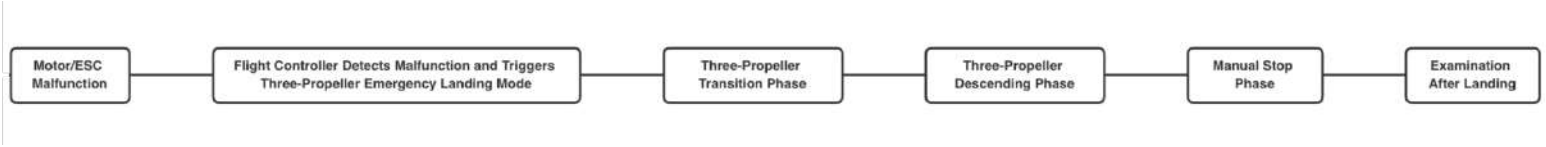
Three-Propeller Emergency Landing of the Matrice 300 RTK

1. General Introduction of Three-Propeller Emergency Landing Function

Historically, quadcopter-style drones have had an Achille's Heel: Should one motor fail, the entire UAS will become uncontrollable and unable to sustain flight. DJI has remedied this with an innovative solution designed for the Matrice 300 RTK (M300 RTK).

Should a single motor fail, the M300 RTK will automatically enter the Three-Propeller Emergency Landing mode. In this mode, the aircraft will re-establish stability before starting a controlled descent to land. This function provides a window for the user to land the aircraft in a suitable location and reduce potential damage to the UAS and third parties.

2. Flow chart of Three-Propeller Emergency Landing



3. Trigger Condition

The M300 RTK's flight controller continuously monitors all four motors during flight. When the controller detects a propulsion system malfunction – either a motor or ESC malfunction that is causing a motor to operate at lower than the required speed – the issue will trigger the Three-Propeller Emergency Landing mode.

4. Limitations

1) The maximum take-off weight supported by the Three-Propeller Emergency Landing function is 7.7 kg. This function may not work properly with weights exceeding 7.7 kg.
2) There will be a horizontal and vertical position drift when the function is triggered. Hence, an open circular space with a horizontal radius of ≥100m and a height of ≥10m is required for this function to work properly. With reduced clearance there could be a collision with nearby obstacles during Three-Propeller Emergency Landing mode.
3) If a propeller is damaged but the motor is still working normally, the aircraft will not enter the Three-Propeller Emergency Landing mode.
4) Three-Propeller Emergency Landing mode is a safety function designed for use specifically with a failure of a motor or ESC. Please don't actively trigger this mode in non-emergencies.
5) Please ensure all firmware is up-to-date.

5. Behavior of the aircraft and RC and how to operate the aircraft in each phase of Three-Propeller Emergency Landing

a) Before the Three-Propeller Emergency Landing is triggered

The flight controller requires about 200ms to detect a motor / ESC malfunction. During this 200ms lag the aircraft may abruptly pitch up to 100°. There will be horizontal drift ≤ 5m and a vertical altitude drop ≤ 1m.

b) **Three-Propeller Transition Phase**

When the flight controller triggers the Three-Propeller Emergency Landing mode, the aircraft will enter the Three-Propeller Transition Phase first.

RC and App behavior: The RC will vibrate once, and beep continuously. The following notification will appear in DJI Pilot: *"Aircraft propulsion system error. Forced landing. Manually control the aircraft and land in an open area."*

Aircraft behavior: The aircraft will begin quickly spinning with an angular velocity of 750-860°/s. This Transition Phase will last for 5 to 15 seconds.
In this phase, the aircraft could drift horizontally up to 30m; vertical movement could reach up to five meters.

How to operate the aircraft: During the transition phase, the aircraft will not respond to stick inputs attempting to control the drone's direction. Once the Three-Propeller Emergency Landing Mode is triggered, you can use the Combination Stick Command (also known as CSC) to stop the propellers in case the flight needs to be terminated immediately to avoid a collision.

c) **Three-Propeller Descending Phase**

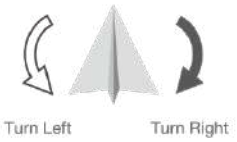
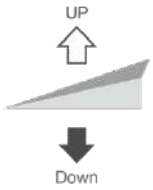
After the aircraft has achieved relative stability, it will enter the Three-Propeller Descending Phase.

RC and App behavior: The RC will beep continuously. The following notification will be displayed in DJI Pilot: *"Aircraft propulsion system error. Forced landing. Manually control the aircraft and land in an open area".*

Aircraft behavior: The aircraft will automatically descend at a constant vertical speed of 5m/s and respond to some stick movements in this phase. The aircraft will keep spinning during descent, with a horizontal drift speed of ≤1.5 m/s.

How to operate the aircraft: In this phase, control stick functionality will adjust. The stick that controls back and forth movement will be adjusted to control North-South (cardinal direction) movement, and the stick used to control the left and right movement will be adjusted to control East-West movement. Pushing up the throttle stick can stop the automatic descent of the aircraft and even make the aircraft ascend slowly (max. 1.25m/s). Pushing the throttle stick down will not change the default descent of 5m/s. The aircraft will keep spinning quickly and will not respond to the yaw stick movements.

When the aircraft is close to the ground, the speed will automatically slow due to the obstacle sensing system. It is recommended the UAS be guided to an appropriate landing area as soon as possible in this phase. If the obstacle sensing system's vertical braking distance is not enabled in the DJI Pilot app, the operator will need to slow the descent of the aircraft by using the throttle stick and eventually stop the props by using the Combination Stick Command.

Stick	In normal operation	In Three-Propeller Emergency Landing
Pitch stick	 Forward and backward	North and south
Roll stick	 Left and right	West and East
Yaw stick	 Turn left and right	No response
Throttle stick	 Up and down	Up and down

d) Manual Stop Phase

When the aircraft reaches the brake distance to the ground that the operator has set in the DJI Pilot app, it will enter the manual stop phase.

RC and App behavior: The RC will vibrate once and beep continuously. The following notification will be displayed in DJI Pilot: *"Landing Protection - Push both control sticks to the bottom inner corners to land".*

Aircraft behavior: The aircraft will remain at its current height and respond to the horizontal and vertical stick movements until the Combination Stick Command (CSC) (sticks in and down or sticks out and down) is used to stop the motors.

How to operate the aircraft: In this phase, the stick control method is the same as the previous Three-Propeller Descending Phase. The maximum ascent is 1.25m/s, while the maximum descent speed

depends on the aircraft's altitude. When the aircraft has reached the brake height, it will stop descending and the operator will be unable to further lower the aircraft's height. When the Combination Stick Command (CSC) is used, the motors will stop and the aircraft will land immediately.

The Three-Propeller Emergency Landing is completed at this point. It is recommended to land on a soft surface such as grass, if possible, to minimize the risk of the aircraft of payload being damaged.

e) Post-landing examination

Please check whether the landing gear, propellers, arms, and payload(s) are damaged following landing. It is strongly recommended that you contact DJI aftersales for a comprehensive examination immediately following a Three-Propeller Emergency Landing.

6. Conclusion

Quadcopters, even sophisticated industrial models, generally cannot fly with three motors. DJI's Three-Propeller Emergency Landing Function on the Matrice M300 RTK allows for an autonomous, emergency recovery to take place. Software puts the UAS into a spin and the flight controller is able to re-distribute the work being done by the three remaining motors to regain stability and allow an operator to choose a safe landing zone to minimize any risk of damage. We recommend that operators thoroughly familiarize themselves with the points outlined above, and the revised stick inputs required during this special mode.