelines for operators.

Conditions for Geofence Breach Failsafe Activation

Geofence breach failsafe activates under the following conditions:

- **Boundary Violation:** Occurs when the drone travels beyond the predefined geofence limits, including maximum altitude and distance restrictions.

Actions Taken by the Drone

Upon activation of the geofence breach failsafe, the TEJA-M drone initiates the following actions:

1. **Immediate Response:**
    - The drone immediately halts its current flight path or mission upon detecting a geofence breach.
    - It ceases any further movement away from the operational boundaries to prevent unauthorized flight.
2. **Return to Launch (RTL) Procedure:**
    - **Return Path**: Upon activation, the drone will return to the home location immediately, traveling at **5 m/s** and following the shortest path while maintaining its **current altitude**.

- **Hovering**: Once the drone reaches the home location, it will descend to **5 meters** altitude and hover, allowing the operator to either land the drone manually or await further commands.
- **Landing**: The operator can override the hover phase to initiate a smooth landing, or the drone can remain hovering until a pre-configured timeout or further input is received.

Practical Considerations and Best Practices

1. **Geofence Configuration:**
   - Configure the geofence boundaries in the GCS software based on legal requirements and operational constraints.

Regularly update and verify geofence parameters to reflect changes in flight regulations or operational needs.

2. **Monitoring and Compliance:**
   - Continuously monitor the drone's position relative to the geofence boundaries during flight operations.
   - Adhere to geofence limitations to ensure compliance with airspace regulations and safety protocols.
3. **Emergency Procedures:**
   - Implement emergency procedures for overriding geofence restrictions in case of unforeseen operational requirements or emergencies.

Ensure that all operators are trained in geofence failsafe protocols and emergency response measures.

Visual and Audio Alerts

The TEJA-M drone provides visual and audio alerts to notify the operator of geofence breach failsafe activation:

- **Visual Alert:** The GCS displays a "Fence Breached" message to indicate that the drone has exceeded the geofence boundaries.
- **Audio Alert:** An auditory warning is broadcasted through the GCS speakers, notifying the operator of the geofence breach.

Figure 5.2.2 - Visual Alert

The geofence breach failsafe mechanism in the TEJA-M drone plays a crucial role in preventing unauthorized flight and ensuring compliance with airspace regulations. By promptly halting flight operations outside designated boundaries and initiating the RTL procedure, the system enhances safety and operational integrity during drone missions.

6.2.3. Battery Failsafe:

The TEJA-M drone is equipped with a sophisticated battery failsafe mechanism designed to ensure safe return to the home location when the battery level reaches critical thresholds. This section provides a detailed and descriptive explanation of the battery failsafe process, including the conditions under which it is triggered, the actions taken by the drone, and best practices for operators.

Conditions for Battery Failsafe Activation

The battery failsafe is designed to activate under two critical conditions related to battery voltage levels:

1. **Low Voltage Threshold:**
    - **Trigger**: When the battery voltage drops to or below 42V.
    - **Action**: The drone will display a warning on the Ground Control Station (GCS) and initiate the Return to Launch (RTL) procedure.
    - **Notification**: The GCS will show a "Battery Failsafe" message, and the flight mode will change to RTL.

Return to Launch (RTL) Procedure

- **Return Path**: Upon activation, the drone will return to the home location immediately, traveling at **5 m/s** and following the shortest path while maintaining its **current altitude**.
- **Hovering**: Once the drone reaches the home location, it will descend to **5 meters** altitude and hover, allowing the operator to either land the drone manually or await further commands.
- **Landing**: The operator can override the hover phase to initiate a smooth landing, or the drone can remain hovering until a pre-configured timeout or further input is received.

Important Considerations and Best Practices

1. **Pre-Flight Checks:**
    - **Do:** Ensure the battery is fully charged and in good condition before every flight.
    - **Don't:** Ignore any signs of battery wear or damage, such as swelling or leakage.
2. **Monitoring During Flight:**
    - **Do:** Regularly monitor the battery voltage levels displayed on the GCS.
    - **Don't:** Fly the drone until the battery is completely drained, as this can trigger emergency RTL and potentially cause unsafe landings.

3. **Environmental Factors:**
    - **Do:** Consider environmental factors such as wind and temperature, which can affect battery performance and flight duration.
    - **Don't:** Fly in extreme conditions without adjusting battery failsafe settings accordingly.

Visual and Audio Alerts

The GCS provides both visual and audio alerts to ensure the operator is immediately aware of the battery failsafe activation:

1. **Critical Voltage Alert:**
    - **Visual Alert:** " Battery Failsafe" message displayed on the GCS.
    - **Audio Alert:** " Battery Failsafe" announcement through the GCS speakers.

Figure 5.2.3 - Visual Alert

The battery failsafe mechanism in the TEJA-M drone is crucial for ensuring safe operations and preventing accidents due to low battery levels. By automatically triggering RTL and

providing clear alerts to the operator, the system helps maintain the integrity of the flight and the safety of the drone. Adhering to best practices and regularly checking battery health can further enhance the reliability of the battery failsafe system.

Flying with a critically low battery can result in sudden power loss and crash.

6.2.4. Critical Battery Failsafe

The **Critical Battery Failsafe** mode is an essential safety feature in the TEJA-M, designed to prevent the drone from continuing flight under dangerously low battery levels. This automated mechanism ensures that the drone lands safely to avoid accidents or mid-air shutdowns. Below is a detailed breakdown of how the system operates.

- The **Critical Battery Failsafe** is triggered when the battery voltage drops to **37 V**, indicating the drone's power has reached critical levels.
- This mode ensures the drone executes a controlled landing to prevent in-flight failure.
- It only activates after the first **battery failsafe** at **42 V** has failed to bring the drone home (i.e., RTL mode was not completed, or the drone remained airborne).

Trigger Conditions

- **Battery Voltage Level**:
  - **First Battery Failsafe**: Activates at **42 V**, triggering RTL (Return to Launch).
  - **Critical Battery Level**: If the drone continues to fly after RTL and reaches **37 V**, the Critical Battery Failsafe is automatically engaged.
- **Other Scenarios**:
  - Loss of satellite connection (GPS) can also trigger **Land Mode**, which operates similarly to the Critical Battery Failsafe.

Failsafe Sequence

- **Trigger and Mode Activation**:
  - When the battery voltage drops to **37 V**, the drone immediately initiates **Land Mode**.
- **Descent Control**:
  - **50 cm/s descent rate** using the **Altitude Hold controller**.

- The descent speed ensures a balance between rapid landing and smooth control.

- **Landing Procedure**:
  - Once landed, the drone's motors automatically **shut down and disarm** if the pilot's throttle is at minimum.

Visual and Audio Alerts

The GCS provides both visual and audio alerts to ensure the operator is immediately aware of the battery failsafe activation:

2. **Critical Voltage Alert:**
   - **Visual Alert:** " Battery Failsafe" message displayed on the GCS.
   - **Audio Alert:** " Battery Failsafe" announcement through the GCS speakers.

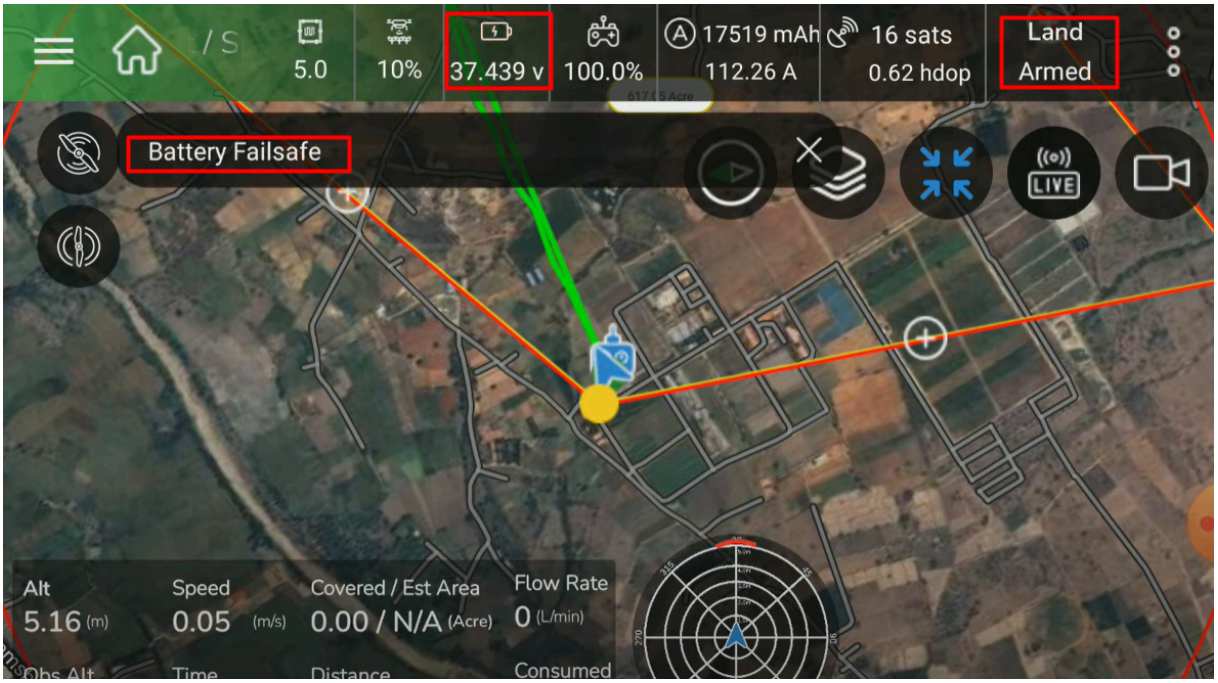


Figure 5.2.3 - Visual Alert

The battery failsafe mechanism in the TEJA-M drone is crucial for ensuring safe operations and preventing accidents due to low battery levels. By automatically triggering RTL and providing clear alerts to the operator, the system helps maintain the integrity of the flight and

the safety of the drone. Adhering to best practices and regularly checking battery health can further enhance the reliability of the battery failsafe system.

Flying with a critically low battery can result in sudden power loss and crash.

Redundancy and Safety Measures

- **The** system ensures that **Land Mode** overrides other flight modes once the critical battery voltage is reached.
- **If** the drone encounters **GPS loss**, it will still attempt to land safely using onboard sensors for descent.

The **Critical Battery Failsafe** mode in TEJA-M ensures the drone lands safely when power levels are dangerously low, minimizing the risk of crashes or mid-air shutdowns. With a well-defined descent rate and automated motor disarm, this system offers a reliable safety mechanism to protect both the drone and its environment.

6.2.5. Liquid Level Failsafe**:**

If the liquid level falls below the pre-set threshold (this feature can be turned on/off by the user), the drone will initiate hover at location to avoid spraying inconsistencies.

- **Do:** Check liquid levels before and during the mission.
- **Don't:** Continue spraying with low liquid levels.

Liquid Level Failsafe can be turned off if not required. Configure it according to your specific use case.

6.2.6. Failsafe Table

S.No	Failsafe	Visual Alert	Audio Alert	Time Taken for GCS	Action
1	Battery failsafe	Battery Failsafe	Battery failsafe	Immediately	RTL

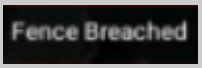
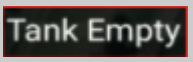
2	Critical Battery Failsafe		Battery failsafe	Immediately	Land
3	C2 Data Link Failure		Communication lost, drone disconnected	5 seconds	RTL
4	Geofence failsafe		Fence Breach	Immediately	RTL
5	Tank Empty		Tank Empty	Immediately	Hover at location

Table 10

7. Emergency Procedures

Emergency procedures are essential for ensuring safe and efficient drone operations. As a pilot, it is your responsibility to be proficient with the aircraft operational manual provided by the vendor before conducting any flight operations. It is a best and safe practice to prepare an Emergency Checklist. The drone should always be ready to execute emergency procedures in instances where there is a lost link, loss of GPS, or other aircraft or obstructions in the flight path. After the drone has safely landed, it should undergo maintenance.

7.1. Detailed Emergency Procedures

7.1.1. RTL Functionality

The Return-to-Launch (RTL) mode ensures the TEJA-M drone autonomously returns to its home location, following a predefined sequence of actions. This mode offers safety redundancy by automatically engaging during critical events or when triggered manually by the operator.

Activation of RTL Mode

RTL mode in the TEJA-M can be triggered:

1. **Manually**: By pressing the **SC key** on the remote control.
2. **Battery Failsafe**: When the **first battery failsafe** activates at **42 V**.
3. **C2 Link Failsafe**: If the **command-and-control (C2) link** is lost.
4. **Fence Breach**: If the drone breaches the set geo-fence.

RTL Procedure

- **Return Path**: Upon activation, the drone will return to the home location immediately, traveling at **5 m/s** and following the shortest path while maintaining its **current altitude**.

- **Hovering**: Once the drone reaches the home location, it will descend to **5 meters** altitude and hover, allowing the operator to either land the drone manually or await further commands.
- **Landing**: The operator can override the hover phase to initiate a smooth landing, or the drone can remain hovering until a pre-configured timeout or further input is received.

7.1.2. Command & Control Link Loss Strategies

Trigger Event: Signal loss with GCS or RC.

Drone's Reaction:

- Hovers in place for 5 seconds.
- Attempts to reestablish communication.
- Initiates RTL if communication is not reestablished within 5 seconds.

Pilot Actions:

- Move to a higher location to reestablish line-of-sight.
- Check for possible signal interference sources.
- Prepare for manual recovery if RTL is not possible.

Alert Mechanism:

- GCS displays "Communication lost".
- RC shows signal loss and provides audio alerts.

For Detailed Loss of communication alert mechanism, refer to 5.2.1

7.1.3. Low Battery Failure

- **Trigger Event:** Battery level drops to critical threshold.
- **Drone's Reaction:**
  - Initiates RTL process.
  - May descend to land immediately if the battery is critically low.
- **Pilot Actions:**
  - Continuously monitor battery levels during flight.
  - Manually initiate RTL or find a safe landing spot if necessary.
- **Alert Mechanism:**
  - Low battery alert on GCS.
  - RC provides audio and visual alerts.

Do's and Don'ts Summary

Do's:

- Always maintain a visual line of sight with the drone.
- Regularly check and calibrate sensors and batteries.
- Pre-plan emergency landing zones before flights.
- Configure RTL settings according to your specific operational environment.
- Practice emergency procedures regularly to ensure readiness.

Don'ts:

- Fly in areas with poor GPS coverage or known signal interference.
- Ignore pre-flight and mid-flight warnings or alerts.
- Overlook the importance of having a clear and obstacle-free landing zone.
- Rely solely on RTL in densely populated or obstructed areas.

By following these detailed emergency procedures and keeping the do's and don'ts in mind, pilots can ensure the safe and effective operation of the TEJA-M drone, minimizing risks and maintaining control during critical situations.

7.1.4. Pilot action to mitigate risks

Sl No	Potential failure	Prevention Control
1	Loss of Hardware Compatibility for Aero GCS	Always ensure to check for the right product documentation and use compatible hardware.
2	Lack of Hardware Resource Requirements for AeroGCS Operations	Always ensure to check for the right product documentation and provision required an amount of hardware resources.
3	Multiple Software Instances on same hardware	Always ensure to have only one software instance on one hardware.
4	Software Malfunction	All standard procedures defined to operate the drone and GCS must be followed in a suitable environment.
5	Non-calibration of drone	Always ensure to calibrate the drone properly and then only do the flights.
6	Hardware issues	Always test motors before first flight
7	Human Error of not calibrating remote controller parameters	Always Configure remote controller before first flight
8	Human Error of not setting flight modes on RC button	Always Configure flight modes before first flight
9	Human Error of not calibrating ESC before first flight	Always calibrate ESC before first flight
10	Human Error of not enabling arming checks before first flight	Always enable Arming Checks before flights
11	Human Error of not configuring appropriate georeferencing in waypoint mission	Always configure appropriate geo-referencing
12	Human Error of not return to launch while flight planning	Always configure appropriate return to launch
13	AeroGCS Software Crash	Always ensure to run minimum applications on the system where GCS is installed and allocate maximum resources for the GCS system.
14	Deletion of Data Accidently	Always ensure to have proper file and folder permission for the folders where GCS data is stored.
15	Overheating/over current	Remote pilot has to trigger RTL and land the drone.

Table: 11

If any deterioration or damage is observed on critical components, **immediately stop flying** and report the issue to the manufacturer. Continuing operation may lead to unsafe flight conditions.

8. Maintenance

This chapter outlines the essential maintenance procedures and schedules for the TEJA-M hexacopter. Adhering to these guidelines will ensure the drone's optimal performance, safety, and compliance with regulatory standards. This chapter provides detailed guidance for users on how to follow the maintenance plan for the TEJA-M hexacopter, including instructions for filling and filing the maintenance logbook, performing various maintenance tasks and responsibilities, understanding potential dangers if maintenance is not performed, and the impact on performance.

8.1. Roles and Responsibilities

- **Maintenance Manager**: A professional role within the customer's organization or an external service provider responsible for overseeing the maintenance activities, ensuring compliance with the maintenance schedule, and coordinating with the OEM as necessary.
- **Maintenance Technician:** A trained individual, either part of the customer's organization or an external service provider, responsible for performing the hands-on maintenance tasks, particularly those that are more technical and require specific expertise.
- **OEM Team:** This refers to the Original Equipment Manufacturer (Pavaman Aviation Private Limited) personnel who provide technical support, perform comprehensive inspections, and conduct non-destructive testing as required. They are also involved in updating maintenance procedures and providing training updates.
- **User:** The end-user or operator of the TEJA-M hexacopter, responsible for performing daily, weekly, and monthly maintenance tasks, maintaining the maintenance logbook, and ensuring the hexacopter is sent to the OEM or authorized service centers for more complex maintenance tasks.

As a user of the TEJA-M hexacopter, you have specific maintenance responsibilities that must be followed to ensure the continued safe and effective operation of your equipment. These responsibilities include:

- Performing daily, weekly, and monthly inspections and maintenance tasks as outlined in the maintenance schedule.
- Documenting all maintenance activities in the maintenance logbook.
- Ensuring the hexacopter is sent to Pavaman Aviation Private Limited for quarterly and annual maintenance, as well as any necessary repairs.
- If there is any deterioration or decay observed on the critical components, the user can stop flying further and bring it to the notice of the manufacturers.
- Following all safety steps and guidelines during maintenance activities.

8.2. Maintenance Plan

The maintenance plan for the TEJA-M hexacopter includes a series of scheduled inspections and maintenance tasks that are to be performed daily, weekly, monthly, half-yearly, and annually.

Follow the maintenance schedule provided in the manual to ensure your TEJA-M remains in optimal condition. The schedule includes routine inspections, troubleshooting, and component replacements.

8.2.1. Maintenance Schedule

8.2.1.1. Daily Maintenance

- **Frequency:** After each flight
- **Responsible Personnel:** User
- **Tasks:**
    - **Clean Airframe:** Remove dirt and mud from the chassis.
    - **Inspect for Cracks:** Check airframe and arms for visible cracks or damage.
    - **Inspect Battery Packs:** Look for bulges, leaks, and ensure secure connections.

- **Check and Clean Tank:** Inspect for leaks and clean the spray system tank.
- **Check GPS Mount:** Ensure GPS is secure and properly aligned.
- **Check Motors for Debris:** Inspect and clean motors.
- **Check Landing Gear Condition:** Inspect for damage and wear.
- **Control Check:** Perform functional tests on control systems.

8.2.1.2. Weekly Maintenance

- **Frequency:** Weekly
- **Responsible Personnel:** User
- **Tasks:**
  - Inspect arm rods, central hub, canopy, landing gear connectors, arm boom, motors, propellers, transmitter, GPS, battery plate and velcro, pneumatic connectors, and XT 90 connectors.
  - Check for cracks, bends, wear, and secure attachment.

8.2.1.3. Monthly Maintenance

- **Frequency:** Monthly
- **Responsible Personnel:** User
- **Tasks:**
  - **Submit Maintenance Logbook:** Compile and submit detailed maintenance logs to OEM.
  - **Inspect Spray System:** Perform a thorough cleaning and inspection.

8.2.1.4. Half Yearly Maintenance

- **Frequency:** Every six months
- **Responsible Personnel:** Maintenance Technician, OEM Team
- **Tasks:**
  - **Perform Detailed Component Tests:** Conduct non-destructive testing on critical components.

- **Review and Analyze Maintenance Logs:** Analyze logs for trends and implement preventive measures.

8.2.1.5. Annual Maintenance

- **Frequency:** Annually
- **Responsible Personnel:** OEM Maintenance Team
- **Tasks:**
  - **Conduct Comprehensive Inspection:** Perform a full inspection and non-destructive testing on all components.
  - **Update Maintenance Procedures:** Review and update procedures based on analysis and new findings.
  - **Provide Training Updates:** Conduct training sessions for maintenance personnel with updated procedures.

8.2.1.6. As Needed Maintenance

- **Frequency:** As required
- **Responsible Personnel:** Maintenance Manager, OEM Team
- **Tasks:**
  - **Perform Root Cause Analysis:** Analyze any component failure or premature withdrawal.
  - **Implement Corrective Measures:** Take necessary actions based on analysis and update records.

8.2.1.7. Emergency Maintenance

- **Frequency:** After Incident
- **Responsible Personnel:** Maintenance Manager, Technician, OEM Team
- **Tasks:**
  - **Inspect and Recover from a Crash:** Conduct a thorough inspection and root cause analysis. Document findings and corrective actions.

- **Report Incidents to OEM:** Submit a detailed report with all relevant information and documentation.
- **OEM Investigation and Support:** OEM conducts a detailed investigation and provides guidance for corrective actions.

8.2.2. Explanation of Maintenance Schedules

- **Daily Maintenance:** Focuses on routine cleaning and basic inspections after each flight to catch immediate issues and maintain cleanliness.
- **Weekly Maintenance:** Involves more thorough inspections of structural and critical components to identify emerging issues before they escalate.
- **Monthly Maintenance:** Ensures detailed inspection and cleaning of major systems, and maintains logbooks for tracking and reporting purposes.
- **Half Yearly Maintenance:** Conducts comprehensive tests and analysis of maintenance data to ensure the overall health of the drone and implement preemptive measures.
- **Annual Maintenance:** Includes a full-scale inspection and potential replacement of parts to ensure long-term reliability and updates to procedures and training.
- **As Needed Maintenance:** Addresses specific issues as they arise, ensuring targeted and effective responses to any problems detected during routine operations.
- **Emergency Maintenance:** Provides a structured response to incidents, ensuring thorough investigation, reporting, and corrective actions are taken promptly.

8.3. Maintenance Logbook and Documentation

1. Maintenance Logbook

Maintaining a comprehensive maintenance logbook is crucial for tracking all maintenance activities of the TEJA-M drone. The logbook should include entries for daily, weekly, monthly, half-yearly, annual, as needed maintenance, and emergency procedures as per the maintenance manual provided. The maintenance logbook is provided with the TEJA-M delivery or ask Pavaman Aviation for the Maintenance logbook.

Ensure the logbook is updated regularly and kept in a safe place for reference.

2. Documentation Submission

Regular submission of logbooks is essential to maintain high standards of performance and safety for the TEJA-M drone.

- **Operations Logbook:** Records all flights, operations, and incidents.
- **Maintenance Logbook:** Tracks all maintenance activities and inspections.
- **Component Monitoring Records:** Continual Component Performance Monitoring followed by corrective actions would lead to improved safety and reliability of Drone operations. It helps to monitor the status and health of key components.
- **Replacement Records:** Documents all component replacements.
- **Battery Logbook:** Tracks battery maintenance activities and inspections.

Submission Process:

1. **Compile Logbooks:**
    - Gather all operations, inspection, and replacement records documented throughout the month.
    - Ensure all entries are complete, accurate, and in accordance with the maintenance and operations manuals.
2. **Review by User:**
    - The user responsible for maintenance and operations reviews the compiled logbooks.
    - Verify that all entries are correctly filled out, including dates, descriptions, responsible personnel, and any notes or remarks.
3. **Submit to OEM:**
    - Choose the submission method: via email.

- Ensure the submission is sent to the OEM Maintenance Department at **vijay.veeramallu@pavaman.in**.
- The submission deadline is by the 30th of each month to facilitate timely review and feedback from the OEM.

Prompt submission of logbooks allows for timely analysis by the OEM, ensuring any issues or trends are identified and addressed promptly. Accurate documentation is crucial for maintaining compliance with maintenance schedules and operational standards. Regularly update and maintain logbooks to provide a comprehensive history of maintenance activities and operational performance.

Monthly Submission Format:

UIN		**UAS Serial No.**	
User Name		**UAS Model name:**	
Date		**Manufacturer name:**	
Flying Hours			
Number of Landings			
Battery Life Cycles			

Any Components Replaced				
Sr. No.	**Name of Component**	**Hours at which it is replaced**	**Reason of Failure**	**Signature**
1				
2				
3				
4				

Any other issues

Table 12

3. Referencing Other Manuals

Operators should refer to the following manuals for detailed procedures and guidelines:

- **Maintenance Manual:** Provides detailed instructions on how to perform maintenance tasks, including schedules, procedures, and safety precautions.
- **Operations Logbook:** Contains operational guidelines, flight procedures, and limitations.
- **Maintenance Logbook:** Specific manuals for components like batteries, motors, and GPS modules for detailed maintenance and troubleshooting.

4. Tracking Maintenance

To ensure compliance and effective maintenance tracking:

- Regularly review and update maintenance logs as per the maintenance manual.
- Cross-reference maintenance tasks with the maintenance schedule to ensure all tasks are completed on time.
- Utilize component monitoring records to predict and prevent failures.
- Submit all required documentation by the specified deadlines to the OEM for review and feedback.

5. Performing Maintenance

Detailed procedures for performing maintenance tasks should be followed as outlined in the maintenance manual:

- Follow step-by-step instructions for each maintenance task.
- Adhere to safety guidelines and recommended practices.
- Use appropriate tools and equipment specified in the maintenance manual.
- Document all findings, inspections, and actions taken in the maintenance logbook.

By referencing the maintenance section of the flight manual, operators will gain a clear understanding of how to:

- Access and utilize the maintenance logbook.
- Submit required documentation.
- Refer to other manuals for detailed procedures.
- Perform maintenance tasks effectively and safely.

8.4. Impact of Neglecting Maintenance

Neglecting the prescribed maintenance tasks can have serious consequences, including:

- **Reduced Flight Safety:** Increased risk of equipment failure, leading to potential accidents and injuries.
- **Decreased Performance:** Poor maintenance can result in reduced efficiency, reliability, and operational capability of the drone.
- **Legal and Regulatory Compliance:** Failure to maintain the drone as required can lead to violations of DGCA regulations, resulting in fines, penalties, or cancellation of the UIN.

By adhering to the maintenance guidelines and schedules outlined in this chapter, users can ensure the safe and effective operation of the TEJA-M hexacopter. Regular maintenance not only enhances performance but also ensures compliance with regulatory standards and extends the operational lifespan of the equipment.

Do Use Recommended Tools and Equipment: Use tools and equipment specified in the maintenance manual to avoid damage to components and ensure accurate maintenance.

Don't Skip Scheduled Maintenance: Neglecting scheduled maintenance tasks can lead to operational failures and compromise flight safety.

Don't Use Unauthorized Parts: Use only OEM-approved parts and components for replacements to maintain warranty validity and ensure compatibility.

Don't Ignore Warning Signs: Address any abnormal operating conditions or warning indicators promptly by consulting the maintenance manual and taking appropriate corrective actions.

9. Technical Data

9.1. Dimensions

Sr No.	Measurement	Reading
1	TEJA - M Folded Length	1844 mm ± 10mm
2	TEJA - M Folded Breadth	2037 mm ± 10mm
3	TEJA - M Folded Height	581 mm ± 10mm
4	TEJA - M unfolded Length	678 mm ± 10mm
5	TEJA - M unfolded Breadth	762 mm ± 10mm
6	TEJA - M unfolded Height	581 mm ± 10mm

Table 12

9.2. Weight

S. No	Parameters	Values
1	Battery Weight	5.32 kg ± 20g
2	Fixed Payload weight with standard nozzles * 4 (Type A)	2.46 kg ± 20g
3	Fixed Payload weight with Centrifugal nozzles * 2 (Type B)	2.78 kg ± 20g
4	Weight of variable payload	10 kg ± 100g
5	Empty weight + battery + fixed payload Type A	19.54 kg ± 300g
6	Empty weight + battery + fixed payload Type B	19.94 kg ± 300g
7	Empty weight + battery weight + fixed payload Type A+ variable payload (AUW 1)	29.40 kg ± 740g
8	Empty weight + battery weight + fixed payload Type B + variable payload (AUW 2)	29.76 kg ± 740g
9	Maximum AUW + Tolerances (MTOW)	30.5 kg

Table 13

AUW - All Up Weight

MTOW - Maximum Take off weight

9.3. Propulsion System:

TEJA - M uses COMBO-XRotor-X6-PLUS Brushless propulsion system. The COMBO - XR motor - X6 - PLUS is a robust plant protection power system designed to accommodate a single-rotor load ranging from 3.5-5.5kg/rotor. Here are its key features:

- Thrust Performance:
  - Maximum thrust of a single-rotor: 11.8kg
  - Suitable for a 30mm carbon fiber tube arm
- Environmental Resilience:
  - IPX6 waterproof rating ensures protection against rain, pesticides, salt spray, high temperature, sand, dust, impact, mud, and sand.
- ESC (Electronic Speed Controller):
  - FOC vector control, optimized using PMSM system algorithm
  - Dual throttle options: digital and analog for enhanced flight stability
  - Comprehensive protection features:, over-current protection
- Communication and Data:
  - Utilizes CAN communication for real-time data transmission
  - Built-in fault storage function for recording and analyzing fault data

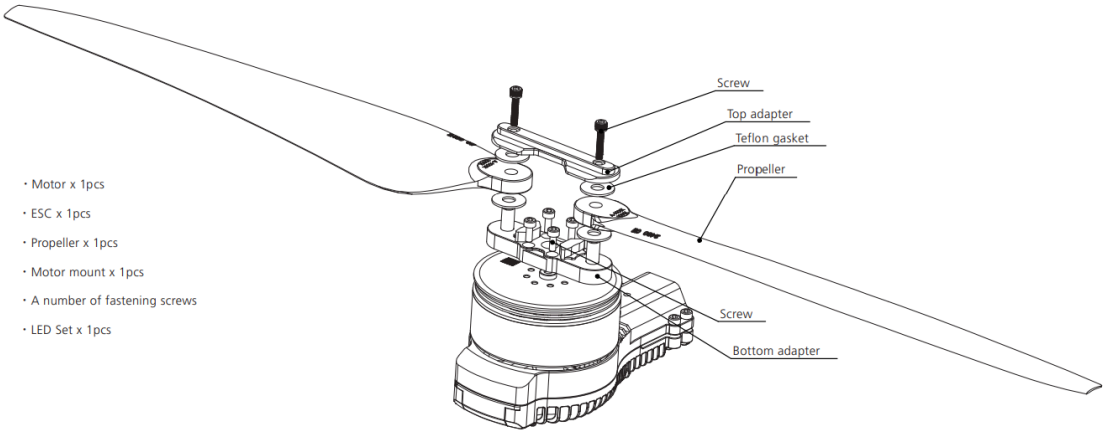


Figure 8.3.1 - Components of the Propulsion System

1. Motors:

The TEJA M hexacopter is equipped with six high-performance motors, strategically positioned on each arm of the airframe. These motors are selected based on their thrust characteristics, efficiency, and reliability.

Hobbywing X6 Plus Motor:

TEJA-M utilizes the Hobbywing X6 Plus motors based on thrust requirements for hover at 50% throttle, determined through internal motor bench tests for propeller integrity and thrust values. The X6 Plus motor features an integrated ESC, contributing to weight reduction and space optimization.

Motor Specifications:

- Voltage: 52.2 V
- Power: 1500-2850W
- Operating Temperature: -10 to 50 degrees Celsius
- Maximum Thrust: 11.8 Kg
- Diameter: 62 mm
- Weight: 790 g

Advantages of Hobbywing X6 Plus:

- ESC integration for weight reduction and space optimization.
- Special ventilation and cooling design for effective heat dissipation.
- Six motors integrated with six respective ESCs for optimal performance.

The selection of the Hobbywing X6 Plus motors reflects a meticulous process considering thrust requirements, internal bench testing, and the advantages offered by the integrated ESC design. This ensures TEJA - M's propulsion system is well-suited for various operational conditions.

Motor Features:

- **Current Protection:**

If the LED indicator flashes **three long times**, it signals an **excessive current draw** that could lead to system failure. The pilot should **immediately land the UAS** to prevent damage or loss of control. Continuing flight after seeing this warning can cause further issues, so it's critical to reduce altitude and land the aircraft as soon as possible.

- **Temperature Protection:**

An alarm is triggered when the ESC temperature exceeds 110°C, indicated by 1 long and 3 short flashes.

ESC may risk burning if the temperature exceeds 130 degrees, prompting an immediate landing upon the alarm.

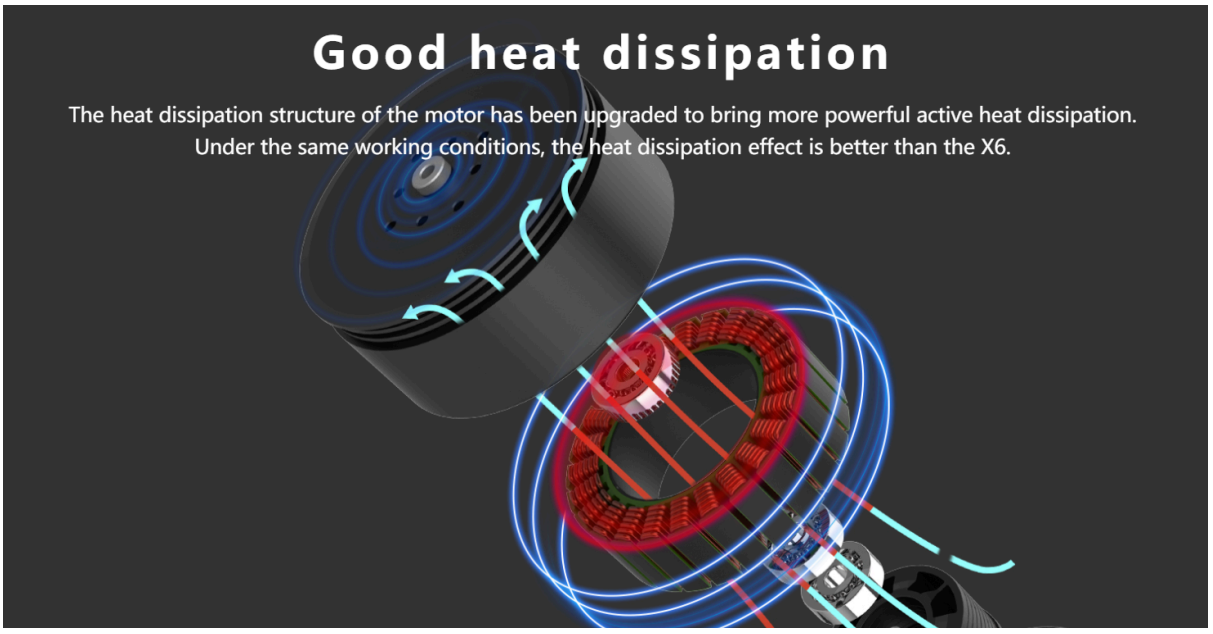


Figure 8.3.2 - Good Heat Dissipation feature of motors

2. Propellers:

These specifications indicate the size and weight characteristics of the propellers used in TEJA-M. The diameter pitch of 24 x 8.0 inches suggests a balance between size and pitch,

impacting the UAS's thrust and efficiency. The weight, including the adapter, is 107g, while the individual weight of a single propeller is 33g. These specifications contribute to the overall performance and stability of the multirotor UAS.

Propeller Specifications - TEJA - M Multirotor UAS

- Diameter Pitch: 24 x 8.0 inches
- Weight (Including Adapter): 107g
- Weight (Single Propeller): 33g

Voltage (V)	Propeller	Throttle (%)	Thrust (g)	Ampere (A)	Power (W)	Speed (RPM)	Efficiency (g/W)
46V (12S LIPO)	HW 24*8.0 Inch Foldable Propeller	40%	2416	4.6	212.2	2455	11.3
		42%	2732	5.5	253.5	2605	10.6
		44%	3058	6.4	296.6	2754	10.3
		46%	3377	7.4	343.8	2900	9.7
		48%	3746	8.7	401.8	3047	9.2
		50%	4106	9.9	460.2	3184	8.9
		52%	4419	11.2	519.9	3325	8.4
		54%	4822	12.5	580.2	3456	8.3
		56%	5209	14.1	653.4	3589	8.0
		58%	5476	15.6	724.6	3716	7.6
		60%	5947	17.3	800.2	3841	7.4
		62%	6370	19.1	886.2	3959	7.2
		64%	6709	20.7	958.4	4080	7.0
		66%	7086	22.6	1048.2	4194	6.7
		68%	7501	24.9	1153.8	4307	6.5
		70%	7779	26.6	1230.2	4415	6.3
		72%	8238	28.8	1332.1	4519	6.2
		74%	8654	31.0	1435.8	4627	6.0
		76%	9016	32.7	1514.0	4723	5.9
		78%	9294	35.1	1626.5	4821	5.7
		80%	9782	37.6	1742.3	4912	5.6
		90%	10731	43.6	2005.6	5142	5.3
		100%	11822	51.8	2399	5442	4.9

Figure 8.3.4 - OEM datasheet for propulsion system performance

Ensure regular maintenance of motors to avoid any unforeseen failures during operation.

9.4. Power Plant

The Power Plant is equipped with a robust and efficient power source, utilizing two MPower 25200mAh batteries connected in series. This configuration ensures reliable and consistent performance, enabling extended flight operations for the agriculture drone. The high-capacity batteries, manufactured by MPower, have been meticulously chosen for their exceptional performance and longevity.

The MPower 25200mAh batteries used in the Power Plant are BIS certified, providing assurance of their compliance with safety, performance, and quality standards. This certification can be verified using the unique R number found on the battery covering.

As shown in the image below, the battery is BIS certified as per IS 16046(Part 2):2018/IEC 62133-2-2017. The R-number of the battery is 61002909.

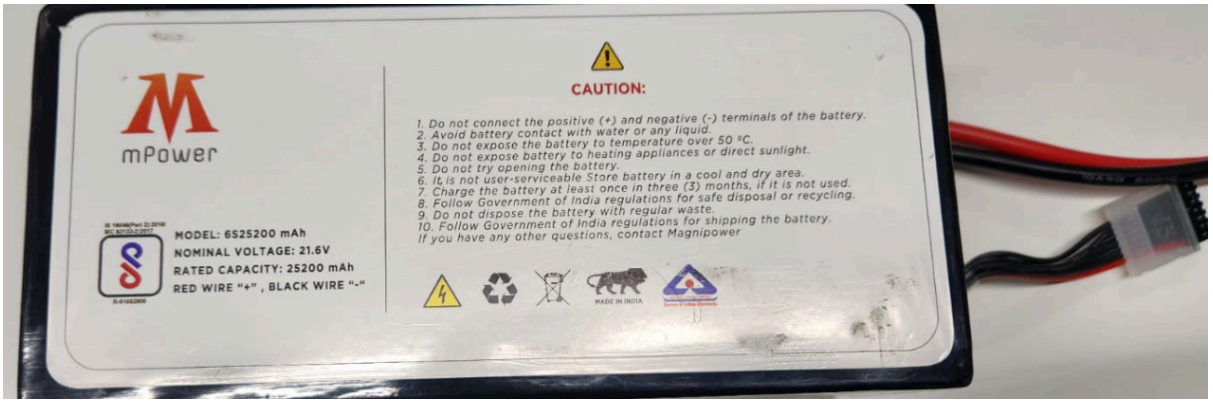


Figure 8.4.1 - mPower 25200 mAh battery

9.4.1. Battery Specifications

Battery chemistry	Lithium Ion
Configuration	6S
Capacity	25200mAh
Discharge rate	11C
Nominal Voltage	21.6V

Charge Current	25A
Dimension(LxWxH)	195x90x80mm ± 3mm
Net Weight	2750±50g
Cells	Cylindrical
Cooling Type	Air
Charging Voltage	25.2V
Set Charging voltage	25.2V
Lower Cutoff Voltage	15V
Set Discharge Voltage	18V
Safe Discharge Voltage	18V
Max. Discharge Current	270A
Storage Humidity	<90% RH
Storage Temperature	-20℃ to 35℃
Connection Options	XT 90
Power rating	544.32 Wh
Energy Density	197.93 Wh/kg
Operating Temperature	Up to 50 ℃

Table 13

Ensure batteries are stored and charged according to manufacturer guidelines to prevent fire hazards or battery damage.

9.5. Control and Communication

9.5.1. Communication link without using Buddy System

Reliable communication is essential for the optimal performance and control of TEJA - M during agricultural spraying operations. The hexacopter utilizes a robust communication system with the following components:

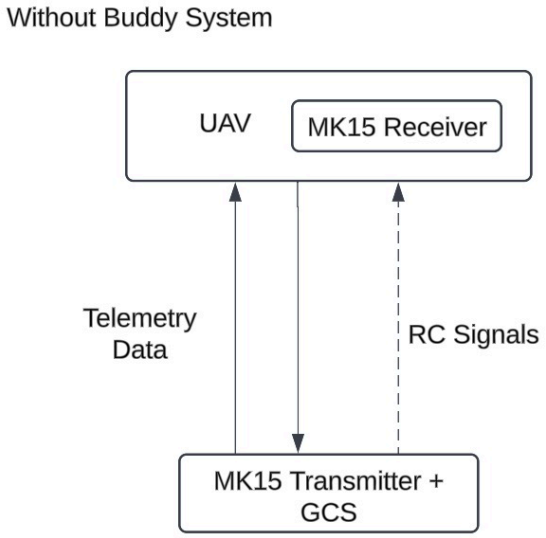


Figure 8.5.1 - Communication link without buddy system active

Communication Protocols and Systems:

- SIYI MK15 SMART AGRICULTURE FPV COMBO:
  - **Features:**
    - 15-kilometer range Android smart controller.
    - Dual 1080p FPV (First Person View).
    - Developed by SIYI Technology with the Qualcomm 8-core CPU platform.
  - **Application:**
    - Commonly used for reliable image transmission and control on agriculture drones, commercial drones, unmanned vehicles, boats, and robotics.

Redundancy Features:

The communication system in TEJA - M incorporates redundancy measures to ensure uninterrupted communication, especially in challenging environments. Redundancy features include:

- Dual Communication Channels:
    - TEJA - M utilizes dual communication channels to enhance reliability.
    - In the event of signal interference or loss in one channel, the system seamlessly switches to the alternative channel, minimizing the risk of communication failure.
- Signal Quality Monitoring:
    - Constant monitoring of signal quality ensures proactive identification of potential issues.
    - The system assesses the quality of communication signals and can dynamically adjust parameters to maintain optimal communication performance.
- Error Correction and Packet Loss Handling:
    - Advanced error correction algorithms are employed to rectify signal errors and mitigate packet loss during data transmission.
    - Redundant data packets are used to reconstruct lost information, ensuring the integrity of communication.
- Dynamic Frequency Selection:
    - TEJA - M is equipped with a dynamic frequency selection mechanism.
    - It automatically selects and switches frequencies to avoid interference and maintain a stable connection, even in crowded signal environments.
- Failover Mechanism:
    - A failover mechanism is in place to automatically switch to backup systems in case of primary system failure.
    - This ensures a seamless transition and prevents disruptions in communication.

The SIYI MK15 SMART AGRICULTURE FPV COMBO, with its 15-kilometer range, dual 1080p FPV, and Qualcomm 8-core CPU

platform, serves as a reliable and advanced component of the communication system, providing solid control and image transmission for TEJA - M during agricultural operations.

9.5.2. Communication link while using buddy system

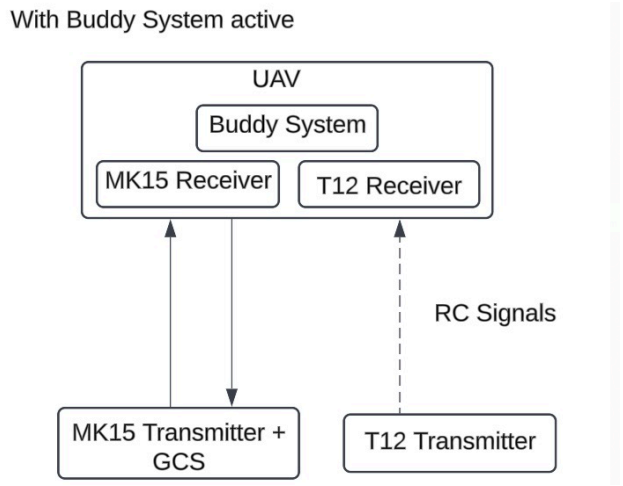


Figure 8.5.2 - Communication link with buddy system active

In a **buddy system** setup, the communication link between the receivers and transmitters is structured to provide primary and secondary control. Here's how the communication link works in this system:

1. **MK15 Receiver and Transmitter**:
    - The **MK15 receiver** serves as the **primary communication link** to the **Ground Control Station (GCS)**.
    - The MK15 receiver connects to the GCS and handles all data transmission between the aircraft (or drone) and the control station.
    - The **MK15 transmitter** allows the operator to regain full control of the aircraft by pressing the **A BUTTON** on the transmitter.
    - This allows the operator to override control, even when the T12 receiver is active and providing limited control.
2. **T12 Receiver and Transmitter**:
    - The **T12 receiver** receives basic **flight control commands** (pitch, roll, yaw, and throttle) from the **MK15 receiver**.

- It communicates only the RC (remote control) commands for flight control; it does not have direct access to the GCS, which remains connected solely to the MK15 receiver.
- The **T12 transmitter** controls the flight based on inputs provided by the MK15 receiver but has no influence on GCS communication.
- If the T12 receiver is active, the operator can control the aircraft, but the MK15 retains the ability to regain complete control when necessary.

3. **Buddy System Control Flow**:
   - **Primary Control (MK15)**: The MK15 receiver maintains communication with the GCS and has overriding control over the aircraft.
   - **Secondary Control (T12)**: The T12 receiver provides basic flight control (pitch, roll, yaw, throttle), but will not affect GCS communication or critical systems.
   - **Switching Control**: The operator can switch control between the MK15 and T12 receivers using the **A BUTTON** on the MK15 transmitter, ensuring a fail-safe mechanism for control regaining.

The T12 telemetry system is used to control and communicate with the UAS as a slave controller in buddy mode. T12 transmitter has 12 channels with frequency ranging from 2.400 to 2.4833 GHz. It is supported by FHSS technology with dual antenna dual-mode. Communication range for this system is about 20 km. Receiver has an operating voltage of 4.5-5.5V. This system comes with a gimbal camera operating at 5V which is connected to the receiver. AeroGCS firmware is compatible with this system.

Figure 8.4.1 - T12 Buddy System Controller

9.6. Camera Integration Overview

In addition to its primary function of crop spraying, the TEJA - M UAS can be equipped with a high-resolution camera to provide live feed monitoring of the crops. This feature enhances

the UAS's functionality, offering real-time observation capabilities which can be crucial for precision agriculture and crop management.

Camera Specifications

The camera used is the A2 mini, which is mounted on the canopy of the UAS. It is tilted at an angle to provide an optimal view of the field without any interference from the propellers or other components. The camera is housed in a protective casing to ensure durability and reliability in various operating conditions.

Key Features of A2 Mini Camera:

- **Overall:**
  - Video Output Port: Ethernet, HDMI, CVBS (AV)
  - Control Signal Input Port: S.Bus, UART, Ethernet UDP
  - Control Signal Output Port: S.Bus
  - High Accuracy 3 Axis Stabilization: Yaw, Pitch, Roll
  - Working Voltage: 11 ~ 25.2 V (Note: Early manufacturing lots may not support 25.2V)
  - Power Consumption: Average 5 W, Summit 12 W
  - Working Temperature: -10 ~ 50 ℃
  - Dimension: 55 x 55 x 70 mm
  - Weight: 95 g
- **Camera:**
  - Lens: Fixed Focal Length, 6X Digital
  - Equivalent Focal Length: 21 mm
  - Image Sensor: Sony 1/1.7-inch, 8 MP effective resolution
  - Aperture: F2.8
  - FOV (Field of View): Horizontal: 81°
  - TF Card Recording Resolution:
    - 4K (4096 x 2160) @ 25 fps
    - 2K (2560 x 1440) @ 30 fps
    - 1080p (1920 x 1080) @ 30 fps
    - 720p (1280 x 720) @ 30 fps
  - Video Storage Bitrate: 12 Mbps (H.265 Codec)
  - Supported File System: FAT32
  - Photography File Format: JPG
  - Video File Format: MP4
  - Supported TF Card Type: MicroSD Class10, max 128 GB
  - Still Photography Mode: Single

- White Balance: Auto

Integration and Customer Customization

The camera is an additional component that can be attached or removed based on customer requirements. Its integration does not interfere with the UAS's primary spraying function and provides added value through live feed capabilities. The camera can be particularly useful for monitoring crop health, identifying problem areas, and ensuring uniform application of fertilizers or pesticides.

Impact on Maximum Takeoff Weight (MTOW)

When installed, the weight of the camera (95 g) is added to the MTOW calculations. This ensures that all operational parameters remain within safe and effective limits, maintaining the integrity and performance of the UAS.

The integration of the A2 mini camera enhances the TEJA - M UAS's versatility and functionality, providing a valuable tool for precision agriculture. Its ability to offer real-time video monitoring alongside crop spraying operations makes it an ideal choice for modern agricultural practices. The camera's robust features and protective mounting ensure reliable performance, making it a worthwhile addition to the TEJA - M UAS.

Camera Integration Benefits

1. Real-time Crop Monitoring: Allows for immediate identification of crop health and problem areas.
2. Enhanced Precision: Ensures accurate application of fertilizers and pesticides.
3. Customer Flexibility: Camera can be added or removed based on specific needs.
4. Durability: Protected by a casing, ensuring longevity in various environmental conditions.
5. High-Quality Imaging: Provides high-resolution images and videos for detailed analysis.

This addendum ensures that all relevant details about the camera integration are documented, providing a comprehensive understanding of its benefits and impact on the TEJA - M UAS's performance.

9.7. Payload

The payload system is designed for targeted and efficient spraying. It includes a dedicated tank for pesticides, a high-performance pump, and a sophisticated control mechanism for

precise payload release. The payload system in the TEJA - M hexacopter is intricately designed for precise and efficient spraying operations in agriculture. The system incorporates various components such as nozzles, pump, tank, connectors, and pipes, each with specific features and specifications. Two types of nozzles, Type-A and Type-B, are utilized, and the pump, a Hobbywing 5L brushless motor, enhances liquid flow. The 10L tank, constructed from durable ABS material, includes anti-surge features, a stainless-steel filter, and a venting mechanism.

Integration is facilitated through advanced control mechanisms, including PWM signal control for the nozzles, intelligent pump control, and safety considerations like frothing prevention. The entire system is designed for compatibility and efficiency in agricultural spraying, with a focus on user-defined water and pesticide mixtures. Safety features such as protection grades and maximum fill recommendations ensure optimal performance in diverse environmental conditions.

9.7.1. Working diagram of payload:

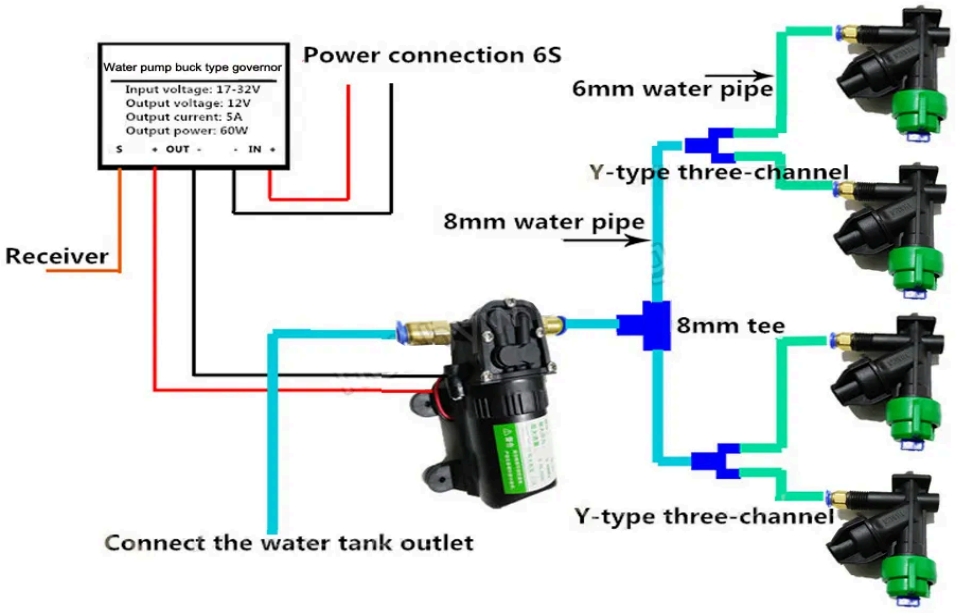


Figure 8.6.1 - Working diagram of payload

9.7.2. Fixed Payload

The fixed payload of TEJA-M is as follows:

Components of Payload	Specifications	Quantity/Capacity
Nozzle bar kit	High pressure, fan-shaped atomization.	4 Nos
Pneumatic connectors	ø6 x ø6 mm coupler	4 Nos
Pneumatic connectors	ø6 x ø6 x ø8 mm T-connector	2 Nos
Pneumatic connectors	ø8 x ø8 x ø12 mm T-connector	1 Nos
Pneumatic connectors	ø12 x ø12 mm Elbow Connector	1 Nos
Pump	5-liter, Max Voltage: 50.4V	1 Nos
Liquid flow meter & level sensor	5V	1 Nos (each)
Pneumatic tubes	ø6mm, ø8mm & ø12mm	8 (4+2+2) Nos
Tank with battery plate	Containing water & pesticide mixture, Varies with crop	10 liters

Table 14

9.7.2.1. Tank Material Specification

The tank of TEJA - M is constructed using Acrylonitrile Butadiene Styrene (ABS) material. ABS is chosen for its durability, chemical resistance, and lightweight properties, making it suitable for containing agricultural liquids, including water-pesticide mixtures.

9.7.2.2. TEJAM - Payload Type A:

Figure 8.6.2 - Fixed Payload with Type A nozzle

- Spraying Capacity: 10 liters of pesticide
- Number of Spraying Outlets: 4
- Total Weight of Payload: 10 kg
- TEJAM Weight with Payload (MTOW): 30.5 kg

Components:

- Nozzle Bar Kit: 4 high-pressure, fan-shaped atomization nozzles with filters
- Pneumatic Connectors: 4 × ø6 x ø6 mm coupler, 2 × ø6 x ø6 x ø8 mm T-connector, 1 × ø8 x ø8 x ø12 mm T-connector, 1 × ø12 x ø12 mm Elbow Connector
- Pump: 5-liter pump with a maximum voltage of 50.4V
- Liquid Flow Meter & Level Sensor: 5V, 1 each
- Pneumatic Tubes: 8 tubes (4 × ø6mm, 2 × ø8mm, 2 × ø12mm)
- Tank with Battery Plate: 10 liters, containing water & pesticide mixture

9.7.2.3. TEJA-M - Payload Type B:

Figure 8.6.3 - Type B Nozzle

- Spraying Capacity: 10 liters of pesticide
- Number of Spraying Outlets: 2
- Total Weight of Payload: Not specified
- TEJAM Weight with Payload (MTOW): 30.5 kg

Components:

- Centrifugal Nozzles: 2 nozzles with a capacity of 5 liters each
- Pneumatic Connectors: 1 × ø8 x ø8 x ø12 mm T-connector
- Pump: 5-liter pump with a maximum voltage of 50.4V
- Liquid Flow Meter & Level Sensor: 5V, 1 each
- Pneumatic Tubes: 4 tubes (2 × ø8mm, 2 × ø12mm)
- Tank with Battery Plate: 10 liters, containing water & pesticide mixture.

9.7.3. Variable Payload Details :-

Water & pesticide mixture: Different types of pesticides are used based on the crop type. The water-pesticide mixture is defined by the farmer/user.

The tank has a maximum capacity of 11 liters, but it is recommended to fill it only up to 10 liters to allow 1 liters of space for frothing. This precaution ensures optimal performance and prevents spillage during operation.

Figure 8.6.4 - Payload limits

9.8. Data Logging Capability

9.8.1. Overview of Data Logging Capability

TEJA-M is equipped with advanced data logging capabilities that are essential for both operational analysis and maintenance tasks. The data logging system records a wide range of parameters during flight operations, providing valuable insights into the performance of the drone and helping with troubleshooting and performance optimization.

Regularly review and analyze the logged data to ensure the safe operation of the RPA and prevent potential issues.

9.8.2. What Data is Logged

TEJA-M's data logging system captures a comprehensive set of flight and operational parameters. The following data types are logged:

Data Type	Description
Flight Time	The total duration of each flight session. Important for monitoring battery life and planning future flights.
Altitude	Current and maximum altitude during the flight. Useful for assessing altitude-related flight performance.
GPS Coordinates	Latitude and Longitude of the RPA's position at different intervals. Essential for tracking flight paths and navigation.
GPS Signal Strength	Quality of the GPS signal received by the drone. Monitor to ensure reliable navigation and positioning.
Battery Voltage	Real-time voltage levels of the drone's battery. Helps in assessing battery health and planning safe flight durations.
Battery Current	Current draw from the battery during flight. Indicates power consumption and helps diagnose battery-related issues.
Temperature	Temperature of critical components like motors and electronics. Prevents overheating and potential component failures.

Speed	The velocity of the RPA, including ground speed and airspeed. Assists in performance analysis and operational planning.
Motor RPM	Revolutions per minute of each motor. Critical for diagnosing motor performance issues and ensuring proper operation.
Flight Mode	Current flight mode (e.g., Loiter, Auto, RTL). Helps in understanding the flight behavior and analyzing mode-specific performance.
Error Codes	Logged error messages and system alerts. Essential for troubleshooting and resolving operational problems.
System Status	Overall health status of the RPA's subsystems (e.g., IMU, GPS, compass). Important for identifying any subsystem malfunctions.

Table 15

TEJA - M can store up to 499 logs at a time. New logs will replace the old logs after completion of the maximum limit to store logs.

End User cannot download the logs. However in case of any abnormalities or malfunction these logs will be used by Pavaman Aviation to determine the issue or error. So report immediately after the issue or malfunction during the operations.

10. Performance Data

10.1. Operational Flight Envelope

Operating speed at standard sea level conditions	10 m/s
Operating temperature	-10° to 50° C
Operational altitude	100 m
Operational envelope	Maximum Altitude: 100 m AGL, Maximum Range: 1500 m, Wind Speed: up to 6 m/sec , Maximum Drone Speed: 10 m/sec
Operational Ceiling height	100 m
Operational Endurance	1. Endurance with maximum variable payload without dispensing: 12 minutes 2. Endurance without variable payload: 25 minutes
Operational Range	0 to 1500 m
Operational Wind Speed (measured on the ground)	upto 6 m/sec
Operational bank angle	upto 25°
Operational MTOW Weight	30.5 kg

Table 16

Emergency Condition Envelope Table:

S.No	Failsafe	Visual Alert	Audio Alert	Time Taken for GCS	Action
1	Battery failsafe	Battery failsafe	Battery failsafe	Immediately	RTL
2	Critical Battery Failsafe	Battery failsafe	Battery failsafe	Immediately	Land
3	C2 Data Link Failure	Communication lost, drone disconnected	Communication lost, drone disconnected	5 seconds	RTL
4	Geofence failsafe	Fence Breach	Fence Breach	Immediately	RTL
5	Tank Empty	Tank Empty	Tank Empty	Immediately	Hover at location

Table 17

Detailed failsafe conditions are mentioned in the failsafe procedures in section 5.2

11. Appendices

1. Contact Information for Service and Support

ADDRESS: 2nd floor, kapil kavuri hub, financial district, nanakramguda, rangareddy -500032, Telangana

CONTACT DETAILS: 8465859571

EMAIL ID: vijay.veeramallu@pavaman.in

COMPANY WEBSITE: https://pavaman.in

2. Recommended Reading and Resources

- The Drone Rules, 2021

https://www.dgca.gov.in/digigov-portal/jsp/dgca/homePage/viewPDF.jsp?page=InventoryList/headerblock/drones/Drone%20Rules%202021.pdf

- Drone (Amendment) Rules, 2022

https://www.dgca.gov.in/digigov-portal/jsp/dgca/homePage/viewPDF.jsp?page=InventoryList/headerblock/drones/Drone%20(Amendment)%20Rules%202022.pdf

- TEJA - M; Maintenance manual

Annexure- 1

1. TOP , SIDE AND FRONT VIEW - ARMS UNFOLDED

Figure AX.1.1- Unfolded Top View

Figure AX.1.2 - Unfolded Front View

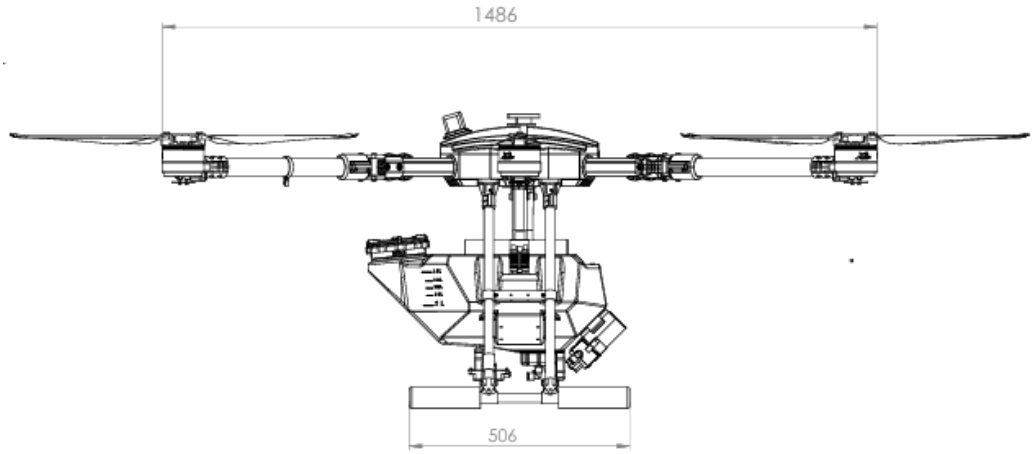


Figure AX.1.3 - Unfolded Side View

2. TOP , SIDE AND FRONT VIEW - ARMS FOLDED

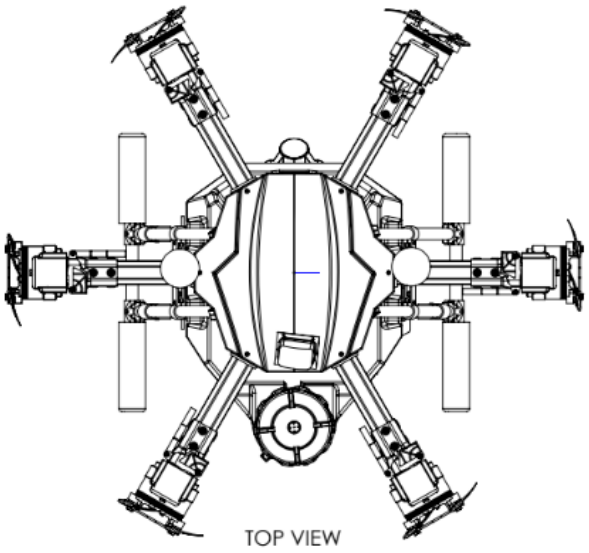


Figure AX.1.4 - Folded Top View

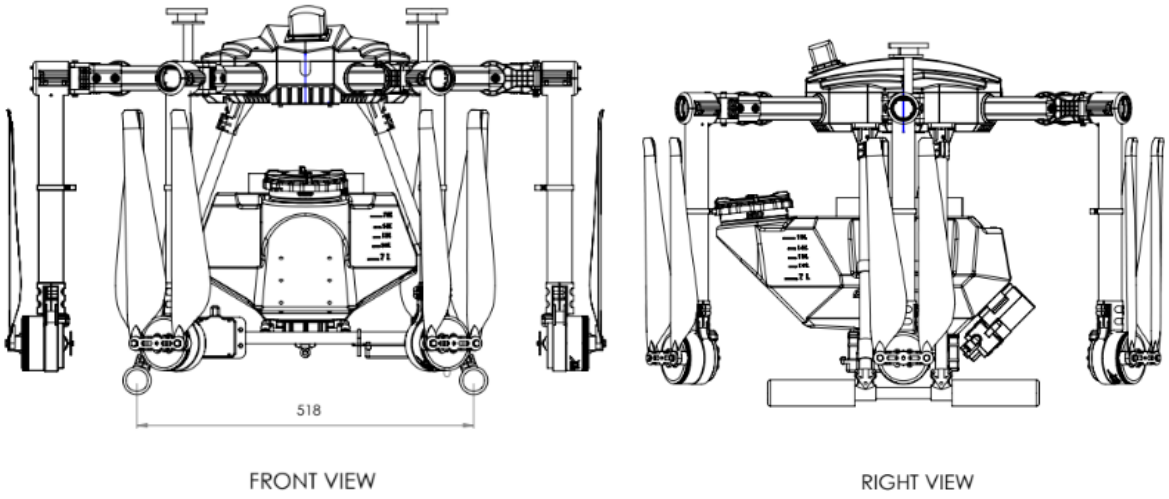


Figure AX.1.5 - Folded Front & Side View

3. ISOMETRIC AND TRIMETRIC VIEW

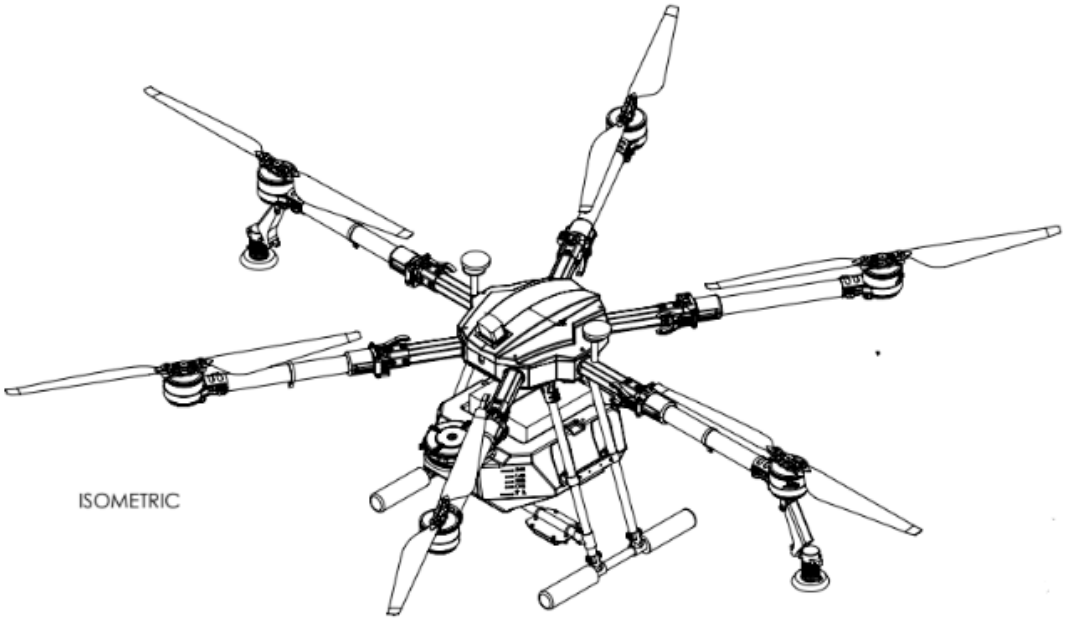


Figure AX.1.6 - Isometric View

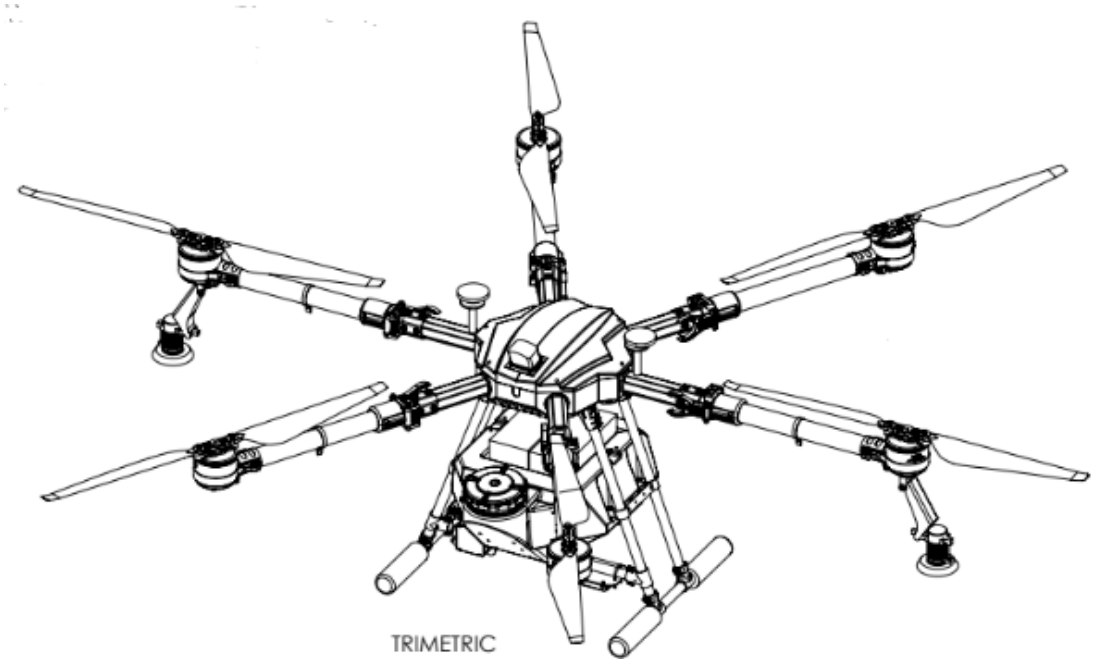


Figure AX.1.7 - Trimetric View

Annexure- 2

Fastener Details of TEJA-M

S.No	Name of the component	Type of screw- Hex Skt Head	Each Qty	No.of components	Total
1	Arm joint	M3x8	8	6 arm sleeves	48
	Arm hinge bolt	M5x50	1		6
2	Landing Gear Connector	Fixed seat M3x8	4	4 Connectors	16
	Vertical positioned-	Vertical positioned- M3x8 -2, M4x12-2	4	4 Connectors	16
3	T Joint Connector	M3x8 -2 nos., M3x 12 -1 no., M3x20-1 no.	4	4 connectors	16
4	Motors	M3x12	4	6 motors	24
5	Pump System	M4x12	4	1 Pump	4
6	Pipes and Hoses	M3x8-2 nos. one arm- 2 clips	2	4 arm 8 clips	8
7	Flat nozzles	M3x8 -1 no., Hub Mount M3x12-2 nos.	3	4 nozzles	12
	Centrifugal Nozzles	M3x12	2	2 nozzles	4
8	Propellers (HW2480)	M3x8 -4 nos., M3x16 -2 nos.	6	6 propellers	36
9	Battery Pack & Connectors	M3x8	6	2 sides of connectors	12
10	Terrain Radar	M4x12	4	1 radar	4
11	Obstacle Avoidance Radar	M3x16	1	1 radar	1
12	Camera	M3x8 with lock nuts	4	1 camera	4
13	GPS	M4x12	2	2 GPS	4
14	Tank	M5x45	4	1 tank	4
15	Canopy	M3x8	6	1 canopy	6
		In case of Flat nozzle			258
		In case of Centrifugal nozzle			250

Note: Before commencing any flight all the fasteners must be checked for any loseness.

Primary Structural Elements of TEJA-M

S.No	Name of the Component
1	Arm Joint
2	Landing Gear Connector
3	T Joint Connector
4	Inner Arm
5	Outer Arm
6	Main Frame
7	Vertical Landing Gear
8	Horizontal Landing Gear
9	Propeller Hub

List of Fasteners of PSEs:

S.No	Name of the Component	Type of Screw	Fastener per Component	Total No. of Components	Total Qty of Fasteners
1	Arm Joint	M3x8	8	6	48
2	Landing Gear Connector	M3x8	4	4	16
3	T Joint Connector	M3x8 - 2, M3x12 - 1, M3x20 - 1	4	4	16
4	Inner Arm	M3x12	6	6	36
5	Outer Arm	M4x12	8	6	48
6	Main Frame	M3x8 - 2, Clips	8	1	8
7	Vertical Landing Gear	M3x8 - 1, Hub Mount M3x12 - 2	5	2	10
8	Horizontal Landing Gear	M3x12	2	2	4
9	Propeller Hub	M3x10 -2 M3x8 -4	6	6	36

Note: Regularly check the fasteners of PSEs and regularly maintain them for safety.

Annexure - 3

List of life of components

Component	Life
Airframe	6500 hours
Landing Gear	8500 landings
Battery	384 cycles
Propeller	500 hours
Motors	500 hours

On completion of life of the airframe, the user is to return the UAS and take up with the manufacturer for replacement of the life expired airframe with a new one. Replacement of airframe is not a user level activity. It is to be replaced by the manufacturer only.

INDEX

List of Figures

List of Tables

Disclaimer

Thank you for purchasing the TEJA-M, an advanced industrial drone developed by Pavaman Aviation Pvt. Ltd. This manual is designed to guide you through the safe and efficient operation of your TEJA-M drone. Please read and follow all instructions carefully. Disregarding the instructions provided in this manual may result in immediate UIN cancellation, voided warranty, and severe legal consequences.

Important Notices

NOTE: Draws attention to any special item not directly related to safety but is important or unusual.

CAUTION: Disregarding the following instructions leads to serious or long-term deterioration of flight safety.

WARNING: Disregarding the following instructions leads to an immediate or severe deterioration of flight safety and hazardous situations, including such resulting in personal injury or damage to property.

Critical Warning: Disregarding the following instructions may result in immediate UIN cancellation, voided warranty, and severe legal consequences.

1. Introduction

1.1. General Information

The TEJA-M stands as an innovative Remotely Piloted Aircraft System (RPAS), specifically engineered as a hexacopter for agricultural spraying applications. This rotorcraft boasts a robust and meticulously designed airframe coupled with cutting-edge electronics, making it a trailblazer in the realm of precision agriculture. Designed to revolutionize precision agriculture through efficient and targeted crop spraying, the TEJA-M not only prioritizes operational efficiency but also integrates a master-slave RC configuration for training. This setup allows for real-time control transfer between instructors and trainees, enhancing hands-on learning and safety in Remote Pilot Training Organizations (RPTOs).

UAS TYPE	Rotorcraft
UAS STRUCTURE	Hexacopter
UAS CLASS	Medium
UAS CATEGORY	Remotely Piloted Aircraft System (RPAS)
UAS APPLICATION	Agricultural Spraying with live monitoring and specialized training for RPTO usage
UAS GROUND CONTROL STATION	AeroGCS Green (Version - v1.39)
UAS PRIMARY TRANSMITTER	SIYI MK15
UAS BUDDY SYSTEM TRANSMITTER (Optional)	Skydroid T12

Table 1

Figure 1.1.1 : TEJA-M Unfolded

Figure 1.1.2: TEJA-M Folded

1.2. Purpose of Flight Manual

The TEJA-M Agriculture Drone Flight Manual is an essential document designed to provide pilots and users with comprehensive information to ensure the safe and efficient operation of the TEJA-M drone. This manual serves as a guide covering all aspects of drone operation, including take-off and landing procedures, flight operations, emergency procedures, and maintenance. It provides detailed instructions and performance data to help pilots understand the capabilities and limitations of the drone and how to use them effectively. By adhering to this manual, pilots and operators can ensure they have the necessary information to fly the drone safely, efficiently, and in compliance with regulations.

It serves as a reference guide for pilots and operators, providing them with the necessary information to fly the drone safely and efficiently.

1.3. Drone Make and Model

Manufacturer: Pavaman Aviation Private Limited

Model: TEJA-M Hexacopter

The TEJA-M is a state-of-the-art hexacopter designed for agricultural monitoring and spraying. It features robust construction, high-precision GPS, a stabilized camera, and multiple flight modes to support a variety of missions.

1.4. TEJA-M Specifications

Specification	**Details**
Dimensions	
Width Unfolded	2.037 meters
Height Unfolded	0.581 meters
Length Unfolded	1.844 meters
Weight	
Empty Weight	11.46 kg
Maximum Takeoff Weight (MTOW)	30.5 kg
Power	
Battery	Li-Ion 6s, 25200 mAh (two batteries in series)
Maximum Power Consumption	2380.29 W
Performance	
Maximum Flight Duration	● Endurance with maximum variable payload without dispensing: 12 minutes ● Endurance without variable payload: 25 minutes
Maximum Horizontal Speed	10 m/s
Maximum Ascend Speed	2.5 m/s
Maximum Descent Speed	0.5 m/s
Operating Temperature	-10°C to 50°C
Wind Resistance	Up to 6 m/s
Operating Voltage Range	36 V to 50.2 V

Table 2

1.5. Component List

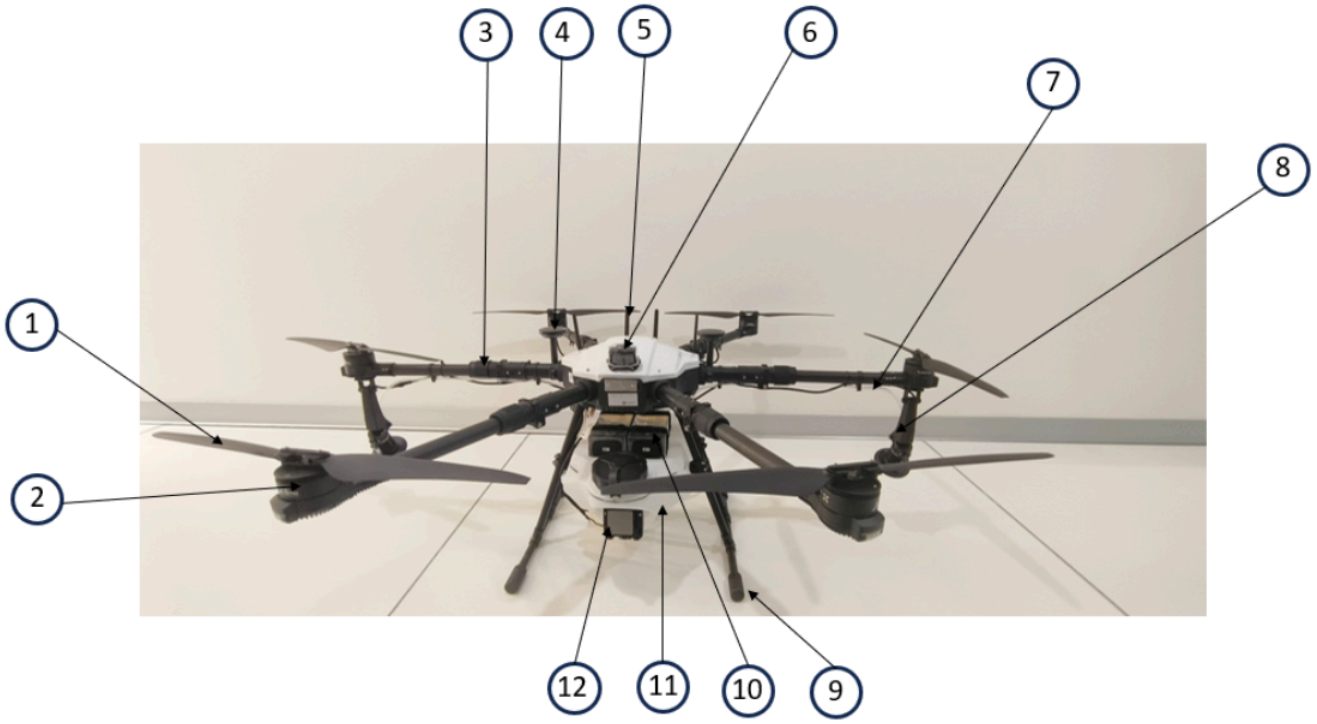


Figure 1.5.1: Component Nomenclature

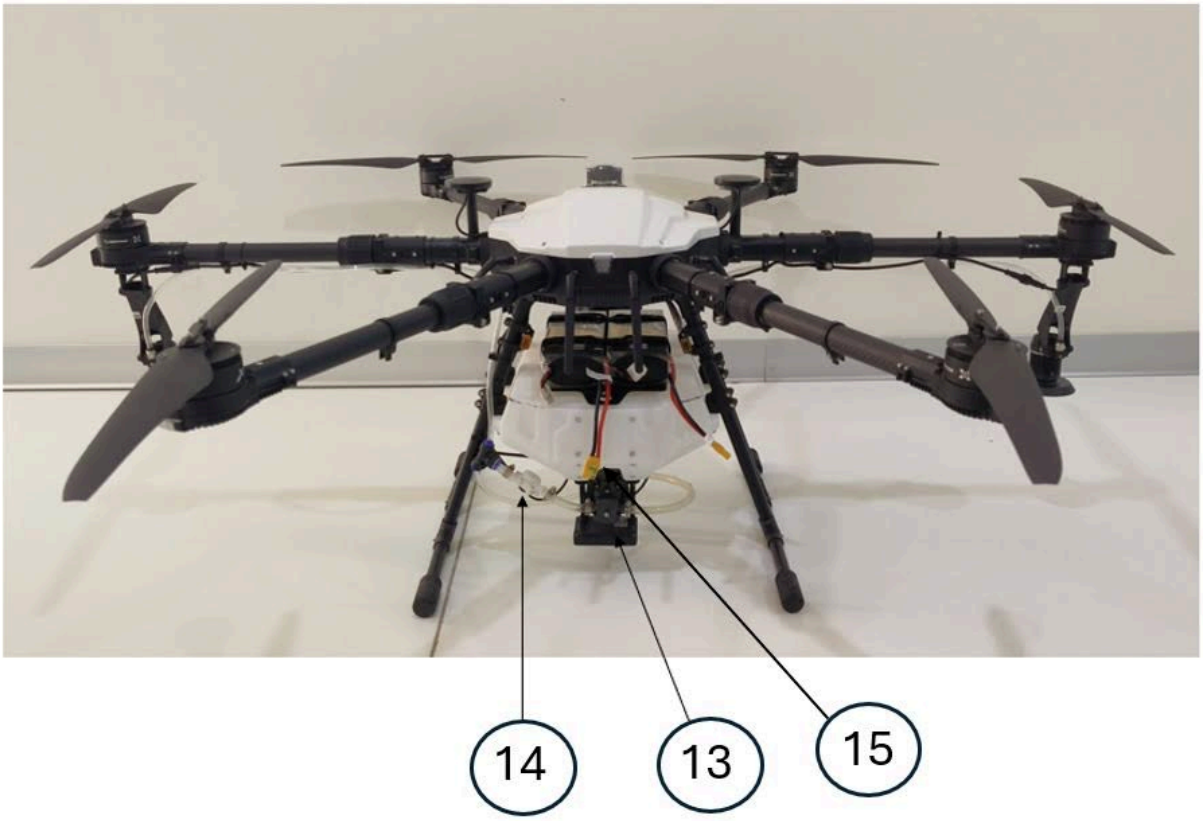


Figure 1.5.2: Component Nomenclature

Sr. No.	Component	Type of component	Quanti ty	Part Number	Description
1	Propellers	User removable	6	TEJA-PROP-0 01	High-efficiency propellers
2	Motor	Non user removable	6	TEJA-MOT-0 01	High-torque brushless motors
3	Hexacopter Airframe	Non user removable	1	TEJA-FRAM E-001	Carbon fiber reinforced airframe
4	GPS	Non user removable	2	TEJA-GPS-00 1	GPS modules for navigation
5	Antennae	Non user removable	4	TEJA-ANT-00 1	Communication antennae

6	Camera	Non user removable	1	TEJA-CAM-A8	A8 mini camera for live feed monitoring
7	Spraying Pipes	User removable	1 set	TEJA-SP-001	Pipes for liquid spraying
8	Centrifugal Nozzles	User removable	2	TEJA-NOZ-001	High-precision centrifugal nozzles
9	Landing Gears	Non user removable	2	TEJA-LG-001	Sturdy landing gears
10	Battery	User removable	2	TEJA-BAT-25200	Li-Ion 6s, 25200 mAh battery packs
11	Tank	Non user removable	1	TEJA-TANK-001	Liquid storage tank
12	Obstacle Avoidance Sensor	Non user removable	1	TEJA-OAS-001	Sensor for obstacle detection and avoidance
13	Terrain following sensor	Non user removable	1	TEJA-TFS-001	Terrain Following Sensor
14	Liquid Level Sensor	Non user removable	1	TEJA-LLS-001	Sensor for monitoring liquid levels in the tank
15	Pump	Non user removable	1	TEJA-PUMP-001	High-efficiency liquid pump

Table 3

Do not tamper with or attempt to remove non-user-removable components. Do not remove or tamper with void tapes. These are in place to ensure the integrity of the drone's components. Do not open the canopy. Unauthorized access to the drone's internal components can lead to serious malfunctions

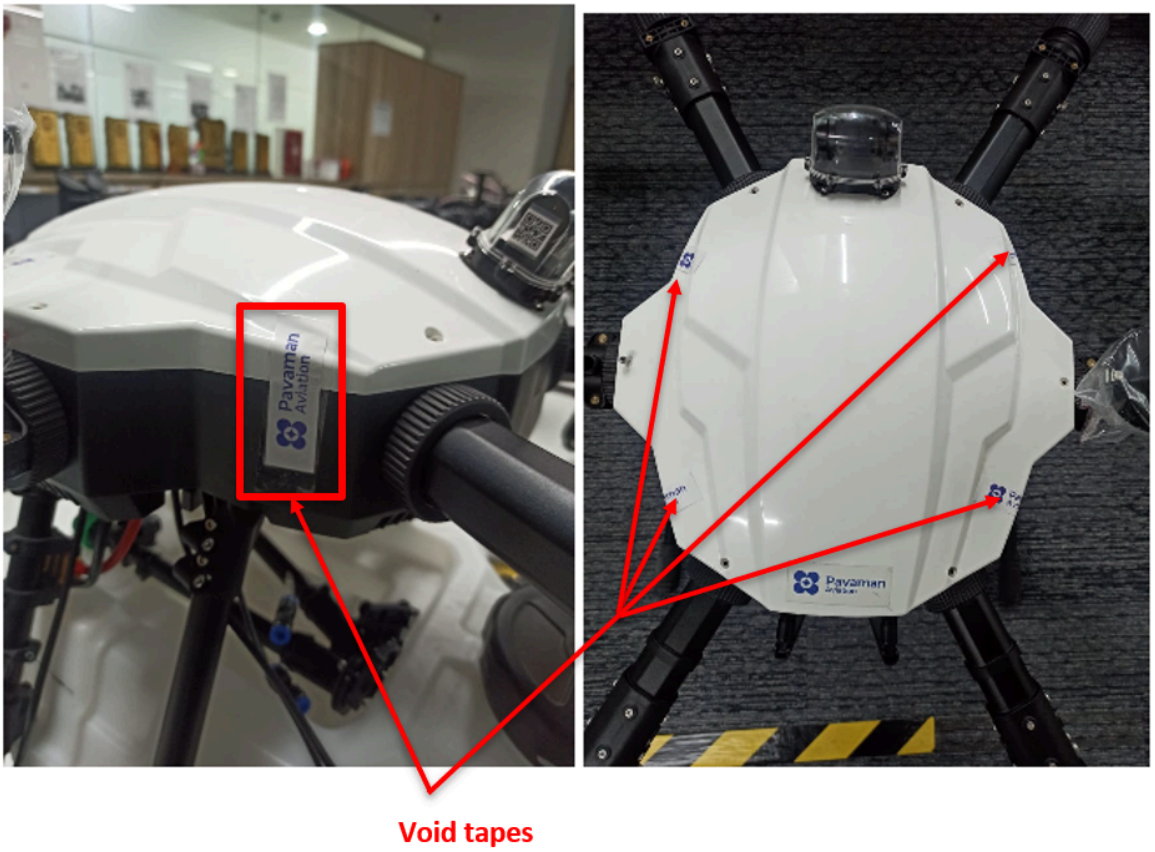


Figure 1.5.3: Void Tape

TEJA - M relies on GPS altitude readings for altitude control. The absence of barometric equipment in TEJA - M is a deliberate design choice tailored to its intended use for agricultural spraying during daylight hours with a restricted altitude ceiling and VLOS operations only. TEJA- M is not equipped with anti-collision strobe lights, as its design and functionality are optimized for daytime operations.

1.6. System Diagram

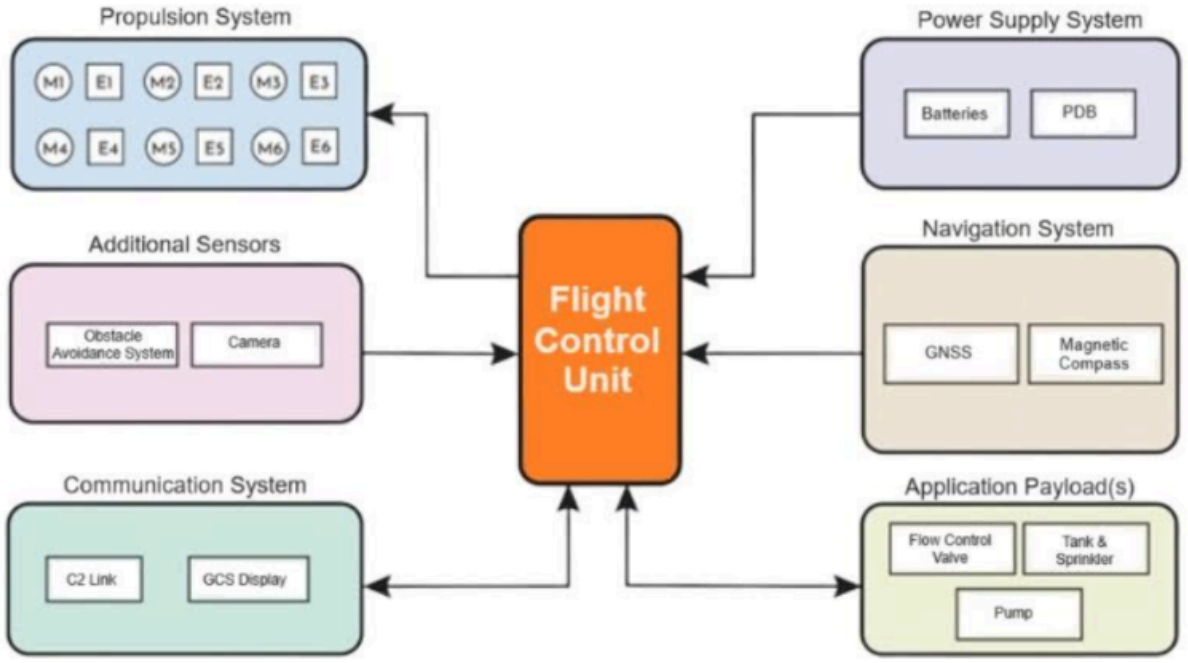


Figure 1.5.4: System Diagram

2. Safety Guidelines

2.1. Safety Protocols for Handling and Operating the Drone

1. Always follow the manufacturer's guidelines for operation and maintenance.
2. Keep a safe distance from the drone while it is in operation.
3. Wear appropriate safety gear (e.g., goggles, gloves) when handling the drone.

Never operate the drone near people, animals, or restricted areas.

Flight trial tests and Vibrational analysis confirms that the drone operates free from resonance and harmful vibrations, ensuring safe and reliable performance.

2.2. Protective Gear

- **Goggles:** Protects eyes from debris and bright sunlight.
- **Gloves:** Provides a better grip and protects hands from sharp edges.
- **Safety Vest:** Enhances visibility in operational areas.

2.3. Local Aviation Regulations

- Adhere to the maximum altitude and distance limits as specified by local authorities.
- Avoid flying in restricted areas such as airports and military zones.
- Obtain necessary permissions and licenses for commercial operations.

Links to Regulatory Bodies for More Detailed Information

- Drone Rules, 2021
- Airspace Map

3. Operational Limitations

Understanding the operational limitations of the TEJA-M drone is crucial for ensuring its safe and efficient use. This section outlines the key operational parameters, their specifications, and implications for flight performance.

3.1. Maximum Takeoff Weight

The maximum takeoff weight (MTOW) for the TEJA-M drone is 30.5 kg.

Implications on Flight:

- Exceeding the MTOW can significantly impair the drone's performance, leading to reduced maneuverability and increased power consumption.
- Overloading the drone may result in structural stress, potentially causing damage to the airframe and components.

Always ensure the combined weight of the drone, payload, and any additional equipment does not exceed the MTOW to maintain optimal performance and safety.

Do's:

- **Do** verify the total weight of the drone and payload before every flight.
- **Do** use a calibrated scale for accurate weight measurement.

Don'ts:

- **Don't** attempt to take off with a weight exceeding 30.5 kg.
- **Don't** ignore weight limitations for the sake of carrying additional payload.

3.2. Maximum Payload Weight

The maximum payload weight for the TEJA-M drone is 10 kg or 10 liters of water. The tank has a maximum capacity of 11 litres, but it is recommended to fill it only up to 10 litres until the marking shown in below image to allow 1 litres of space for frothing. This precaution ensures optimal performance and prevents spillage during operation. The user must not fill the tank beyond 10 litres, it may cause safety problems.

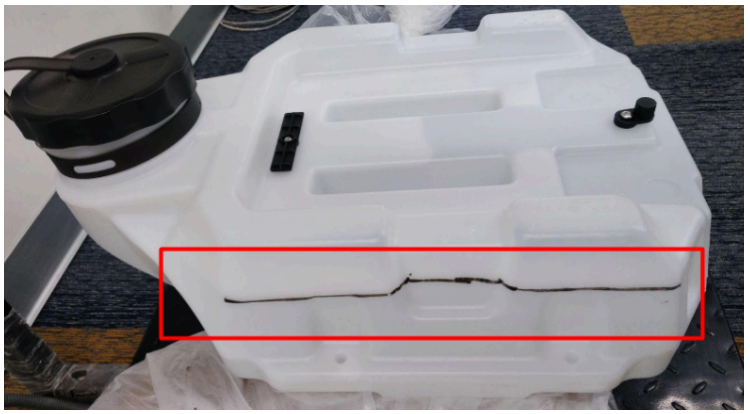


Figure 3.1 - Payload Tank limit

Impact on Performance:

- Payload weight directly affects the drone's flight duration, speed, and handling characteristics.
- Higher payload weights result in shorter flight times due to increased power consumption.

Balancing payload weight with mission requirements is essential to achieve the desired performance without compromising safety.

Do's:

- **Do** plan your mission according to the payload capacity.
- **Do** regularly check the payload attachment for security.

Don'ts:

- **Don't** exceed the 10 kg payload limit.
- **Don't** assume the drone can handle additional weight without testing.

TEJA-M is not equipped with SSR Transponder, Actuators, Servos, GSM, RFID, ADS-B, Barometric equipment with sub-scaling settings

3.3. Environmental Operating Conditions

Temperature Range:

- The TEJA-M drone is designed to operate in temperatures ranging from -10°C to 50°C.

Cold temperatures below -10° C will negatively impact the performance and endurance of the flight. The pilot must be aware and compensate during flight planning.

Wind Speed Limits:

- Maximum safe operational wind speed is 6 meters per second.
- High wind conditions can impair flight stability and control, requiring cautious operation and potentially limiting mission scope.

The pilot must be aware that a wind speed of 6 m/s as recorded on the ground may in fact be stronger as the altitude increases. The wind rating of 6 m/s does not distinguish between a constant wind speed and a gust. Pilots understand that flying the UAS in wind conditions greater than 6 m/s is at their own risk.

Humidity Considerations:

- The drone can operate in relative humidity levels up to 90%, but pilots should be aware of the potential for condensation and moisture ingress, especially in tropical environments.

Proper maintenance and storage are essential to prevent moisture damage.

Do's:

- **Do** check environmental conditions before each flight.
- **Do** operate the drone within the specified temperature and humidity range.

Don'ts:

- **Don't** fly the drone in adverse weather conditions without proper assessment.
- **Don't** ignore humidity and temperature warnings.

Understanding and adhering to these operational limitations ensures the safe and effective use of the TEJA-M drone. Operators should always consider these parameters during mission planning and execution to maximize performance and ensure compliance with regulatory requirements.

By following these guidelines, operators can ensure the longevity and reliability of the TEJA-M drone, while maintaining safety and legal compliance.

TEJA-M is not built for operation in rain, snow or in intensely-dusty conditions.

Do not operate the TEJA-M RPA during nighttime or in low-visibility conditions without proper lighting and permissions.

4. Operating Procedures

4.1. Turning ON/OFF the Transmitter and Connecting to Ground Control Station

Turning ON the Transmitter:

1. **Power Button Sequence:**
    - **Single Press:** Give a single press on the power button of the transmitter.
    - **Long Press:** Follow it with a long press on the power button until the transmitter powers up.

Figure 4.1.1: Power Button Sequence

2. **Confirmation:** The transmitter screen will light up, indicating it is powered on.

Connecting to Ground Control Station (GCS):

1. **Open GCS App:**
    - Click on the **Aero GCS Green** app on your device.
2. **Access Connection Menu:**
    - Once the app is open, locate and click on the **three dots symbol** at the top right corner of the screen.
    - From the menu that appears, select the "**Connect**" option.

Figure 4.1.2: Connecting GCS

3. **Select Communication Link:**
    - In the connection settings, click on the **communication link type drop-down menu** and choose **"Bluetooth."**

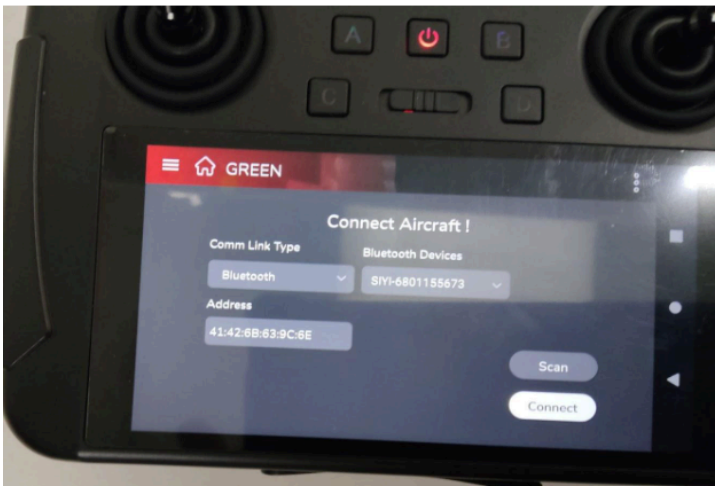


Figure 4.1.3: Selecting Communication Link

4. **Scan for Devices:**
    - Click on the **"Scan"** option to discover available Bluetooth devices.
5. **Select and Connect:**
    - From the list of devices, select the **"SIYI-6801155673"** Bluetooth device.
    - Click on the **"Connect"** button to establish a connection between the GCS and the drone.

6. **Confirmation of Connection:**
    - Once connected, the app should display a screen indicating the successful connection.

Figure 4.1.4: Visual Signal After Connection Successfully

Disconnecting and Turning OFF the Transmitter:

1. **Disconnecting the Drone:**
    - To disconnect the drone and RC, **disconnect the batteries**. This will terminate the communication link between the drone and the remote control (RC).
    - The RC may display a **red indicator**, indicating that the drone is disconnected.
2. **Turning OFF the RC:**
    - **Single Press:** Give a single press on the power button.
    - **Long Press:** Follow it with a long press until the transmitter powers down.

Figure 4.1.5: Turning Off the C2 link transmitter

Following these steps will help you properly turn ON and OFF the transmitter, establish a connection with the GCS using Bluetooth, and manage the communication link between the drone and the RC.

Always turn on the transmitter before connecting the drone's battery to avoid unexpected behavior.

Turning off the transmitter before disconnecting the drone's battery may result in loss of control.

4.2. Control And Communication

The TEJA - M hexacopter utilizes the SIYI MK15 communication system, offering advanced features for remote control and high-definition image transmission. The MK15 radio controller serves as a comprehensive and cost-effective solution, seamlessly integrating RC, video, data, and an Android system into one device.

The **TEJA-M Hexacopter** primarily utilizes the **MK15 Transmitter** for its communication and telemetry systems. This transmitter serves as the primary link for real-time control, data transmission, and operational feedback between the drone and the pilot.

In addition to the MK15 transmitter, the TEJA-M is equipped with a **T12 Transmitter and Receiver** system, which allows for the operation in **Buddy Mode** (Master/Slave configuration). This feature enables two pilots to share control of the drone, which is particularly useful for training and educational purposes, such as during Remote Pilot Training Organizations (RPTOs).

- **Primary Communication**: The MK15 transmitter is the primary system for controlling the TEJA-M and providing telemetry feedback.
- **Buddy Mode**: In Buddy Mode, the T12 system allows one pilot (slave) to control the drone while the second pilot (Master) can take over control if needed. This system is ideal for training scenarios, allowing an instructor to take control of the aircraft in case of emergencies or to guide the trainee in learning drone operation.
- **Control Switching**: The control of the drone can be switched between the MK15 and T12 transmitters, depending on the mode selected. While the T12 system can be used for training, the MK15 remains the primary telemetry and control interface.

This dual-communication setup enhances operational flexibility, making the TEJA-M suitable for both agricultural spraying operations and as a training platform for RPTOs.

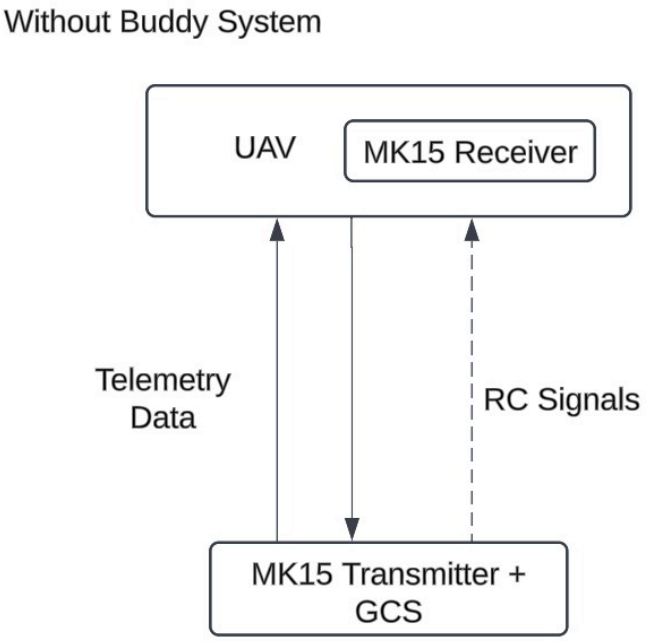


Figure 4.2.1: Communication link without Buddy system

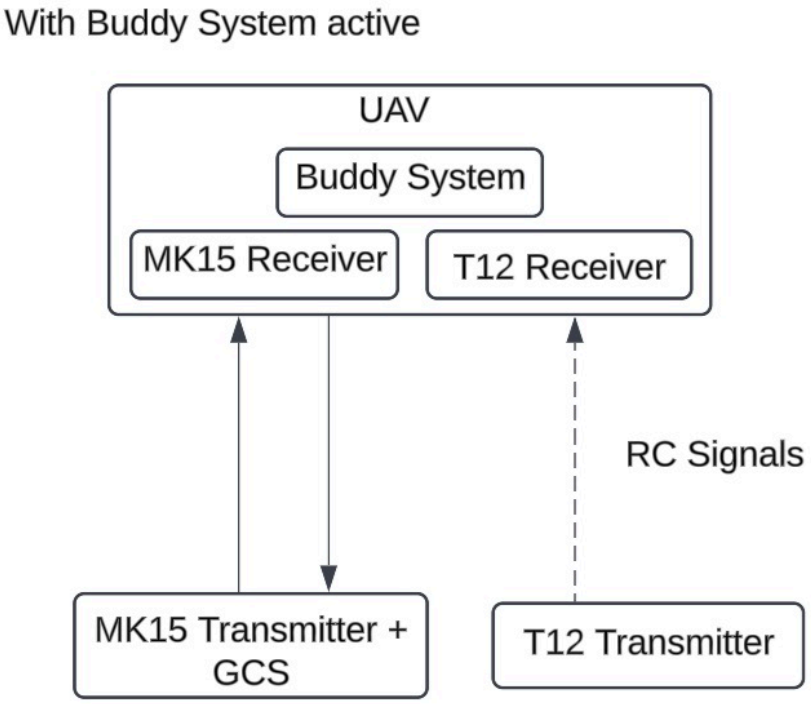


Figure 4.2.2: Communication link with Buddy system

4.2.1. Transmitter Nomenclature

Figure 4.2.3: C2 Link Transmitter Nomenclature

Figure 4.2.4: C2 Link Transmitter Nomenclature

Do not touch the antenna during operation. Doing so could interfere with transmission, causing a crash.

Do not carry or pull the transmitter by the antenna. The antenna wire could break and prevent transmission.

Figure 4.2.5: C2 Link Transmitter Nomenclature

Figure 4.2.6: C2 Link Transmitter Nomenclature

4.2.2. Button / Switch Types and Default Channel Definitions

MK15 remote controller comes with 13 physical channels and 16 communication channels in total. Communication channels 10 to 14 are also PWM channels 1 to 5 by default.

Channel No.	**Physical Channel Type**	**Default Mapping**
1	Roll	Joystick
2	Pitch	Joystick
3	Throttle	Joystick
4	Yaw	Joystick
5	Mode Switch	3-Stage Switch SA
6	Pump On/Off	3-Stage Switch SB
7	-	3-Stage Switch SC
8	Master/Slave	Button A
9	RTL	Button B

Table 4

4.2.3. Indicator Definition

The status indicators on MK15 remote controller and air unit use three different colors and different blinking frequencies to indicate the system's working or abnormal status.

4.2.3.1. Transmitter Indicator

🔴 Solid Red: No communication between transmitter and Air Unit.

🔴 Fast Red Blinks: The transmitter is binding to the Air Unit.

🔴 Slow Red Blinks: Firmware does not match.

🔴🔴🔴 Triple Red Blinks: Image transmission initialization failed.

🔴🔴🔴🔴 Four-time Red Blinks: The Transmitter requires calibration.

🔴🟢🔴🟢🔴 Red-Green-Red-Green-Red Blinks: Unexpected power off of MK15

4.2.4. RPA Manoeuvres

4.2.4.1. Arming/Take-off/Landing

- **Arming:** Perform a Combination Stick Command (CSC). The drone is armed.

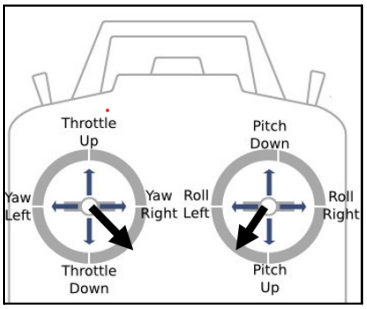


Figure 4.2.7 - RC Arming

- **Take-off:** Push the throttle stick up to take off.

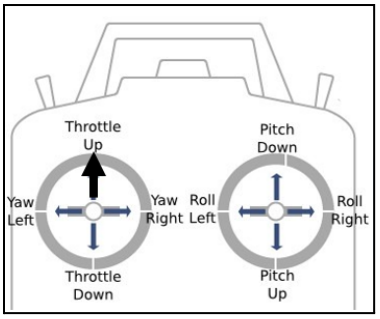


Figure 4.2.8 - RC take off

- **Landing:** To land, pull down on the throttle stick to descend until the aircraft touches the ground.

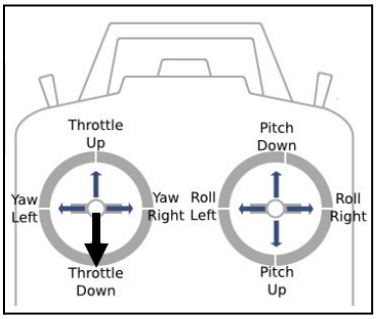


Figure 4.2.9 - RC Landing

- **Disarm**: Perform a Combination Stick Command (CSC). The drone is Disarmed.

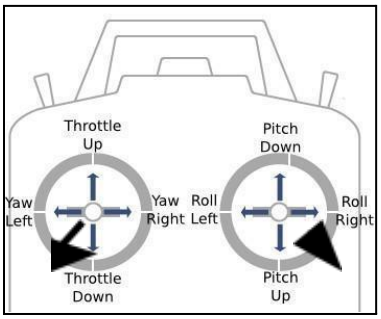


Figure 4.2.10 Disarming

4.2.4.2. Cruise / Maneuvering Flight

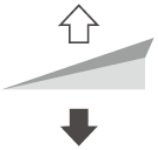
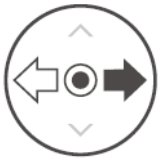
Remote Controller	Aircraft (Indicates nose direction)	Remarks
Left Stick 		Throttle Stick: Move the left stick vertically to control the elevation of the aircraft. Push up to ascend and push down to descend. Use the left stick to take off when the motors are spinning at an idle speed. The aircraft hovers in place if the stick is in the centre position. The further the stick is pushed away from the centre position, the faster the aircraft changes elevation.
Left Stick 		Yaw Stick: Move the left stick horizontally to control the heading of the aircraft. Push left to rotate the aircraft counter clockwise and push right to rotate clockwise. The aircraft hovers in place if the stick is in the centre position. The further the stick is pushed away from the centre position, the faster the aircraft rotates.
Right Stick 		Pitch Stick: Move the right stick vertically to control the pitch of the aircraft. Push up to fly forwards and press down to fly backward. The aircraft hovers in place if the stick is in the centre position. Push the stick further for a larger pitch angle and faster flight.
Right Stick 		Roll Stick: Move the right control stick Horizontally to control the roll of the aircraft. Push the stick left to fly left and right to fly right. The aircraft hovers in place if the stick is in the central position. Push the stick Further for a larger roll angle and faster flight.

Table 5

4.3. Standard Operating Procedure (SOP) for changing Speeds, Altitude, Range, Spray rate.

4.3.1. Flight parameters which user can change

The flight parameters which can be changed by the users but with a limit are

1. Speed (0 - 10 m/s)
2. Altitude (0-100m)
3. Range (0 - 1500m)
4. Spray Rate (0 - 100)

The objective of this SOP is to provide a step-by-step guide for the changing Speeds, altitude, range and Spray rate in the TEJA - M hexacopter used for agricultural spraying. Users can change the following parameters but with limits.

4.3.2. Procedure

Step 1: Select Flying Method -Automatic	

Step 2: Select Field Plot	
Step 3: Create Field Plot - Map	

Step 4: Add Point-Create Plot	
Step 5: Save Plot	


A
B
C
D
Add Point
Clear All
Save
Create Plan
Plot saved successfully
Obstacle
Plot


A
B
C
D
Add Point
Clear All
Save
Create Plan
AeroGCS GREEN
Do you want to use saved crop template for planning?
NO
YES
Obstacle
Plot

Step 6: Change Spray rate pressing symbols - in the left or + in the right or scrolling the center line.	
Step 7: Change Spray altitude pressing symbols - in the left or + in the right or scrolling the center line.	

Step 8: Change flight speed pressing symbols - in the left or + in the right or scrolling the center line.	
Step 9: Change Fence boundary pressing symbols - in the left or + in the right or scrolling the center line.	

Step 10:Save changes made	
Step 11: Upload the mission	

	
Step 12: Reviewing set parameters. The set parameters can be reviewed under the saved plan as shown above. Then start the mission.	

4.4. Battery Operation and Charging

Installation and Safety Precautions

Incorrect use can lead to serious fire, damage to your device, property damage, collateral damage, and serious injury. Read and follow all instructions carefully.

Do not use batteries other than recommended by Pavaman Aviation Private Limited

4.4.1. Battery Installation:

1. **Battery Tray:**
    - Place the set of batteries in the battery bay located on the tank.

Figure 4.3.1 - Battery Tray Location

2. **Battery Placement:**
    - Place the batteries as shown in image below and put straps on the battery

Figure 4.3.2 - Battery Placement

Ensure battery straps are securely tightened to prevent the battery from shifting during flight, which could lead to a loss of control.

3. **Connecting XT-90 Connectors:**
    - Connect the XT-90 connector of the drone with battery.

Figure 4.3.3- Connecting XT-90 Connectors

    - Listen for a single beep sound, indicating a proper connection.

The XT90 connectors prevent reverse connections and misalignment.

4.4.2. Pre-use Inspection:

1. **Damage Check:** Inspect the battery for any visible damage. Do not use it if damaged.
2. **Swelling Check:** Ensure the battery is not swollen. Do not use it if it is swollen.
3. **Leak Check:** Check for any electrolyte leakage. Do not use it if it is leaking.
4. **Connector Safety:** Avoid contact between connectors and metal or carbon fiber products to prevent short circuits.
5. **Temperature Safety:** Ensure the cell temperature does not exceed 50°C. Higher temperatures pose safety hazards.
6. **Power and Health Check:** Regularly monitor battery power and health.

4.4.3. Charging and Discharging:

1. **Noting Battery voltages:** The voltage is displayed in the battery charger. Battery voltages to be noted before charging and after charging and recorded in the battery log book.
2. **Monitoring:** Do not charge or discharge the battery without monitoring.
3. **Temperature Range:** Charge and discharge between 0°C to 40°C.
4. **Cold Environment Use:** Capacity drops sharply in cold environments. Fully charge the battery and keep it warm if operating between -10°C to 5°C. Avoid using below -10°C.
5. **Overcharging:** Never overcharge the battery.
6. **Short Circuit:** Never connect battery positive and negative terminals together.
7. **Polarity:** Ensure correct polarity connection to equipment.
8. **Over-discharge:** Avoid over-discharging to prevent battery damage and swelling.
9. **Electrolyte Safety:** Avoid contact with skin or eyes. Rinse immediately with water if contact occurs, and seek medical help if necessary.
10. **Disassembly:** Never disassemble the battery.

4.4.4. Charging

Recommended charging settings:

- No. of cell : 6
- Voltage : 22.2 V
- Current : 8 A Mode
- Charge / Balance Charge
- Battery type : LiPo

PC1080 Charger:

- Capable of balancing and charging 2 packs of 6 cell batteries simultaneously.
- Three modes: fast charge, balance charge, and storage.

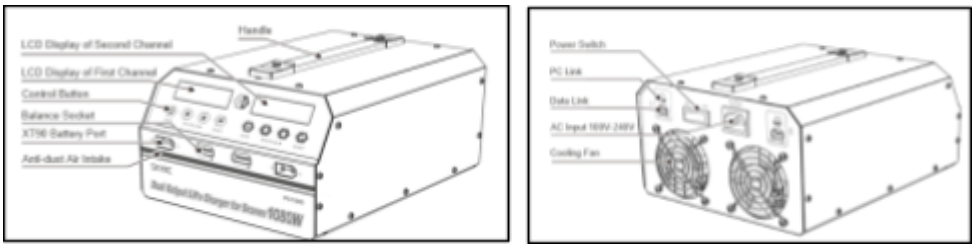


Figure 4.3.4 - Battery Charger

Features:

- Support charging 2 packs of 6S Li-ion batteries.
- Battery memorizing last charging current.
- Modes: fast charge, balance charge, storage.
- Safety: short circuit protection, reverse polarity protection, overheat protection.
- 2x16 LCD screen for real-time status display.
- Battery voltage meter and resistance meter.

Operational Steps:

1. **Power On:** Connect to the power source and turn on the switch. Listen for a beep sound and check the LCD screen.

Figure 4.3.5 - Charger Display

2. Parameter Settings:

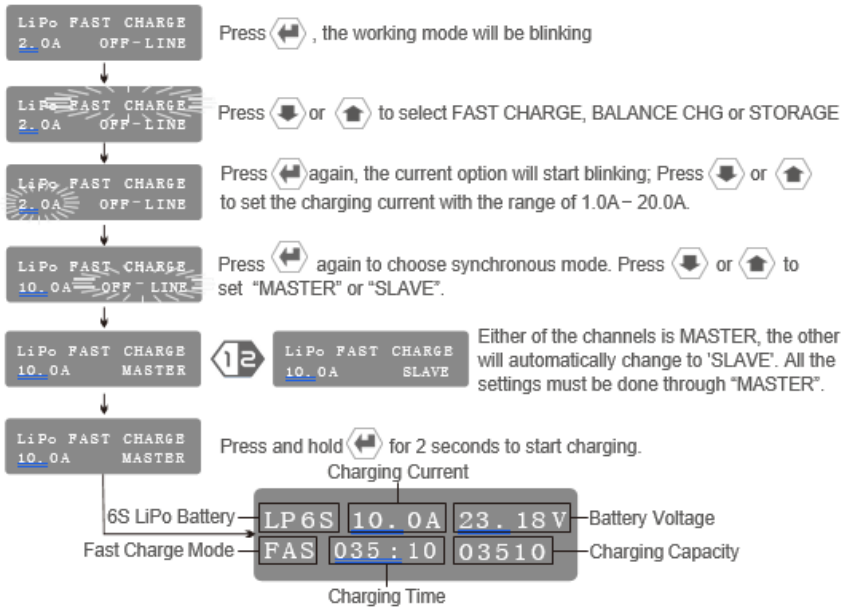


Figure 4.3.6- Parameter Settings:

3. **Battery Connection:** Connect batteries to the PC1080 charger as shown.

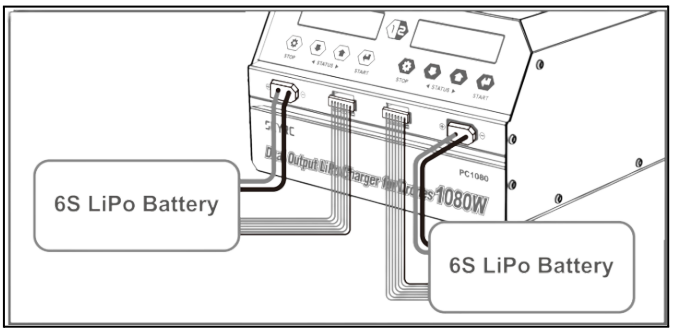


Figure 4.3.7 - Charging Operational Step

4. **Mode Change:** Change mode as shown below:

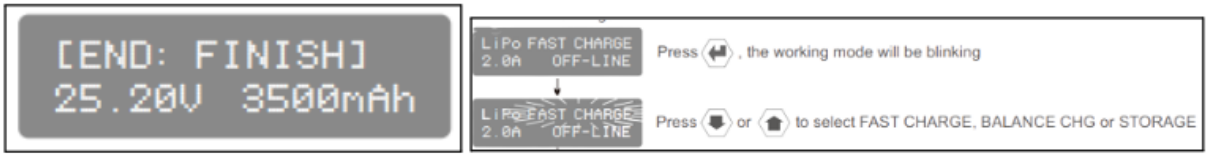


Figure 4.3.8 - Charging Finish Display

5. **Storage Mode**: If a Lithium battery is not used for a long time of more than a month, it's highly recommended to charge or discharge the battery with STORAGE mode so as to extend the battery life. If the battery voltage is higher, the charger will discharge the battery; if battery voltage is less, then the charger will charge the battery under STORAGE mode.

Battery Voltage Meter:

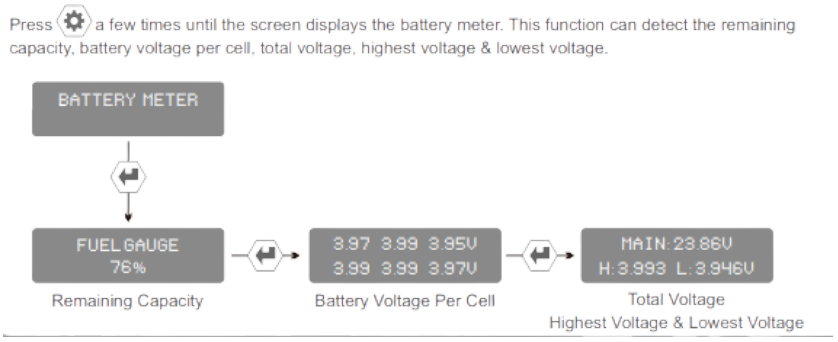


Figure 4.3.9 - Battery Voltage Meter:

Battery Resistance Meter:

Press a few times until the screen displays the battery resistance meter. This function can detect internal resistance per cell and total resistance. The lower the battery resistance is, the higher the battery performance will be. Internal resistance will increase after the battery is commonly used.

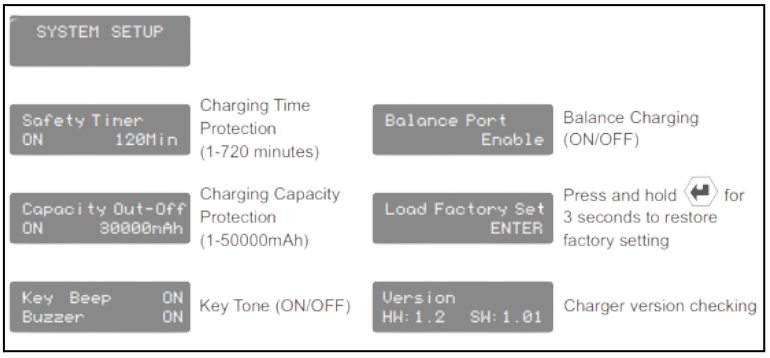


Figure 4.3.10 - Battery Resistance Meter

Specifications

- Input Voltage: 100-240V
- Output Power: 1080W (540W×2)
- Discharging Power: 50W×2
- Charging Current Range: 1.0-20.0A×2
- Balance Current: 1.2A Max.
- Battery Type: Li-Ion
- Battery Cell Count: 6S×2
- Charging Modes: Fast Charge/Balance Charge/Storage
- Size: 272×202×118.6mm
- Weight: 4.88kg

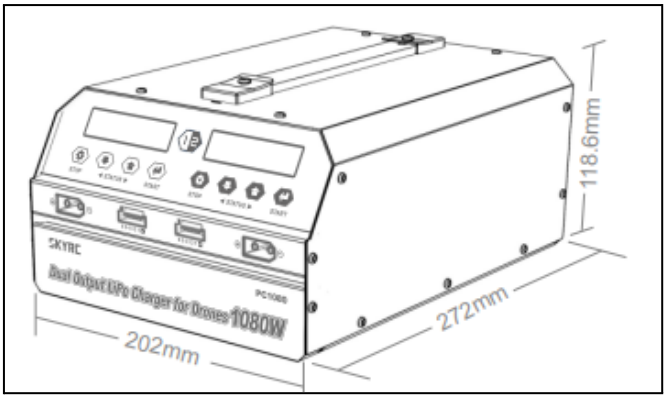


Figure 4.3.11 Charger dimension

4.4.5. Warnings and Safety Precautions

1. **Unattended Charging:** Never leave the charger unattended when connected.
2. **Malfunction:** Terminate the process immediately if any malfunction occurs.
3. **Environment:** Keep the charger away from dust, moisture, heat, direct sunlight, and vibration.
4. **Surface:** Place on a heat-resistant, non-flammable, non-conductive surface. Avoid placing on car seats, carpet, etc.
5. **Battery Types:** Never charge/discharge batteries that are:

- Different cell types or manufacturers.
- Already fully charged or slightly discharged.
- Non-rechargeable (Explosion hazard).
- Faulty or damaged.
- With integral charge circuits or protection circuits.
- Installed in other devices.

4.4.6. Battery Storage and Transportation

Guidelines:

1. **Humidity:** Avoid storing batteries in humid environments. Use LiPo Bags for a controlled environment.
2. **Fire Safety:** Keep batteries away from fire and heat sources.
3. **Child Safety:** Store batteries out of reach of children.
4. **Temperature:** Store at 25°C.
5. **Storage Space:** Ensure ample space to avoid squeezing batteries.
6. **Regular Checks:** Inspect storage every two weeks. Perform charge and discharge cycles to maintain stability.

Safe Storage Instructions:

1. **Storage locations:**·
   - There should be separate racks for keeping discharged batteries and charged batteries. These racks should be clearly marked for the respective use. Faulty batteries are not to be kept in the vicinity of serviceable batteries. Those are immediately disposed as per the disposal procedure.
   - The batteries should be placed by not touching each other. Nevertheless, 3-to-4-inch distance should be maintained while storing.

Figure 4.5.1 - Battery storage clearance

2. **Inspection:**

On every 90th day of storage:

1. **Visually inspect** the battery for swelling, corrosion, leaks, or connector damage.
2. **Measure total voltage** and **individual cell voltages** using a calibrated battery checker or smart charger.
3. Ensure the battery remains within the storage **voltage range** of **21.6V to 22.8V.**
4. Check cell balance: cells should be within **±0.03 V** of each other.
5. If the battery is to be reused, **charge to full** before deployment.
6. If the battery is **not being used**, adjust charge to **storage level** (approx. 3.80 V/cell).
7. **Update logbook** with inspection results and actions taken.

The battery should always be stored in a LiPo safe bag in order to maintain temperature and humidity.

Before storing in a LiPo safe bag, ensure that the LiPo safe bag is not damaged and has no cut or any other damage exposing the LiPo battery stored inside to the outside environment. In case the LiPo bag is damaged, dispose of the damaged lipo bag and use a new one.

The users should follow a separate battery log for each battery.

4.4.7. Decommissioning and Discarding Batteries:

- **Cycle Limit:** Decommission batteries after 384 cycles or if damaged/swollen.
- **Hazardous Chemistry:** Proper disposal to prevent fire and contamination.
- **Steps:**
    - Track cycles and monitor for damage.
    - Discharge in saltwater until voltage reaches zero.
    - Wear PPE during handling.
    - Return to manufacturer for disposal.

Strictly adhere to guidelines for safety and environmental responsibility.

4.5. Pre-flight Checklists

Detailed Pre-flight Checklist:

Step	Description	Tick Box
1	Inspect airframe for damage	☐
2	Check propellers for wear and secure attachment	☐
3	Ensure battery is fully charged and properly installed	☐
4	Verify all payloads are securely attached	☐
5	Check all fasteners of Primary structural elements mentioned in Annexure - 2 for looseness and integrity	☐
6	Inspection of critical components for in-service wear due to weathering effect and corrosions	☐
7	Power on the transmitter	☐
8	Connect the battery to the drone	☐
9	Perform a control surface check	☐
10	Confirm GPS lock and home point	☐
11	Satellite counts more than 10 sat	☐

12	HDOP value less than 1	☐

Table 6

The VDOP allowable is less than 2.5 normally. However the VDOP value is not viewed by the users in GCS. . Only Satellite counts and HDOP value can be monitored using GCS. The recommended value for Satellite count and HDOP value is mentioned in the above Table 6.

Do's and Don'ts:

- **Do's:**
  - **Do** complete the checklist before every flight.
  - **Do** verify each item thoroughly.
- **Don'ts:**
  - **Don't** skip any checklist items.
  - **Don't** start the flight if any issues are found.
  - **Don't** fly the drone if the sat count value is less than 10 and HDop value is more than 1.

Ensure that the flight plan avoids any HIRF areas and restricted airspace to prevent interference and maintain safety.

4.6. Payload Installation

Step-by-Step Installation Process:

1. **Check for the pump motor to be clear with the air blocks.**

Ensure the pump motor is free of obstructions to avoid malfunction during operation.

2. Check that the motor is tightly fitted.

A loosely fitted motor can lead to vibrations and potential detachment mid-flight.

3. Check that the nozzle rods are fitted properly.

Properly fitted nozzle rods ensure accurate spraying and effective payload delivery.

4. Check that the pipeline and pneumatic connectors are free from leaks. Refer to the maintenance manual for detailed SOP of leak check and its resolution.

Leaking connectors can lead to loss of chemicals and pose a safety hazard.

5. Check that the nozzle tips are free from debris.

Debris in nozzle tips can block the flow, reducing efficiency and accuracy.

6. Check that the water tank is filled up to the 10L mark.

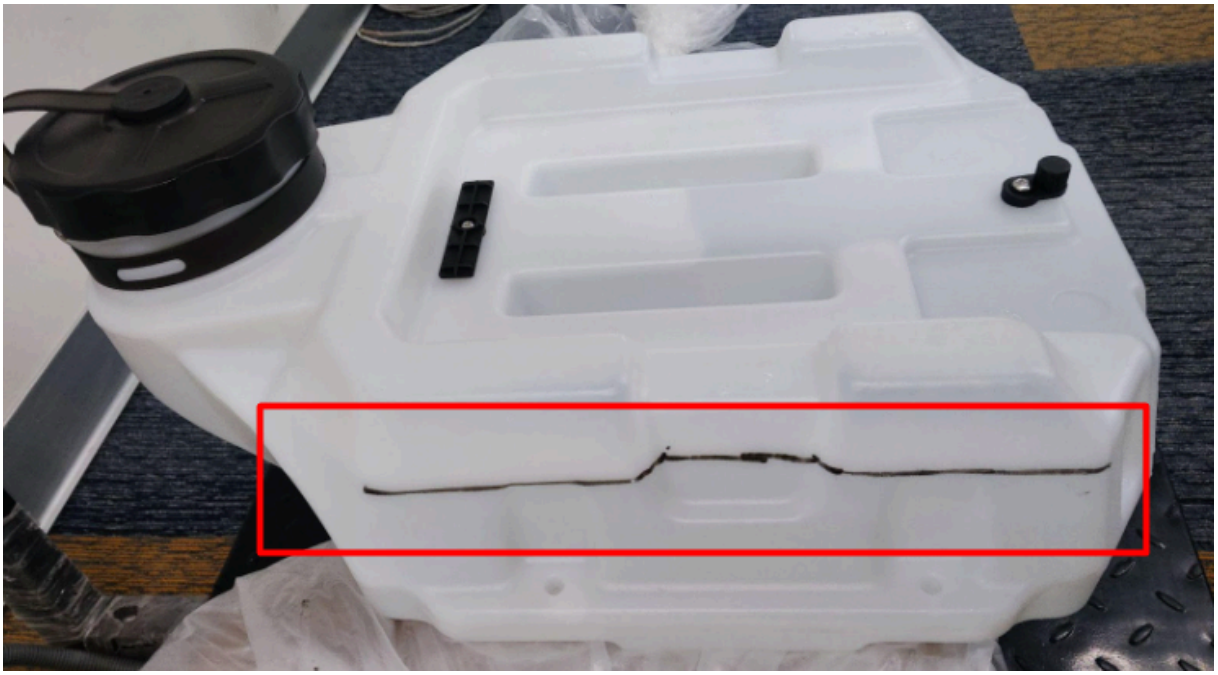


Figure 4.5.2 - Payload Tank limit

The maximum tank capacity is 11 litres. But the tank to be filled is 10 liters up to the mark. Under no circumstances, a tank should be filled beyond 10 litres marking.

Do's and Don'ts:

- **Do's:**
  - **Do** check all components for secure attachment.
  - **Do** ensure the water tank is filled correctly to avoid imbalance.
- **Don'ts:**
  - **Don't** operate the drone if any checks fail.
  - **Don't** skip any steps in the checklist.

4.7. Takeoff Procedures

As TEJA-M being a rotorcraft, it has the ability to vertically takeoff without any requirement of any special launching mechanism. Even though the following points must be kept in mind for safe flights.

Detailed Instructions for Safe Takeoff:

1. Position the drone on a flat, open surface free from obstacles.

Ensure the area is clear to avoid collisions during takeoff.

2. Turn on the transmitter and check for a stable connection with the drone.

A weak connection can lead to loss of control.

3. Perform the arming check to ensure all systems are functioning correctly.

When arming TEJA-M, ensure the throttle (left stick) is pulled all the way down before confirming. Failing to hold the throttle down will cause the aircraft to leap into the air once armed.

4. Gradually increase the throttle to lift the drone off the ground.

Avoid sudden throttle increases to prevent instability.

5. Maintain a steady ascent to a safe altitude before initiating flight maneuvers.

A steady ascent helps in maintaining control and stability.

4.8. Landing Procedures

As TEJA-M being a rotorcraft, it has the ability to vertically land without any requirement of any special landing mechanism. Even though the following points must be kept in mind for safe flights.

Safe Landing Techniques:

1. **Clear Landing Area:**
    - Perform a visual check of the area before initiating the descent.

Ensure the landing area is free of obstacles and people to prevent potential accidents.

2. **Controlled Descent:**
    - Monitor the drone’s alignment with the landing spot and keep it level.

Gradually decrease the throttle to maintain stability during descent.

3. **Align and Stabilize:**
    - Make minor adjustments to keep the drone steady and aligned with the landing area.

Misalignment during descent can cause the drone to tip over.

4. **Gentle Touchdown:**
    - Aim for a smooth and gentle touchdown to minimize impact.

Reduce the throttle gradually to avoid a hard landing.

5. **Power Down:**
    - Ensure the motors are completely off before handling the drone.

After touchdown, turn off the motors first, then the transmitter.

Additional Landing Guidelines:

- **DO:**
    - Always land the drone in an open space.
    - Always land the drone in the direction of the wind.
    - Perform a pre-landing check of the drone's batteries, propellers, and other components.
    - Check the weather conditions and avoid landing if the wind speed exceeds safe limits.
    - Maintain a safe distance from the drone during landing.

- Disarm and switch off the drone immediately after landing.

- **DON'T:**
  - Never attempt to land on uneven or unstable ground.
  - Never land the drone near people, animals, or buildings.
  - Never abruptly reduce throttle during descent.

The TEJA-M does not have a shock-absorbing mechanism in its landing gear. Exercise caution and controlled landing to prevent damage to the drone. Choose landing surfaces carefully, ensuring they are free from obstructions and suitable for the absence of a shock-absorbing system.

4.9. Geofencing Capability & Procedure

The TEJA-M has geofencing capability to enhance flight safety by preventing the RPA from entering restricted or hazardous areas.

Manual Setup Instructions:

- **Step 1:** Open the AeroGCS Green application and connect with the RC via Bluetooth or Serial. The UI will appear as shown below.
- **Step 2:** Click on "Start Here" to begin the setup process.
- **Step 3:** You will be redirected to a page where you can choose the manual mode of flying.
- **Step 4:** After clicking "Manual," you will see a square fence with green lines and yellow dots on the edges on your screen.
- **Step 5:** To update the fence, click on the yellow dots and move them as needed. You will receive a notification that the fence has been updated.

When to Set Up Geofence:

- **Before Every Flight:** Always set up a geofence to prevent the RPA from entering restricted or hazardous areas.
- **During Flight Planning:** Include geofence setup as part of the flight planning process to ensure compliance with local regulations and safety guidelines.

4.10. Sensor Operations

4.10.1. Liquid Level Sensor Operation

The liquid level sensor provides valuable information about the remaining liquid inside the tank, ensuring smooth and interruption-free drone operations.

Figure 4.9.1 - Liquid Level Sensor

Working of Liquid Level Sensor:

- **Monitoring Tank Levels:** The sensor continuously measures the liquid level within the tank.
- **Real-time Data Transmission:** It sends real-time data to the drone's flight controller.
- **User Accessibility:** The flight controller processes the data, making it accessible to users through telemetry or a ground control station.

Configuring through AeroGCS GREEN:

1. Set the auxiliary pin to Aux 3.
2. Reboot the drone, and the sensor initiates operation.

3. Navigate to AeroGCS GREEN:
    - Spray setting ==> Level sensor setting ==> Set the Auxiliary pin for the sensor's signal output.

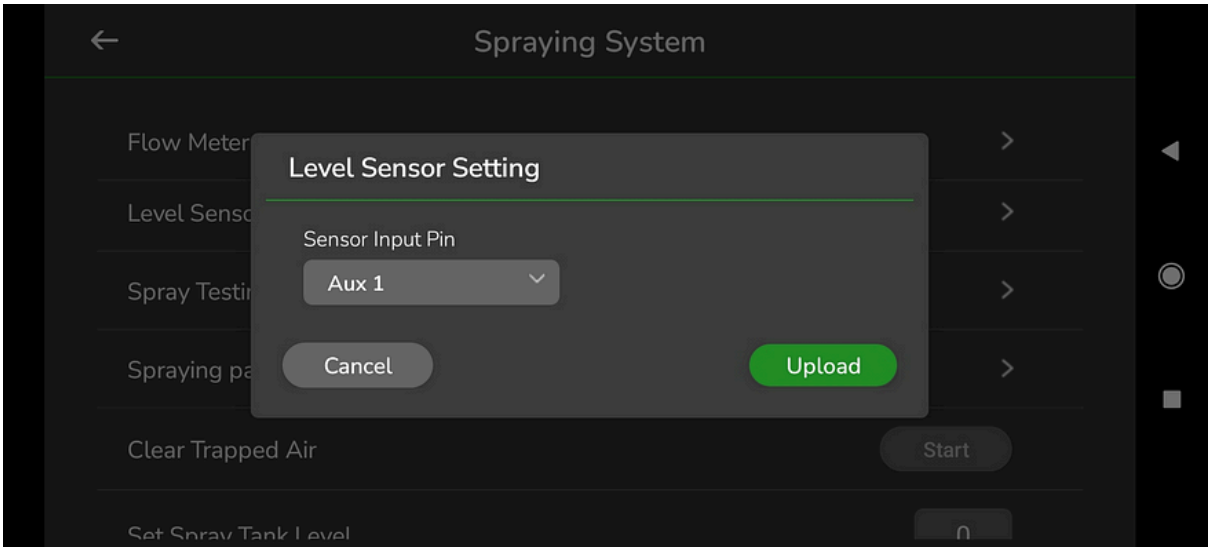


Figure 4.9.2 - Level Sensor Settings

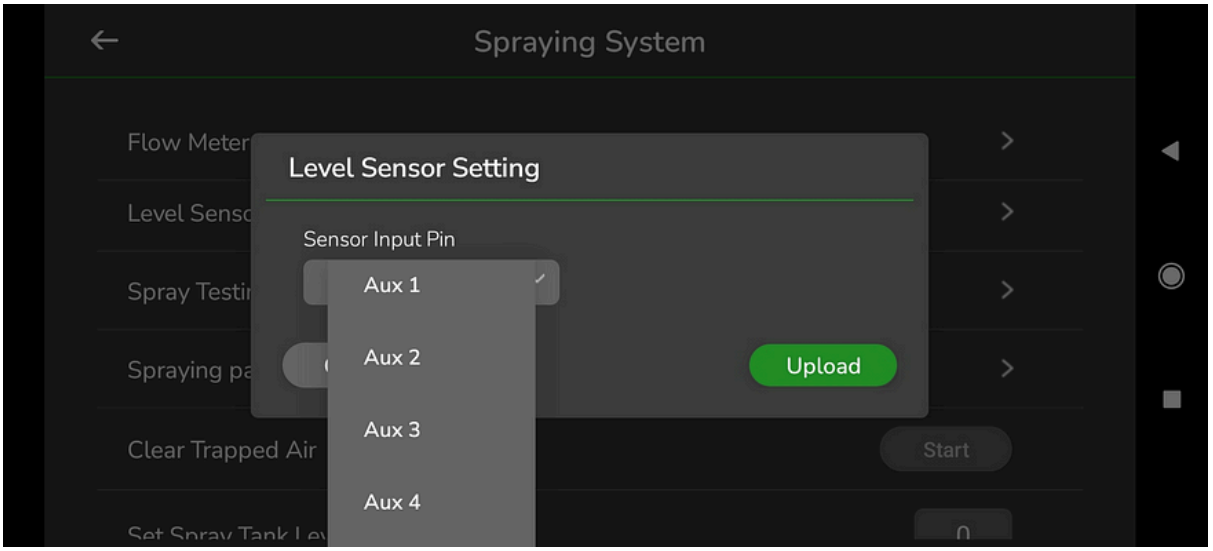


Figure 4.9.3 - Level Sensor Settings

Operation and Monitoring:

- When the tank is empty, the configured action (RTL/Hover) is triggered, and a "LUA: Tank Empty" message is displayed in the status.

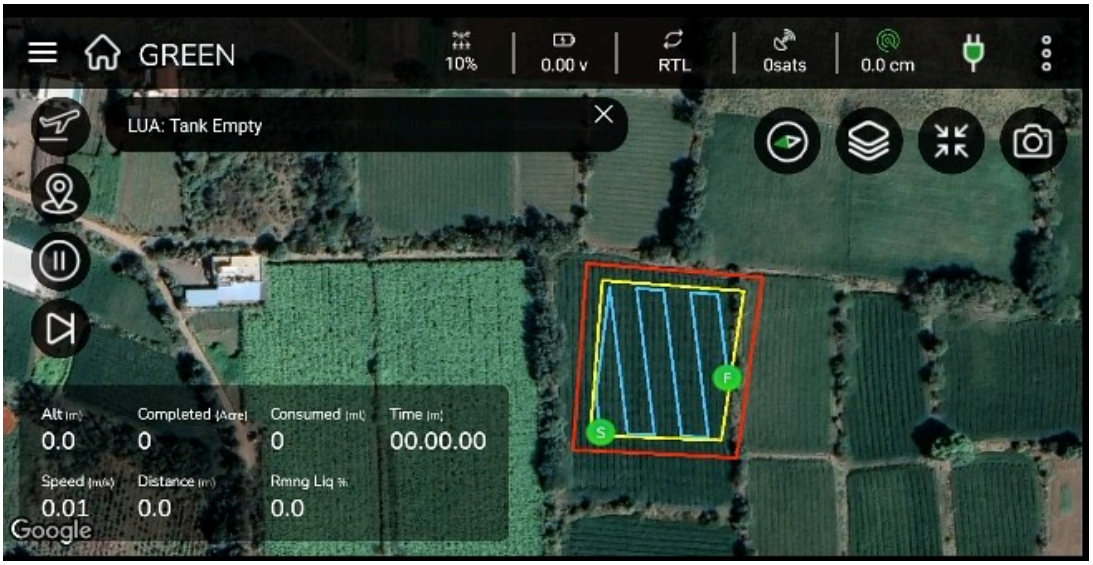


Figure 4.9.4 - AeroGCS GREEN Fly View

4.10.2. Flow Level Sensor Operation

The flow sensor plays a crucial role in regulating the liquid flow from the tank to the spray system.

Figure 4.9.5 - Flow Sensor

The TEJA-M drone is equipped with advanced sensing technologies to enhance its operational safety and adaptability to diverse environments. The following sensors contribute to obstacle avoidance and terrain following capabilities, ensuring a secure and efficient flight experience.

Working of Flow Level Sensor:

- **Measuring Flow Rate:** The sensor accurately measures the rate of liquid flow from the tank.
- **Adjusting Flow:** It allows for precise adjustment of the flow rate based on the liquid application requirements.
- **Connection to Flight Controller:** The flow sensor is connected to an available PWM input port on the drone's flight controller.

Configuration through AeroGCS GREEN:

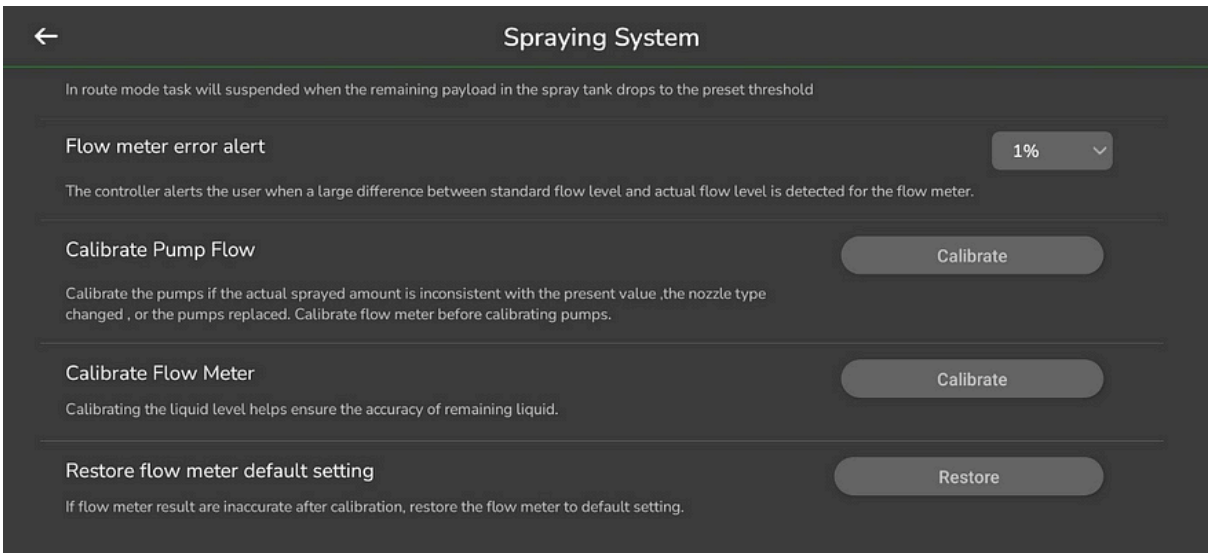


Figure 4.9.6 - Spraying system in AeroGCS GREEN

1. Spraying System Configuration:
    - Configurations include selecting the flow sensor type, flow input pin value, and specifying the fuel tank capacity in ml.
2. Clear Trapped Air:

- Ensure pump and drone are powered, and there is water in the tank to clear trapped air.

3. Restore Flow Meter Default Settings:
   - Allows users to restore all flow-related settings to default.

Flow Meter Settings:

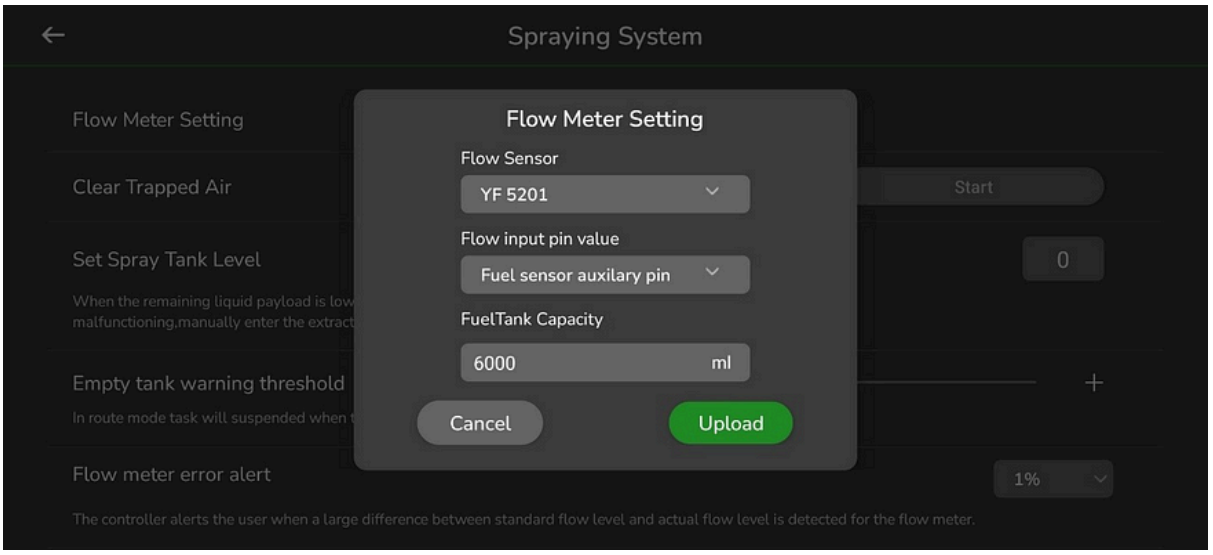


Figure 4.9.7 - Flow Meter Settings

- Flow Sensor:
  - User-selectable flow sensor type.
- Flow Input Pin Value:
  - User-selectable input pin value type.
- Fuel Tank Capacity:
  - User-entered liquid amount in ml.

Clear Trapped Air:

- Procedure:
    - Ensure the pump is on, the drone is powered, and there is water in the tank.

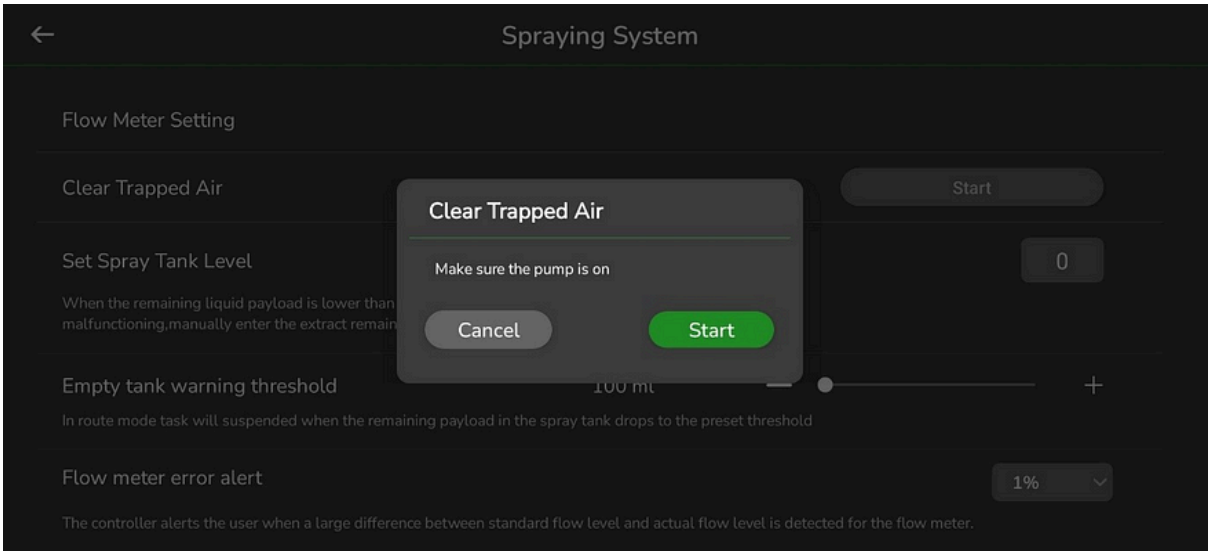


Figure 4.9.8 - Clear Trapped Air

Restore Flow Meter Default Setting:

- Option:
    - Users can restore default settings for all flow-related configurations.

Flow meters play a pivotal role in precise liquid application for spraying drones.

4.10.3. Obstacle Avoidance Sensor Operation (Optional Sensors)

The TEJA-M has obstacle avoidance capability to enhance flight safety by preventing the RPA from colliding with obstacles in the path.

The obstacle avoidance sensor is designed to detect obstacles within a range of 25 meters. In case of detection, the TEJA-M drone will promptly halt and maintain a safe distance of 10 meters from the obstacle. Detects obstacles within an azimuth width of ±15° and an elevation width of -5° to +3°.

Figure 4.9.9 - Obstacle Avoidance Sensor

Operating Instructions:

1. **Monitoring:** Continuously monitor the telemetry data for obstacle detection alerts.
2. **Manual Override:** Be prepared to manually navigate the drone if the obstacle avoidance system detects an obstacle.

4.10.4. Terrain Following Sensor Operation (Optional Sensors)

The TEJA-M drone, equipped with advanced terrain-following capabilities, ensures safe and efficient agricultural spraying operations over varying landscapes. It can detect maximum up to 25 meters of distance. This functionality enhances flight safety by adapting to changes in elevation. Below are the details of the terrain-following system:

Figure 4.9.10 - Terrain Following Sensor Operating Principle

1. **Manual Mode**

When the drone is flown manually using pilot inputs:

- **Activation Threshold**:
  - Terrain-following functionality activates only when the drone's altitude exceeds **5 meters**.
  - At lower altitudes, the system remains inactive to prevent errors during ground operations.
- **Response to Terrain Changes**:
  - If the terrain rises and the pilot does not adjust altitude, the drone will:

        - **Slow down automatically**.
    - After reaching the appropriate altitude, the drone resumes forward motion.

2. Auto Mode (Pre Planned Missions)

When operating in auto mode with a pre planned mission:

- **Safe Altitude Monitoring**:
    - The drone continuously monitors the distance between its altitude and the terrain below.
    - **Mission Suspension**:
        - The drone halts the mission and switches to **Loiter Mode**.
        - It prompts the operator for input, asking whether to resume the mission from the same point.
    - **Automatic Altitude Adjustment**:
        - The drone ascends slightly to maintain clearance from the terrain.
        - After adjustment, the drone remains in Loiter Mode until instructed by the operator.
- **Loiter Mode Functionality**:
    - In Loiter Mode, the drone maintains its position and altitude while awaiting further operator commands.

3. Operational Considerations

- **Mission Planning**:
    - Careful planning is essential to ensure the drone maintains safe terrain clearance.
    - Operators must consider terrain elevation changes and ensure the flight path avoids abrupt altitude variations.
- **Avoidance of Close Environments**:
    - **Top Clearance**: The drone's terrain-following sensor is downward-facing and does not detect obstacles above it.
    - When flying manually or planning missions, ensure there are no obstacles overhead, such as tree canopies, power lines, or structures.

Operator Guidelines

1. **Altitude Awareness**:
    - In manual mode, maintain an altitude greater than **5 meters** for terrain-following functionality to activate.
2. **Mission Preparation**:
    - While designing pre planned missions, avoid flight paths with sharp elevation changes to prevent unnecessary mission halts.
3. **Obstacle-Free Environment**:
    - Ensure a clear environment above the drone, particularly during spraying operations, as the system cannot detect upward obstacles

This terrain-following system significantly improves operational efficiency and safety by adapting to ground elevation changes and ensuring optimal clearance. Operators must adhere to the provided guidelines to maximize the benefits of this functionality while minimizing risks during agricultural spraying missions.

Figure 4.9.11 - Terrain Following Sensor

4.11. Post-flight Procedures

Steps to Take After Landing:

1. **Turn off the drone and transmitter.**

Ensure both the drone and transmitter are powered down to prevent accidental activation.

2. **Disconnect the battery from the drone.**
    - Disconnecting the battery prevents power surges and accidental starts.
3. **Inspect the drone for any damage or wear.**
    - Check for damages to avoid future malfunctions.
4. **Clean the drone and remove any debris.**
    - Regular cleaning ensures the longevity of the drone.
5. **Fill out the logbook with flight details and any observations.**
    - Accurate log entries help in tracking flight history and performance.
6. **Update the maintenance manual with any performed maintenance or noted issues.**
    - Documenting maintenance actions ensures proper record-keeping and regulatory compliance.
7. **Store the drone and components in a dry, safe place.**
    - Proper storage prevents damage and ensures readiness for next use.
8. **Check any looseness of PSE fasteners.**

Post-flight Checklist:

Task	Completed
Turn off drone and transmitter	Yes ( ) / No ( )
Disconnect battery	Yes ( ) / No ( )
Inspect for damage	Yes ( ) / No ( )
Clean the drone	Yes ( ) / No ( )
Fill out the logbook	Yes ( ) / No ( )
Update the maintenance manual	Yes ( ) / No ( )
Store properly	Yes ( ) / No ( )
Check Primary structural elements for looseness and integrity	Yes ( ) / No ( )
Inspection of critical components for in-service wear due to weathering effect and corrosions	Yes ( ) / No ( )

Table 7

Proper storage is essential to prolong the life of your drone.

Always clean the drone to prevent dust and debris from affecting its performance.

Failure to update the logbook and maintenance manual can result in undetected issues leading to potential flight safety hazards.

Ensure all post-flight procedures are meticulously followed to maintain the warranty and operational integrity of the TEJA-M drone.

5. Master/ Slave Modes for RPTO Training

5.1. Master-Slave Mode – Operational Procedure for RPTO Training

5.1.1. **Purpose:**

The purpose of this procedure is to define the use of **Master-Slave mode** during practical drone flying training in the Remote Pilot Training Organisation (RPTO). This ensures **safe, controlled, and effective** transfer of control between the instructor and the trainee, in compliance with DGCA regulations.

5.1.2. **Scope:**

This procedure applies to **all practical flight training sessions** conducted by the RPTO involving students undergoing training under **DGCA-approved RPTO courses** for Remotely Piloted Aircraft Systems (RPAS).

5.1.3. **Definitions:**

- **Master Controller:** The primary Remote Controller handled by the RPTO-certified Instructor (Remote Pilot Instructor - RPI).
- **Slave Controller:** The secondary Remote Controller operated by the Trainee (Student Remote Pilot).
- **Master-Slave Mode:** A training mode where control authority is shared between the Instructor and the Student with override capability for the Instructor at any time.

5.1.4. **Responsibilities:**

- **Instructor (Master):**
    - Retains **overall authority and responsibility** for the safety of the flight.
    - Provides continuous guidance and supervision.

- Shall intervene immediately in case of any unsafe actions or loss of control by the trainee.

- **Trainee (Slave):**
  - Operates the RPAS as per instructor guidance.
  - Shall yield control back to the instructor upon command or intervention.

5.1.5. Operational Guidelines:

1. **Pre-Flight Setup:**
   - Ensure that both the **Master and Slave controllers** are properly configured and paired with the RPAS.
   - Conduct a pre-flight briefing to explain the control-sharing protocol.
   - Verify the instructor's ability to override the slave control at all times.
2. **During Flight:**
   - The instructor may transfer control to the trainee for specific maneuvers or phases of flight.
   - Control transitions must be **clearly communicated** using predefined verbal commands (e.g., "You have control" / "I have control").
   - The instructor shall monitor trainee actions continuously.
3. **Emergency Override:**
   - The instructor must immediately take back control in the event of:
     - Incorrect maneuvering
     - Loss of situational awareness by the trainee
     - Any external hazard or emergency
4. **Post-Flight Review:**
   - Conduct a **debrief session** to review trainee performance and provide feedback.
   - Log the usage of Master-Slave mode in the flight training records.

5.1.6. **Safety and Compliance:**

- Mandatory use of Master-Slave mode for:
    - First-time trainees performing critical operations like takeoff, landing, and emergency procedures.
    - Practical flight assessments under supervision.
- This procedure aligns with **DGCA RPTO guidelines** and industry best practices for pilot training safety.

5.1.7. **Documentation:**

- Record of each Master-Slave training session shall be maintained in the trainee's logbook.
- Any instructor interventions during flights must be documented for training evaluation purposes.

5.2. How MASTER / Slave Mode works

The **TEJA-M Hexacopter** primarily utilizes the **MK15 Transmitter** for its communication and telemetry systems. This transmitter serves as the primary link for real-time control, data transmission, and operational feedback between the drone and the pilot.

In addition to the MK15 transmitter, the TEJA-M is equipped with a **T12 Transmitter and Receiver** system, which allows for the operation in **Buddy Mode** (Master/Slave configuration). This feature enables two pilots to share control of the drone, which is particularly useful for training and educational purposes, such as during Remote Pilot Training Organizations (RPTOs).

- **Primary Communication**: The MK15 transmitter is the primary system for controlling the TEJA-M and providing telemetry feedback.
- **Buddy Mode**: In Buddy Mode, the T12 system allows one pilot (slave/ student) to control the drone while the second pilot (Master/ Instructor) can take over control if needed. This system is ideal for training scenarios, allowing an instructor to take

control of the aircraft in case of emergencies or to guide the trainee in learning drone operation.

- **Control Switching**: The control of the drone can be switched between the MK15 and T12 transmitters, depending on the mode selected. While the T12 system can be used for training, the MK15 remains the primary telemetry and control interface.

This dual-communication setup enhances operational flexibility, making the UV suitable for both agricultural spraying operations and as a training platform for RPTOs.

1. **MK15 Receiver and Master MK 15 Transmitter**:
    - The **master receiver** serves as the **primary communication link** to the **Ground Control Station (GCS)**.
    - The **master** receiver connects as the GCS and handles all data transmission between the drone and the control station.
    - The **transmitter** allows the operator to regain full control of the aircraft by pressing the **A BUTTON** on the transmitter.
2. **T12 Receiver and Slave T12 Transmitter**:
    - The slave **receiver** receives basic **flight control commands** (pitch, roll, yaw, and throttle) from the Transmitter 2
    - It communicates only the RC (remote control) commands for flight control; it does not have direct access to the GCS, GCS remains connected solely to the receiver 1.

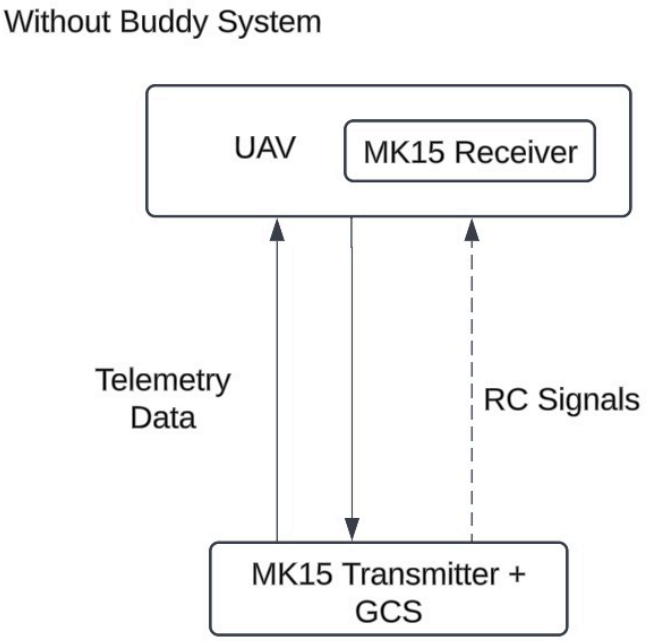


Figure 5.1.1: Communication link without Buddy System

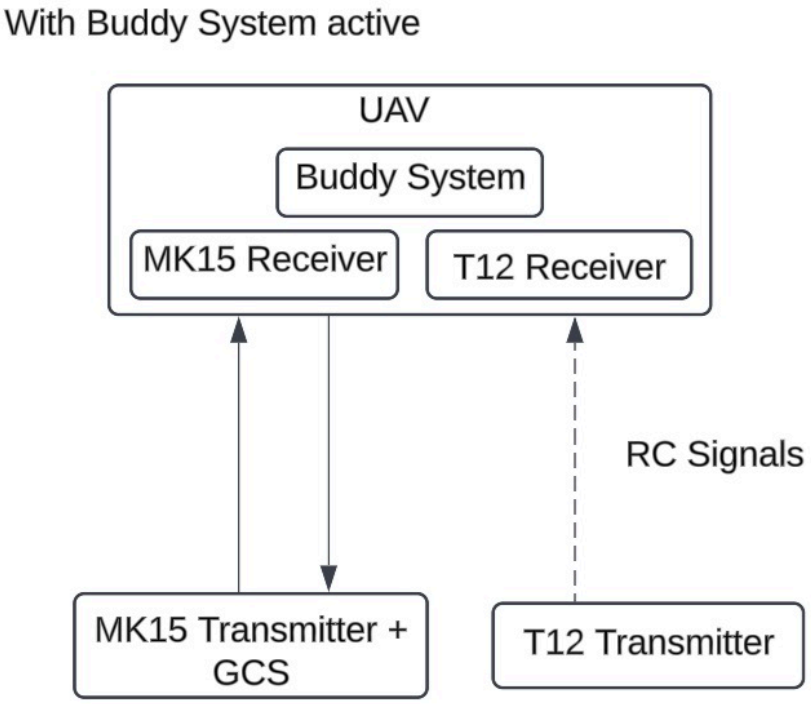


Figure 5.1.2: Communication link with Buddy System

5.3. Button / Switch Types and Default Channel Definitions

The MK15 remote controller comes with 13 physical channels and 16 communication channels in total. Communication channels 10 to 14 are also PWM channels 1 to 5 by default.

Channel No.	**Physical Channel Type**	**Default Mapping**
1	Roll	Joystick
2	Pitch	Joystick
3	Throttle	Joystick
4	Yaw	Joystick
5	Mode Switch	3-Stage Switch SA
6	Pump On/Off	3-Stage Switch SB
7	-	3-Stage Switch SC
8	Master/Slave	Button A
9	RTL	Button B

Table 8

5.4. Activation of Master to Slave Mode

To activate Master/Slave Mode, press the “A” button on the MK15 radio. The controls will shift to the T12 radio, making the MK15 the master and the T12 the slave. In Master Mode, the MK15 can take control to navigate obstacles by pressing the "A" button again.

Skydroid T12 Slave Transmitter

Siyi M15 Master Transmitter

Figure 5.1.3: Master and Slave transmitters with A button OFF

Figure 5.1.4: Master and Slave transmitters with A button ON

1. The control is always with Master Remote (MK 15 transmitter) whenever the Master is willing to give control to a student, A button to be switched ON. When the

auxiliary switch A in the Master transmitter is ON, the A switch glows, The control goes to Student/ Slave. Trainee/ Slave can control the drone.

2. When the auxiliary switch A in the Master transmitter is OFF, Master/ Instructor can control the drone.
3. The instructor must immediately take back control in the event of:
    a. Incorrect maneuvering
    b. Loss of situational awareness by the trainee
    c. Any external hazard or emergency

Fail safe scenarios while using buddy system:

Table 9

Sr. No.	Control with	Contingency	Action by UAV
1	Master	Master Fails	RTL
2	Master	Slave Fails	No action
3	Slave	Slave Fails	Radio fail safe warning comes on GCS and RTL is triggered. Master has the authority to resume control
4	Slave	Master Fails	Control remains with the slave.

Note: In the case of the buddy system, the same failsafe procedure will be displayed on the GCS, and the drone will trigger the failsafe in a manner similar to the actual failsafe with MK15.

6. Flight Operations

6.1. Flight Modes

1. **Loiter Mode:**

In Loiter Mode, the drone maintains its current position and altitude using GPS to stabilize. To activate Loiter Mode, push the button located on the top left of the RC in the upward direction. It is also useful during windy conditions to stabilize the drone.

- **Do:** Ensure GPS signal is strong (More than 10 sats) before engaging Loiter Mode.
- **Don't:** Activate Loiter Mode in areas with poor GPS coverage or high electromagnetic interference.

Engaging Loiter Mode in areas with poor GPS signal can result in drift or loss of control.

2. **Auto Mode:**

In Auto Mode, the drone autonomously follows a pre-programmed flight path and executes designated tasks. To activate Auto Mode, push the button located on the top left of the RC in the downward direction. Use Auto Mode for repetitive tasks like mapping or surveillance, where precision and consistency are critical. Ideal for long-distance flights where manual control would be impractical.

- **Do:** Double-check the pre-programmed flight path for obstacles.
- **Don't:** Change the flight path mid-mission without pausing the drone.

Ensure the pre-programmed flight path avoids restricted airspace and obstacles. Unauthorized flight paths can result in severe legal consequences.

3. Return to Launch (RTL):

The Return-to-Launch (RTL) mode ensures the TEJA-M drone autonomously returns to its home location, following a predefined sequence of actions. This mode offers safety redundancy by automatically engaging during critical events or when triggered manually by the operator.

Activation of RTL Mode

RTL mode in the TEJA-M can be triggered:

1. **Manually**: By pressing the **SC key** on the remote control.
2. **Battery Failsafe**: When the **first battery failsafe** activates at **42 V**.
3. **C2 Link Failsafe**: If the **command-and-control (C2) link** is lost.
4. **Fence Breach**: If the drone breaches the set geo-fence.
5. **Tank Failsafe**: If the **tank becomes empty** during agricultural operations.

RTL Procedure

- **Return Path**: Upon activation, the drone will return to the home location immediately, traveling at **5 m/s** and following the shortest path while maintaining its **current altitude**.
- **Hovering**: Once the drone reaches the home location, it will descend to **5 meters** altitude and hover, allowing the operator to either land the drone manually or await further commands.
- **Landing**: The operator can override the hover phase to initiate a smooth landing, or the drone can remain hovering until a pre-configured timeout or further input is received.

- **Do:** Configure RTL settings according to your operational environment.
- **Don't:** Rely solely on RTL in densely populated or obstructed areas.

RTL can be configured as per requirement. Contact Pavaman Aviation Private Limited for custom configurations.

4. **Land Mode:**

Land Mode is designed for automatic emergency landings, ensuring the drone safely reaches the ground when faced with critical system failures, such as battery depletion or sensor malfunction.

Activation Conditions:

- The drone will automatically enter **Land Mode** when:
    - **Critical Battery Voltage** is crossed.
    - **EKF Failure** is detected.

Features of Land Mode:

- **Descent**: The drone will attempt to bring itself straight down to the ground.
    - It will descend to a height of **10 meters** or until the **sonar** detects an object beneath the drone.
    - The descent rate is controlled by the regular **Altitude Hold** controller at a speed of **50 cm/s**.
- **Landing and Disarm**:
    - Upon reaching the ground, the drone will automatically **shut down the motors** and **disarm** if the pilot's throttle is set to minimum.

5. **Altitude**

As per design, the UAS can achieve a maximum altitude of 100 m Above Ground Level. But the spraying height from the crop is as per user requirement and generally above 5-10 m.

6.2. Fail Safe Procedures

6.2.1. C2 Data Link Failsafe:

The TEJA-M drone is equipped with a robust data link failsafe mechanism designed to ensure safe operations in the event of a loss of communication between the drone and the Ground Control Station (GCS). This section provides a detailed explanation of how the data link failsafe operates, its triggers, actions taken by the drone, and practical considerations for operators.

Conditions for Data Link Failsafe Activation

Datalink failsafe activates under the following conditions:

- **Loss of Communication:** Occurs when the connection between the drone and the GCS or RC is interrupted due to factors such as signal interference or hardware malfunction.

Actions Taken by the Drone

Upon activation of the data link failsafe, the TEJA-M drone initiates the following actions:

1. **Alert Generation:**
    - The GCS immediately displays a "Communication link loss, drone disconnected" message to alert the operator.
    - An auditory warning is also issued through the GCS speakers, notifying the pilot that the drone has lost connection.
2. **Failsafe Mode Activation:**
    - After a 10-second delay of lost connection, the drone automatically enters failsafe mode.
    - During this time, the drone ceases its current mission or flight path and prepares to execute the Return to Launch (RTL) procedure.
3. **Return to Launch (RTL) Procedure:**

- **Return Path:** Upon activation, the drone will return to the home location immediately, traveling at 5 m/s and following the shortest path while maintaining its current altitude.
- **Hovering**: Once the drone reaches the home location, it will descend to 5 meters altitude and hover, allowing the operator to either land the drone manually or await further commands.
- **Landing**: The operator can override the hover phase to initiate a smooth landing, or the drone can remain hovering until a pre-configured timeout or further input is received.

Practical Considerations and Best Practices

1. **Pre-Flight Checks:**
   - Ensure that the data link between the drone and GCS is stable and within operational range before flight.
   - Verify that all equipment, including antennas and connections, are securely fastened and functioning properly.
2. **Monitoring During Flight:**
   - Continuously monitor the GCS for any alerts or warnings related to data link connectivity.
   - Maintain visual line of sight with the drone to facilitate manual intervention if necessary.
3. **Environmental Factors:**
   - Consider environmental conditions such as electromagnetic interference and weather conditions that may affect datalink performance.
   - Plan flight operations accordingly to minimize risks associated with potential communication loss.

Visual and Audio Alerts

The TEJA-M drone employs visual and audio alerts to inform the operator of data link failsafe activation:

- **Visual Alert:** "Communication link loss, drone disconnected" message prominently displayed on the GCS screen.
- **Audio Alert:** Auditory warning broadcasted through the GCS speakers indicating "Drone disconnected."

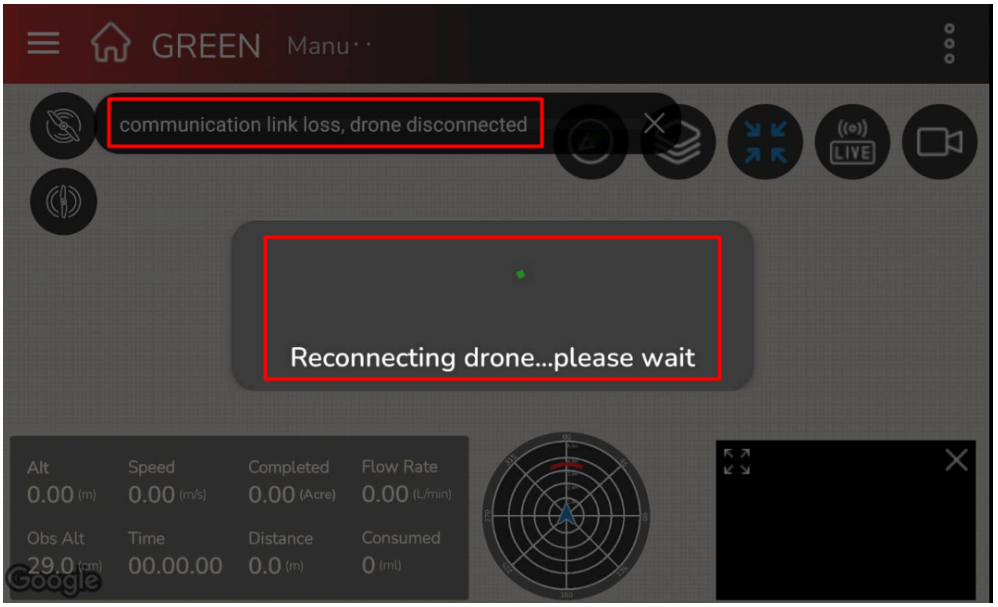


Figure 5.2.1 - Visual Alert

The data link failsafe mechanism in the TEJA-M drone is critical for maintaining safe operations by ensuring immediate response to communication disruptions between the drone and the GCS. By initiating the RTL procedure and providing clear alerts, the system enhances situational awareness and supports timely intervention to safeguard the drone and its surroundings.

Sr. No.	Control with	Contingency	Action by UAV
1	Master	Master Fails	RTL
2	Master	Slave Fails	No action
3	Slave	Slave Fails	Radio fail safe warning comes on GCS and RTL is triggered. Master has the authority to resume control
4	Slave	Master Fails	Control remains with the slave.

Note: In the case of the buddy system, the same failsafe procedure will be displayed on the GCS, and the drone will trigger the failsafe in a manner similar to the actual failsafe with MK15.

6.2.2. Geofence Breach**:**

The TEJA-M drone incorporates a geofence breach failsafe mechanism to prevent unauthorized flight outside predefined operational boundaries. This section details how the geofence failsafe operates, its triggers, actions taken by the drone, and practical guidelines for operators.

Conditions for Geofence Breach Failsafe Activation

Geofence breach failsafe activates under the following conditions:

- **Boundary Violation:** Occurs when the drone travels beyond the predefined geofence limits, including maximum altitude and distance restrictions.

Actions Taken by the Drone

Upon activation of the geofence breach failsafe, the TEJA-M drone initiates the following actions:

1. **Immediate Response:**
    - The drone immediately halts its current flight path or mission upon detecting a geofence breach.
    - It ceases any further movement away from the operational boundaries to prevent unauthorized flight.
2. **Return to Launch (RTL) Procedure:**
    - **Return Path**: Upon activation, the drone will return to the home location immediately, traveling at **5 m/s** and following the shortest path while maintaining its **current altitude**.

- **Hovering**: Once the drone reaches the home location, it will descend to **5 meters** altitude and hover, allowing the operator to either land the drone manually or await further commands.
- **Landing**: The operator can override the hover phase to initiate a smooth landing, or the drone can remain hovering until a pre-configured timeout or further input is received.

Practical Considerations and Best Practices

1. **Geofence Configuration:**
   - Configure the geofence boundaries in the GCS software based on legal requirements and operational constraints.

Regularly update and verify geofence parameters to reflect changes in flight regulations or operational needs.

2. **Monitoring and Compliance:**
   - Continuously monitor the drone's position relative to the geofence boundaries during flight operations.
   - Adhere to geofence limitations to ensure compliance with airspace regulations and safety protocols.
3. **Emergency Procedures:**
   - Implement emergency procedures for overriding geofence restrictions in case of unforeseen operational requirements or emergencies.

Ensure that all operators are trained in geofence failsafe protocols and emergency response measures.

Visual and Audio Alerts

The TEJA-M drone provides visual and audio alerts to notify the operator of geofence breach failsafe activation:

- **Visual Alert:** The GCS displays a "Fence Breached" message to indicate that the drone has exceeded the geofence boundaries.
- **Audio Alert:** An auditory warning is broadcasted through the GCS speakers, notifying the operator of the geofence breach.

Figure 5.2.2 - Visual Alert

The geofence breach failsafe mechanism in the TEJA-M drone plays a crucial role in preventing unauthorized flight and ensuring compliance with airspace regulations. By promptly halting flight operations outside designated boundaries and initiating the RTL procedure, the system enhances safety and operational integrity during drone missions.

6.2.3. Battery Failsafe:

The TEJA-M drone is equipped with a sophisticated battery failsafe mechanism designed to ensure safe return to the home location when the battery level reaches critical thresholds. This section provides a detailed and descriptive explanation of the battery failsafe process, including the conditions under which it is triggered, the actions taken by the drone, and best practices for operators.

Conditions for Battery Failsafe Activation

The battery failsafe is designed to activate under two critical conditions related to battery voltage levels:

1. **Low Voltage Threshold:**
    - **Trigger**: When the battery voltage drops to or below 42V.
    - **Action**: The drone will display a warning on the Ground Control Station (GCS) and initiate the Return to Launch (RTL) procedure.
    - **Notification**: The GCS will show a "Battery Failsafe" message, and the flight mode will change to RTL.

Return to Launch (RTL) Procedure

- **Return Path**: Upon activation, the drone will return to the home location immediately, traveling at **5 m/s** and following the shortest path while maintaining its **current altitude**.
- **Hovering**: Once the drone reaches the home location, it will descend to **5 meters** altitude and hover, allowing the operator to either land the drone manually or await further commands.
- **Landing**: The operator can override the hover phase to initiate a smooth landing, or the drone can remain hovering until a pre-configured timeout or further input is received.

Important Considerations and Best Practices

1. **Pre-Flight Checks:**
    - **Do:** Ensure the battery is fully charged and in good condition before every flight.
    - **Don't:** Ignore any signs of battery wear or damage, such as swelling or leakage.
2. **Monitoring During Flight:**
    - **Do:** Regularly monitor the battery voltage levels displayed on the GCS.
    - **Don't:** Fly the drone until the battery is completely drained, as this can trigger emergency RTL and potentially cause unsafe landings.

3. **Environmental Factors:**
    - **Do:** Consider environmental factors such as wind and temperature, which can affect battery performance and flight duration.
    - **Don't:** Fly in extreme conditions without adjusting battery failsafe settings accordingly.

Visual and Audio Alerts

The GCS provides both visual and audio alerts to ensure the operator is immediately aware of the battery failsafe activation:

1. **Critical Voltage Alert:**
    - **Visual Alert:** " Battery Failsafe" message displayed on the GCS.
    - **Audio Alert:** " Battery Failsafe" announcement through the GCS speakers.

Figure 5.2.3 - Visual Alert

The battery failsafe mechanism in the TEJA-M drone is crucial for ensuring safe operations and preventing accidents due to low battery levels. By automatically triggering RTL and

providing clear alerts to the operator, the system helps maintain the integrity of the flight and the safety of the drone. Adhering to best practices and regularly checking battery health can further enhance the reliability of the battery failsafe system.

Flying with a critically low battery can result in sudden power loss and crash.

6.2.4. Critical Battery Failsafe

The **Critical Battery Failsafe** mode is an essential safety feature in the TEJA-M, designed to prevent the drone from continuing flight under dangerously low battery levels. This automated mechanism ensures that the drone lands safely to avoid accidents or mid-air shutdowns. Below is a detailed breakdown of how the system operates.

- The **Critical Battery Failsafe** is triggered when the battery voltage drops to **37 V**, indicating the drone's power has reached critical levels.
- This mode ensures the drone executes a controlled landing to prevent in-flight failure.
- It only activates after the first **battery failsafe** at **42 V** has failed to bring the drone home (i.e., RTL mode was not completed, or the drone remained airborne).

Trigger Conditions

- **Battery Voltage Level**:
  - **First Battery Failsafe**: Activates at **42 V**, triggering RTL (Return to Launch).
  - **Critical Battery Level**: If the drone continues to fly after RTL and reaches **37 V**, the Critical Battery Failsafe is automatically engaged.
- **Other Scenarios**:
  - Loss of satellite connection (GPS) can also trigger **Land Mode**, which operates similarly to the Critical Battery Failsafe.

Failsafe Sequence

- **Trigger and Mode Activation**:
  - When the battery voltage drops to **37 V**, the drone immediately initiates **Land Mode**.
- **Descent Control**:
  - **50 cm/s descent rate** using the **Altitude Hold controller**.

- The descent speed ensures a balance between rapid landing and smooth control.

- **Landing Procedure**:
  - Once landed, the drone's motors automatically **shut down and disarm** if the pilot's throttle is at minimum.

Visual and Audio Alerts

The GCS provides both visual and audio alerts to ensure the operator is immediately aware of the battery failsafe activation:

2. **Critical Voltage Alert:**
   - **Visual Alert:** " Battery Failsafe" message displayed on the GCS.
   - **Audio Alert:** " Battery Failsafe" announcement through the GCS speakers.

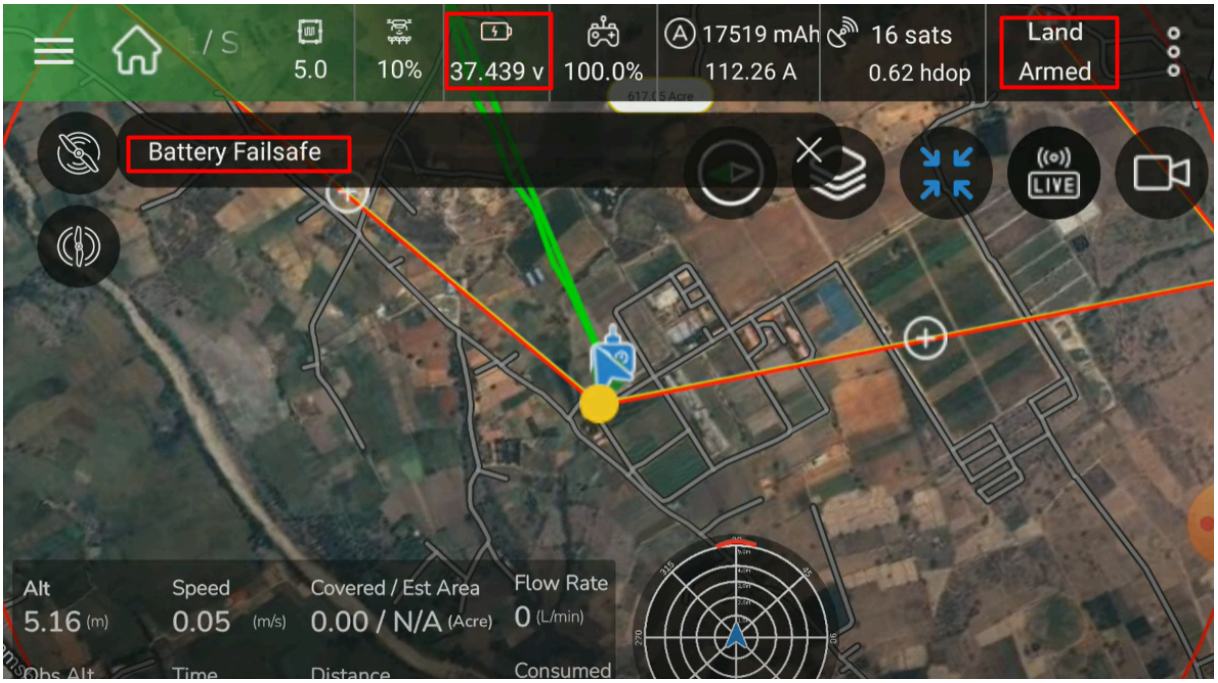


Figure 5.2.3 - Visual Alert

The battery failsafe mechanism in the TEJA-M drone is crucial for ensuring safe operations and preventing accidents due to low battery levels. By automatically triggering RTL and providing clear alerts to the operator, the system helps maintain the integrity of the flight and

the safety of the drone. Adhering to best practices and regularly checking battery health can further enhance the reliability of the battery failsafe system.

Flying with a critically low battery can result in sudden power loss and crash.

Redundancy and Safety Measures

- **The** system ensures that **Land Mode** overrides other flight modes once the critical battery voltage is reached.
- **If** the drone encounters **GPS loss**, it will still attempt to land safely using onboard sensors for descent.

The **Critical Battery Failsafe** mode in TEJA-M ensures the drone lands safely when power levels are dangerously low, minimizing the risk of crashes or mid-air shutdowns. With a well-defined descent rate and automated motor disarm, this system offers a reliable safety mechanism to protect both the drone and its environment.

6.2.5. Liquid Level Failsafe**:**

If the liquid level falls below the pre-set threshold (this feature can be turned on/off by the user), the drone will initiate hover at location to avoid spraying inconsistencies.

- **Do:** Check liquid levels before and during the mission.
- **Don't:** Continue spraying with low liquid levels.

Liquid Level Failsafe can be turned off if not required. Configure it according to your specific use case.

6.2.6. Failsafe Table

S.No	Failsafe	Visual Alert	Audio Alert	Time Taken for GCS	Action
1	Battery failsafe	Battery Failsafe	Battery failsafe	Immediately	RTL

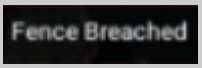
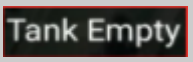
2	Critical Battery Failsafe		Battery failsafe	Immediately	Land
3	C2 Data Link Failure		Communication lost, drone disconnected	5 seconds	RTL
4	Geofence failsafe		Fence Breach	Immediately	RTL
5	Tank Empty		Tank Empty	Immediately	Hover at location

Table 10

7. Emergency Procedures

Emergency procedures are essential for ensuring safe and efficient drone operations. As a pilot, it is your responsibility to be proficient with the aircraft operational manual provided by the vendor before conducting any flight operations. It is a best and safe practice to prepare an Emergency Checklist. The drone should always be ready to execute emergency procedures in instances where there is a lost link, loss of GPS, or other aircraft or obstructions in the flight path. After the drone has safely landed, it should undergo maintenance.

7.1. Detailed Emergency Procedures

7.1.1. RTL Functionality

The Return-to-Launch (RTL) mode ensures the TEJA-M drone autonomously returns to its home location, following a predefined sequence of actions. This mode offers safety redundancy by automatically engaging during critical events or when triggered manually by the operator.

Activation of RTL Mode

RTL mode in the TEJA-M can be triggered:

1. **Manually**: By pressing the **SC key** on the remote control.
2. **Battery Failsafe**: When the **first battery failsafe** activates at **42 V**.
3. **C2 Link Failsafe**: If the **command-and-control (C2) link** is lost.
4. **Fence Breach**: If the drone breaches the set geo-fence.

RTL Procedure

- **Return Path**: Upon activation, the drone will return to the home location immediately, traveling at **5 m/s** and following the shortest path while maintaining its **current altitude**.

- **Hovering**: Once the drone reaches the home location, it will descend to **5 meters** altitude and hover, allowing the operator to either land the drone manually or await further commands.
- **Landing**: The operator can override the hover phase to initiate a smooth landing, or the drone can remain hovering until a pre-configured timeout or further input is received.

7.1.2. Command & Control Link Loss Strategies

Trigger Event: Signal loss with GCS or RC.

Drone's Reaction:

- Hovers in place for 5 seconds.
- Attempts to reestablish communication.
- Initiates RTL if communication is not reestablished within 5 seconds.

Pilot Actions:

- Move to a higher location to reestablish line-of-sight.
- Check for possible signal interference sources.
- Prepare for manual recovery if RTL is not possible.

Alert Mechanism:

- GCS displays "Communication lost".
- RC shows signal loss and provides audio alerts.

For Detailed Loss of communication alert mechanism, refer to 5.2.1

7.1.3. Low Battery Failure

- **Trigger Event:** Battery level drops to critical threshold.
- **Drone's Reaction:**
  - Initiates RTL process.
  - May descend to land immediately if the battery is critically low.
- **Pilot Actions:**
  - Continuously monitor battery levels during flight.
  - Manually initiate RTL or find a safe landing spot if necessary.
- **Alert Mechanism:**
  - Low battery alert on GCS.
  - RC provides audio and visual alerts.

Do's and Don'ts Summary

Do's:

- Always maintain a visual line of sight with the drone.
- Regularly check and calibrate sensors and batteries.
- Pre-plan emergency landing zones before flights.
- Configure RTL settings according to your specific operational environment.
- Practice emergency procedures regularly to ensure readiness.

Don'ts:

- Fly in areas with poor GPS coverage or known signal interference.
- Ignore pre-flight and mid-flight warnings or alerts.
- Overlook the importance of having a clear and obstacle-free landing zone.
- Rely solely on RTL in densely populated or obstructed areas.

By following these detailed emergency procedures and keeping the do's and don'ts in mind, pilots can ensure the safe and effective operation of the TEJA-M drone, minimizing risks and maintaining control during critical situations.

7.1.4. Pilot action to mitigate risks

Sl No	Potential failure	Prevention Control
1	Loss of Hardware Compatibility for Aero GCS	Always ensure to check for the right product documentation and use compatible hardware.
2	Lack of Hardware Resource Requirements for AeroGCS Operations	Always ensure to check for the right product documentation and provision required an amount of hardware resources.
3	Multiple Software Instances on same hardware	Always ensure to have only one software instance on one hardware.
4	Software Malfunction	All standard procedures defined to operate the drone and GCS must be followed in a suitable environment.
5	Non-calibration of drone	Always ensure to calibrate the drone properly and then only do the flights.
6	Hardware issues	Always test motors before first flight
7	Human Error of not calibrating remote controller parameters	Always Configure remote controller before first flight
8	Human Error of not setting flight modes on RC button	Always Configure flight modes before first flight
9	Human Error of not calibrating ESC before first flight	Always calibrate ESC before first flight
10	Human Error of not enabling arming checks before first flight	Always enable Arming Checks before flights
11	Human Error of not configuring appropriate georeferencing in waypoint mission	Always configure appropriate geo-referencing
12	Human Error of not return to launch while flight planning	Always configure appropriate return to launch
13	AeroGCS Software Crash	Always ensure to run minimum applications on the system where GCS is installed and allocate maximum resources for the GCS system.
14	Deletion of Data Accidently	Always ensure to have proper file and folder permission for the folders where GCS data is stored.
15	Overheating/over current	Remote pilot has to trigger RTL and land the drone.

Table: 11

If any deterioration or damage is observed on critical components, **immediately stop flying** and report the issue to the manufacturer. Continuing operation may lead to unsafe flight conditions.

8. Maintenance

This chapter outlines the essential maintenance procedures and schedules for the TEJA-M hexacopter. Adhering to these guidelines will ensure the drone's optimal performance, safety, and compliance with regulatory standards. This chapter provides detailed guidance for users on how to follow the maintenance plan for the TEJA-M hexacopter, including instructions for filling and filing the maintenance logbook, performing various maintenance tasks and responsibilities, understanding potential dangers if maintenance is not performed, and the impact on performance.

8.1. Roles and Responsibilities

- **Maintenance Manager**: A professional role within the customer's organization or an external service provider responsible for overseeing the maintenance activities, ensuring compliance with the maintenance schedule, and coordinating with the OEM as necessary.
- **Maintenance Technician:** A trained individual, either part of the customer's organization or an external service provider, responsible for performing the hands-on maintenance tasks, particularly those that are more technical and require specific expertise.
- **OEM Team:** This refers to the Original Equipment Manufacturer (Pavaman Aviation Private Limited) personnel who provide technical support, perform comprehensive inspections, and conduct non-destructive testing as required. They are also involved in updating maintenance procedures and providing training updates.
- **User:** The end-user or operator of the TEJA-M hexacopter, responsible for performing daily, weekly, and monthly maintenance tasks, maintaining the maintenance logbook, and ensuring the hexacopter is sent to the OEM or authorized service centers for more complex maintenance tasks.

As a user of the TEJA-M hexacopter, you have specific maintenance responsibilities that must be followed to ensure the continued safe and effective operation of your equipment. These responsibilities include:

- Performing daily, weekly, and monthly inspections and maintenance tasks as outlined in the maintenance schedule.
- Documenting all maintenance activities in the maintenance logbook.
- Ensuring the hexacopter is sent to Pavaman Aviation Private Limited for quarterly and annual maintenance, as well as any necessary repairs.
- If there is any deterioration or decay observed on the critical components, the user can stop flying further and bring it to the notice of the manufacturers.
- Following all safety steps and guidelines during maintenance activities.

8.2. Maintenance Plan

The maintenance plan for the TEJA-M hexacopter includes a series of scheduled inspections and maintenance tasks that are to be performed daily, weekly, monthly, half-yearly, and annually.

Follow the maintenance schedule provided in the manual to ensure your TEJA-M remains in optimal condition. The schedule includes routine inspections, troubleshooting, and component replacements.

8.2.1. Maintenance Schedule

8.2.1.1. Daily Maintenance

- **Frequency:** After each flight
- **Responsible Personnel:** User
- **Tasks:**
    - **Clean Airframe:** Remove dirt and mud from the chassis.
    - **Inspect for Cracks:** Check airframe and arms for visible cracks or damage.
    - **Inspect Battery Packs:** Look for bulges, leaks, and ensure secure connections.

- **Check and Clean Tank:** Inspect for leaks and clean the spray system tank.
- **Check GPS Mount:** Ensure GPS is secure and properly aligned.
- **Check Motors for Debris:** Inspect and clean motors.
- **Check Landing Gear Condition:** Inspect for damage and wear.
- **Control Check:** Perform functional tests on control systems.

8.2.1.2. Weekly Maintenance

- **Frequency:** Weekly
- **Responsible Personnel:** User
- **Tasks:**
  - Inspect arm rods, central hub, canopy, landing gear connectors, arm boom, motors, propellers, transmitter, GPS, battery plate and velcro, pneumatic connectors, and XT 90 connectors.
  - Check for cracks, bends, wear, and secure attachment.

8.2.1.3. Monthly Maintenance

- **Frequency:** Monthly
- **Responsible Personnel:** User
- **Tasks:**
  - **Submit Maintenance Logbook:** Compile and submit detailed maintenance logs to OEM.
  - **Inspect Spray System:** Perform a thorough cleaning and inspection.

8.2.1.4. Half Yearly Maintenance

- **Frequency:** Every six months
- **Responsible Personnel:** Maintenance Technician, OEM Team
- **Tasks:**
  - **Perform Detailed Component Tests:** Conduct non-destructive testing on critical components.

- **Review and Analyze Maintenance Logs:** Analyze logs for trends and implement preventive measures.

8.2.1.5. Annual Maintenance

- **Frequency:** Annually
- **Responsible Personnel:** OEM Maintenance Team
- **Tasks:**
  - **Conduct Comprehensive Inspection:** Perform a full inspection and non-destructive testing on all components.
  - **Update Maintenance Procedures:** Review and update procedures based on analysis and new findings.
  - **Provide Training Updates:** Conduct training sessions for maintenance personnel with updated procedures.

8.2.1.6. As Needed Maintenance

- **Frequency:** As required
- **Responsible Personnel:** Maintenance Manager, OEM Team
- **Tasks:**
  - **Perform Root Cause Analysis:** Analyze any component failure or premature withdrawal.
  - **Implement Corrective Measures:** Take necessary actions based on analysis and update records.

8.2.1.7. Emergency Maintenance

- **Frequency:** After Incident
- **Responsible Personnel:** Maintenance Manager, Technician, OEM Team
- **Tasks:**
  - **Inspect and Recover from a Crash:** Conduct a thorough inspection and root cause analysis. Document findings and corrective actions.

- **Report Incidents to OEM:** Submit a detailed report with all relevant information and documentation.
- **OEM Investigation and Support:** OEM conducts a detailed investigation and provides guidance for corrective actions.

8.2.2. Explanation of Maintenance Schedules

- **Daily Maintenance:** Focuses on routine cleaning and basic inspections after each flight to catch immediate issues and maintain cleanliness.
- **Weekly Maintenance:** Involves more thorough inspections of structural and critical components to identify emerging issues before they escalate.
- **Monthly Maintenance:** Ensures detailed inspection and cleaning of major systems, and maintains logbooks for tracking and reporting purposes.
- **Half Yearly Maintenance:** Conducts comprehensive tests and analysis of maintenance data to ensure the overall health of the drone and implement preemptive measures.
- **Annual Maintenance:** Includes a full-scale inspection and potential replacement of parts to ensure long-term reliability and updates to procedures and training.
- **As Needed Maintenance:** Addresses specific issues as they arise, ensuring targeted and effective responses to any problems detected during routine operations.
- **Emergency Maintenance:** Provides a structured response to incidents, ensuring thorough investigation, reporting, and corrective actions are taken promptly.

8.3. Maintenance Logbook and Documentation

1. Maintenance Logbook

Maintaining a comprehensive maintenance logbook is crucial for tracking all maintenance activities of the TEJA-M drone. The logbook should include entries for daily, weekly, monthly, half-yearly, annual, as needed maintenance, and emergency procedures as per the maintenance manual provided. The maintenance logbook is provided with the TEJA-M delivery or ask Pavaman Aviation for the Maintenance logbook.

Ensure the logbook is updated regularly and kept in a safe place for reference.

2. Documentation Submission

Regular submission of logbooks is essential to maintain high standards of performance and safety for the TEJA-M drone.

- **Operations Logbook:** Records all flights, operations, and incidents.
- **Maintenance Logbook:** Tracks all maintenance activities and inspections.
- **Component Monitoring Records:** Continual Component Performance Monitoring followed by corrective actions would lead to improved safety and reliability of Drone operations. It helps to monitor the status and health of key components.
- **Replacement Records:** Documents all component replacements.
- **Battery Logbook:** Tracks battery maintenance activities and inspections.

Submission Process:

1. **Compile Logbooks:**
    - Gather all operations, inspection, and replacement records documented throughout the month.
    - Ensure all entries are complete, accurate, and in accordance with the maintenance and operations manuals.
2. **Review by User:**
    - The user responsible for maintenance and operations reviews the compiled logbooks.
    - Verify that all entries are correctly filled out, including dates, descriptions, responsible personnel, and any notes or remarks.
3. **Submit to OEM:**
    - Choose the submission method: via email.

- Ensure the submission is sent to the OEM Maintenance Department at **vijay.veeramallu@pavaman.in**.
- The submission deadline is by the 30th of each month to facilitate timely review and feedback from the OEM.

Prompt submission of logbooks allows for timely analysis by the OEM, ensuring any issues or trends are identified and addressed promptly. Accurate documentation is crucial for maintaining compliance with maintenance schedules and operational standards. Regularly update and maintain logbooks to provide a comprehensive history of maintenance activities and operational performance.

Monthly Submission Format:

UIN		**UAS Serial No.**	
User Name		**UAS Model name:**	
Date		**Manufacturer name:**	
Flying Hours			
Number of Landings			
Battery Life Cycles			

Any Components Replaced				
Sr. No.	**Name of Component**	**Hours at which it is replaced**	**Reason of Failure**	**Signature**
1				
2				
3				
4				

Any other issues

Table 12

3. Referencing Other Manuals

Operators should refer to the following manuals for detailed procedures and guidelines:

- **Maintenance Manual:** Provides detailed instructions on how to perform maintenance tasks, including schedules, procedures, and safety precautions.
- **Operations Logbook:** Contains operational guidelines, flight procedures, and limitations.
- **Maintenance Logbook:** Specific manuals for components like batteries, motors, and GPS modules for detailed maintenance and troubleshooting.

4. Tracking Maintenance

To ensure compliance and effective maintenance tracking:

- Regularly review and update maintenance logs as per the maintenance manual.
- Cross-reference maintenance tasks with the maintenance schedule to ensure all tasks are completed on time.
- Utilize component monitoring records to predict and prevent failures.
- Submit all required documentation by the specified deadlines to the OEM for review and feedback.

5. Performing Maintenance

Detailed procedures for performing maintenance tasks should be followed as outlined in the maintenance manual:

- Follow step-by-step instructions for each maintenance task.
- Adhere to safety guidelines and recommended practices.
- Use appropriate tools and equipment specified in the maintenance manual.
- Document all findings, inspections, and actions taken in the maintenance logbook.

By referencing the maintenance section of the flight manual, operators will gain a clear understanding of how to:

- Access and utilize the maintenance logbook.
- Submit required documentation.
- Refer to other manuals for detailed procedures.
- Perform maintenance tasks effectively and safely.

8.4. Impact of Neglecting Maintenance

Neglecting the prescribed maintenance tasks can have serious consequences, including:

- **Reduced Flight Safety:** Increased risk of equipment failure, leading to potential accidents and injuries.
- **Decreased Performance:** Poor maintenance can result in reduced efficiency, reliability, and operational capability of the drone.
- **Legal and Regulatory Compliance:** Failure to maintain the drone as required can lead to violations of DGCA regulations, resulting in fines, penalties, or cancellation of the UIN.

By adhering to the maintenance guidelines and schedules outlined in this chapter, users can ensure the safe and effective operation of the TEJA-M hexacopter. Regular maintenance not only enhances performance but also ensures compliance with regulatory standards and extends the operational lifespan of the equipment.

Do Use Recommended Tools and Equipment: Use tools and equipment specified in the maintenance manual to avoid damage to components and ensure accurate maintenance.

Don't Skip Scheduled Maintenance: Neglecting scheduled maintenance tasks can lead to operational failures and compromise flight safety.

Don't Use Unauthorized Parts: Use only OEM-approved parts and components for replacements to maintain warranty validity and ensure compatibility.

Don't Ignore Warning Signs: Address any abnormal operating conditions or warning indicators promptly by consulting the maintenance manual and taking appropriate corrective actions.

9. Technical Data

9.1. Dimensions

Sr No.	Measurement	Reading
1	TEJA - M Folded Length	1844 mm ± 10mm
2	TEJA - M Folded Breadth	2037 mm ± 10mm
3	TEJA - M Folded Height	581 mm ± 10mm
4	TEJA - M unfolded Length	678 mm ± 10mm
5	TEJA - M unfolded Breadth	762 mm ± 10mm
6	TEJA - M unfolded Height	581 mm ± 10mm

Table 12

9.2. Weight

S. No	Parameters	Values
1	Battery Weight	5.32 kg ± 20g
2	Fixed Payload weight with standard nozzles * 4 (Type A)	2.46 kg ± 20g
3	Fixed Payload weight with Centrifugal nozzles * 2 (Type B)	2.78 kg ± 20g
4	Weight of variable payload	10 kg ± 100g
5	Empty weight + battery + fixed payload Type A	19.54 kg ± 300g
6	Empty weight + battery + fixed payload Type B	19.94 kg ± 300g
7	Empty weight + battery weight + fixed payload Type A+ variable payload (AUW 1)	29.40 kg ± 740g
8	Empty weight + battery weight + fixed payload Type B + variable payload (AUW 2)	29.76 kg ± 740g
9	Maximum AUW + Tolerances (MTOW)	30.5 kg

Table 13

AUW - All Up Weight

MTOW - Maximum Take off weight

9.3. Propulsion System:

TEJA - M uses COMBO-XRotor-X6-PLUS Brushless propulsion system. The COMBO - XR motor - X6 - PLUS is a robust plant protection power system designed to accommodate a single-rotor load ranging from 3.5-5.5kg/rotor. Here are its key features:

- Thrust Performance:
  - Maximum thrust of a single-rotor: 11.8kg
  - Suitable for a 30mm carbon fiber tube arm
- Environmental Resilience:
  - IPX6 waterproof rating ensures protection against rain, pesticides, salt spray, high temperature, sand, dust, impact, mud, and sand.
- ESC (Electronic Speed Controller):
  - FOC vector control, optimized using PMSM system algorithm
  - Dual throttle options: digital and analog for enhanced flight stability
  - Comprehensive protection features:, over-current protection
- Communication and Data:
  - Utilizes CAN communication for real-time data transmission
  - Built-in fault storage function for recording and analyzing fault data

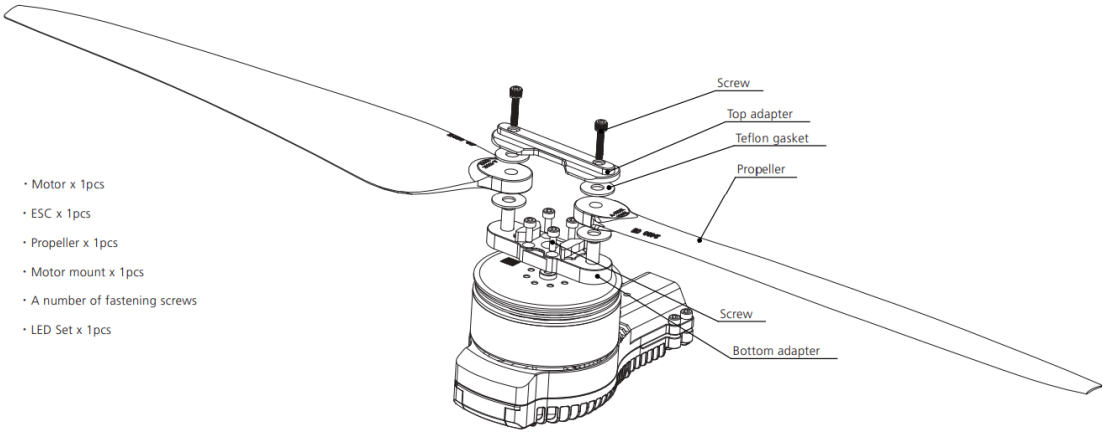


Figure 8.3.1 - Components of the Propulsion System

1. Motors:

The TEJA M hexacopter is equipped with six high-performance motors, strategically positioned on each arm of the airframe. These motors are selected based on their thrust characteristics, efficiency, and reliability.

Hobbywing X6 Plus Motor:

TEJA-M utilizes the Hobbywing X6 Plus motors based on thrust requirements for hover at 50% throttle, determined through internal motor bench tests for propeller integrity and thrust values. The X6 Plus motor features an integrated ESC, contributing to weight reduction and space optimization.

Motor Specifications:

- Voltage: 52.2 V
- Power: 1500-2850W
- Operating Temperature: -10 to 50 degrees Celsius
- Maximum Thrust: 11.8 Kg
- Diameter: 62 mm
- Weight: 790 g

Advantages of Hobbywing X6 Plus:

- ESC integration for weight reduction and space optimization.
- Special ventilation and cooling design for effective heat dissipation.
- Six motors integrated with six respective ESCs for optimal performance.

The selection of the Hobbywing X6 Plus motors reflects a meticulous process considering thrust requirements, internal bench testing, and the advantages offered by the integrated ESC design. This ensures TEJA - M's propulsion system is well-suited for various operational conditions.

Motor Features:

- **Current Protection:**

If the LED indicator flashes **three long times**, it signals an **excessive current draw** that could lead to system failure. The pilot should **immediately land the UAS** to prevent damage or loss of control. Continuing flight after seeing this warning can cause further issues, so it's critical to reduce altitude and land the aircraft as soon as possible.

- **Temperature Protection:**

An alarm is triggered when the ESC temperature exceeds 110°C, indicated by 1 long and 3 short flashes.

ESC may risk burning if the temperature exceeds 130 degrees, prompting an immediate landing upon the alarm.

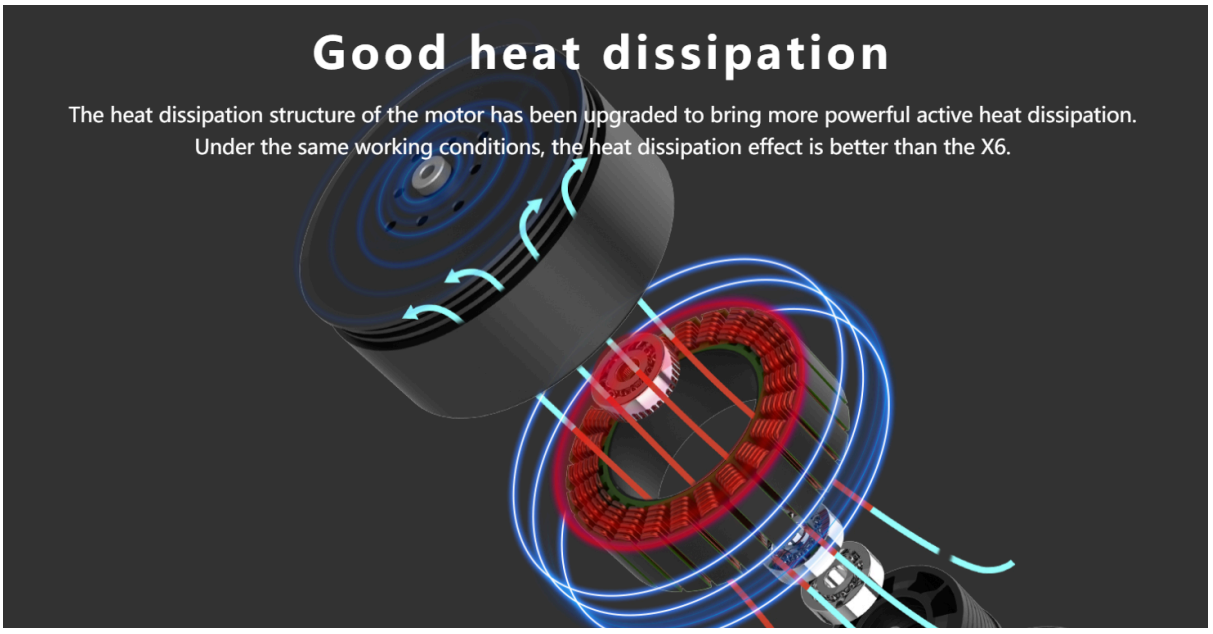


Figure 8.3.2 - Good Heat Dissipation feature of motors

2. Propellers:

These specifications indicate the size and weight characteristics of the propellers used in TEJA-M. The diameter pitch of 24 x 8.0 inches suggests a balance between size and pitch,

impacting the UAS's thrust and efficiency. The weight, including the adapter, is 107g, while the individual weight of a single propeller is 33g. These specifications contribute to the overall performance and stability of the multirotor UAS.

Propeller Specifications - TEJA - M Multirotor UAS

- Diameter Pitch: 24 x 8.0 inches
- Weight (Including Adapter): 107g
- Weight (Single Propeller): 33g

Voltage (V)	Propeller	Throttle (%)	Thrust (g)	Ampere (A)	Power (W)	Speed (RPM)	Efficiency (g/W)
46V (12S LIPO)	HW 24*8.0 Inch Foldable Propeller	40%	2416	4.6	212.2	2455	11.3
		42%	2732	5.5	253.5	2605	10.6
		44%	3058	6.4	296.6	2754	10.3
		46%	3377	7.4	343.8	2900	9.7
		48%	3746	8.7	401.8	3047	9.2
		50%	4106	9.9	460.2	3184	8.9
		52%	4419	11.2	519.9	3325	8.4
		54%	4822	12.5	580.2	3456	8.3
		56%	5209	14.1	653.4	3589	8.0
		58%	5476	15.6	724.6	3716	7.6
		60%	5947	17.3	800.2	3841	7.4
		62%	6370	19.1	886.2	3959	7.2
		64%	6709	20.7	958.4	4080	7.0
		66%	7086	22.6	1048.2	4194	6.7
		68%	7501	24.9	1153.8	4307	6.5
		70%	7779	26.6	1230.2	4415	6.3
		72%	8238	28.8	1332.1	4519	6.2
		74%	8654	31.0	1435.8	4627	6.0
		76%	9016	32.7	1514.0	4723	5.9
		78%	9294	35.1	1626.5	4821	5.7
		80%	9782	37.6	1742.3	4912	5.6
		90%	10731	43.6	2005.6	5142	5.3
		100%	11822	51.8	2399	5442	4.9

Figure 8.3.4 - OEM datasheet for propulsion system performance

Ensure regular maintenance of motors to avoid any unforeseen failures during operation.

9.4. Power Plant

The Power Plant is equipped with a robust and efficient power source, utilizing two MPower 25200mAh batteries connected in series. This configuration ensures reliable and consistent performance, enabling extended flight operations for the agriculture drone. The high-capacity batteries, manufactured by MPower, have been meticulously chosen for their exceptional performance and longevity.

The MPower 25200mAh batteries used in the Power Plant are BIS certified, providing assurance of their compliance with safety, performance, and quality standards. This certification can be verified using the unique R number found on the battery covering.

As shown in the image below, the battery is BIS certified as per IS 16046(Part 2):2018/IEC 62133-2-2017. The R-number of the battery is 61002909.

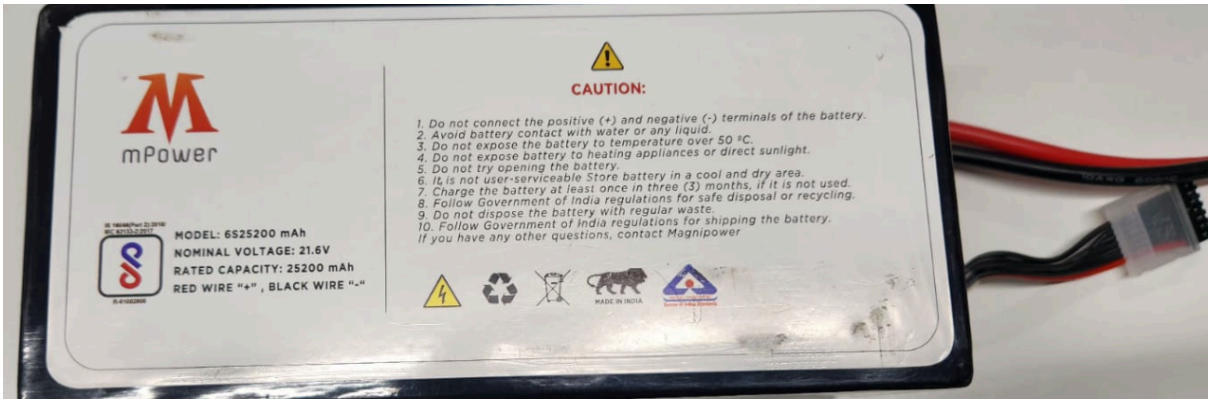


Figure 8.4.1 - mPower 25200 mAh battery

9.4.1. Battery Specifications

Battery chemistry	Lithium Ion
Configuration	6S
Capacity	25200mAh
Discharge rate	11C
Nominal Voltage	21.6V

Charge Current	25A
Dimension(LxWxH)	195x90x80mm ± 3mm
Net Weight	2750±50g
Cells	Cylindrical
Cooling Type	Air
Charging Voltage	25.2V
Set Charging voltage	25.2V
Lower Cutoff Voltage	15V
Set Discharge Voltage	18V
Safe Discharge Voltage	18V
Max. Discharge Current	270A
Storage Humidity	<90% RH
Storage Temperature	-20℃ to 35℃
Connection Options	XT 90
Power rating	544.32 Wh
Energy Density	197.93 Wh/kg
Operating Temperature	Up to 50 ℃

Table 13

Ensure batteries are stored and charged according to manufacturer guidelines to prevent fire hazards or battery damage.

9.5. Control and Communication

9.5.1. Communication link without using Buddy System

Reliable communication is essential for the optimal performance and control of TEJA - M during agricultural spraying operations. The hexacopter utilizes a robust communication system with the following components:

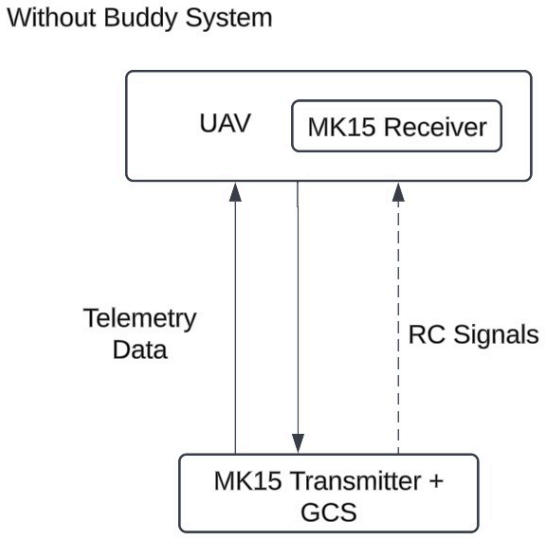


Figure 8.5.1 - Communication link without buddy system active

Communication Protocols and Systems:

- SIYI MK15 SMART AGRICULTURE FPV COMBO:
  - **Features:**
    - 15-kilometer range Android smart controller.
    - Dual 1080p FPV (First Person View).
    - Developed by SIYI Technology with the Qualcomm 8-core CPU platform.
  - **Application:**
    - Commonly used for reliable image transmission and control on agriculture drones, commercial drones, unmanned vehicles, boats, and robotics.

Redundancy Features:

The communication system in TEJA - M incorporates redundancy measures to ensure uninterrupted communication, especially in challenging environments. Redundancy features include:

- Dual Communication Channels:
    - TEJA - M utilizes dual communication channels to enhance reliability.
    - In the event of signal interference or loss in one channel, the system seamlessly switches to the alternative channel, minimizing the risk of communication failure.
- Signal Quality Monitoring:
    - Constant monitoring of signal quality ensures proactive identification of potential issues.
    - The system assesses the quality of communication signals and can dynamically adjust parameters to maintain optimal communication performance.
- Error Correction and Packet Loss Handling:
    - Advanced error correction algorithms are employed to rectify signal errors and mitigate packet loss during data transmission.
    - Redundant data packets are used to reconstruct lost information, ensuring the integrity of communication.
- Dynamic Frequency Selection:
    - TEJA - M is equipped with a dynamic frequency selection mechanism.
    - It automatically selects and switches frequencies to avoid interference and maintain a stable connection, even in crowded signal environments.
- Failover Mechanism:
    - A failover mechanism is in place to automatically switch to backup systems in case of primary system failure.
    - This ensures a seamless transition and prevents disruptions in communication.

The SIYI MK15 SMART AGRICULTURE FPV COMBO, with its 15-kilometer range, dual 1080p FPV, and Qualcomm 8-core CPU

platform, serves as a reliable and advanced component of the communication system, providing solid control and image transmission for TEJA - M during agricultural operations.

9.5.2. Communication link while using buddy system

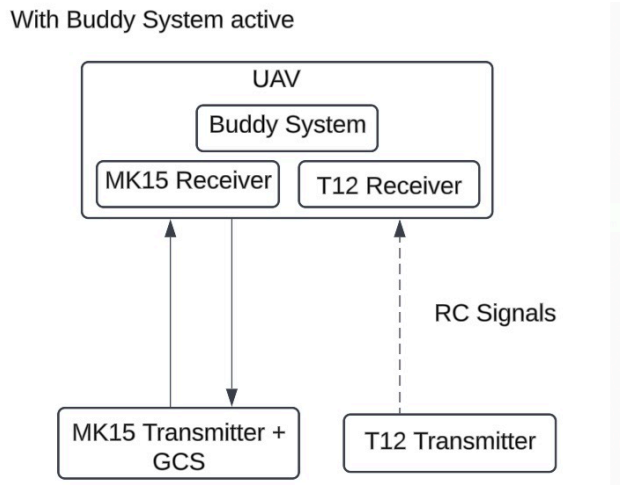


Figure 8.5.2 - Communication link with buddy system active

In a **buddy system** setup, the communication link between the receivers and transmitters is structured to provide primary and secondary control. Here's how the communication link works in this system:

1. **MK15 Receiver and Transmitter**:
    - The **MK15 receiver** serves as the **primary communication link** to the **Ground Control Station (GCS)**.
    - The MK15 receiver connects to the GCS and handles all data transmission between the aircraft (or drone) and the control station.
    - The **MK15 transmitter** allows the operator to regain full control of the aircraft by pressing the **A BUTTON** on the transmitter.
    - This allows the operator to override control, even when the T12 receiver is active and providing limited control.
2. **T12 Receiver and Transmitter**:
    - The **T12 receiver** receives basic **flight control commands** (pitch, roll, yaw, and throttle) from the **MK15 receiver**.

- It communicates only the RC (remote control) commands for flight control; it does not have direct access to the GCS, which remains connected solely to the MK15 receiver.
- The **T12 transmitter** controls the flight based on inputs provided by the MK15 receiver but has no influence on GCS communication.
- If the T12 receiver is active, the operator can control the aircraft, but the MK15 retains the ability to regain complete control when necessary.

3. **Buddy System Control Flow**:
   - **Primary Control (MK15)**: The MK15 receiver maintains communication with the GCS and has overriding control over the aircraft.
   - **Secondary Control (T12)**: The T12 receiver provides basic flight control (pitch, roll, yaw, throttle), but will not affect GCS communication or critical systems.
   - **Switching Control**: The operator can switch control between the MK15 and T12 receivers using the **A BUTTON** on the MK15 transmitter, ensuring a fail-safe mechanism for control regaining.

The T12 telemetry system is used to control and communicate with the UAS as a slave controller in buddy mode. T12 transmitter has 12 channels with frequency ranging from 2.400 to 2.4833 GHz. It is supported by FHSS technology with dual antenna dual-mode. Communication range for this system is about 20 km. Receiver has an operating voltage of 4.5-5.5V. This system comes with a gimbal camera operating at 5V which is connected to the receiver. AeroGCS firmware is compatible with this system.

Figure 8.4.1 - T12 Buddy System Controller

9.6. Camera Integration Overview

In addition to its primary function of crop spraying, the TEJA - M UAS can be equipped with a high-resolution camera to provide live feed monitoring of the crops. This feature enhances

the UAS's functionality, offering real-time observation capabilities which can be crucial for precision agriculture and crop management.

Camera Specifications

The camera used is the A2 mini, which is mounted on the canopy of the UAS. It is tilted at an angle to provide an optimal view of the field without any interference from the propellers or other components. The camera is housed in a protective casing to ensure durability and reliability in various operating conditions.

Key Features of A2 Mini Camera:

- **Overall:**
  - Video Output Port: Ethernet, HDMI, CVBS (AV)
  - Control Signal Input Port: S.Bus, UART, Ethernet UDP
  - Control Signal Output Port: S.Bus
  - High Accuracy 3 Axis Stabilization: Yaw, Pitch, Roll
  - Working Voltage: 11 ~ 25.2 V (Note: Early manufacturing lots may not support 25.2V)
  - Power Consumption: Average 5 W, Summit 12 W
  - Working Temperature: -10 ~ 50 ℃
  - Dimension: 55 x 55 x 70 mm
  - Weight: 95 g
- **Camera:**
  - Lens: Fixed Focal Length, 6X Digital
  - Equivalent Focal Length: 21 mm
  - Image Sensor: Sony 1/1.7-inch, 8 MP effective resolution
  - Aperture: F2.8
  - FOV (Field of View): Horizontal: 81°
  - TF Card Recording Resolution:
    - 4K (4096 x 2160) @ 25 fps
    - 2K (2560 x 1440) @ 30 fps
    - 1080p (1920 x 1080) @ 30 fps
    - 720p (1280 x 720) @ 30 fps
  - Video Storage Bitrate: 12 Mbps (H.265 Codec)
  - Supported File System: FAT32
  - Photography File Format: JPG
  - Video File Format: MP4
  - Supported TF Card Type: MicroSD Class10, max 128 GB
  - Still Photography Mode: Single

- White Balance: Auto

Integration and Customer Customization

The camera is an additional component that can be attached or removed based on customer requirements. Its integration does not interfere with the UAS's primary spraying function and provides added value through live feed capabilities. The camera can be particularly useful for monitoring crop health, identifying problem areas, and ensuring uniform application of fertilizers or pesticides.

Impact on Maximum Takeoff Weight (MTOW)

When installed, the weight of the camera (95 g) is added to the MTOW calculations. This ensures that all operational parameters remain within safe and effective limits, maintaining the integrity and performance of the UAS.

The integration of the A2 mini camera enhances the TEJA - M UAS's versatility and functionality, providing a valuable tool for precision agriculture. Its ability to offer real-time video monitoring alongside crop spraying operations makes it an ideal choice for modern agricultural practices. The camera's robust features and protective mounting ensure reliable performance, making it a worthwhile addition to the TEJA - M UAS.

Camera Integration Benefits

1. Real-time Crop Monitoring: Allows for immediate identification of crop health and problem areas.
2. Enhanced Precision: Ensures accurate application of fertilizers and pesticides.
3. Customer Flexibility: Camera can be added or removed based on specific needs.
4. Durability: Protected by a casing, ensuring longevity in various environmental conditions.
5. High-Quality Imaging: Provides high-resolution images and videos for detailed analysis.

This addendum ensures that all relevant details about the camera integration are documented, providing a comprehensive understanding of its benefits and impact on the TEJA - M UAS's performance.

9.7. Payload

The payload system is designed for targeted and efficient spraying. It includes a dedicated tank for pesticides, a high-performance pump, and a sophisticated control mechanism for

precise payload release. The payload system in the TEJA - M hexacopter is intricately designed for precise and efficient spraying operations in agriculture. The system incorporates various components such as nozzles, pump, tank, connectors, and pipes, each with specific features and specifications. Two types of nozzles, Type-A and Type-B, are utilized, and the pump, a Hobbywing 5L brushless motor, enhances liquid flow. The 10L tank, constructed from durable ABS material, includes anti-surge features, a stainless-steel filter, and a venting mechanism.

Integration is facilitated through advanced control mechanisms, including PWM signal control for the nozzles, intelligent pump control, and safety considerations like frothing prevention. The entire system is designed for compatibility and efficiency in agricultural spraying, with a focus on user-defined water and pesticide mixtures. Safety features such as protection grades and maximum fill recommendations ensure optimal performance in diverse environmental conditions.

9.7.1. Working diagram of payload:

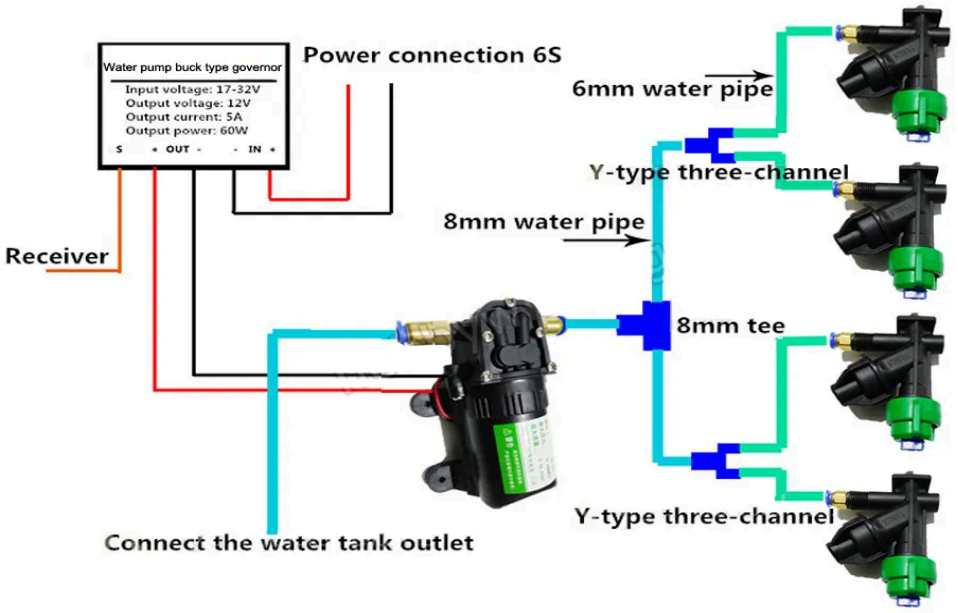


Figure 8.6.1 - Working diagram of payload

9.7.2. Fixed Payload

The fixed payload of TEJA-M is as follows:

Components of Payload	Specifications	Quantity/Capacity
Nozzle bar kit	High pressure, fan-shaped atomization.	4 Nos
Pneumatic connectors	ø6 x ø6 mm coupler	4 Nos
Pneumatic connectors	ø6 x ø6 x ø8 mm T-connector	2 Nos
Pneumatic connectors	ø8 x ø8 x ø12 mm T-connector	1 Nos
Pneumatic connectors	ø12 x ø12 mm Elbow Connector	1 Nos
Pump	5-liter, Max Voltage: 50.4V	1 Nos
Liquid flow meter & level sensor	5V	1 Nos (each)
Pneumatic tubes	ø6mm, ø8mm & ø12mm	8 (4+2+2) Nos
Tank with battery plate	Containing water & pesticide mixture, Varies with crop	10 liters

Table 14

9.7.2.1. Tank Material Specification

The tank of TEJA - M is constructed using Acrylonitrile Butadiene Styrene (ABS) material. ABS is chosen for its durability, chemical resistance, and lightweight properties, making it suitable for containing agricultural liquids, including water-pesticide mixtures.

9.7.2.2. TEJAM - Payload Type A:

Figure 8.6.2 - Fixed Payload with Type A nozzle

- Spraying Capacity: 10 liters of pesticide
- Number of Spraying Outlets: 4
- Total Weight of Payload: 10 kg
- TEJAM Weight with Payload (MTOW): 30.5 kg

Components:

- Nozzle Bar Kit: 4 high-pressure, fan-shaped atomization nozzles with filters
- Pneumatic Connectors: 4 × ø6 x ø6 mm coupler, 2 × ø6 x ø6 x ø8 mm T-connector, 1 × ø8 x ø8 x ø12 mm T-connector, 1 × ø12 x ø12 mm Elbow Connector
- Pump: 5-liter pump with a maximum voltage of 50.4V
- Liquid Flow Meter & Level Sensor: 5V, 1 each
- Pneumatic Tubes: 8 tubes (4 × ø6mm, 2 × ø8mm, 2 × ø12mm)
- Tank with Battery Plate: 10 liters, containing water & pesticide mixture

9.7.2.3. TEJA-M - Payload Type B:

Figure 8.6.3 - Type B Nozzle

- Spraying Capacity: 10 liters of pesticide
- Number of Spraying Outlets: 2
- Total Weight of Payload: Not specified
- TEJAM Weight with Payload (MTOW): 30.5 kg

Components:

- Centrifugal Nozzles: 2 nozzles with a capacity of 5 liters each
- Pneumatic Connectors: 1 × ø8 x ø8 x ø12 mm T-connector
- Pump: 5-liter pump with a maximum voltage of 50.4V
- Liquid Flow Meter & Level Sensor: 5V, 1 each
- Pneumatic Tubes: 4 tubes (2 × ø8mm, 2 × ø12mm)
- Tank with Battery Plate: 10 liters, containing water & pesticide mixture.

9.7.3. Variable Payload Details :-

Water & pesticide mixture: Different types of pesticides are used based on the crop type. The water-pesticide mixture is defined by the farmer/user.

The tank has a maximum capacity of 11 liters, but it is recommended to fill it only up to 10 liters to allow 1 liters of space for frothing. This precaution ensures optimal performance and prevents spillage during operation.

Figure 8.6.4 - Payload limits

9.8. Data Logging Capability

9.8.1. Overview of Data Logging Capability

TEJA-M is equipped with advanced data logging capabilities that are essential for both operational analysis and maintenance tasks. The data logging system records a wide range of parameters during flight operations, providing valuable insights into the performance of the drone and helping with troubleshooting and performance optimization.

Regularly review and analyze the logged data to ensure the safe operation of the RPA and prevent potential issues.

9.8.2. What Data is Logged

TEJA-M's data logging system captures a comprehensive set of flight and operational parameters. The following data types are logged:

Data Type	Description
Flight Time	The total duration of each flight session. Important for monitoring battery life and planning future flights.
Altitude	Current and maximum altitude during the flight. Useful for assessing altitude-related flight performance.
GPS Coordinates	Latitude and Longitude of the RPA's position at different intervals. Essential for tracking flight paths and navigation.
GPS Signal Strength	Quality of the GPS signal received by the drone. Monitor to ensure reliable navigation and positioning.
Battery Voltage	Real-time voltage levels of the drone's battery. Helps in assessing battery health and planning safe flight durations.
Battery Current	Current draw from the battery during flight. Indicates power consumption and helps diagnose battery-related issues.
Temperature	Temperature of critical components like motors and electronics. Prevents overheating and potential component failures.

Speed	The velocity of the RPA, including ground speed and airspeed. Assists in performance analysis and operational planning.
Motor RPM	Revolutions per minute of each motor. Critical for diagnosing motor performance issues and ensuring proper operation.
Flight Mode	Current flight mode (e.g., Loiter, Auto, RTL). Helps in understanding the flight behavior and analyzing mode-specific performance.
Error Codes	Logged error messages and system alerts. Essential for troubleshooting and resolving operational problems.
System Status	Overall health status of the RPA's subsystems (e.g., IMU, GPS, compass). Important for identifying any subsystem malfunctions.

Table 15

TEJA - M can store up to 499 logs at a time. New logs will replace the old logs after completion of the maximum limit to store logs.

End User cannot download the logs. However in case of any abnormalities or malfunction these logs will be used by Pavaman Aviation to determine the issue or error. So report immediately after the issue or malfunction during the operations.

10. Performance Data

10.1. Operational Flight Envelope

Operating speed at standard sea level conditions	10 m/s
Operating temperature	-10° to 50° C
Operational altitude	100 m
Operational envelope	Maximum Altitude: 100 m AGL, Maximum Range: 1500 m, Wind Speed: up to 6 m/sec , Maximum Drone Speed: 10 m/sec
Operational Ceiling height	100 m
Operational Endurance	1. Endurance with maximum variable payload without dispensing: 12 minutes 2. Endurance without variable payload: 25 minutes
Operational Range	0 to 1500 m
Operational Wind Speed (measured on the ground)	upto 6 m/sec
Operational bank angle	upto 25°
Operational MTOW Weight	30.5 kg

Table 16

Emergency Condition Envelope Table:

S.No	Failsafe	Visual Alert	Audio Alert	Time Taken for GCS	Action
1	Battery failsafe	Battery failsafe	Battery failsafe	Immediately	RTL
2	Critical Battery Failsafe	Battery failsafe	Battery failsafe	Immediately	Land
3	C2 Data Link Failure	Communication lost, drone disconnected	Communication lost, drone disconnected	5 seconds	RTL
4	Geofence failsafe	Fence Breach	Fence Breach	Immediately	RTL
5	Tank Empty	Tank Empty	Tank Empty	Immediately	Hover at location

Table 17

Detailed failsafe conditions are mentioned in the failsafe procedures in section 5.2

11. Appendices

1. Contact Information for Service and Support

ADDRESS: 2nd floor, kapil kavuri hub, financial district, nanakramguda, rangareddy -500032, Telangana

CONTACT DETAILS: 8465859571

EMAIL ID: vijay.veeramallu@pavaman.in

COMPANY WEBSITE: https://pavaman.in

2. Recommended Reading and Resources

- The Drone Rules, 2021

https://www.dgca.gov.in/digigov-portal/jsp/dgca/homePage/viewPDF.jsp?page=InventoryList/headerblock/drones/Drone%20Rules%202021.pdf

- Drone (Amendment) Rules, 2022

https://www.dgca.gov.in/digigov-portal/jsp/dgca/homePage/viewPDF.jsp?page=InventoryList/headerblock/drones/Drone%20(Amendment)%20Rules%202022.pdf

- TEJA - M; Maintenance manual

Annexure- 1

1. TOP , SIDE AND FRONT VIEW - ARMS UNFOLDED

Figure AX.1.1- Unfolded Top View

Figure AX.1.2 - Unfolded Front View

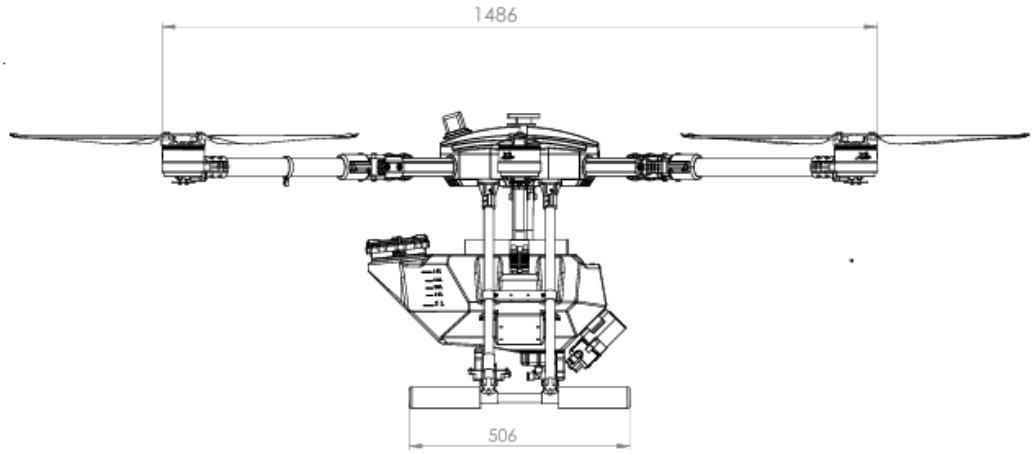


Figure AX.1.3 - Unfolded Side View

2. TOP , SIDE AND FRONT VIEW - ARMS FOLDED

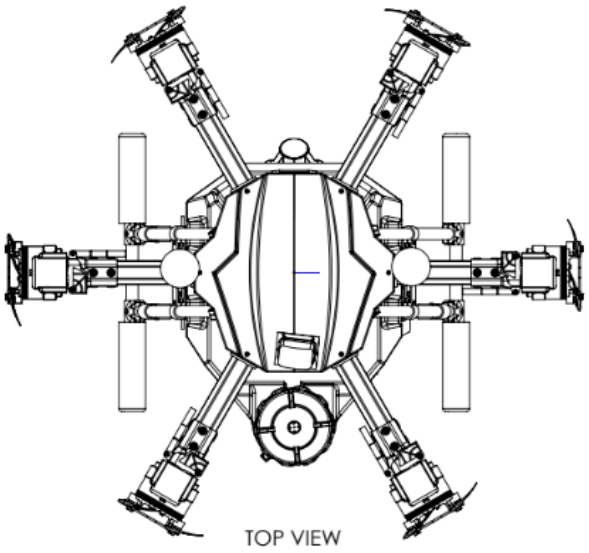


Figure AX.1.4 - Folded Top View

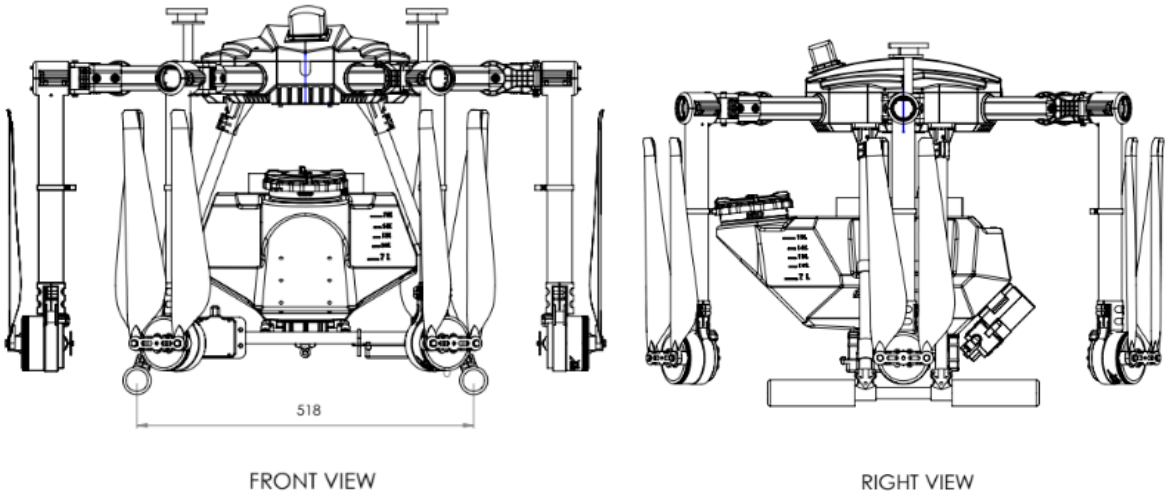


Figure AX.1.5 - Folded Front & Side View

3. ISOMETRIC AND TRIMETRIC VIEW

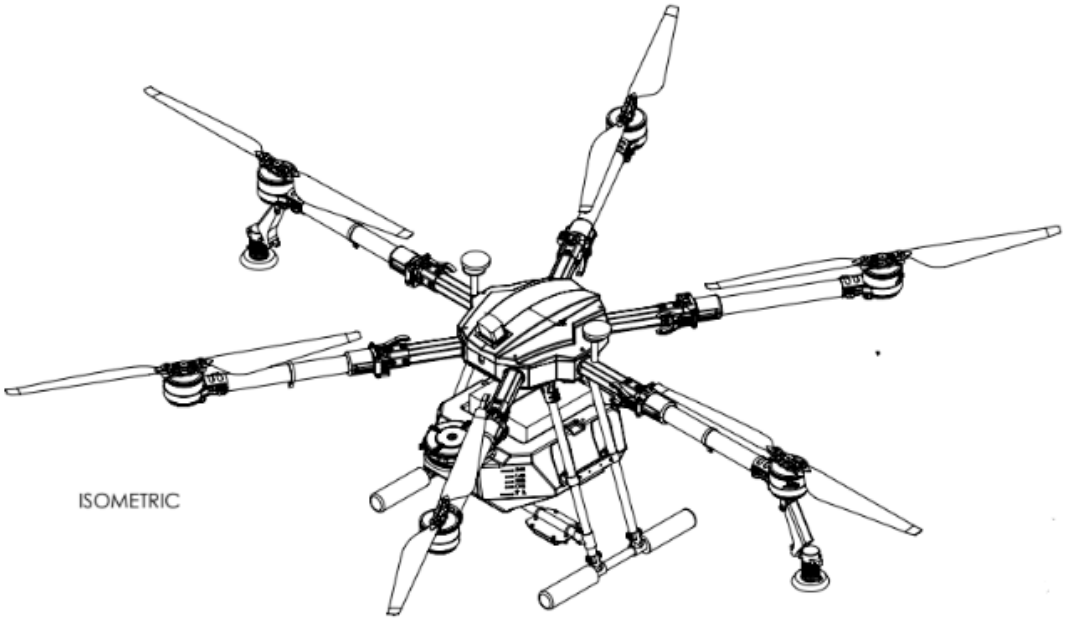


Figure AX.1.6 - Isometric View

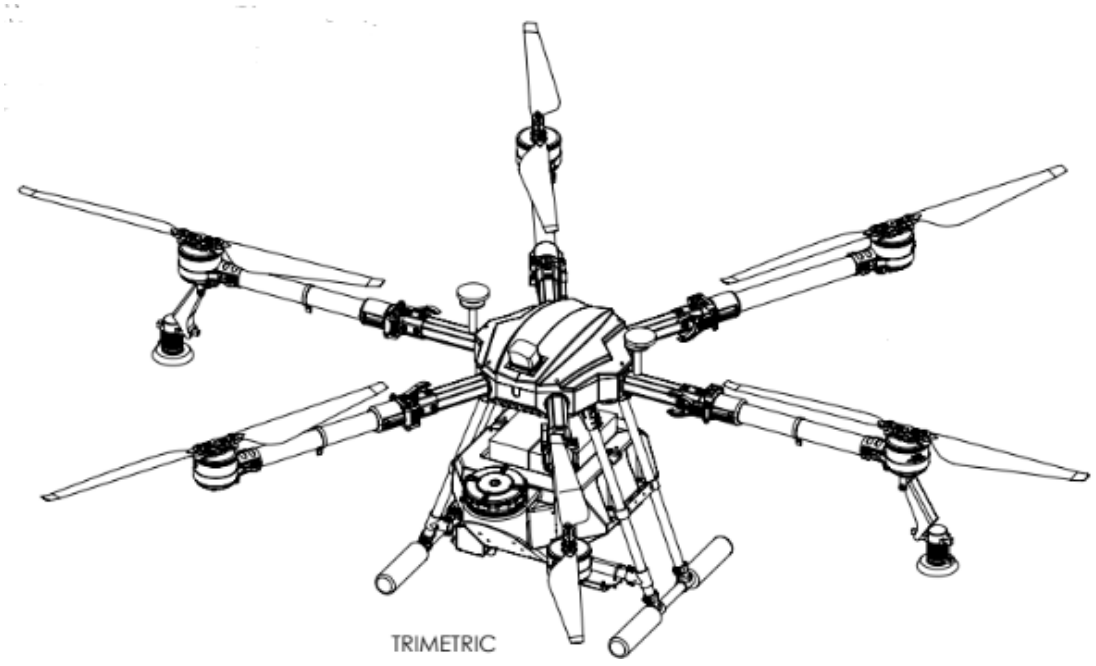


Figure AX.1.7 - Trimetric View

Annexure- 2

Fastener Details of TEJA-M

S.No	Name of the component	Type of screw- Hex Skt Head	Each Qty	No.of components	Total
1	Arm joint	M3x8	8	6 arm sleeves	48
	Arm hinge bolt	M5x50	1		6
2	Landing Gear Connector	Fixed seat M3x8	4	4 Connectors	16
	Vertical positioned-	Vertical positioned- M3x8 -2, M4x12-2	4	4 Connectors	16
3	T Joint Connector	M3x8 -2 nos., M3x 12 -1 no., M3x20-1 no.	4	4 connectors	16
4	Motors	M3x12	4	6 motors	24
5	Pump System	M4x12	4	1 Pump	4
6	Pipes and Hoses	M3x8-2 nos. one arm- 2 clips	2	4 arm 8 clips	8
7	Flat nozzles	M3x8 -1 no., Hub Mount M3x12-2 nos.	3	4 nozzles	12
	Centrifugal Nozzles	M3x12	2	2 nozzles	4
8	Propellers (HW2480)	M3x8 -4 nos., M3x16 -2 nos.	6	6 propellers	36
9	Battery Pack & Connectors	M3x8	6	2 sides of connectors	12
10	Terrain Radar	M4x12	4	1 radar	4
11	Obstacle Avoidance Radar	M3x16	1	1 radar	1
12	Camera	M3x8 with lock nuts	4	1 camera	4
13	GPS	M4x12	2	2 GPS	4
14	Tank	M5x45	4	1 tank	4
15	Canopy	M3x8	6	1 canopy	6
		In case of Flat nozzle			258
		In case of Centrifugal nozzle			250

Note: Before commencing any flight all the fasteners must be checked for any loseness.

Primary Structural Elements of TEJA-M

S.No	Name of the Component
1	Arm Joint
2	Landing Gear Connector
3	T Joint Connector
4	Inner Arm
5	Outer Arm
6	Main Frame
7	Vertical Landing Gear
8	Horizontal Landing Gear
9	Propeller Hub

List of Fasteners of PSEs:

S.No	Name of the Component	Type of Screw	Fastener per Component	Total No. of Components	Total Qty of Fasteners
1	Arm Joint	M3x8	8	6	48
2	Landing Gear Connector	M3x8	4	4	16
3	T Joint Connector	M3x8 - 2, M3x12 - 1, M3x20 - 1	4	4	16
4	Inner Arm	M3x12	6	6	36
5	Outer Arm	M4x12	8	6	48
6	Main Frame	M3x8 - 2, Clips	8	1	8
7	Vertical Landing Gear	M3x8 - 1, Hub Mount M3x12 - 2	5	2	10
8	Horizontal Landing Gear	M3x12	2	2	4
9	Propeller Hub	M3x10 -2 M3x8 -4	6	6	36

Note: Regularly check the fasteners of PSEs and regularly maintain them for safety.

Annexure - 3

List of life of components

Component	Life
Airframe	6500 hours
Landing Gear	8500 landings
Battery	384 cycles
Propeller	500 hours
Motors	500 hours

On completion of life of the airframe, the user is to return the UAS and take up with the manufacturer for replacement of the life expired airframe with a new one. Replacement of airframe is not a user level activity. It is to be replaced by the manufacturer only.