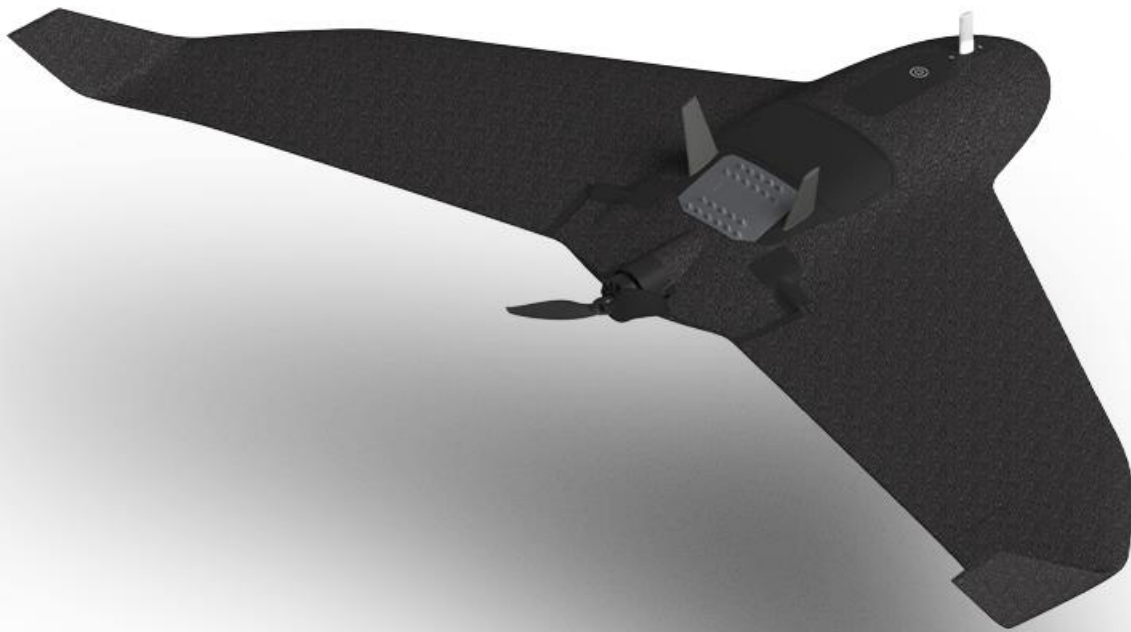


eBee

VISION



White paper

Version 1.5 | February 2024

Introduction

eBee VISION is the lightest and most affordable fixed-wing UAS for military, public safety, and 1st responder personnel to conduct Intelligence, Surveillance, and Reconnaissance (ISR), security patrol, and incident response missions.

- Thanks to its dual camera (daylight and night condition), the eBee VISION can detect a vehicle at 5 km / 3.1 mi distance (a small vehicle is 11x4 pixels in image) without being seen.
- eBee VISION provides up to 5 km / 3.1 mi operational range with the included short-range antenna, up to 15 km / 9.3 mi with optional external medium-range antenna and up to 20 km / 12.4 mi operational range with optional long-range antenna.
- At just 1.6 kg / 3.5 lbs, this ultra-lightweight UAV is one-person operable, easily transportable and launchable by hand, and provides up to 1.5 hours of flight endurance.
- eBee VISION comes with a backpack and hardcase for easy and safe transport and storage.
- eBee VISION is ready to fly in less than 3 minutes.

Swiss Export Authority (SECO) has granted to AgEagle a General License to export the eBee VISION system in group 1 countries. Due to the De-Minimis rule, eBee VISION system is not subject to US BIS export restriction for group 1 countries.

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1 Technical specifications

1.1 The UAS kit

1.1.1 Unmanned Aerial Vehicle (UAV)

eBee VISION UAV – see without being detected.



eBee VISION with deployed gimbal



eBee VISION with folded (secured) gimbal

eBee VISION is designed specifically to provide real-time, enhanced situational awareness for critical Intelligence, Surveillance, and Reconnaissance (ISR) missions.

- eBee VISION is fitted with stabilized payload that can detect, track, and geo-locate objects in both day and night conditions.
- 32x zoom for RGB camera and 5x zoom for thermal camera.
- eBee VISION delivers high-resolution, long-range video imagery for up to 20 km / 12.4 mi with optional long-range antennas from the GCS.
- eBee VISION is cybersecure (system protected by a secure element) and manufactured in Switzerland in accordance with the U.S. NDAA requirements (eBee VISION does not use, integrate nor embed embargoed critical components).
- eBee VISION weighs 1.6 kilograms / 3.5 lbs.

- eBee VISION can be transported in a backpack and operated by a single person.
- eBee VISION navigation software does not require an internet connection and is compatible with Jpeg, Jpeg2000 and PNG map tiles and Tiff and Dted1/2 elevation data.
- eBee VISION operator can locate targets using the Coordinates of Target feature, available on both RGB and thermal views, with less than 50 m / 164 ft error radius at an undetectable distance from the target. Operators can share the location immediately in latitude/longitude or MGRS coordinates.
- Video broadcasting from the GCS to a remote observer via the USB-C/HDMI, Nett Warrior/Ethernet output and TAK integration.

1.1.2 Ground Control Station (GCS)

The eBee VISION GCS with AgEagle proprietary software specifically designed for the eBee VISION UAV.



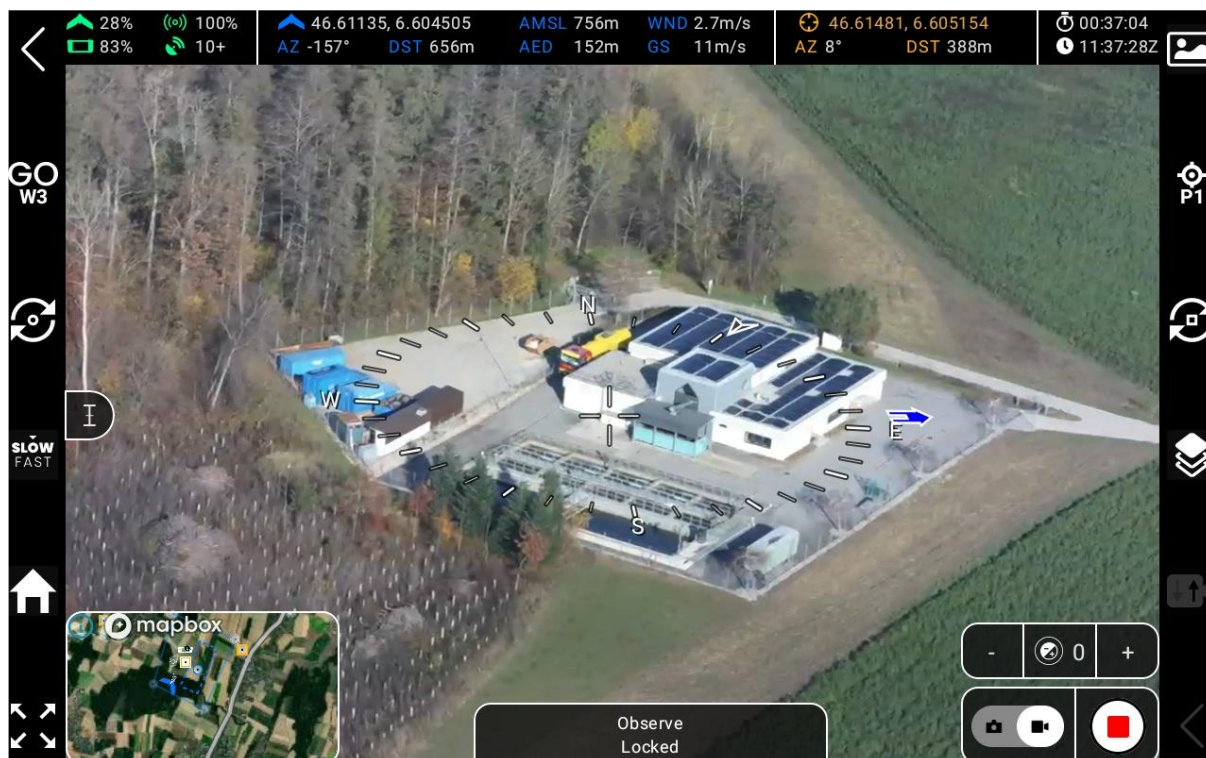
A ruggedized GCS built on top of the Panasonic FZ-S1. The eBee VISION GCS offers high communication flexibility through the new innovative radio platform SRM and the Nett Warrior connector directly mounted in the controller handle.

Connectivity	Human interfaces	Mechanical specifications
Wi-Fi Bluetooth 4G, LTE 1 x USB-C connector 1 x Nett Warrior connector 1 x SRM dock (Radio) 2 x SBM (Swappable battery module)	Front 1 x APEM 5D joystick 2 x OTTO Hall-effect joystick 4 x pushbuttons 12 x bezel buttons Top 2 x single axis joystick 2 x push buttons Back 2 x operator presence buttons	Screen size: 7 in / 17.78 cm Weight: 950 g / 2.1 lbs Dimensions : 256 x 140 x 68 mm / 10 x 5.5 x 2.7 in

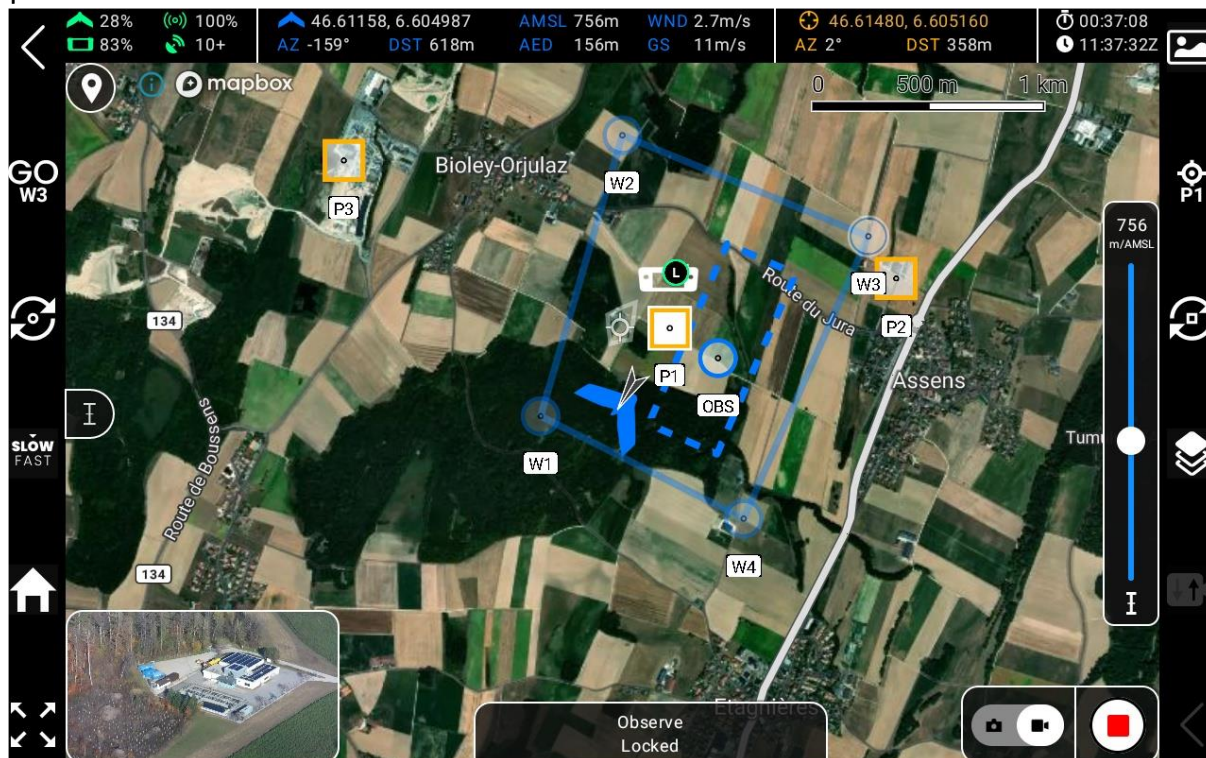
1.1.3 VISION flight application

The eBee VISION flight application provides all functionality required to complete successful ISR missions. The flight interface has been designed so that the operator can maintain the maximum level of focus on the video feedback.

Video view



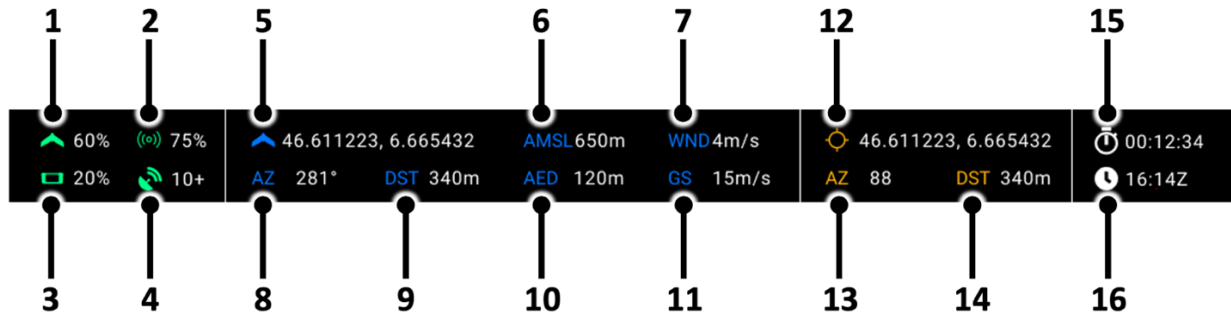
Map view



Telemetry bar

Telemetry data is organized and colored by function.

- Green: eBee VISION system state
- Blue: eBee VISION UAV flight data
- Yellow: Target data
- White: Timestamps



- | | | | |
|------------------------------------|--|----------------------------------|-------------------------|
| (1) UAV battery | (5) UAV coordinates | (12) Coordinates of Target | (15) Operation duration |
| (2) Radio link strength | (6) UAV Altitude above mean sea level (AMSL) | (13) Azimuth from UAV to Target. | (16) Time |
| (3) GCS battery | (7) Wind speed | (14) Distance from UAV to Target | |
| (4) Number of satellites connected | (8) Azimuth from GCS to UAV | | |
| | (9) Distance from GCS to UAV | | |
| | (10) UAV Altitude above elevation data (AED) | | |
| | (11) Ground speed | | |

1.1.4 Batteries and other equipment required for operation

The eBee VISION system includes:

- UAV
- GCS
- Radio module with short range antenna
- Smart batteries
- Smart charger
- Radio module auxiliary battery
- Radio module auxiliary battery charger
- Backpack
- Hard transport case



1.2 Unmanned Aerial Vehicle (UAV)

1.2.1 Type: unmanned fixed-wing aircraft

eBee VISION is a small (120 cm / 50 in wingspan) and lightweight (1.6 kg / 3.5 lbs) fixed-wing UAV.

1.2.2 Horizontal take-off (hand launch) and landing (HTOL)

eBee VISION has been designed to be hand launchable for ultimate portability. The launch and landing procedures do not require additional equipment.

1.2.3 Ready to fly

The system from its backpack is ready to launch in 3 minutes including time taken to acquire GNSS signal.

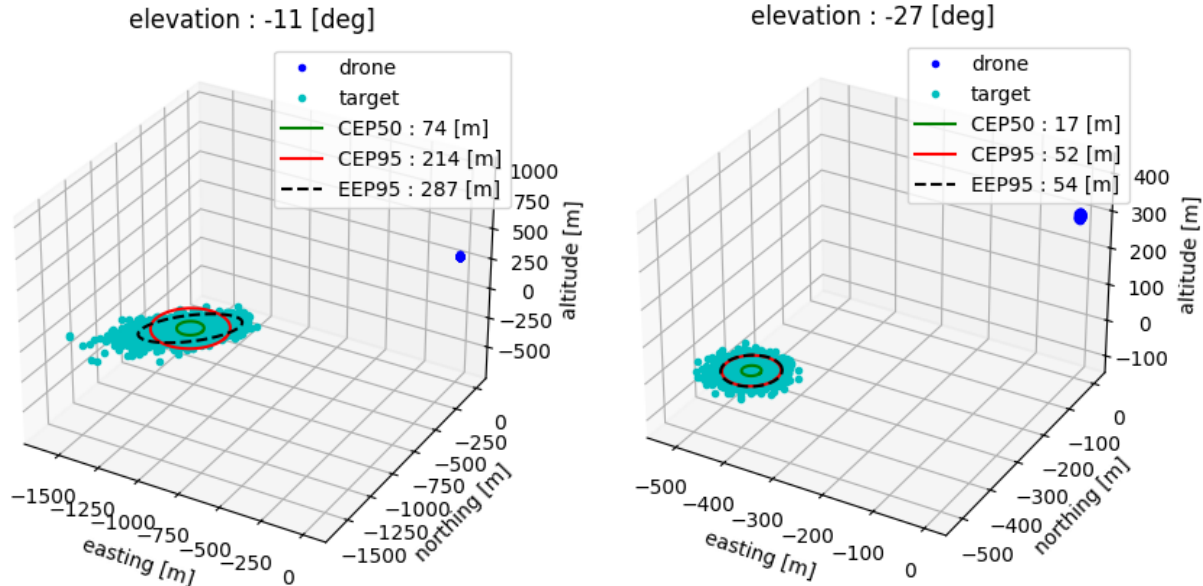
1.2.4 Coordinate of Target (COT)

eBee VISION pointing accuracy is approximately 2 deg with 95% confidence interval.

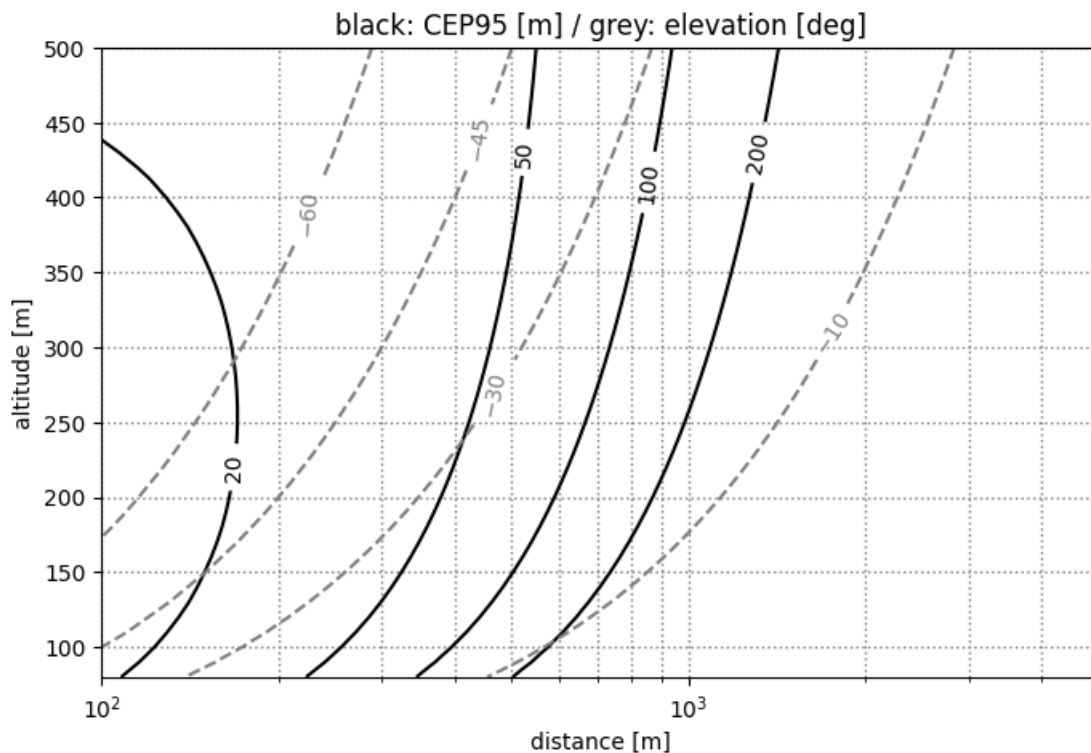
The color of the COT in the telemetry bar indicates the accuracy:

- White: CEP95 < 50 m / 165 ft
- Orange: 50 m / 165 ft <= CEP95 between < 200 m / 656 ft
- Red: 200 m / 656 ft <= CEP95

The following graphs show Monte-Carlo simulations of the pointing accuracy in various conditions:



eBee VISION's COT accuracy is depending on altitude and distance to target can be extracted from this graph:



1.2.5 Standard landing

- Landing point is automatically defined at take-off location.
- The operator can change the landing location at any time during the operation.
- eBee VISION gives operator wind Information to land in best conditions.
- The system can automatically land the UAV in a 10 x 30 m / 33 x 98 ft area.

1.2.6 Silent tactical landing

- The landing point is automatically placed below the drone's current location.
- Automatically facing wind for minimum speed at impact.
- Totally silent (motor turned off).
- Can be used to safely land on top of trees.

1.2.7 Automatic stabilization

eBee VISION autopilot provides a highly stabilized flight by using:

- Advanced non-linear control algorithms.
- Redundant robust state estimation.

1.2.8 Return To Home (RTH)

- The Return-To-Home (RTH) position is at the landing location, it can be edited at any time.
- The GCS has an RTH button that can be activated anytime during the mission.

- The RTH can also be automatically invoked (e.g., low battery level, lost connection) but can be overridden by the user if the mission needs outweigh the deliberate loss of the UAV.

1.2.9 Geofence and other restrictions override

- Geofencing is optional and can be turned off by the user. It is the user's responsibility to adhere to local laws and regulations.
- The system provides optional altitude fencing and geo restrictions for civilian use.

1.2.10 Video streaming

eBee VISION UAV streams live video (resolution 720p, H264), still images and metadata to the GCS. Operation metadata is available on screen on the GCS as well as embedded in the video and still images stored in the GCS. They can also be stored on the drone if equipped with an SD card.

Drone to GCS video stream key features

- H264 encoding with RTSP transmission protocol between the drone and the GCS.
- The video stream is compatible with RTSP-compatible players (VLC or ffmpeg).
- Metadata in video includes GPS time stamp, Coordinates of Target, and payload bearing.
- 720p, 30 fps, 5 Mbit/s, bandwidth adaptation to deal with long-range flights.
- Reduced latency (< 300 ms glass-to-glass).

Video sharing

- Screen duplication to a secondary screen via the USB-C to HDMI adapter.
- Video and metadata can be broadcasted through compatible modems connected on the Nett Warrior connector, WiFi or LTE.
- The video stream is STANAG 4609 compatible (MPEG2-TS/H.264).
- Video stream metadata is STANAG 4609 compatible (KLV), embedded in the video stream.
- Compatible with the following standards: ISO/IEC 14496-10 AVC, ITU-T H.264, RFC 3550, RFC 2326.

1.2.11 TAK connectivity

eBee VISION application can be configured to share flight metadata to a TAK server. Several pieces of information are pushed to the server using the COT (Cursor-On-Target) protocol, for example drone callsign, location, speed, course and attitude, payload attitude and battery status.

If the server has video forward capabilities, the COT message includes video stream information to enable automatic stream detection in compliant TAK software (WinTak for example).

Note: The GCS must be connected to an external network where the TAK server is available. This can be achieved through an additional modem connected on the Nett Warrior connector, WiFi or LTE.

1.2.12 Visible spectrum (EO) and thermal spectrum (IR) capabilities

eBee VISION embeds dual camera module: 2 visible spectrum sensors (1 wide-angle and 1 zoom) and 1 thermal sensor.

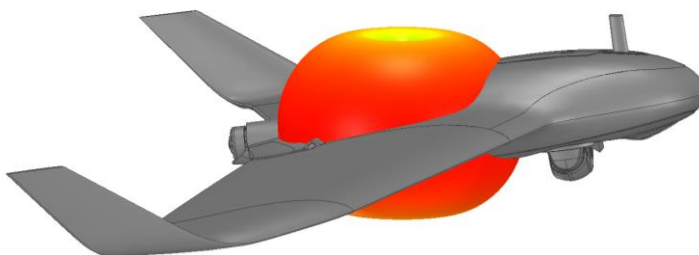
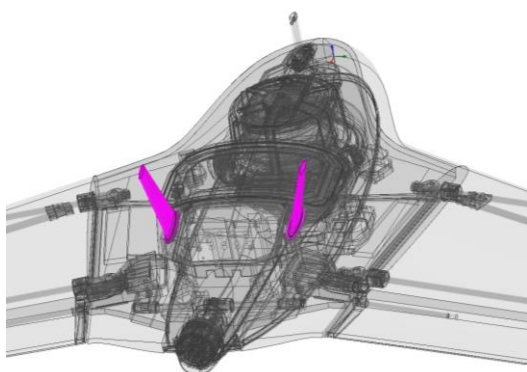
- Users can seamlessly toggle between RGB and thermal views and switch between different thermal color gradients (white hot and black hot).
- The system supports in-flight thermal sensor calibration, i.e., flat field correction (FFC) for optimal IR visibility during long operations.



1.2.13 Radio link

- eBee VISION system frequencies are in the 2.4GHz worldwide ISM bands and do not require special permissions.
- The embedded radio modules are CE and FCC certified.
- The UAV includes a standard connector for compatibility with other radio modules (provided as custom solutions depending on customer needs).

eBee VISION is carrying two custom shark antennas to minimize the drag effect. Both antennas are flexible for robustness and fine-tuned to eBee VISION's radio link frequency.



1.2.14 Maximum flight time in optimal conditions without additional charging

eBee VISION UAV flight time is 90 minutes and provides 60 minutes of observation time at 10 km / 6.2 mi from take-off position.

1.2.15 Maximum telemetry and video transmission distance

eBee VISION provides video stream up to 20 km / 12.4 mi from the GCS with optional long-range antennas, up to 15 km / 9.3 mi with optional external medium-range antennas, and up to 5 km / 3.1 mi with included short-range antennas.

1.2.16 Flight distance with one battery charge

eBee VISION flies up to 60 km / 37 mi with one battery.

1.2.17 Maximum airspeed

eBee VISION max airspeed is 20 m/s (45 mph or 72 km/h).

1.2.18 Horizontal cruising speed

eBee VISION cruising speed is from 13.5 to 20 m/s (30 mph to 45 mph or 48.6 km/h to 72 km/h).

1.2.19 Maximum wind resistance

eBee VISION max wind resistance is 17 m/s (38 mph or 61 km/h).

1.2.20 Operating temperature

eBee VISION operating temperature is -10°C +49°C / +14°F +120°F.

1.2.21 Sensors

The eBee VISION is embedding all the necessary sensors for navigation and Image stabilization.

Autopilot:

- Dual band GNSS receiver with GPS, GLONASS and Galileo constellations.
- IMU.
- Barometer.
- Magnetometer.
- LIDAR for ground avoidance and precise landing.
- Pitot probe designed for water and dust intake resilience.

Gimbal:

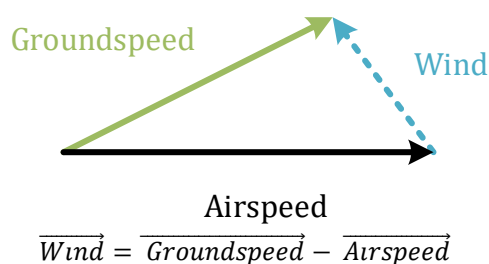
- HALL sensor.
- IMU.

1.2.22 Robust redundant state estimation

State estimation architecture is focused on robustness and redundancy. It contains several separated Extended Kalman Filter (EKF) to avoid error propagation and offer back-up solution in case of sensor failure.

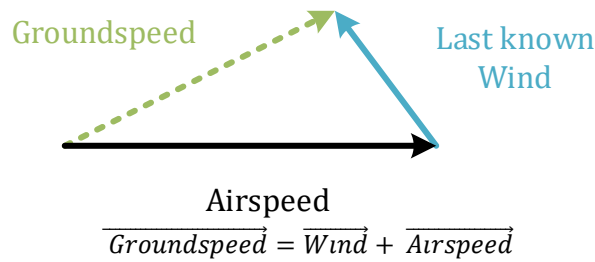
1.2.22.1 Standard operating conditions

Wind is determined by solving the speed triangle:



1.2.22.2 GNSS failure

In case of GNSS malfunction like jamming, the estimation is made by assuming the wind is constant and the speed triangle will be used to get an estimated groundspeed:



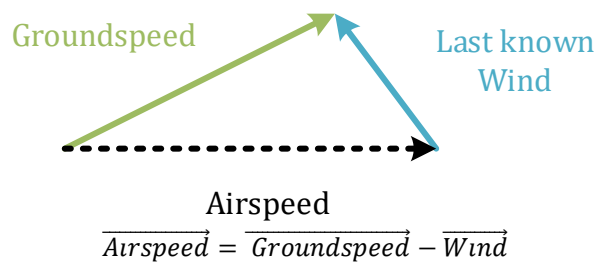
This estimated groundspeed is then fused with IMU to perform airspeed odometry.

This method is drifting overtime due to the integration of errors, as a result the uncertainty of the eBee VISION's position is increasing overtime. The order of magnitude is 1 km / 0.6 mi error after 10 km / 6.2 mi distance.

1.2.22.3 Pitot failure

In case of pitot probe malfunction, like heavy rain.

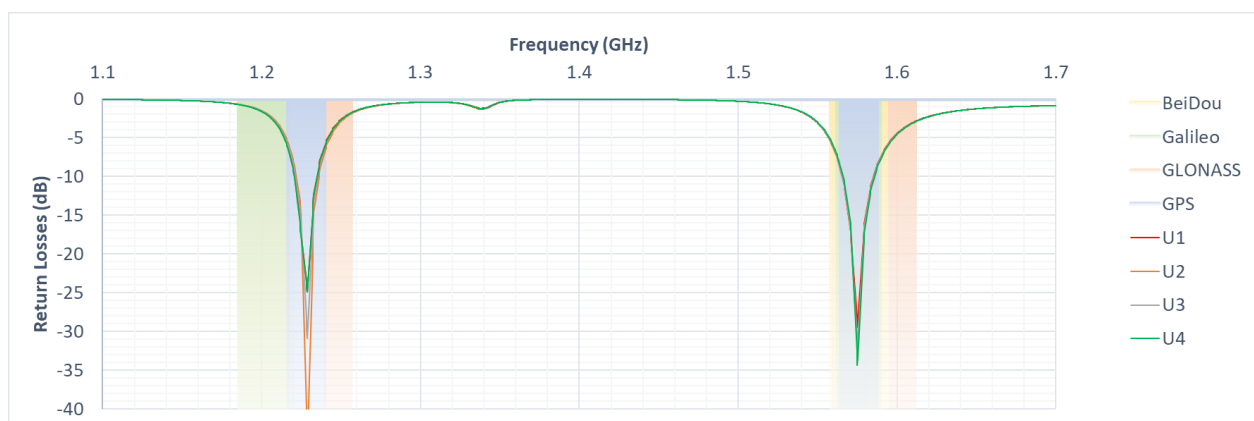
Airspeed is estimated from groundspeed and last known wind value.



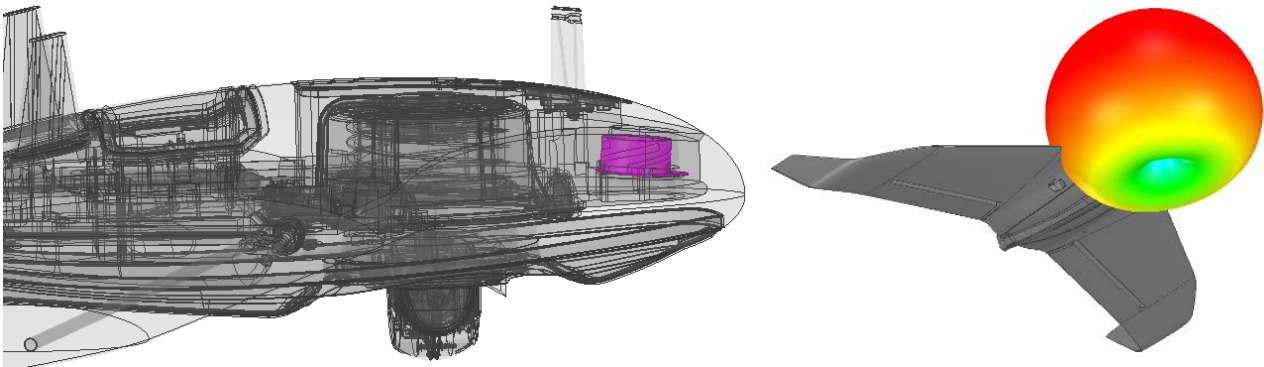
This mechanism allows to safely operate the eBee VISION but endurance management will be less efficient.

1.2.23 GNSS antenna

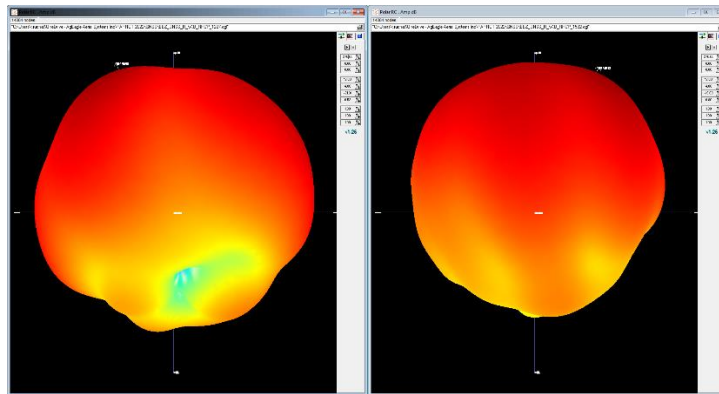
eBee VISION is embedding a home-made high grade multi-band GNSS smart antenna optimized in size and weight.



The antenna has been precisely tuned for GPS, GLONASS and Galileo constellations. Antenna also features low directional gain on the lower region making it resilient to both multipath and jamming from ground.



Integration / Simulation



Measurements: L2 band RHCP gain (left) / L1 band RHCP gain (right)

1.2.24 Image and video capture

1.2.24.1 Dual camera: Visible spectrum (EO) and thermal (IR)

eBee VISION dual camera module embeds 3 sensors:

- 1 EO (visible spectrum) camera with large field of view.
- 1 EO (visible spectrum) with narrow field of view.
- 1 IR (thermal) camera.

The camera module is both mechanically and software stabilized.



1.2.24.2 RGB cameras

eBee VISION EO (visible spectrum) camera module embeds two 4K HDR cameras.

Wide angle EO / RGB camera:

- SONY IMX230 1/2.4"
- Video: 4K HDR (24 fps)
- Photo: 21 MP
- Zoom: 1x => 4.8x
- Focal length: 4mm
- FOV 72° x 45°
- F2.4 aperture

Telephoto EO / RGB camera

- SONY IMX230 1/2.4"
- Video: 4K HDR (24 fps)
- Photo: 21 MP
- Zoom: 4.9x => 32x
- Focal length: 16mm
- FOV 21° x 12°
- F2.4 aperture

1.2.24.3 Thermal camera

eBee VISION camera module embeds 1 thermal camera:

- FLIR BOSON 640x512
- Focal length: 18mm
- FOV: 24° x 19°
- Frequency: 30Hz
- Sensitivity: 50mK

1.2.24.4 Detection, Recognition and Identification (DRI) capabilities:

Examples of pilot view in operating conditions:



47% 100% 46.61367, 6.599169 AMSL 910m WND 0.8m/s 46.60554, 6.587459 00:09:50
100% 10+ AZ -117° DST 0m AED 305m GS 14m/s AZ -135° DST 1.27kr 11:44:44Z



Flying: Flight plan

- 0 +

5204 3

59% 100% 46.62181, 6.599172 AMSL 731m WND 0.5m/s 46.62586, 6.603860 00:04:05
100% 10+ AZ -47.9° DST 0m AED 131m GS 14m/s AZ 38.42° DST 575m 11:38:59Z



Flying: Flight plan

- 0 +

5258 0

Example of picture at 1 km / 0.6 mi distance:

GPS Time 2023-08-30T11:44:02.8169+0200
COI 32TLS 16852 63721
BRG 155.76°



Distance of observation	Type of object	Size in pixel		
		Wide angle	Zoom	Thermal
1 km / 0.6 mi	Person	7	26	3
	Small vehicle	15x5	57x21	6x2
	Armored vehicle	22x11	85x43	9x5
2 km / 1.2 mi	Person	3	13	2
	Small vehicle	7x3	28x11	3x1
	Armored vehicle	11x6	43x21	5x2
3 km / 1.8 mi	Person	2	9	1
	Small vehicle	5x2	19x7	2x1
	Armored vehicle	7x4	29x14	3x2
4 km / 2.4 mi	Person	2	6	1
	Small vehicle	4x1	14x5	1
	Armored vehicle	5x3	21x11	2x1
5 km / 3.1 mi	Person	1	5	not visible
	Small vehicle	3x1	11x4	not visible
	Armored vehicle	4x2	17x9	not visible

1.2.24.5 Photo and video formats

eBee VISION streams and stores photos and videos in following formats:

Real time streaming to GCS:

- Photos / screenshots
 - Resolution: 1280x720
 - Format: JPEG
- Video
 - Resolution: 1280x720
 - Format: MP4 (H264)

Photos and videos stored on the UAV SD card:

- Photos
 - RGB
 - Resolution: 5344 x 4016
 - Format: JPEG
 - IR
 - Resolution: 640 x 512
 - Format: JPEG
- Video
 - RGB
 - Resolution: 1920 x 1080
 - Format: MP4 (H264)
 - IR
 - Resolution: 1280 x 720
 - Format: MP4 (H264)

1.2.25 Radio link loss

eBee VISION system warns the user in case of a weak radio link. If eBee VISION does not regain a connection, it will return to home after 3 minutes.

1.2.26 Repairability

eBee VISION has a modular design that allows easy maintenance and fast repairs on the field.

User replaceable parts include:

- Propeller
- Wings
- Pitot tube
- Lower body and blister
- Servos

1.2.27 Data storage

eBee VISION stores media on an encrypted SD card. The encryption of the SD card protects the data stored into the drone, even if the UAV is lost or stolen. Once the encryption is activated, the videos and photos are stored on an AES-XTS 512 bits-encrypted LUKS2 volume.

eBee VISION can be used without SD card, in that case no data is recorded.

1.3 Ground Control Station (GCS)

eBee VISION GCS is a drop-resistant remote controller designed for challenging environments. All controls are optimized for ease of use and switching between drone and sensor operations. UXV's SRoC is a ruggedized GCS built on the robust MIL-STD-810H certified Panasonic FZ-S1 that offers a modern solution designed for GCS users in harsh environments.



Modular radio platform with Nett Warrior and USB-C connectors integrated into the controller handle provides exceptional communication flexibility.

1.3.1 Radio module



eBee VISION GCS includes a swappable radio module which together with the standard connector on the UAV provide flexibility for the VISION system radio configuration.

- eBee VISION uses Microhard pMDDL2450 by default.
- The radio is CE and FCC certified.
- Frequencies are in the 2.4 GHz worldwide ISM band and do not require additional permission.

Other radio configurations can be provided by customer request based on the compatibility with existing design.

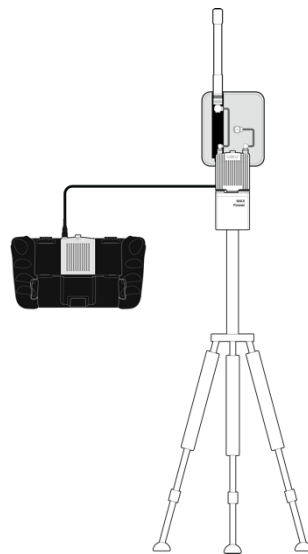
1.3.2 Antenna setups

eBee VISION GCS radio module provides compatibility with various antenna setups.

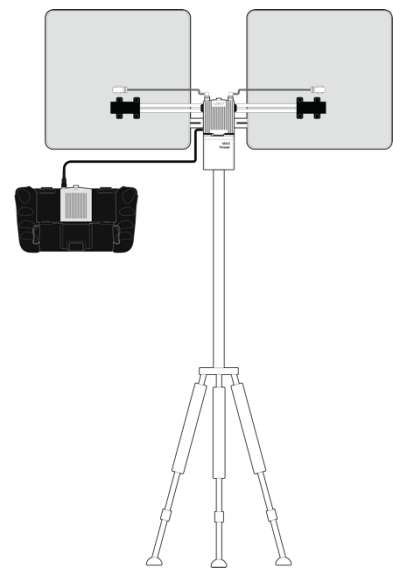
1. Included short-range antennas connected directly to the radio module behind the GCS.
 - Optimized for portability and fast deployment.
2. Optional medium-range antenna on a tripod connected to the GCS using a radio extension kit.
 - Optimized for link-range, portability, and operation in windy conditions.
3. Optional long-range antennas on a tripod connected to the GCS using a radio extension kit.
 - Optimized for long link-range.
4. Other antenna setups are available by request.



Short-range
5 km / 3.1 mi
(included)



Medium-range setup
15 km / 9.3 mi
(optional)



Long-range setup
20 km / 12.4 mi
(optional)

1.3.3 Screen

- 7" WXGA 1280 x 800
- 10-point capacitive multi touch with rain sensing and glove touch modes
- Display with direct bonding
- Anti-reflective (AR) screen treatment
- 750nit brightness

1.3.4 Connectivity

eBee VISION GCS provides excellent connectivity through:

- Wi-Fi
- Bluetooth
- 4G, LTE
- 1 x USB-C connector

- 1 x Nett Warrior connector
- 1 x SRM dock (Radio)
- 2 x SBM (Swappable battery module)

eBee VISION GCS can be fully utilized without connection to the Internet.

1.3.5 Processors

Qualcomm® SDM660 2.2GHz / 1.843GHz Octa-core provides processing power for advanced application requirements.

1.3.6 Operation time

eBee VISION GCS provides up to 4 hours of operation time with battery warm-swap capability.

1.3.7 Weight

950 g / 2.1 lbs controller only.

1.4 Flight application

1.4.1 Flight application functionalities

eBee VISION flight application installed on the GCS provides full set of capabilities to manage and operate the eBee VISION system.

The features include, but not limited to:

- Mission planning
- Flight views: map and pilot (camera)
- Map and elevation data management
- Data gallery from data collection operations
- Logbook
- Settings: Interface, Flight Plans, Payload, Radio, Safety, Storage, etc.

1.4.2 Flight modes

eBee VISION flight application provides multiple operation modes to suit all operation needs.

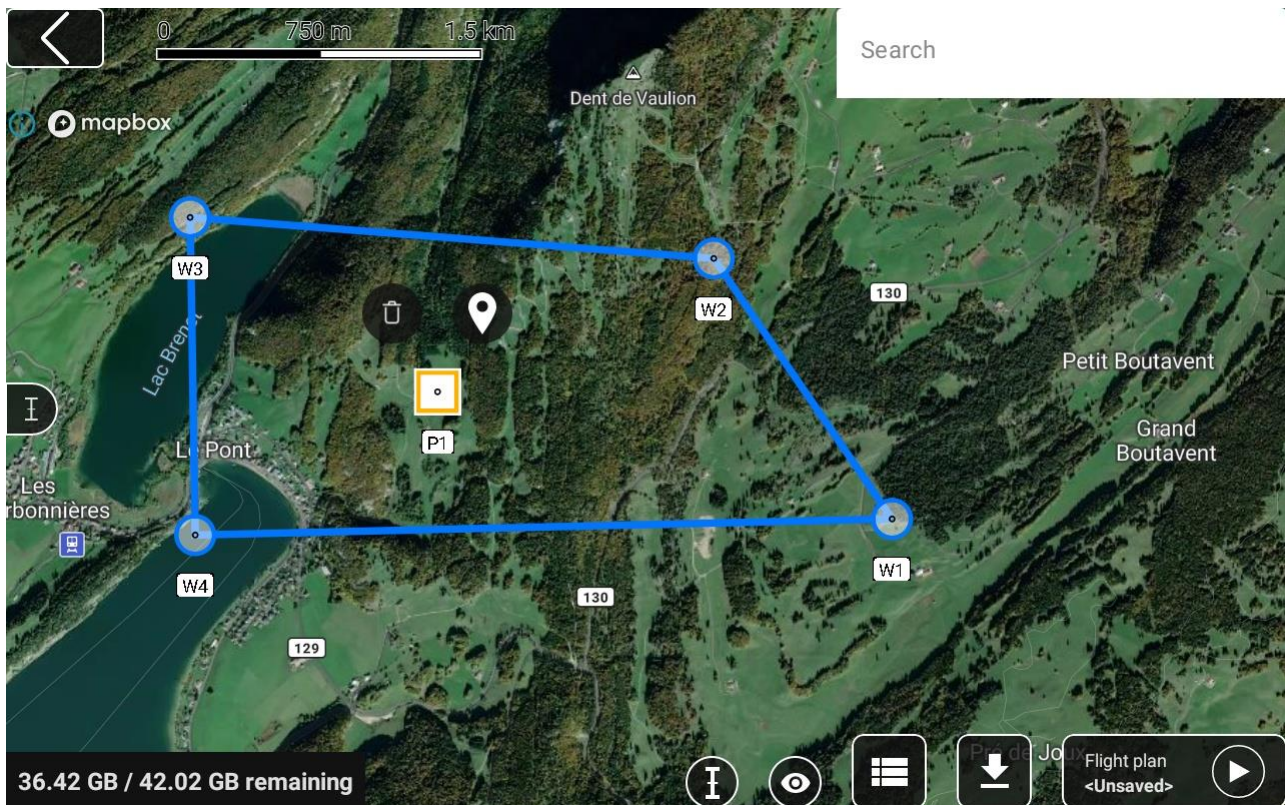
Operation modes include the following:

- Flight plan
 - Flight plan enables the user to fully prepare and configure missions on their GCS in advance, from anywhere. This is a traditional, pre-defined data collection operation for a large land area. User can modify it during flight.
- Observation mode
 - Observation mode allows the operator to fully focus on the video stream by automatically adjusting the flight path to give maximum visibility.
- Scouting mode
 - Explore / track moving targets.
- Manual mode
 - Manually control the drone for your specific flight maneuvers.

In GNSS denied environments, the eBee VISION can return to home without GNSS signal from a 10 km / 6.2 mi distance with approximately 1 km / 0.6 mi accuracy.

1.4.2.1 Flight plan

Flight plan – Create and execute multi-waypoint predefined missions.



The Flight plan mode provides mission planning capabilities:

- Define multiple waypoints.
- Set altitude of waypoints.
- Define POIs, which the user can activate during the mission.
- Adjust the flight plan against terrain profile.
- One way trip, loop or round trip.
- Operator can activate fast mode.

Multiple flight plans / missions can be stored on the GCS.

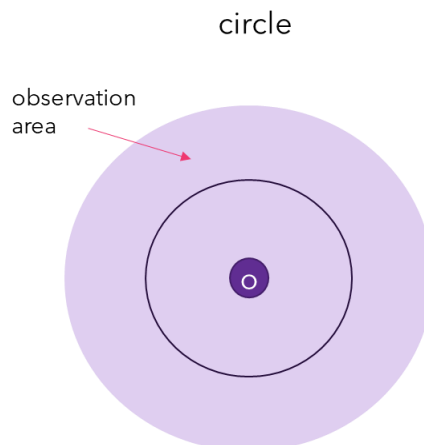
1.4.2.2 Fast-mission flight plan

To maximize efficiency on the field, if no flight plan has been predefined, eBee VISION sets a default square flight plan around the take-off area that the operator can then modify in flight to adapt to his mission.

1.4.2.3 Observation mode

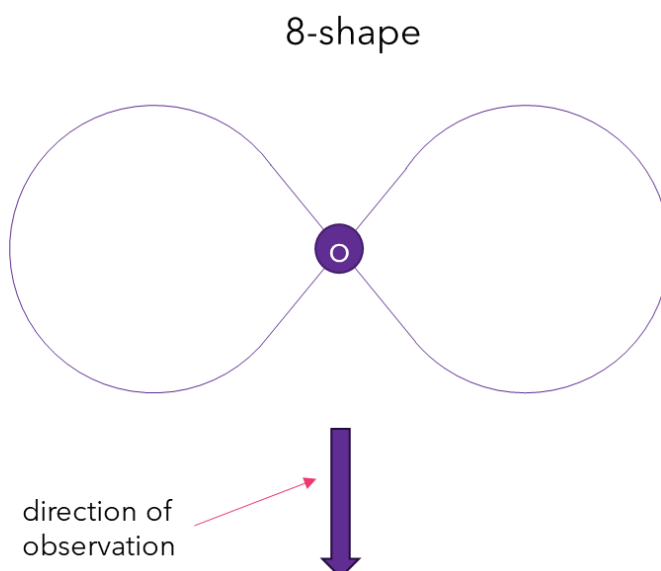
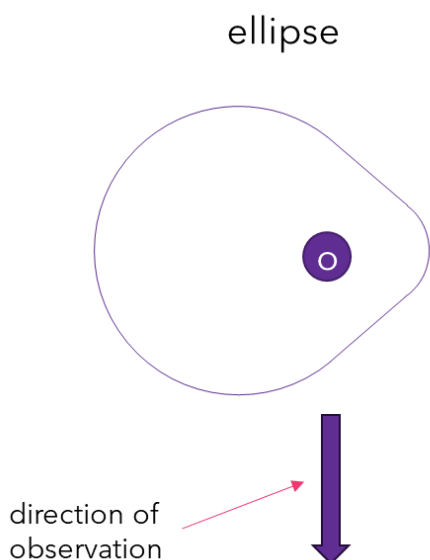
Observing an object of interest from a safe distance. The UAV will optimize flight path to give maximum visibility (8-pattern / ellipse / circle) at a set distance from the POI.

Close range pattern is a circle.



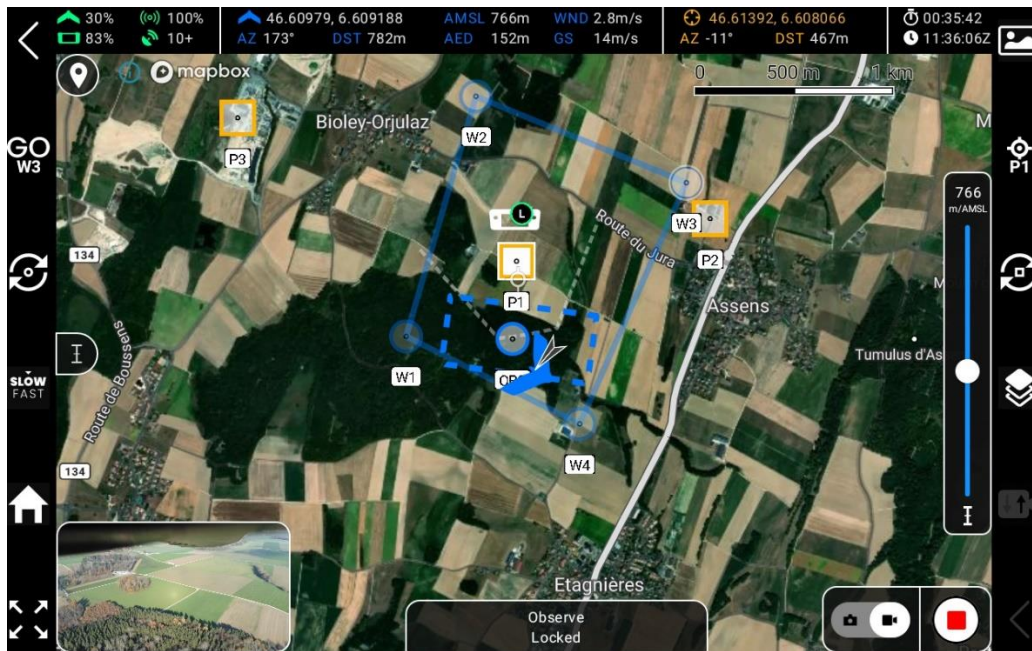
Circle gives best result when looking inside. It can also be used to look on the outside, but this will cause a gimbal wrapping every turn.

The long-range patterns are the ellipse and the 8-shape.



8-shape has the advantage of avoiding any gimbal wrapping at the cost of a large area, while ellipse on the other hand is much more compact but generates a gimbal wrapping at each turn. Based on the combination of the direction of observation and direction of wind, eBee VISION will adjust the dimensions of the flight pattern and choose between ellipse and 8.

The app displays the observation waypoint and the area that the drone will use to perform the chosen flight pattern.

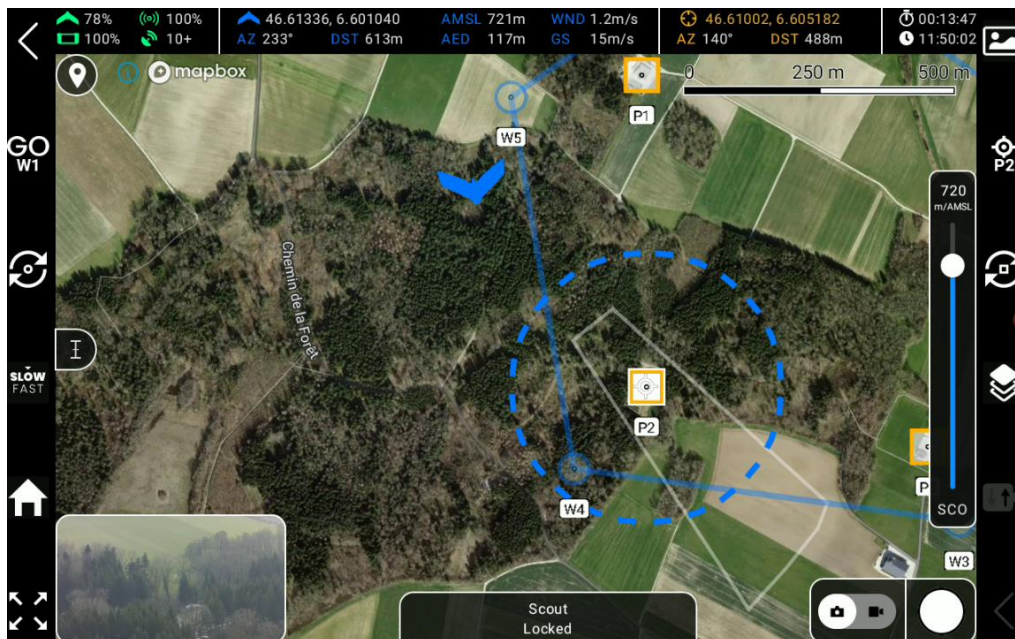


The user can adjust:

- Observation waypoint position (i.e., the center of 8-pattern / ellipse / circle).
- Observation waypoint altitude.
- Observation waypoint distance from the target.
- Location of the target.
- Operator can activate fast mode.

1.4.2.4 Scouting mode

Scouting mode enables the user to explore / track moving targets.



In scouting mode eBee VISION follows the target in view. The user can adjust:

- UAV final distance to target.
- UAV altitude.
- UAV loiter direction (clockwise / counterclockwise).
- Operator can activate fast mode.

1.4.2.5 Manual mode

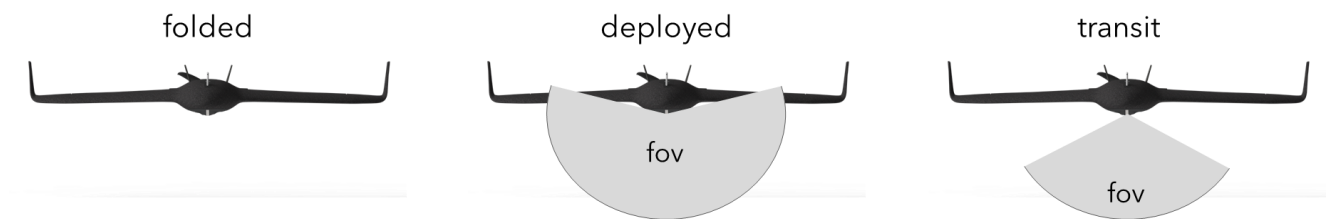
- Manual mode allows user to manually control the drone for specific flight maneuvers.
- In manual model the user controls the drone using the left joystick, while the camera looks forward angled down towards direction of the flight.
- Operator is in control of altitude and course of the UAV.
- Operator can activate fast mode.

1.4.3 Gimbal modes

1.4.3.1 Folded / deployed / transit

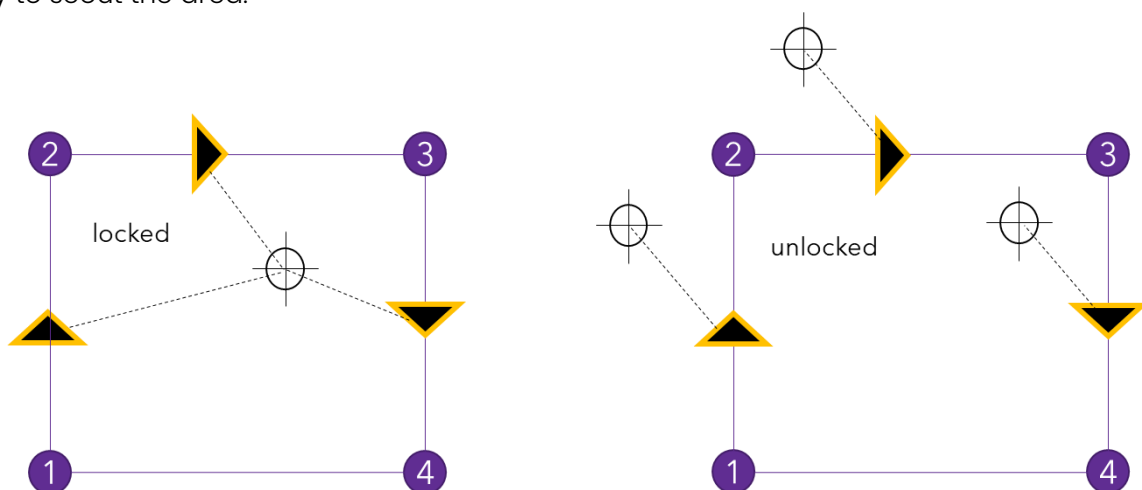
During take-off and landing gimbal is folded inside eBee VISION's body and mechanically locked to prevent any damage to the payload.

Once in operation, gimbal is deployed to give maximum field of view. During flight plan, user is able to put the gimbal in transit mode where it goes up into the body and looks below the drone reducing drag and therefore increasing flight time.



1.4.3.2 Locked / unlocked line of sight

During operation, the user can lock the line of sight on a target or on the opposite have it move freely to scout the area.



1.5 Batteries and other accessories

1.5.1 Transport case and backpack

eBee VISION system includes a ruggedized transport case which carries all parts of the system. System also includes a backpack that fits all parts required for a mission.

1.5.2 Batteries and chargers

eBee VISION system includes:

- For UAV
 - 2 batteries.
 - Power supply with 2 charging ports.
 - 1 charging block (1.5 h charging time for 1 battery, 3 h for 2).
 - Wintering mode: automatic discharge and inactivation to prolong the battery life.
- For GCS
 - 1 internal battery.
 - Charging cable to connect the GCS to power supply.
- For radio
 - 1 auxiliary battery.
 - Power supply.
 - 1 charging block.

1.5.2.1 eBee VISION UAV battery specification

- 1 battery provides 90 minutes of flight time.
- 4 High Density cells (233.5 Wh/kg / 105.9 Wh/lbs).
- Smart Power Management.

1.5.3 Media storage

eBee VISION system includes a 64GB SD card.

1.5.4 Spare parts

eBee VISION system includes:

- Pair of spare wings.
- 1 spare propeller (2 blades).
- 1 spare pitot tube.

1.5.5 Set of cables

eBee VISION systems includes the required cables to operate and charge the system.

1.5.6 User manual

eBee VISION systems includes following documentation:

- User Manual for UAV, GCS, Flight application, Batteries and Chargers, including details for:
 - Precautions for use.
 - Warnings, Cautions, and Advisories.

- Details Of Loss-Link and Flight Termination Emergency Procedures.
- Maintenance manual.

1.6 Cybersecurity

1.6.1 Key features

- NDAA compliant.
- Made in Switzerland.
- SD card AEX-XTS encryption with a 512 bits key.
- No data shared by default.
- Secure Element.

1.6.2 Secure Element

eBee VISION embeds a SEALSQ Secure Element which is NIST FIPS140-2 Level 3 compliant and Common Criteria EAL5+ certified.

The Secure Element:

- performs cryptographic operations
- stores and protects sensitive information

It features a ECDSA private key, with P521 domain parameters, unique to each drone. This private key cannot be extracted from the Secure Element. The certificate associated to this key is signed by a certification authority.

1.6.3 Software integrity and protection of the UAV

eBee VISION's software is digitally signed, which ensures that each update comes from AgEagle and has not been tampered with. Access to eBee VISION's operating system is protected. The drone has no local nor remote access to its embedded system.

1.6.4 SD Card encryption

- Full disk encryption of the SD card protects the confidentiality of data stored on the UAV, even if it is captured by an adverse party.
- Once the encryption is activated, the videos and photos are stored in a LUKS2 volume encrypted with AESXTS and a 512-bit key. 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 passphrase is carried within the Flight application on the GCS and is never stored permanently on the UAV, which protects the data from forensics analysis.

1.6.5 Data management

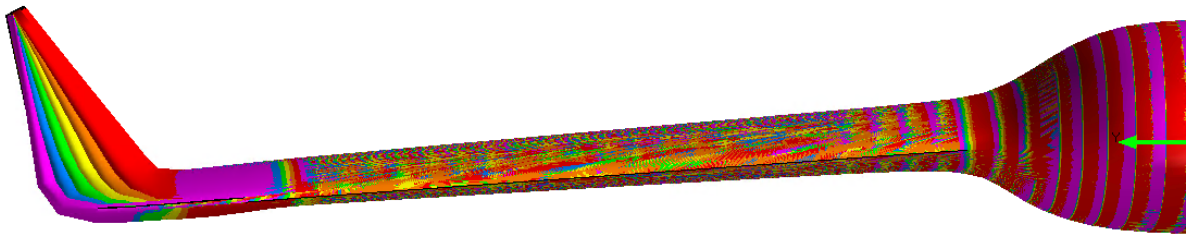
eBee VISION system does not share any data with AgEagle or any third party.

1.7 Elements of design

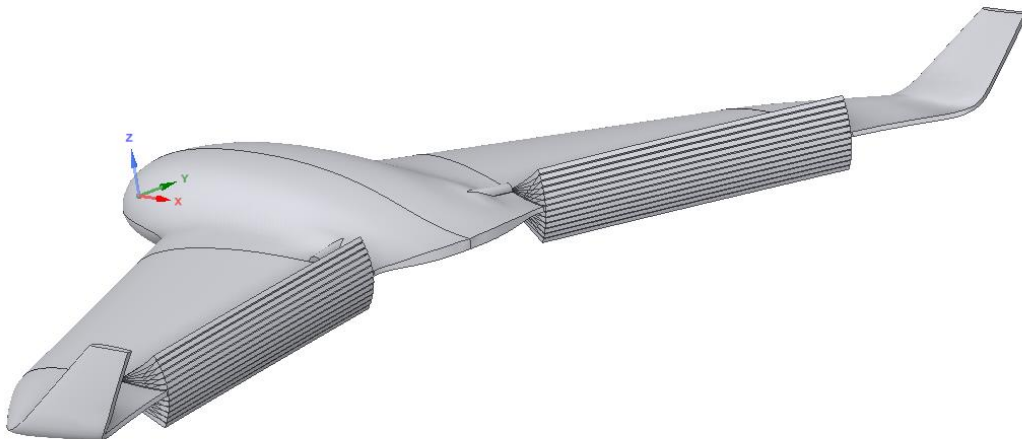
eBee VISION is built to be compact, light weighted, hand launchable, efficient, and robust. The flying wing type of aircraft, although challenging for the stability and control, has the lowest possible weight and drag when compared with other aircraft shapes.

1.7.1 Aerodynamics

eBee VISION's airframe is optimized for aerodynamic efficiency. This has been made possible by the creation of a highly parametrizable 3D model.



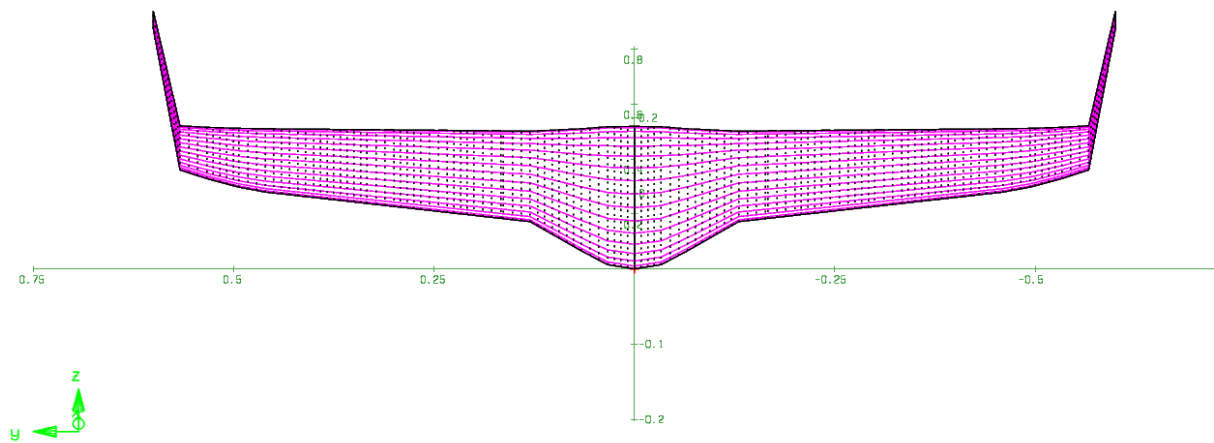
Example of winglet cant angle parametrization



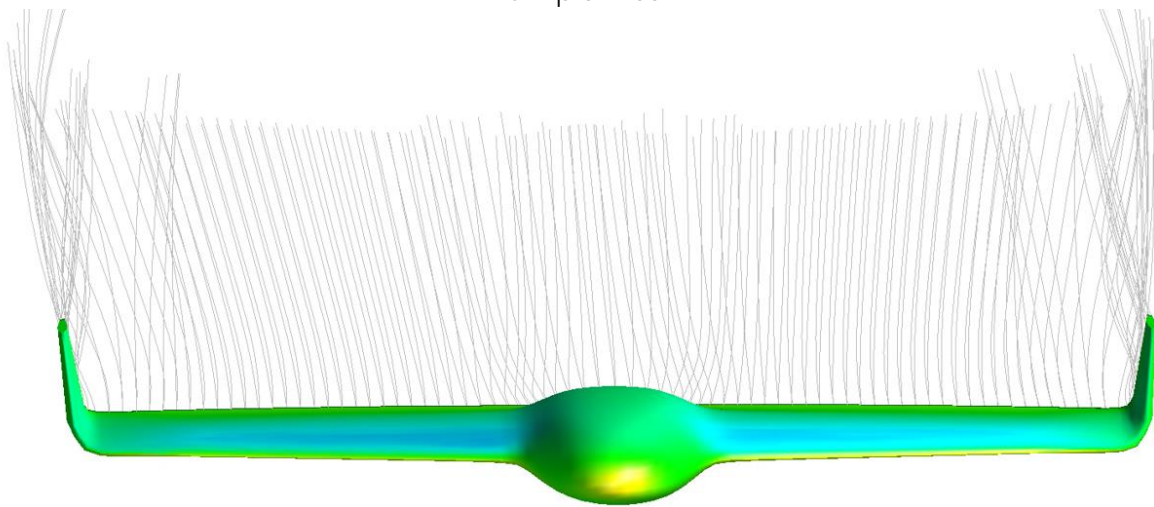
Example of control surface deflection

Three main groups of tools have been used during the design of eBee VISION: AVL (developed at MIT) and FlightStream, computational fluid dynamics (CFD) (OpenFOAM/ ANSYS Fluent) and wind tunnel testing.

Lower fidelity models (AVL, FlightStream), can provide aerodynamic results within seconds or minutes (respectively).

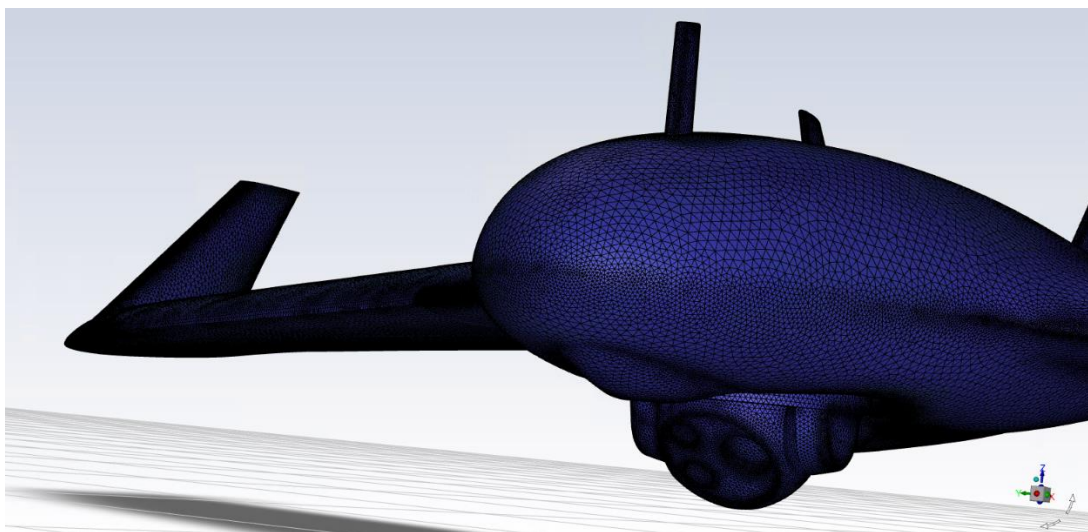


Simple mesh

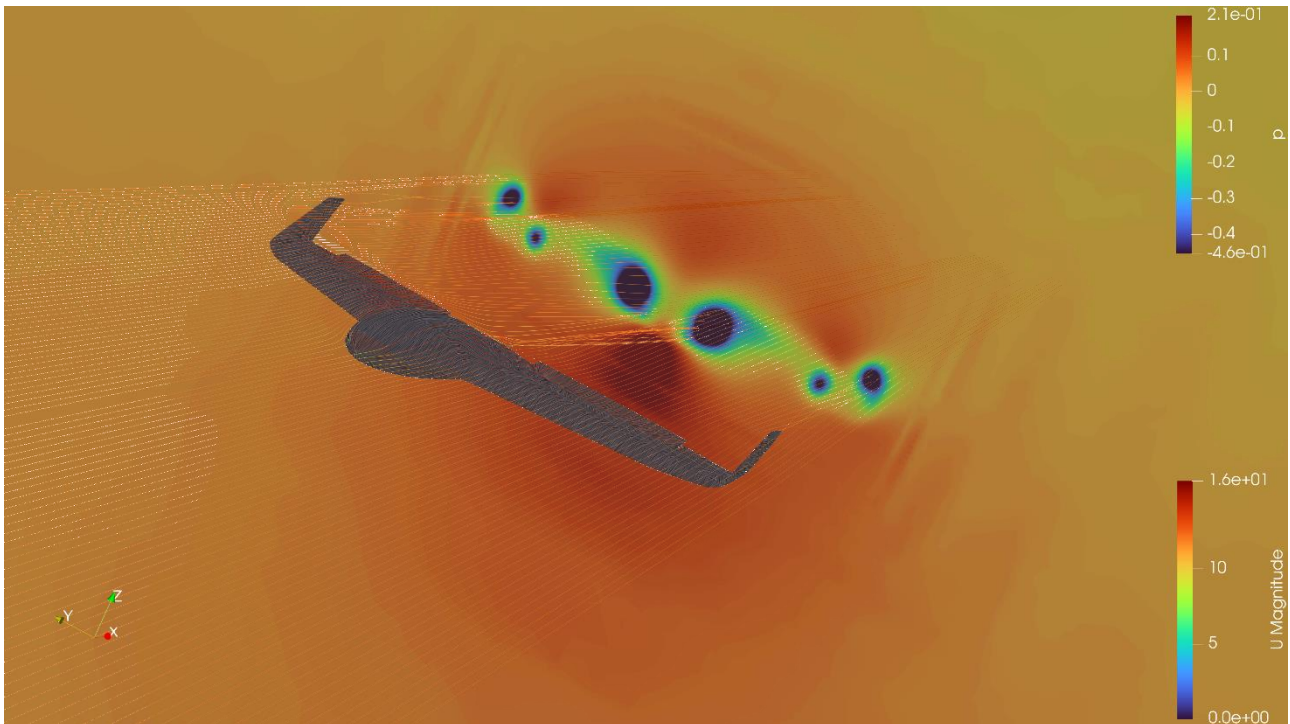
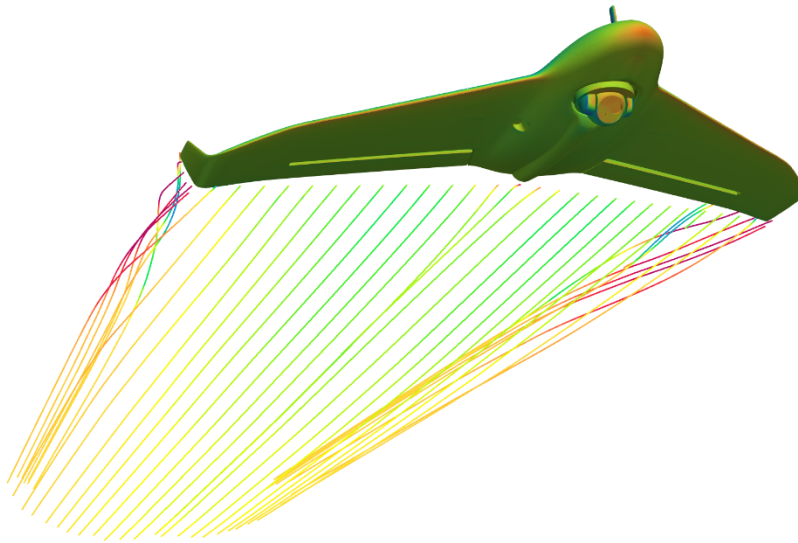


Example of FlightStream simulation

More realistic numerical models can be obtained thanks to CFD. However, the computational cost of simulating one geometry at one flying condition is of the order of magnitude of several hours.



Detailed mesh including gimbal



Examples of CFD result

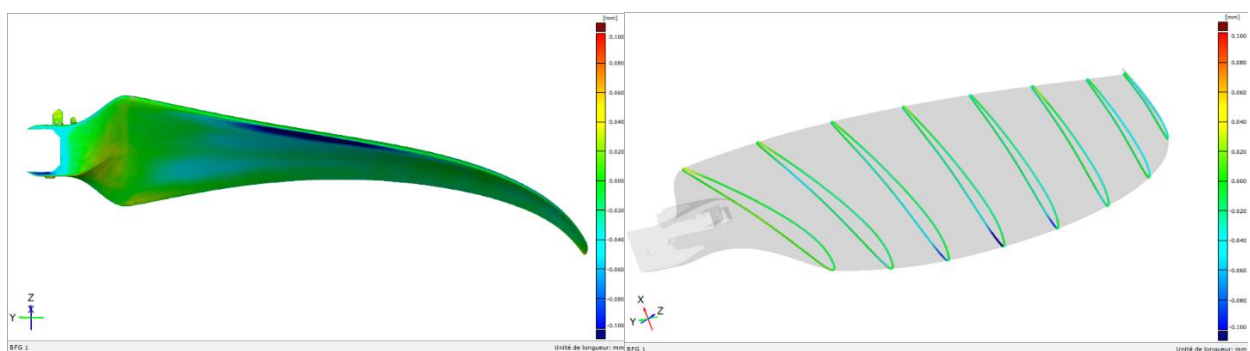
The important milestones in the design were validated with a wind tunnel campaign.



1.7.2 Propulsion

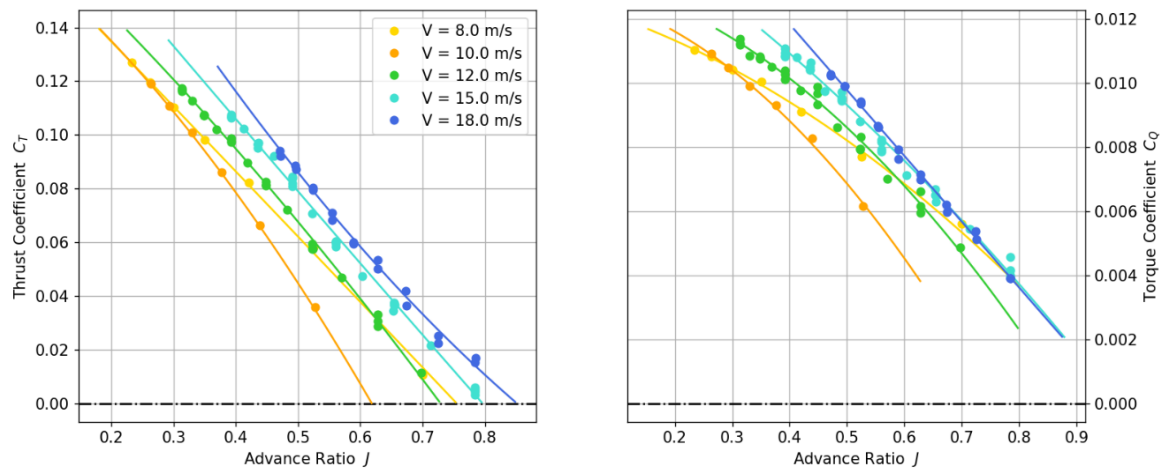
eBee VISION's propeller as the rest of the body has been optimized via CFD to perfectly match the operating conditions of the airframe.

Production of such complex shape is challenging, to guarantee fidelity between the 3D model and final part, propellers have gone through a 3D scanning process.



The data gathered during wind tunnel testing has been used to create a realistic model of the thrust and torques generated by the propeller.

Propulsion System Fit

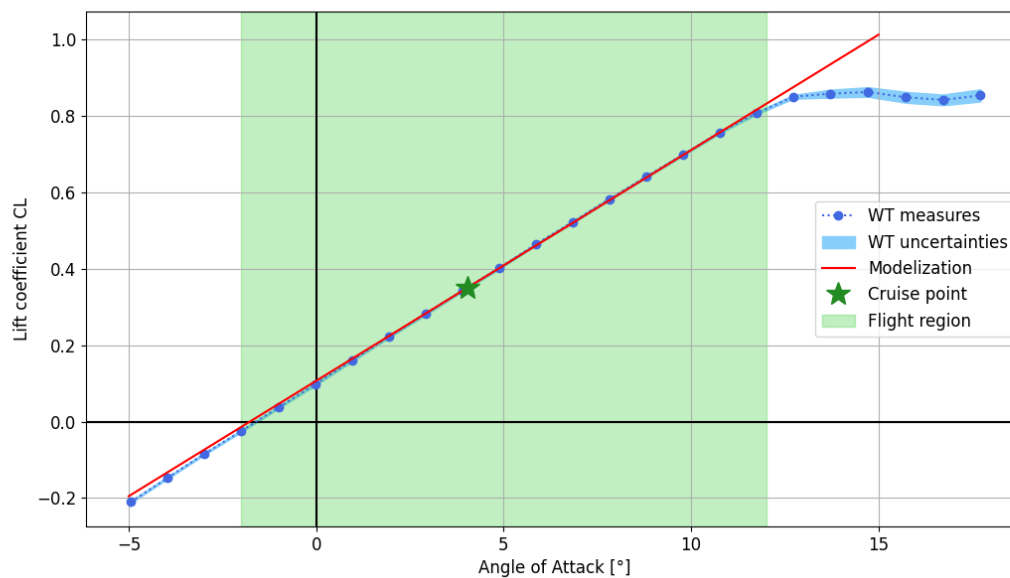


1.7.3 Modelling

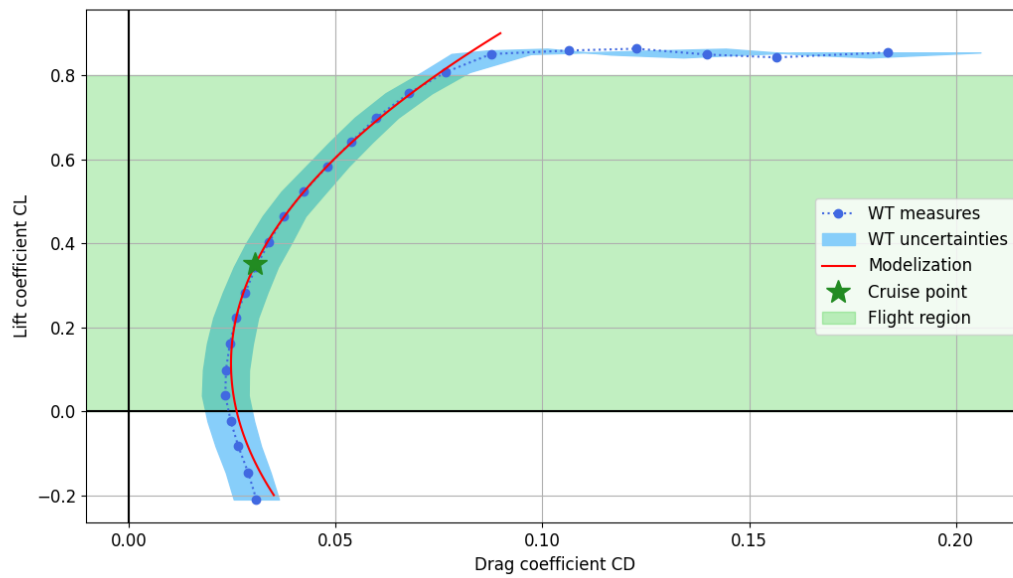
The combination of both CFD and wind tunnel results were used to create a digital twin of eBee VISION which is used for both design and validation of the autopilot.

Below is an example of lift and drag polars models.

Evaluation and modelization of the lift polar

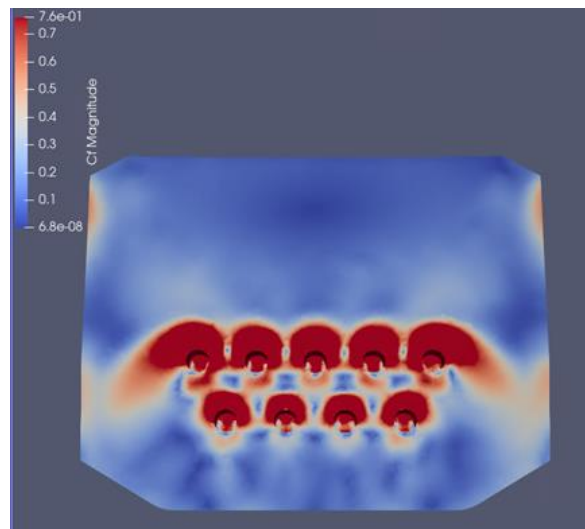
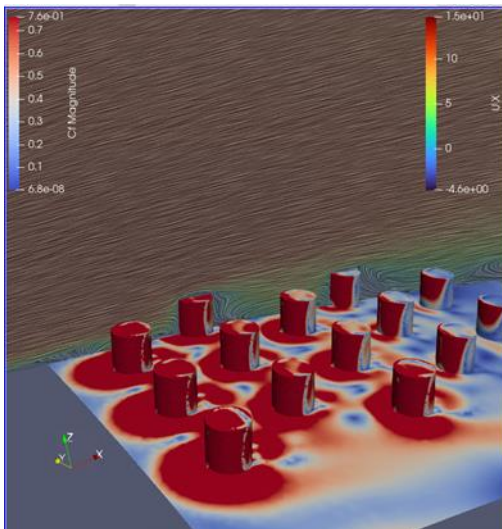


Evaluation and modelization of the drag polar

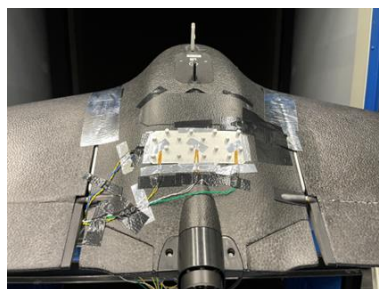


1.7.4 Thermal analysis

eBee VISION's electronics is cooled down with a heat sink optimized by CFD simulations, ensuring maximum thermal efficiency with lowest drag possible.



Simulations results have been confirmed during wind tunnel testing.



2 Q&A

Question	Answer
Bundle	
Basic system content	See packaging list at the end of this document.
Basic system total shipping weight	25 kg / 55 lbs detailed content in chapter 3.
Radio	
Frequency bands	2402 - 2478 MHz MicroHard pMDDL2450 Other frequency band possible with Non Refundable Engineering (NRE)
E.I.R.P. (CE mode)	100mW
Power Long Range FCC	1W
Link range	- Up to 5 km / 3.1 mi with included short-range antennas. - Up to 15 km / 9.3 mi with optional medium-range antennas. - Up to 20 km / 12.4 mi with optional long-range antennas.
Radio link encryption	AES 256
Frequency hopping	No
Operating conditions	
Max Altitude	5 000 m / 16 000 ft
Maximum Take Off above AMSL	Tested up to 3 000 m / 9 800 ft. For higher altitude please contact us.
Temperature range	-10 °C to +49 °C / +14 °F to +120 °F
Endurance	90 minutes
Landing area	10 m x 30 m / 33 x 98 ft including slides on ground
Noise signature	85dB at 60 m / 197 ft distance from observer with ambient noise. Non-audible from 500 m / 0.3 mi with low natural ambient noise.
Visible signature	Invisible to human eye from 500 m / 0.3 mi.
Water landing	No
Payload swappable	No
GCS	
Brand	UXV
Endurance	4h
Screen size	7"
Outputs	Nett Warrior and USB-C
Elevation data	DTED1, DTED2
Offline map	JPEG, JPEG2000, PNG
Video stream resolution	720p
Video sharing to another device	Yes
How many hours of video can be recorded in the GCS?	The GCS can store up to 17 hours of video
Compatibility	
STANAG 4609 compatible	Yes
ATAK / WINTAK compatible	Yes
MAVLINK compatible	Yes
QGC-Gov compatible	Yes, in Dec 2023

Map format	Map tiles: Jpeg, Jpeg2000 and Png Elevation data: Tiff and Dted1/2
Video format	H264
Coordinate systems	LatLng: Latitude Longitude MGRS: Military Grid Reference System DMS: Degree Minutes Seconds
Flight mode	
Is it possible to update the flight plan during mission?	Yes, the flight plan can be modified at any time, to add a waypoint user must go to mission preparation screen (can be done in flight).
How many waypoints can be defined for a flight plan?	No limit.
How many flight plans / missions can be created?	No limit.
What is the Return To Home (RTH) location?	RTH location is at the landing point.
Is it possible to define the RTH position different from the take-off position?	Yes, the RTH location i.e. landing point can be modified at any time.
Is it possible to modify the RTH location during the mission?	Yes, the RTH location i.e. landing point can be modified at any time.
Are there any Obstacle Avoidance capabilities?	Yes. A ground obstacle avoidance LiDAR system.
Target tracking	Yes, with Scouting mode.
Is there an automatic target detection?	Not yet – Planned for future.
Manual mode	Ability to fly the drone using a joystick on the GCS. During manual mode the sensor is locked to forward looking position.
Low battery	The drone will automatically engage RTH and land with enough energy to successfully land. The further the drone flies, the sooner this behavior will engage. Silent tactical landing is activated when the battery level becomes critical.
Software update required before flight	If the application on the GCS is manually updated, we may require to also update the drone for major releases. The GCS will request update of the drone when connected after GCS update.
How does the eBee VISION's landing system work?	The landing is 100% automatic. The drone first goes to base waypoint (60 m / 196 ft above ground) and waits for clearance allowing the user to visually check the landing space. Once the landing is cleared, the drone starts the descent, during this phase user can do small corrections on the landing path using the left joystick or cancel the landing. During descent eBee VISION is checking the terrain with its LiDAR, if it detects a discrepancy between LiDAR and elevation data, it will perform a low pass. A low pass consists in the drone flying above the landing point to measure its actual altitude with LiDAR, updating the landing plan and finally going back to base for new landing clearance.

Behavior	
Does the system have to be connected to the Internet?	No
Connection lost	Return To Home (RTH) after 3 minutes.
GNSS denied conditions	eBee VISION can return-to-home without GNSS with 10% error margin.
Geofencing	RTH if vertical or horizontal breach. Horizontally, if the drone reaches the 2nd limit (1st limit plus 200 m / 656 ft buffer) silent tactical landing.
Cyber security	
NDAA compliant (U.S. rules)	Designed, assembled in Switzerland and supported in the U.S. National Defense Authorization Act (NDAA) compliant.
Does AgEagle collect data?	No, AgEagle collects no data from eBee VISION system.
Secure Element	eBee VISION embeds a SEALSQ Secure Element chip which is NIST FIPS140-2 Level 3 compliant and Common Criteria EAL5+ certified. This Secure Element performs cryptographic operations, stores and protects sensitive drone information. It features an ECDSA private key, with P521 domain parameters, unique to each drone. This private key cannot be extracted from the Secure Element. The certificate associated with this key is signed by a certification authority. The Secure Element protects the integrity of the embedded software, provides a unique identity to the drone, and features a unique digital signing of the pictures taken by the drone. The drone's boot sequence is secured: the system checks that it uses AgEagle 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.
Export Control	
Swiss	General license for Group 1.
U.S.	No need to apply for a license.
Other than Group 1	Required to apply for Swiss and U.S. authorization (3 weeks).
Maintenance	
200h service interval. Serviceable by the user	The 200-hour product service, done by the user, consists of the following: • Replacement of two servos. • Replacement of pitot tube. • Replacement of lower body plastic and foam parts.

3 Packaging list

eBee VISION drone

Drone with payload
Wings Pair
Drone smart batteries 2x
Drone battery charger
Spare pitot tube
Spare propeller kit
SD card 64GB
T8 screwdriver
User manual
Check list
Backpack
Hard transport case

eBee VISION Ground Control Station

eBee GCS
Swappable radio module
Radio module auxiliary battery
Radio module auxiliary battery charger
Radio module antenna 2x
Charger cable
GCS harness
GCS hardcase

External Antenna Kit (Option)

Tripod
Swappable radio module for external antenna
Radio module dock holder for external antenna
Patch antenna
Dipole antenna
Coaxial cables
Tripod protective cover