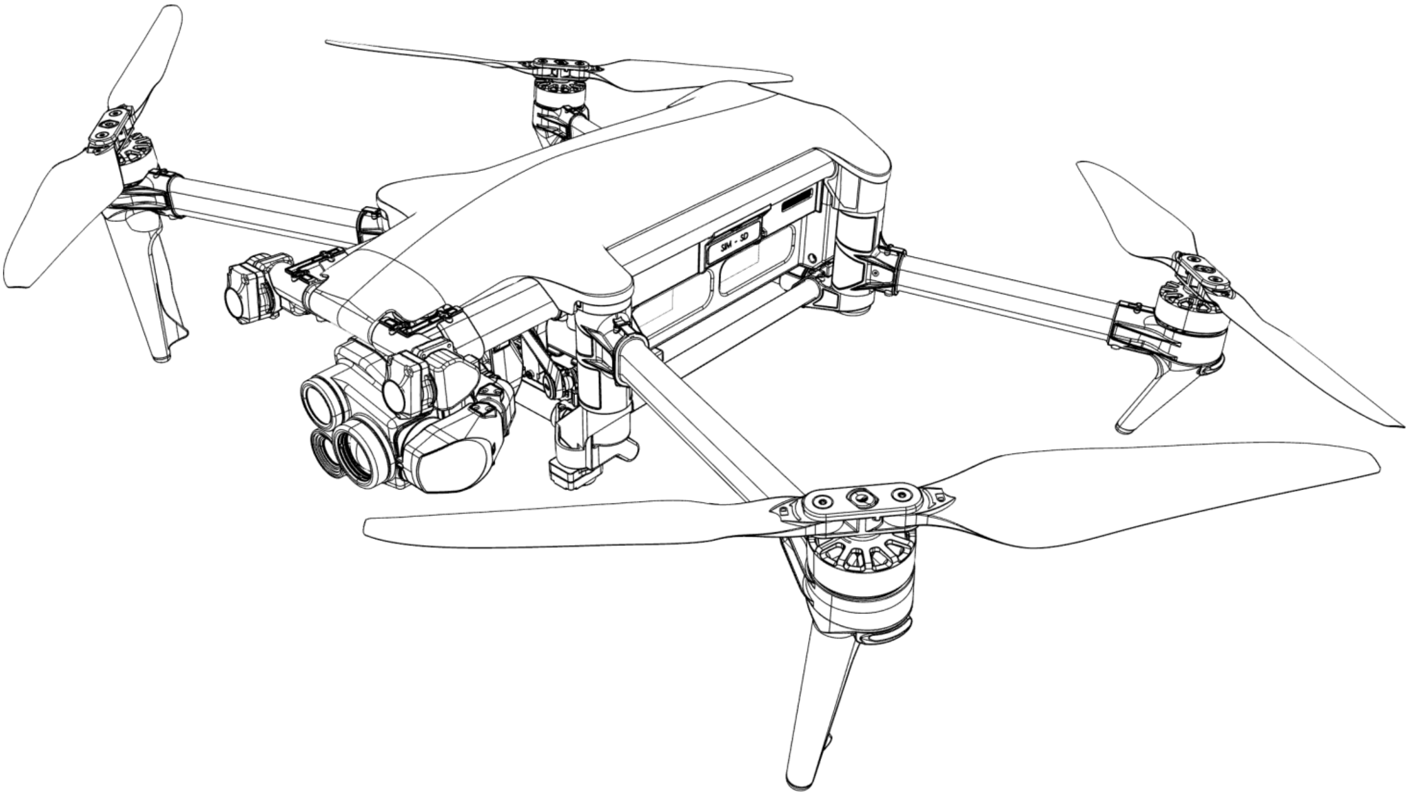
ANAFI UKR

White Paper



Version: 8.3.2.0

Updated: November 13th, 2025

Parrot

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1 Technical specifications

AIRCRAFT

- Size folded: 245 x 160 x 116 mm (9.6 x 6.3 x 4.6")[1]
- Size unfolded: 350 x 665 x 116 mm (13.8 x 26.2 x 4.6 ")
- Mass:
  - With standard smart battery: 1,024 g (2.26 lb)
  - With XLR smart battery: 1,356 g (2.99 lb)
- Maximum take-off mass (MTOM): 1,450 g (3.20 lb)
- Maximum transmission range (*LOS – Line of Sight*) with Skycontroller UKR:
  - MARS: 15 km (9.32 mi) [2]
  - Wi-Fi: 5 km (3.11 mi) [2]
  - LoRa: 20 km (12.43 mi)
  - 5G: Unlimited (provided there is 5G coverage)[2]
- Maximum flight time:
  - Standard smart battery: 38 min at 6 m/s
  - XLR smart battery: 70 min at 6.5 m/s airspeed
- Maximum flight distance: 40 km (24.85 mi) at 14 m/s airspeed[3]
- Maximum horizontal airspeed: 17 m/s (38.1 MPH) [2]
- Maximum horizontal groundspeed[4]:
  - With Standard smart battery: 29.6 m/s (66.2 MPH)
  - With XLR smart battery: 28.6 m/s (64.0 MPH)
- Maximum ascent speed: 8 m/s (17.9 MPH)
- Maximum descent speed: 8 m/s (17.9 MPH)
- Maximum wind resistance:
  - During flight: 15 m/s (33.5 MPH)
  - During take-off and landing: 15 m/s (33.5 MPH)
- Maximum propeller speed: 8,500 RPM
- Sound power level: 77 dBA [5]
- Service ceiling: 5,000 m above MSL (Mean Sea Level)
- Operating temperature: -36 °C to 50 °C (-33 °F to 122 °F)
- No take-off temperature limitation - if battery temperature is maintained between -20 °C and 50 °C (-4 °F to 122 °F)
- IP53: Rain and dust resistant
- Maximum static thrust: 27 N
- Thrust to weight ratio: 2.7
- No NFZ (no-fly zone) limitation
- Takes off from / lands in the hand of the operator
- Full capability in GNSS denied flight conditions
- Indoor flight
- Connectivity and storage:
  - USB-C port
  - MicroSD card slot
  - SIM card port
  - 512 GB internal memory
- Deployment time: < 2 min

SENSORS

- Satellite navigation:
  - GPS
  - GLONASS
  - Galileo
  - BeiDou
- Barometer
- Magnetometer
- Front stereo cameras, vertical stereo cameras and vertical range sensor
- 4 inertial measurement units. Each IMU includes:
  - 3-axis accelerometers
  - 3-axis gyroscopes

CYBERSECURITY

- Zero data shared without user consent
- TAA & NDAA compliant
- Blue sUAS program approved
- Manage your data privately between drone and device OR share anonymous data on secured European servers
- MicroSD card AES-XTS encryption with a 512-bit key
- Digitally signed firmware
- Compliant with FIPS140-2

EO IMAGE CHAIN

- 2X Sensors: 1/2.4''
- Digital zoom: 35x
- Electronic shutter speed: 1/25 s to 1/10,000 s
- ISO range: 100-12,800
- Video resolution: 4k (2160p) / FHD (1080p)
- Video format: MP4 (H.264 & H.265)
- Photo resolution: 21 MP, 4K - 24, 25, 30 fps, 1080 – 50, 60 fps
  - Wide: 84° HFOV;
  - Rectilinear: up to 75.2° HFOV
- Photo formats: JPEG, DNG (Digital Negative raw)

IR IMAGE CHAIN

- Sensor: FLIR BOSON
- 640x512 sensor resolution
- Temperature range: -40 °C to 250 °C (-40 °F to 482 °F)
- Thermal sensitivity: <60 mK
- Measured IR wavelength range: 8 to 14 micrometers
- Photo format: JPEG, PNG
- Video format: MP4 (H.264 & H.265)
- Video recording resolution: UHD, 8.6 fps

IMAGE STABILIZATION

- 3-camera IR/EO stabilized gimbal:
  - Hybrid: 3-axis
  - Mechanical: 3-axis
  - Electronic (EIS): 3-axis
- Controllable gimbal tilt range: -90° to +90°

STANDARD SMART BATTERY

- Size: 136 x 73 x 46 mm (5.4 x 2.9 x 1.8")
- Mass: 354 g (0.78 lb)
- Type: High density LiPo (225 Wh/kg)
- Capacity: 6,800 mAh
- Voltage (nominal): 11.55 V (3 x 3.85 V cells)
- USB-C port
- Charges fully in 2 h 30 min with a USB-PD (Power Delivery) charger included in the pack
- Maximum charging power: 45 W

XLR SMART BATTERY [6]

- Size: 156 x 105 x 49 mm (6.1 x 4.1 x 1.9")
- Mass: 686 g (1.51 lb)
- Type: High density Li-ion (300 Wh/kg)
- Capacity: 20,200 mAh
- Voltage (nominal): 10.20 V (3 x 3.40 V cells)
- USB-C port
- Charges fully in 5 h 15 min with a USB-PD (Power Delivery) charger included in the pack
- Maximum charging power: 45 W

GROUND CONTROL STATION

- Size folded: 171 x 302 x 77 mm (6.7 x 11.9 x 3.0")
- Size unfolded: 171 x 302 x 215 mm (6.7 x 11.9 x 8.5")
- UKR Mass: 1,765 g (3.89 lb)
- UKR Mission Mass: 1,450 g (3.2 lb)
- UKR GOV Mass: 1,765 g (3.89 lb)
- UKR XLR Mass: 1,765 g (3.89 lb)
- Battery capacity: 10,000 mAh
- Battery voltage (nominal): 7.2 V
- Battery charging duration: 2 h (2 h 30 min with tablet)
- Battery life: 4 h 30 min
- Connectivity:
  - USB-C port
  - USB-A port
  - HDMI port
  - Ethernet port
- IP53: Rain and dust resistant
- Operating temperature: -36 °C to 50 °C (-33 °F to 122 °F)

CARRY CASE

- Size: 405 x 503 x 192 mm (15.9 x 19.8 x 7.6")
- Mass: 6,659 g (14.68 lb)

MARS RANGER

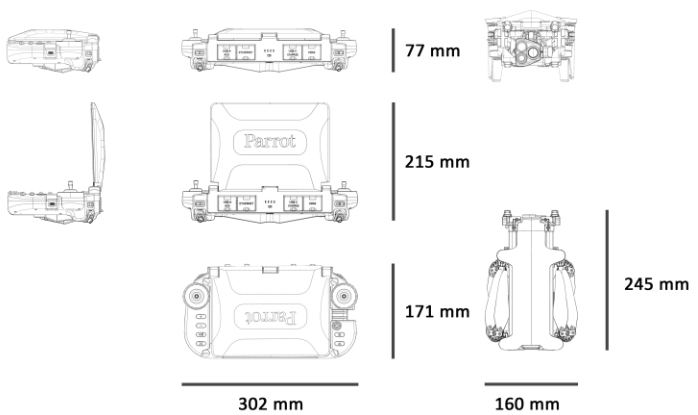
- Size folded: 170 x 240 x 50 mm (6.7 x 9.4 x 2.0 ")
- Size unfolded: 170 x 240 x 200 mm (6.7 x 9.4 x 7.9 ")
- Mass: 1,200 g (2.65 lb)
- Battery capacity: 10,000 mAh
- Battery voltage (nominal): 7.2 V
- Battery charging duration: 2 h
- Battery life: 4 h 30 min
- Connectivity:
    - USB-C port
    - Ethernet port
- IP53: Rain and dust resistant
- Operating temperature: -36 °C to 50 °C (-33 °F to 122 °F)

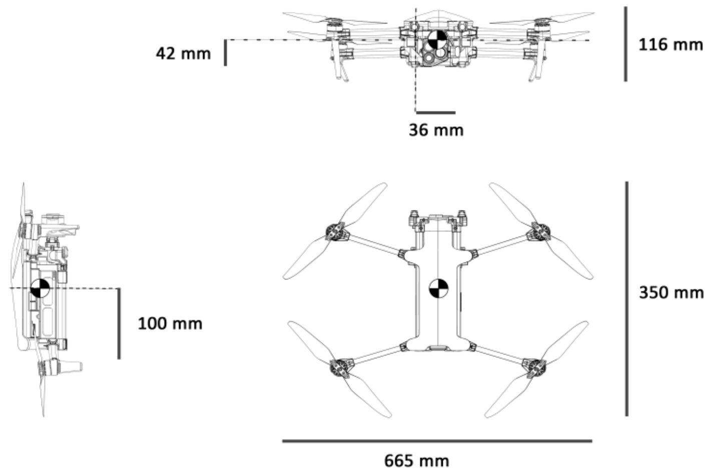
RADIO LINK

- MARS
    - Over 1.5 GHz bandwidth:
        - spread across 8 bands 1.8 – 5 GHz (ANAFI UKR)
        - spread across 10 bands 1.8 – 5.85 GHz (ANAFI UKR XLR)
    - TX & RX differentiated frequencies
    - Radio-jamming resistance through Frequency hopping
    - Direct video stream resolution: 1080p 30 fps
    - AES 256 encryption: packet and radio level
- Wi-Fi (ANAFI UKR GOV only):
    - Wi-Fi 802.11ax
    - Direct video stream resolution: 1080p 30 fps
    - AES 256 encryption: Packet and radio level
    - Operating frequencies: 2.4 GHz, 5GHz UNII-1, & UNII-3
- LoRa:
    - Activates when main link is lost
    - AES 128 and ChaCha20 encryption
    - Frequency bands: EU - 863 to 870 MHz, US - 902 to 928 MHz
- Cellular (ANAFI UKR GOV & ANAFI UKR XLR only):
    - Cellular connectivity: 5G NR with 4G LTE fallback
    - AES 256 encryption: Packet level
    - Seamless 5G / Wi-Fi switching
    - Flies Beyond Visual Line of Sight

[1] Folding is not possible with the XLR smart battery installed.
[2] Version dependent.
[3] Extreme temperatures, or suboptimal conditions may affect maximum range or battery autonomy.
[4] Maximum ground speed depends on current wind speed. Active cruise control is enabled by default (and cannot be disabled). At 12 m/s airspeed the range in km is maximized.
[5] 77 dBA is the guaranteed sound power level, however, in typical flight conditions ANAFI UKR has a sound power level of 75 dBA.
[6] Only available for XLR, and GOV versions.

DIMENSIONS





Images not to scale.
Center of gravity.
Measurements indicating the center of gravity are based on the drone's body rather than the propellers or arms.
Do not alter the center of gravity

2 ANAFI UKR Aircraft

2.1 Flight performance

MAXIMUM FLIGHT PERFORMANCE	
HORIZONTAL SPEED	17 m/s
WIND RESISTANCE	15 m/s
ASCENT SPEED	8 m/s
DESCENT SPEED	8 m/s
MAX FLIGHT DURATION	Standard smart battery: 38 min at 6 m/s airspeed XLR smart battery: 70 min at 6.5 m/s airspeed
HOVER FLIGHT DURATION	36 min
SERVICE CEILING ABOVE SEA LEVEL	5,000 m
RANGE	40 km at 14 m/s without wind
ANGULAR VELOCITY	300°/s on pitch and roll axis & 200°/s on yaw axis
ACOUSTIC LEVEL (SOUND POWER L_{WA})	77dB$_A$

2.2 Acoustic perception range

77 dBA is the guaranteed sound power level, however, in typical flight conditions ANAFI UKR has a sound power level of 75 dBA.

In a calm daytime countryside environment, a person on the ground can hear an incoming ANAFI UKR drone at the following approximate distances:

- Vertical approach: 140 m
- Horizontal forward approach (at 50m above ground): 200 m

2.3 Propulsion

2.3.1 Propulsive group

2.3.1.1 Optimized for performance.

The design of the propulsion group is aimed at achieving the following targets:

- A flight duration of over 38 minutes
- A maximal forward speed of 17 m/s

A propeller diameter of 9.4 inches was selected.

Multiple propeller designs underwent systematic examination, with adjustments made to parameters such as chord, twist, and airfoil design. The goal was to attain optimal performance on both hovering and forward flight phases. Experimental characterization of the propeller was performed on a 6-axis balance, both on a static test bench to assess hover performance, and in a wind tunnel for performance at high incoming air speeds. Additionally, the propeller performance was validated through in-flight tests encompassing various flight phases.

Various materials were investigated to evaluate the structural integrity of the propeller, employing Finite Element Analysis (FEA) simulations and experiments. A suitable lightweight carbon fiber material was chosen to minimize weight and counteract propeller vibrational modes.

Aerodynamic studies were conducted on the drone body design with the aim of minimizing drag. Design refinements were executed through Computational Fluid Dynamics (CFD) simulations, followed by validation through wind tunnel experiments.

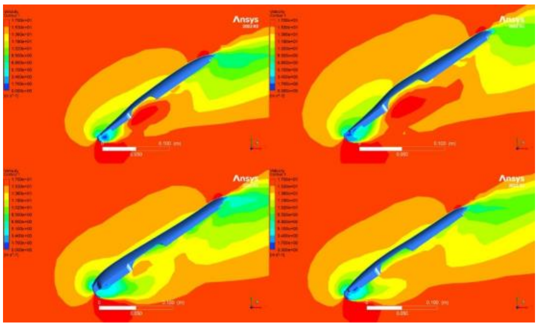


FIGURE 1 AN EXAMPLE OF TOP COVER OPTIMIZATION TO MINIMIZE DRAG

The motor was designed to endure at least 750 hours (i.e. 1,200 full battery flights).

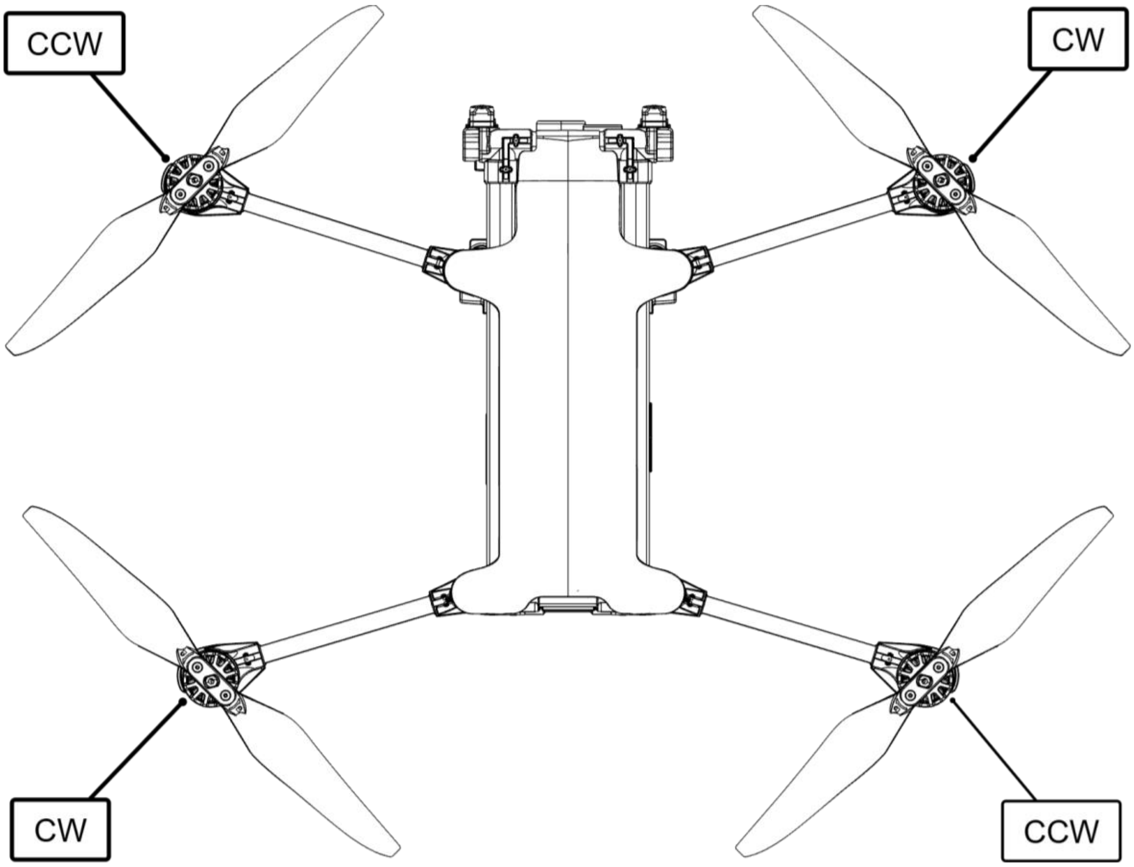
The goal was to obtain the maximum efficiency of the motor at a hovering speed of 4500 rpm (speed corresponding to hover) and to be able to reach a maximum speed of 8500 rpm.

The motor material was selected to minimize the mass of the motor as well as maximize efficiency:

- The feet and the bell are made of magnesium.
- The stator is made of steel with the fewest number of laminations possible to reduce losses, and the copper density was maximized to increase strength.

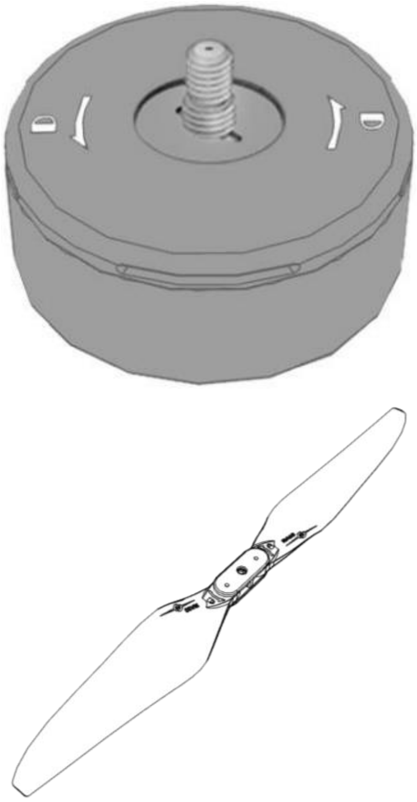
2.3.1.2 Easy to install propellers

Propeller assemblies can be installed by hand. No tools are required.

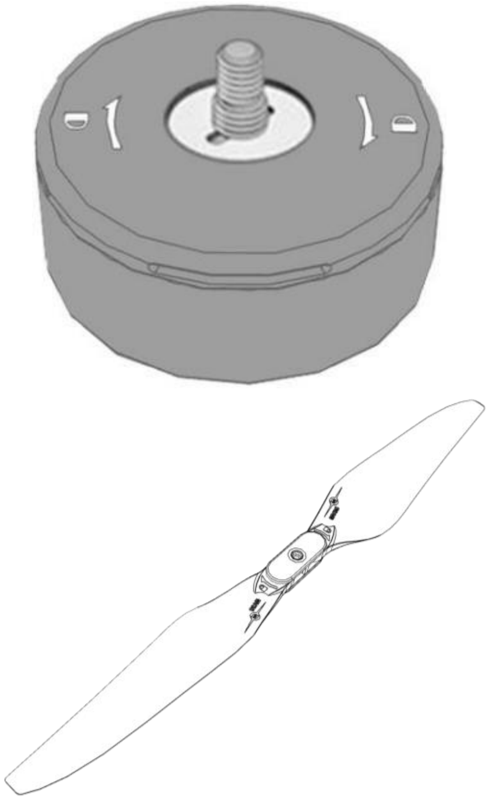


The locking direction is indicated on the motor and the propellers. To attach and lock the propeller assembly to the motor, screw the propeller hub onto the motor shaft following the direction of the arrows displayed on the motor.

Clockwise motor

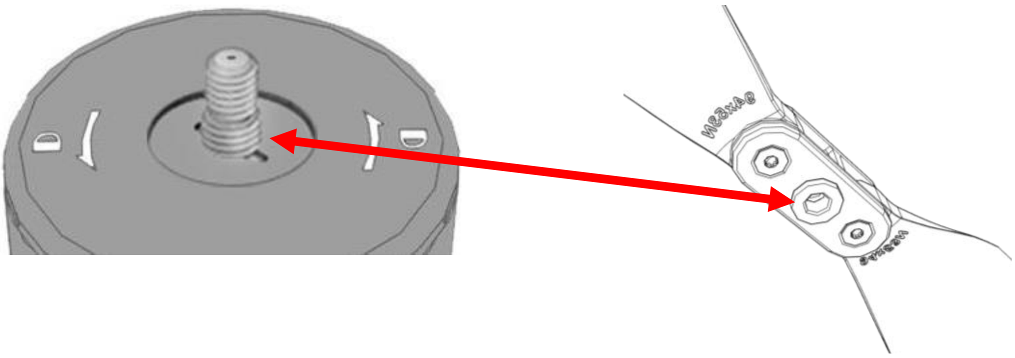


Counterclockwise motor

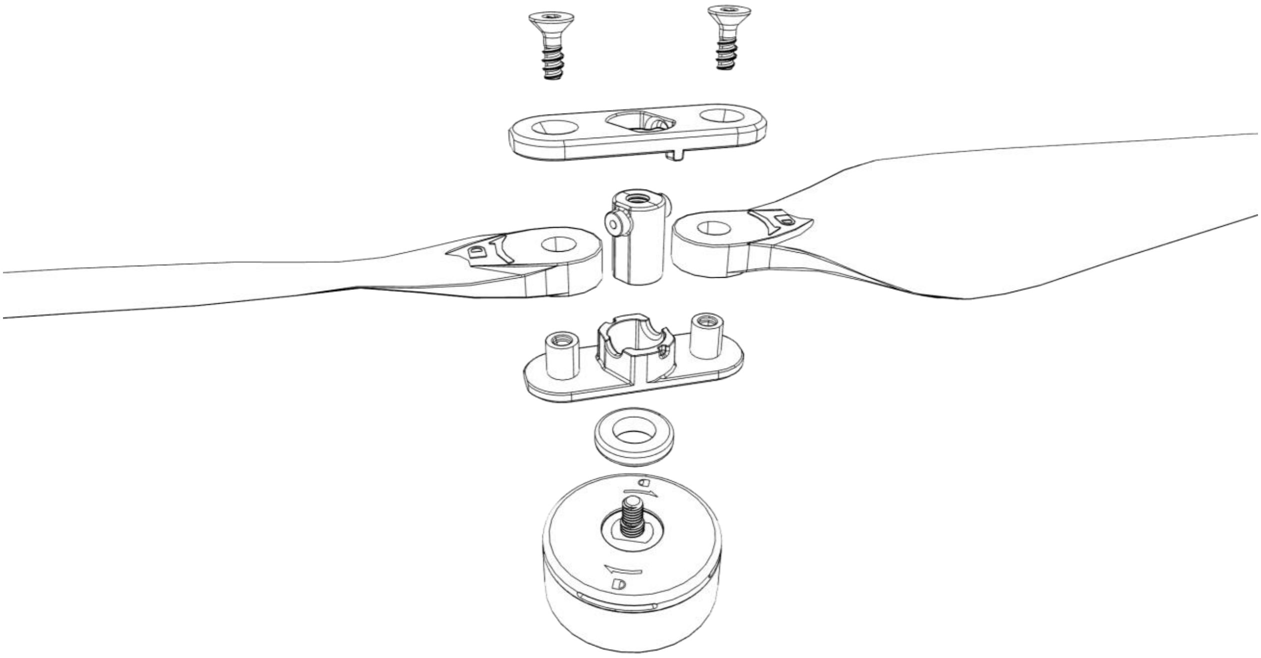


The thread direction is related to the propeller spin to prevent the propeller from becoming loose during flight.

Electronic Speed Controllers (ESC) are used to control brushless motors. They use active braking to offer the Autopilot the maximum propeller dynamics for both ramping up and down. To ensure that propellers remain securely fastened to the motor shaft during the fastest decelerating phases, the propeller hubs feature an embedded Nylstop nylon ring overmolded on the magnesium hub. The threaded shaft on the motor has a larger diameter at the base of the thread which allows the nylon ring to lock onto the shaft. The propellers are foldable and so it is not necessary to remove the propellers once they are screwed on. Removing the propellers regularly may impact the thread lock, and therefore the propeller assembly fixation quality.



The ANAFI UKR propulsion system features a proprietary pivoting hub design allowing blades to pivot around their radial axis. This additional degree of freedom reduces the pitching moment, and the second harmonic vibration in flight.

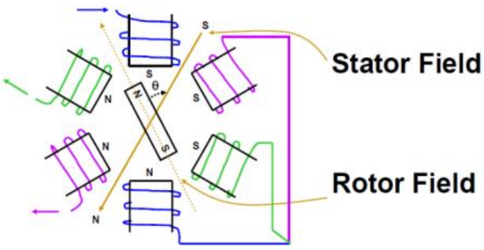


The whole propulsion system has been extensively tested. Among other tests, a full endurance test of the motor and propeller assembly was performed based on RPM scenarios of a dynamic real-life flight. The scenario was looped for 750 hours (i.e. 1200 full battery flights). After the test, the system remained functional.

2.3.2 Motor control

2.3.2.1 FEC

Field Estimated Control (FEC) is a variation of Field Oriented Control (FOC). FEC consists of modulating the magnetic field vector generated by the stator to maximize the motor efficiency depending on the rotor orientation:



Its algorithm is based on the measurement of the rotor orientation by a dedicated sensor rather than on an estimation from electrical measurements.

Main advantages:

- Maximum motor efficiency
- Maximum motor responsiveness
- No starting ramp is required
- Very large operating range

- No risk of stalling, for example following a collision
- No requirement for a current measurement generally performed with a shunt which reduces the efficiency by joule effect

Performance:

- The Parrot proprietary FEC ESC offers an efficiency improvement compared to the best "off-the-shelf" ESCs.
- It can apply the maximum motor torque throughout the whole RPM working range whether it is in acceleration or deceleration, which ensures maximum responsiveness.

2.3.2.2 Motor performance

MAXIMUM MOTOR PERFORMANCE	
MOTOR TYPE	Brushless
MASS	24.8 g
CAGE DIAMETER	26.2 mm
PHASE RESISTANCE	170 mOhm
INDUCTANCE	22 µH
NO-LOAD SPEED	13,600 rpm
KV (SPEED CONSTANT)	1,008 rpm/V
MAXIMUM SPEED WITH PROPELLER AT SEA LEVEL	8,500 rpm
TORQUE AT 8,500 RPM	81.6 mNm

2.4 Electronics

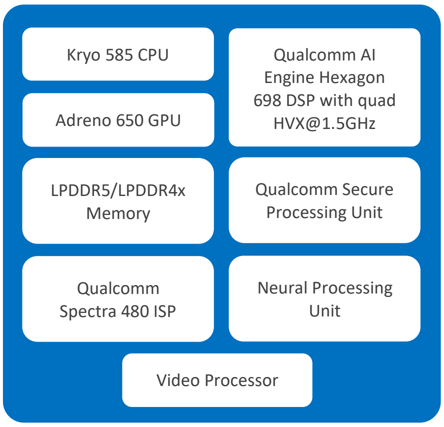
2.4.1 Architecture overview

The ANAFI UKR electronics design is based on components from Europe, US, or NATO partner countries. No sensitive electronic components come from China to ensure compliance with the Blue UAS program and NDAA requirements.

2.4.1.1 Main Processor

- Main processor: Qualcomm QRB5165, high end SOC for Smart applications
- DDR: Micron LPDDR5 POP 64Gb
- Flash memory storage: Kioxia Flash UFS3, 512GB

QRB5165 Block Diagram



QRB5165 SPECIFICATIONS

PACKAGE	12.4 x 12.7mm LP4, 12.4 x 14mm LP5 MEP
CPU	Kryo 585 CPU, 64-bit, up to 2.84 GHz Qualcomm® Kryo™ 585 CPU: Manufactured in 7nm process node, optimized across four high-performance Kryo Gold cores and four low-power Kryo Silver cores.
ISP	Qualcomm Spectra 480 ISP with Dual 14-bit image signal processing
CAMERA	Up to 200 MP photo capture Up to 25 MP dual camera @ 30 FPS w/Zero Shutter Lag Up to 64 MP dual camera @ 30 FPS w/Zero Shutter Lag Support for 12 cameras by D-PHY & 18 cameras By C-PHY (7 concurrent)
VIDEO	8K video capture @ 30 FPS, Up to 10-bit color depth Video capture, 4K video capture + 64 MP Photo, 4K video capture @ 120 FPS, 4K HDR video capture
GPU	Adreno 650 GPU w/ support for Open GL ES & Open CL
DSP	Hexagon 698 DSP with HVX; Hexagon Tensor Accelerator and Hexagon Scalar Accelerator
MEMORY	LPDDR5 up to 2750 MHz, LPDDR4X up to 2133 MHz Memory Density: up to 16 GB
SECURITY	Camera Security, Crypto Engine, Cryptographic Accelerator Qualcomm Trusted Execution Environment, Secure Boot, Qualcomm© Crypto Engine Core is FIPS 140-2 certified

Qualcomm spectra, Qualcomm Krya, Qualcomm Secure Processing Unit, Qualcomm Trusted Execution Environment, Qualcomm Crypto Engine Core and Qualcomm Aqstic are products of Qualcomm Technologies, Inc, and/or its subsidiaries.

2.4.1.2 Interface for data transfer and accessories

A USB-C port is available on the base of the drone. This USB port features:

- USB-3 SuperSpeed for fast data transmission (such as content download to a computer)
- The ability to power an accessory up to 5V/2A.

2.4.1.3 Radio

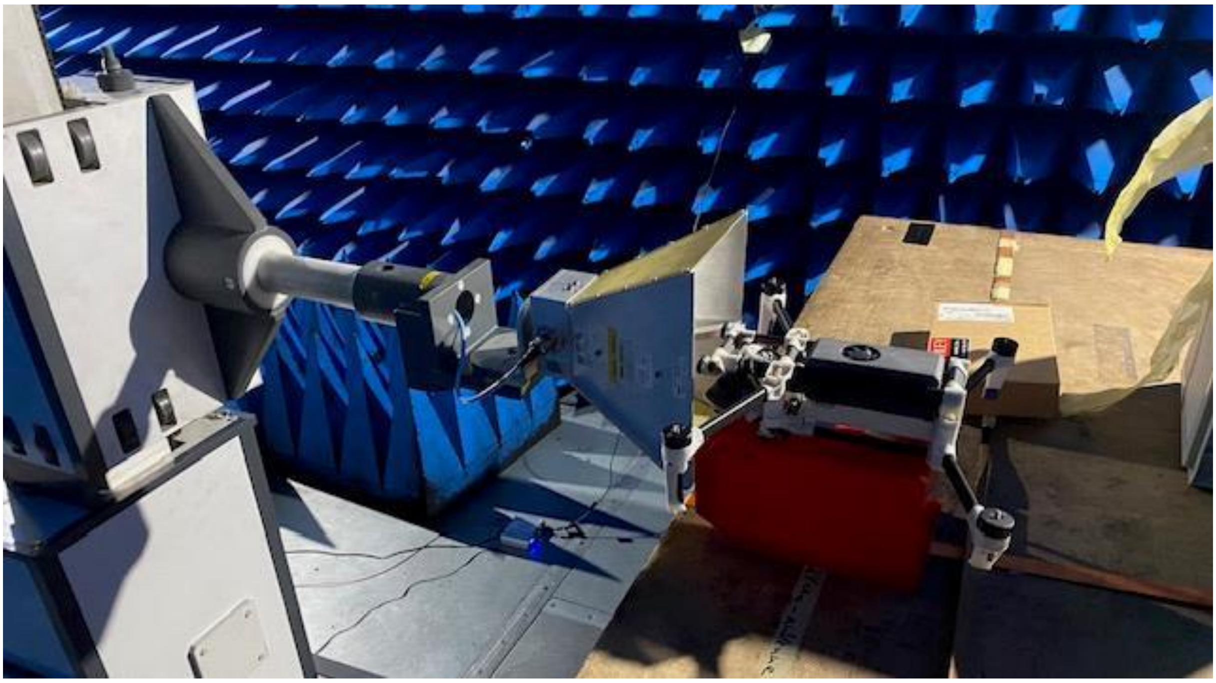
- **MARS** main radio: based on Xilinx FPGA, Analog device radio & Skywork PA
- **LoRa** alternative radio: Murata LoRa module, certified for Europe, USA, Canada, Japan, UK, South Korea, and Taiwan.

2.4.1.4 Motor controllers

- Microcontrollers for motors control: ST STM32

2.4.2 EMI robustness

ANAFI UKR electronics are tested with regards to MIL STD 461 protocol and are robust to EMI aggressions up to at least 300V/m from 800MHz to 6GHz.

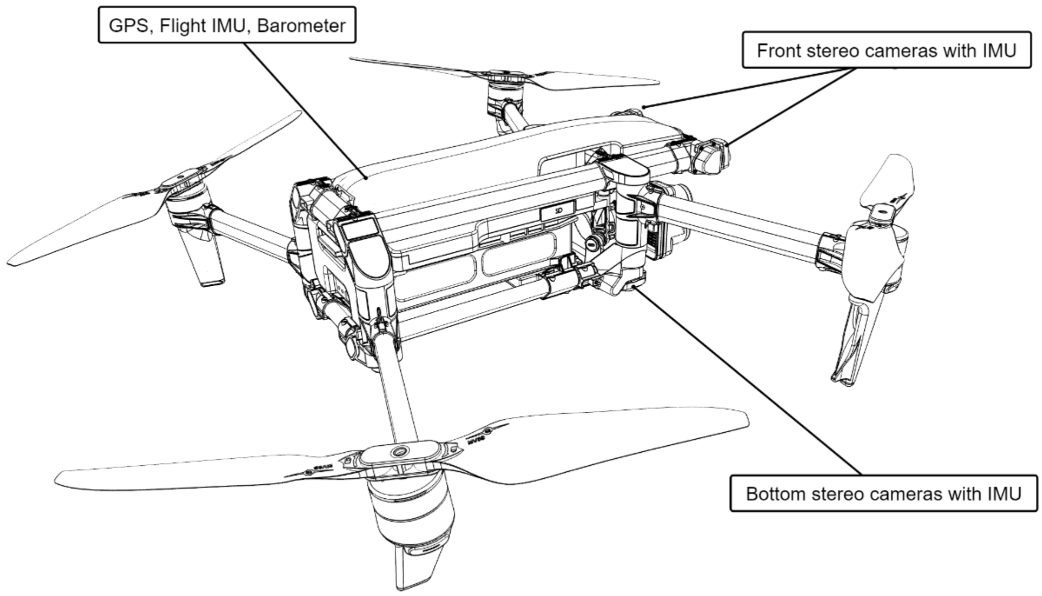


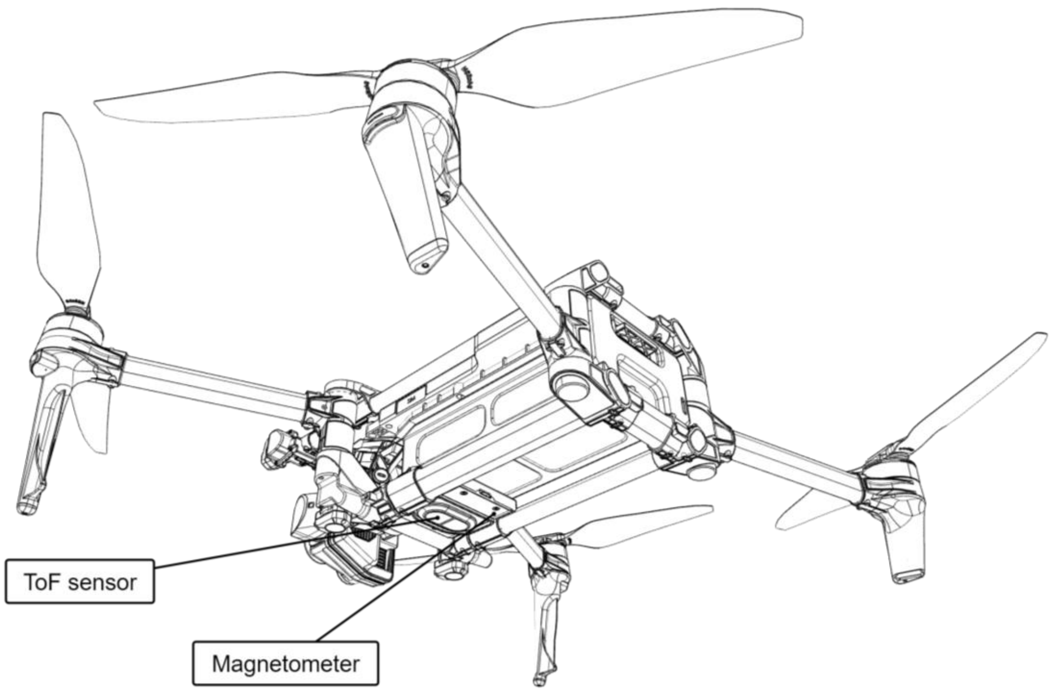
Parrot

2.5 Sensors

To ensure its safe flight, ANAFI UKR is equipped with:

- 5x IMUs (1x ICM-40609-D and 4x ICM42688-P)
- 1x magnetometer LIS2MDL
- 1x GNSS chip UBX-M10Q
- 2x 5G antennas
- 2x WI-FI antennas
- 1x Time-of-Flight (ToF) sensor TI OPT3101
- 1x barometer LPS22HB
- 2x stereo-cameras (1 pointing forward and 1 pointing downward)





2.5.1 Flight IMU: ICM-40609-D

- 3-axis gyroscope
- Range: ± 2000 °/s
- Resolution: 16.4 LSB/°/s
- Bias/accuracy: ± 0.05°/s (after thermal and dynamic calibration)
- 3-axis accelerometer
- Range: ± 16g
- Resolution: 2.048 LSB/mg
- Bias/accuracy: ± 0.5 mg (X-Y) ± 1 mg (Z) (after thermal and dynamic calibration)
- Temperature regulation: controlled heating system related to ambient temperature, stabilized within: ± 0.15°C
- Measurement frequency: 2 kHz

2.5.2 Magnetometer: LIS2MDL

- Range: ± 49.152 G
- Resolution: 1.5 mG
- Bias/accuracy: ± 15 mG (after compensation, at maximum motor speed)
- Measurement frequency: 100 Hz

2.5.3 Barometer: LPS22HB

- Range: 260 to 1260 hPa
- Resolution: 0.0002 hPa
- Bias/accuracy: ± 0.1 hPa
- Temperature regulation: controlled heating system in relation to the ambient temperature, stabilized within: ± 0.2°C
- Frequency of measurement: 75 Hz
- Measurement noise: 20 cm RMS

2.5.4 GNSS: UBX-M10Q

- Ceramic patch antenna of 25 x 25 x 4 mm
- Sensitivity: cold start -148 dBm / tracking & navigation: -167 dBm
- Time-To-First-Fix: 24 seconds
- Bias/accuracy
    - Position: standard deviation 1.4 m
    - Speed: standard deviation 0.5 m/s
- System compatibility: GPS, Galileo, GLONASS, BeiDou

2.5.5 5G

2 rigid side antennas LB-HB are integrated into the horizontal Fiber-Glass tubes of the bottom frame

- Radiation: Omnidirectional
- Polarization: Linear
- 90 x 14 mm^2

1 HF antenna is inserted into the rear Fiber-Glass tube, also part of the bottom frame

- Radiation: Omnidirectional
- Polarization: Linear @horizontal
- 40x14 mm^2

For all three antennas, MHF4 side cables of 24 cm are used, stripped at 20 cm to allow direct grounding to the MB.

2.5.6 Wi-Fi

- Range: about 3Km (Between controller and drone)
- Measuring frequency => Dual Band:
  - Low Band: center frequency 2G4
  - High Band: center frequency 5G
- Antenna on the drone:
  - Front foot antenna: Dual Band @2G4 & @5G
    - Radiation: Omnidirectional
    - Polarization: Linear @horizontal
  - Rear foot antenna: High Band @5G
    - Radiation: Omnidirectional
    - Polarization: Linear @horizontal
- Antenna on the controller:
  - @2G4 & @5G: Radiation => directional antenna

2.5.7 ToF: TI OPT3101

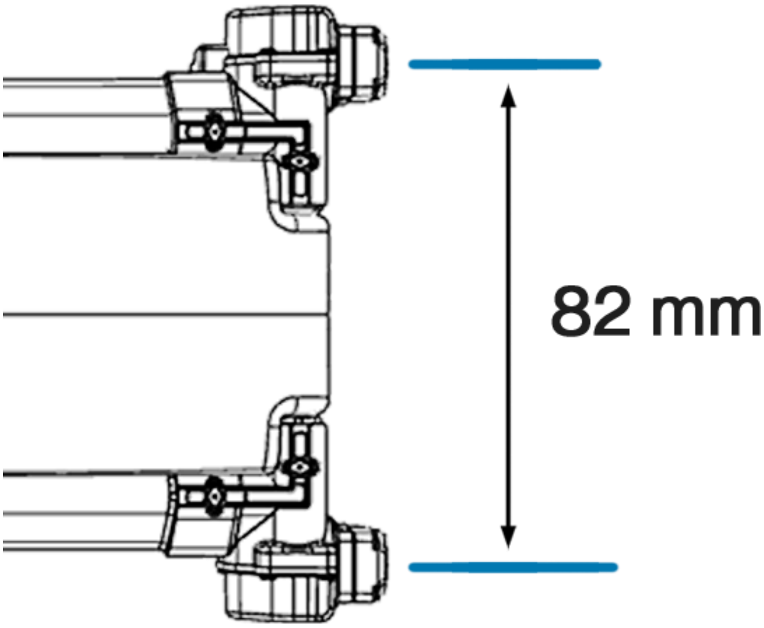
- Range: 0-15 m
- Resolution: 0.3 mm
- Bias: ± 2 cm (after calibration)
- Measuring frequency: 64 Hz

2.5.8 Stereo cameras

Two fixed stereo cameras pointing forward and downward are used to detect and avoid obstacles:

- IMU sensor: ICM-42688-P
  - 3-axis gyroscope
  - Range: ± 2000 °/s
  - Resolution: 16.4 LSB/°/s
  - Bias/accuracy: ± 0.1 °/s (after dynamic calibration)
  - 3-axis accelerometer
  - Range: ± 16g
  - Resolution: 2.048 LSB/mg
  - Bias/accuracy: ± 2.0 mg (X-Y) ± 5.0 mg (Z) – after dynamic calibration
  - Measuring frequency: 2 kHz
  - Hardware synchronization with the left camera, accuracy: 1 µs
- Camera module: Onsemi AR0144CSSM28SUD20
  - Color: Black & White
  - Resolution: 1280 x 800 pixels
  - Frame rate: 30 fps
  - Global shutter
  - Full horizontal field of view: 118° (110° used for perception)
  - Full vertical field of view: 93° (86° used for perception)
  - Focal length: 1.13 mm (0.061”)
  - Aperture: f/2.28
  - Optical flow ground speed measures at 60 Hz
  - Point of interest calculation for accurate hovering at 15 Hz & accurate landing at 5 Hz

- Stereo camera pair
  - Baseline/distance: 82 mm (3.23”)
  - Synchronous acquisition at 30 fps



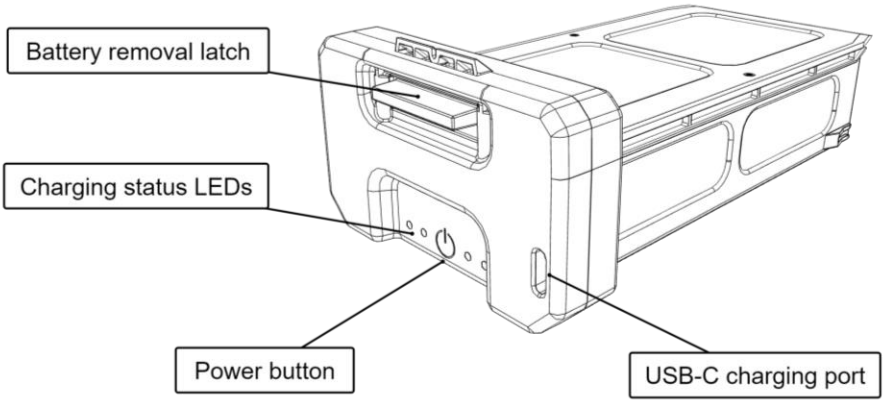
2.6 Environmental robustness

TEST	PARAMETERS
IP GRADE: DUST PROOF	IP5X
IP GRADE: RAIN PROOF	IPX3
COLD EXPOSURE	Functional at -40°C
DRY HEAT EXPOSURE	Functional at +50°C
DAMP HEAT EXPOSURE	Functional at +50°C / 93% RH
EXTREME TEMPERATURE EXPOSURE	Functional after 4h at -40°C & 4h at +70°C
THERMAL SHOCKS	Functional after 20 cycles of [1h at -40°C/1h at +50°C]
RANDOM VIBRATION	Functional after 1h at 6.65gRMS (Freq. Range: 10 to 2000Hz; 3 axis)
SINE VIBRATION	Sine test 3mm/6g | Freq. Range: 5 to 2000Hz | One sweep 2oct/min 5 to 2000 to 5Hz
DRONE DYNAMIC AUTOMATIZED FLIGHT ENDURANCE	100h of continuous flight with altitude variations
DRONE TAKE-OFF / LANDING ENDURANCE	1000 cycles
GIMBAL ENDURANCE	500h of gimbal movement
MOTOR AND PROPELLER ENDURANCE	Motors flight scenario: 380h for the propellers and 760h for the motors
BATTERY CONNECTION/DISCONNECTION ENDURANCE	6000 cycles on Drone side 2000 cycles on Battery side
USB-C CONNECTORS ENDURANCE	Equivalent to 10000 uses
HALT (HIGHLY ACCELERATED LIFE TEST)	Cold stress (-95°C), Hot stress (+110°C), Temperature variation stress ([-95°C/+110°C]), Vibration stress (50gRMS)
ON / OFF ENDURANCE	500 x [1min ON - 1min OFF] at 20°C; and 500 at -40°C; and 500 at +50°C
PACKAGING VIBRATION	Truck (1h at 0.52gRMS), Rail (1h30 at 0.29gRMS), Air (2h at 1.05gRMS)
PACKAGING DROP	1m drops on concrete on 1 corner, 3 edges and 6 faces

2.7 Smart Battery

2.7.1 Standard battery Key features

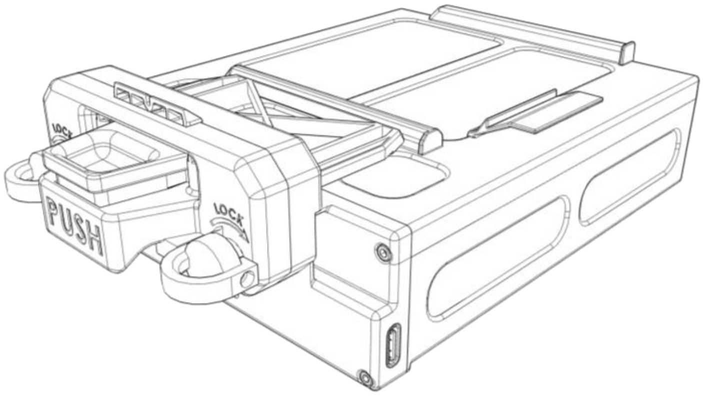
- Energy: 78.5 Wh
- Capacity: 6,800 mAh
- Smart Battery Management System
- Smart Charging optimization
- Wintering mode for protection over time
- Black Box function for battery health monitoring
- Power bank mode



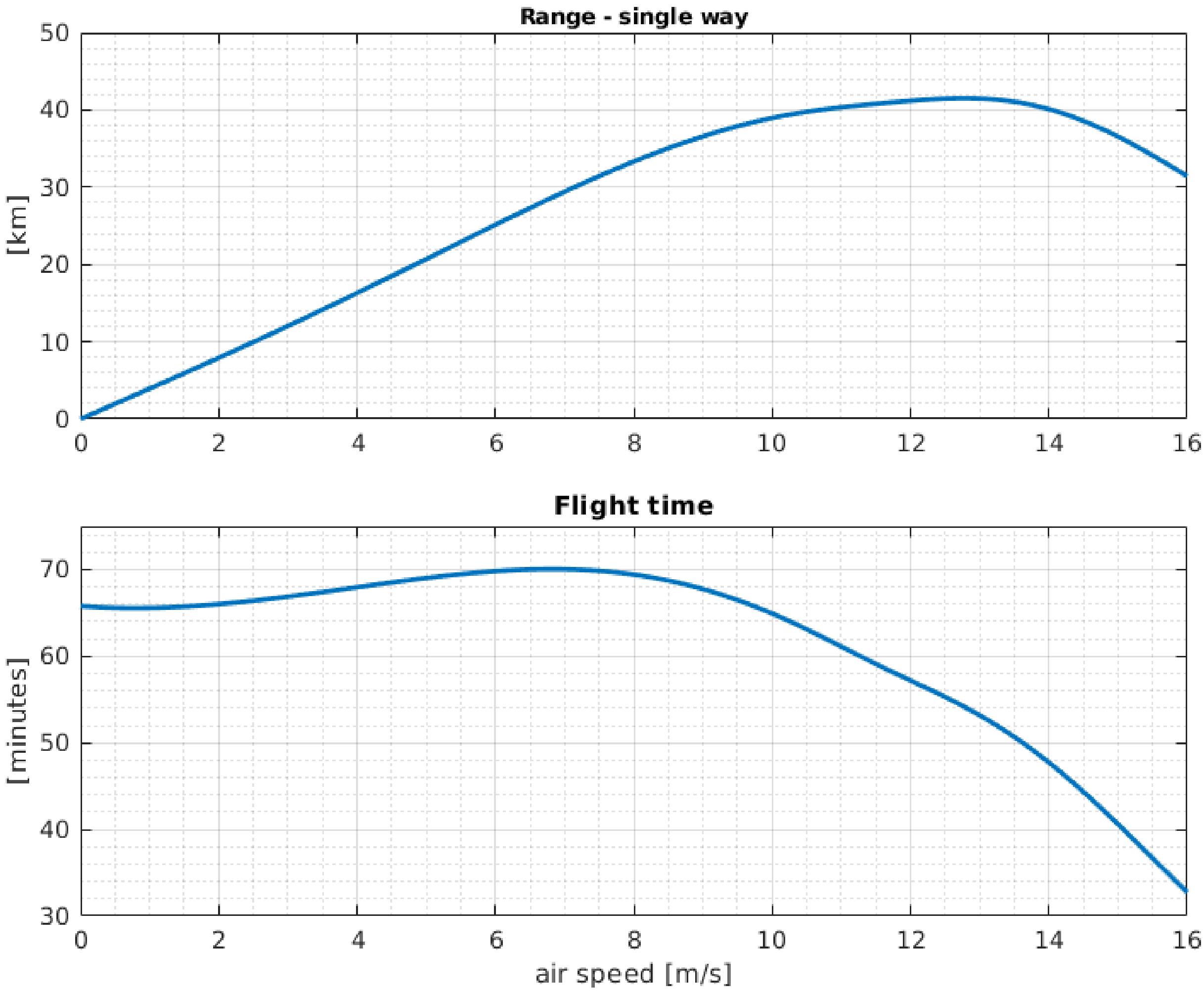
BATTERY ENVIRONMENT ROBUSTNESS	
DURABILITY	80% capacity after 300 charge/discharge cycles
RECOMMENDED LONG-TERM STORAGE TEMPERATURE RANGE	-20°C to 35°C
CHARGING TEMPERATURE RANGE	11°C to 45°C
OPERATING TEMPERATURE RANGE	-20°C to 50°C

2.7.2 XLR battery Key features

- Capacity: 20,200 mAh
- Smart Battery Management System
- Smart Charging optimization
- Wintering mode for protection over time
- Black Box function for battery health monitoring
- Power bank mode



The following graphs show the XLR battery's range and flight time:



2.7.3 Characteristics

2.7.3.1 High Density

The battery cells use LiPo technology. The chemistry enables the battery to be charged up to 4.4 V per cell.

2.7.3.2 Smart battery management system

The battery is equipped with a gauge which measures in real time the battery's main parameters: voltage, current and temperature. The internal algorithms enable the system to compute available energy in real time, based on these parameters and on the cells' *state of health*.

The estimate’s precision is used by the **Smart RTH** function. The battery provides the information which enables the drone to determine the energy required to return to its take-off point safely.

2.7.3.3 Smart charging

With its embedded 45 W charger, ANAFI UKR's battery can be charged quickly and easily using any USB-C adapter. The battery is 3.0 USB-PD (Power Delivery) compatible. This protocol results in a full charge in 2 h 30 mins.

The charging power is automatically adapted to ambient temperatures to avoid damaging the cells.

2.7.3.4 Power bank

The smart battery can be used as a power bank to recharge other devices through the USB-C port.

Available Power Delivery Object (PDO):

- 5V/3A (15 W),
- 9V/3A (27 W),
- 12V/3A (36 W)

Specifically, it can be used to recharge the Skycontroller UKR.

In this configuration, the Skycontroller UKR and Android tablet use approximately 12 W in internal consumption, and 24 W to recharge the Skycontroller UKR’s batteries.

A dedicated, open-source CAD model of a power bank holder accessory is available upon request. When manufactured on a 3D printer, it can be attached to the back of the Skycontroller UKR via the 4 existing screws. When the power bank holder is attached to Skycontroller UKR and the battery removed from it, it is still compatible with the remote-antenna tripod fixation of the Skycontroller UKR. Refer to *chapter 19 Accessories* for more information.

2.7.3.5 Wintering

After 10 days of inactivity (no charge or flight), the battery automatically discharges itself to 60% charge, the optimal storage charge, and switches to wintering mode.

This mode guarantees that the battery is in an optimal state of storage. All current leakage is prevented by isolating the cells from the electronic circuit. This ensures that the cells do not reach a voltage level which would deteriorate the chemistry of the battery (3 V). Therefore, the batteries can be stored safely for a full year.

Batteries exit the wintering mode when plugged into a power source.

2.7.3.6 Black Box

Equipped with an internal memory, the battery records the history of its measurements (charge/discharge cycles, state of health) and transfers them to FreeFlight 8. This data can also be exploited by Parrot Support for analysis in case of malfunction.

2.7.3.7 Charge indicator

The battery's four LEDs indicate the charge level in the following situations:

- battery under charge
- power button activated
- battery installed on ANAFI UKR and drone powered on
- power bank mode activated

2.7.3.8 Thermal limits

NOTE: If the smart battery's gauge temperature surpasses 85°C, the maximum drone inclination is progressively limited to allow the gauge cool down. When the gauge temperature returns below 75°C, all autopilot limitations are removed. FreeFlight 8 does not inform the pilot of this limitation.

If the smart battery's cell temperature surpasses 65°C, the drone initiates an USB key. This RTH can be overruled by the pilot, but the battery's future health and performance may be degraded.

If the cell temperature surpasses 75°C, the drone initiates an auto landing (in training mode only)

2.7.4 Quality

- Parrot is ISO 9001 certified.
- Batteries are UN38.3 certified for transportation.
- Batteries are CE and FCC certified.
- Quality control process:
  - Parrot has implemented a reinforced quality control process for battery manufacturing (audit of suppliers, IQC controls) and set up test benches for each step of the assembly process.
  - Parrot performs random X-ray and tomography controls on samples, to permanently monitor cell quality (electrode stacking, soldering)
- If users choose to share their data with Parrot, their ANAFI UKR batteries' state of health is transferred to Parrot's cloud for support and statistical purposes.

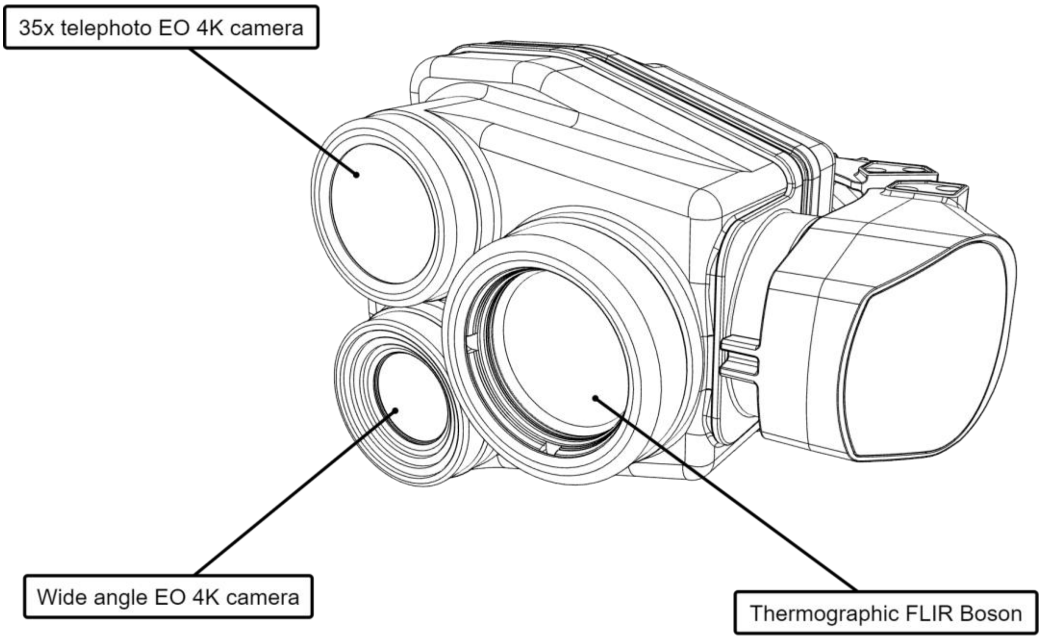
3 ANAFI UKR Payload

3.1 Overview

ANAFI UKR's gimbal houses 3 gyrostabilized cameras: a wide angle EO 4K camera, a 35x telephoto EO 4K camera and a Long-Wave IR thermographic FLIR Boson® camera.

3.2 Electro Optical system

3.2.1 Key characteristics of the 2 EO cameras



WIDE ANGLE EO CAMERA	
SENSOR	Sony IMX 230 1/2.4''
RGB	4K (up to 30 fps)
PHOTO	21 MP
ANGULAR RESOLUTION	0.016°/pixel
MTF	> 43 % at 160 lp/mm
ZOOM	1x to 5x in 1080 p
APERTURE	F2.4

TELEPHOTO EO CAMERA	
SENSOR	Sony IMX 230 1/2.4''
RGB	4K (up to 30 fps)
PHOTO	21 MP
ANGULAR RESOLUTION	0.004°/pixel
MTF	> 45 % at 160 lp/mm
ZOOM	5x to 35x in 1080 p
APERTURE	F2.4

3.2.2 Continuous 1x to 35x zoom

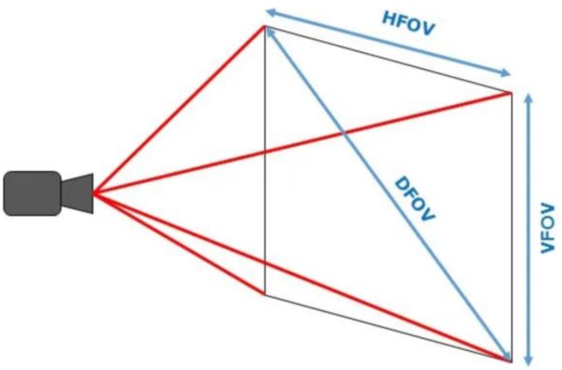
The focal leap between the wide camera (1x to 5.3x) and the telephoto camera (5.4x to 35x) is automatic, which guarantees a continuous zoom.

3.2.3 Optical unit

ANAFI UKR uses low dispersion aspheric lens architectures (110° and 26° diagonal fields of view, respectively for the wide and tele lenses). The optical units are composed of six lenses optimized to minimize the level of parasitic light while providing a high-resolution image across a wide temperature range (-43 °C to 45 °C).

3.2.4 Diagonal (DFoV) and Horizontal (HFoV) fields of view

The wide-angle camera lens covers the full diagonal of the sensor with a 110° DFoV. It has a 75° HFoV for the standard photo and video mode, and a 84° HFoV for the wide photo mode.



The telephoto camera lens covers the full diagonal of the sensor with a 26° DFoV. It has a 16° HFoV for the standard video and photo mode.

3.2.5 Angular resolution and discernable details

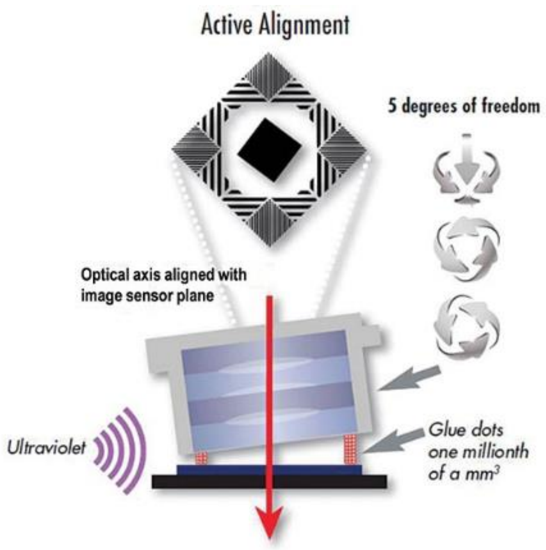
The angular resolution of a lens expresses the angular separation between two pixels of the associated sensor. With the angular resolution of 0.004° on its telephoto lens, ANAFI UKR enables its users to discern 10 cm (approximately 4’’) details at 1,500 m, or 1 cm details at 150 m.

3.2.6 Optical unit manufacturing: Active alignment

The optical unit is assembled with the sensor using an Active Alignment technique. The optical block is positioned and held in place using a robotic arm, to achieve the following performance:

- the optical block is positioned above the sensor to ensure the desired focus at a set temperature (23 °C ±2 °C) and to guarantee resolution specifications in the scene.
- in yaw, roll and pitch, the optical block is positioned respecting the optical axis to obtain a uniform resolution on the edge of images.
- the sensor is aligned with the optical block axis to achieve the best performance in the center of the image.
- the optical center is aligned with the sensor center (<32 µm).

To guarantee the ISP’s image quality specifications, the factory performs a calibration of the optical center. In its internal memory, each optical unit carries parameters for optical center, dead pixel mapping, lens shading mapping (luminance and color) and white balance.



Parrot

3.2.7 Optic quality

Several optical tests are performed during the production process:

- MTF checks on the image center
- MTF checks on the image borders
- Camera module checks while in production:
    - Center MTF
    - MTF at 40 % of the field
    - MTF at 70 % of the field
    - Light blemishes (dark or light areas on the image, dust suspicions)
    - Dead pixels (checking the total number)
    - Optical center
- Cosmetic defects (stains, scratches, etc.)

3.2.8 Image quality

ANAFI UKRs Image Signal Processor (ISP) is tuned by Parrot using both a lab objective evaluation and a natural subjective one.

Exposure, tone, color accuracy, sharpening, and noise are measured using standard charts under controlled illumination.

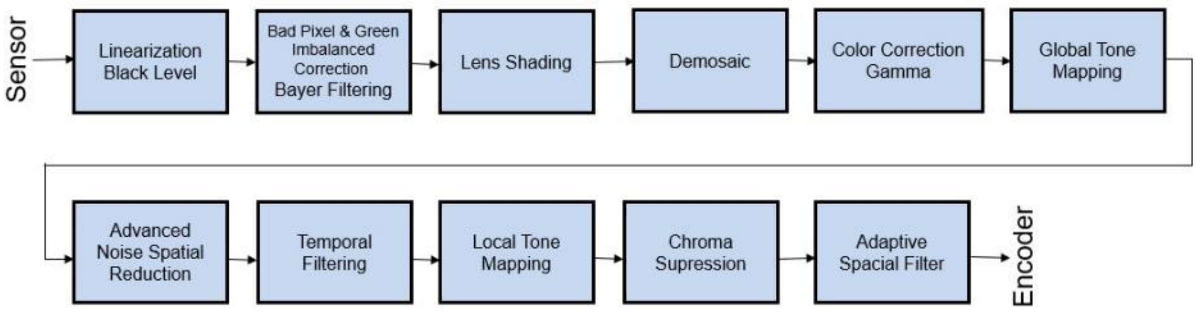
Each ISP configuration is tested in a natural environment under various weather conditions.

ANAFI UKRs ISP is fine tuned for UAV’s specificity. AWB is fine tuned to manage difficult transitions such as moving from a green scene with vegetation to a blue sky.

AE is set to give more weight for a good ground exposure rather than sky exposure. ANAFI UKR benefits from a spatial and temporal denoising paired with a local contrast enhancement.

A specific ISP’s tuning is done to improve IQ when the zoom is maximal.

Overview of IQ pipeline:



3.3 Infra-Red (thermal) system

MODEL	FLIR BOSON 9HZ MICROBOLOMETER
SPECTRUM	Longwave infrared: 8 to 14 µm
RESOLUTION	640 x 512 pixels
PIXEL PITCH	12 µM
SENSITIVITY	60 mK
FOCAL LENGTH	13.6 mm
HFOV	32°
FREQUENCY	8.6 Hz
MEASURABLE TEMPERATURE RANGE	-40°C to 250°C
CORRECTION OF DISCREPANCIES	Manual correction on gimbal holder

3.3.1 Thermal video/photo modes

Users can switch between thermal and visible modes without interruption of the video (in 4k or 1080p). Since the thermal camera is running at 8.57fps, thermal video is at 8.57fps. The raw thermal flux is colorized and displayed as is, or blended with visible flux (refer to *chapter 3.4 IR/Visible blending* for more information). Full thermal mode (left), blended mode (right):

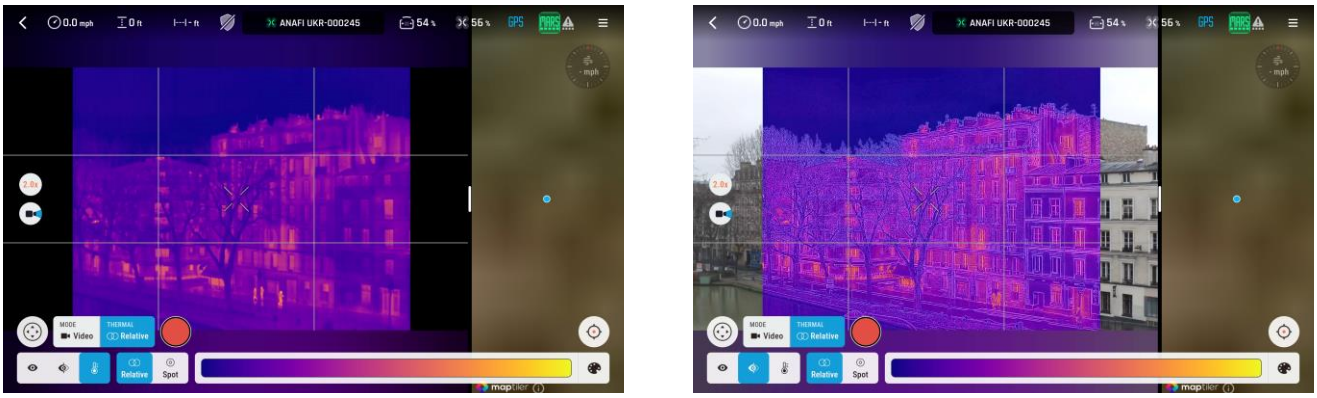


FIGURE 2: FULL THERMAL MODE (LEFT), BLENDED MODE (RIGHT)

3.3.2 Colorization

The 16bit single channel output of the thermal camera is processed to display a high contrast 8bit RGB image. To do so the image is converted to 8bit using a custom algorithm which allows to have a high contrast over all the image even in high dynamic range cases while keeping the temperature gaps perceptible. For instance, an image converted to 8 bits using a linear mapping between min and max on the left and the image colorized using Parrot algorithm on the right:

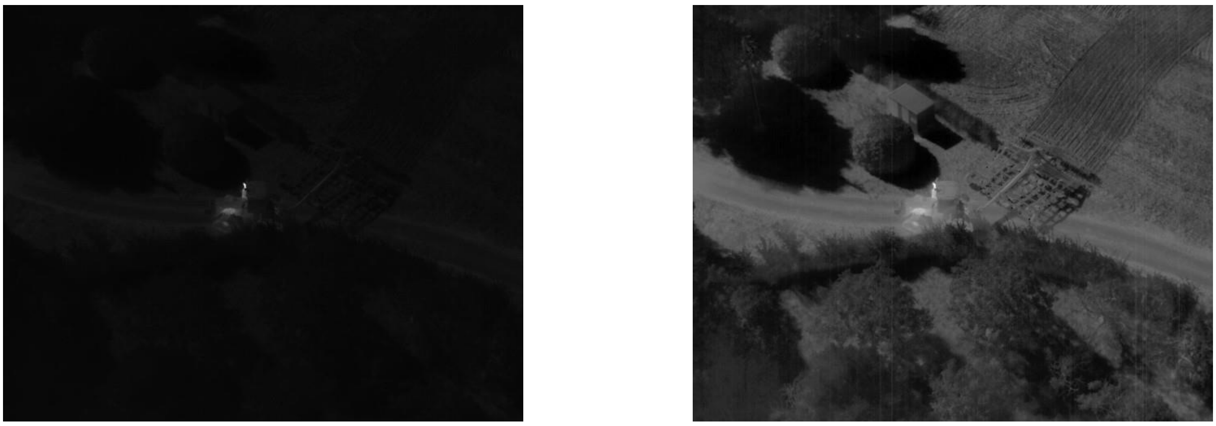


FIGURE 3: LINEAR MAPPING BETWEEN MIN AND MAX (LEFT), IMAGE COLORIZED USING PARROT ALGORITHM (RIGHT)

A perceptually uniform (as of CAM02-UCS standards) colormap is applied to represent at the best temperature gradients. 4 colormaps are available plasma (top left), rainbow (top right), white-hot (bottom left) and black-hot (bottom right) - colormap can be selected by clicking the palette icon on the bottom right of the screen.

FIGURE 4: PLASMA

FIGURE 5: RAINBOW

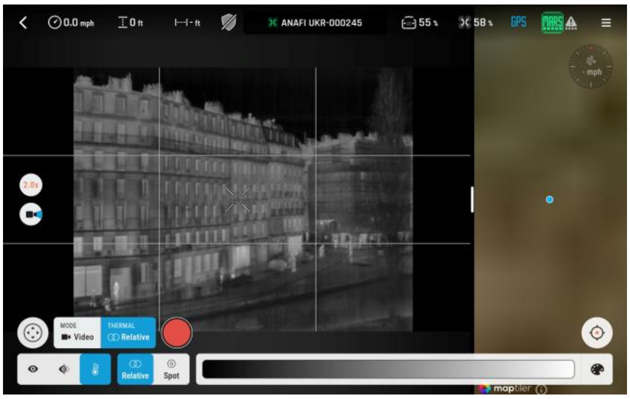


FIGURE 6: WHITE HOT

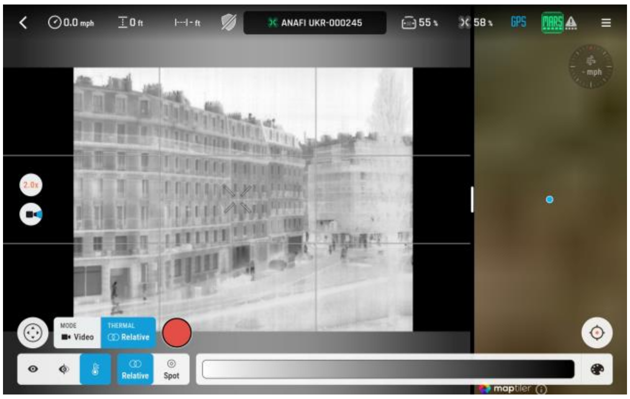
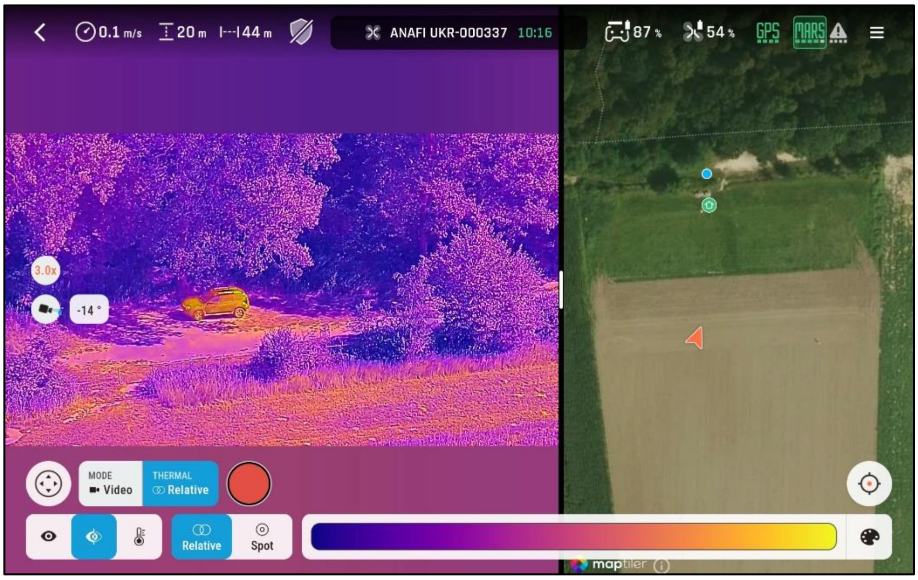


FIGURE 7: BLACK HOT

3.3.2.1 Relative mode

The relative mode displays a general thermographic view of a scene, on a colored scale (with configurable colors), graduated from 0 to 100.



3.3.2.2 Spot mode

The user can choose to colorize the image only on the highest temperatures or the lower ones (hot spot/cold spot) by setting the threshold with the top left buttons of the controller. For example, in hot spot mode:

3.3.3 Media formats

Several files are saved in photo or video:

- Video
  *Blended/full thermal flux 1920x1080/3840x2160 8bit 8.57fps
  *Raw thermal flux 640x512 16bit 8.57fps
  *Visible flux 1920x1080/3840x2160 8bit 8.57 fps

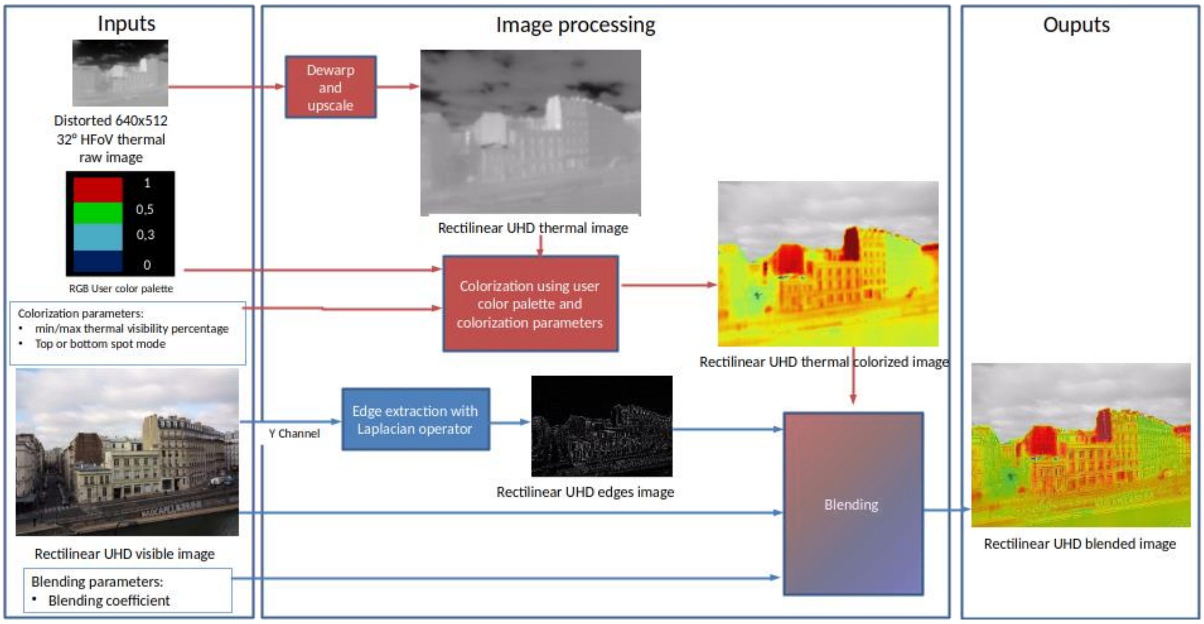
- Photo rectilinear
  *Blended/full thermal photo 21Mpx 8bit JPG
  *Visible photo 21Mpx 8bit JPG
  *Raw thermal photo 640x512 16bit PNG

3.4 IR/Visible blending

To compensate for the lower resolution of the IR thermographic image in comparison to the EO visible image, and to add information that is not available through the thermal spectrum, ANAFI UKR fuses the information of the two cameras. The data of the visible image is added to the output footage, by luminance, to highlight the scene's contours.

The fusion of images consists of:

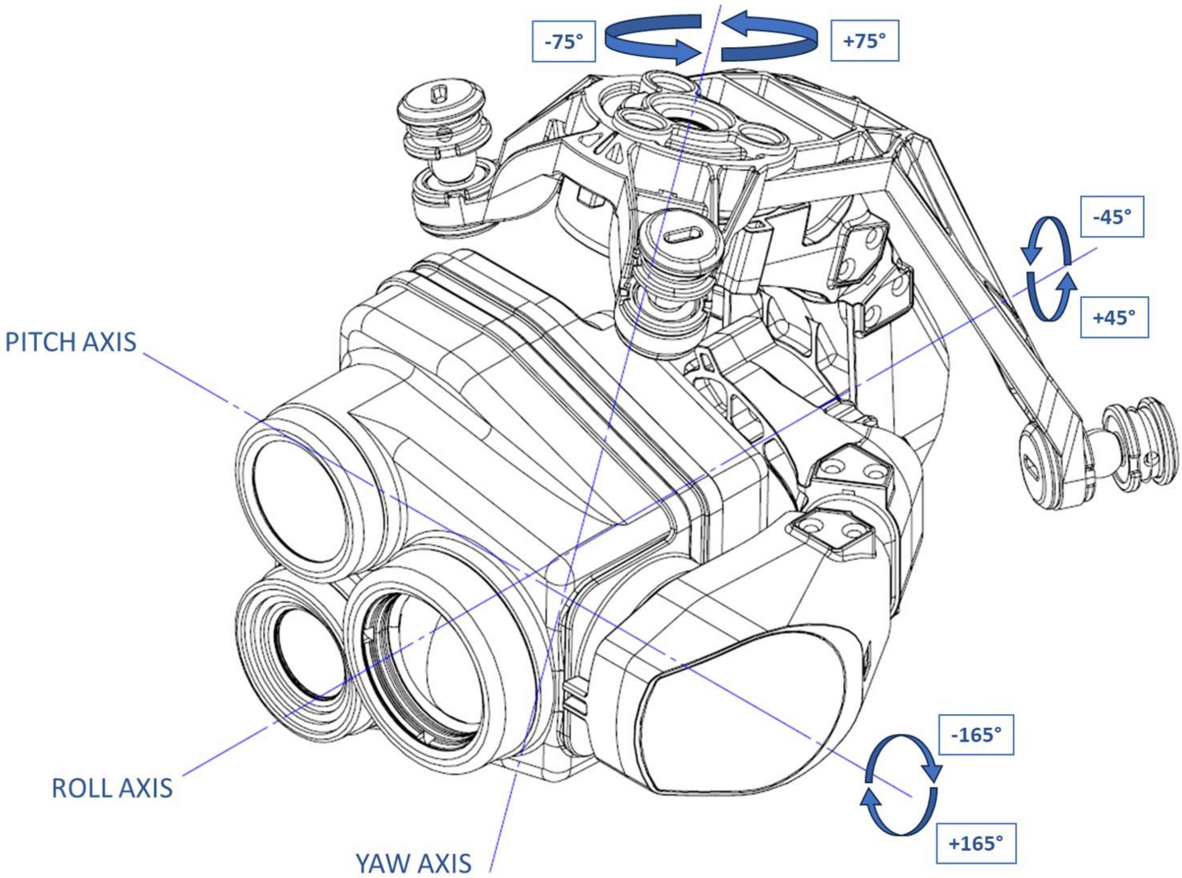
- acquisition of visible image;
- acquisition of thermographic data;
- reprojection of thermographic data with distortion correction;
- colorization of thermographic image;
- extraction of visible images contours;
- mixing.



3.5 Gimbal

The ANAFI UKR front cameras achieve accurate 3-axis stabilization through the mechanical gimbal.

3.5.1 Key features



- 3-axis of mechanical stabilization
- 330° pitch range
- Field of View without obstruction from the drone body from -130° to +35°

ANGULAR STABILIZATION ACCURACY	±1°
STABILIZATION RANGE	Pitch: ±165° Roll: ±45° Yaw: ±75°
GIMBAL TILT ROTATION RANGE	-90° to +90°C
MANUAL ROTATION RANGE	Pitch: -130° to +35°C
MAXIMAL ROTATION SPEED	Pitch: ±180°/s
PROTECTION	Front camera crashproof self-protection

3.5.2 Mechanical stabilization

Position estimation

The gimbal position is estimated based on the 3-axis gyroscope from the ICM-42688 embedded in it, and the DRV5053 hall sensors for motor positioning.

Control Loop

The camera's aiming axis is stabilized regardless of the drone's orientation. Stabilization is achieved via a set of three motors piloted using a cascaded loop control structure for angular position and velocity.

The control loop relies upon the world pose estimation, which is performed by fusing the camera IMU with the angle measurements provided by the Hall sensors embedded in the motors.

3.5.3 Electronic Image stabilization

The EIS algorithm digitally stabilizes the image along the 3 axes (yaw, pitch, and roll). It corrects the effects of wobble (high frequency micro vibrations). The methodology consists of applying a geometric transformation to each image of the camera. This transformation is computed using IMU signals which are precisely synchronized with camera frames, along with a camera model.

3.5.4 Stabilization at high zoom

An image-based features movement tracker is activated when zooming. The estimated movement of this computed feature is fed to both the mechanical stabilization loop and the electronic image stabilizer to improve state estimation and allow optimal experience when observing targets from afar. Both loops are also tuned to minimize blur in such use cases at low lighting.

3.5.5 Robustness

The mechanical stabilization relies upon the calibration choreography at startup, which allows the drone to:

- initialize the gyroscope bias
- calibrate the hall sensors
- initialize position estimation initialization on the motors endstop.

For better robustness, if the choreography is disturbed on the ground by the environment, a last try is performed after flight. In case the choreography cannot be fully achieved, it will be bypassed and the mechanical stabilization will enter a ”best effort” mode.

3.6 Detection and Identification performance

- Detect* human-sized targets during daylight at a range from the SUAS at 121m Above Ground Level (AGL)
    - Based on Johnson criteria (Detect = 1.5px EO for 50cm human width): 4.8km
    - Based on experimental tests in sub-optimal conditions: 3.2km
- Detect* human-sized targets during darkness at a range from the SUAS at 121m AGL
    - Based on Johnson criteria (Detect = 1.5px IR for 50cm human width): 384m
- Identify** human-sized targets during daylight at a range from the SUAS at 121m AGL
    - Based on Johnson criteria (Identify = 12px EO for 1.83m human length): 2.2km
    - Based on experimental tests in sub-optimal conditions: 1.6km
- Identify** human-sized targets during nighttime at a range from the SUAS at 121m AGL
    - Based on Johnson criteria (Identify = 12px IR for 1.83m human length): 173m
- Classify*** human-sized targets at a range from the SUAS at 121 m AGL
    - Based on Johnson criteria (Classify = 1.5px EO for 25mm detail): 242m
    - Based on experimental tests in sub-optimal conditions: 135m
- Track**** human-sized targets at a range from the SUAS at 121m AGL
    - Based on Johnson criteria (Track = 8px EO for 1.83m human length): 3.3km
      Based on experimental tests in sub-optimal conditions: 2.4km

*Detection: Mission-Essential Task (MET) expected to be performed by the system whereby the detection of moving things is discoverable and locatable upon a display without complete recognition or accurate identification (a defined number of false alarms is allowed.)

**Identification: MET expected to be performed by the system to support 1) the process of determining the friendly or other-than-friendly character of an unknown detected contact, and 2) the process of attaining an accurate characterization of detected objects to the extent of high confidence, timely application of tactical options and resources can occur (a defined number of false alarms is allowed).

***Classification: MET expected to be performed by the system to allow assignment of an appropriate level of threat or importance to an IoI. This normally involves viewing an image with sufficient detail to show special facial features, numbers on a license plate, colors, small IoIs (e.g., unconcealed long weapon), etc. (a defined number of false alarms is allowed.)

****Track: MET expected to be performed by the system such that the movement of IoIs over time and distance are monitored and displayed (a defined number of false alarms is allowed.)

3.7 External payloads

ANAFI UKR was designed and optimized to fly as is, however it can fly with accessories or external payloads. Depending on payload characteristics (size, mass, and current consumption), impacts on system performances can be expected, including, but not limited to: aerodynamics, autonomy, flight stability, radio link performance, navigation sensor reliability.

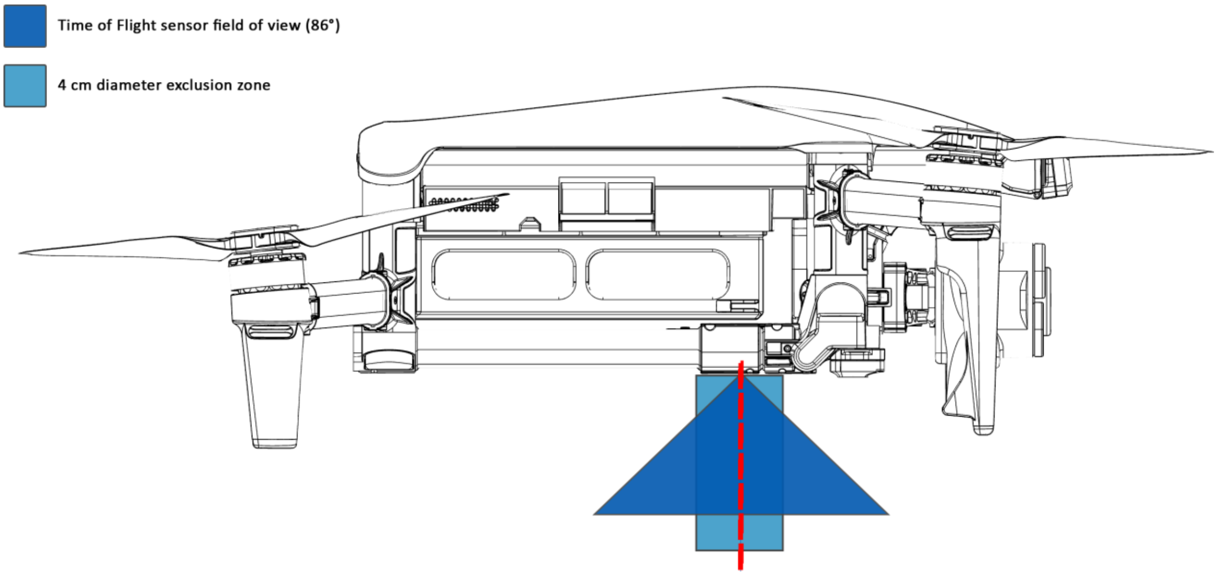
IMPORTANT: The maximum take-off mass (MTOM) of ANAFI UKR is 1,450 g (3.20 lb). If you equip ANAFI UKR with an accessory, it can reduce its autonomy.

The maximum mass of the external payload that ANAFI UKR can carry depends on the battery installed in ANAFI UKR:

- Standard smart battery: up to 400 g.
- XLR smart battery: up to 100 g

CAUTION: Do not alter the center of gravity of the drone. Do not block or obstruct in any way the front stereo cameras, the bottom stereo cameras, or the Time-of-Flight sensor. Any obstruction of the sensors, even partial obstruction of the field of view may cause ANAFI UKR to read false data, to have erratic flight behavior, resulting in a crash. The required Field of View for the stereo cameras and the Time-of-Flight sensor is 86° (2x43°). Do not put any object under the Time-of-Flight sensor. Keep a clear cylindrical exclusion zone with a diameter of 4 cm directly below the sensor.

The following image shows the Field of View for ANAFI UKR's Time-of-Flight sensor, including the exclusion zone.



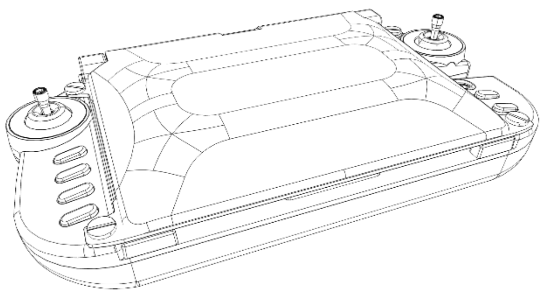
Parrot recommends that you do not attach a payload to ANAFI UKR's top cover. Payloads attached to the top cover can impede or degrade GNSS/IMU performance.

Users can control the power supply of the battery USB-C port and the aircraft USB-C port via FreeFlight 8. The USB-C ports can be used to power accessories which require a power supply.

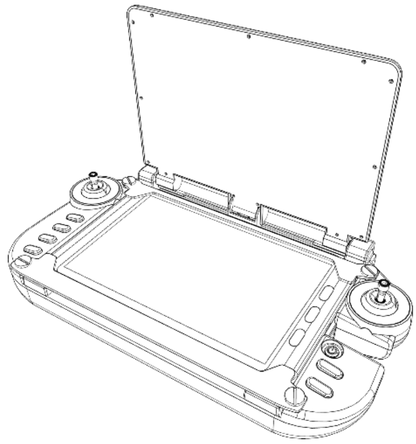
SPECIFICATION	AIRCRAFT USB C PORT	BATTERY USB C PORT
MAX POWER OUTPUT	5 V, 2 A (10 W max)	5 V, 3 A (15 W max)
DATA OUTPUT	Supported	Not supported
TEMPERATURE LIMITATION	None	Power output blocked when battery internal gauge temperature reaches 80 °C

4 Skycontroller UKR

4.1 Physical characteristics



Storage position



Flight position

4.2 Key features

- HDMI port for real-time broadcast to external screen/display
- Detachable and storable joysticks for ease of transport
- Integrated tablet for streaming display (choice between Samsung Android tablet and iPad Mini)
- Quick USB-PD charging through the USB-C port (2 hours for a 99% charge)
- Autonomy of 4 hours 30 minute (enough for 4 full battery drone flights)

4.2.1 Design compatible with Android

TABLET CHARACTERISTICS	ANDROID
MODEL	Samsung Galaxy Tab Active 5
SCREEN DISPLAY	8.0”
MASS	433 g
DIMENSIONS	126.8 x 213.8 x 10.1mm
BRIGHTNESS	600 nits
STORAGE	128 GB
LTE CONNECTIVITY	5G
ENVIRONMENT GRADE	IP68

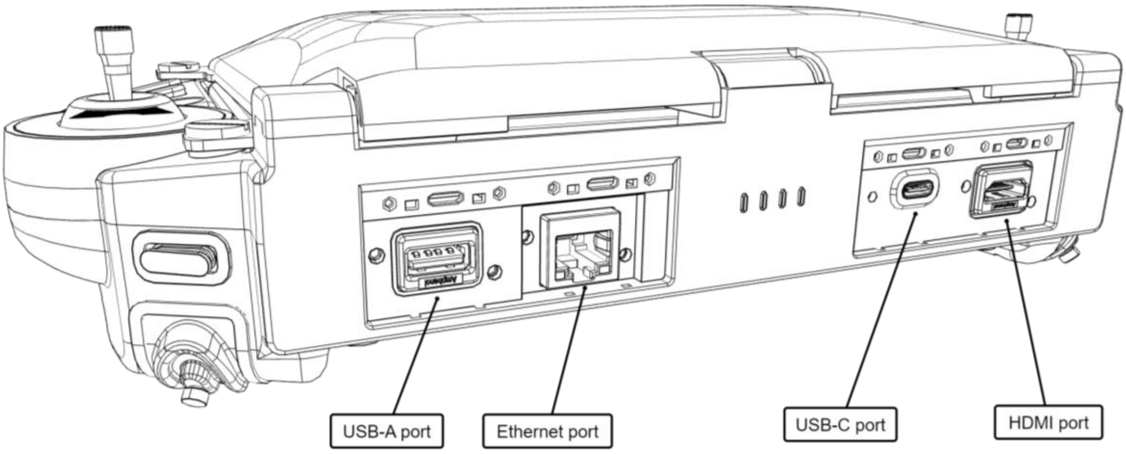
4.2.2 Joystick with hall sensor technology

The Skycontroller UKR is equipped with a new generation of joystick based on hall sensors. Hall sensors allow a 2.5-degree dead zone, and therefore provide more precise control over the drone. Furthermore, they also allow for a design more resistant to dust.

4.2.3 Interfaces

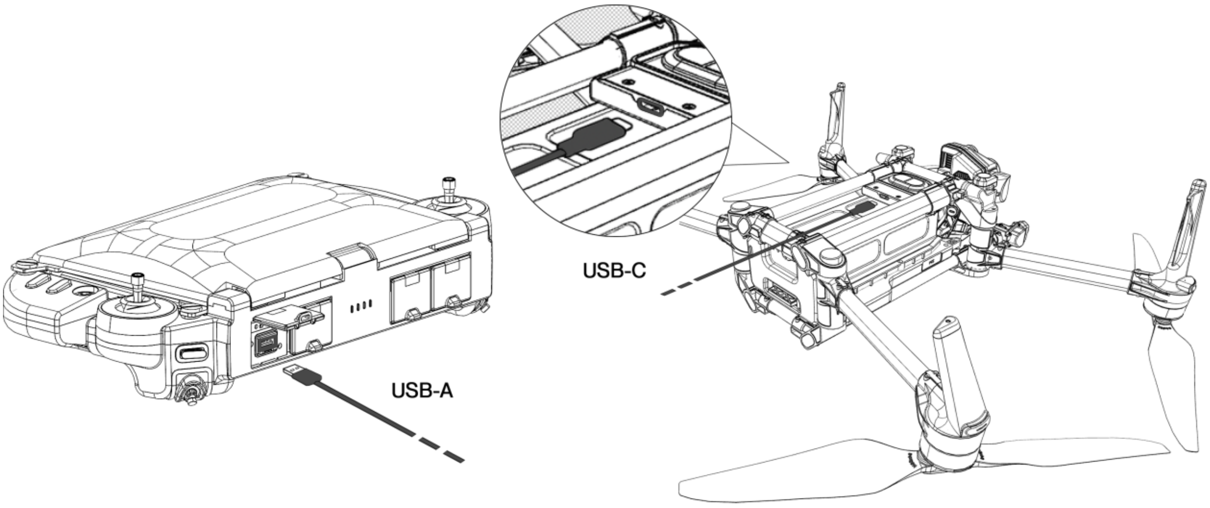
The Skycontroller UKR interfaces are waterproof and certified IP68.

- 1x USB-A port
- 2x USB-C ports
- 1x Ethernet port
- 1x HDMI port



4.3 Pairing

Easily pair the controller with a drone by connecting the controller to the drone with a USB cable.



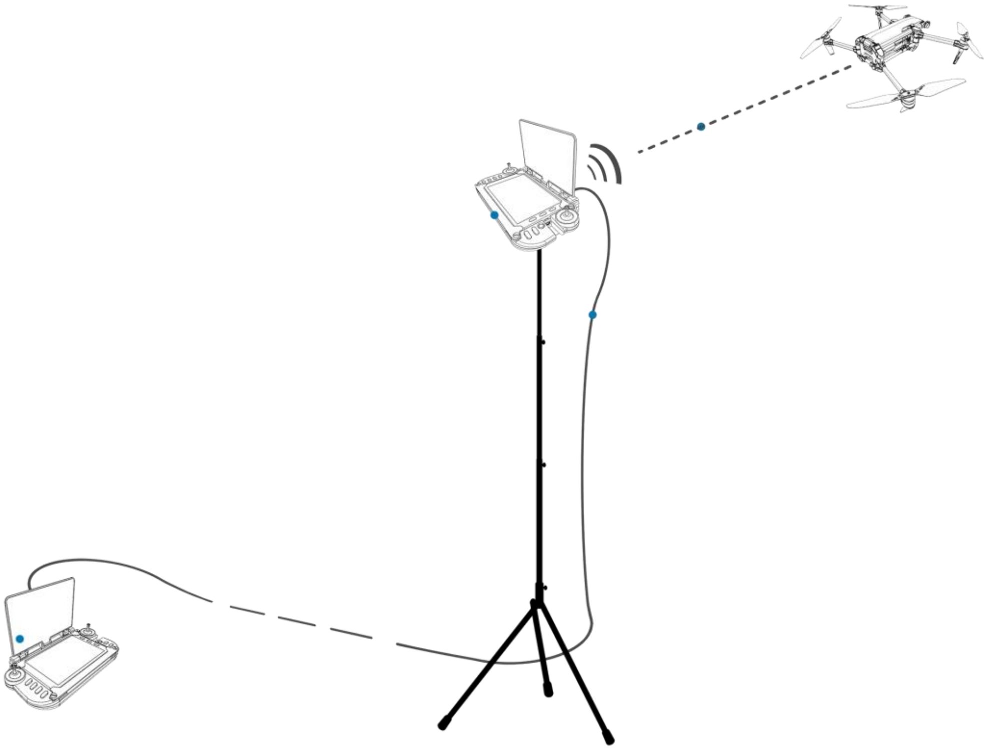
The status LED of the controller will blink green during the pairing process. Once the pairing process is complete, the status LED will turn fixed blue.

4.4 Remote antenna with a second Skycontroller UKR

For safety reasons, it can be very useful to have the drone pilot located in one place (for example indoors), and a remote antenna in a second location. The ANAFI UKR system allows this via the Remote antenna feature:

- A main Skycontroller UKR is used to pilot the drone
- This main Skycontroller UKR is connected via an RJ45 Ethernet cable to a second Skycontroller UKR acting as an external antenna (i.e. a Remote Antenna).

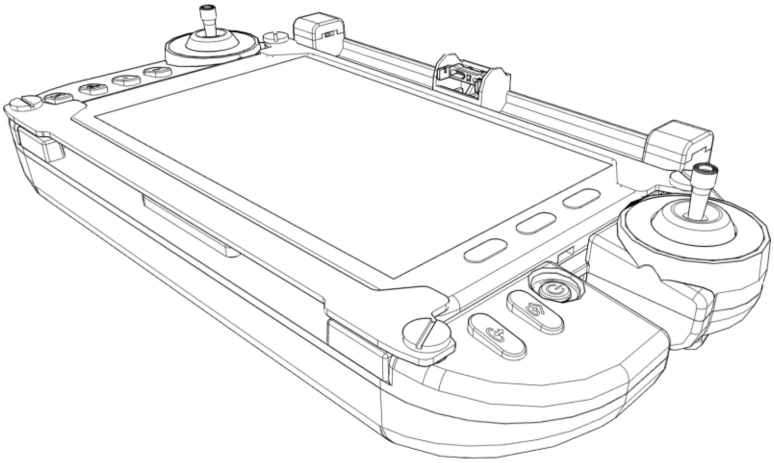
This allows the drone pilot to control the drone indoors, or in a vehicle for example, with an external antenna fixed outdoors for optimal radio link performance. The ethernet cable between the 2 Skycontrollers UKR can be up to 100m long (must be RJ45 Cat5 minimum). The external antenna controller can be powered ON and powered OFF remotely via the main (piloting) Skycontroller UKR, meaning Skycontroller UKR can be used as a remote antenna at will.



NOTE: Tablet is not mandatory for the outdoor remote antenna.

4.5 Remote antenna with Skycontroller Mission and MARS Ranger

ANAFI UKR mission pack contents includes a simplified Skycontroller UKR. This simplified version does not include an antenna or a radio.

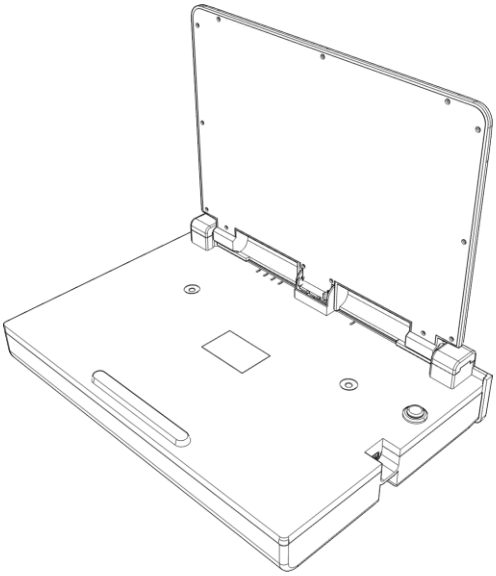


The Skycontroller UKR Mission interfaces are waterproof and certified IP68.

- 1x USB-A port
- 2x USB-C ports
- 1x Ethernet port
- 1x HDMI port

4.5.1 MARS Ranger

MARS Ranger is a dedicated remote antenna system based on Skycontroller UKR without the piloting interface (MARS Ranger does not include a tablet, the FreeFlight 8 application, or the piloting buttons).

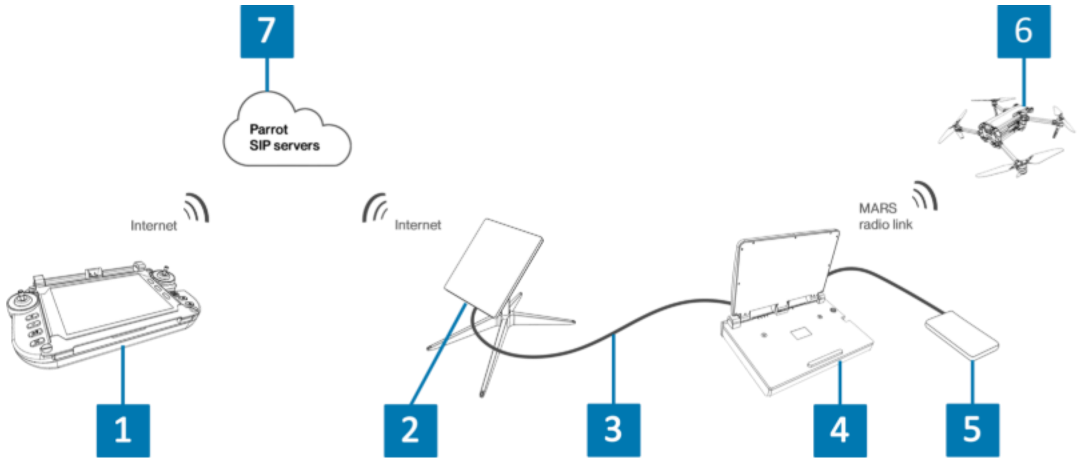


The Skycontroller UKR Mission interfaces are waterproof and certified IP68.

- 1x USB-C ports
- 1x Ethernet port

4.5.2 Cloud antenna

The Skycontroller UKR Mission can remotely connect to the MARS Ranger via an internet network, eliminating the need for an Ethernet cable.



1. Skycontroller UKR Mission
2. Starlink mini
3. Ethernet cable
4. MARS Ranger
5. Power bank
6. ANAFI UKR
7. Parrot SIP servers

4.6 Environmental robustness

TEST	PARAMETERS
IP GRADE: DUST PROOF	IP5X
IP GRADE: RAIN PROOF	IPX3
COLD EXPOSURE	Functional after 16h at -20°C
DRY HEAT EXPOSURE	Functional after 16h at +45°C
COMPOSITE TEMPERATURE / HUMIDITY CYCLIC TEST	240h climatic test (-10°C to [+65°C;93%HR])
IMPACT TEST ON JOYSTICKS (IK)	IK04
BUMP RESISTANCE	Total of 10000 bumps | half sine 4g10ms | 3 axis in remote antenna configuration
JOYSTICK ASSEMBLY ENDURANCE	1000 cycles
SLIDERS ENDURANCE	22000 cycles
COVER CONNECTOR ENDURANCE	Equivalent to 1000 uses

4.7 Battery

4.7.1 Characteristics

The battery cells use Lithium-ion technology. The chemistry enables the battery to be charged up to 4.2 V per cell. The Skycontroller UKR is equipped with 2 packs of 2 cells.

Each pack's battery characteristics:

- Capacity: 5,000 mAh
- Energy: 36 Wh
- Wintering mode for protection over time

The batteries are equipped with a gauge which measures in real time the battery's main parameters: voltage, current and temperature. The internal algorithms enable the system to compute available energy in real time, based on these parameters and on the cells' *state of health*.

Autonomy durations for Skycontroller UKR and Android Tablet at 100%

EXTERNAL TEMPERATURE	AUTONOMY
-20°C	3:05
+20°C	4:30
+45°C	4:20

4.7.2 Charge duration

The Skycontroller UKR batteries can be charged quickly and easily using any USB-C adapter (total power of 34W). The Skycontroller UKR is 3.0 USB-PD (Power Delivery) compatible. This protocol results in a full charge in 2 h 50 mins.

The charging power is automatically adapted to ambient temperatures to avoid damaging the cells.

Charge durations for Skycontroller UKR and Android Tablet at 0%

EXTERNAL TEMPERATURE	CHARGE
0°C	3:20
+20°C	2:50
+30°C	2:40

4.8 Samsung tablet

4.8.1 Characteristics

- Model: Samsung Galaxy Tab Active 5
- Screen: 8'' TFT LCD 120 Hz
- Luminosity: 600 Nits
- Battery capacity: 5,050 mAh
- Memory capacity: 128 GB
- IP68 certified
- WiFi 6 802.11 a/b/g/n/ ac ax (2.4G+5GHz), HE80,
- 5G embedded
- GPS (used for the RTH feature)

4.8.2 Smart Charging

The Samsung tablet is connected to the Skycontroller UKR via a USB-C/USB-C cable, for data and power delivery.

Between 100% and 35% of charge, the Skycontroller UKR charges the tablet at 1,500 mAh, resulting in a fully charged tablet in 2 h 40 mins.

When the Skycontroller UKR is below 35% of charge, the charging tablet current is limited to 500 mAh allowing a better overall autonomy.

5 Autopilot

5.1 Drone state estimator

ANAFI UKR uses an estimation process “KIWI” (which stands for Kalman Is Well Implemented), as a Kalman filter which estimates all useful states for the flight of the drone using all sensors (GNSS, computer vision algorithms, barometer, IMU, etc.). These states include position in local frames, position in geographic frames, velocities, airspeeds, as well as internal states such as sensor biases.

KIWI provides state estimation (and status, accuracy, etc.) by channel (horizontal, vertical, and heading) and by frame (local and global). This allows clear and precise interaction with your guidance modes.

KIWI adapts to all sensor configurations and all conditions. Whether GNSS data are available, denied or not available at all, whether computer vision algorithms are available or not, KIWI will reconfigure itself to ensure it always provides the most accurate state estimation possible.

KIWI is AI-boosted. KIWI is trained using advanced AI algorithms and our extensive flight log database. Because naive Kalman filters are not robust to bad measurements, KIWI leverages AI to:

- detect bad measures from any of its input sensors by inputting data such as sensor temperature, sensor saturation, signal-to-noise ratio, image quality indicators, coherence tests between sensors etc.
- Improve measurements by predicting sensor biases.

KIWI will always estimate all states, including geographic position, even when GNSS is denied (using computer vision algorithms and external "hints").

KIWI is accurate, under normal circumstances (GNSS available or during daytime when computer vision algorithms work), KIWI’s performances are:

- Pitch/Roll error < 0.11°; Yaw error < 3°
- Local position: <5% drift
- Altitude error < 1m
- Geographic error with GNSS < 2m
- Geographic error without GNSS
    - < 50m with help from our satellite map algorithm (when the drone is flying at an altitude of over 100m)
    - <8% drift at lower altitudes

Bad or suspicious measurements are either rejected or used with a lower confidence.

Many adverse conditions on sensors can occur during flight, such as passing by a magnetic structure which distorts the geomagnetic field. KIWI assumes any sensor can become defective at any point during the flight, and they can also be restored to a healthy state at any time.

Conditions that lead usual Kalman filters to diverge, like a takeoff from a moving ship, with a fixed GNSS signal and a bad magnetic heading due to the steel deck, are also handled by KIWI.

5.2 Drone Control

The flight controller is composed of two levels:

1. A first level ensures flight stability by controlling roll, pitch, yaw, and altitude;
2. A second level aims to control the drone along the trajectory, on a more sophisticated level.

5.2.1 Flight stability control

This level of control takes inputs for roll, pitch, yaw angles, and desired altitude.

It is composed of a first block generating feedforward motor commands based on a physical model of the drone. The second step uses a PID controller to finetune motor commands and correct errors due to model imperfections.

The flight control implements various algorithms to adapt itself seamlessly to changes such as:

- Flights at high altitude with a low air density
- Abnormal motor friction which gives it reduced performance
- Propeller icing when flying in cold misty conditions.

5.2.2 Trajectory guidance

In many cases, it is more precise and ergonomic to follow commands in trajectory rather than direct user inputs (POI, Cameraman) and when you want to use obstacle avoidance.

A trajectory sent to the control module is evaluated at 33Hz and is formulated as a combination of position, velocity and acceleration in 3 dimensions.

5.3 Flight Supervisor

This process, written in Python, contains the Autopilot state machine. Each state regulates the configuration of each of the flight modes ensuring consistency of the data exchanged.

The machine states are divided as follows: 6 states (Level 0) and 25 substates (Level 1).

A description of each state of levels 0 and 1 is presented below:

- Ground
  - **ground.reset**: reset the orientation of the front camera for the next takeoff.
  - **ground.idle**: drone on the ground, engines off.
  - **ground.magneto_calibration**: manual calibration of the magnetometer by the user. Calibration is done by rotating the drone on its X, Y, and Z axes based on the instructions given by the application.
- Takeoff
  - **takeoff.normal**: takeoff procedure from starting the engines at minimum speed until reaching an altitude stabilization point; on the horizontal path, the drone can either maintain zero speed or move longitudinally/laterally according to pilot commands.
  - **takeoff.hand**: takeoff procedure consists of starting the motors at their minimum speed, then waiting for the user to launch the drone. Once free fall is detected, flight control algorithms are activated to stabilize the drone at launch altitude.
  - **takeoff.flightplan**: takeoff procedure executed when the drone receives a request to start a flightplan from the ground (functionally identical to normal takeoff).

- Hovering
    - **hovering.fixed**: fixed point state, in which the drone seeks to maintain its horizontal position. In this state, it can receive vertical and yaw commands.
    - **hovering.gotofix**: braking state from horizontal movement until reaching zero speed. In this state, the drone can receive vertical and yaw piloting commands.
    - **hovering.freeze**: state in which the drone brakes and remains in a fixed point when obstacle avoidance becomes unavailable in manual flight.
    - **hovering.rth**: waiting state during an RTH in case of a delayed landing
- Flying
    - **flying.manual**: state in which the drone moves in the horizontal plane based on user commands in pitch/roll. When these commands stop, the drone switches to **hovering.gotofix**.
    - **flying.rth**: return home procedure. This essential procedure for flight safety is triggered automatically in certain situations related to autopilot errors.
    - **flying.look_at**: procedure for framing a target. The camera pitch and heading angles are locked to frame the target (the drone heading angle is aligned with the camera heading angle) and the user can pilot the drone around it via pitch, roll and vertical commands.
    - **flying.flightplan**: a flight plan is composed of a series of waypoints placed on a map that the drone reaches with a configurable speed and respecting a predefined camera orientation. ANAFI UKR FlightPlan engine is compliant with MAVLink protocol, to describe the trajectory of the drone and control gimbal and camera recording.
    - **flying.move_by**: performs relative movement on the horizontal, vertical or heading axis.
    - **flying.move_to**: movement to the geographic coordinates of a point placed on a map.
    - **flying.panorama**: creation of a sequence of camera movements with several image shots to construct different types of panoramic image.
    - **flying.poi**: procedure for framing a point placed on a map. The camera pitch and heading angles are locked to frame the point (the drone heading angle is aligned with the camera heading angle) and the user can pilot the drone around it via pitch, roll and vertical speed commands.
- Landing
    - **landing.normal**: landing procedure in which the drone descends at a vertical speed which gradually reduces until touching the ground. In this state, the user can still provide steering commands in the horizontal plane (pitch, roll) as well as heading.
    - **landing.hand**: landing procedure carried out when the drone detects the presence of a hand. This procedure consists of a first step where the drone moves horizontally until it aligns itself with the hand, followed by a phase of descent.
    - **landing.rth**: procedure executed when the drone completes the descent phase of an RTH with end behavior set to ‘landing’ (identical to normal landing from a functional point of view).
    - **landing.flightplan**: Procedure executed when a landing is included in a flight plan sequence.

- Critical
    - **critical.emergency_ground:** the drone folds the cameras following the detection of a free fall with the engines off, an engine shutdown or a too high tilt angle in flight.
    - **critical.emergency_landing:** automatic landing procedure following the detection on the barometer or an unwanted significant gain in altitude. In this state, the user can still provide steering commands in the horizontal plane (pitch, roll) as well as heading. This procedure cannot be interrupted. This critical procedure for flight safety is triggered automatically in certain cases of Autopilot errors.
    - **critical.critical_landing:** automatic landing procedure triggered when the remaining battery energy is very close to the energy needed to descend to the ground given the current altitude and wind level. In this state, the user can still provide steering commands in the horizontal plane (pitch, roll) as well as heading. This procedure cannot be interrupted. This critical procedure for flight safety is triggered automatically in certain cases of Autopilot errors.

5.4 Emergency procedures

5.4.1 Mayday (Minimal Autopilot Your Drone Activates for safetY.)

This is an emergency autopilot that executes separately from the main autopilot. It runs on the sensors DSP (on a separate chip where the flight sensors are also acquired). It has access to the following sensors:

- IMU: Accelerometer/Gyroscope;
- Barometer;
- GNSS;
- Motors.

During normal operation, it runs in the background and estimates the drone's state at 200Hz with its input sensors. It is also fed regularly by the main autopilot with some data that it doesn't compute for both performances and code simplicity (sensors bias, in particular) as well as the home position.

Mayday installs a watchdog on main autopilot motors commands that detect a loss of control resulting from a wide range of failure:

- Linux kernel crash;
- Linux process crashes like drone controller. It can also be activated on demand via a dedicated request to the sensor DSP.
- Once activated, Mayday takes control of the motors and disables all commands coming from the main autopilot. It then performs a simple RTH procedure:
- Route estimation based on GNSS and consecutive positions of the drone;
- Control of the position by the route and the speed. A first loop handles the route and speed references;
- Calculate the route towards the desired point at each step using the GNSS difference position. The error is filtered (first order) to have a slowly moving reference;
- Calculate cruise speed. The speed is filtered with a simple ramp to ensure a smooth movement;
- Control over speed and heading;
- Landing: to avoid deriving too much, the drone performs a fast descent (up to 4m/s) until it reaches 10m above the home position. It then slows down to finalize landing.

Once landed the drone needs to be rebooted to come back to normal operation.

5.4.2 3-motor flight

When a motor undergoes a critical error, instead of falling, ANAFI UKR autopilot switches to a mitigated 3-motor controlled landing mode, where the heading of the drone is no longer controlled, focusing on stabilizing the drone's attitude and altitude. By spinning the drone at 2 revolutions per second, the autopilot can control both the attitude and direction of the per-revolution average thrust, provided by the 3 remaining motors.

When a single motor cutout is detected, an alert is displayed on FreeFlight 8, and the drone performs a straight landing at a descent speed of 3m/s. If the GNSS is available, the drone maintains its horizontal location. Otherwise, it might drift with the wind during the descent. When at a distance of 10cm from the ground, the drone turns off its motors to finalize the emergency landing.

As the drone position is not precisely controlled in this mode, it is highly recommended to keep a safe distance from the drone during a 3-motor descent.

6 Radio

Parrot ANAFI UKR products can support different radio links depending on variant configurations:

1. **MARS** (Military Adaptive Radio System): main radio link designed for robustness and large data bandwidth to manage all use cases (supported on ANAFI UKR, ANAFI UKR XLR and ANAFI UKR Mission)
2. **Wi-Fi:** main radio link (supported on ANAFI UKR GOV)
3. **5G:** main radio link (supported on ANAFI UKR XLR and ANAFI UKR Mission)
4. **LoRa** (Long Range): alternative radio link based on LoRa as a backup link for safe operation in case of loss of the main radio signal (supported on ANAFI UKR, ANAFI UKR GOV, ANAFI UKR XLR and ANAFI UKR Mission)

6.1 MARS main radio

MARS was developed specifically to withstand crowded frequencies and jamming.

Its main characteristics include:

- Range of up to 15 km
- Over 1.5 GHz bandwidth spread across:
  - 8 bands 1.8 – 5 GHz (ANAFI UKR)
  - 10 bands 1.8 – 5.85 GHz (ANAFI UKR XLR)
- High sensitivity
- Interference rejection up to -3dBm
- Data rate up to 6.2 Mbps
- Adaptative TX Power (up to 0.5W)
- Adaptive Frequency Hopping
- MARS main radio link is protected by encryption.

ANAFI UKR monitors radio wave propagation and when the conditions are met (Line of sight, limited RF signal reflection on the ground) it activates MiMo beam forming algorithm to enhance the radio link. Beam forming is achieved by matching the phase of each emitted RF signal every 12.6ms depending of the RX signal phase.

6.2 LoRa alternative radio

The **LoRa** alternative radio is onboarded to operate when **MARS** radio link is completely jammed, or the link is lost. This second link is based on LoRa protocol with a range up to 40 km.

LoRa (Long Range), is a wireless modulation technique derived from Chirp Spread Spectrum (CSS) technology. It allows long range transmission with low power consumption. It is well suited for applications that transmit small chunks of data with low bit rates, as it offers a very limited bandwidth.

LoRa allows the user to pilot the drone and save the drone and visualize the position during autonomous flight. The LoRa link can operate in two different frequency bands EU: 863 to 870 MHz / US: 902 to 928 MHz.

When using the backup datalink, operation from the pilot is limited to manual piloting commands and RTH / landing function. The drone will provide a limited dataset of telemetry including position, heading, altitude, battery level, flight state. The video stream from the drone is not available.

The alternative LoRa data link is also securely encrypted, it uses a combination of AES-128 and ChaCha20, AES-128 for critical commands such as RTH and Kill Switch, and ChaCha20 for piloting commands.

6.3 Wi-Fi

Key features

- Max range: 4 km (CE), 9 km (FCC) with Skycontroller UKR.
- Gain in 2.4 ANAFI UKR: 3.5 dBi +/-1.5 dB
- Gain in 5 ANAFI UKR: 3.5 dBi +/-1 dB
- Omni-directional transmission system

ANAFI UKR has 2 omnidirectional antennas for 2.4 in the front feet with reflector (gain: 2.5 dBi/antenna). With a recombined gain of 3.5 +/-1.5 dBi in the horizontal plane of the drone.

6.3.1 High Power Radio Front-End Design

The radio front end maximizes the power at the foot of the antenna with a very good level of linearity and sensitivity (-94 dBm at 6.5 Mbs), allowing ANAFI UKR to reach the maximum power of the FCC limit.

6.3.2 Robust Wi-Fi Connection

6.3.2.1 Parameters 802.11ax

The more recent 802.11ax chipset was selected. This provides better performance than the 802.11n chipset, and allows better communication in crowded RF environments.

A subset of protocol parameters was selected to optimize performance, with the following characteristics:

- Relatively low throughput, low latency, variability in reception levels due to drone speed, long range,
- Presence of interferers. These parameters include aggregation, number of retries, MiMo technology
- (STBC), management frame data rate, and disconnection conditions.

6.3.2.2 Flow adaptation and monitoring

ANAFI UKR continuously monitors its connection status at 4 Hz and can detect the presence of interference. This allows ANAFI UKR to dynamically optimize the throughput and the size of the transmitted packets. It also alerts the pilot if he is in a particularly interference-laden environment, or if he is close to losing the signal.

6.3.2.3 Smart interference avoidance system

ANAFI UKR has a channel avoidance algorithm (dual band 2.4 GHz and 5 GHz) in case of interference detection.

6.3.2.4 Bandwidth reduction

At the limit of its range and if the conditions allow it, ANAFI UKR can switch to 10 MHz bandwidth to improve its sensitivity by 3 dB and gain 40% in range.

6.3.3 Radio Performances

Physical layer: OFDM (Wi-Fi Ax)

List of channels:

2.4 GHZ EU	2.412 TO 2.462 GHZ (5 MHZ STEPS)
2.4 GHZ US	2.412 to 2.462 GHz (5 MHz steps)
5 GHZ EU	5.745 to 5.825 GHz (20 MHz steps)
5 GHZ US	5.745 to 5.825 GHz (20 MHz steps)

AVERAGE AT 2.4 GHZ:	0 DB (REF)
RADIANCE VARIABILITY (2.4 GHZ):	-1 dB
AVERAGE AT 5 GHZ:	0 dB (ref)
RADIANCE VARIABILITY (5 GHZ):	-1 dB
SENSITIVITY (ANTENNA BOTTOM):	-95 dBm
OVERLAPPED:	0 dB (ref)
ACR (+25 MHZ):	0 dB (ref)

6.4 5G connectivity

6.4.1 5G band usage by US mobile operators

VERIZON	AT&T	T-MOBILE
N260	n260	n260
N261	n261	n261
N77	n258	n258
N5	n77	n41
N2	n5	n71
	n2	n2

6.4.2 4G/5G bands supported by the modem

ANTENNA PORT	TECHNOLOGY	TX BANDS	RX BANDS
ANT 0	WCDMA	B1, B2, B3, B4, B5, B6, B8, B9, B19	B1, B2, B3, B4, B5, B6, B8, B9, B19
	LTE	B1, B2, B3, B4, B5, B7, B8, B12, B13, B14, B17, B18, B19, B20, B25, B26, B28, B30, B34, B38, B39, B40, B41, B66, B71	B1, B2, B3, B4, B5, B7, B8, B12, B13, B14, B17, B18, B19, B20, B25, B26, B28, B29, B30, B32, B34, B38, B39, B40, B41, B42, B43, B46, B48, B66, B71
	5G NR FR1	n1, n2, n3, n5, n7, n8, n12, n20, n28, n38, n40, n66, n71	n1, n2, n3, n5, n7, n8, n12, n20, n25, n28, n38, n40, n41, n48, n66, n71, n77, n78, n79
ANT 1	WCDMA	–	B1, B2, B3, B4, B5, B6, B8, B9, B19
	LTE	B42, B43, B48	B1, B2, B3, B4, B5, B7, B8, B12, B13, B14, B17, B18, B19, B20, B25, B26, B28, B29, B30, B32, B34, B38, B39, B40, B41, B42, B43, B46, B48, B66, B71
	5G NR FR1	n48, n77, n78, n79	n1, n2, n3, n5, n7, n8, n12, n20, n25, n28, n38, n40, n41, n48, n66, n71, n77, n78, n79
ANT 2	WCDMA	–	–
	LTE	–	B1, B2, B3, B4, B7, B25, B30, B32, B34, B38, B39, B40, B41, B42, B43, B46, B48, B66
	5G NR FR1	n25, n41	n1, n2, n3, n7, n25, n38, n40, n41, n48, n66, n77, n78, n79

7 Datalink

7.1 Video encoding

7.1.1 Key features

- H.264 encoding with RTSP and RTP transmission protocols
- Multi-camera: ability to access stereo (horizontal and vertical) and disparity map streams in addition to the main camera stream
- The video stream is compatible with RTP players, like VLC or mplayer
- Up to 1080p at 30 fps, up to 6 Mbps
- Reduced latency (< 350 ms glass-to-glass)

7.1.2 Stream performance

- Resolution: up to 1080p
- Frame-rate: up to 30 fps
- Bit rate: up to 6 Mbps
- Video encoding: H.264/AVC
- Protocol: RTP streaming with RTSP session management
- Latency: < 350 ms

7.1.3 Parrot Gen4 Streaming: video stream optimization algorithms

Advanced encoding for Error resilience

The H.264 stream is tuned to minimize the impact of packet loss on the radio network, and to avoid network congestion. Error propagation due to inter-frame prediction is also minimized.

The algorithm combines the following methods:

- **Slice-encoding**: divides frames into independent portions to minimize the impact of sporadic network losses.
- **Intra-refresh**: images are encoded in P-frames only (inter prediction) to smooth the stream bitrate and avoid network congestion. Random access to the stream is allowed by intra-encoding successive image bands that scan the image surface over time.
- **Hierarchical predictions**: combining multiple levels of frame references allows decimation of the encoded bitstream and improves error resilience. If an image of a given layer is missing, it affects only this layer and layers above, and does not affect the layers below. For example, 1 image out of 4 is in the base layer (lowest), 1 out of 2 are non-reference frames (highest) and the remaining 1 out of 4 is in the intermediate layer: [1][3][2][3][1][3][2][3][1][3][2][3]...

Error concealment

This algorithm reduces the visual impact of losses on the network, and it enables the interoperability of all decoders, while ensuring a syntactically complete stream. Missing images parts are reconstructed as skipped portions, identical to those of the reference image.

The glitches are therefore contained within zones impacted by losses, and do not spread to the entire image.

Congestion control

The algorithm estimates the radio environment and sustainable data rate to anticipate and avoid packet loss and congestion on the network, thus helping to reduce latency.

The algorithm is based on an estimate of the link capacity calculated from the error rate and latency at the application level; it then acts on the H.264 video encoding and RTP payloading parameters.

Metadata
Metadata are transmitted with the video stream. They contain drone telemetry elements (position, altitude, speed, battery level, etc.) and video metrics (camera orientation, exposure value, field of view, etc.).

The synchronization of the images and the metadata allows functions such as precise map positioning, flight instruments tracing on a video overlay or augmented reality.

The inclusion of metadata is using standard methods (RTP header extension). The format of the data defined by Parrot is public and available within Parrot's SDK.

7.2 Backup Link using LoRa

When the **MARS** main radio link is not available, the **LoRa** alternative (backup) radio allows the user to maintain minimum telemetry info and minimum control over the drone. The video streaming is not available on the backup radio. Backup telemetry data includes:

- Flying state
- Battery charge percentage
- Drone speed (norm and heading)
- Drone position (altitude above takeoff, latitude and longitude)

8 Optical Navigation and Flight

8.1 GNSS issues detection

Key GNSS parameters are monitored in real-time to decide whether GNSS velocity and positioning is accurate.

By doing so, it is possible to detect and identify the 2 main issues with GNSS:

- Jamming, i.e. the presence of a signal preventing good reception of satellites signals.
- Spoofing, i.e. the presence of a signal trying to deceive the drone about its real location.

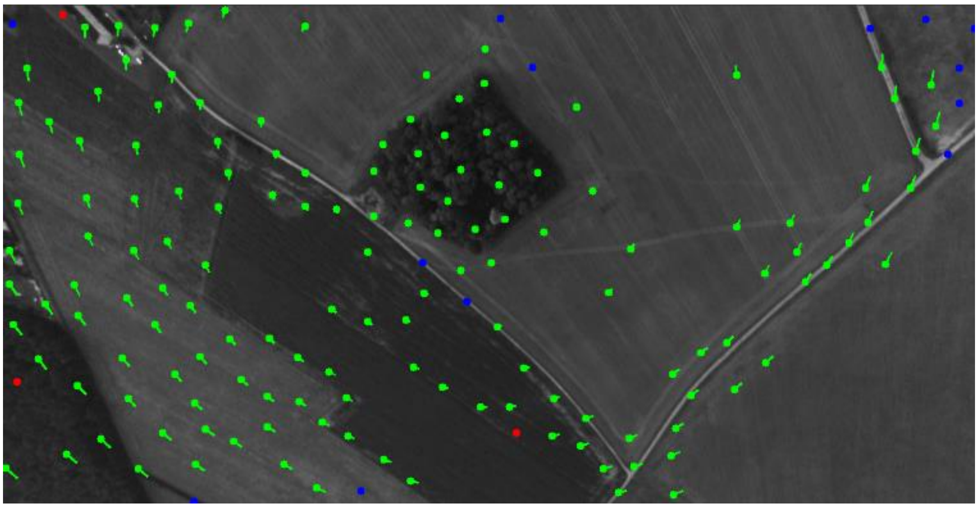
Jamming detection is based on monitoring intrinsic parameters, such as the number of satellites detected, and standard deviations computed by the GNSS module on both position and velocity. If the number of satellites drops, or the standard deviations quickly increase, the drone is experiencing jamming, and the GNSS data are invalidated.

Spoofing detection is done by comparing computing trajectories on short term time windows between GNSS and IMU. If the drone detects recurring diverging trajectories, the drone is experiencing spoofing and GNSS data are invalidated.

8.2 Parrot Visual Inertial Odometry

8.2.1 Algorithm basics

As the drone travels, the drone tracks the evolution of the scene on its vertical camera through optical flow (matching key points from an image to the next one and measuring movement). The optical flow is then used by Parrot Inertial Visual Odometry (PIVO), which uses it to detect and track key features in the image. These features are then combined with IMU measurements to deduce position, velocity, and orientation of the drone.



EXAMPLE OF PIVO POINTS VISUAL TRACKING

8.2.2 Inputs of Parrot Visual Odometry

Parrot's visual-inertial algorithms use embedded data obtained by IMU and video acquisition.

To have an accurate estimation, the scene must have sufficient details; it is harder to see changes in the optical flow when the filmed scene is lacking texture.

8.2.3 Outputs of Parrot Inertial Visual Odometry

PIVO is a local algorithm, which means it provides measurements relevant to the latest part of the drone trajectory, as it progressively loses visibility towards reference points defined at the beginning. It is therefore bound to drift spatially when considering the trajectory as a whole.

PIVO provides a local position, an instantaneous velocity and an orientation of the drone, by keeping by itself a part of the trajectory which goes as far back as 10 seconds in memory.

8.2.4 Performance

The two main parameters which dictate the performance of PIVO are the flight time and the distance to the scene, i.e. the altitude in the case of the vertical camera.

Parrot Visual Inertial Odometry can provide measurements 80% of the time on Parrot's test database of 500 flights with altitude going from 15m to 300m. Its mean spatial drift then depends on the altitude. Parrot's measurements show a mean spatial drift of 4% when the altitude is lower than 100m, and a mean spatial drift of 8% when the altitude is greater than 100m.

CAUTION: Non-GNSS flight is a vision-based flight feature. Algorithm performance may be degraded when flying above non-contrasted ground (for example: snowy fields without any contrast points). Do not use the feature when flying above clouds or heavy fog. You must fly the drone 150 m / 492 ft above ground level when using optical navigation maps, for optimum performance as the feature is based on ground vision algorithm.

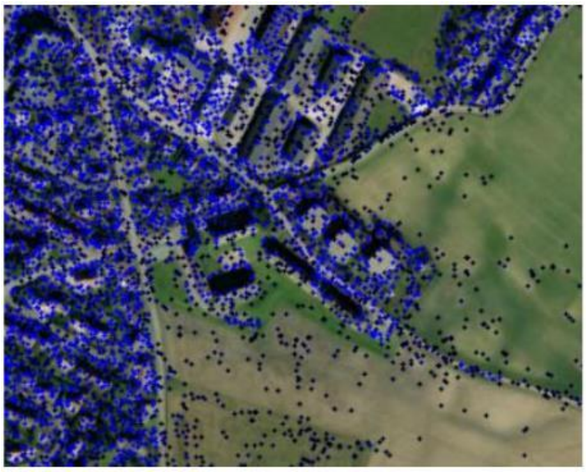
8.3 Parrot Visual Geo-Positioning

8.3.1 Geo-Positioning description

The strategy for optical navigation localization is to compare vertical camera pictures taken from the drone with satellites images. The algorithm is looking for key points and shapes matching in both.

8.3.1.1 Geo-Positioning KeyPoint Pipeline

The key point method works very well in urban areas (lots of texture in the image), whereas shapes give a global shape description and is best suited for the countryside (forest and fields with low texture on the image)

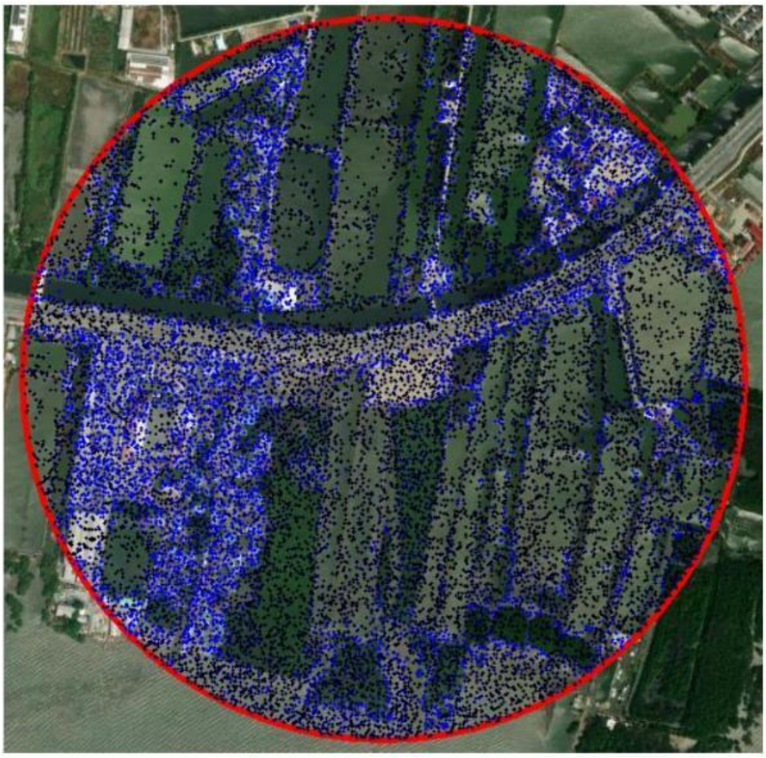


KEY POINTS IN URBAN AREAS

SHAPES ON FORESTS AND FIELDS

To limit the computations, the area of search is a circular area, the radius of which depends on:

- the current estimated GNSS position
- The estimated maximum drift (m)
- The current estimated altitude (m)



Every key point / shape from satellite tiles falling into the search area is used to match the base stereo camera field of view.

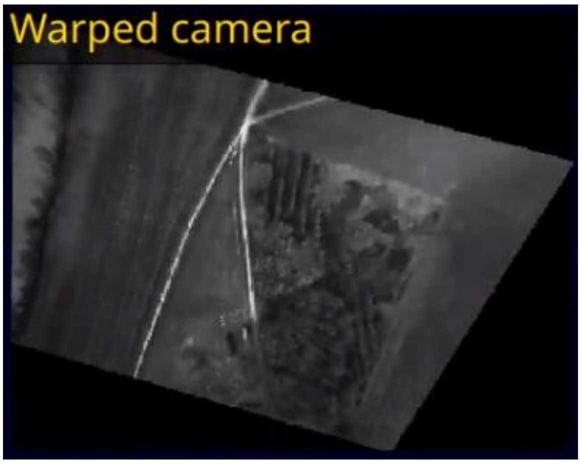
8.3.1.2 Geo-Positioning Shape Pipeline

The Geo-Positioning Shape Pipeline method uses a neural network that Parrot has trained to detect structurally important shapes in satellite images, including:

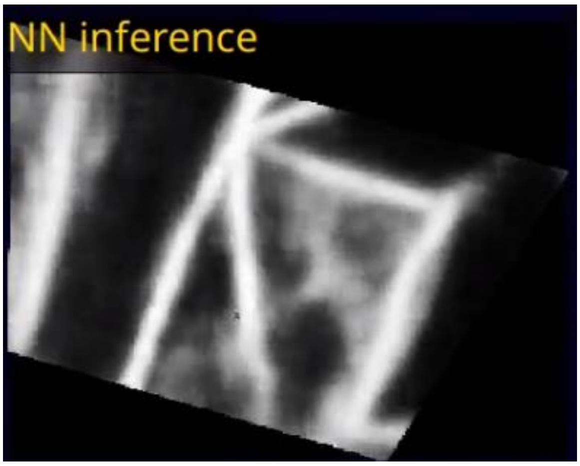
- Roads
- Field boundaries, forests boundaries, lakes, rivers, etc.

The satellite maps are encoded using the same neural network as the one used during flight. Every second, the neural network predicts shapes, and the drone relocates using these detections.

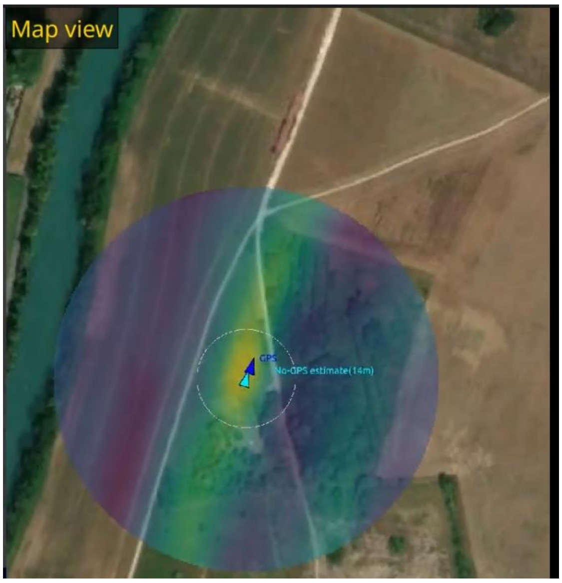
Dstcam Image



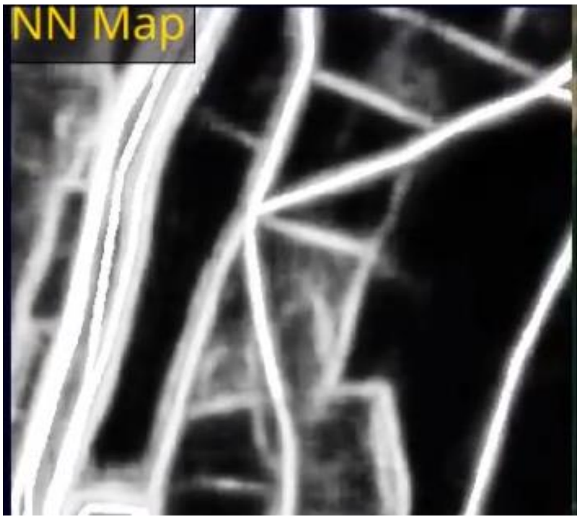
Neural Network inference



Satellite Map, Autopilot Uncertainty,



Neural Network inference on Satellite maps



So by taking as input the uncertainty of the autopilot, the estimated position and the satellite maps described by our own neural networks, we are able to reposition the drone in the geographical reference frame, as you can see in the image above where our sensor's estimate (cyan arrow) is 14 m from the real GPS position (not used during the flight).

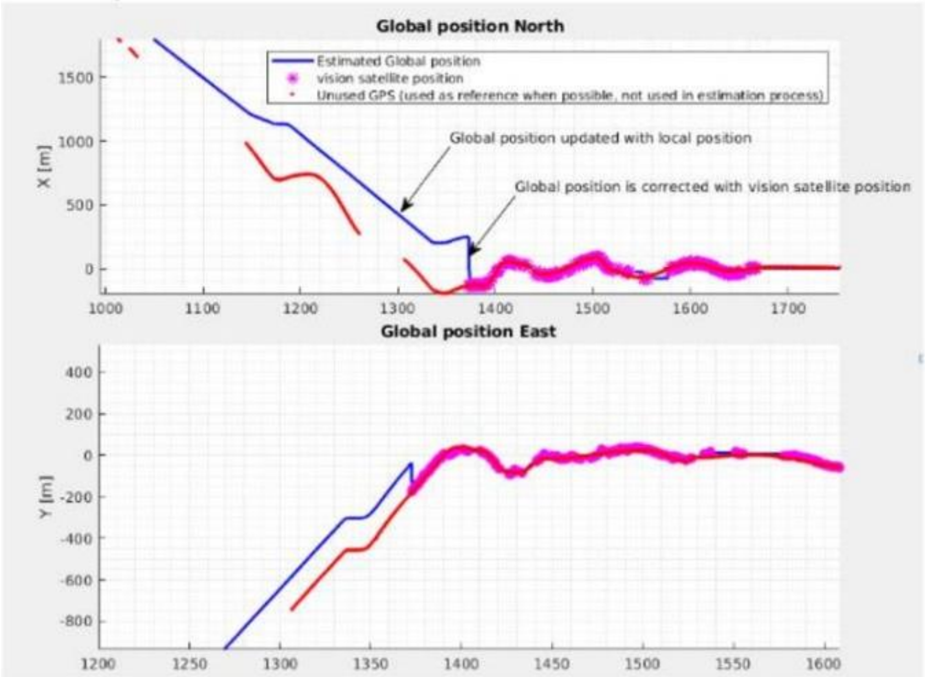
8.3.2 Performance

Performance is computed on our test dataset consisting of more than 300 flight sequences in different scenarios. The algorithm runs at 1 fps. In 82.3% of the time, the algorithms return a position with an error below 50 meters.

In the following example:

- 2.5km are travelled.
- GNSS is not functional, and the drift is limited to 200m (~8%), using VIO.

Then Parrot's Visual Geo-Positioning algorithm is fused to autopilot and the error drops to 20m.



8.4 Kalman Neural Network

Parrot's autopilot is an extended Kalman filter.

This algorithm merges various sensors (gyro, IMU, vision sensors, etc.) to estimate the drone's movements as accurately as possible.

The estimate of a Kalman filter can diverge when sensors with poor estimates are merged.

To make the fusion of vision sensors more robust, Parrot has developed a neural network based on an LSTM architecture, to determine at all times which sensors are the most viable.

This new method enables the autopilot to maximize vision sensor mergers, while having a very high capacity for filtering out sensors that have diverged. This ensures that the user can pilot Anafi UKR with a high level of performance at all times during the flight.

9 Obstacle avoidance

When the user enables the Obstacle avoidance feature, the supervision starts and the system evaluates environmental conditions, the aircraft's altitude and operational status to determine when to activate or deactivate obstacle avoidance functions. This intelligent control allows the aircraft to engage obstacle avoidance only when truly necessary, balancing safety with flight performance.

Visual feedback is provided through the obstacle avoidance pictogram in status bar in FreeFlight 8.

9.1 Key features

- 2 stereo cameras pointing forward and downward.
- Surrounding environment depth extraction from stereo matching forward and downward
- Multi resolution occupancy grid representation of the environment
- Global path planning with environment awareness to fulfill long term missions
- Local path planning for obstacle avoidance at speed up to 10 m/s (36 km/h – 22.5 mph)
- The avoidance is disabled for any motion out of camera field of views

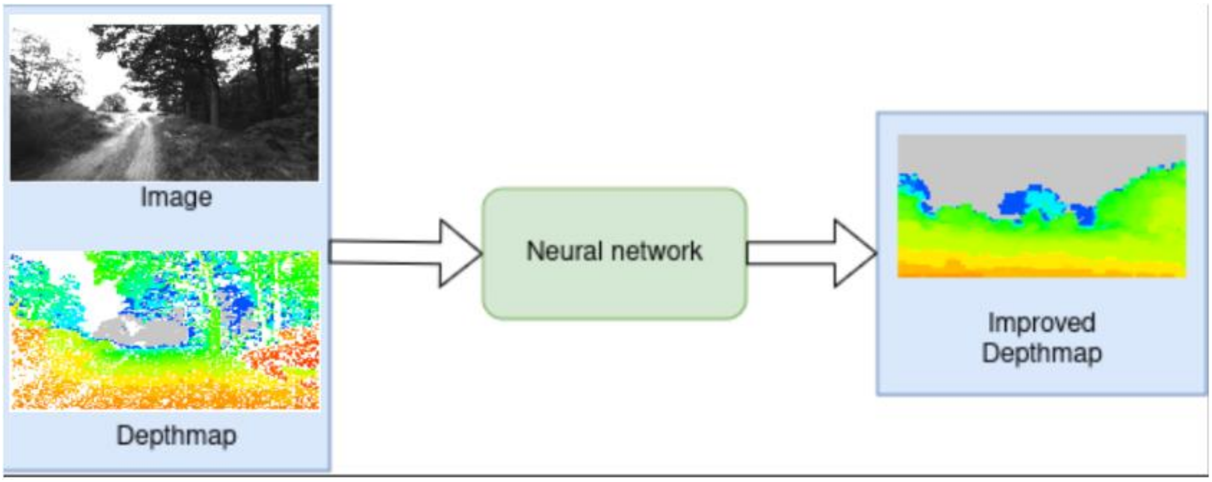
9.2 Ghost Buster

The depth map obtained from stereo matching is not sufficient for obstacle avoidance. This depth map suffers from a few defects:

- Noise: wrong depth values. The drone can hallucinate false obstacles and can get stuck even though there are no obstacles. The drone can also hit an obstacle because of the missing information of the presence of the object.
- Missing data: the depth value can be unavailable because of a lack of texture. The drone can also be stuck because of these missing values.

Parrot has developed a neural network capable of doing image completion to cope with noise and missing data. The neural network features are:

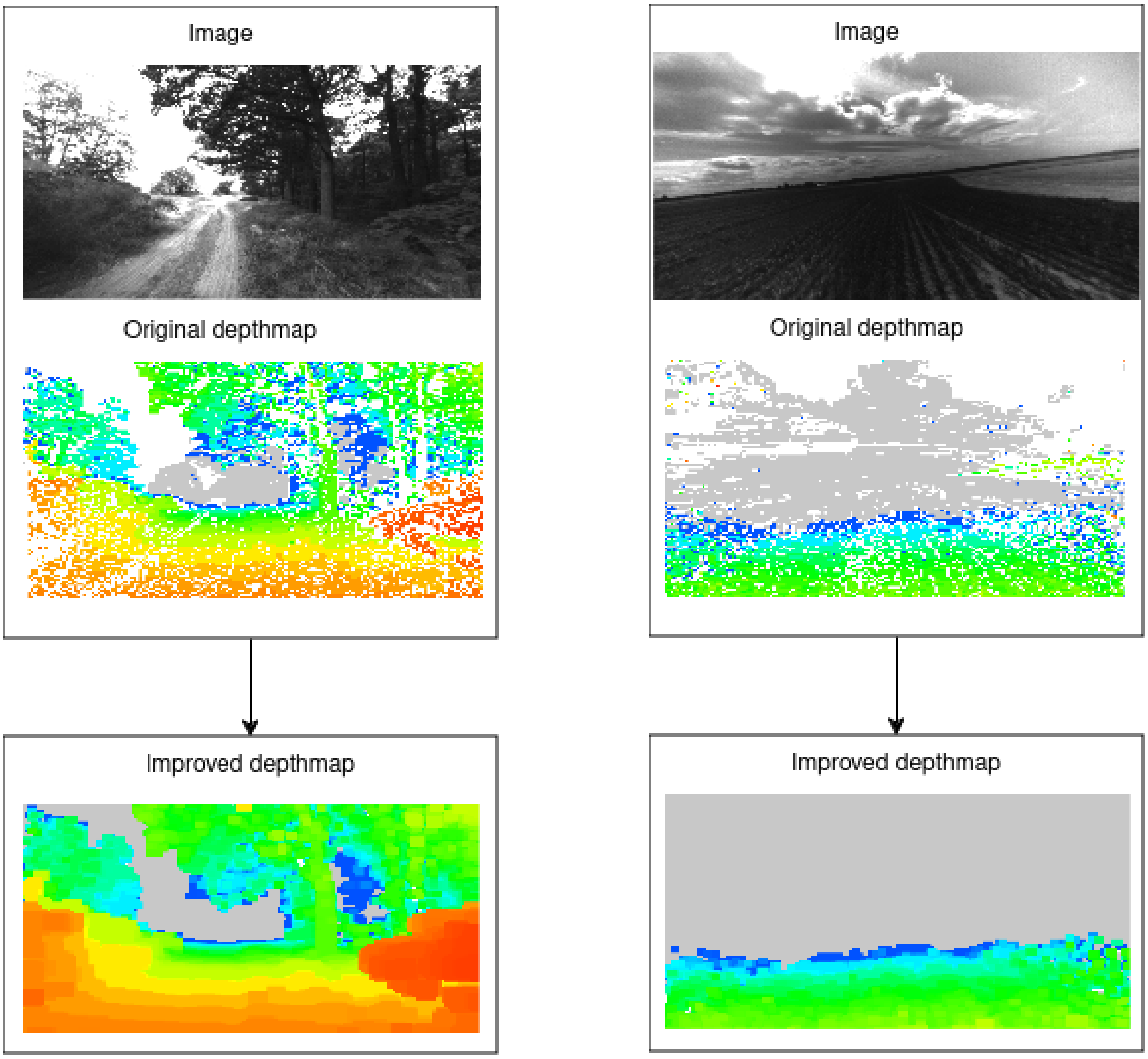
- it denoises the depth map
- it fills unavailable values of the depth map issued from stereo matching
- it runs in real time on both stereo cameras: front and down stereo cameras. The network is optimized and runs in parallel with other neural networks in constrained computational power.



Here are some visual examples.

- Top: the image from camera
- Middle: the depth map before the neural network
- Bottom: the depth map after the neural network

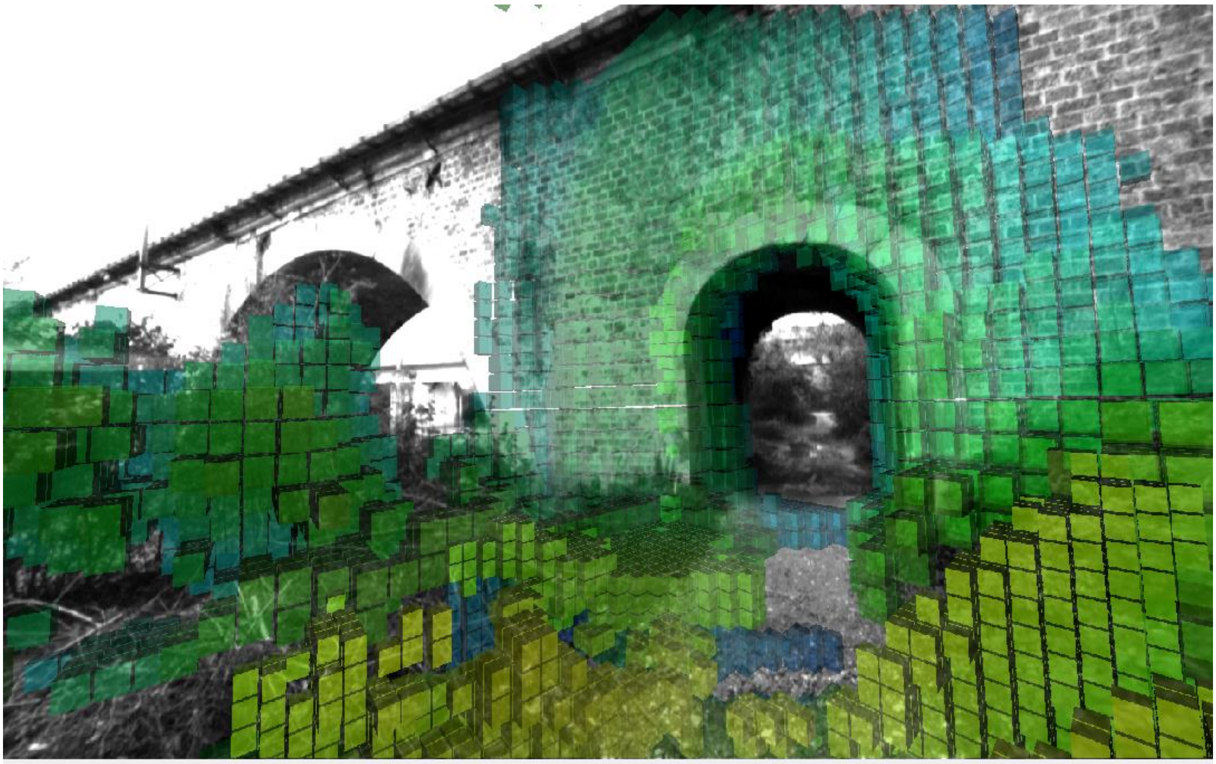
For depth map, the closest objects are in red color. The color goes from red, to orange, to yellow, to blue, to gray, as the object's distance increases. Gray color means superior to 16m.



9.3 3D Mapping of environment – Multigrid for occupancy

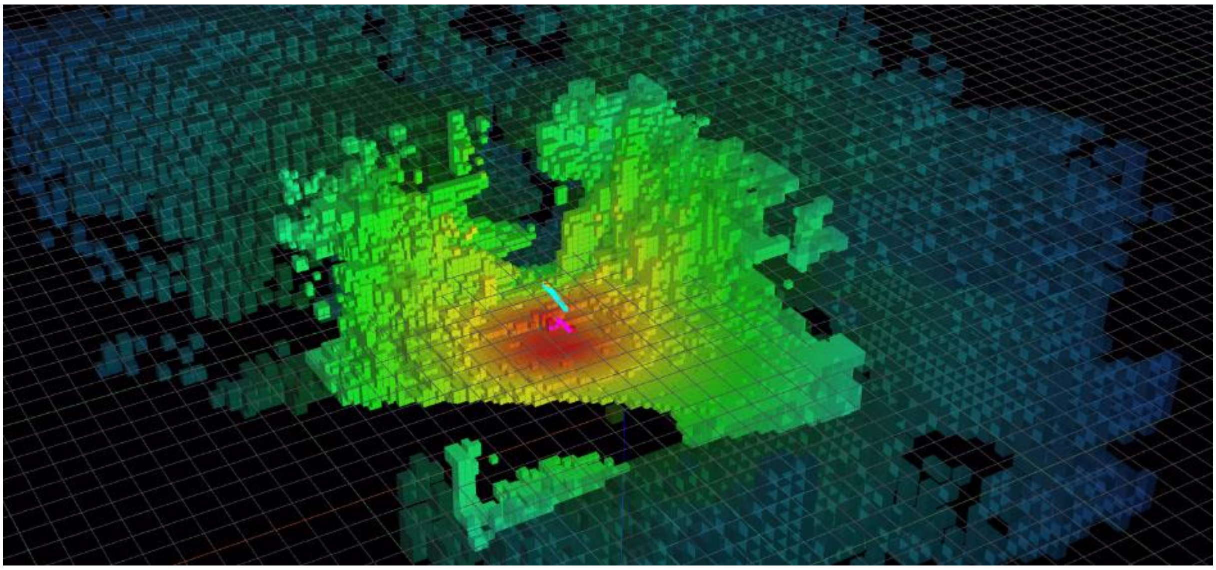
Update process

- Widening the depthmap provided by the different stereo pairs
- Conversion to distance map (equivalent to an instant cloud point in the FOV camera)
- Shift the multi occupancy grid to keep the drone in the center
- Raycast in the pixel direction of the distance map for editing



Characteristics:

- 2 resolutions: 25cm within 8m of the drone, 50cm beyond
- Dimensions: horizontal - 32m, vertical - 16m



9.4 Planning

Obstacle avoidance trajectories are generated at 33Hz by the guidance module. The guidance module takes user commands (waypoints, manual control) as inputs, and deduces a predicted trajectory – known as a nominal trajectory – over a few seconds in the future.

The optimal control algorithm then looks for the best possible trajectory by validating various criteria:

- Staying as close as possible to the nominal trajectory "desired" by the user
- Staying at a minimum distance from obstacles
- Respecting the dynamic constraints of the drone

Characteristics:

- Horizontal: 10m/s, vertical: 4m/s
- Safety distance to obstacles: 1m/s and quadratically up to 1.6m to 10m/s
- Minimum accessible path: 1.6m x 1.6m

10 Tracking

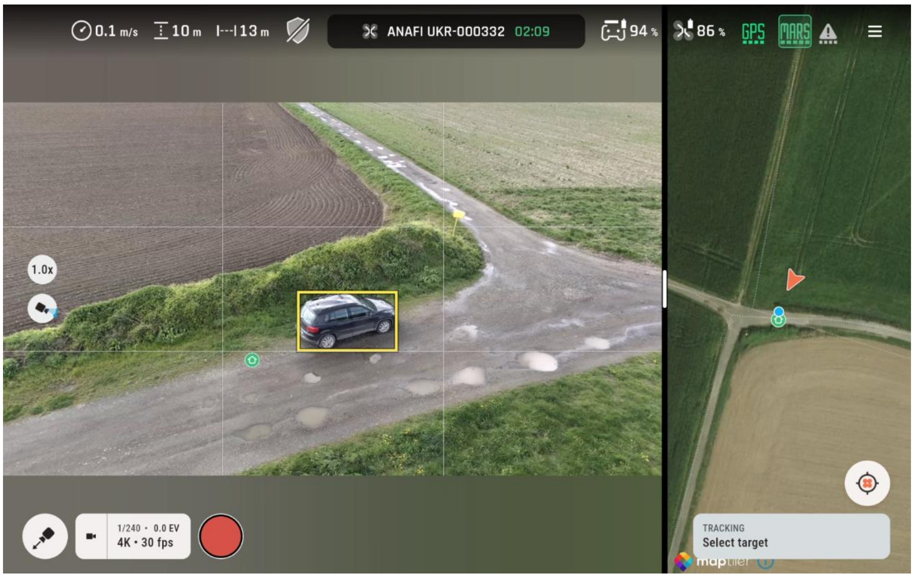
10.1 Target propositions

The first neural network is trained to find cars, people and animals. Target proposals are displayed on the FreeFlight 8 screen. The user selects the target on the screen according to 2 possibilities:

- The user selects a target from those suggested;
- The user draws a rectangle to define a target.

The convolutional neural network identifies objects in the scene and recognizes them regardless of their silhouette. This network is optimized on a base of Parrot images from Parrot drones for a high level of reliability.

The network can detect different classes of objects such as: people, cars, bikes, motorcycles, boats, animals (cows, dogs and cats), etc. These are the objects with the classes that are proposed to the users to select a target.



10.2 Tracking

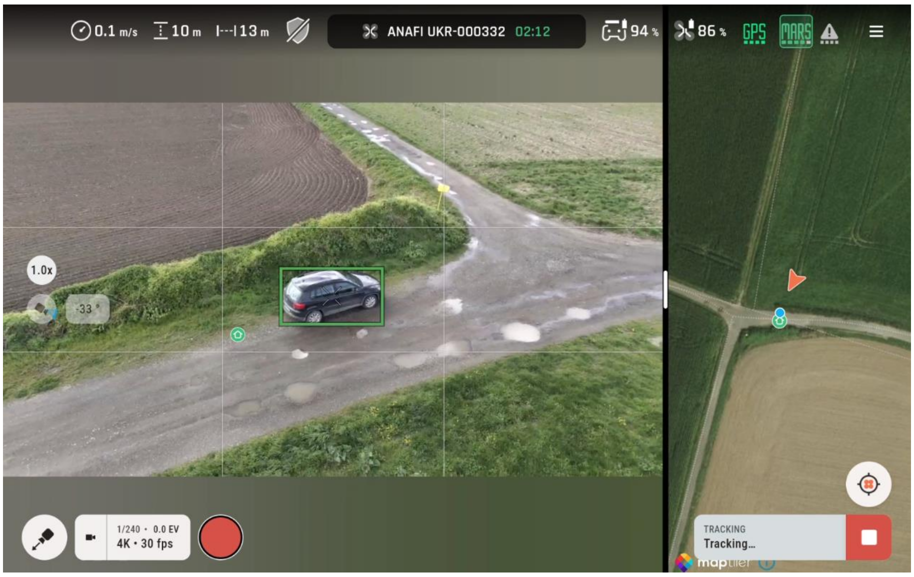
The visual tracking consists of merging:

- A motion model of the target relative to the drone
- A visual tracking neural network

The visual tracking neural network initiates the tracking with a single image and continues to learn the target model over time. The algorithm can track changes in the silhouette of the target, e.g. the algorithm can track changes in the direction of a moving vehicle (side view followed by rear view).

This network is optimized on a base of Parrot images from Parrot drones for a high level of reliability thanks to a large range of target kinds.

This tracking algorithm is also accessible when the thermal camera is activated, as well as with the SDK as a service on the drone.



Parrot

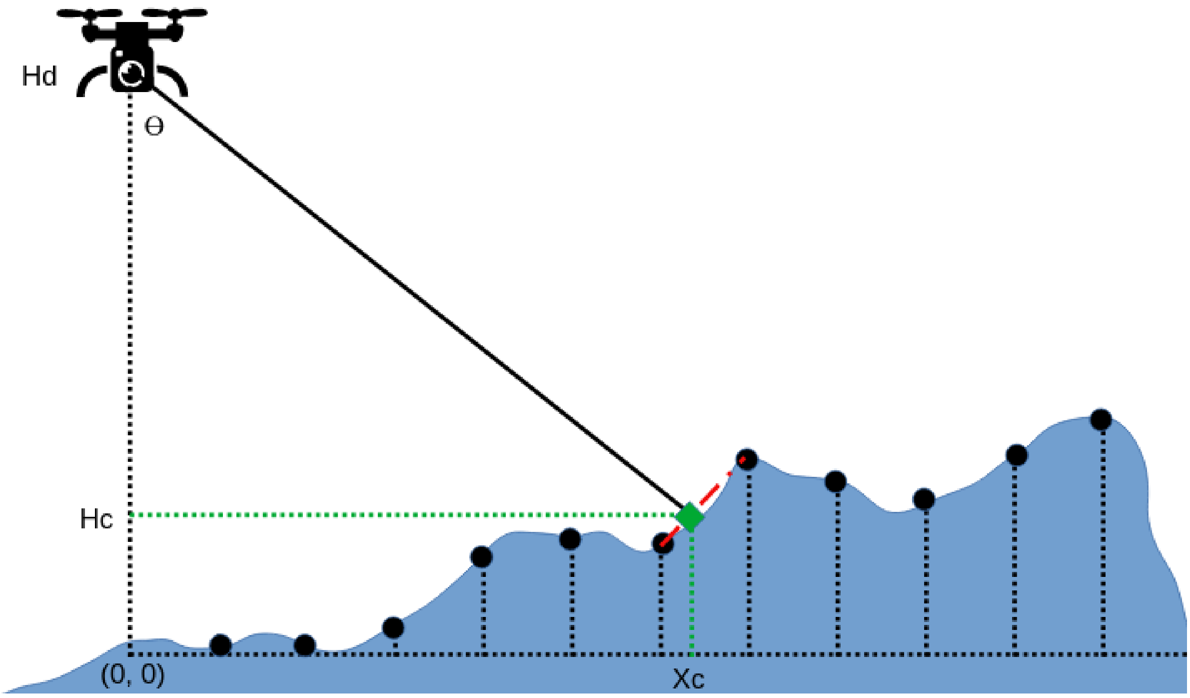
11 Cursor on Target (CoT)

The Cursor on Target (CoT) feature allows the user to simply get the full location information of the person or object the camera is pointing at.

The location information provided includes:

- GPS coordinates of the pointed or tracked object
- The distance between the drone and the targeted object
- The distance between the drone and the pilot

Coordinates are computed by the intersection between the drone's line of sight and a terrain elevation map.



CoT is available regardless of GPS availability or terrain maps availability

11.1 CoT's accuracy

The CoT's accuracy is measured using CEP N (radius of the circle containing the target N% of the time). The value of the CEP67 is displayed in FreeFlight 8.

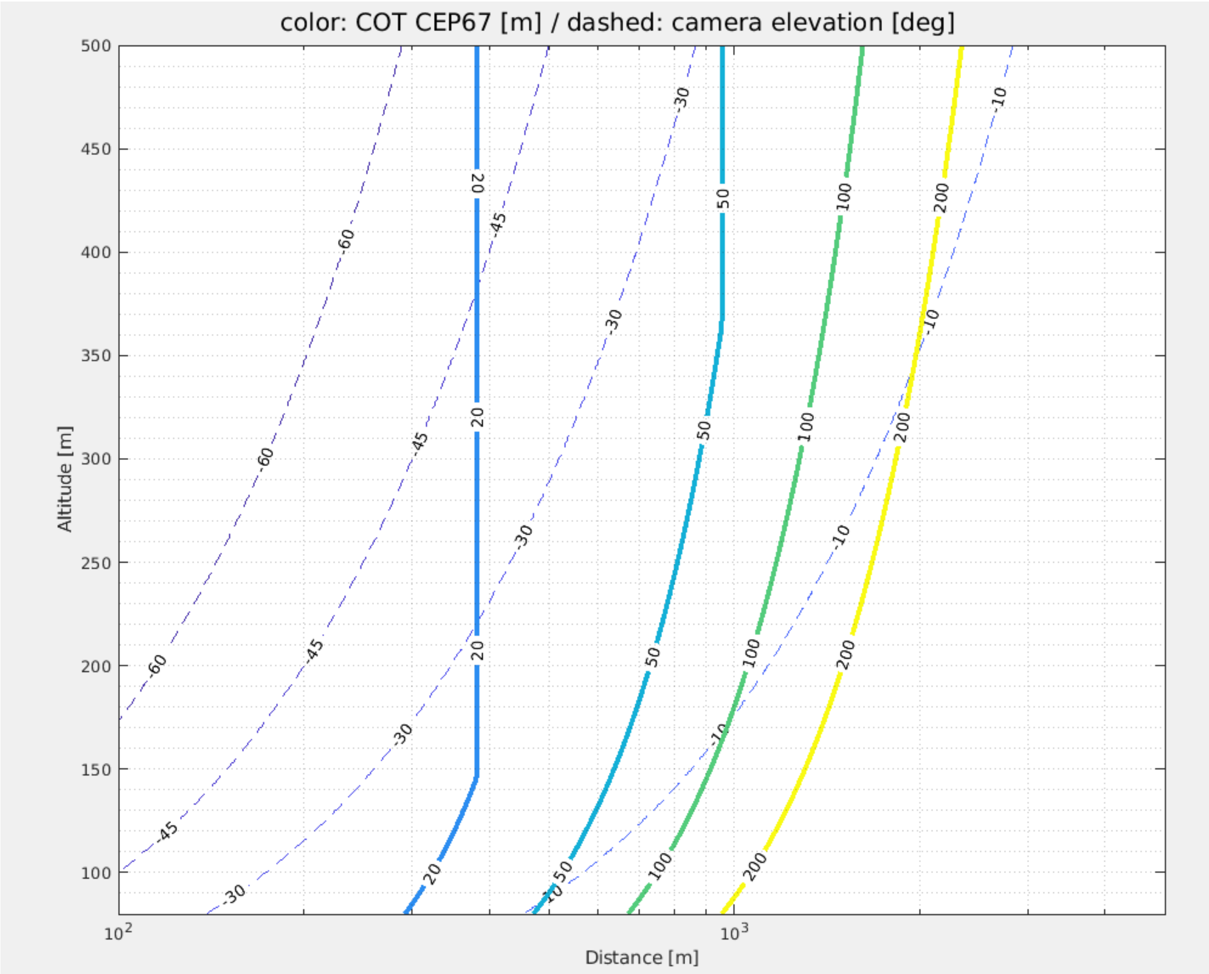
CEP N = Drone positioning CEP n+ terrain variation effect + Camera pointing effect

Typical CoT errors include:

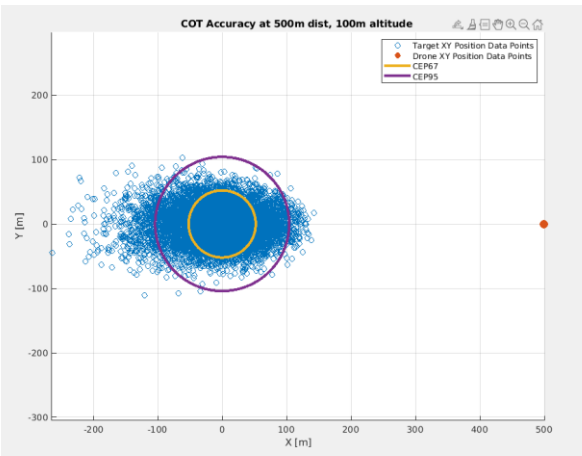
1. Drone positioning error:
   - 5m with GPS
   - 50m in no GPS mode (for more information, refer to *Chapter 8. Optical Navigation and Flight*)

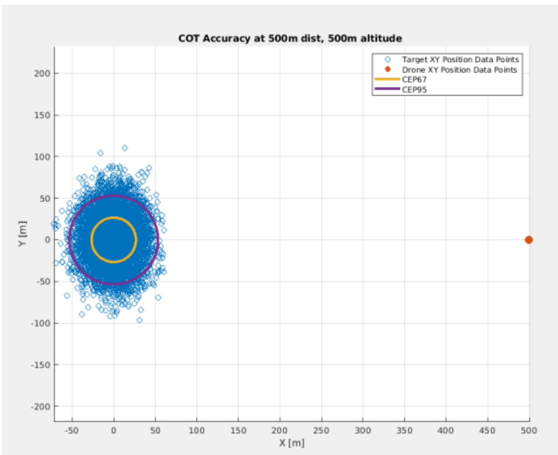
2. Terrain error depends on whether terrain elevation maps are loaded on the drone. When these maps are loaded on the drone, this effect may be neglected in most cases.

3. The camera pointing effect depends on typical angle errors and on the relative positioning of the drone and the target (see graphs below for details)



The charts below show an example of error distribution depending on relative positioning between the drone and the target.





12 Cybersecurity

12.1 Key features

- SD card AES-XTS encryption with a 512-bit key
- Internal storage encryption (AES-256-XTS) for media data
- FIPS140-2 compliant and CC EAL5+ certified Secure Elements
- AES-256 based encrypted radio link(s)

12.2 SD card encryption

The SD card encryption protects the confidentiality of data stored on the drone, even if it is lost or stolen. Once the encryption is activated, videos and photos are stored in an AES-XTS 512 bit-encrypted LUKS2 volume. The use of a unique identifier for each container enables the management of a fleet of SD cards which can be used on several drones.

Once the SD card is encrypted, it can never be accessed without the encryption key. The key is carried by FreeFlight 8 and is never stored permanently on the drone.

12.3 Internal storage encryption

Internal storage encryption protects the confidentiality of media data generated by users and stored by the drone, even if it is lost or stolen. Once the encryption is activated, videos and photos are stored encrypted in AES-256-XTS for contents and AES-256-CBC-CTS for filenames.

Once the internal storage is encrypted, user data can never be accessed without the encryption key, which is carried by FreeFlight 8 and never stored permanently on the drone.

12.3.1 Log files

Log files from the flights are stored in encrypted format, based on public/private key owned by Parrot. These log files are encrypted using Parrot’s public key and their content can only be read by Parrot company.

12.4 FIPS140-2 compliant and CC EAL5+ certified Secure Element

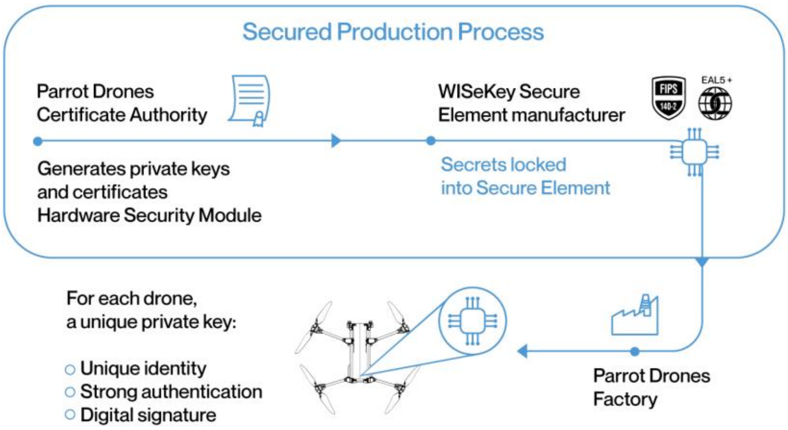
ANAFI UKR embeds a Wisekey Secure Element which is NIST FIPS140-2 Level 3 compliant and Common Criteria EAL5+ certified. A similar Secure Element is also embedded on the Skycontroller UKR.

The Secure Element:

- performs cryptographic operations;
- stores and protects sensitive information.

It features both EC NIST P-521 and EC NIST P-384 key pairs, unique to each drone. These private keys cannot be extracted from the Secure Element. The certificates associated with those keys are signed by a certificate authority.

The Secure Element protects the integrity of the embedded software, provides a unique identity to the drone for strong authentication, and features a unique digital signature of the pictures taken by the drone.



12.5 Secure boot: manufacturing

Two chains of trust are used on ANAFI-UKR and Skycontroller UKR, and are managed and owned by Parrot:

The first chain of trust uses SoC eFuses. These eFuses store the certificate chain, in the form of a chain of X509 certificates, and a digital signature which authenticates the hash table. The eFuses are immutable read only memory segments. The first certificate (called the root certificate) is authenticated against values burnt into the hardware, and each subsequent certificate is authenticated against the prior certificate.

The second chain of trust uses the WiseKey Secure Element hardware component and allows kernel authentication and file system content integrity. The Secure Element protects digital assets such as certificates against attacks.

These chains of trust are populated during manufacturing and cannot be tampered with later, considering their immutable properties.

12.6 Secure boot procedure

The boot sequence is secured by ensuring that the system checks that it is using Parrot software, and that this software has not been tampered with. A security check is performed at each initialization. The update service also controls the digital signature of software updates.

The drone and controller use the same secure initialization procedure. Once powered up, the drone and controller's initialization procedure consists of three phases:

1. Primary Bootloader: this step loads the bootloader, checks its signature and if validated, runs the bootloader step. It is based on Qualcomm SoC facilities to store a certificate chain (eFuses), forming a chain of trust, generated by Parrot.
2. Secondary Bootloader: this step checks the OS image’s integrity by checking the kernel image signature, using communication means with Secure Element.
3. OS boot: once started, the kernel checks the filesystem integrity by using a cryptographic digest of the file system content.

12.7 Secured update

The update procedure is based on the same principles for the drone and controller.

The update procedure consists of four phases:

1. Prior to the update start, i.e. in the context of the operational system to which the update image is sent, the update image is received, and its signature is checked against the secure element challenge. If this check succeeds, the information of a running update is stored in the system for the bootloader in the following steps, to retrieve it.
2. Device is rebooted
3. The primary bootloader step is run (step 2 in section *Secure boot procedure*)
4. The secondary bootloader retrieves the update status and if set, checks the kernel image signature of the updater system, using communication means with Secure Element. If this succeeds, the updater OS is launched, checks the update image integrity and signature and installs it if the signature is ok.

12.8 Secured data link

The **MARS** main radio link is protected by 2 levels of AES-256 based encryption at packet level and at radio level.

The alternative **LoRa** data link is also securely encrypted, it uses a combination of AES-128 and ChaCha20, AES-128 for critical commands such as RTH and Kill Switch, and ChaCha20 for piloting commands.

In all cases, keys are renewed at each connection.

13 Cloud

13.1 No data shared by default

Parrot does not collect any data without the user's consent. The user can decide whether to share data to Parrot's infrastructure or not. Data hosted by Parrot enables the user to synchronize flight data and flight plans between different devices, aids support, and helps Parrot to enhance our products.

ANAFI UKR is compliant with the European Union General Data Protection Regulation (GDPR) and goes even further. For example, users are in complete control of their data, and can delete all data with just 1-Click in the FreeFlight 8 app, or in the privacy settings of their Parrot.Cloud account. As a result, users not only have the ability to stop sharing data at any time, but they can also delete all data very easily.

Should the user consent to share data, data processing is fully transparent and described in the *Parrot Privacy Policy*.

13.2 Data collection mechanism

During the drone's flight, data collection is completed and encrypted on the internal flash, in a lite form and a more complete one. The complete data collection log files are kept on the drone, and not exported by any automatic means. At the end of a flight, a lite flight log is retrieved from the drone in the FreeFlight 8 data store, exported in gutma format (json) to produce the flight report that can be read in the app.

If sharing is allowed, the lite flight log is uploaded to Parrot.cloud.

13.3 Collected data

Parrot cloud collects 4 data types:

- "Static" (product data)
  - Drone, Battery and Controller serial number
  - Firmware version for drone, battery and controller
  - Hardware version for drone, battery and controller
  - Device model
  - FreeFlight 8 release version
- "Events"
  - Alerts: battery, autopilot, sensors, gimbal, camera
  - Connectivity: connection/disconnection, streaming start, interference alert, weak signal
  - Camera: streaming statistics, settings changes
  - Flight: status change (take-off, landing, hovering, etc.), flight mission activation (Flight Plan, Tracking)
- "Contextual images"
  - Timelapse pictures (one every 2 minutes)
  - Deep learning (matching more objects, landscapes for flight autonomy improvement, tracking, obstacle avoidance)
  - Stereo vision (depth map)
  - Images triggered by event
  - Start and ending of precise hovering phrases, precise landing
  - Drone crash
  - Faces are automatically blurred when transferred
- "Telemetry" (refer to the following table for details)

SYSTEM	DESCRIPTION	SAMPLING
FLIGHT CONTROL	GNSS Position, speed, height, drone's attitude (phi, theta, psi angles), wind strength estimate	5Hz
CONNECTIVITY	Wi-Fi/5G/RADIO Physical layer: RSSI, PER (packet error rate), throughput estimator, tx/rx bytes tx/rx packets, interference measurement Streaming RTP statistics Piloting commands (jitter, lost count)	1Hz
CAMERA	Zoom factor, shutter time, gain, NED reference	1Hz
GNSS	Number of satellites (in sight, in synch, precision) – GPS, Glonass, Galileo	1Hz
GIMBAL	Camera tilt	5Hz
BATTERY	Temperature, tension, current, remaining capacity.	1Hz
AUTOPILOT	Position, speed, height, drone's attitude	5Hz
VERTICAL CAMERA	Exposure time, gain, brightness	1Hz
CONTROLLER	Roll, Pitch, Yaw, and Speed commands	1Hz
	Zoom command	
	Gimbal command	

13.4 Data Usage

13.4.1 Maintenance management

<u>Preventive maintenance:</u> Parrot tools collect all information relevant to missions (mission type, time of take-off and landing, missions count, drones' locations, flight speed, Flight Plan, and AirSDK settings). This offers Parrot an accurate real time status of drone fleets (as well as their controllers and batteries).

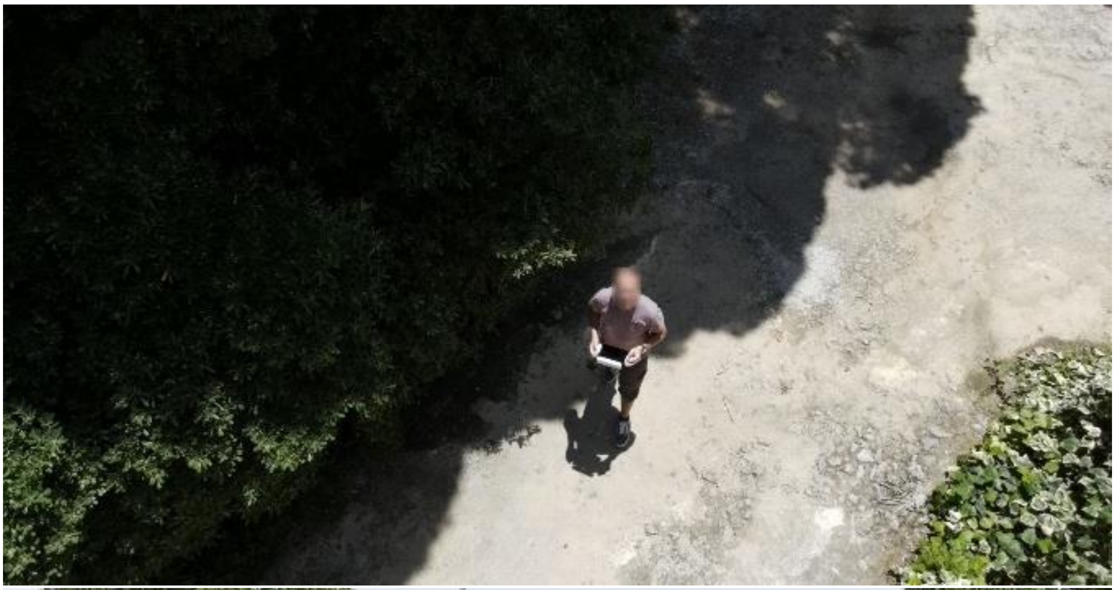
<u>Corrective maintenance:</u> Collected information is useful to quickly pinpoint information pertaining to the state of a particular drone or battery.

13.4.2 Artificial Intelligence (AI) improvement

AI elements onboard Parrot drones offer users unequalled services and performance, including obstacle avoidance, target following, several flight modes, etc. The quality of AI relies on the quantity and quality of data (images and videos) collected. This data feeds the machine learning. In that respect, the quality of the data is not the only crucial element, the metadata associated with this data is fundamental too. For this reason, Parrot tools collect images and metadata on a regular basis and depending on events, for a total of 1 to 2 Mb/minute flight.

Finally, all texts and faces contained on collected images are automatically blurred, once by the FreeFlight 8 app before sharing, and once at reception with Amazon cloud services. On the cloud, 3 analyses are done:

- Amazon recognition “detect_faces”
- Amazon recognition “detect_texts “
- Amazon recognition “detect_labels”



Images, videos, and metadata collection is an essential asset to widen the learning field of Parrot’s vision algorithms, and to add new and complex situations to enhance the visual autonomy of Parrot drones.

14 SDK

14.1 Key features

- Embed your code on the drone with **Air SDK**
- Create mobile apps with **Ground SDK**
- Use state-of-the-art drone simulation with **Sphinx**
- Develop Python scripts with **Olympe**
- Process video and metadata with **PDrAW**

Parrot **S**oftware **D**evelopment **K**it is a set of tools and open-source software for developers. Since the first A.R. Drone in 2010, open-source has been at the heart of our platforms and developer tools, and Parrot continually contributes to the open-source community.

All Parrot SDK resources are available for free, without registration or tracking, on the *Parrot Developer Portal*.

Join thousands of developers on Parrot's developer *forum* and discuss directly with Parrot engineers.

14.2 Run your code on the tablet

The ground SDK is a Ground Control Station (GCS) framework for mobile devices (both iOS and Android are supported). It allows any developer to create a mobile application for ANAFI UKR, controlling the drone directly from the mobile device. All the features of the aircraft (control, video, settings) are accessible through an easy-to-use and fully documented API.

14.3 Run your code on ANAFI UKR

Air SDK provides a breakthrough technological architecture to load and run code directly on ANAFI UKR. Developers can program custom-designed flight missions with access to all drone sensors, connectivity interfaces, and autopilot features.

Air SDK gives onboard access to:

- All the sensors (IMU, GNSS, TOF, …) and flight states
- Video streams and metadata from all cameras
- USB communication interfaces
- Depth maps and occupation grids
- Obstacle avoidance trajectory generation

Any developer can:

- Modify the drone state-machine by creating Flight Missions
- Change the guidance mode
- Add onboard Linux processes (such as computer vision algorithms on camera images)

Air SDK supports C, C++, and Python programming languages. Air SDK comes with a comprehensive installation guide and API documentation. Many sample applications illustrate all the possibilities offered by its unique architecture.

Get Air SDK documentation on https://developer.parrot.com/docs/index.htm

15 Simulator

15.1 Key features

Parrot Sphinx is a state-of-the-art drone simulation tool. Parrot engineers use it to develop and test all the current and upcoming features and performance of Parrot drone platforms.

The main concept is to execute the drone firmware, with all its sensors and actuators, in a visually and physically realistic environment, isolated from the computer host system.

Parrot Sphinx allows you to virtually fly an ANAFI UKR to become familiar with the drone, the controller, and the FreeFlight 8 app.

For this, Parrot Sphinx runs the same software as is onboarded on the drone. It simulates all sensors, including cameras, in a realistic environment. Simply connect the Skycontroller UKR to your computer to discover the ANAFI UKR flight experience.

15.1.1 Main characteristics of the simulator:

- Real-time
- Hardware-In-the-Loop mode to run specific code directly on ANAFI UKR processor.
- Realistic 3D scenes rendered by Unreal Engine with realistic camera effects
    - shot noise
    - distortion
    - photodiode saturation
    - lens flare
    - lens shading
    - fisheye
- Available interfaces
    - main viewer
    - web dashboard
- Special cameras
    - ground truth depth maps
    - segmentation maps
    - optical flow
- Weather and lighting of the scene
    - clouds
    - fog
    - wind
    - light direction and intensity

15.1.2 Advanced usage

- Moving pedestrians and vehicles
- Build your own scene
- All usages fully scriptable

15.2 Flight training with ANAFI UKR

Parrot Sphinx is provided on a USB key as part of the drone's pack contents or can be downloaded from our developer platform (https://developer.parrot.com/docs/sphinx/installation.html).

15.2.1 System requirements

Linux environment

The USB key provided embeds Parrot Sphinx, and is loaded with an adequate version of Linux. This is the recommended usage. For other usages, Parrot Sphinx runs on the latest Ubuntu and Debian distribution (Linux kernel version: 5.8 or higher).

UEFI Secure Boot must be disabled on the workstation for Parrot Sphinx to start.

Recommended system requirements

- 12-core CPU @ 2.5GHz
- 16 GB DDR
- Nvidia RTX 2070 or better GPU with 8 GB GDDR (with up-to-date Nvidia drivers)
- 30 GB of free disk space, SSD
- "Low-latency" kernel variant (e.g. 5.13.0-27-low latency)

15.2.2 Installation and Quick Start

Setup

The Parrot Sphinx version provided on a USB key is a standalone version and does not require installation. However, an *Installation procedure* available online. This procedure retrieves the latest version from Parrot servers.

Directly connect the Skycontroller UKR using an Ethernet cable

The easiest way is to connect the Skycontroller UKR to the PC using an Ethernet cable. The controller will be recognized automatically by Parrot Sphinx and used to pilot the drone in the simulation.

16 FreeFlight 8

16.1 Presentation

FreeFlight 8 is the latest version of the mobile application developed by Parrot for ANAFI UKR.

FreeFlight 8 is built with Flutter technology. Flutter is an open-source framework developed and supported by Google that allows developers to build native applications for all popular platforms.

Parrot used Flutter to build the FreeFlight 8 application for both iOS and Android platforms with one single codebase.

16.2 Key features

FreeFlight 8 has been developed to provide the best-in-class user interfaces for drone use, and includes:

- Live streaming view from the drone main camera
- Follow drone position on the map
- HUD with key telemetry data available at first look
- Manage drone cameras (visible and IR)
- Access to all settings (drone, controller, and application settings)
- Visualize media recorded by the drone in the Gallery
- Visualize flight logs
- Manage Parrot.Cloud login for flight logs and project synchronization

16.3 Flight modes

FreeFlight 8 offers four different flight modes.

- Piloting
- Tracking
- Touch & Fly
- Flight Plan

16.4 Parrot.Cloud synchronization

Flight data synchronization on Parrot.Cloud can be done upon operator decision.

In order to activate synchronization on Parrot.Cloud, the device must be logged onto a Parrot.Cloud account. Another condition that needs to be met is to activate the data sharing mode.

In private mode, absolutely no data is synchronized, even if the device is logged onto a Parrot.Cloud account.

	Logged on Parrot.Cloud	Not logged on Parrot.Cloud
Private mode	No data is shared	No data is shared
Sharing mode	Flight logs are synchronized Flight Plan projects are synchronized Crash reports and drone sensor images are uploaded to Parrot servers	Crash reports are anonymously uploaded to Parrot servers

For security reasons, sharing mode cannot be activated without the lock screen enabled on the device.

17 Maintenance recommendations

COMPONENT	RECOMMENDED REPLACEMENT INTERVAL
PROPELLERS	100 hours
MOTORS & ARMS	760 hours
ANAFI UKR SMART BATTERY	80% capacity after 300 charge/discharge cycles

18 Webserver

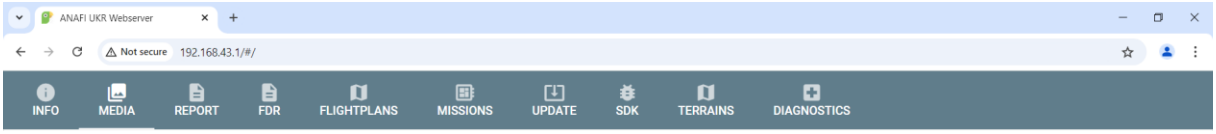
ANAFI UKR and Skycontroller UKR have a webserver feature. This feature allows the user to access additional information, and additional options for the drone and controller.

Access to the webserver requires:

- A computer
- An internet browser
- An appropriate cable - an Ethernet cable (controller), a USB-C to USB-A cable (drone)
- The appropriate URL (Drone - 192.168.43.1, Controller - 192.168.53.1)

18.1 ANAFI UKR webserver

The webserver interface has the following tabs:

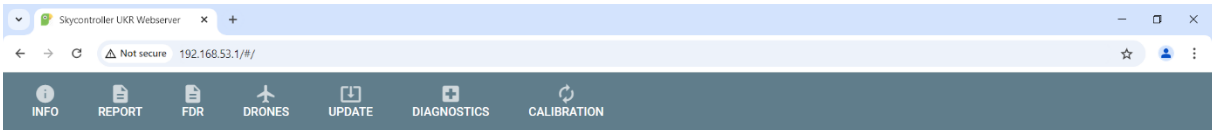


Each of the 10 tabs displays additional information about ANAFI UKR, or provides additional options:

- **INFO**
- **MEDIA**
- **REPORT**
- **FDR**
- **FLIGHTPLANS**
- **MISSIONS**
- **UPDATE**
- **SDK**
- **TERRAINS**
- **DIAGNOSTICS**

18.2 Skycontroller UKR webserver

The webserver interface has the following tabs:



Each of the 7 tabs displays additional information about Skycontroller UKR, or provides additional options:

- **INFO**
- **REPORT**
- **FDR**
- **DRONES**
- **UPDATE**
- **DIAGNOSTICS**
- **CALIBRATION**

19 Accessories

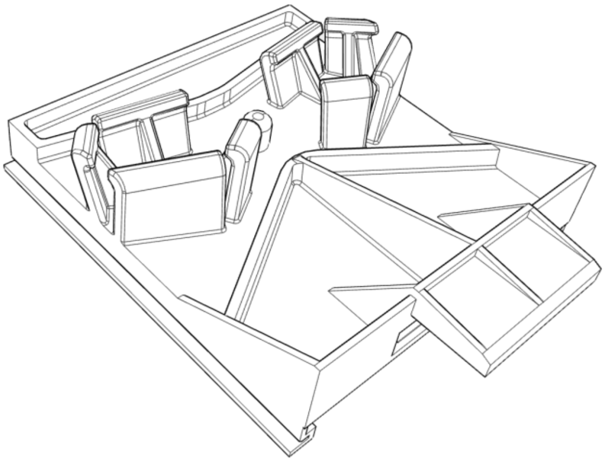
Multiple accessories are available for ANAFI UKR and Skycontroller UKR.

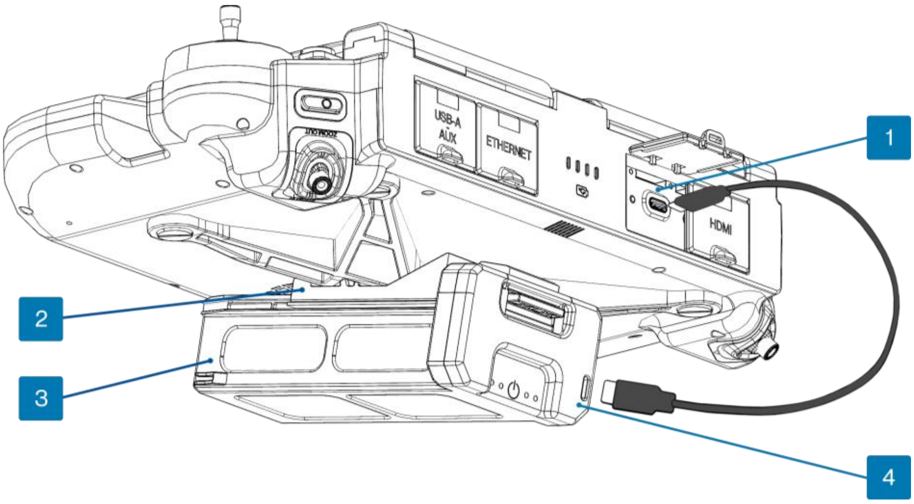
19.1 Open-source 3D printable accessories

Contact Parrot or your Parrot reseller to obtain the CAD files for the following accessories:

19.1.1 Power bank holder for Skycontroller UKR

The power bank holder fits onto the tripod holder on the bottom of Skycontroller UKR.





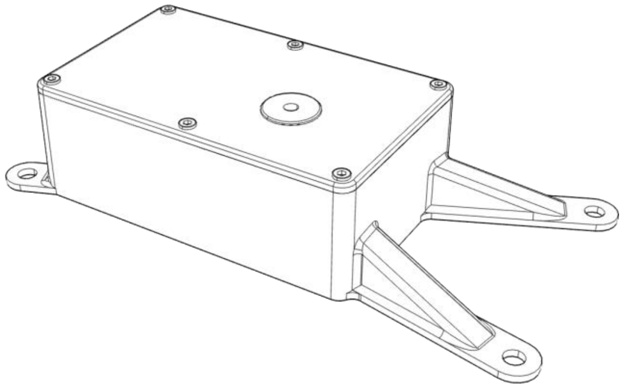
1. Skycontroller UKR USB-C charging port
2. Power bank holder
3. Smart LiPo battery
4. Smart LiPo battery charge port

19.2 Proprietary accessories

Contact Parrot or your Parrot reseller to purchase the following accessories

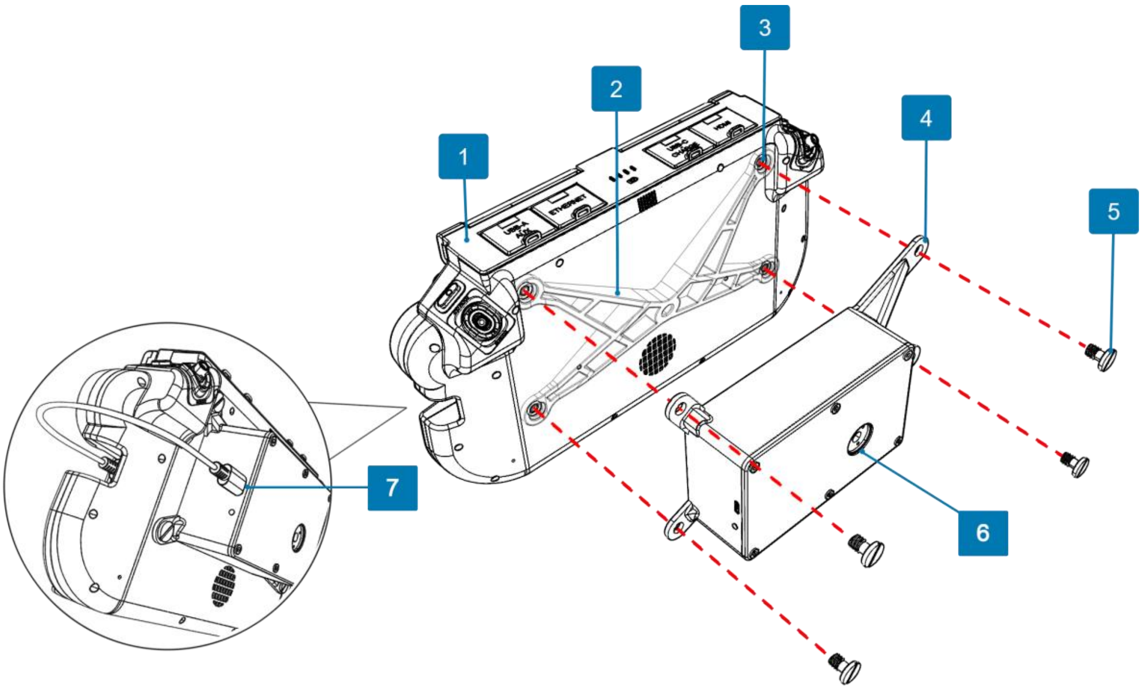
19.2.1 MARS Orbiter

MARS Orbiter is a small, motorized box that attaches to the underside of the remote Skycontroller UKR, or MARS Ranger. When mounted on a tripod, MARS Orbiter rotates the remote Skycontroller UKR to ensure that it always faces the aircraft's direction.



TECHNICAL SPECIFICATIONS

DIMENSIONS	207 x 107 x 55 mm (8.1 × 4.2 × 2.2")
MASS	525 g
TRIPOD INTERFACE	Standard UNC ¼" screw
ROTATION SPEED	1 RPM
MAX SLEW RATE	6°/s
INGRESS PROTECTION (IP) RATING	IP53



1. Remote Skycontroller UKR
2. Tripod bracket
3. Locating holes
4. MARS Orbiter

5. Screws (1 of 4)
6. Tripod interface
7. USB-C to USB-C cable

19.3 3rd party accessories

The following accessories are available from 3rd parties:

- Harness for Skycontroller UKR: brand Mobilis, ref. 001024

- Anti-glare filter for the tablet: brand Brotect, ref. 1952729
- Tripod for Skycontroller UKR:
  - Brand: K&F Concept, ref. KF09.116
  - Brand: K&F Concept, ref. K234 A0

20 Certifications

All certifications and reports are available upon request.

20.1 Smart battery

COUNTRY	NAME	TESTING STANDARDS
INTERNATIONAL	CB Scheme	IEC 62133-2: 2017+A1:2021
	Transport	UN 38.3
	MSDS	Material Safety Data Sheet test report
EUROPEAN UNION	CE-EMC	EMC directive: 2014/30/UE, EN61000 6.1, EN61000 6.3
	CE-Safety	EN 62368-1: 2014+A11:2017
	Battery Directive	HR2024
	ROHS	RoHS Directive 2011/65/EU and amendment directives (EU) 2015/863 on Lead, Cadmium, Mercury, Hexavalent Chromium, PBBs & PBDEs, Phthalates (DBP, BBP, DEHP, DIBP) content
	REACH	Two hundred and thirty-five (235) substances in the Candidate List of Substances of Very High Concern (SVHC) for authorization published by European Chemicals Agency (ECHA) regarding Regulation (EC) No 1907/2006 and its amendment directives concerning the REACH in the components of submitted sample as the requirement of client
UNITED STATES	UL test report by BACL	UL62133 for the battery
	FCC	FCC Part 15B (EMC)
	PROP65 for California	Total lead and Phthalates (DEHP)
JAPAN	PSE	J62133
AUSTRALIA/ NEW-ZEALAND	RCM- Safety	use CB of IEC 62133-2: 2017+A1:2021
	RCM - EMC	AS/NZS 61000.6.3:2021

20.2 ANAFI UKR

COUNTRY	NAME	TESTING STANDARDS
EUROPEAN UNION	**CE** EMC	EMC directive: 2014/30/UE EN 55032:2015/A1:2020/ EN 301 489-1, EN 301 489-3
		MIL STD 461-G (250 V / m)
	CE Safety	EN 62368-1: 2014+A11:2017
		Machinery Directive EN60204 （EN1050）, ISO12100-1, ISO13849-1, EN61558
		SAR evaluation EN IEC 62311: 2020
	CE RADIO	ETSI EN 300 220-1 V3.1.1 (2017-02) ETSI EN 300 220-2 V3.1.1 (2017-02) ETSI EN 300 328 V2.2.2 (2019-07) EN IEC 62311: 2020
	CE ROHS	RoHS Directive 2011/65/EU and amendment directives (EU) 2015/863
	Cybersecurity	ETSI EN 303 645 V2.1.1 (2020-06) & ETSI TS 103 701 V0.0.9 (2021-05)
	CE REACH	Two hundred and thirty-five (235) substances
UNITED STATES	FCC EMC	FCC PART 15B, CLASS B
	FCC RADIO	FCC Part 15.247 ; SAR FCC
	FCC PROP65	Total lead and Phthalates （DEHP）
CANADA	**IC** EMC	ICES-003, ISSUE 7, OCTOBER, 2020
	IC RADIO	RSS-247, SAR RSS-102
OTHER	**Acoustic**	ISO 3744 (acoustic Power level)
	European Drone Regulation For open and specific categories Commission Delegated Regulation (EU) 2019/945 amended by: Commission Delegated Regulation (EU) 2020/1058	prEN 4709-001

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20.3 Skycontroller UKR

COUNTRY	NAME	TESTING STANDARDS
EUROPEAN UNION	CE EMC	EMC directive: 2014/30/UE EN 55032:2015/A1:2020/ EN 301 489-1, EN 301 489-3
	CE Safety	EN 62368-1:2014+A11:2017
		SAR evaluation EN IEC 62311: 2020 EN 50360:2017,EN 62479:2010,EN 50663:2017 SAR testing
	CE RADIO	ETSI EN 300 220-1 V3.1.1 (2017-02), ETSI EN 300 328 V2.2.2 (2019-07)
	CE ROHS	RoHS Directive 2011/65/EU and amendment directives (EU) 2015/863
	CE REACH	Two hundred and thirty-five (235) substances
UNITED STATES	FCC EMC	FCC PART 15B, CLASS B
	FCC RADIO	FCC Part 15.247 ; SAR FCC
	FCC PROP65	Total lead and Phthalates （DEHP）
CANADA	IC EMC	ICES-003, ISSUE 7, OCTOBER, 2020
	IC RADIO	RSS-247, SAR RSS-102
OTHER	USB	USB–IF Compliance testing
	Cybersecurity	ETSI EN 303 645 V2.1.1 (2020-06) & ETSI TS 103 701 V0.0.9 (2021-05)
	European Drone Regulation For open and specific categories Commission Delegated Regulation (EU) 2019/945 amended by : Commission Delegated Regulation (EU) 2020/1058	prEN 4709-001

20.4 ANAFI UKR Product Robustness Validation

CATEGORY	TEST	TEST STANDARDS
CLIMATIC	Damp heat exposure	NF EN 60068-2-78
CLIMATIC	Extreme temperature exposure	NF EN 60068-2-1 & 2-2
CLIMATIC	Thermal shocks	NF EN 60068-2-14
CLIMATIC	IP5X – dust protection	IEC60529 IP5X
MECHANIC	Drone Vibration	NF EN 60068-2-64
MECHANIC	Sine vibration	NF EN 60068-2-6
MECHANIC	Drone Take-off / Landing endurance	Internat test protocol: DR-2023-0078
MECHANIC	Gimbal endurance	Internat test protocol: DR-2023-0073
MECHANIC	Motor and propeller endurance	Internat test protocol: DR-2023-0037
MECHANIC	Battery connection/disconnection endurance	Internat test protocol: DR-2023-0066
MECHANIC	USB-C Connectors endurance	USB_Type-C_Compliance_Document_rev_1_2 - August 2017
MECHANIC	HALT (Highly Accelerated Life Test)	QUALMARK-HALT-TESTING-GUIDELINES 2010
MECHANIC	Sound power level determination	ISO 3744
ELECTRIC	ON / OFF endurance	Internat test protocol: DR-2023-0060
ELECTRIC	EMC Radiated emission	EN55032
ELECTRIC	EMC Radiated immunity	MIL STD 461G
PACKAGING	Packaging vibration	Internat test protocol (inspired by ASTM D4169): UTS_VS_001
PACKAGING	Packaging drop	Internal test protocol (inspired by ISTA2A): DR-2023-0102
CLIMATIC	Cold exposure	NF EN 60068-2-1
CLIMATIC	Dry heat exposure	NF EN 60068-2-2
CLIMATIC	Extreme temperature exposure	NF EN 60068-2-1 & 2-2
CLIMATIC	Thermal shocks	NF EN 60068-2-14
MECHANIC	Handling Drop	NF EN 60068-2-32 (for Drops) NF EN 60068-2-27 (for Shocks)
ELECTRIC	Battery charge / discharge endurance	Custom

20.5 Skycontroller UKR Product Robustness Validation

CATEGORY	TEST	TEST STANDARDS
CLIMATIC	Damp heat exposure	NF EN 60068-2-78
CLIMATIC	Extreme temperature exposure	NF EN 60068-2-1 & 2-2
CLIMATIC	Thermal shocks	NF EN 60068-2-14
CLIMATIC	IP5X – dust protection	IEC60529 IP5X
MECHANIC	Drone Vibration	NF EN 60068-2-64
MECHANIC	Sine vibration	NF EN 60068-2-6
MECHANIC	Drone Take-off / Landing endurance	Internat test protocol: DR-2023-0078
MECHANIC	Gimbal endurance	Internat test protocol: DR-2023-0073
MECHANIC	Motor and propeller endurance	Internat test protocol: DR-2023-0037
MECHANIC	Battery connection/disconnection endurance	Internat test protocol: DR-2023-0066
MECHANIC	USB-C Connectors endurance	USB_Type-C_Compliance_Document_rev_1_2 - August 2017
MECHANIC	HALT (Highly Accelerated Life Test)	QUALMARK-HALT-TESTING-GUIDELINES 2010
MECHANIC	Sound power level determination	ISO 3744
ELECTRIC	ON / OFF endurance	Internat test protocol: DR-2023-0060
ELECTRIC	EMC Radiated emission	EN55032
ELECTRIC	EMC Radiated immunity	MIL STD 461G
PACKAGING	Packaging vibration	Internat test protocol (inspired by ASTM D4169): UTS_VS_001
PACKAGING	Packaging drop	Internal test protocol (inspired by ISTA2A): DR-2023-0102
CLIMATIC	Cold exposure	NF EN 60068-2-1
CLIMATIC	Dry heat exposure	NF EN 60068-2-2
CLIMATIC	Extreme temperature exposure	NF EN 60068-2-1 & 2-2
CLIMATIC	Thermal shocks	NF EN 60068-2-14
MECHANIC	Handling Drop	NF EN 60068-2-32 (for Drops) NF EN 60068-2-27 (for Shocks)
ELECTRIC	Battery charge / discharge endurance	Custom

20.6 Hardcase

20.6.1 DEF-STAN 81-41

TEST TYPE	STANDARD & DESCRIPTION	TEST ITEM
WATER SPRAY/RAIN	Test L; DEF STAN 00-35 Part 3 Chapter 3-27, Test CL27 Exaggerated rain method for 40 minutes/face	Nanuk 930R and Nanuk 955R
LOW TEMPERATURE	Test G; DEF STAN 00-35 Part 3 Chapter 3-05, Test CL5-55°C; 72 Hours	Nanuk 930R and Nanuk 955R
DRY HEAT	Test C; DEF STAN 00-35 Part 3 Chapter 3-02, Test CL2 71°C; 48 Hours	Nanuk 930R and Nanuk 955R
VIBRATION	Test K; DEF STAN 00-35 Part 3 Chapter 2-01 Annex A Figure A1 75 minutes per axis in each of three mutually perpendicular axes	Nanuk 930R and Nanuk 955R
IMPACT/DROP	Test E; DEF STAN 00-35 Part 3 Chapter 2-05, Test M5 26 drops at 1.25 m onto concrete	Nanuk 930R and Nanuk 955R

20.6.2 STANAG 4280

TEST TYPE	STANDARD & DESCRIPTION	TEST ITEM
WATER SPRAY/RAIN	STANAG 4280 Ed 3 Method 310 Procedure II of AECTP 300 under STANAG 4370 Exaggerated rain method for 40 minutes/face	Nanuk 930R and Nanuk 955R
LOW TEMPERATURE	STANAG 4280 Ed 3 Method 303 Procedure I of AECTP 300 under STANAG 4370 -55°C; 72 Hours	Nanuk 930R and Nanuk 955R
HIGH TEMPERATURE	STANAG 4280 Ed 3 Method 302 Procedure I of AECTP 300 under STANAG 4370 71°C; 48 Hours	Nanuk 930R and Nanuk 955R
VIBRATION	STANAG 4280 Ed 3 Method 401 of AECTP 400 under STANAG 4370; Figure A-1 75 minutes per axis in each of three mutually perpendicular axes	Nanuk 930R and Nanuk 955R
TRANSIT DROP	STANAG 4280 Ed 3 Method 414 of AECTP 400 26 drops at 1.25 m onto concrete	Nanuk 930R and Nanuk 955R

20.6.3 MIL-SDT-810H

TEST TYPE	STANDARD & DESCRIPTION	TEST ITEM
WATER SPRAY/RAIN	MIL-STD-810H Method 506.6 Procedure II Exaggerated rain method for 40 minutes/face	Nanuk 930R and Nanuk 955R
LOW TEMPERATURE	MIL-STD-810H Method 502.7 Procedure I -55°C; 72 Hours	Nanuk 930R and Nanuk 955R
HIGH TEMPERATURE	MIL-STD-810H Method 501.7 Procedure I 71°C; 48 Hours	Nanuk 930R and Nanuk 955R
VIBRATION	MIL-STD-810H Method 514.8 Procedure I Category 4 75 minutes per axis in each of three mutually perpendicular axes	Nanuk 930R and Nanuk 955R
TRANSIT DROP	MIL-STD-810H Method 516.8 Procedure IV 26 drops at 1.25 m onto concrete	Nanuk 930R and Nanuk 955R

20.6.4 ATA Specification 300 Category 1

TEST TYPE	STANDARD & DESCRIPTION	TEST ITEM
IMPACT	3.2 cm bar with hemispherical end, weighing 6 kg dropped from 0.5 m onto weakest points of any exterior surface	Nanuk 930R and Nanuk 955R

20.6.5 Nanuk 930 Certification Declaration

TEST CATEGORY	STANDARDS / METHODS
IMMERSION	IP67 IEC 60529, MIL-STD-810F Method 512.4
WATER SPRAY / RAIN	DEF-STAN 81-041 Test L, STANAG 4280 Method 310, MIL-STD-810H Method 506.6
LOW TEMPERATURE	DEF-STAN 81-041 Test G, STANAG 4280 Method 303, MIL-STD-810H Method 502.7
DRY HEAT / HIGH TEMP	DEF-STAN 81-041 Test C, STANAG 4280 Method 302, MIL-STD-810H Method 501.7
VIBRATION	DEF-STAN 81-041 Test K, STANAG 4280 Method 401, MIL-STD-810H Method 514.8
IMPACT / TRANSIT DROP	DEF-STAN 81-041 Test E, STANAG 4280 Method 414, MIL-STD-810H Method 516.8, ATA Specification 300 Category 1

20.6.6 Certification No: CTC 9730

TEST NAME	STANDARD(S) / REFERENCE(S)	CONDITIONS / NOTES
IMPACT RESISTANCE TEST	ATA 300 (a), Quote CTQ 7933 Item 1 (f)	13.2 lbs bar, 3.2 cm hemispherical end, dropped from 0.5 m at -20 °C (Custom Foam)
SCHEDULE A HANDLING TEST	ASTM D4169 §10.2.3 (b), Quote CTQ 7933 Item 2 (f)	Drop height based on weight, conditioned at ambient, -28 °C, +60 °C (Custom Foam)
SCHEDULE F LOOSE LOAD VIBRATION TEST	ASTM D4169 §13.1 (b), Quote CTQ 7933 Item 3 (f)	30 min along main axis + 30 min other orientations (Custom Foam)
SCHEDULE H ENVIRONMENTAL RAINFALL TEST	ASTM D4169 §15.2 (b), Quote CTQ 7933 Item 4 (f), ASTM D951, Assurance Level 1	Temp cycling + water spray (Custom Foam)
IMMERSION TEST	MIL-STD-810F Method 512.4 (c), Quote CTQ 7933 Item 5 (f)	10 °C above water temp, 3 ft depth, 30 min immersion (Foam)
DUST TEST	CEI/IEC 60529:2001 §13.4 (d), IP-6X Cat 2, Quote CTQ 7933 Item 6 (f)	8 hrs, 2 kg/m^3 talcum powder dust exposure (Foam)
TEMPORARY IMMERSION TEST	CEI/IEC 60529:2001 §14.2.7 (d), IP-X7, Quote CTQ 7933 Item 7 (f)	1 m water depth, 30 min immersion (Foam)

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