# System Description

# Trinity F90+

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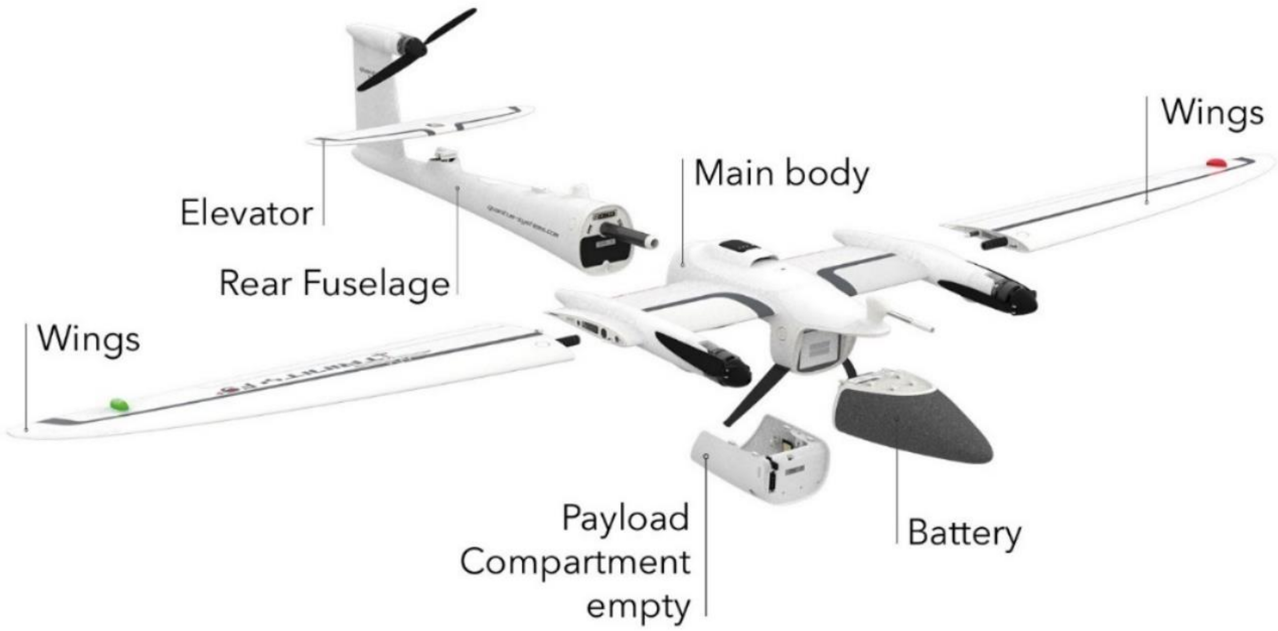
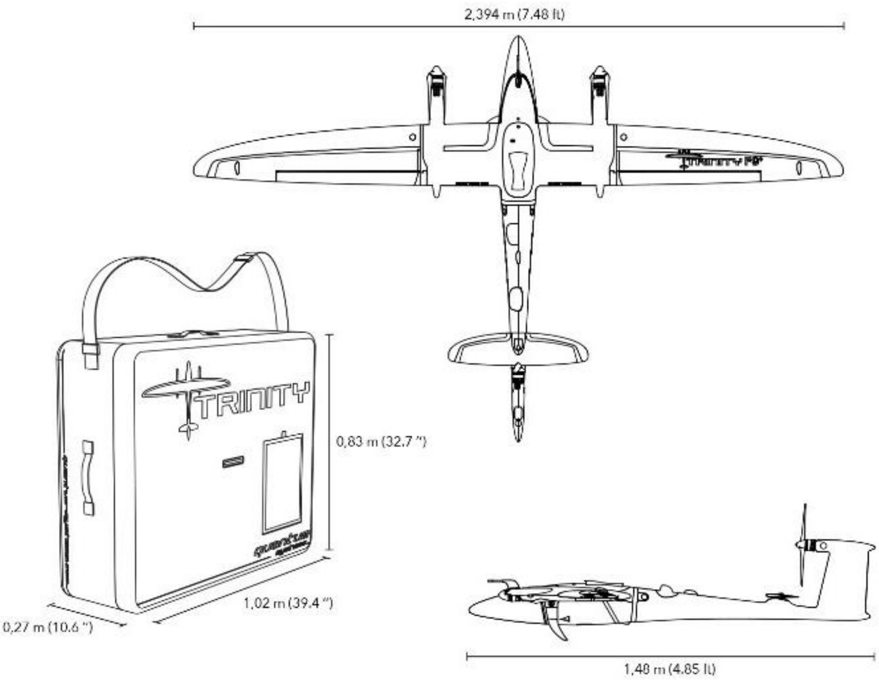
# 1. Introduction

The Trinity is a UAV that combines hovering capabilities with fixed-wing flight. To ensure vertical take-off and landing (VTOL), the three motors are directed upwards. The engines are tilted forward for cruise. The thrust for the forward flight is generated by the rear motor, while the two front motors are switched off. Depending on the integrated sensor, the Trinity is suitable for a variety of applications. The fuselage is made of Elapor® and is moulded around a rigid carbon fibre structure.

# 2. Aircraft



## 2.1. Airframe




| | |
|---|---|
| Max take-off weight (MTOW) | 5.0 kg (11.0 lbs) |
| Data link range control | 5 – 7.5 km (3.1 – 4.7 mi) |
| Wingspan | 2.394 m (7.85 ft) |
| Length | 1.48 m / 4.85 ft |
| Backpack dimensions | 1002 x 830 x 270 mm<br>(39.4 x 32.7 x 10.6 inch) |
| Box empty | Ca. 4Kg |

### 2.1.1. Used Material Airframe

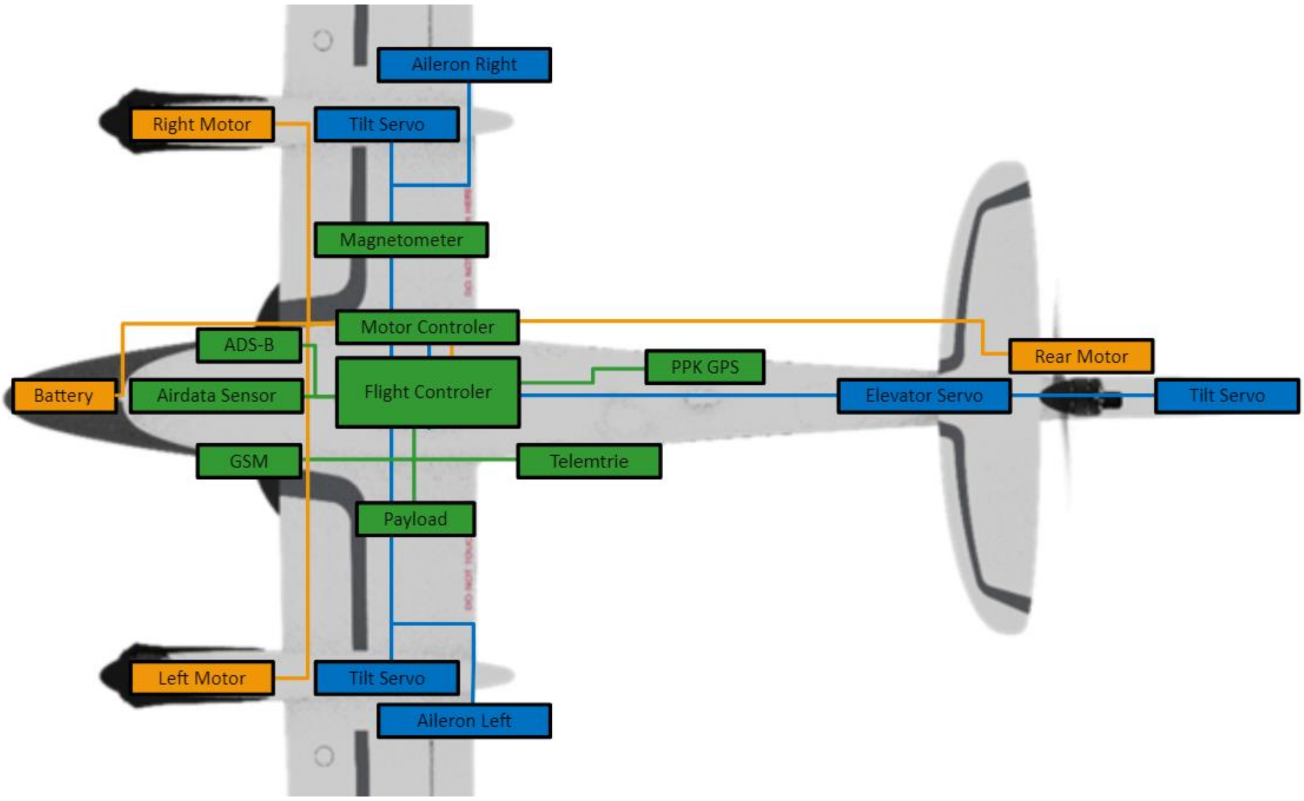
The entire load bearing UAS cell (Airframe) is made of carbon fibre reinforced ELAPOR foam.

### 2.1.2. Loads

The UAV can withstand load multiples of +2.5 g and -2.5 g. The autopilot ensures that there is no structural overload of the UAV in flight.

### 2.1.3. Subsystems

| |
|---|
| Battery |
| Airspeed Sensor |
| Flight Control Computer Board (FCC), Quantum Skynode) |
| Triple Engine Speed Controller Board (TEB) |
| Datalink and -antennas |
| Magnetometer |
| GPS Board and Antennas |
| Actuators (Tilt and Control Surfaces) |
| Motors |
| Payload and Payload Management Board (PMB) |
| ADS-B Ping and Antenna |



### 2.1.4. Trinity F90+ Battery

The Trinity is powered by 6S 4P Li-Ion batteries with a total nominal voltage of 21.6 V and delivers 12 Ah. The four batteries are completely physically separated and are in the nose of the Trinity F90 +. Each battery provides 65 Wh of energy. The battery is encased in fireproof ARPRO material.

### 2.1.5. QS Battery Charger

The QS charger is suitable for charging the Trinity battery with a voltage of 100V to 240V AC and for charging the battery using a 12V car battery.

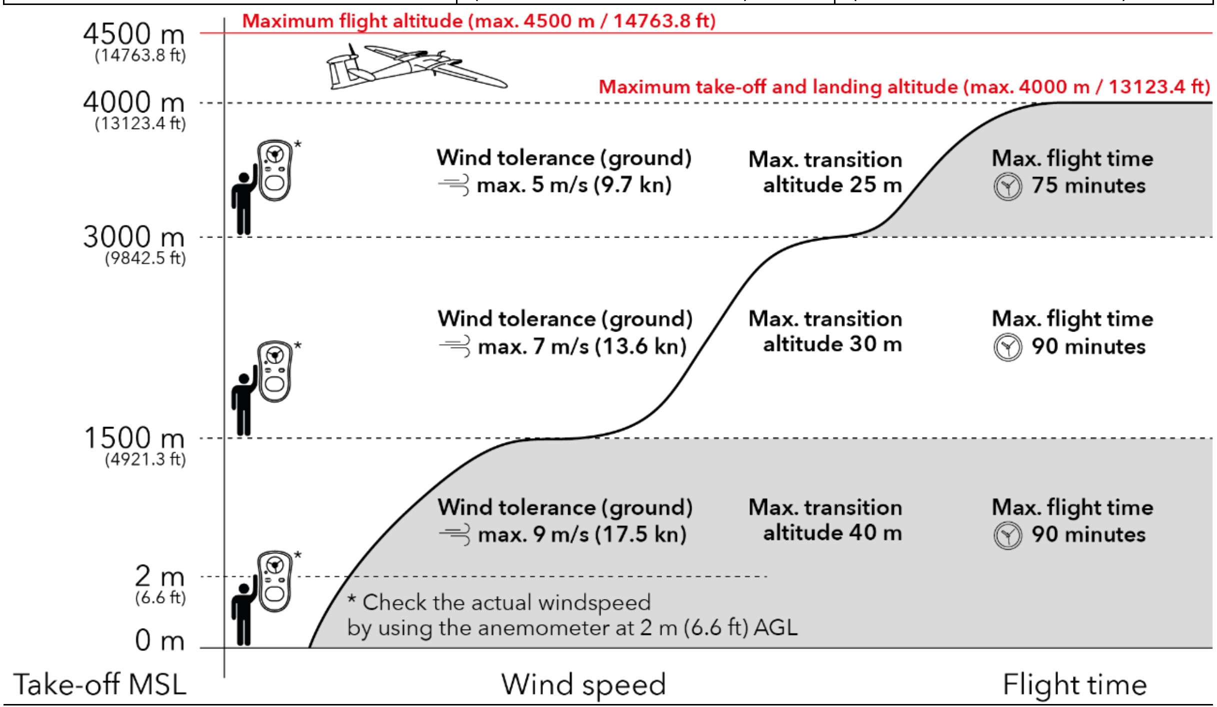
The QS RC transmitter can be charged on the front of the charger.

| Technical specifications | |
|---|---|
| Charging current | 12A |
| Discharge current | 2A |
| Discharge voltage | 3,1V |
| TVC voltage | 4,17V |
| Loading time | About 1 hour (depending on the state of discharge) |
| USB port charging current | 2.1 A |

## 2.2. Flight Performance

The table shows the flight performance parameters of the Trinity. All sizes refer to 0 meters MSL with ICAO standard atmosphere (ISA) and with maximum take-off weight (MTOW).

| | Trinity F90+ Locked <60 min | Trinity F90+ Unlocked 90 min |
|---|---|---|
| Max. Take-off Weight | 5.0 kg (11.0 lbs) | 5.0 kg (11.0 lbs) |
| Max. Flight Time | 60 min | 90+ min |
| Max. Range (Area Coverage) | 70 km = 500 ha<br>(43 mi = 1235 ac) | 100 km = 700 ha<br>(62 mi = 1730 ac) |
| Maximum Flight Altitude (MSL) | 4500 m (14763.8 ft) | 4500 m (14763.8 ft) |
| Command and Control Range<br>** under optimal conditions | 5 – 7.5 km** (3.1 – 4.7 mi) | 5 – 7.5 km** (3.1 – 4.7 mi) |
| Payload (with compartment) | max. 935 g (2,06 lbs) | max. 935 g (2,06 lbs) |
| Optimal Cruise Speed | 17 m / s (33 kn) | 17 m / s (33 kn) |
| Wind Tolerance (ground) | up to 9 m/s (17.5 kn) < 1500m MSL<br>up to 7 m/s / (13,6 kn) 1500m - 3000m MSL<br>up to 5 m/s / (9.7 kn) > 3000m MSL | up to 9 m/s (17.5 kn) < 1500m MSL<br>up to 7 m/s / (13,6 kn) 1500m - 3000m MSL<br>up to 5 m/s / (9.7 kn) > 3000m MSL |
| Wind Tolerance (cruise) | Bis zu 12 m / s (23.3 kn) | Bis zu 12 m / s (23.3 kn) |
| Battery Weight | 1.5 kg (3.3 lbs) | 1.5 kg (3.3 lbs) |
| Telemetry Link & RC Transmitter Frequency | 2.4 GHz | 2.4 GHz |
| Telemetry Link (QBase Modem) Power | max. 100 mW | max. 100 mW |
| Operating Temperature Range | -12 °C bis 50 °C<br>(10.4 °F to 122 °F) | -12 °C bis 50 °C<br>(10.4 °F to 122 °F) |
| Wingspan | 2.394 m (7.85 ft) | 2.394 m (7.85 ft) |
| Transport Case Dimensions | 1002 x 830 x 270 mm<br>(39.4 x 32.7 x 10.6 inch) | 1002 x 830 x 270 mm<br>(39.4 x 32.7 x 10.6 inch) |



## 2.3. Flight propulsion

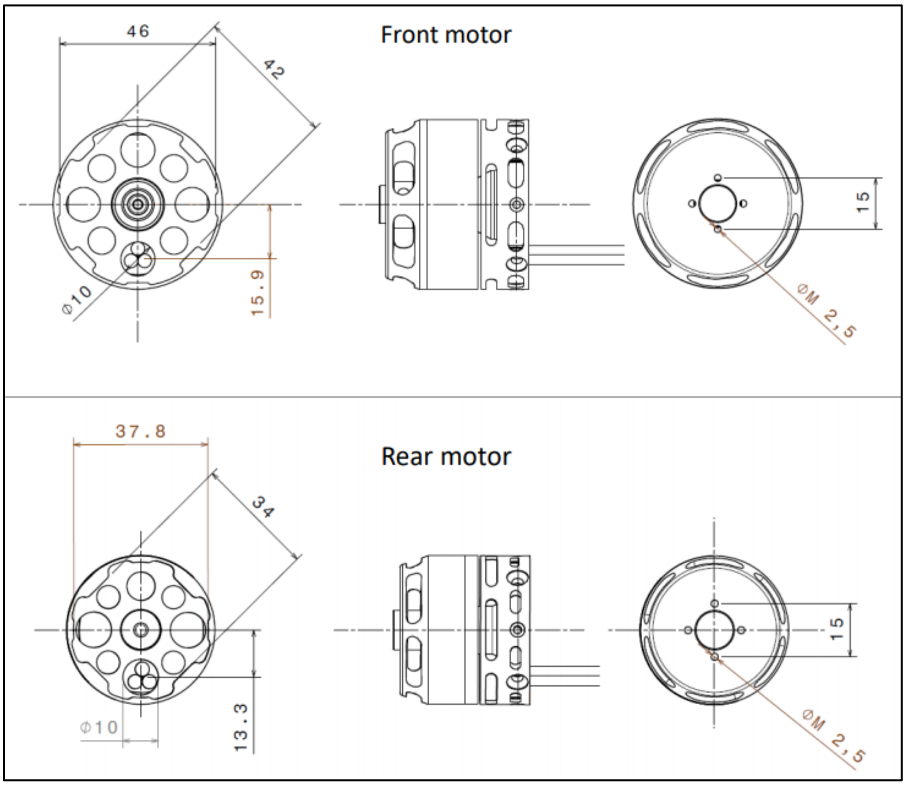
The Trinity flight drive essentially consists of the following components: Two front and one rear motor, two front folding propellers and a rigid rear propeller and the Trinity TEB (Triple Electronic Speed Controller Board).

The Trinity's electric drive system is supplied from a central power source.

The drive system is controlled and monitored via the autopilot using the Trinity-TEB. The speed, current and voltage of the three electric motors and the temperature of the ESC are controlled or reported back.

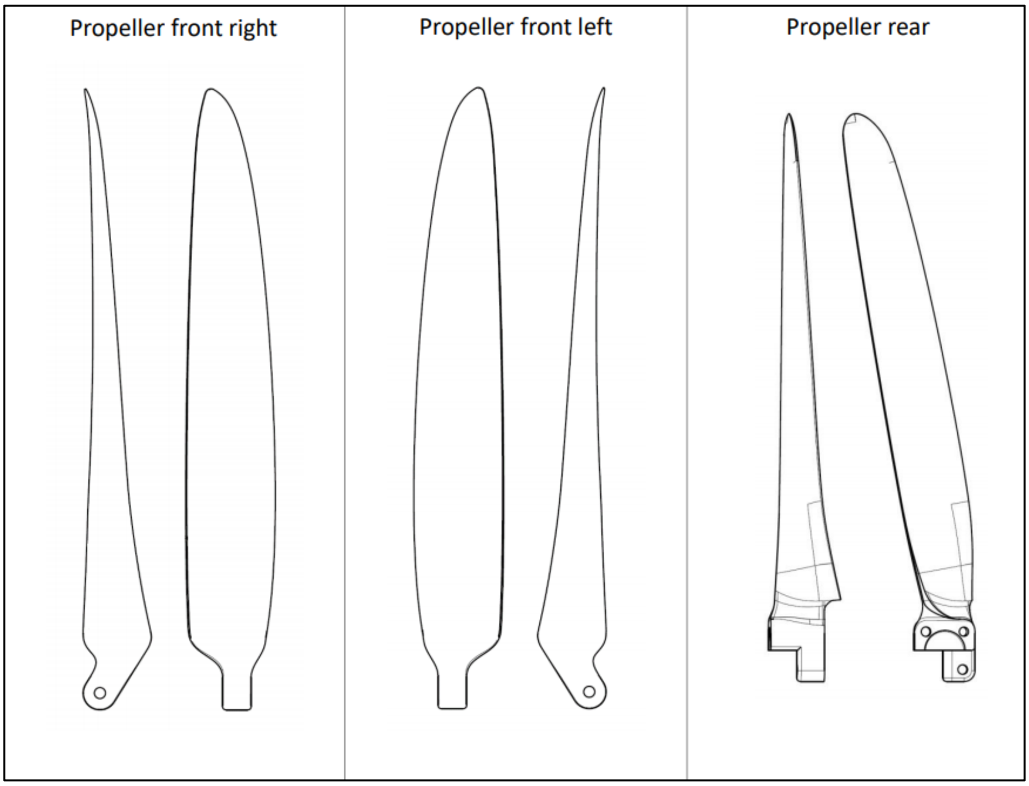
A failure of a component of the propulsion system during the hover during take-off or landing generally leads to the failure of the entire flight system. A failure or drop in performance of the rear engine while cruising is compensated for by switching on the two front engines.

### 2.3.1. Engine




| | Motor front | Motor rear |
|---|---|---|
| Type | permanent magnet synchronous motor | |
| Stator-Diameter | 41 mm | 35 mm |
| Stator-Length | 12 mm | 8 mm |
| Length | 44 mm | 36,7 mm |
| rpm [min^-1/V] | 780 | 736 |
| Weight | 220g | 100 g |

## 2.3.2. Propeller

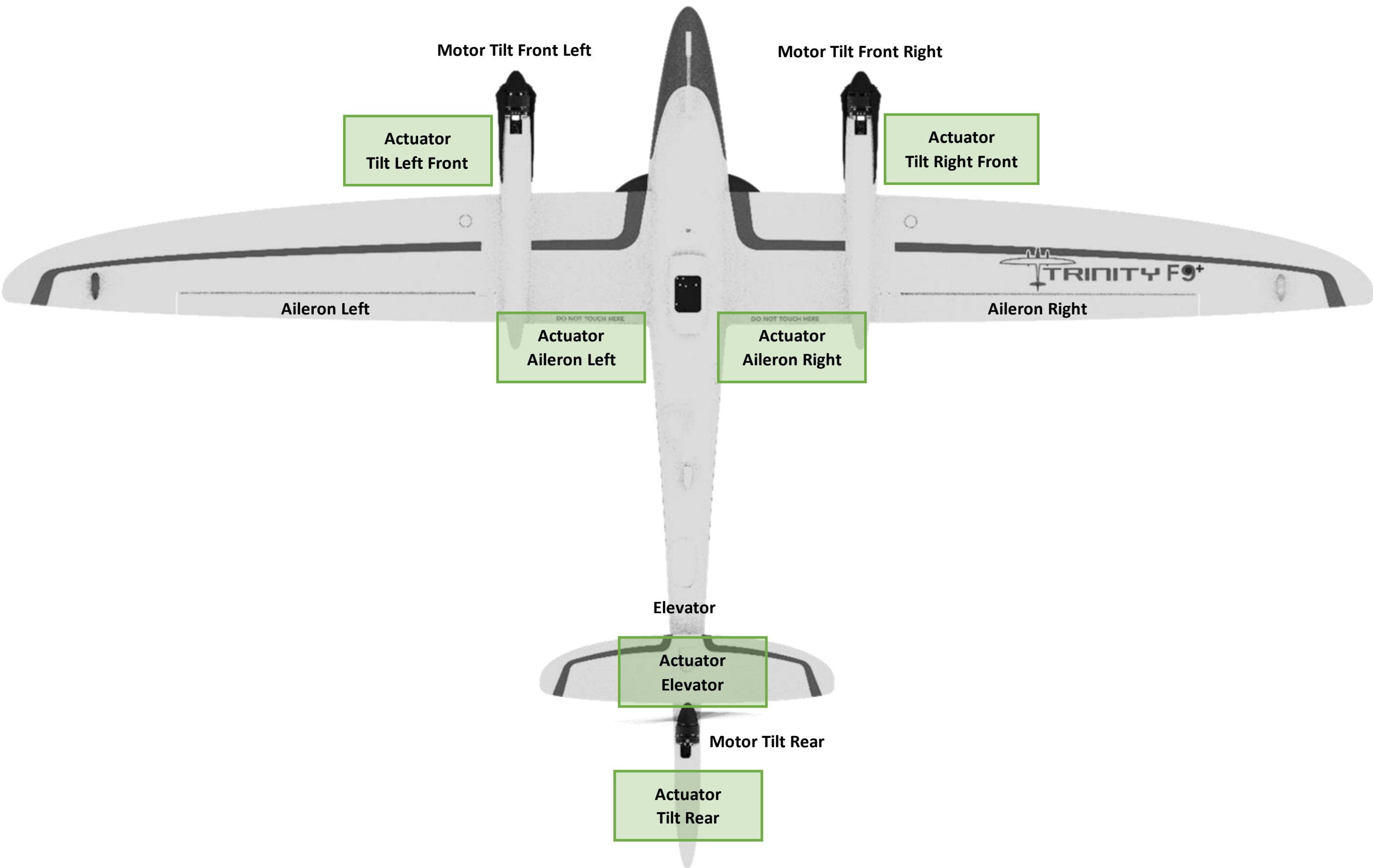



| | Propeller Front Right | Propeller Front Left | Propeller Rear |
|---|---|---|---|
| Type | Folding | | Fixed mount |
| Interpretation | High thrust | | Highly efficient cruise |
| Diameter in operation | 381 mm | | 254 mm |
| Surface | 201 mm | | 188 mm |
| Material | injection moldedcarbon fibre reinforced plastic | | |

## 2.4. Flight control surfaces and actuators

The following table gives an overview of all actuators and their function.

| Function | Trinity F90+ |
|---|---|
| Front engine tilt | MD245MW |
| Rear engine tilt | MD245MW |
| Elevator | MD89MW |
| Ailerons | MD89MW |
| Rudder | MD89MW |



## 2.5. Sensors

### 2.5.1. Air Data Sensor

The Trinity Air Data Sensor is a development by Quantum Systems. The special shape diverts incoming rainwater and keeps the pitot tube free of water for measuring the dynamic pressure. It is attached to the UAV using a magnetic contact. The air speed sensor can be removed from the fuselage of the UAV and cleaned. For use it is necessary that all measuring openings are free from contamination. If the airspeed sensor fails during use, the UAV automatically returns to the starting point and lands safely.

## 2.6. Payloads

The Trinity system can be equipped with different payloads, depending on the intended use. The following payloads are currently available:

Qube 240 LiDAR

MicaSense Dual Camera System

UMC-R10C + RedEdge-MX Double Payload

Sony UMC-R10C

MicaSense RedEdge-MX

Sony RX1R II

MicaSense Altum

# 3. Flight Controls

## 3.1. Generally


The flight control of the UAS Trinity takes place via the ground control station QBase (laptop), the Multiplex Cockpit SX serves as a backup radio link and as a second mobile interface.

Only the QBase ground control station (laptop) is required for operation. Updates can be carried out either via USB A (data carrier) or W-LAN (Internet). The internet connection is encrypted via HTTPS.

## 3.2. Navigation

The entire flight planning in advance and the control and navigation during the mission takes place with the help of QBase. The UAV can be controlled manually at any time during the mission using the Multiplex Cockpit SX. The position of the UAV is determined via GNSS and is continuously shown on the display on a corresponding map via QBase.

## 3.3. Autopilot

### 3.3.1. Quantum Skynode

The Trinity Autopilot Quantum Skynode belongs to the Auterion product family and is based on the Pixhawk open-source project. This is used to control flight behaviour, communication with the ground control station and control of the payload. The autopilot consists of an ARM Cortex-M3 Base Board, an ARM Cortex-M7 Flight Management Unit and a Cortex-A53 AI Unit. The hardware has been developed proprietary by Quantum and Auterion. The Skynode can be operated with the software solution from Quantum Systems as well as with open-source software.

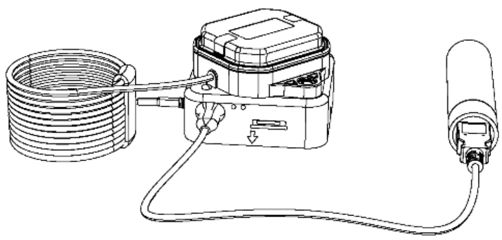
### 3.3.2. Quantum FCC

The Trinity Autopilot Quantum FCC was developed by Quantum Systems and is not freely available on the market. This is used to control flight behaviour, communication with the ground control station and control of the payload. The autopilot consists of a main board with a microcontroller and a stack board with additional connections. The FCC can only be operated with the Quantum-Systems specially developed software.

## 3.4. Ground Control Station (GCS)

The QBase ground control station serves as the user interface for the entire planning and implementation of the mission. The software is programmed in C # with Microsoft WPF (Windows Presentation Foundation) and .Net Framework. The QBase can also be operated with user-specific map material and provides an overview of the relevant information and requirements for using the QBase. Detailed information on operating the QBase is described in detail in the user manual.

### 3.4.1. iBase



The iBase is a GNSS reference station. it automatically logs GNSS reference measurements on the ground in a file on a micro-SD card. This file enables QBase3D to process the PPK data collected in flight.

## 3.5. Collision Warning System

As part of flight planning, but also while the mission is being carried out, the ground control station (QBase) actively warns of collisions with the terrain in relation to the stored terrain model. Airspaces can also be represented accordingly and considered in the flight planning to prevent an unintentional flight into a restricted area. For this purpose, “NoFlyZones” can be defined in advance as part of the mission planning. The current weather conditions (especially wind conditions) can be entered directly online or manually in the QBase with an existing internet connection.

### 3.5.1. ADS-B Transponder


The UAV Trinity has ADS-B to avoid collisions with other aircraft. The ADS-B position of the UAV and that of all other air traffic participants is transmitted to the ground control station via an ADS-B receiver and displayed directly in the QBase.

| Technical specifications | |
|---|---|
| Standards | DO-181E Class 1 Stage 1els (20 W output power)<br>DO-260B class B1S (20 W output power)<br>DO-160F<br>ICAO Annex 10, Volume IV<br>EuroCAE ED-115 class Lc2 es V3 (20 W output power)<br>EU-RED Annex VII |
| Software | RTCA DO-178B Level C |
| Hardware | RTCA DO-254 Level C |
| Power consumption | 11-16VDC. Typical 2.4W on/Alt, 0.1W Standby. |
| Max height | 35,000ft |
| Temperature range | -45°C to +70°C |
| Humidity | Tested according to category DO-160G category B2 |
| Transmission frequency | 1090MHz ±1MHz |
| Transmission power | 20 W nominal; At least 16 W on the antenna after taking 0.5 dB connection losses and 1.5 dB cable losses into account. |
| Transmitter modulation | 6M75 V1D |
| Receiver frequency | 1030MHz |
| Reception sensitivity | -74dBm ±3dB |
| Weight | 15grams |
| Height | 13mm |
| Length | 40mm |
| Width | 25mm |

### 3.5.2. Position Lights (ACSL)

To avoid collisions, the UAV Trinity has position lights that can be switched off on the wings and fuselage.

| Technical specifications | |
|---|---|
| Dimensions | 48mm x 15mm x 14mm |
| Weight | 5.8 g |
| Battery type | 1S LiPo, 85mAh |
| Security | Integrated undervoltage protection |
| Light period | Depending on the selected mode: |

Arrangement:

- in the direction of travel or flight, front right: green
- Front left in the direction of travel or flight: red
- to the rear: white

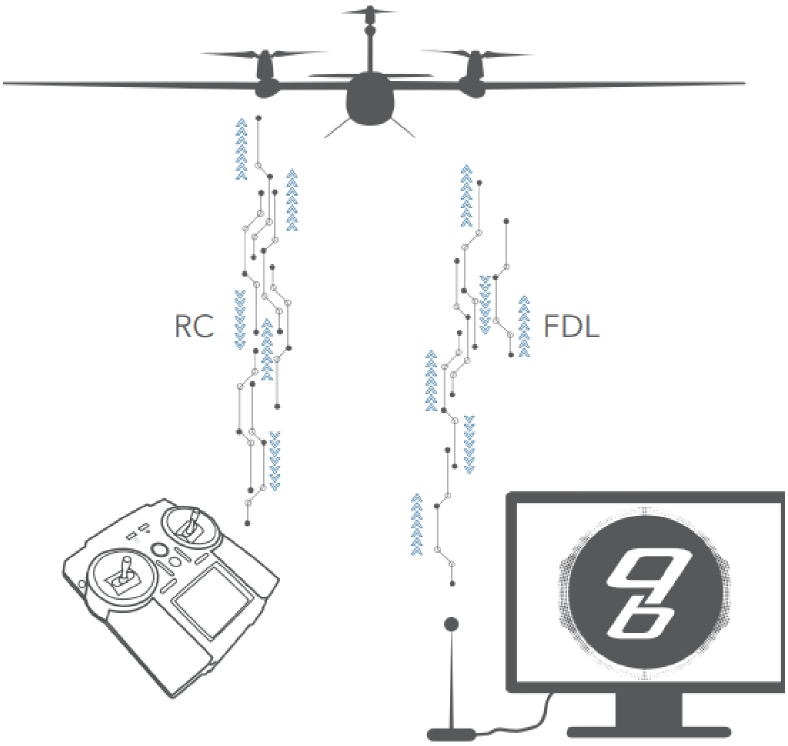
# 4. Transport system

### Transport box Trinity

The Trinity system is packaged in a fully integrated transport system (soft case), which contains all the components required to carry out a mission.



# 5. Communication Link




The communication with the UAV is ensured by two links. The UAV is connected to QBase via a 2.4 GHz flight data link, a downlink sending telemetry data from the Trinity to QBase and an uplink sending commands from QBase to the UAV. The connection is ensured by the QBase modem. The other link is a 2.4 GHz RC link between the transmitter and the UAV, that is used as an uplink for control commands and as a downlink sending telemetry data from the UAV to the transmitter. It is possible to continue the mission even though one link is lost. In case of a loss of both links, the UAV flies to the link re-establishing waypoint and tries to re-establish the connection. If the connection is successful, either CONTINUE the mission or select COME HOME on the transmitter. If both connections cannot be re-established, a COME HOME will be initiated after the loiter time that was set in QBase expired. The UAV will land automatically.

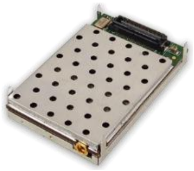
## 5.1. Multiplex Cockpit SX

The Multiplex Cockpit SX is a remote-control transmitter for radio control of models operating in the 2.4GHz band using frequency hopping spread spectrum technology.

| Technical specifications | |
|---|---|
| Operating frequency: | 2400 - 2483.5MHz |
| Output Power: | <20dBm EIRP |
| Antenna: | Printed PCB antenna; Gain: 5dBi |
| Modulation/Channels: | GFSK / 39 (AFHSS) |

M-LINK is a bidirectional AFHSS-system using LBT based Detect and Avoid Mechanism. M-Link is hopping over 39 channels in the 2.4GHz ISM-Band. The hopping sequence is generated during production by a random generator, so in every sequence each hopping frequency appears uniquely. To ensure the even usage of the band generated channels are registered in a table and will used sequential, in a cyclic order. To make the usage of the band even more random, a second random parameter selects if the hopping table uses only even (2,4,6 ..78) or only odd channels (3,5,7, ..79). The hopping channel separation is 2MHz. The maximum output power is 20dBm EIRP in the radio control system it is possible to change AFHSS characteristic by selecting “Fast Response”. Depending on selection “Fast Response” ON/OFF the hopping frequency changes every 14ms/21ms though the dwell time is only 7ms/11ms. The result is a duty-cycle limitation per hopping-frequency to 1.3%.

## 5.2. Microhard n2420 2,4 GHz Wireless Modem



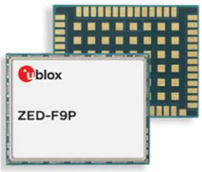
The QBase data link, based on the Microhand n2420 2.4 GHz wireless modem, enables bidirectional data exchange between the UAV and the ground control station.

All data required to carry out the mission are transmitted from the ground control station to the UAV via the data link.

All real-time data for monitoring the mission process and the flight attitude are transmitted from the UAV to the ground control station.

| Technical specifications | |
|---|---|
| **Frequency** | 2.4000 - 2.4835 GHz |
| **Spreading Method** | Frequency Hopping / DTS |
| **Band Segments** | Selectable via Freq Restriction |
| **Forward Error Detection** | Hamming<br>BCH<br>Golay<br>Reed-Solomon |
| **Error Detection** | 32 bits of CRC, ARQ |
| **Encryption** | Optional (see –AES option) |
| **Range** | 30+ miles (50+ km) |
| **Sensitivity n2420F** | -107 dBm @ 10-6 |
| **Output Power** | 100mW - 1W (20-30dBm) |
| **Serial Interface**<br>OEM<br>Enclosed | <br>TTL<br>RS232/RS485/RS422 |
| **Serial Baud Rate** | Bis zu 230,4 kbit / s asynchron |
| **Link Rate** | 115 kbps bis 230.4 kbps |
| **Operating Modes** | Point-to-Point, Point-to-Multipoint, Store & Forward Repeater, Peer-to-Peer |
| **Signals Interface** | RxD1, TxD1, RTS, CTS DCD, DSR, DTR, RxD2, TxD2, RSSI LEDs, Tx/Rx LEDs, Re-set, Config, Wake-up, RSmode |
| **Input IP3 (Antenna Con-nector)** | +12 dBm |
| **RF Selectivity**<br>Adjacent Channel<br>Alternate Channel<br>Out of Band | <br>60 dB<br>75 dB<br>>90 dB |
| **Remote Diagnostics** | Battery Voltage, Temperature, RSSI, Packet Statistics |
| **Environmental**<br>Temperature<br>Humidity | <br>-40oF to +185oF (-40oC to +85oC)<br>5-95%, non-condensing |
| **Approvals** | FCC Part 15.247, IC RSS210, CE, ETSI EN 300 328 V1.8.1 (2012-06)<br>Japan MIC (n2420BF) |

## 5.3. GNSS-Modul




The ZED-F9P is a multiband GNSS module. The module enables precise navigation and automation of the UAV Trinity. ZED-F9P guarantees the security of positioning and navigation information using secure interfaces and technologies for the detection of interference signals.

| Features | |
|---|---|
| Receiver type | 184-channel u-blox F9 engine<br>GPS L1C/A L2C, GLO L1OF L2OF,<br>GAL E1B/C E5b, BDS B1I B2I,<br>QZSS L1C/A L2C |
| Nav. update rate | RTK bis 20 Hz |
| Position accuracy | RTK 0.01 m + 1 ppm CEP |
| Convergence time | RTK < 10 sec |
| Acquisition | Cold starts 24s<br>Aided starts 2s<br>Reacquisition 2s |
| Sensitivity | Tracking & Nav. -167 dBm<br>Cold starts -148 dBm<br>Hot starts -157 dBm<br>Reacquisition -160 dBm |
| Assistance | AssistNow Online<br>OMA SUPL & 3GPP compliant |
| Oscillator | TCXO |
| RTC crystal | Built-In |
| Anti-jamming | Active CW detection and removal Onboard band pass filter |
| Anti-spoofing | Advanced anti-spoofing algorithms |
| Memory | Flash |
| Moving base | For attitude sensing and heading applications |
| Supported antennas | Active |
| **Electrical data** | |
| Supply voltage | 2.7 V bis 3.6 V |
| Power consumption | 68 mA @ 3.0 V (continuous) |
| Backup supply | 1.65 V bis 3.6 V |
| **Environmental data, quality & reliability** | |
| Operating temp. | −40 °C bis +85 °C |
| Storage temp. | −40 °C bis +85 °C |
| RoHS compliant (2015/863/EU) | |
| Green (halogen-free) | |
| EU Radio Equipment Directive compliant 2014/53/EU | |
| Qualification according to ISO 16750 | |
| Manufactured and fully tested in ISO/TS 16949 certified production sites | |
| High vibration and shock resistance | |

# 6. Safety functions

For the exact operation and application of the functions see user manual. The operator can in principle ignore all warnings and continue flying (then operate the UAV outside the operating limits at your own risk).

| TEXT | DESCRIPTION | WHAT TO DO |
|---|---|---|
| **ABORTED** | The calibration was aborted manually. | - |
| **ACC ERROR** | An acceleration sensor error occurred during the preflight check. | 1. Make sure the UAV is not moving during the preflight check.<br>2. Disconnect the battery from the UAV and connect it again. Turn on the UAV again.<br>3. Repeat the preflight check.<br>4. If the problem persists, contact your reseller. |
| **ACTUATOR MALFUNCTION! REMOVE BATTERY IMMEDIATELY!** | A malfunction of an actuator has been detected. | Remove the battery immediately to prevent further damage. Contact your Quantum-Systems reseller. The actuator has to be replaced. |
| **AILERON MALFUNTION!** | Reduced roll control effectiveness was detected in flight, pointing to a mechanical problem with the aileron control surfaces. | → COME HOME is automatically initiated.<br>→ Wait for the UAV to come home.<br>→ Do not fly again, contact your reseller. |
| **AIRSPEED ERROR** | An airspeed sensor error occurred during the preflight check or during the transition.<br><br>Possible reasons are a transition with tail wind or a blocked airspeed sensor tube. | **During preflight check:**<br>1. Disconnect the battery from the UAV and connect it again.<br>2. Turn on the UAV again.<br><br>**During transition:**<br>1. The transition is aborted and the UAV returns to the home waypoint.<br>2. Please land the UAV manually at the home waypoint by carefully pulling the left stick towards you. |
| **AIRSPEED INITIALIZATION ERROR** | Sensor init error during startup | Disconnect the battery from the UAV and connect it again. |
| **AIRSPEED SENSOR MALFUNCTION** | The airspeed sensor does not work correctly | **No manual input necessary** except for collision avoidance.<br>1. **The UAV will return home and land automatically.**<br>2. The mission cannot be continued. |
| **ASSISTED FLIGHT** | The UAV is controlled manually in assisted mode. | Control the UAV according to the commands of the assisted mode (see chapter 9.1) or select CONT to switch to automatic mode. |
| **AUTOPILOT INFO ERROR** | Autopilot configuration error. | Contact your reseller. |

| | | |
|---|---|---|
| **BARO ERROR** | A baro sensor error occurred during the pref-light check. | 1. Disconnect the battery from the UAV and connect it again.<br>2. Turn on the UAV again.<br>3. Repeat the preflight check. |
| **BARO INITIALIZATION ERROR** | Sensor Init Error during Startup | Disconnect the battery from the UAV and connect it again. |
| **BATTERY CRITICAL** | During preflight check: The remaining battery capacity is below minimum.<br>During flight: The remaining capacity is needed to return and to land. | No manual input necessary except for collision avoidance.<br>→ The UAV will return home and land automatically.<br>→ The mission cannot be continued. |
| **BATTERY LOW** | A warning 10 minutes before the UAV will return home due to low battery capacity. | Please select COME HOME. |
| **CAL ERROR** | One of the sensors is not calibrated correctly. | Please check QBase for detailed information. |
| **CAL ERROR ACC** | The accelerometer has not been calibrated correctly. | The last accelerometer calibration failed. Please calibrate the accelerometer and try again (see chapter 13.3). |
| **CHECK LINK REEST. ALTITUDE** | There is an issue with the link reestablishing waypoint. | Adjust the altitude of the link reestablishing waypoint in QBase and upload the flight plan to the UAV again. |
| **CHECK LINK REEST. LOITER RADIUS** | There is an issue with the loiter radius. | Adjust the radius of the link reestablishing waypoint in QBase and upload the flight plan to the UAV again. |
| **CHECK LINK REEST. LOITER TIME** | There is an issue with the loiter time. | Adjust the loiter time of the link reestablishing waypoint in QBase and up-load the flight plan to the UAV again. |
| **CHECK PMB! (NIR / EO) EXPOSURE AND TRIG-GER NOT EQUAL** | 10 or more missing exposures (per camera, NIR or EO) | 1. If you have a stabil telemetrylink please be aware that there might be pictures missing afterwards.<br>2. This error occurs if you don't have a stabil link. Please check your SD card or the kml. file afterwards. |
| **CHECK PMB! NOT TRIGGERING** | Trigger count is 0 (per camera) | 1. Check connection of payload compartment and manual trigger on ground.<br>2. This error also occurs if you are using a CPC Payload and one camera is not triggering.<br>3. This error occurs if you don't have a stable telemetry link. Please check your SD card or the .kml file afterwards. |
| **CHECK PMB! TRIGGER NOT EQUAL** | 10 or more triggers difference between cam1 and cam2 | Check connection of payload compartment and verify that both camaras are triggering through manual triggers on ground. |
| **CHECK QBASE** | An error occurred | Please check the message box in QBase for additional information. |

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| **ELEVATOR MALFUNCTION** | Reduced pitch control effectiveness was detected in flight, pointing to a mechanical problem with the elevator or tilt nacelle actuators. | → COME HOME is automatically initiated. In severe cases, an immediate retransition and landing is performed.<br>→ Do not fly again, contact your reseller. |
| **EMERGENCY LANDING** | Land immediately was selected. The landing is carried out automatically. Please be aware that the landing process might damage the UAV. | - |
| **ERROR** | An error occurred during the calibration. | 1. Disconnect the battery from the UAV and connect it again.<br>2. Turn on the UAV again.<br>3. Repeat the calibration process. |
| **ERROR LOADING MISSION** | Error loading the mission from the SD card. | 1. Repeat write mission to UAV.<br>2. Repeat the preflight check. |
| **EXCEEDED MISSION TIME** | The warning comes up at an automatic COME HOME due to a 60 minutes flight time restriction. | - |
| **FINISHED** | The automated flight is finished. | Please land the UAV manually at the home waypoint by carefully pulling the left stick towards yourself. |
| **GPS ERROR** | A GPS sensor or reception error occurred during the initialization. | Disconnect the battery from the UAV and connect it again. |
| **GPS LOST** | The GPS signal is lost during the preflight check. | Please wait until enough satellites are found. |
| **GYRO ERROR** | A Gyro sensor error occurred during the preflight check. | 1. Disconnect the battery from the UAV and connect it again.<br>2. Turn on the UAV again.<br>3. Repeat the preflight check.<br>4. If still not working: contact your reseller. |
| **HARDWARE FAILURE CAN** | Communication problem to PMB during initialization. | Disconnect Battery, check the connection and latching of payload compartment and try again. |
| **HOME WAYPOINT TOO FAR AWAY** | The home waypoint in QBase can not be adjusted to the actual take-off position as the two positions are too far apart. | 1. Ensure that the correct mission was uploaded to the UAV by downloading the flight plan from the UAV.<br>2. If the mission is correct: adjust the home waypoint and the retransition waypoint manually.<br>3. Upload the flight plan to the UAV again.<br>4. Repeat the preflight check. |

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| **HOVER TIME** | A warning after 55 seconds of hovering. | Please land UAV as soon as possible. An automatic landing is initiated after 70 seconds hover time. |
| **HOVER TIME EXCEEDED** | A warning after 70 seconds of hovering. | **No manual input necessary** except for collision avoidance.<br>→ **The UAV will land automatically.**<br>→ The flight cannot be continued. |
| **LINK LOST** | **The message is shown on the transmitter and in QBase**<br>• Both communication links are lost. The UAV will fly to the link reestablishing waypoint automatically and try to reestablish the communication. | **Only the flight data link (QBase) can be reestablished.**<br>• Either select COME HOME or CONTINUE in the UAV command panel in QBase.<br><br>**Only the RC link (transmitter) can be reestablished.**<br>• Either select COME HOME or CONTINUE on the transmitter.<br><br>**Both communication links cannot be reestablished.**<br>• The UAV will land at the home waypoint automatically. This landing option might damage the UAV.<br><br>**Both communication links can be reestablished.**<br>• Either select COME HOME or CONTINUE. |
| | **The message is only shown on the RC**<br>• Only the RC link is lost. | The mission can be continued with the flight data link. |
| **IMU INITIALIZATION ERROR** | Sensor communication error during startup. | Disconnect the battery from the UAV and connect it again.<br>If the error still occurs please contact your reseller for exchanging the autopilot. |
| **IMU SELFTEST FAILED** | Sensor error during startup. | Disconnect the battery from the UAV and connect it again.<br>If the error still occurs please contact your reseller for exchanging the autopilot. |

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| **- MAG ERROR<br>- MAG NOT CALIBRA-TED MAG MAGNI-TUDE TOO HIGH<br>- MAG VARIANCE ERROR<br>- MAG NOT FULLY COVERED<br>- MAG INCLINATION ERROR<br>- MAG DIVERGENCE ERROR** | A magnetometer sensor error occurred during the preflight check. | 1. Disconnect the battery from the UAV and connect it again.<br>2. Turn on the UAV again.<br>3. Repeat the preflight check.<br>4. If it is still not working please calibrate the magnetometer |
| **MAG INITIALIZATION ERROR** | Sensor initialization error during startup. | Disconnect the battery from the UAV and connect it again.<br>If the problem persists, please recalibrate the magnetometer (see chapter 13.2). |
| **MAG NOT CALIBRATED** | The magnetometer has not been calibrated correctly. | The last magnetometer calibration failed. Please recalibrate the magneto-meter and try again. |
| **MAG SELFTEST FAILED** | Sensor initialization error during startup. | Disconnect the battery from the UAV and connect it again. |
| **MISSION ERROR** | Mission is incorrect. | Please check the message box in QBase for additional information. |
| **MISSION FINISHED** | The automated flight is finished. | Please land the UAV manually at the home waypoint by carefully pulling the left stick towards yourself. |
| **MISSION NOT COMPLETE** | Missing data in mission. | 1. Repeat uploading the flight plan to the UAV.<br>2. Repeat the preflight check. |
| **MOTOR CONTROLLER ERROR** | Motor (1,2 or 3) RPM too high or too low or motor current too high or too low Error during arming. | RPM: Please make sure that the UAV is aligned horizontally during arming.<br>Current: Disconnect the battery from the UAV and connect it again. |
| **MOTOR TEMP. TOO HIGH** | Temperature monitoring during hover mode. Temperature of at least one motor controller is too high during the preflight check or during hovering.<br><br>green: <65°C = fine<br>yellow: >65° C = warning<br>red: >95°C = emergency landing | During preflight check: Let the UAV cool down and try again.<br>After Retransition: Land the UAV carefully as normal. Let the UAV cool down.<br><br>green: No action required.<br>yellow: Let the UAV cool down after flight until it is green again.<br>red: automatic emergency landing. |

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| **MOTORS ERROR** | Motor error during the preflight check or during arming. One of the motors / propellers does not run correctly. | 1. Disconnect the battery from the UAV and connect it again.<br>2. Turn on the UAV again.<br>3. Repeat the preflight check. |
| **MOVING** | The UAV is moving during the preflight check. | Ensure that the UAV is not moving to allow a correct initialization. |
| **NO TELEMETRY** | The remote control does not receive data from the UAV anymore. Without this link, the data displayed at the remote control can not be updated. | The UAV is too far away for the range of the RC telemetry link. |
| **OK** | The calibration was succesful. | - |
| **OUT OF TRANSITION DIRECTION** | The direction of the UAV does not comply with the allowed transition cone during auto climb. | Automatic hover to base and landing is initiated. |
| **PAYLOAD ERROR** | A communication error to the payload occurred during the preflight check. | 1. Disconnect the battery from the UAV and connect it again.<br>2. Turn on the UAV again.<br>3. Repeat the preflight check. |
| **PMB NOT FOUND** | The connection to the payload could not be established during preflight check. | Disconnect Battery, check connection and latching of payload compartment and try again. |
| **POSSIBLE COLLISION IN RETURN PATH** | Low altitude in come home path (come home path = path from current UAV position to re-transition waypoint including descend circle and landing path). Come home path is estimated in case of low battery, manual come home command, exceeding of flight time restriction or finish of the mission. | Check come home path displayed in map if necessary assume manual control to avoid collision |
| **MOTOR (NR) RPM TOO HIGH OR TOO LOW** | Error during arming. | Please make sure that the UAV is aligned horizontally during arming. |
| **REAR TILT MALFUNCTION!** | Occurs when hardware is defective or in case of a tilt mechanism malfunction. | 1. Automatic retransition and landing is initiated<br>2. **Do not fly!** Contact your reseller. |
| **RTR TOO FAR AWAY** | The retransition waypoint is too far away from the take-off position. | 1. Relocate the retransition waypoint closer to the home waypoint<br>2. Write mission to UAV again.<br>3. Repeat the preflight check. |

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| **SD CARD ERROR** | An error with the autopilot SD-card occurred during the preflight check. | 1. Disconnect the battery from the UAV and connect it again.<br>2. Turn on the UAV again.<br>3. Repeat the preflight check. |
| **SENSOR ERROR** | A sensor error occurred during the preflight check. | 1. Disconnect the battery from the UAV and connect it again.<br>2. Turn on the UAV again.<br>3. Repeat the preflight check. |
| **SENSOR INIT ERROR** | Error during the sensors initialization. | 1. Disconnect the battery from the UAV and connect it again.<br>2. Turn on the UAV again. |
| **TOO MANY WAYPOINTS** | Waypoint limit has been exceeded. | Re-plan the mission with a lower number of waypoints. |
| **TRANSITION AIRSPEED TOO LOW** | The airspeed could not build up during transition.<br>Minimum flight speed could not be reached during transition. | The transition is stopped and the UAV returns to the home waypoint.<br>Possible reasons are a transition in tail wind or a blocked airspeed sensor tube.<br>Contact your Quantum-Systems reseller in case the transition … was planned under valid wind conditions. |
| **WIND SPEED/WIND TOO STRONG** | The wind is too strong either during launch or in-flight. | **Launch:** The UAV will abort the mission and return to the launch point.<br>**In-Flight:** If wind speed exceeds 12 m/s, an automatic COME HOME is initiated. |

# 7. Reference documents

Trinity User Manual

# 8. List of abbreviations

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| QS | Quantum-Systems GmbH |
| UAS | Unmanned Aerial System |
| UAV | Unmanned Aerial Vehicle |
| eVTOL | electrically powered vertical take-off and landing |
| MTOW | Maximum take-off weight |
| FCC | Flight Control Computer |
| TEB | Triple Electronic Speed Controller Board |
| PDB | Power Distribution Board |
| PMB | Payload Management Board |
| ADS-B | Automatic Dependent Surveillance - Broadcast |
| GCS | Ground Control Station |
| WPF | Windows Presentation Foundation |
| GNSS | Global Navigation Satellite System |
| SOC | State of Charge |
| SOH | State of Health |
| ULP | Ultra-Low Power |
| C2 | Command and Control |
| MIMO | Multiple Input and Output |
| IR | Infrarot |
| EO | electrooptic |
| FOV | Field of View |
| ICAO | International Civil Aviation Organisation |
| ISA | ICAO Standard Atmosphere |
| MSL | Mean Sea Level |