



FLYABILITY
ELIOS 2 RAD

USER MANUAL

VERSION 1.2
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1 Before starting

This manual focuses on the features of the dosimetry payload of Elios 2 RAD. It complements the following documents, which the Elios 2 RAD user must also read and understand fully:

- ELIOS 2 Original Instructions – certification compliance, safety guidelines and checklists
- ELIOS 2 User Manual – complete user guide
- ELIOS 2 Smart Battery Guidelines – safety guidelines

2 ELIOS 2 RAD System

The Flyability ELIOS 2 was developed explicitly as a flying platform capable of entering confined and cluttered environments. Elios 2 RAD is equipped with an additional dosimetry sensor.

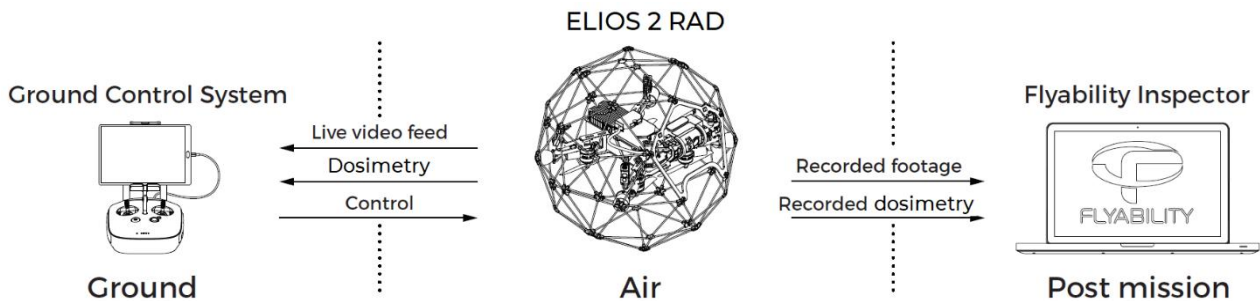
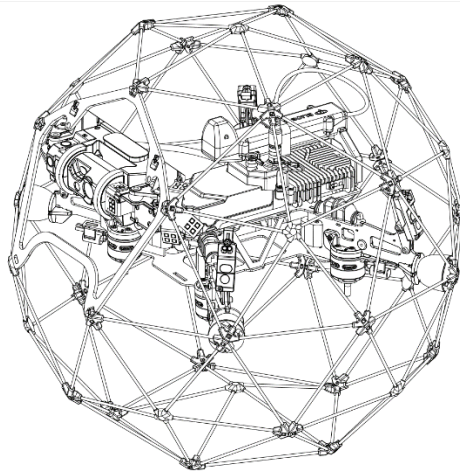


Figure 2.1: System overview

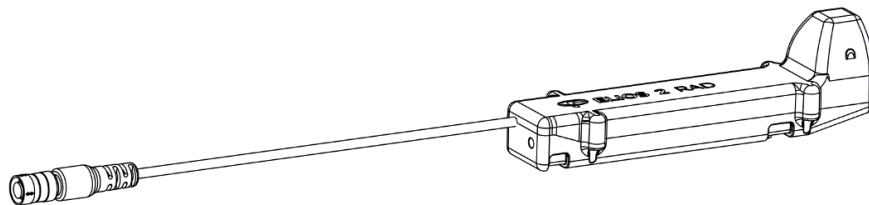
The operator will enjoy full control of Elios through the Ground Control System (GCS). A tablet allows the operator to monitor a live video feed and instantaneous dose rate transmitted by ELIOS 2 RAD. The Flyability Inspector post-mission analysis software provides a simple solution to visualize the recorded video, the thermal video and dosimeter data. Inspector 3.0 premium allows the user to recreate a 3D image of the flight environment to better visualize the dose rates measured in various locations.

3 Elios 2 RAD



Elios 2 RAD is a specially modified Elios 2 designed to carry a dosimetry detector module. Apart from the mounting bracket for the detector module, and the modified casing with a connector, all user changeable parts are compatible with a standard Elios 2. There is no significant change in flight behaviour and collision resilience, though flight time is reduced slightly due to the added weight of the sensor module.

4 ELIOS 2 RAD detector module



This module allows Elios 2 RAD to measure ambient radiation. At its core, the sensor module has an energy-compensated Geiger-Müller tube capable of detecting both Gamma and X-rays.

The sensor module is removable for calibration, but can only be installed on the specially modified Elios 2 RAD drone. To remove the sensor, undo the straps that hold it in place, and disconnect the cable that plugs into the body of the drone.

The detector unit should not be installed or removed while the drone is powered (battery connected). In case a disconnection is detected, Cockpit will show a warning : "Sensor error - restart your aircraft". In this case, the measurement of the flight shall be discarded.

Elios 2 RAD is shipped with one LOW dose detector model.

4.1 Detector Specifications

LOW LEVEL RADIATION DETECTOR

Detector technology
 Types of radiation detected
 Calibration Energy
 Maximum measurement uncertainty
 Angular response
 H*(10) dose rate range – 10k
 Sensitivity
 Maximum measurement uncertainty
 Statistical coefficient of variation

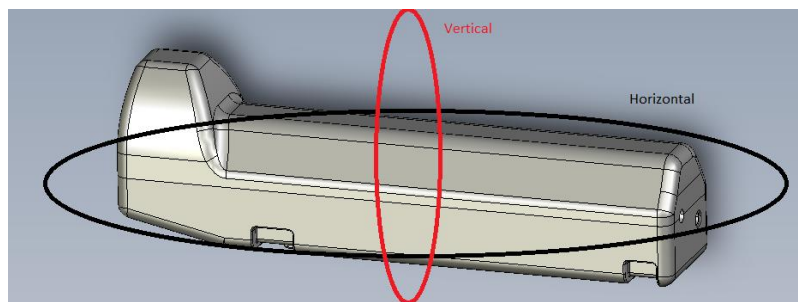
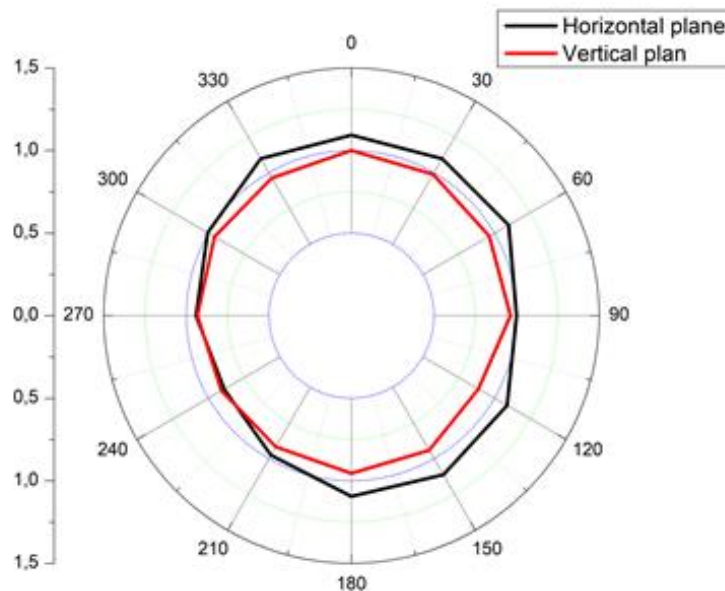
Energy-compensated Geiger-Müller
 Gamma, X-ray
 Cs137
 +-10% for ¹³⁷Cs from 2 to 8mSv/h
 <30% over 180°
 3.5uSv/h - 10mSv/h @ 1 Hz
 2.12 cps/uSv/h
 +- 20% (60 keV – 7000 keV)¹²
 5%

¹ In order to reach +-20% with the sample rate of 1 second, the minimum dose rate is 1mSv/h.

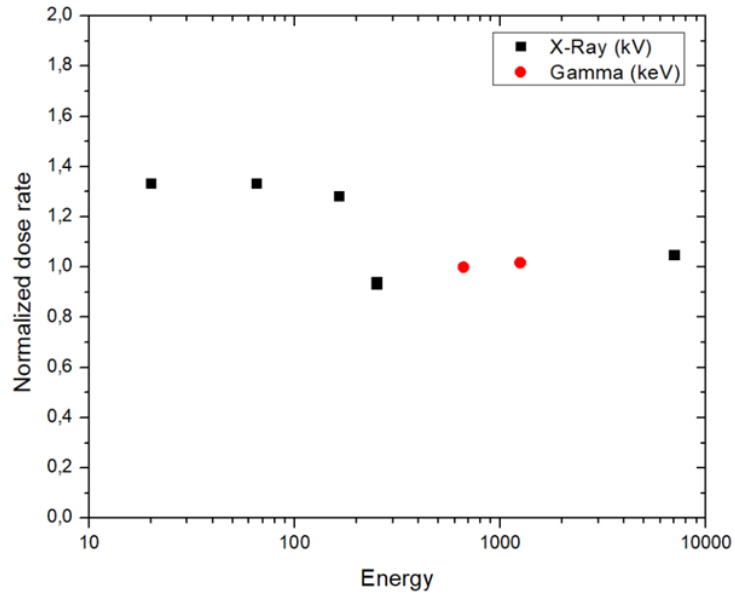
² Range of energy defined with the measurement presented in section 4.2 Radiation detection patterns.

4.2 Radiation detection patterns

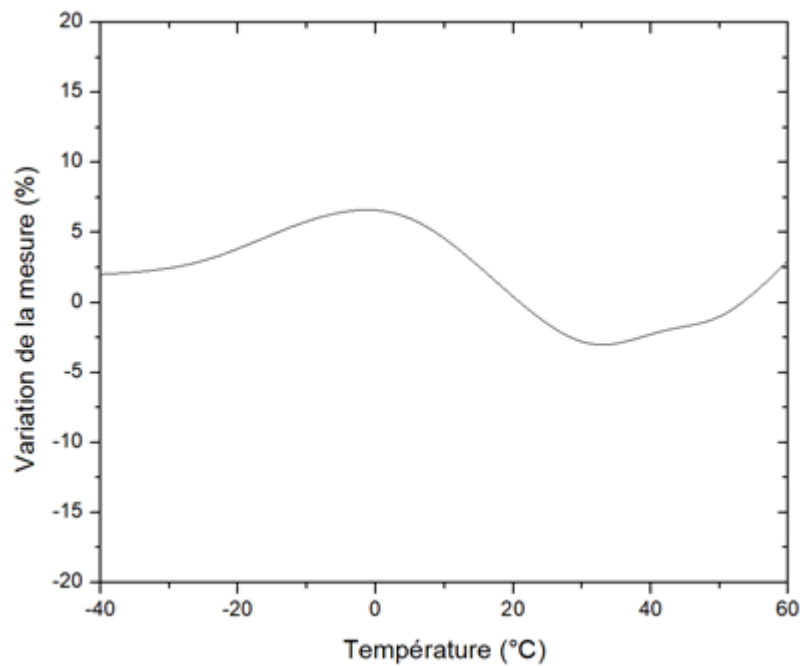
LOW level sensor:



Angular response to Uranium Ore source.



Energy response normalized to Cs137 in compliance with IEC 60846 Radiation protection instrumentation – Ambient and/or directional dose equivalent (rate) meters and/or monitors for beta, X and gamma radiation

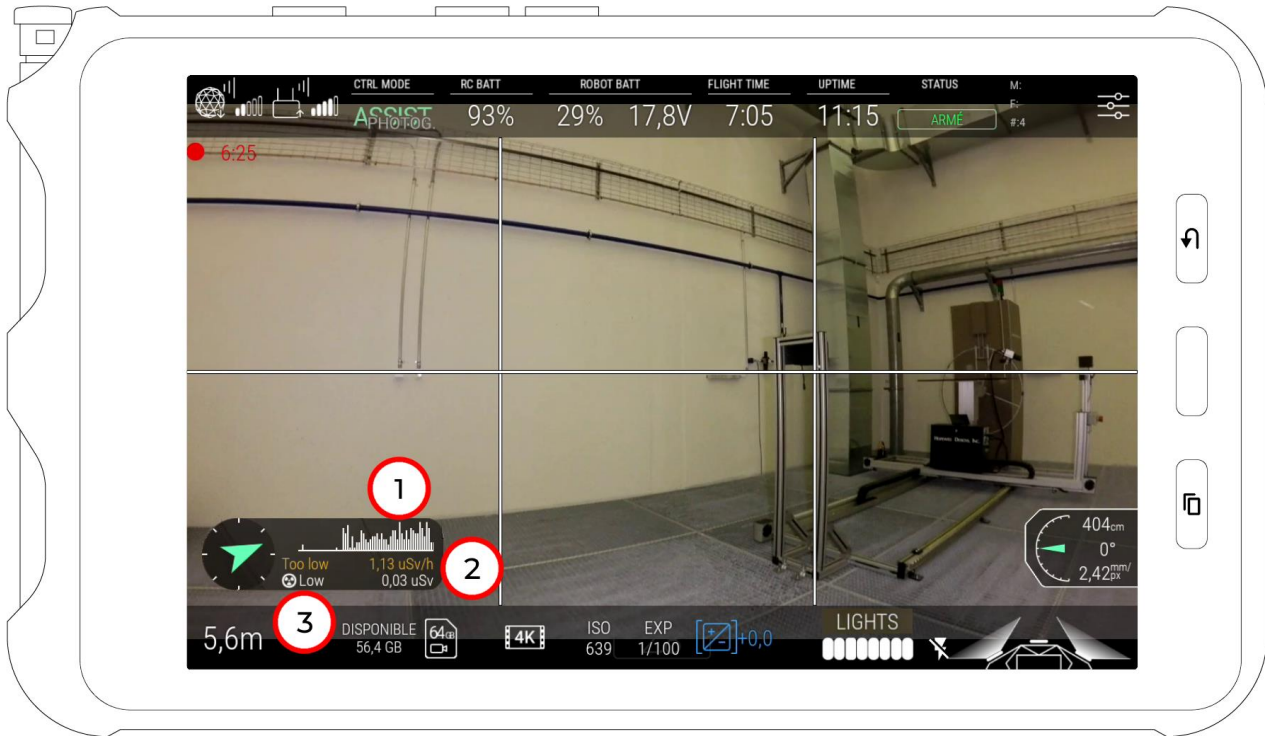


Normalized at 21°C with an Uranium Ore source

5 Cockpit Interface

The dosimetry data is streamed directly to the ground station and can be monitored in real time on the Cockpit application.

5.1 Flight Display



DOSE RATE PLOT

A graphical representation of the dose rates measured over the past few seconds is displayed in the lower left corner (1).

DOSE RATE

The dose rate is displayed below the plot (2)

TOTAL DOSE

The dose rate is displayed below the plot (2) On the left, an indicator shows if the value is out of the range of the detector (too low in yellow or saturated in red), see section 5.2 Out of range behavior).

SENSOR

The type of sensor currently connected is indicated in the lower left corner of the plot area (3). This will indicate either: Low, medium, or High. Only the LOW sensor is currently shipped.

5.2 Out of range behaviour

The Elios 2 RAD detector will provide accurate readings within its specified range. Below the lower limit of the sensor, the dose rate value will be displayed in orange, and the message "Too low" will appear.

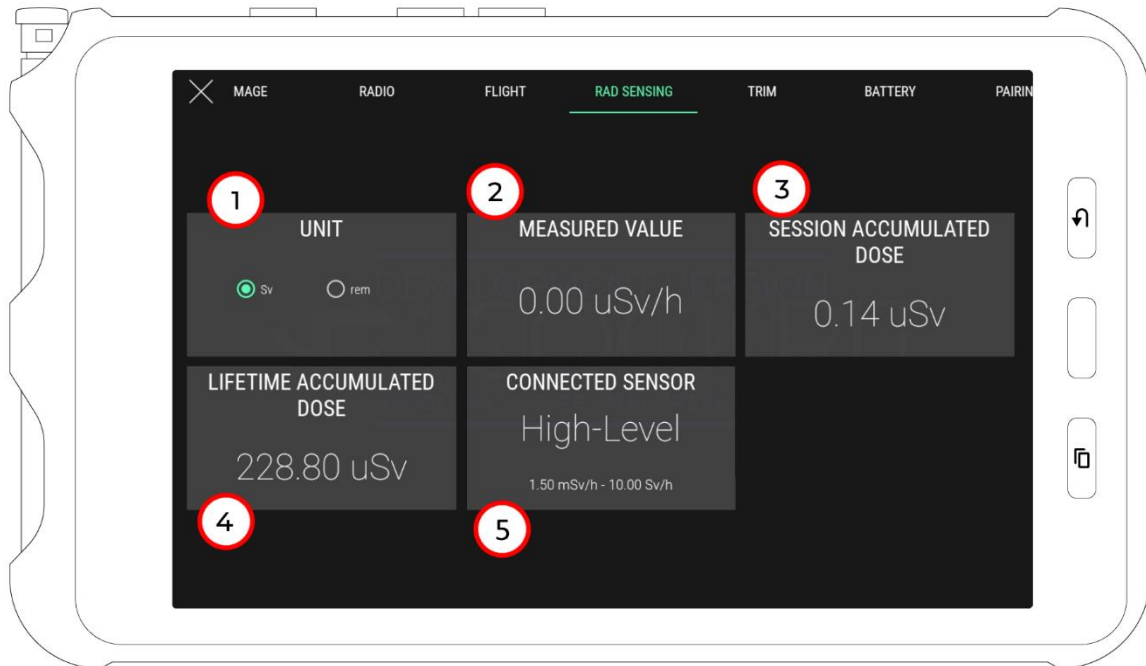
Above the maximum range the detector reaches its saturation point, above this value, the values will continue to rise but they will no longer be accurate. Above the maximum range, the dose rate value will be displayed in red, and the message "SATURATED" will appear next to the value.

When the ambient dose rate largely exceeds the saturation level of the detector, the output measurement values will even decrease slightly. This fold-back effect is not automatically detected.

If the detector type is not detected in the RAD menu panel, the out-of-range behavior will not be available.

5.3 Settings Menu

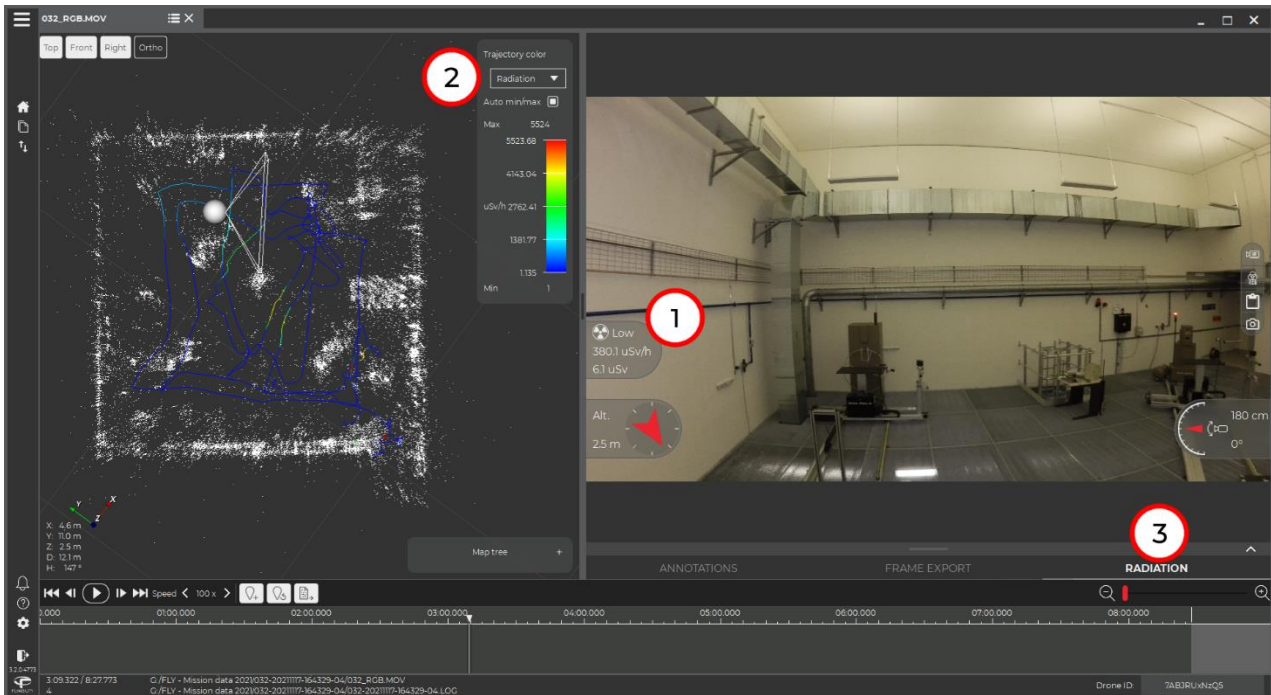
The cockpit settings menu contains the additional 'RAD SENSING' menu tab. This contains the following information and settings:



1. Unit, the unit in which the dose and dose rate are displayed, this can either be Sievert or Rem
2. Measured Value, the dose rate currently measured by the detector, updated every 2 seconds
3. Session Accumulated Dose, the total dose absorbed by the drone since the battery is connected
4. Lifetime Accumulated Dose, the total dose absorbed by the drone over its lifetime before this session
5. Connected sensor, this indicates the range of the detector currently connected.

6 Post flight analysis with Inspector 3

The flight data can be downloaded onto a PC using Inspector 3. The basic version allows the dosimeter data to be displayed alongside the video, while the premium version can re-create a 3D model of the flight environment, with the flight path being colored corresponding to the locally measured dose rate values.



DOSE RATE GAUGE (1)

This gauge will display the dose rate at the current point in the video, and the total dose absorbed until that point in the flight. The user can choose whether the value is displayed in Sievert or Rem in the settings menu.

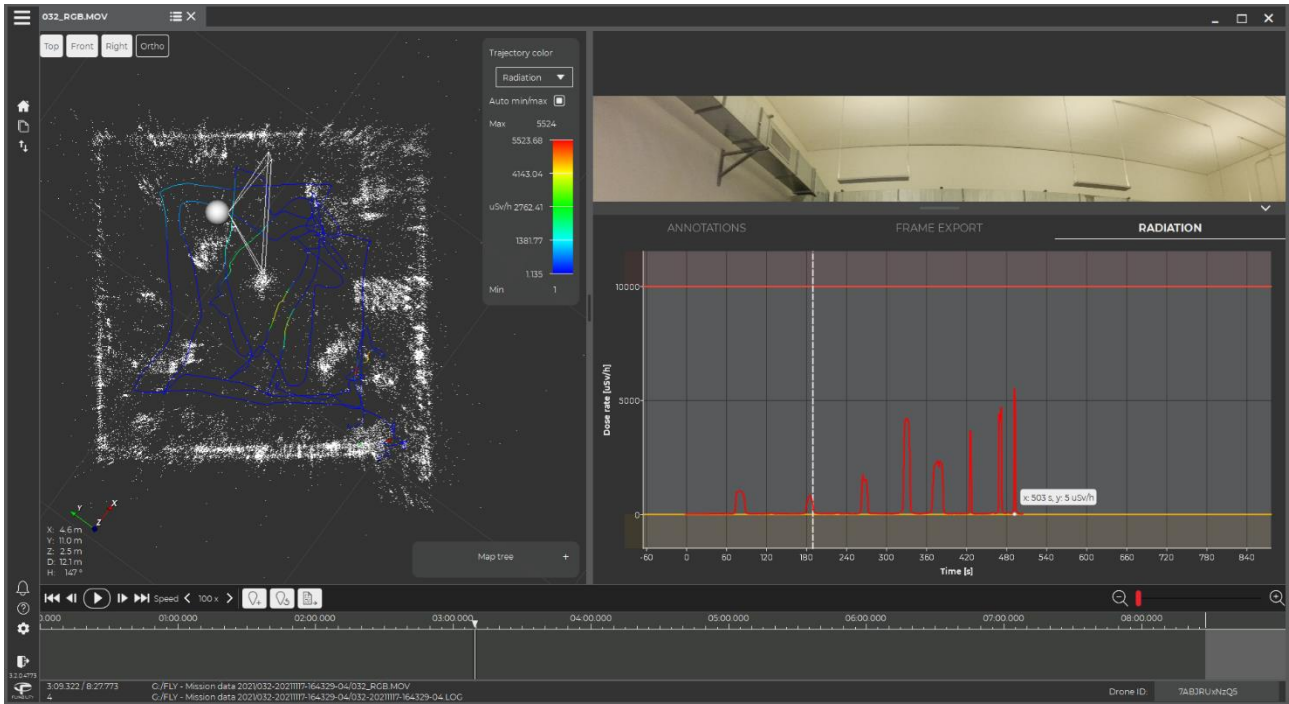
TRAJECTORY COLOR BAR (2)

This menu allows you to change the color mapping of the flight path line in the 3D model. By default, it will autoscale from the minimum to the maximum value.

RADIATION TAB (3)

Click on this tab to expand a plot of the measured dose rate throughout the flight, this allows you to quickly identify hotspots. The lower limit of the detector is indicated in orange and the upper (saturation) limit in red.

If a sensor disconnection was detected, the value will be equal to -1 in the graph



7 Calibration

When used in safety critical applications, we recommend calibrating the detector modules prior to first use. Additionally, the detector units may become damaged due to rough handling during shipping and transport. Such defects can be identified by verifying the calibration.

Additionally, it is recommended to verify the uncertainty below 20% by measurements at 20%, 50% and 80% of the global dose rate range regularly.

The detector modules can be calibrated using the manufacturer's software by connecting the sensor module to a PC via the provided cable. The following software are required:

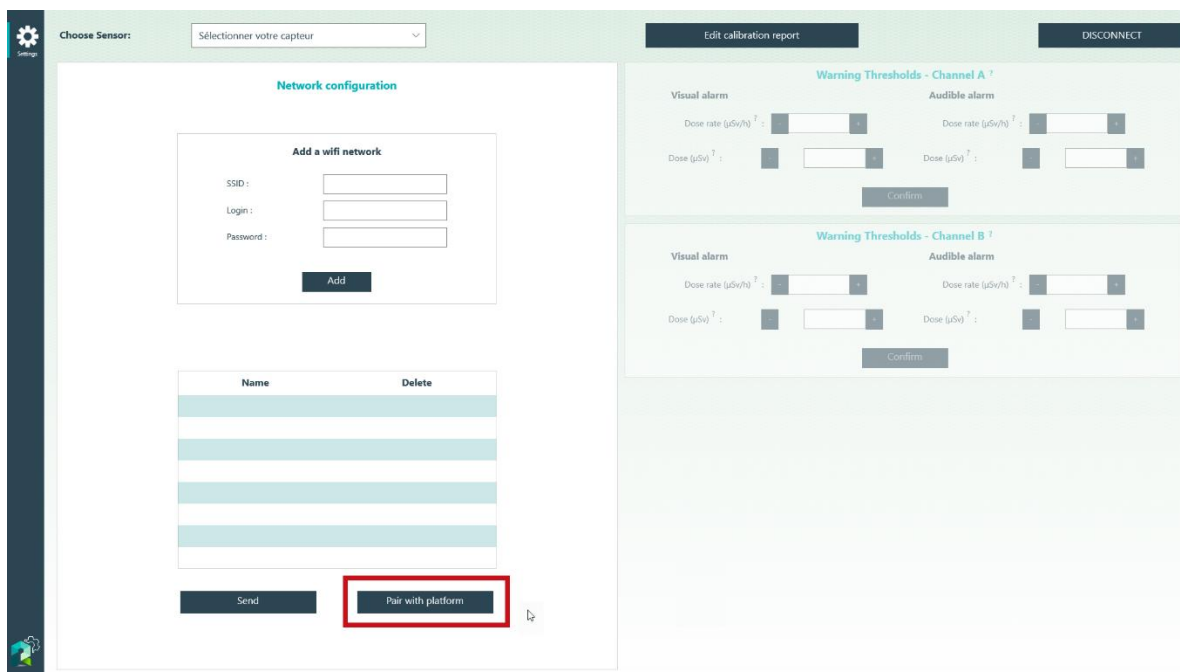
1. RIUMCONFIG calibration software, [available for free on the windows store](#)
2. The FTDI driver for the connection cable, [available here](#)

You will also need a license for the RIUMCONFIG software, this is a .csv file provided with the drone. If you do not have this file, then contact support@flyability.com and you will be given a new one free of charge.

7.1 Setting up RiumConfig

This software is developed by Icohup, the manufacturer of the detector unit. It can only be installed via the Windows Store. Follow the instructions to install it.

When launching the program, you will be given the option to create a password (mot de passe means password). This is not needed for the Elios 2 RAD sensor module, but we recommend you do it anyways, because otherwise it will just keep bothering you with it. You may encounter parts of the program that are not translated, to help you we show you the main translated parts here below.



To activate the license, click on "Pair with platform". This will open a window where you can select your .CSV license file. Once you have done this, restart the program. You will notice that there is no exit button, so you must press Alt+F4 to terminate it.

Start the program again. A second "calibration" button will have appeared on the left hand bar. You have successfully installed and activated RiumConfig.

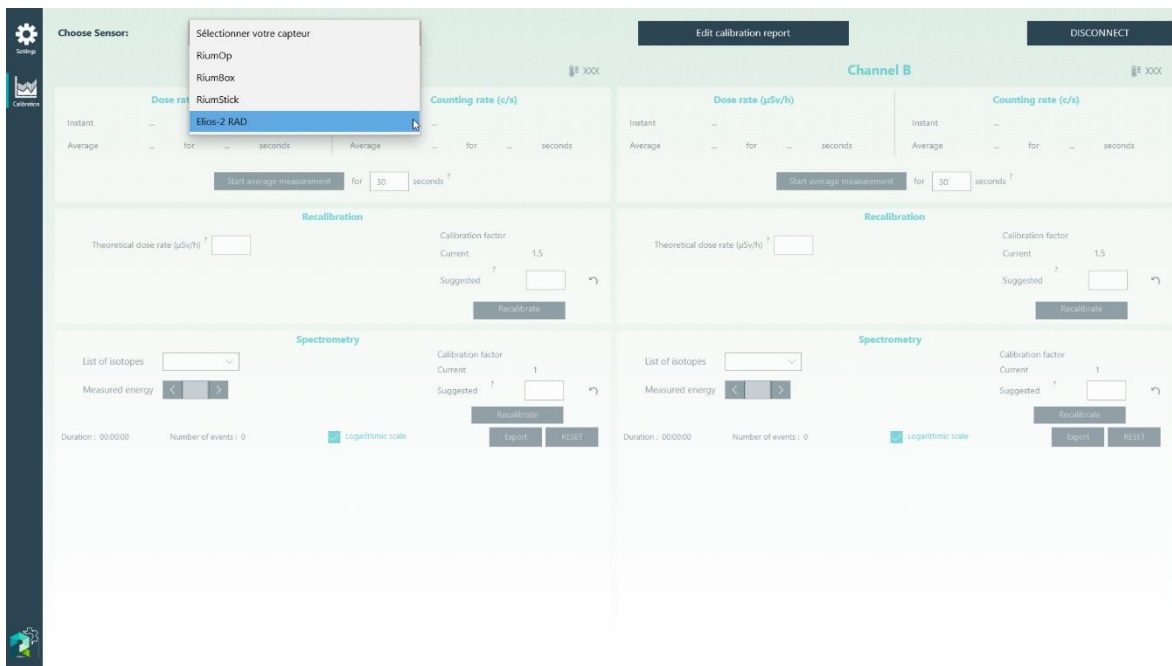
7.2 Calibrating the Elios 2 RAD sensor module

Use the provided USB adapter to connect the sensor module to your PC.

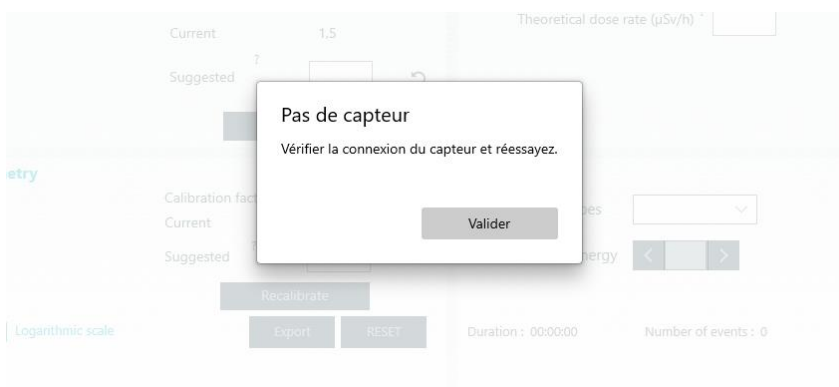
In RiumConfig, click on the “Calibration” tab on the bar to the left, then select it from the drop down menu in the top left.

E2RAD comes with three types of detectors, which are named as follows in RiumConfig:

High level	10K	
Mid level	K	(not available)
Low level	X	(not available)



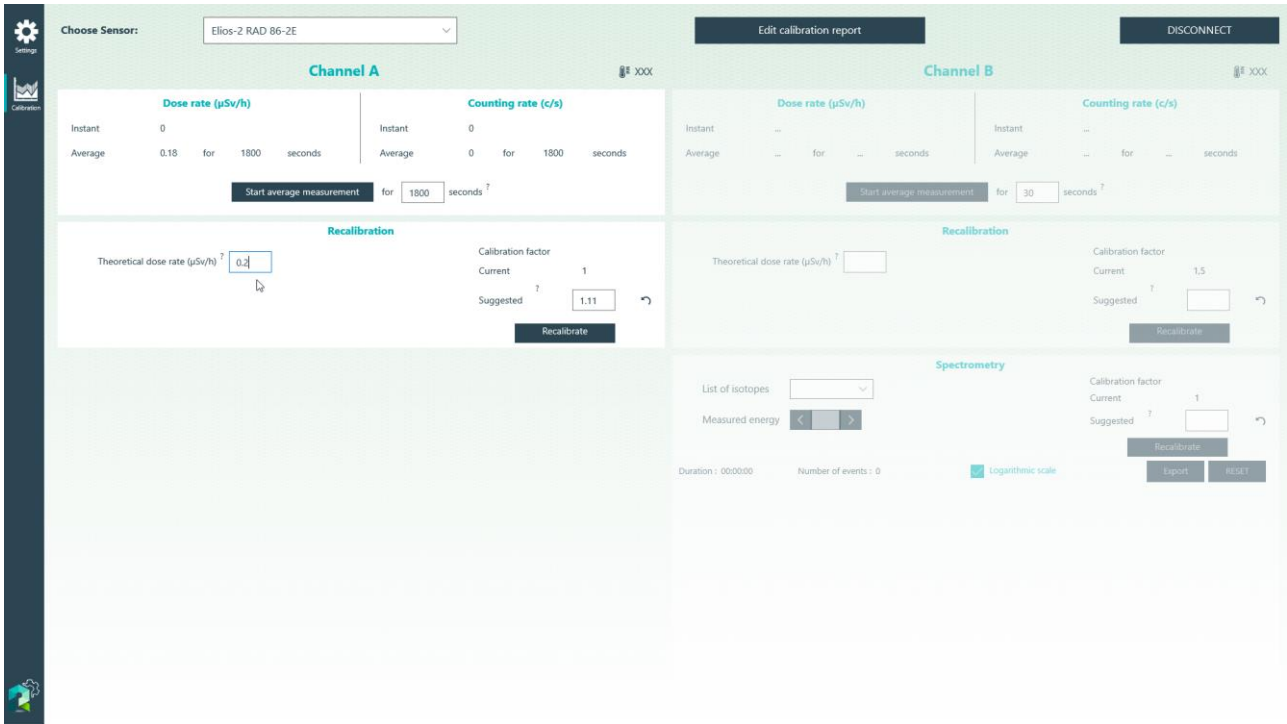
If the Elios 2 RAD sensor module is not connected to your PC at this point, then you will get this message



This message means: “No sensor, verify the connection and try again”. This can be due to a faulty connection, or due to the drivers not being installed correctly. Be sure that the FTDI drivers have been installed.

If the sensor module is successfully connected you will get a message saying: “Confirmation de connexion”, click ‘Valider’ to continue.

You can now calibrate the E2 RAD detector unit by making an average measurement and comparing it with the theoretical value of a known reference source. A suggested value for the calibration factor will appear in the field when you enter the theoretical dose rate of the known reference source.



7.3 Radiation Source

The manufacturer of the detector module recommends calibration by using an irradiator with an homogeneous irradiation field at least 3 times larger than the sensor.

7.4 Position

The sensor must be positioned as follows:

1. the center of the field must fit with the center marks on the sensors.
2. the depth of irradiation must fit with the center on the sensor.

The position of the center of detection is indicated by a gray dot on the casing, as shown on the image below.



The manufacturer of the detector recommends calibration by using ^{137}Cs emitting 662keV gamma particles with a dose rate in the following range: from 3 to 6 mSv/h and 60 seconds irradiation time. Once the calibration factor is adjusted, we suggest validating an uncertainty below 10% from measurements at 20%, 50% and 80% of the global dose rate range.

The irradiation duration must be adjusted in function of the dose rate to reach a sufficient statistic on the count rate.

8 Technical Specifications

AIRCRAFT

CONFIGURATION	Quadcopter
DIMENSIONS	Fits in a < 400 mm sphere; 15.75 in
MOTORS	4 fast reversing electric brushless motors
MOTOR POWER RATING	120W average power, 750W nominal peak power
PROPELLERS	4 propellers, 5 inches
TAKE-OFF WEIGHT	< 1450 g; < 3,2 lbs
MAX FLIGHT TIME	Includes battery, payload & protection Up to 9 min with RAD payload
MAX ASCENT SPEED	1.3 m/s; 4.3 ft/s
MAX DESCENT SPEED	1.3 m/s; 4,3 ft/s
MAX SPEED	1.3 m/s (Assist mode); 4,3 ft/s 4 m/s (Atti mode); 13 ft/s 6.5 m/s (Sport mode); 21 ft/s
MAX PITCH/ROLL ANGLES	0.15 rad (Attitude mode) 0.2 rad (Assist mode) 0.3 rad (Sport mode)
MAX WIND RESISTANCE	3 m/s (Assist mode); 10 ft/s 5 m/s (Sport mode); 16,4 ft/s
FLIGHT CONTROL SENSORS	IMU, magnetometer, barometer, 7 vision and distance sensors
MATERIALS	Carbon fiber composites, magnesium alloy, aeronautical grade aluminum, high-quality thermoplastics
OPERATING TEMP.	0 °C to 50 °C ¹ * (32 °F to 122 °F)
FLIGHT MODES	ASSIST - Assist mode ATTI - Attitude mode SPORT - Sport mode
FAIL-SAFE	Auto-landing on signal lost Forced-descent when battery critically low
OPERATING FREQUENCY	2404 – 2483 MHz (UAV to RC)
EIRP	2.4 GHz: ≤ 32 dBm (FCC); ≤20 dBm (CE); ≤10 dBm/MHz (MIC)
INGRESS PROTECTION	Splash and dust resistant
NOISE LEVEL	99 dB(A) hover 120 dB(A) max @ 1m
ROHS COMPLIANCE	Detector contains lead. Applications exempted from the restriction in Article 4(1) specific to medical devices and monitoring and control instruments. DIRECTIVE 2011/65/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

SMART BATTERY

RATED CAPACITY	5200 mAh
NOMINAL VOLTAGE	19 V
BATTERY TYPE	LiPo 5S HV Smart Battery: - Improved safety (protection for: overcharge, overcurrent, over/under-temperature) - Plug-and-play charging - Self-balancing - Storage self-discharge - Cycle counter - Battery ID
ENERGY	98.8 Wh
CHARGING TIME	1.5 h
BATTERY CHANGE TIME	< 1 min
COMPLIANCE	Approved for carry-on luggage. Complies with IATA Dangerous Good Regulation.
NET WEIGHT	550 g ; 1.2 lbs
OPERATING TEMPERATURE	0-50°C

¹Additional precautions must be taken between 0-10°C and 40-50°C. Stability, flight performance and flight time might be reduced.

additional precautions must be taken between 0-10°C and 40-50°C. Stability, flight performance and flight time might be reduced.

CHARGING TEMPERATURE 10 - 40°C ; 50°F - 113°F
 MAX CHARGING POWER 150 VA AC power
 CHARGER Elios 2 Smart Battery Charger

PAYLOAD CHASSIS

PAYLOAD HEAD Damped for vibrations
 CAMERA POD UPWARD TILT +90 degrees
 CAMERA POD DOWNWARD TILT -90 degrees
 PAYLOAD PROTECTION Load limiting mechanism to protect the payload in the case of a frontal shock.

MAIN CAMERA

SENSOR 1/2.3" CMOS
 Effective Pixels: 12.3 M
 Sensitivity: Optimized for low light performance
 PHOTO FORMATS JPG
 VIDEO FORMATS MOV
 VIDEO RECORDING RESOLUTIONS 4k Ultra HD: 3840 x 2160 at 30 fps
 FHD: 1920 x 1080 at 30 fps
 VIDEO STREAMING RESOLUTION FHD: 1920 x 1080 at 30 fps or SD 640 x 480 at 30fps
 MOVIE FOV 114° horizontal, 130.8° diagonal
 PHOTO FOV 118.8° horizontal, 148.6° diagonal
 TOTAL VERTICAL FOV approximately 260° including camera tilt
 LENS 2.71 mm focal length
 Fixed focal
 CONTROL MODES Auto mode with manual EV compensation
 FILE STORAGE MicroSD card (onboard the aircraft)
 Min Capacity: 64GB
 Max capacity: 128 GB
 Recommended model: Sandisk Extreme micro SDXC UHS-I V30
 SUPPORTED FILE SYSTEM exFAT

THERMAL CAMERA

SENSOR Lepton 3.5 FLIR
 VIDEO RECORDING RESOLUTION 160 x 120 at 9 fps
 LENS FOV 56° x 42°, Depth of field 15cm to infinity
 SENSITIVITY (NETD) <50 mK
 TEMPERATURE RANGE -10°C to 140°C (14°F to 284°F)
 WAVELENGTH (LWIR) 8-14 µm
 FILE STORAGE MicroSD card (onboard the aircraft)
 Max capacity: 32 GB
 Recommended model: Sandisk Extreme micro SDXC UHS-I V30
 SUPPORTED FILE SYSTEM FAT32

LIGHTING SYSTEM

TYPE High-efficiency LEDs for even lighting in front, top and bottom, optimized for low impact of dust on picture quality.
 IR light used for stabilization system.
 CONTROL From the remote controller, adaptive light beam controlled by camera pitch
 MODES Indirect/dustproof lighting
 Close up lighting
 Selective/oblique lighting
 LIGHT OUTPUT Max 10k lumens

OPERATION SAFETY AND CRASHWORTHINESS

NAVIGATION LIGHTS Green (starboard) and red (port) lights.

PROTECTION CAGE	Carbon fiber cage with soft coating, modular subcomponents for maintenance ease, thermoplastic elastomer suspensions, front opening dimensioned for easy battery access.
COLLISION TOLERANCE	Uniform all around the drone, up to 3 m/s on flat objects, up to 1.5 m/s on sharp objects
REMOTE CONTROLLER	
OPERATING FREQUENCIES	2404 - 2483 MHz (RC to UAV) 5738 - 5808 MHz (RC to RC) 920.6 - 928 MHz (RC to RC, Japan only)
MAX TRANSMISSION DISTANCE	Up to 500 m in direct line of sight
EIRP	2.4 Ghz ≤20 dBm, 5.8 GHz ≤13 dBm, 920 MHz ≤10 dBm
WEIGHT	810 g (924 g with tablet holder)
OPERATING TEMP.	0 °C to 40 °C
OUTPUT PORT	HDMI, SDI, USB
BATTERY	6000 mAh 2S
CONTROLS	Aircraft control and payload settings
OPTIONS	Optional remote controller (camera operator) with video stream reception on a secondary screen, and dual control of camera settings.
BATTERY CHARGER	17.4 V / 57 W
TABLET	
MODEL	Samsung Galaxy Tab Active 2
BATTERY CHARGER	USB Charger 5V
OPERATING TEMP.	-15 °C to 40 °C
CHARGING TEMP.	-15 °C to 40 °C
CHARGING TIME	5 hours
WORKING TIME	5 hours (when receiving video stream) to 76 hours (idle)
WEIGHT	415 g
TRANSPORT CASE	
DIMENSIONS	61 x 44 x 53 cm
WEIGHT	11.5 kg
COMPLIANCE	IATA compliant for checked-in luggage.
COCKPIT SOFTWARE	
FEATURES	Real-time video and UAV telemetry, status visualization (remaining battery, payload settings, warnings, etc.), control payload settings and various configurations.
OPERATING SYSTEM	Android. Optimized for tablet provided with the ELIOS 2 system
INSPECTOR SOFTWARE	
FEATURES	Video and thermal video viewer (frame by frame), flight log analysis including point of interests recorded during flight, screenshots, and flight data export.
OPERATING SYSTEM	Windows 7, 8 and 10 (32 and 64 bits)

9 ELIOS System transmitted Power

ELIOS 2

FREQUENCY BAND TX	2406 – 2476 MHz
MAXIMUM OUTPUT POWER	60mW, 18dBm in 2.4GHz band (CE mode) 456mW, 26.6dBm in 2.4GHz band (FCC mode)
DESIGNATION OF EMISSIONS	Digital bidirectional video and data downlink to remote controller, command and data uplink to to UAV
TECHNOLOGY	OFDM, wideband
MODULATION TYPE	OFDM
E-FIELD STRENGTH	7.13V/m (measured at 20cm)

GCS

FREQUENCY BAND TX	2404 – 2480 MHz 5738 – 5808MHz (CamOp, standard version) 920.6 MHz to 928 MHz (CamOp, Japan version)
MAXIMUM OUTPUT POWER	40mW, 16dBm in 2.4GHz band (CE and FCC mode) 6.3mW, 8dBm in 5.8GHz band (CE mode) 4.4mW, 6.4dBm in 5.8GHz band (FCC mode)
DESIGNATION OF EMISSIONS	Radio Video Downlink and telemetry and uplink of the from Drone
TECHNOLOGY	OFDM, wideband
MODULATION TYPE	OFDM

To comply with both FCC and CE standards concerning transmission power, the ground unit uses a GPS module to determine its geographic location and the power is adjusted accordingly. FCC mode is used in the following regions: USA, Canada, Mexico, Australia, Brazil, Taiwan. In other regions, or if no GPS position can be obtained, the system uses the more conservative CE standard.

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Content subject to change.
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