ADS-B AND FLARM RECEIVERS, OMEA 8C ALL SKY CAMERA, BOLTWOOD CLOUD SENSOR

Reception report: specifications and setup instructions

YLARA Project

YLARA-LS-60-I01,2,3/YLARA-BS-50-I01 (CDT Technical Report 2019-07)

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Yebes Observatory, IGN-CNIG

July, 2019

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RADARCAPE ADS-B SYSTEM

Reception report: specifications and setup instructions

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YLARA-LS-60-I01 (CDT Technical Report 2019-07)

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Applicable and reference documents

[1] Radarcape - High Performance. ADS-B-Receiver with Embedded Linux. User Manual. Jetvision. 2016. https://wiki.jetvision.de/wiki/Radarcape:Contents

[2] Radarcape - Quick Start Guide. Jetvision. 2018.

[3] Active Diapason Antenna 868 MHz – Data Sheet and Quick Start Guide. Jetvision. 2016.

[4] ADS-B technology informs the SGF in-sky aircraft safety system. NERC Space Geodesy Facility. Herstmonceux. http://sgf.rgo.ac.uk/operations/adsb.html

[5] Radarcape - ADS-B Receiver Full Featured. https://shop.jetvision.de/radarcape_en

[6] ADS-B RECEIVER MLAT, Radarcape all built-in device. https://radarcape.com/

1. Radarcape ADS-B receiver

1.1. Introduction

- ADS-B (Automatic Dependent Surveillance - Broadcast).
- Aircrafts periodically transmit their state vector (horizontal and vertical position, horizontal and vertical velocity) and other information.
- ADS-B is **automatic** because no external stimulus is required; it is **dependent** because it relies on on-board navigation sources and on-board broadcast transmission systems to provide surveillance information to other users.
- The aircraft or vehicle originating the broadcast may or may not have knowledge of which users are receiving its broadcast; any user, either aircraft or ground-based, within range of this broadcast, may choose to receive and process the ADS-B surveillance information.
- ADS-B supports improved use of airspace, reduced ceiling/visibility restrictions, improved surface surveillance, and enhanced safety such as conflict management.

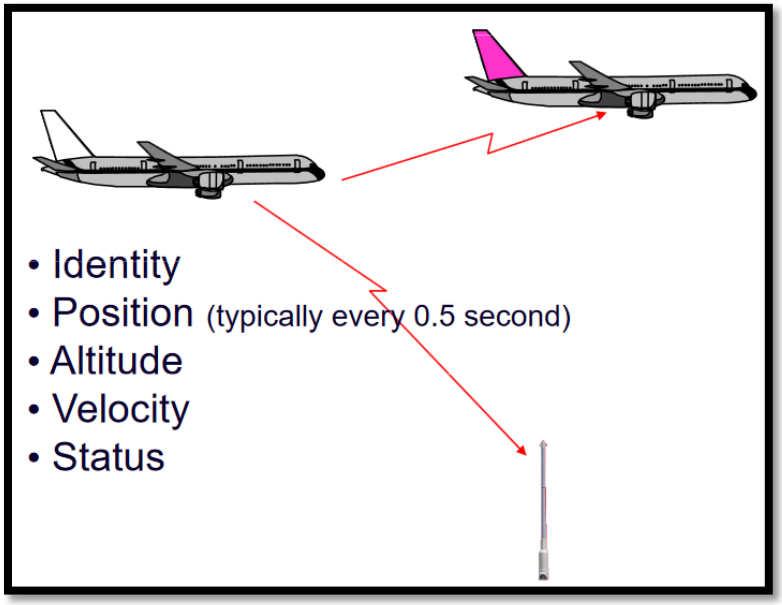


Figure 1: ADS-B fundamentals I.

1.2. ADS-B working principle

- Aircraft determines its position (typically using GPS).
- Broadcast position, identity, altitude and velocity information (ADS-B out).
- Ground stations receive the broadcast and relay the information to air traffic control.

- Other aircraft receive broadcast and display to pilot (ADS-B in).

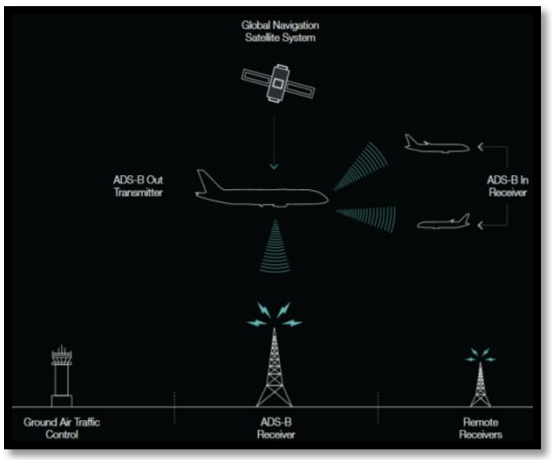


Figure 2: ADS-B fundamentals II.

Typical receiver antenna specifications:

- Omnidirectional, frequency: 1090 MHz, peak gain: 5.5dBi

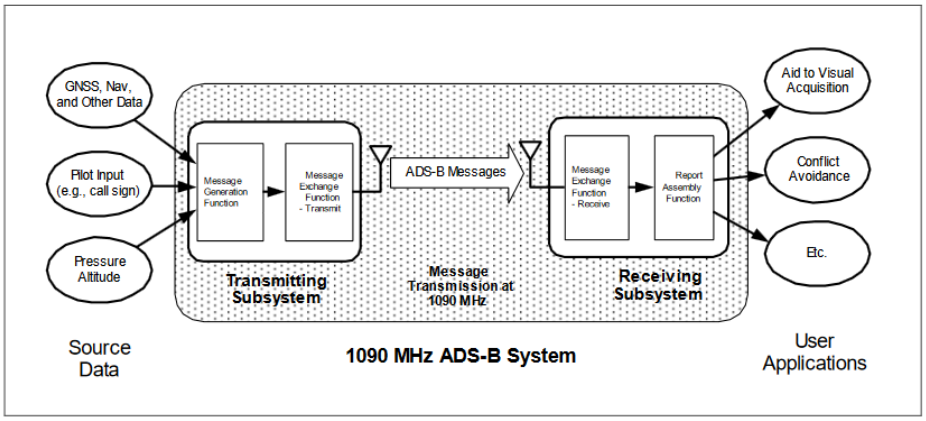


Figure 3: ADS-B components.

1.3. Radar Vs ADS-B

Far different from radar, which works by bouncing radio waves from fixed terrestrial antennas off of airborne targets and then interpreting the reflected signals, ADS-B uses conventional Global Navigation Satellite System (GNSS) technology and a relatively simple broadcast communications link as its fundamental components.

Also, unlike radar, **ADS-B accuracy does not seriously degrade with range**, **atmospheric conditions**, **or target altitude** and update intervals do not depend on the rotational speed or reliability of mechanical antennas.

ADS-B ground stations are simple and economical.

ADS-B will someday replace most of the World's Surface Surveillance Radars (SSR's) for routine Air Traffic Control functions.

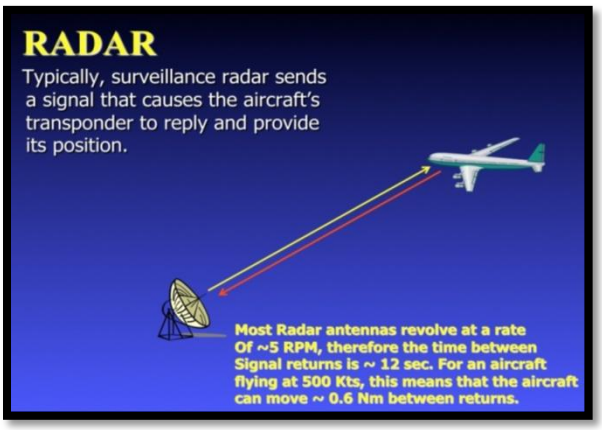


Figure 4: RADAR.

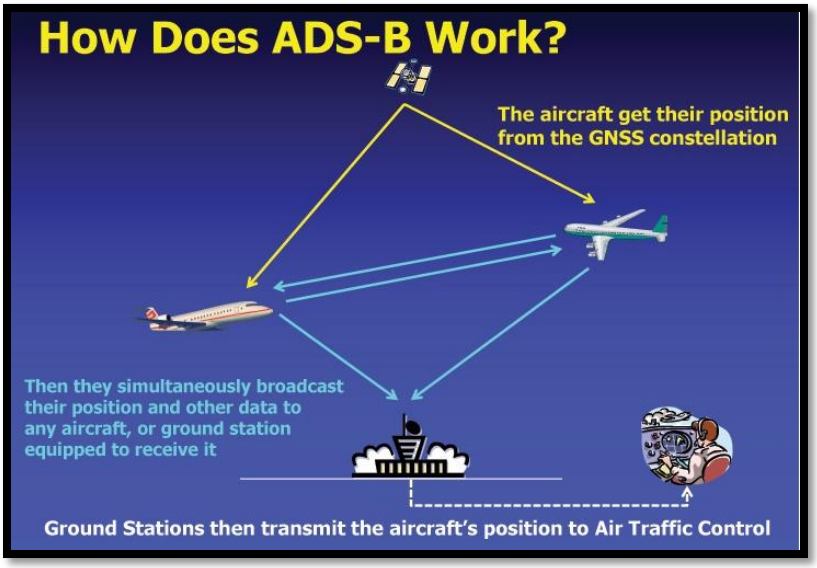


Figure 5: ADS-B working principle.

ADS-B is an environmentally friendly technology that enhances safety and efficiency, and directly benefits pilots, controllers, airports, airlines, and the public. It forms the foundation for NextGen by moving from ground radar and navigational aids to precise tracking using satellite signals.

With ADS-B, pilots for the first time see what controllers see: displays showing other aircraft in the sky. Cockpit displays also pinpoint hazardous weather and terrain, and give pilots important flight information, such as temporary flight restrictions.

ADS-B reduces the risk of runway incursions with cockpit and controller displays that show the location of aircraft and equipped ground vehicles on airport surfaces – even at night or during heavy rainfall. ADS-B applications being developed now will give pilots indications or alerts of potential collisions.

ADS-B also provides greater coverage since ground stations are so much easier to place than radar. Remote areas without radar coverage, like the Gulf of Mexico and parts of Alaska, now have surveillance with ADS-B.

Relying on satellites instead of ground navigational aids also means aircraft will be able to fly more directly from Point A to B, saving time and money, and reducing fuel burn and emissions.

And RADAR can be a problem when working in a Radio Observatory, interferences to VLBI radio telescopes…!

1.4. ADS-B and SLR

Aircraft transmit real-time updates of their positions and velocities which are monitored for early warnings in case they approach the SLR laser beam.

ADS-B technology allows to inform the SLR observer of nearby aircraft and to make real time predictions to avoid pointing the laser beam in the direction of an aircraft.

Aircraft carrying ADS-B equipment broadcast binary messages containing their identification, position and velocity at approximately one second intervals. These signals are sent on a frequency of 1090 MHz and can be intercepted by a radio antenna.

The latitudes, longitudes and altitudes are converted to in-sky azimuths and elevations and can be plotted for the SLR observer. The broadcast velocity components allow predictions to be made and warnings to be sent in advance of an approaching aircraft.

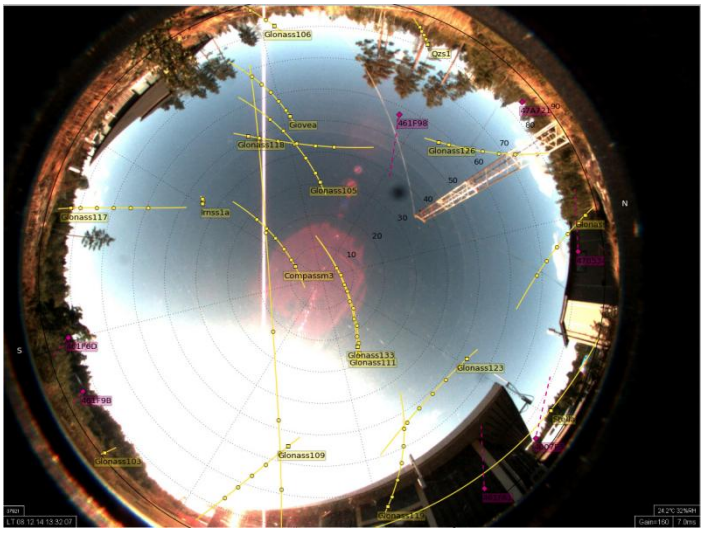


Figure 6: All-sky camera image with ADS-B information.

1.5. RADARCAPE setup

Box contains (**received at Yebes, 09/01/2019**):

- Radarcape receiver (SN: 1304-1826, MAC=98:84:e3:b7:22:41)
- Power supply (input: 220AC, output: 5V, 2.1A)
- 5 m ethernet cable
- GPS antenna (cable length 5 m), Trimble PN: 66800-00 C, SN: 15670250
- "Active Diapason" Antenna, 1090 MHz, (PN:68200, SN: HS 85177000)
- Bias Tee (for power supply of the LNA over USB-jack of a computer). 50-2500MHz, DC=5-12V, 200mA
- USB cable
- Antenna mount (The antenna mast is **not included**!)
- 20 m antenna cable (SMA_m to SMA_m).

Figure 7: Radarcape ADS-B receiver components.

MAC=98:84:e3:b7:22:41
IP (Yebes): 172.16.3.143

1. Connect the mode-S antenna with the antenna cable to the Radarcape, place the antenna as free and as high as possible. **Make sure that the antenna has a conductive connection to ground to avoid damage of Radarcape or internet router.**

   Static electricity around the antenna can damage your Radarcape or internet router if there is not ground connection.

   Do NOT mount the antenna on isolated ground, without any connection to ground. The antenna MUST be grounded.

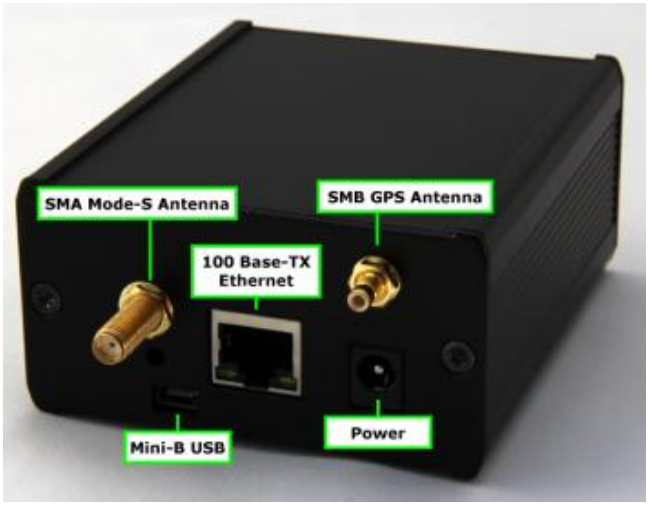


Figure 8: Radarcape back side.

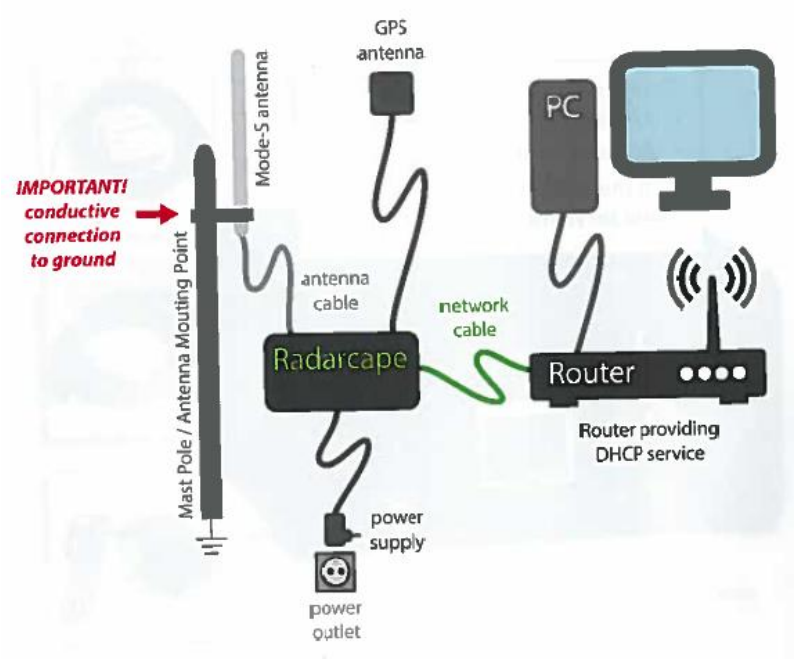


Figure 9: Radarcape setup diagram.

2. Connect the GPS antenna to the Radarcape. Place the GPS antenna to a location with at least half of sky view.
3. Connect the network cable to the ethernet port and the Radarcape.
4. Connect the power supply to the Radarcape and the power outlet.

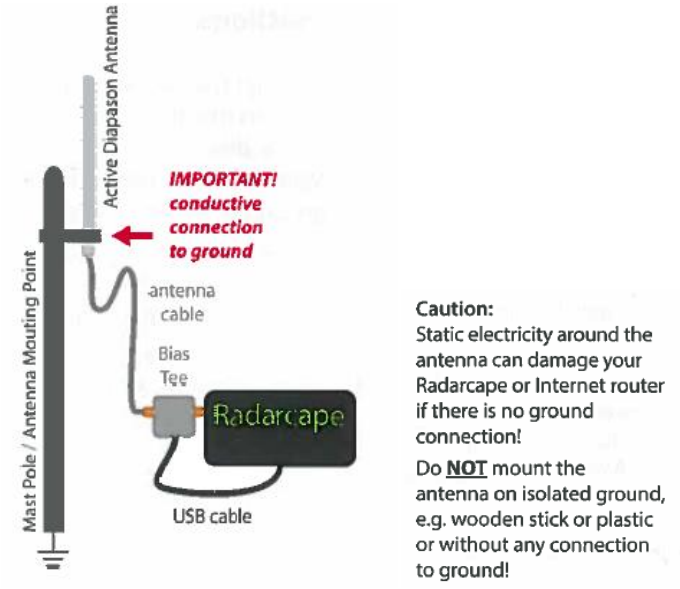


Figure 10: Active diapason antenna installation.

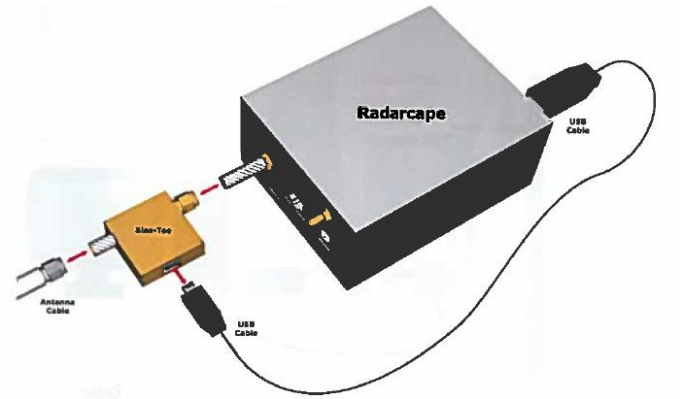


Figure 11: Bias tee installation.

LED description:

- Power led: green when power is applied to the device.
- Mode-S led: flashing on each data frame that has been received from aircraft. If no frames are received, it flashes one per second in order to indicate working state.
- GPS led: flashing green once each second exactly when the second changes.

STARTUP:

1. Wait a few minutes to make sure the network is connected.
2. Open an internet browser on your PC.
3. Enter http://radarcape to open the Radarcape user interface.

   In rare cases, http://radarcape.local must be used as some router models use a non-standard configuration.

4. Multilateration (MLAT): join the public Jetvision Multilateration (MLAT) network to display also those locations of aircraft which are equipped with only a mode-S transponder but not transmitting ADS-B information, such as older commercial, private and military aircraft.

   As a non commercial user there is just a small registration fee. http://shop.jetvision.de/Jetvision-Flight-Tracking-Network/en

   For closed user groups or local installation, the MLAT product is also available as dedicated and private installation. Contact Jetvision for more details.

5. Go to Aircraft data>Live 2D OpenLayers Map to see the received aircraft on a 2D map.

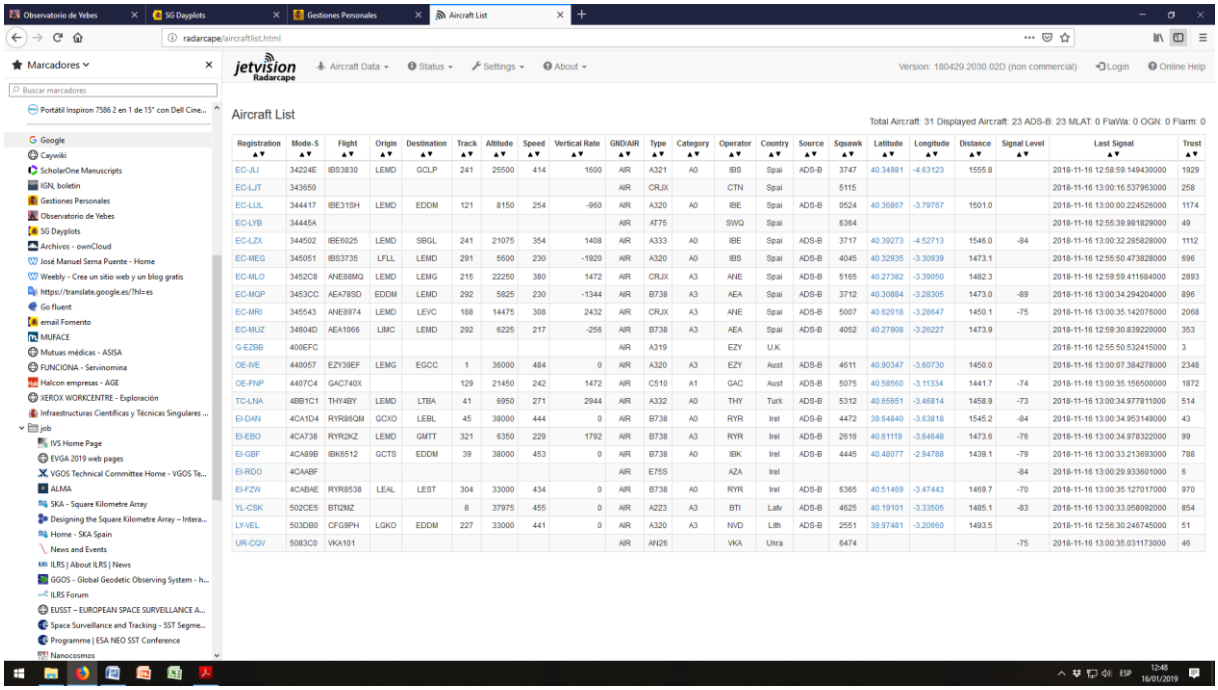


Figure 12: Aircraft list.

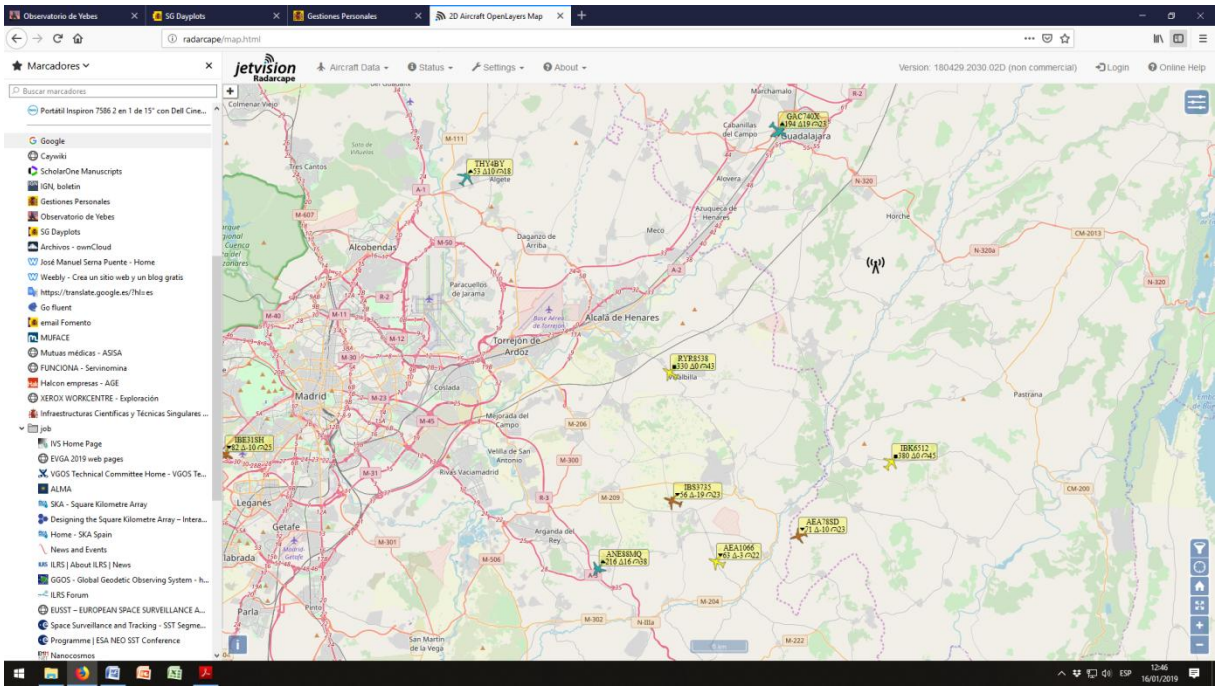
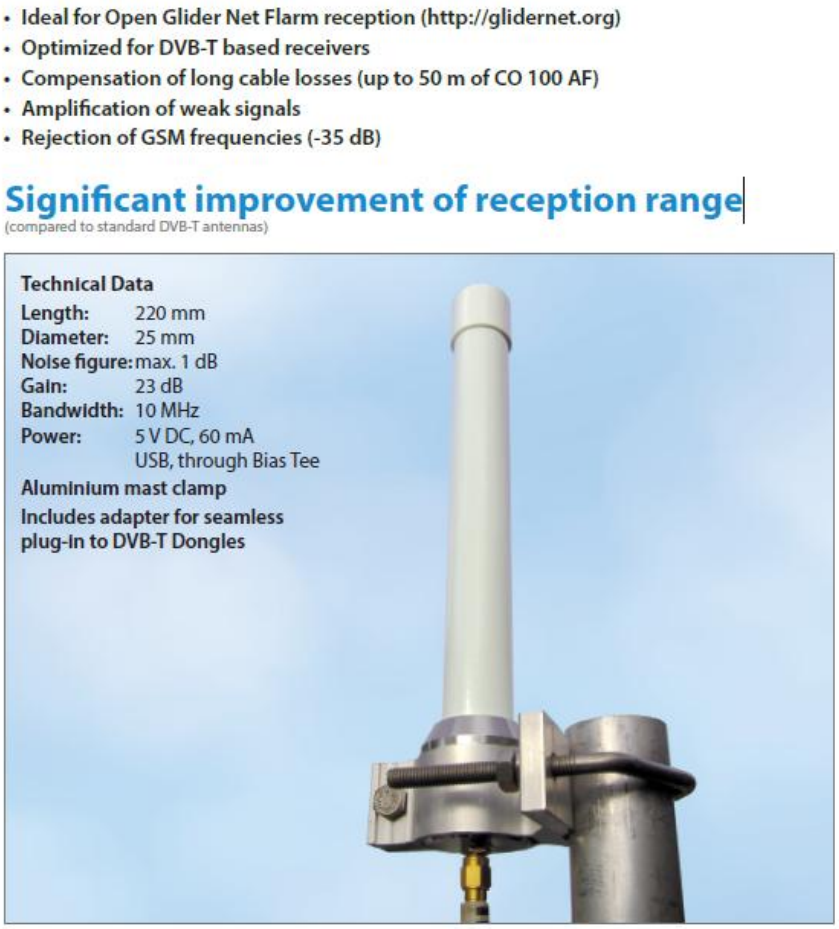


Figure 13: Live 2D OpenLayers Map.

2. Annexes

2.1. Active Diapason Antenna 868 MHz



Active Diapason Antenna Characteristics.

2.2. First setup

First setup, January 2019. (just to check the device works after the reception)

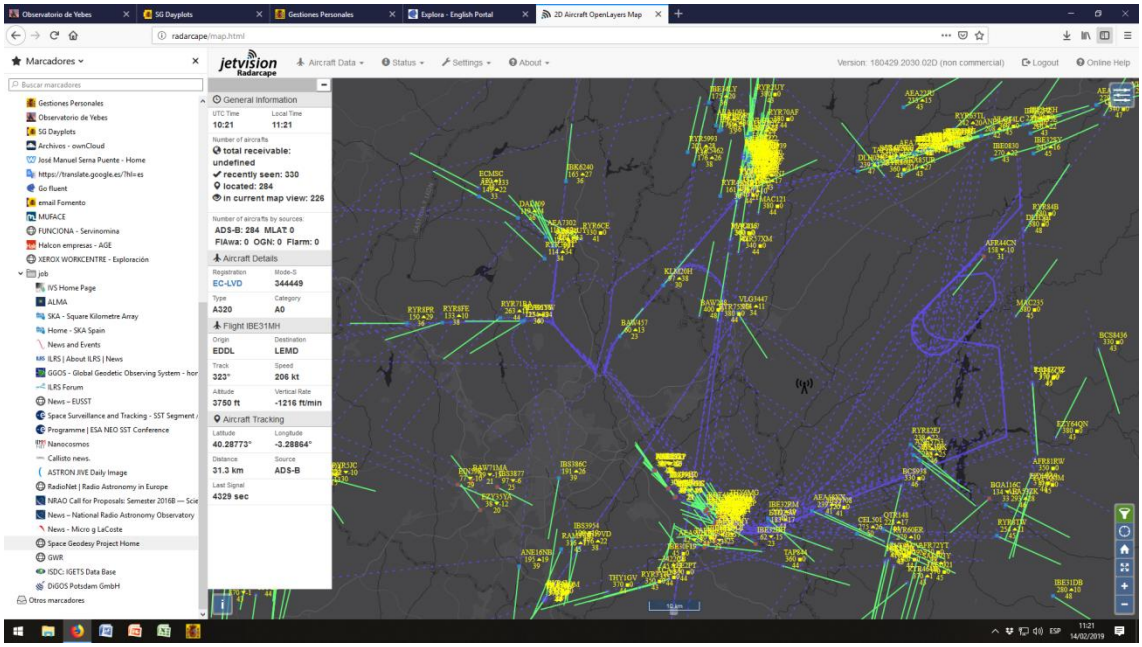
2.3. Web server trajectory plotter setup

- Open layers 2D map / ATC view.

- Delete time = 300 min (10 min default).

- Omit time = 300 min (5 min default).

- Filter: set track length to 99999 (and tick ✓).



Yebes, 13022019

2.4. Planeplotter

http://www.coaa.co.uk/planeplotter.htm

21 days free license (later 25€)

Movie generator: PlanePlotter can generate an AVI movie file showing a speeded up version of the display window. You can review aircraft movements, including those received by sharing, at a later date by playing the AVI file in, for example, Windows Media Player.

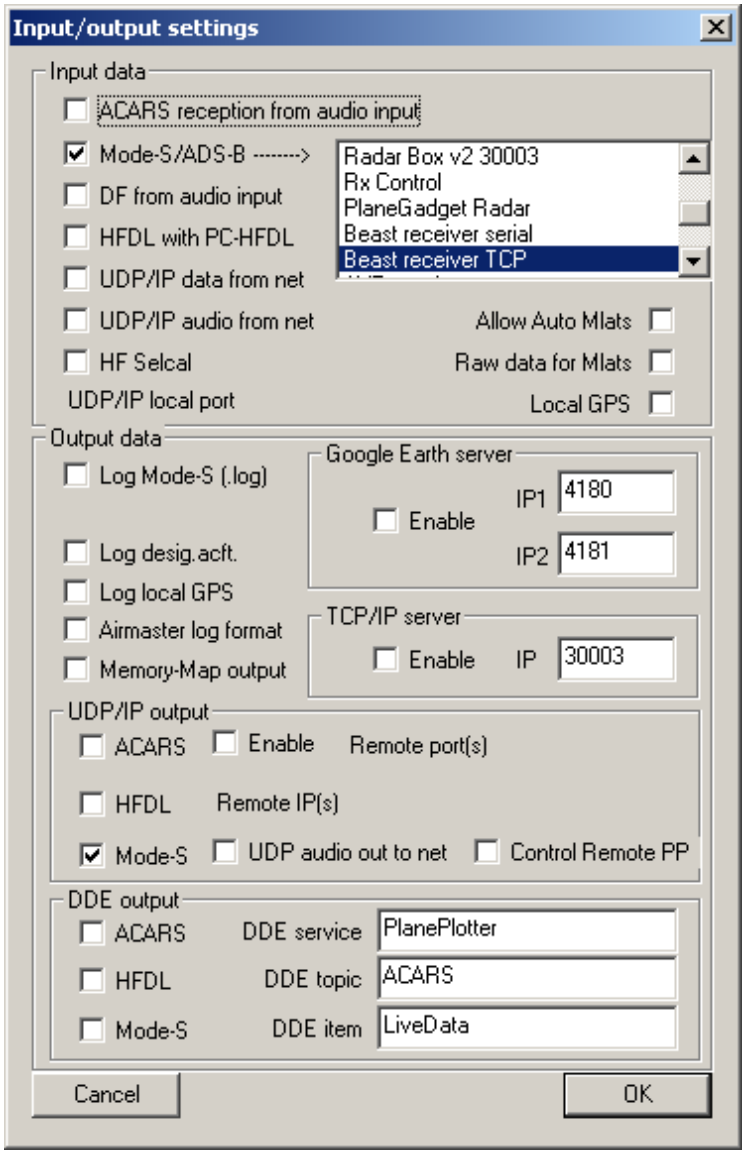
Using Planeplotter with the Radarcape

Step 1: Download, install, and start Planeplotter

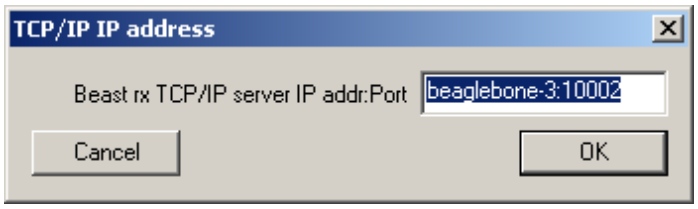
- http://www.coaa.co.uk/planeplotter.htm

GPS location: 40.5248N, 3.08867W

Step 2: Options -> IO-Settings



Step 3: Options -> Mode-S Receiver -> Beast Receiver -> Setup TCP/IP Client



Replace *beaglebone-3* with the DNS name or IP address of your Radarcape (*172.16.3.143:10002*).

Step 4: Press green start button

Movie generator: options - Graphics output (AVI).

Radarcape ADS-B Syste,
Observatorio de Yebes, January 2019

AT-1 RECEIVER / FLARM SYSTEM

Reception report: specifications and setup instructions

YLARA Project

YLARA-LS-60-I02 (CDT Technical Report 2019-07)

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Applicable and reference documents

[1] Air Traffic (AT-1) receiver, traffic avoidance system - Installation Manual. Air Avionics. January 2020 (MAN0070A0001).

[2] Air Traffic (AT-1) – Pilot's Manual. Air Avionics. January 2020 (MAN0070A00021).

[2] Traffic Avoidance Systems, Air Avionics. https://www.air-avionics.com/ (https://www.air-avionics.com/?page_id=253)

[3] FLARM Website. https://flarm.com/, https://flarm.com/technology/traffic-collision-warning/

[4] The Affordable Collision Avoidance Technology for General Aviation and UAV – Basic Description. FLARM. 2017

[5] http://www.air-store.eu/ (for missing parts or spare parts, installation material or tools)

1. AT-1 Receiver / FLARM System

1.1. AT-1 Receiver

AIR Traffic (AT-1), from **Air Avionics** [3], marks the heart of the traffic avoidance installation. It is a collision avoidance system for hidden/remote installation. **The system combines ADS-B and Transponder reception with a latest generation FLARM® transmitter and receiver** (PowerFLARM with two FLARM antennas and antenna diversity).

It can be installed remotely, integrating into existing cockpits and sending traffic data to traffic displays, navigation systems or wirelessly to apps.

Figure 1: AT-1device: Traffic Warning System based on FLARM and ADS-B Technology.

Traffic Technology

FLARM, ADS-B, and Mode-S

AIR Traffic receives the exact 3D-position of FLARM® and ADS-B Traffic as well as distance and relative altitude of Mode-S transponders. Additionally the own position is sent out to all FLARM® compatible systems - over 35.000 in use worldwide.

Integrates seamlessly

RS232, ARINC429, and WiFi® Interfaces

AIR Traffic's flexible interface concept allows for direct integration into exisiting cockpits. It works with traffic indicators, navigation systems (including IFR certified panelmount systems such as GARMIN® GTN®), or even wirelessly with apps like ForeFlight® via an integrated WiFi® interface.

Easy to install

Easy mounting, robust connectors, small size

We have sold thousands of traffic systems, and have listened closely to installers. AIR traffic features robust connectors, a smaller design, and better mounting options. It can even be combined with an AIR Traffic Display to a single, panelmount unit.

Simple configuration

Wirelessly with any smartphone, tablet, or PC

Configuration of an AIR Traffic is as simple as using the internet - with any smartphone, tablet or PC. Simply connect to the WiFi® network AIR Traffic provides and open a website. Additionally it features advanced diagnostics functions that help testing and verifying its correct function.

Professional IO

Audio, switches, relay.

In addition to its data interfaces, AIR Traffic features an audio output for warning signals, discrete inputs for connection of panel- or airframe switches, and a special relay in/output for control of external devices such as anti collision lights.

Certified installation

Installable into many aircraft types

Minor Change Approvals are available for many aircraft types simplifying the legal part of the installation process. AIR Traffic has been qualified according to RTCA DO-160 for environmental conditions. It can be integrated into larger aircraft types and helicopters by maintenance organizations.

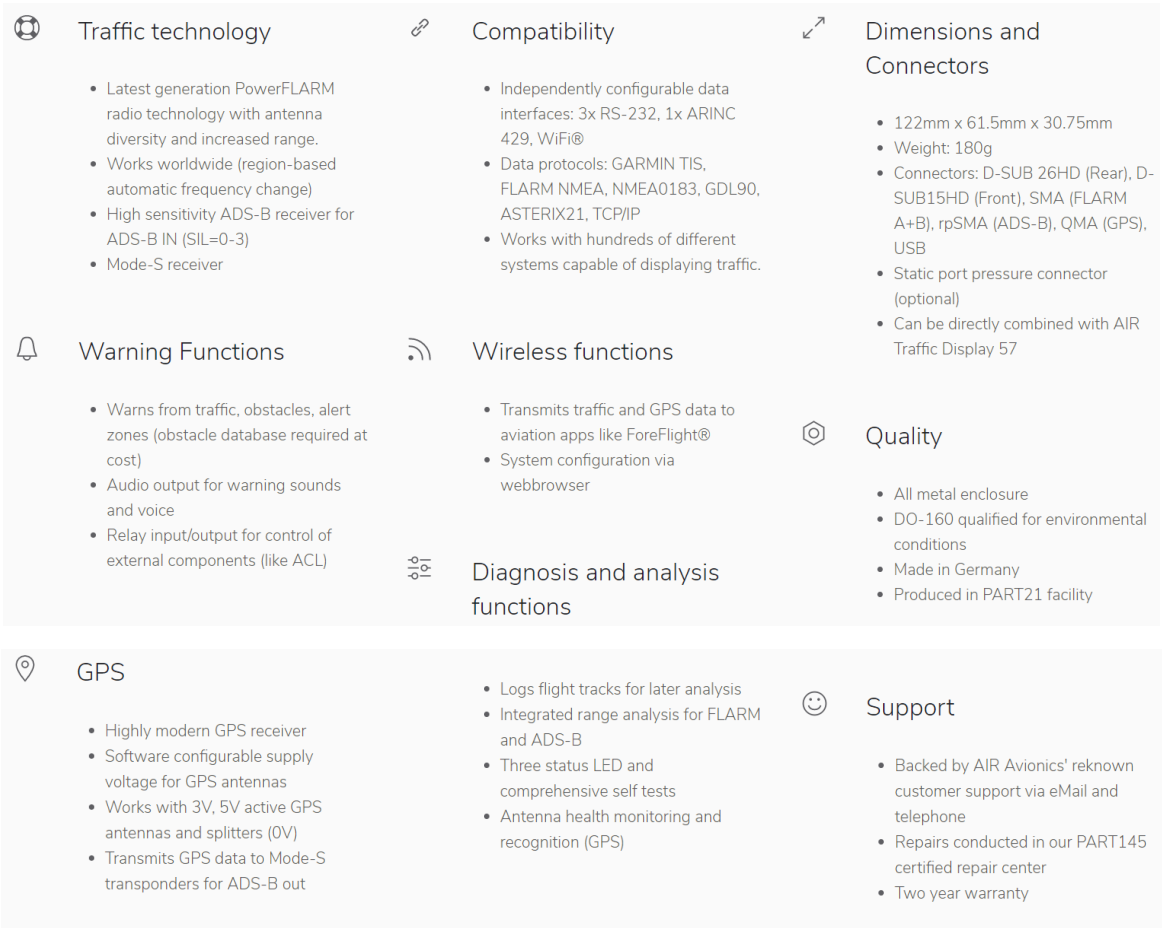

Figure 2: AT-1 characteristics [3].

1.2. FLARM System: working principle

FLARM works by calculating and broadcasting its own future flight path to nearby aircraft. At the same time, it receives the future flight path from surrounding traffic. A smart motion prediction algorithm calculates a collision risk for each aircraft based on an integrated risk model. When a collision is imminent, the pilots are alerted with the relative position of the intruder, enabling both to avoid a collision.

Each FLARM system determines its position and altitude with a sensitive **GNSS receiver**. Based on speed, acceleration, track, turn radius, wind, and other parameters, a precise projected flight path is calculated. This flight path, together with additional information such as a unique identifier, is encoded before being broadcast over an encrypted radio channel.

The channel is encrypted to ensure safety, integrity and privacy. Users can freely configure the level of privacy they require. All FLARM devices are interoperable with each other and share the same communication protocol. The protocol is continually improved as part of an annual innovation update cycle. The frequencies used are in the license-free SRD and ISM bands, meaning that no radio license is required for installation or operation [3].

Several FLARM systems also incorporate an ADS-B and transponder receiver. This enables all transponder equipped aircraft to be included in the collision prediction algorithm and is especially valuable when flying in high density traffic airspace.

In addition to preventing collisions between aircraft, FLARM can also warn about fixed obstacles. The integrated obstacle collision warning system is kept up-to-date by installing periodic obstacle database updates. The database contains complex and 3d obstacle types, not usually seen in other avionics.

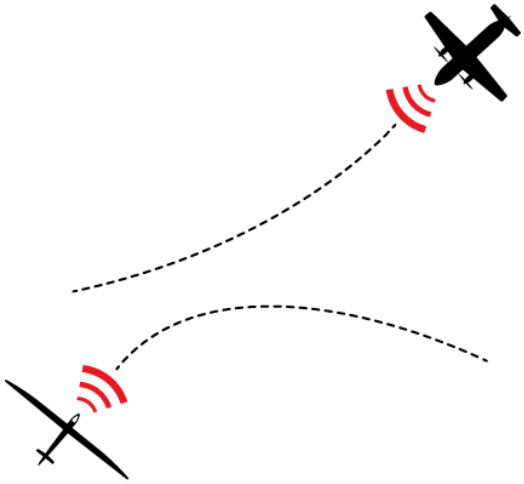

Figure 3: FLARM fundamentals. [4]

Highlights

- Leading detect & avoid solution for GA (general aviation) and UAV (unmanned aerial vehicle) since over a decade, with over 30.000 aircraft equipped.
- Designed for the safety benefit of pilots and small aircraft; not ATC (air traffic control), airliners, or military.
- Smart trajectory prediction and collision warning algorithms, optionally complemented by UAV autopilot mission data.
- Transmit, receive, and processing combined in one compact system.
- Unique coverage for lower airspace below FL100 (flight level) and VLL (very low level) operations outside of airports where ADS-B is nearly nonexistent.
- Independent of limitations, interference, and marginal innovation on legacy 1090 MHz ATC technologies.
- Real-time, low-latency, vehicle to vehicle communication, faster than ADS-B and mobile networks.
- Key to any detect & avoid risk mitigation strategy for UAV in lower airspace and BVLOS (Beyond the Visual Line of Sight).
- Approved by EASA, recommended by Eurocontrol, CAAs, aeroclubs, and insurance companies.
- Access to real-time tracking network and remote identification with opt-out privacy.

- Integrated 3D fixed obstacle warning system (power lines, aerial lift cables, wind turbines, etc.).

Typical **receiver antenna specifications**:

- Omnidirectional, frequency: **868 MHz**

1.3. FLARM technology and SLR

Aircraft transmit real-time updates of their positions and velocities which are monitored for early warnings in case they approach the SLR (Satellite Laser Ranging) laser beam.

FLARM technology allows to inform the SLR observer of nearby aircraft and to make real time predictions to avoid pointing the laser beam in the direction of an aircraft.

Aircraft carrying FLARM equipment broadcast binary messages containing their identification, position and velocity at approximately one second intervals. These signals are sent on a frequency of 868 MHz and can be intercepted by a radio antenna.

The latitudes, longitudes and altitudes are converted to in-sky azimuths and elevations and can be plotted for the SLR observer. The broadcast velocity components allow predictions to be made and warnings to be sent in advance of an approaching aircraft.

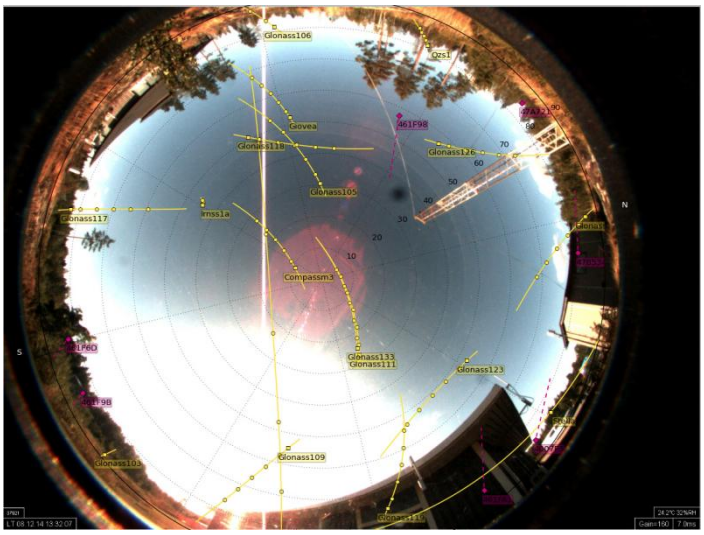

Figure 4: All-sky camera image with FLARM information.

1.4. AT-1 and FLARM installation

Box contains (received at Yebes, 09/01/2019):

- **AT-1 receiver** (SN: AT1-00118), **ADS-B in (1090MHz)** and **FLARM in/out (868/915MHz)**.
- Power supply cable (B581 Rev.1, 20302-00017). D-SUB26 HD female connector.
- Pin 1-10=red=Vin, pin 5-9=black=GND.
- ADS-B indoor antenna (1m cable).
- FLARM indoor antenna (1 m cable).
- GPS antenna (QMA connector) with 1m cable (indoor).
- FLARM building antenna (PN: B578, Nf connector) and mast clamps. 868 MHz, 3+2m cable. See installation instructions.
- ADS-B building antenna (PN: B596, Nf connector), 1090 MHz, 3+2m cable. See installation instructions.
- Type C to USB connector adapter.
- Receiver support.

Figure 5: AT-1 FLARM receiver components.

FLARM antenna installation

In Europe, FLARM signals are transmitted with an **output power** of roughly between **10 and 25 mW**. This is about 10.000 times weaker than a typical transponder signal or 200 times weaker than a VHF radio. Therefore, especially the **FLARM antenna installation is crucial**, if antennas are not installed in an optimum position, range and coverage are limited.

Please ensure that all of the below-mentioned requirements are met as closely as possible.

FLARM Cockpit Antenna (for aircrafts)

- The FLARM cockpit antenna included with delivery is a dipole antenna that has an adhesive pad in the center.
- Installation instructions:
  - Always install FLARM antennas vertically.
  - Ensure that the antenna cable is routed away from the antenna in an orthogonal way in the first 15 cm (6 inches) or use angled antenna connectors.
  - Do not coil the antenna cable. Make sure it is as short as possible. Only experts with professional tools may shorten the FLARM antenna cable.
  - Ensure that no conductive parts (metal, carbon fiber) are close to the antenna.
  - Install the antenna in a location where it has a clear view and is not obstructed by structural parts.
  - If using multiple FLARM antennas, please make sure that they are located far away from each other to increase coverage. The reception range is not increased by multiple antennas, only the reception coverage is increased. Therefore, it makes little sense installing two FLARM antennas closely to each other, because then they cover the same area.
- Using a second FLARM antenna may provide better results as the reception coverage would be increased.

FLARM External Antenna (for aircrafts)

- In aircraft that are mostly made of conductive materials such as metal or carbon _ber, we recommend the installation of at least one external antenna for FLARM. Normally, such an external antenna would be placed underneath the fuselage of the aircraft.

  In larger metal aircraft, coverage can be significantly increased by using two external antennas on the top and on the bottom of the fuselage.
- Installation instructions:
  - See above points (from 1 to 6).
  - Try to avoid placing the antenna closer than 1m from the aircraft's transponder, DME, and TAS antennas. Try to avoid placing the antenna closer than 30 cm from the aircraft's VHF antennas.

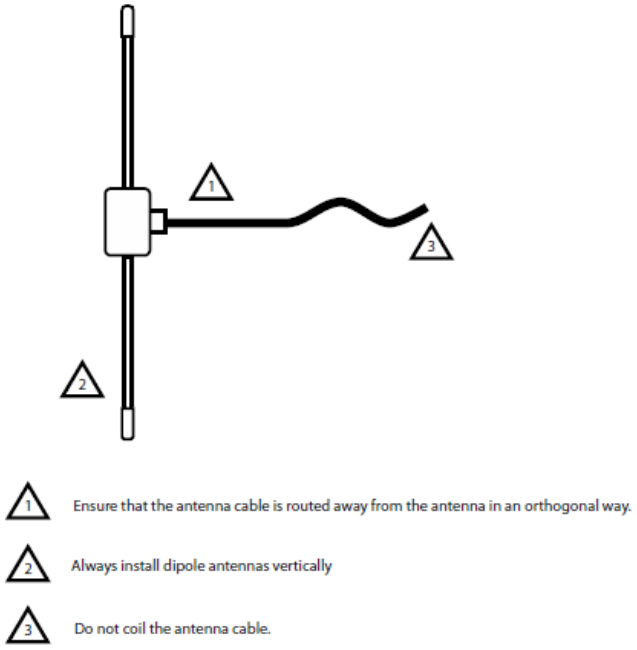

Figure 6: Cockpit antenna installation (for aircrafts) and required orientation.

FLARM building antenna

Exterior, weather-resistant, high gain antenna to be installed in buildings **for ground receivers**.

- Frequency: 868 MHz
- Impedance: 50 Ohm
- 9 dBi Gain
- VSWR: > 1.5
- Horizontal aperture: 360°
- Vertical aperture: 25°
- Lenght (without cable): 83 cm
- Connector: N-female

Figure. FLARM Building Antenna.

ADS-B antenna (1091 MHz) installation

Transponder and ADS-B signals are sent with a high output power. Therefore, even in suboptimal antenna installations good reception ranges can be achieved.

ADS-B Cockpit and External Antenna (for aircrafts)

- In most cases, the indoor antennas included with delivery are sufficient for good operation. Although not being as critical as FLARM antennas, make sure the requirements below are met for optimum performance.
  - Always install 1090 MHz antennas vertically.
  - Ensure that the antenna cable is routed away from the antenna in an orthogonal way in the first 15 cm (6 inches) or use angled antenna connectors (for external antennas).
  - Do not coil the antenna cable.
  - Ensure that no conductive parts (metal, carbon fiber) are close to the antenna.
  - Install the antenna in a location where it has a clear view and is not obstructed from nearby structural parts.
  - Try to avoid placing the external antenna closer than 1m from the aircraft's transponder, DME, and TAS antennas.

GPS antenna installation

AT-1 comes with a cockpit GPS antenna with an adhesive pad. It can be installed on the instrument panel glare shield or any other place with unobstructed view of the sky. Good GPS performance is important for correct operation. Please make sure that the requirements below are met as closely as possible.

- Always install the GPS antenna lying at horizontally and facing upwards.
- Do not coil the antenna cable.
- Do not paint or cover the antenna.
- Ensure that no conductive parts (metal, carbon _ber) are located above of the antenna. Conductive, grounded parts below of the antenna may improve GPS antenna performance.
- Install the antenna in a location where it has a clear view of the sky and the largest unobstructed possible opening angle.
- Do not install the antenna closer than 30 cm away from another active GPS antenna.

AT-1 installation instructions

Parameter	*Data*	*Unit*
Mechanical		
Dimensions	61.5 × 60.75 × 131.15	mm
Mounting	with mounting tray or attached to an AIR Traffic Display 57 (ATD-57)	
Mass	0.143	kg
Electrical		
Voltage (nom.)	13.8	V DC
Voltage (operational)	9 to 32	V DC
Low voltage shutdown	8	V DC
Current (nom.)	0.15	A

Figure 7: AT-1 specifications.

AT-1 has an all-metal housing. It features **two power/signal connectors (D-SUB)**, four RF connectors, an optional static port connector, a USB port for data exchange, and an integrated Wi-Fi antenna for wireless connectivity.

The device status is presented using three multi-color LEDs on the back of the unit.

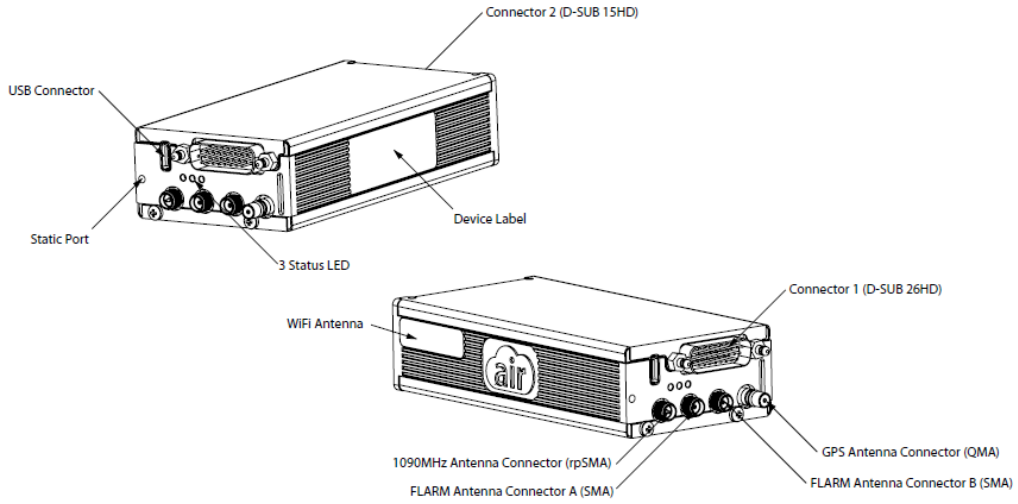

Figure 8: Housing and connector overview.

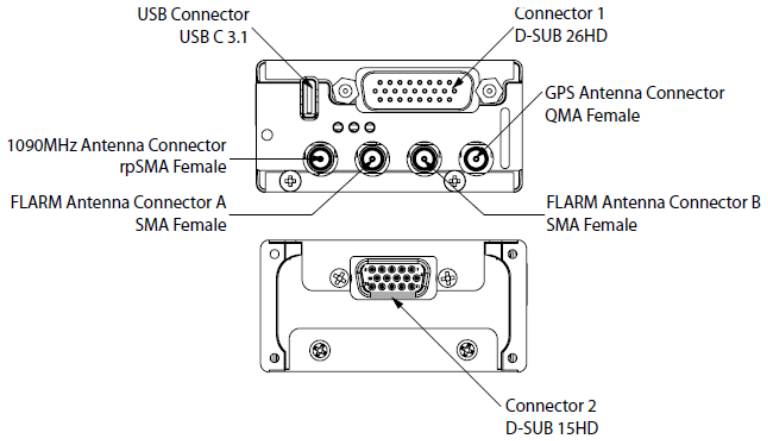

Figure 9: System interconnects overview.

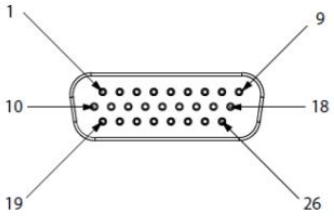

Figure 2.2.: Connector 1 pin map

Pin Name	Pin number	I/O
Aircraft Power (VIN)	1.1	In
RS-232 Port 1 receive data (RXD1)	1.2	In
RS-232 Port 2 receive data (RXD2)	1.3	In
RS-232 Port 3 receive data (RXD3)	1.4	In
Aircraft Ground (GND)	1.5	–
Analog Input (AIN)	1.6	In
Relay Output (ROUT)	1.7	Out
Relay Input (RIN)	1.8	In
Aircraft Ground (GND)	1.9	–
Aircraft Power (VIN)	1.10	In
RS-232 Port 1 transmit data (TXD1)	1.11	Out
RS-232 Port 2 transmit data (RXD2)	1.12	Out
RS-232 Port 3 transmit data (TXD3)	1.13	Out
Power Output 3.3V (3v3out)	1.14	Out
Audio Output (AUD)	1.15	Out
Discrete Input 1 ($\overline{\text{DIN1}}$)	1.16	In
Discrete Input 2 ($\overline{\text{DIN2}}$)	1.17	In
Discrete Input 3 ($\overline{\text{DIN3}}$)	1.18	In
Data Bus Low Signal (CANLO)	1.19	In/Out
Data Bus High Signal (CANHI)	1.20	In/Out
Data Bus Termination 120R (CANTERM)	1.21	–
Enable ($\overline{\text{EN}}$)	1.22	In
Aircraft Ground (GND)	1.23	–
ARINC429 Out A (A429A)	1.24	Out
ARINC429 Out B (A429B)	1.25	Out
Aircraft Ground (GND)	1.26	–

Figure 10: Connector 1 pinout (pin 1-10=red wire=Vin, pin5-9=black wire=GND) ([1], page 8).

Both connectors (1 and 2) feature a pin that enables power when pulled to ground/low. For AT-1 to power up, at least one of these two pins must be connected to ground (GND). Active-Low discrete inputs like the Enable Interface are considered active if either the voltage to ground is below a certain minimum or if the resistance to ground is below approximately 300 Ohms.

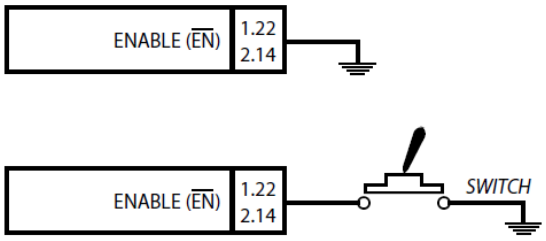

Figure 11: Connectors Enable.

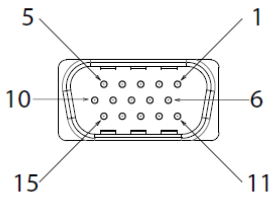

Figure 2.3.: Connector 2 pin map

Pin Name	Pin number	I/O
Aircraft Power Out (VOUT)	2.1	Out
RS-232 Port 2 transmit data (TXD2)	2.2	Out
RS-232 Port 2 receive data (RXD2)	2.3	In
Enable ($\overline{\text{EN}}$)	2.4	Out
Aircraft Ground (GND)	2.5	–
Aircraft Power Out (VOUT)	2.6	Out
Data Bus Low Signal (CANLO)	2.7	In/Out
Data Bus High Signal (CANHI)	2.8	In/Out
Not Connected	2.9	–
Not Connected	2.10	–
Not Connected	2.11	–
Not Connected	2.12	–
Not Connected	2.13	–
Aircraft Ground (GND)	2.14	–
Not Connected	2.15	–

Figure 12: Connector 2 pin-out ([1], page 9).

AT-1 features a USB 3.1 type C connector which serves as a USB host interface for USB thumb drives. A USB-C to USB-A jack (panel mount) extension cable is included with delivery. A standard USB thumb drive (USB-A) can be connected using this cable.

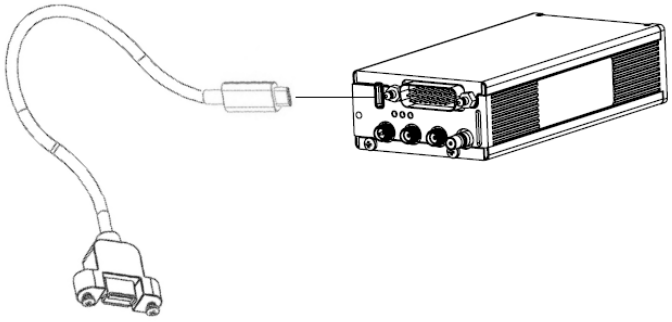

Figure 13: USB connector and extension cable.

Note: AT-1 does not supply enough power to charge personal devices via USB. Only connect USB thumb drives to the USB port. Connecting smart phones, tablets, or PCs may damage AT-1. If an over current is detected, i.e. if a device draws more current from the USB port than specified, the USB power supply is switched off until AT-1 is restarted.

For some of its functions, AT-1 measures the **barometric altitude**. The unit features an integrated pressure sensor. For more precise readings, this pressure sensor can be connected to the aircraft's static pressure port using an optional static pressure port connector.

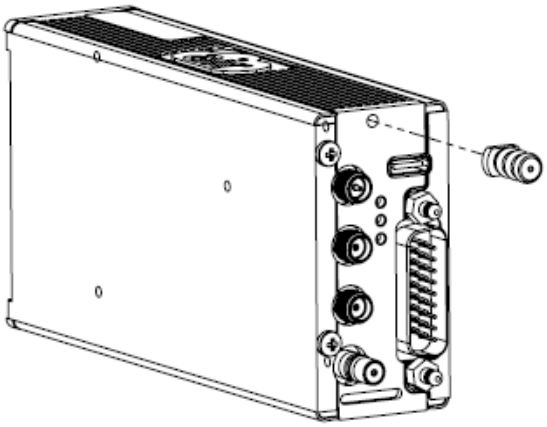

Figure 14: Static port pressure.

1.5. System status and error messages

AT-1 features comprehensive self-test and diagnosis functions. These functions help the installer and the user to identify issues and to check the system status.

In addition to transmitting failure and status messages over its data ports to connected aviation instruments, AT-1 features three multi-color status LED and shows its status on the AT-1 configuration webpage via Wi-Fi.

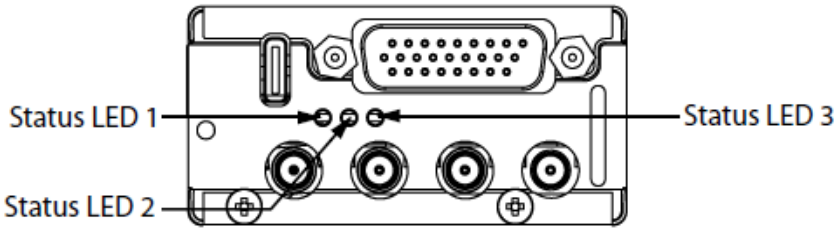

Figure 15: Status LEDs.

Each status LED is assigned to specific functional modules inside the AT-1:

- LED 1: status of the integrated 1090 MHz receiver module.
- LED 2: status of the integrated FLARM transceiver module.
- LED 3: status of the integrated GPS receiver module, the integrated Wi-Fi module and the general system state.

Status	*LED 1 Pattern*	*LED 1 Color*
Fatal error/failure, 1090 MHz receiver module unavailable.		red
Last dataset from 1090 MHz receiver module has been received over 30 seconds ago.		red
Last dataset from 1090 MHz receiver module has been received over 3 seconds ago.		red
Reduced function error of 1090 MHz module		yellow
Normal operation, ADS-B/Transponder traffic has been received or is currently received		green
Never received a traffic signal via 1090 MHz (ADS-B/Transponder)		green

Figure 16: LED1, normal operation.

Status	*LED 2 Pattern*	*LED 2 Color*
Fatal error/failure, FLARM transceiver module unavailable.		red
FLARM software incompatible or expired.		red
Last dataset from FLARM transceiver module has been received over 30 seconds ago.		red
Last dataset from FLARM transceiver module has been received over 3 seconds ago.		red
Reduced function error of FLARM module		yellow
No GPS datasets received from FLARM module.		yellow
No FLARM data (about the own ship) sent out by FLARM transceiver module.		yellow
Power supply problem in the FLARM transceiver module.		yellow
Normal operation, FLARM traffic has been received and is sent.		green
Never received a traffic signal via FLARM		green

Figure 17: LED2, normal operation.

Status	*LED 3 Pattern*	*LED 3 Color*
Fatal error/failure, AT-1 main system unavailable.		red
Fatal error of GPS or WiFi, for example, GPS antenna not connected		red
Last GPS position has been received over 30 seconds ago or never.		red
Last GPS position has been received over 3 seconds ago.		red
Reduced function error affecting traffic data processing and warnings. For example, no barometric pressure data is available.		yellow
Reduced function error not directly affecting traffic data processing/warnings. For example, the USB interface has detected a current consumption above maximum rating.		yellow
Warning: Bad GPS reception		yellow
Normal function, GPS 3D fix, no errors		green
GPS 2D fix		green
GPS has invalid fix quality, no error		green
GPS acquiring satellite data, no errors		green

Figure 18: LED3, normal operation.

Status	*LED 1*	*LED 2*	*LED 3*
Searching for USB thumb drive after power-on	blue	blue	blue
Reading configuration from USB thumb drive	blue	blue	off
Reading config. from USB successfully finished	blue	blue	green
Reading config. from USB failed: no or invalid file	blue	blue	yellow
Reading config. from USB failed: file syntax	blue	blue	red
Writing log file to USB USB thumb drive	blue	off	blue
Writing log file to USB successfully finished	blue	green	blue
Writing log file to USB failed	blue	red	blue
Initiating maintenance of the 1090 MHz module	blue	off	off
Initiating maintenance of the FLARM module	off	blue	off
Updating the FLARM module	off	blue	off
Loading FLARM license or obstacle file	off	blue	off
Initiating maintenance of the WiFi module	off	off	blue
Updating WiFi module	off	off	blue
Updating WiFi module, 2nd attempt after update error	off	off	blue

Figure 19: LEDs patterns for maintenance operation.

Situation	*LED 1*	*LED 2*	*LED 3*
Initializing bootloader	magenta	off	off
Bootloader initialized successfully	off	magenta	off
Flash checked: no application installed	magenta	off	magenta
Flash checked: application installed ok	off	off	magenta
Flash checked: incompatible application	magenta	magenta	magenta
Bootloader processing a software container file	magenta	magenta	magenta
Bootloader is installing application	magenta	magenta	magenta
Bootloader has finished the installation ok	magenta	magenta	magenta

Figure 20: LEDs patterns for bootloader/update operation.

1.6. AT-1 system configuration

Configuration webpage

The AT-1 configuration webpage is accessible via any Wi-Fi capable device such as a PC, a smart phone, or a tablet (referred to as a "personal device" here). Please follow these steps to access the configuration webpage.

1. Open the Wi-Fi configuration page in your personal device. Normally you can find this page in the settings/system preferences app of your personal device.
2. Select the AIR TraficWiFi network and establish a connection. The network name/SSID will be ‘‘AIR-Trafic-’’ followed by the last two digits of the serial number of the AT-1.
3. Enter the network password. The password is the full serial number as printed below the bar code on the sticker on the device (AT1-00118).

[If establishing a connection is not possible, please ensure the Wi-Fi interface in AT-1 has been activated during installation. Depending on its setup, the Wi-Fi interface might only work for 15 minutes after power-on. In this case, please open the AT-1 configuration webpage directly after switching the device on and change the setup for the Wi-Fi interface setup to be permanently active].

Opening the AT-1 Configuration Webpage

1. Open a web browser in your personal device.
2. Enter the following address into the address bar of the browser and hit enter: **http://192.168.1.1**

As the AT-1 factory defaults already cover most of the requirements for normal installations, only few changes have to be made. Therefore, a simple configuration mode is available that covers the basic configuration parameters required for normal installations.

We strongly recommend to only use the simple configuration mode, unless you are a very experienced installer and know exactly what you are doing. Setup parameters in the expert configuration mode will negatively affect device performance if not set correctly.

In the advanced configuration mode, more parameters are configurable. In the expert configuration mode, all parameters are configurable without limitations. To enter the expert configuration mode, a pin code entry is required. In the advanced configuration mode, on the AT-1 configuration webpage, please enter the pin code and click on Switch To Expert Configuration to open the expert configuration.

Pin code: 3000

1.7. Data access

AT-1 does not feature a display or a speaker.

Other systems must be used to make received traffic data and threat information available.

AT-1 is designed to be connected to a broad range of different systems that display and process traffic data.

Care must be taken to ensure that all connected devices are compatible with the AT-1.

The following list gives an overview of the most common compatible systems. In general, several hundred systems are compatible. If AT-1 is to be connected with other than the below mentioned tested devices, compatibility must be assessed on a per installation level.

Not all functions supported by AT-1 are supported by all compatible devices. For example, not all configuration parameters can be set inside the menus of such devices.

Device	*P/N*	*Make*	*Interface*	*3D Traffic Display*	*Non BRG Traffic*	*Setup.*
AIR Traffic Display 57	ATD-57	AIR Avionics	RS232 NMEA	•	•	•[3]
Butterfly Display 57	B102	AIR Avionics	RS232 NMEA	•	•	–
Butterfly Display	B101	AIR Avionics	RS232 NMEA	•	•	–
FLARMView 57		LXNav	RS232 NMEA	•	•	–
FLARMView		LXNav	RS232 NMEA	•	•	–
FLARMLED		LXNav	RS232 NMEA	Limited	Limited	–
Traffic Monitor		LXNavigation	RS232 NMEA	•	•	–
V2		Ediatec	RS232 NMEA	Limited	–	–
V3 / V3+ / V4		Aboba	RS232 NMEA	Limited	Limited	–

[3] Please note that this function will not be available in the AIR Traffic Display before 2019

Figure 21: Compatible cockpit displays of traffic information.

Device	*Status*	*Make*	*Interface*	*3D Traffic Display*	*Non BRG Traffic*	*Setup*
GNS430/520/W	Tested. Ver. 6.03	GARMIN	ARINC429	•	•	–
GTN650/750	Tested. Ver. 6.42	GARMIN	ARINC429	•	•	–
G500/G1000	Not tested but assumed compatible	GARMIN	ARINC429	•	•	–
IFD440/540	Not tested but assumed compatible	Avidyne	ARINC429	•	•	–
Evolution	Not tested but assumed compatible	Aspen	ARINC429	•	•	–
G3X / G3X touch	Tested	GARMIN	RS232 TIS	•	Limited	–
Skyview	Tested	Dynon	RS232 TIS	•	Limited	–

Figure 22: Compatible navigation systems (panel mount).

Device	*Make*	*Interface*	*3D Traffic Display*	*Non BRG Traffic*	*Setup.*
495/496	GARMIN	RS232 TIS	•	Limited	–
695/696	GARMIN	RS232 TIS	•	Limited	–
AERA 500/550	GARMIN	RS232 TIS	•	Limited	–
AERA 600	GARMIN	RS232 TIS	•	Limited	–
AERA 795	GARMIN	RS232 TIS	•	Limited	–

Figure 23: Compatible navigation systems (portable).

App	*Make*	*Interface*	*3D Traffic Display*	*Non BRG Traffic*	*Setup. and updates*
iGlide/iPilot	AIR Avionics	WiFi	•	•	–
Skydemon	Skydemon	WiFi	•	•	–
AirNav Pro	XAMPLE	WiFi	•	•	–
Runways HD	AIRBOX	WiFi	•	•	–
SkyMap	SkyMap	WiFi	•	•	–
FlyMap	Stauff	WiFi	•	•	–
EasyVFR	PocketFMS	WiFi	•	•	–

Figure 24: Compatible navigation applications.

1.7.1. Serial data interface

AT-1 is capable of interfacing with other aviation instruments by sending and/or receiving serial data on its three serial data ports. All three serial data ports can be configured individually.

Pin Name	*Pin number*	*I/O*
RS-232 Port 1 data out (TXD1)	1.11	Out
RS-232 Port 1 data in (RXD1)	1.2	In
RS-232 Port 2 data out (TXD2)	1.12 / 2.2	Out
RS-232 Port 2 data in (RXD2)	1.3 / 2.3	In
RS-232 Port 3 data out (TXD3)	1.13	Out
RS-232 Port 3 data in (RXD3)	1.4	In

The serial inputs/outputs conform to RS-232C (EIA Standard) with a positive and a negative output voltage of at least 5V when driving a standard RS-232 load.

> It is not sufficient that power supply ground on both devices is connected to aircraft ground. An additional direct ground connection is mandatory.

The use of a twisted pair shielded cable, e.g. MIL-C-27500-22TG 2T14 is highly recommended. With this cable both data wires and the GND reference can be connected using a single cable.

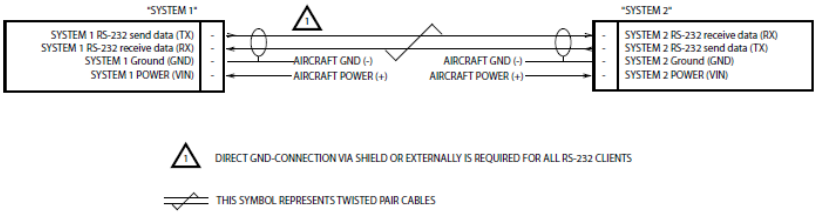

Figure 3.1.: Generic RS-232 wiring recommendation between "System 1" and "System 2"

The table below contains maximum recommended cable lengths when using shielded data cables for an RS-232 data interface. Exceeding these cable lengths may reduce signal integrity and compromise the reliability of the data interface.

Data Rate	*Max. Cable Length (meter)*	*Comment*
4800 Bd	30	Standard NMEA 0183 data rate, for GPS position data only
9600 Bd	15	Standard data rate for traffic data in the GARMIN TIS protocol
19,200 Bd	7.6	Standard data rate for traffic data in the FLARM protocol
38,400 Bd	3.7	–
57,600 Bd	2.6	–

AT-1 connector 2 (SubDB15_m)	**USB to RS232 adapter** (USB-RS232-WE-1800-BT_3.3, by fTDI Chip)
pin 2: TXD2	yellow wire: RXD
pin 3: RXD2	orange wire: TXD
pin 5-14: GND	black wire: GND

Serial port setup: COM3, Speed: 19200 Bd, Data bits: 8, Stop bits: 1, Parity: none, Flow control: none

NMEA standard

2. Annexes

2.1. First setup

First setup results, January 2019. (just to check the device works after the reception).

AT-1 Receiver / FLARM System
Observatorio de Yebes, May 2019

OMEA 8C ALL SKY CAMERA

Reception report: specifications and setup instructions

YLARA Project

YLARA-LS-60-I03 (CDT Technical Report 2019-07)

J.M. Serna Puente, B. Vaquero Jiménez, A. García Marín

Yebes Observatory, IGN-CNIG

March 5th, 2019

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Index

Change index

Version	Date	Section	Change Description
V01	3-2019	All	Initial version
V02	5-2020	Several sections and Annexes	Questions solved by the manufacturer

Applicable and reference documents

[1] OMEA “All Sky” Camera - Installation and user manual. Alcor System. April 28th, 2019 revision.

[2] « All-Sky » cameras for sky watching. Alcor System. April, 2013.

[3] Alcor System: http://www.alcor-system.com/new/AllSky/Omea_camera.html

[4] Alcor System: http://www.alcor-system.com/new/AllSky/AllSky_Software.html

1. OMEA 8C, All sky camera

1.1. Introduction

The purpose of these systems is to carry out **all or full sky surveillance of the night or day sky**, and in a continuous fashion.

It is possible to assess, in real time, the night sky quality, and to record fast phenomena (meteors and fireballs) or slower (satellites, rockets, noctilucent clouds, zodiacal light, aurora, airglow...).

Thanks to its high sensitivity, this system can record a very good image quality of the night sky, while producing images of stars that will not be trailed by natural Earth rotation, no star tracking is required.

The **OMEA camera** embeds a dome heating system, based on environment humidity and temperature.

Name	Sensor	Fisheye circle "Illuminated" pixels	Detector resolution	Field of view	Pixel Scale	Daylight imaging
OMEA 6M	Monochrome	4.5 Million pixels	3100 x 2100 pixels	180° x **130°**	3.3 arcmin/pix	Yes
OMEA 6C	Color	4.5 Million pixels	3100 x 2100 pixels	180° x **130°**	3.3 arcmin/pix	Yes
OMEA 3M	Monochrome	2.9 Million pixels	3100 x 2100 pixels	180° x 180°	5.4 arcmin/pix	Yes
OMEA 3C	Color	2.9 Million pixels	3100 x 2100 pixels	180° x 180°	5.4 arcmin/pix	Yes
OMEA 5M	Monochrome	10 Million pixels	5500 x 3650 pixels	180° x 180°	3.0 arcmin/pix	Yes
OMEA 5C	Color	10 Million pixels	5500 x 3650 pixels	180° x 180°	3.0 arcmin/pix	Yes
OMEA 8M	Monochrome	8.8 Million pixels	4600 x 3520 pixels	180° x 180°	2.9 arcmin/pix	Yes
OMEA 8C	Color	8.8 Million pixels	4600 x 3520 pixels	180° x 180°	2.9 arcmin/pix	Yes

Figure 1: Alcor OMEA cameras specifications.

Note: The sensor installed in the YLARA OMEA 8C camera is the **IMX294 sensor**, which size is **4144x2822 pixels**.

All parts are made of anodized aluminium, water tight by o'rings seals. Automatic dome heater located at dome's base allow to warm up the acrylic dome in order to remove frost and icing, to preserve good image quality.

By default, all cameras model records two basic external weather parameters: relative humidity and external temperature. Internal relative humidity and camera temperature are recorded.

Figure 2: OMEA 8C camera.

Figure 3: OMEA 8C image sample.

This camera combines high resolution, and full 180°x180°. It embeds cooled sensor cameras, remote controlled auto iris and remote focusing adjustements.

1.2. Part list

- OMEA 8C all-sky camera (SN: 127404).
- Camera support assembly.
- Power adapter: 220Vac to 24Vdc@2.5A (RS code: 188-781).
- AC power cable.
- USB to RS232 adapter (RS code: 760-8711).
- Temperature and humidity sensors and cable.
- USB 2.0 to camera cable, length: 20 meters.
- Camera power cable, lenght: 15 meters.
- User manual.
  http://www.alcor-system.com/common/allSky/docs/
- Software (for Windows, Linux software under request).
  http://www.alcor-system.com/new/AllSky/AllSky_Software.html

Figure 4: Supplied material.

1.3. Summary of specifications

Parameter	Value
Field of view	**180° x 130 ° (OMEA 6x)** **180° x 180° (OMEA 3x, OMEA 5x and OMEA 8x)** Wavelength range : 350 to 750 nm (IR cut filter) Factory focused and tilt tuned with respect to the whole image sensor field.
Camera resolution	3100 x 2100 (OMEA 3x & 6x) 2.4 µm pixel size (Rolling shutter) 4600 x 3500 (OMEA 8x) 3.8 µm pixel size (Rolling shutter) 5500 x 3600 (OMEA 5x) 2.4 µm pixel size (Rolling shutter) All monochrome or color, progressive scan, anti-blooming sensor.
ADC resolution	**14 bits for OMEA 3x and 6x, 12 bits for other cameras**
Video stream	**ALL Cameras have video stream capabilities** **AVI file stream can be created** OMEA 8x & 5x : 2.5 fps USB 2.0 - 15 fps USB 3.0 OMEA 3x & 6x : 6.5 fps USB 2.0 - 30 fps USB 3.0
Exposure time	From 32µs to one hour exposure (All-Sky mode, typically 20s to 75s)
Gain	Variable, Logarithmic mode from 30x to 10000x
Dome	Acrilic dome BK7 Glass optical dome : on request
Image download time	OMEA 8x & 5x : 400ms Max OMEA 3x & 6x : 150 ms Max
Auto-Iris	Only OMEA 8x, other models do not have this feature.
Remote re-focusing	Only OMEA 8x, other models do not have this feature.
Image Sensor Cooling	Only OMEA 8x and OMEA 5x have image sensor cooling capacity, other cameras do not have these features.
Control software	ALCOR SYSTEM's All Sky software supplied at no additionnal costs.
Operating system	Windows 32&64 bits (Seven and 10) Linux (contact us) SDK available
To PC Interface	USB 2.0 + 20 m length cable, perfectly full time reliable operation. Ethernet link on request. USB 3.0 + 15 m length cable, on request (this has added value only in video stream mode)
Top dome heater	Automatic dome defrost based on provided external temperature and humidity sensors. User tunable heating power from 18W to 36W
Power supply	24V / 3A (Power supply provided)
Other informations	Enduring bad weather condtions (rain/snow), anodized aluminium casing, acrylic dome, water tight connectors and body / IP67 protection
Weight	3.5 kg , OMEA 8x is 4.5 kg
Dimensions	OMEA 8/5 : ø130mm x 270 mm, other is ø130mm x 210 mm height, three holes for mast attachment.
Operating temperature range	from -35°C to +45°C

Camera support can be supplied (picture below), so that to minimize time for installation. This is an optionnal feature. Please ask for it, if needed.

Figure 5: All-sky camera specifications.

1.4. Camera installation

The camera is intended for outdoor operation.

It is advised to level the camera with respect to the ground.

This version of camera has manual enabled heater that can remove external condensation that can occur on sphere surface.

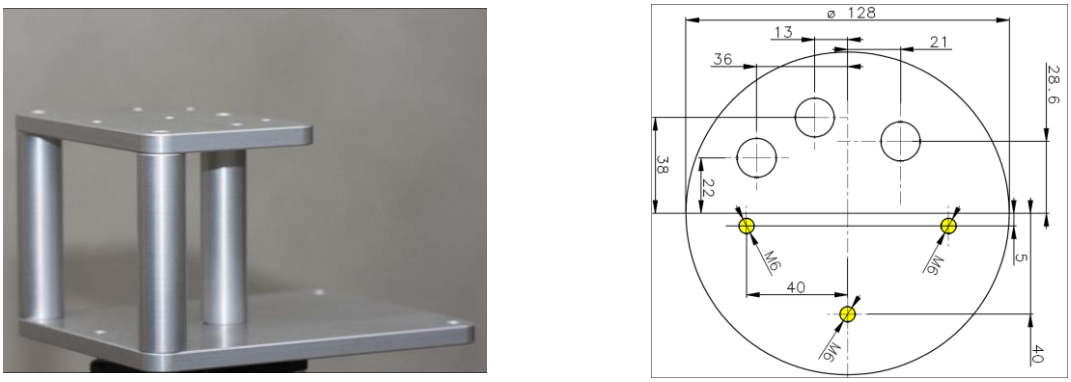


Figure 6: Camera stand and camera securing screws.

Warning: take care when connecting the three different connectors to the camera (push the connector straight and turn the connector's collar in clockwise fashion).

Note: It is not necessary to to have all the connectors (#2 and #3) plugged in and then turn on the PC.

1.4.1. Camera optical settings (OMEA 8xx)

The tilt of the lens with respect to the image sensor is factory tuned. It is possible to perform focus changes remotely by using the RS232 link. ALCOR-SYSTEM will provide to the user the best focus encoder count (from 900 to 1100 encoders steps). Some variation may occurs around this value during the life of the camera.

FOCUS ENCODER COUNT: 1270

By the same link, F-number can be user selected. The lowest F/ is **F2.8** and must be used **overnight**. **During the day F/5.6 or F/8 can be used**. This can be set by PC software.

Sharpness may vary from center to edges, according to the lens design and lens manufacturing quality variations.

Opening the dome is possible, but this will jeopardize inner camera dryness: some desiccants bags are installed inside the camera, and if the dome is opened, those bags must be replaced!

Infrared light (> 680 nm) and UV light is blocked (< 420 nm). Pixel size is 3.8 µm.

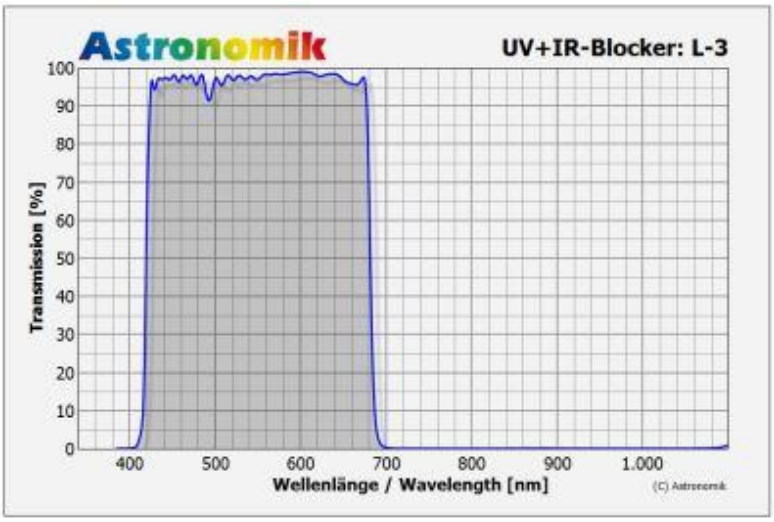


Figure 7: L3 filter (spectral transmission curve).

1.4.2. Camera connections

Connector	Role	Gender (camera side)
#1	Temperature / Humidity sensor	Female 5 pins
#1	Weather station module	Male 7 pins
#2	Power connector and RS232 link	Male 4 pins
#3	USB link	Male 6 pins

Figure 8: Camera connectors.

Temperature sensor and humidity connector (#1)

It is a 5-pin connector. The probe located at the end of the cord will be placed preferably in the shade, as far as possible from the camera, **and always with two set Ø4mm screws with the direction given in the next picture and horizontally. It put upside down (or in the wrong side), this can destroy the sensor and warranty will not apply.**

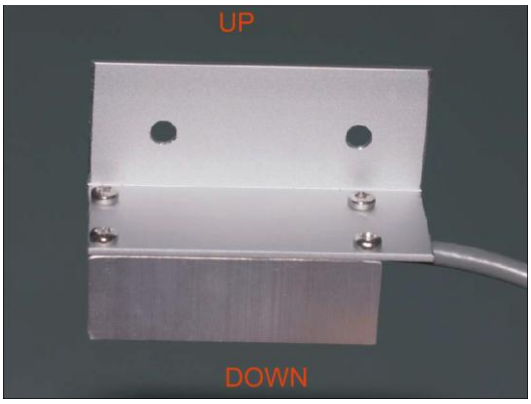


Figure 9: Sensors installation.

This sensor is intended to provide outdoor temperature and relative humidity in order to automatically trigger dome heating, (only when weather conditions are prone to develop dew on the camera's dome).

Note: the sensor might be killed on heavy rains in case of not being pointed to the floor. Besides, this sensor should be placed away from the ground to prevent splashed water drops from reaching it.

Power connector and RS232 (#2)

To provide power to the camera and RS232 link.

The RS232 connector is a DB9 connector type female and attaches to the serial port of the PC. New PCs are not equipped with serial port, so an USB adapter is supplied.

The **power supply** is **24 V @ 2.5 A**, 110 V 60 Hz and **220 V 50 Hz** compliant. The current provided by the PSU is enough to power the camera and the dome heater.

Once connected to the PC, the driver is loaded automatically for **Windows 10**. For other OS, please go here to pick up the proper driver: http://www.ftdichip.com/FTDrivers.htm (Note: currently, drivers can not be found in this website)

ZWO ASI Cameras driver 3.0.0.5	ZWO	28/01/2020	5,09 MB	3.0.0.5
ZWO ASI Cameras DirectShow driver 3.0.1.1	ZWO	28/01/2020	43,9 MB	3.0.1.1

Figure 10: The two loaded drivers.

The PC must have TWO USB port free for the system, one for the camera image data stream, and another for this RS232 to USB link. **This RS232 data link is used to get**:

- Weather information from the camera (outdoor temperature, outdoor relative humidity, inner camera temperature and humidity, dome heater temperature).
- Optional Weather station module information (wind speed, wind direction, atmospheric pressure …).
- Lens focus and iris settings.

Always have the RS232 link connected to the camera in one side and to the PC in the other side. Failure to comply with this requirement will jeopardize camera operation and performance. Keep the COM number (very important). In case of USB to RS232 converter, keep the converter in the same USB port, otherwise COM number will change.

USB (2.0) connector (#3)

This is tied up to a 6 pin connector. Please, **always connect the camera first and then connect to PC second**. The cable that goes to the PC is **20 m length**.

1.4.3. Software setup

Follow user manual instructions (page 16).

- **Software** (**for Windows**, Linux software under request).
- http://www.alcor-system.com/new/AllSky/AllSky_Software.html

Software version: 3.0.9 build 126 07/03/2019

Figure 11: Camera setup (USB ports: up power supply and RS232, down data).

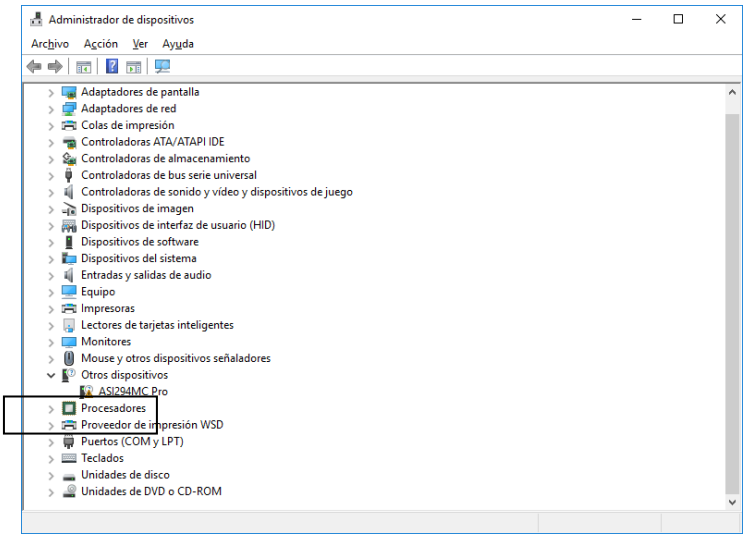


Figure 12: Camera appears with an icon tagged exclamation point.

- Run **setup_skywatch.exe** as administrator (it will install all the software required for this camera).
- Once the drivers are installed, the camera appears in the device manager:
  ZWO ASI294MC Pro Camera.

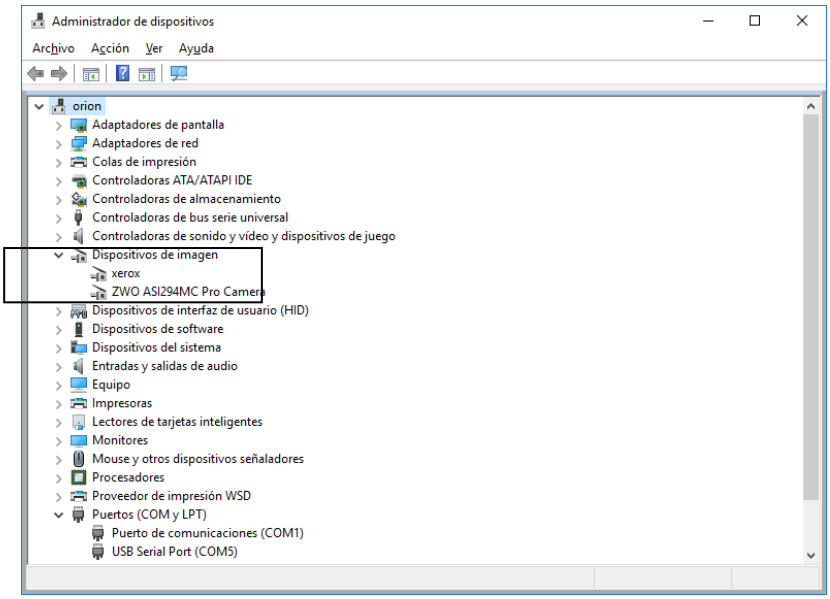


Figure 13: Device manager after camera installation.

- USB Serial port: COM5.
- The installed program appear as:

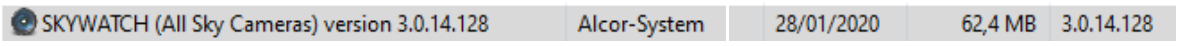


Figure 14: Skywatch program.

- The main's software icon appears on the desktop.

Figure 15: Software icons after installation.

- Software installation is now completed.

27/02/2020 10:37:23 : Software Startup
27/02/2020 10:37:23 : Software parameters loaded
27/02/2020 10:37:23 : Data recording path created
27/02/2020 10:37:24 : Recorded camera : OMEA Camera 8C/8M
27/02/2020 10:37:24 : Camera Object created
27/02/2020 10:37:24 : Camera Gain min=0, and max gain = 570
27/02/2020 10:37:24 : Camera linked and started : ZWO ASI294MC Pro
27/02/2020 10:37:24 : 4144x2822, niveau de saturation: 65000
27/02/2020 10:37:24 : Gain réglable, Gain min=0, Gain Max=570, Gain en cours=0
27/02/2020 10:37:25 : CCD, cooling stopped, raising temperature to 1.0 °C, DAY comes, Sun located 36.2° wrt horizon
27/02/2020 10:37:25 : Min exposure : 32 µs, max exposure 33m 20s
27/02/2020 10:37:25 : Readout COM4 port
27/02/2020 10:37:25 : This system has a focuser and iris that can be set remotely
27/02/2020 10:37:27 : Focuser set to "HOME" at F2.8
27/02/2020 10:37:27 : This system has no filters !
27/02/2020 10:37:27 : This system has no filters !
27/02/2020 10:37:27 : Set to focuser position 1250 encoder steps
27/02/2020 10:37:28 : Day Mode, set to F/8.0
27/02/2020 10:37:28: Initialization completed

Table 1. Start up report appearing on the screen after turning on the camera.

1.5. Using the camera software control

The software is fairly intuitive; the documentation will focus on features that are more difficult to acquire. See user manual (page 19).

1.5.1. Initializing

On first software startup, the software display a log window, which disappear by itself within 20 seconds and heating control window.

Set the correct COM number and press CONNECT.

Once connection is fine, outdoor temperature and relative humidity will be displayed.

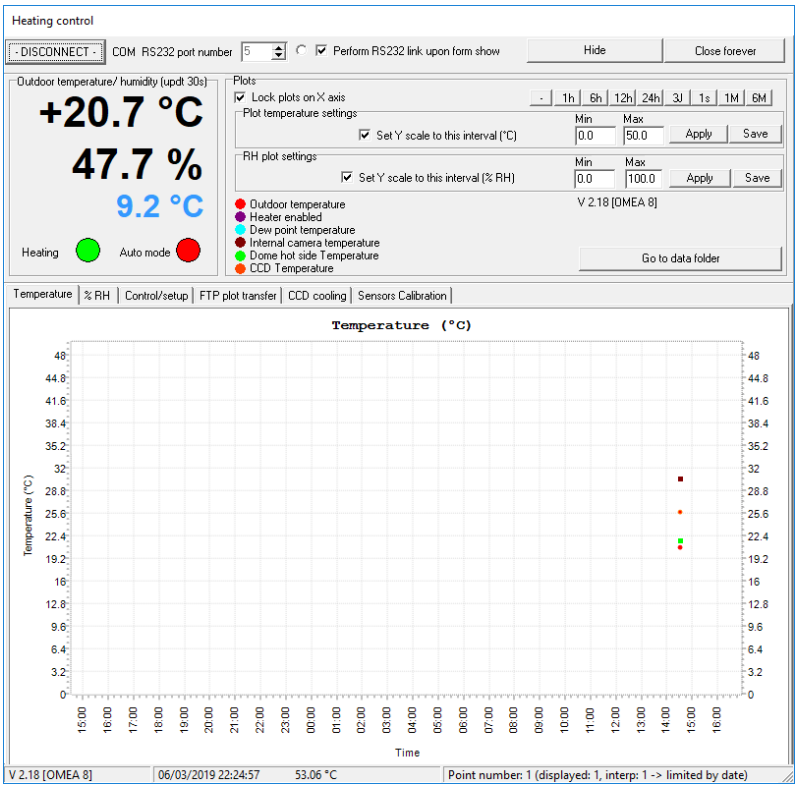
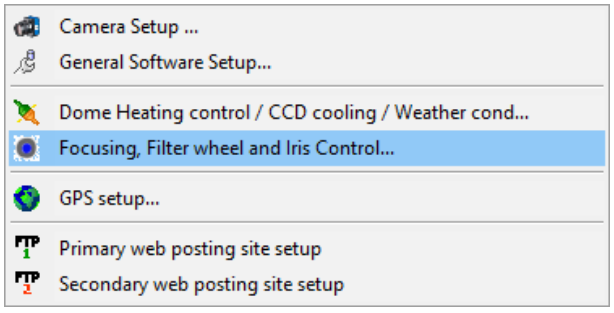


Figure 16: Heating control window with temperature and humidity information (RS232 COM port is 5 in this case).

Once the port COM entered and connected to the camera, for OMEA 8C the user needs to enter the focus encoder value provided by ALCOR-SYSTEM (**1270**).



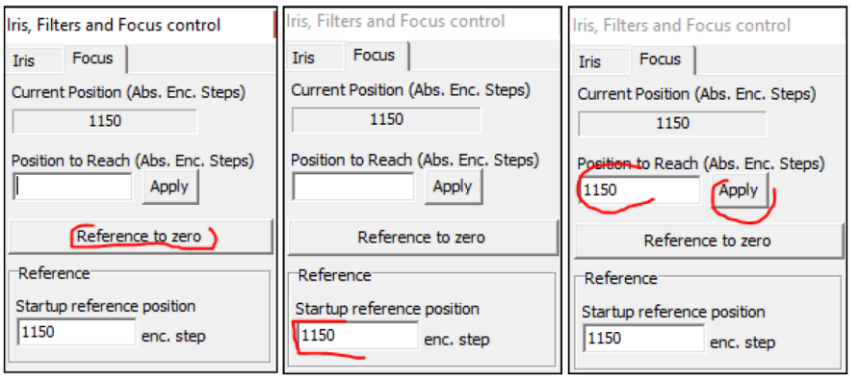


Figure 17: Focus encoder value setup.

Focus must be achieved overnight, F2.8 full opened. Zoom must be set to 1 .The focus tilt is set on factory, user shall not bother with that. The next set of 6 images shows the effect of different focus encoder value on the image. 1000 is clearly very bad, and 1200 is a good figure (star are sharp), whereas 1400 is not nice.

Accuracy must be within +/- 50 encoder steps, difference can be seen between 1150 and 1200 steps. If this procedure is not achieved, images will not be focused properly.

1.5.2. Camera setup

The software is set to simulation camera, and must be changed to the proper camera. Click "Options/Camera Setup…"

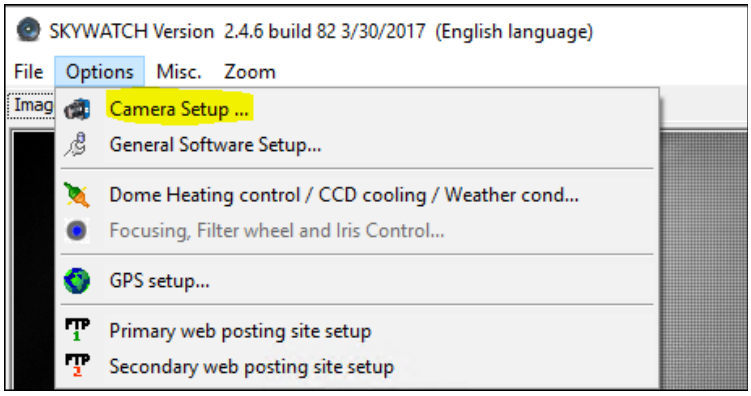


Figure 18: Camera setup.

Select «OMEA 8C camera", the connected camera must appear below.

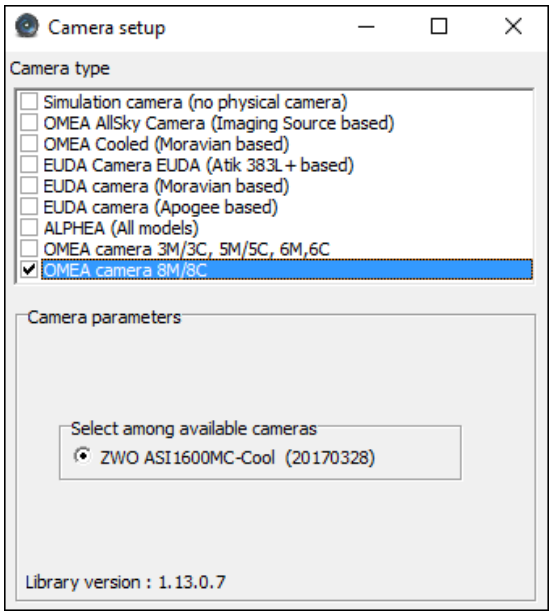


Figure 19: Selected OMEA 8C camera.

When OK is pressed, camera will start recording images. Now go to "Options/General Software Setup".

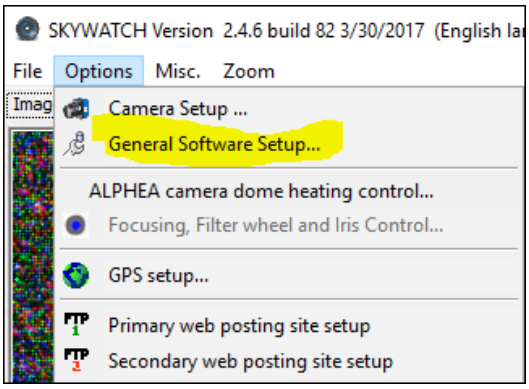


Figure 20: General software setup.

The next panel appears, and must be filled accordingly, especially this is very important to setup place (longitude and latitude).

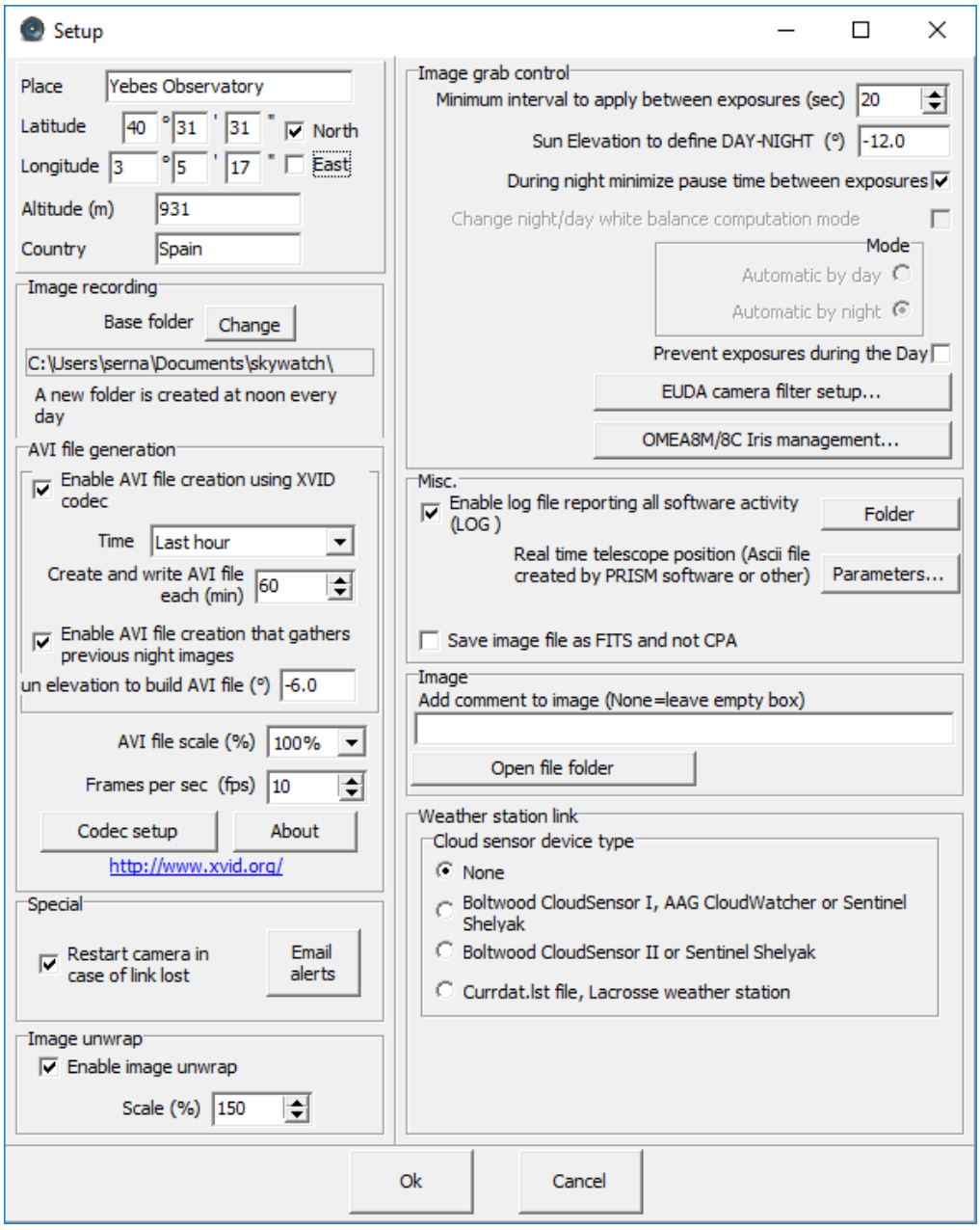


Figure 21: General software setup main window.

1.5.3. OMEA 8M/8C cooling setup

OMEA 8C has the ability to cool down the image sensor inside the camera. This only needs to be a moderate cooling, because exposure time of the camera is 60 s at the maximum. To access cooling control, use this menu.

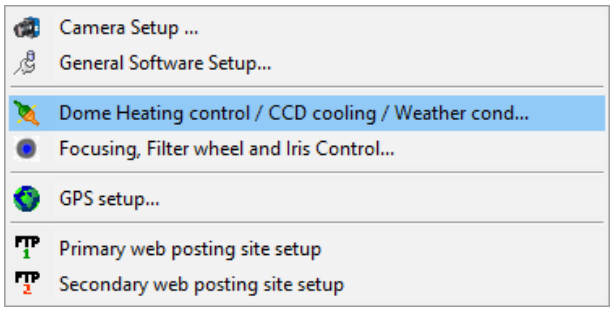


Figure 22: Cooling setup menu.

This form shows up, and the user has to go to the "**CCD cooling**" tab. The hardware link to control the image sensor cooling is the USB link, not the RS232 link.

It is strongly recommend to check the "**Auto cooling**" box, which will disable cooling during daytime and enable it during night time.

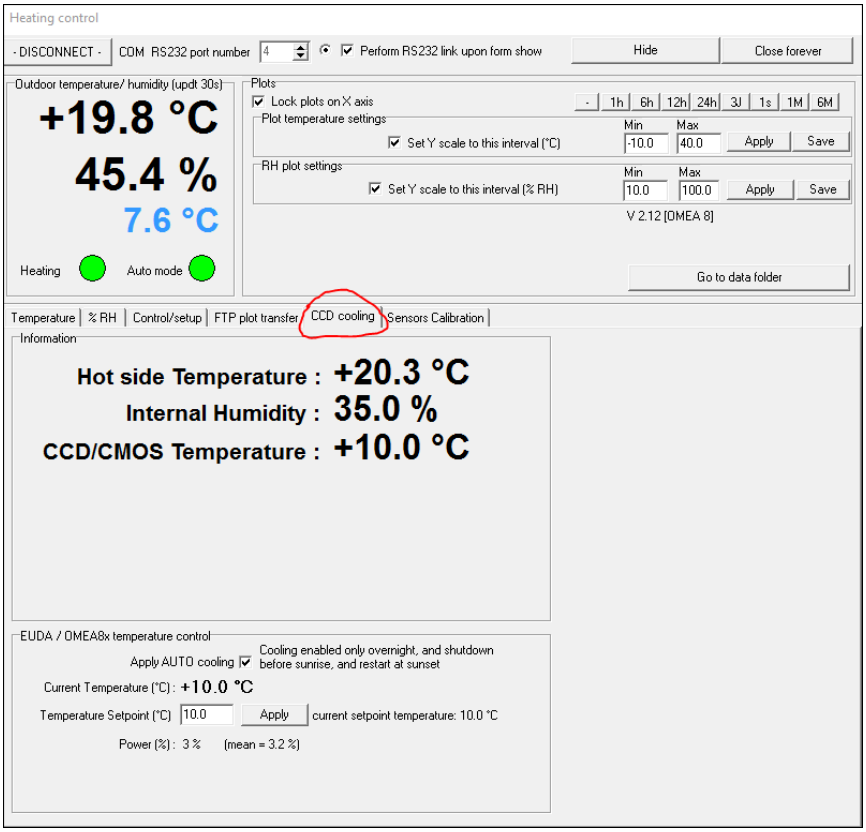


Figure 23: Auto cooling set.

It is recommended to set temperature set point to 0°C in summer, and -10°C in winter. In any case, the system will raise automatically sensor temperature if power used is larger than 60%. Also on software exit, the camera cooling is turned off. CCD temperature is plotted in the temperature tab plot.

Image hot pixel removal using dark frame image

Note: For cooled cameras such as OMEA 5x and OMEA8x, this can be ignored. For other cameras, this can also be ignored in most cases (high latitude sites, with cool nights).

For not cooled sensor cameras, hot pixels can be removed thanks tosoftware features (User Manual page 31).

1.5.4. Exposure control

Once the camera is selected, the exposures start immediately. Then, do not forget to check the "**Auto Exposure**" box after the first image has been displayed. It should be by default.

For color camera, the raw image from color camera is a black and white, this is called Bayer pattern image. So the true color image shall be computed.

Check the box "**Color image from Bayer array**" and set it to #4 for OMEA 3C/6C cameras and to number **#3 for OMEA 8C**.

Only the color cameras have this option enabled, monochrome cameras (black and white cameras) do not.

Maximum recommended gain is 250 for OMEA 3C/6C, the more the gain is high, and image quality will be jeopardized by image sensor readout noise.

Note: Maximum recommended gain is between 150 - 200 for OMEA 8C (recommended by the manufacturer).

Going above these settings may jeopardize image quality due to high noise.

Maximum recommended exposure is 30s OMEA 8x. Going above these exposures times may render visible star trailing due to Earth rotation.

Then check "**Circular fisheye**" for the area to be used for computing automatic exposure time.

The area used for auto exposure computation, is displayed in red in the image of the sky.

It is very important to tune this circle properly, then go to the **Display tab in the control** panel form.

They check boxes as follows, and tune the X center, Y center, Radius, and north position, so that the stars match with the cross.

To be successful with this operation, the camera must be positioned with a water bubble level. If the camera is tilted, the matching between the star cross and the actual star in the image is not possible.

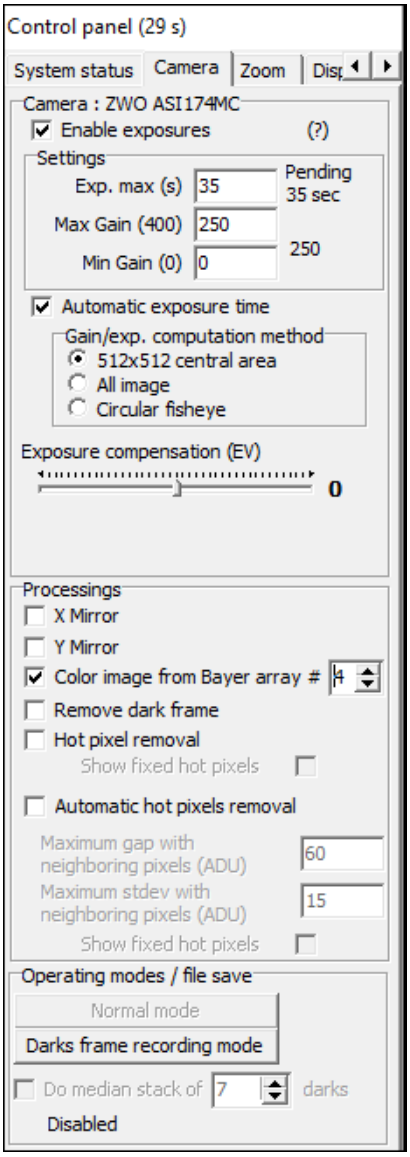


Figure 24: Exposure control menú.

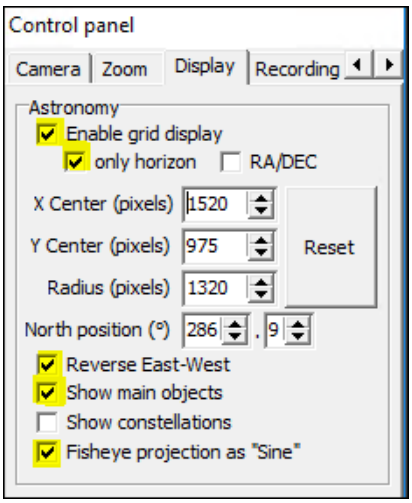


Figure 25: Default settings.

1.5.5. First test image

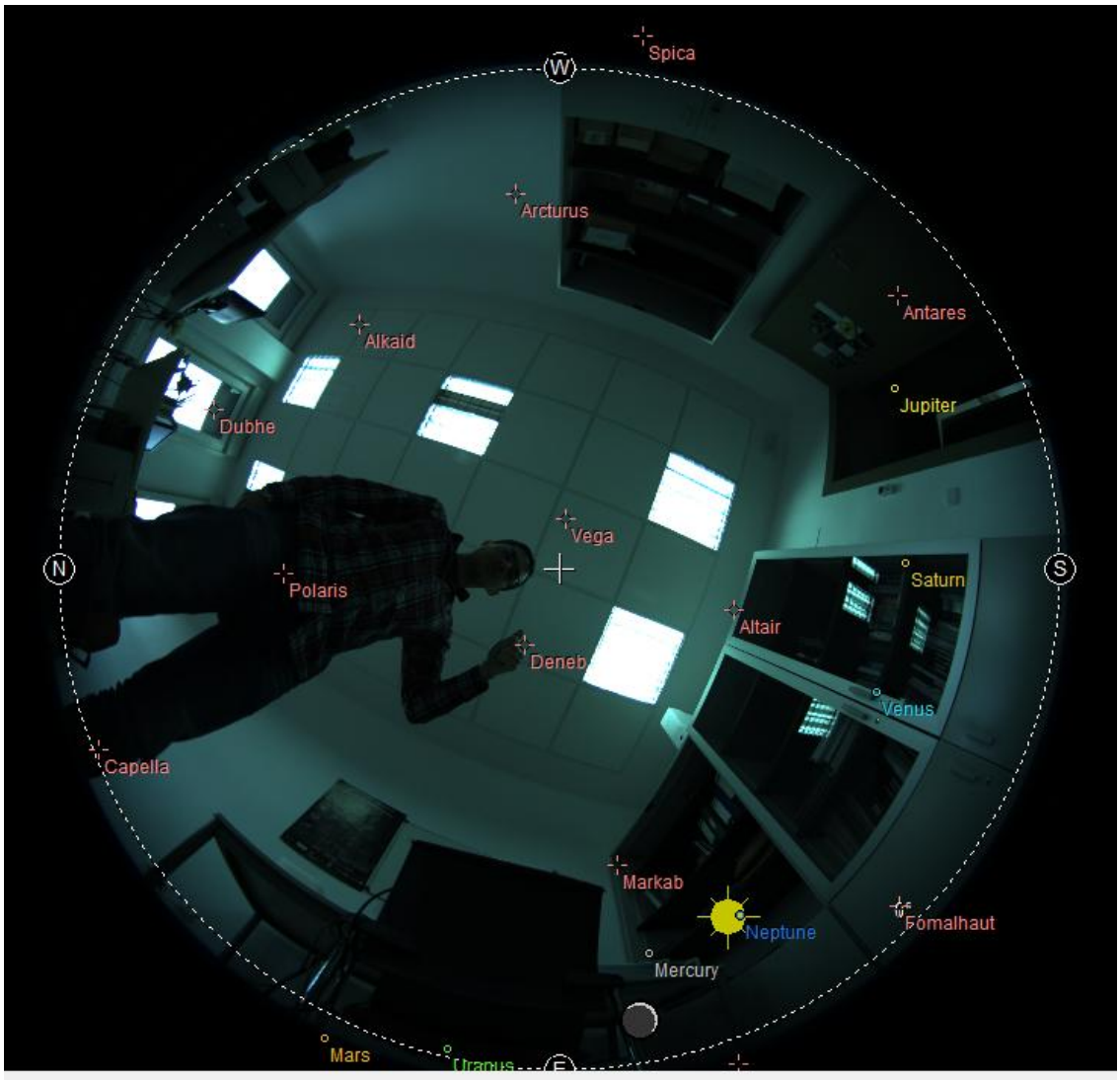
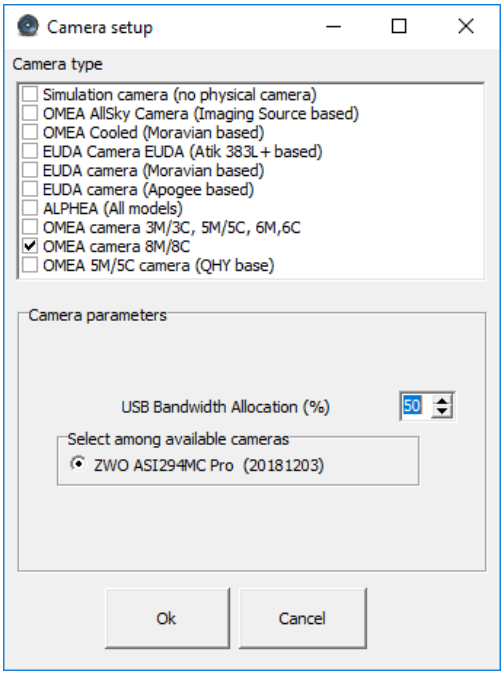
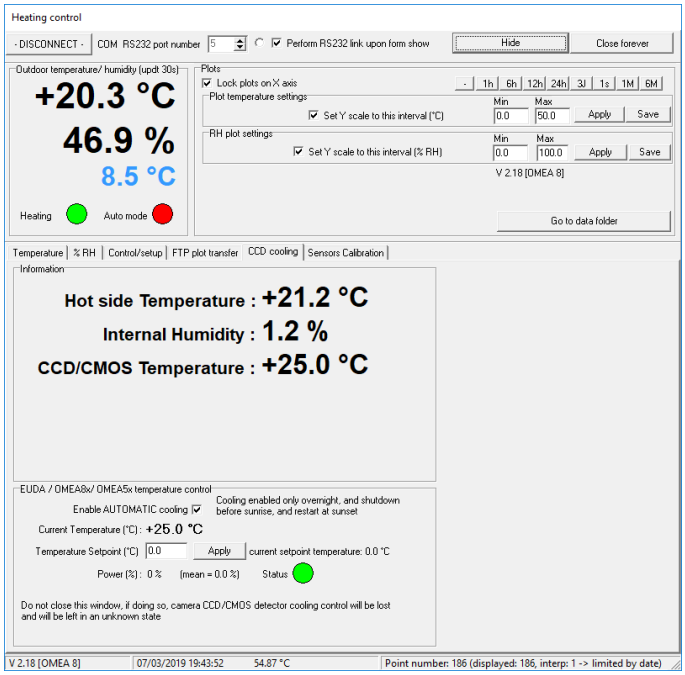
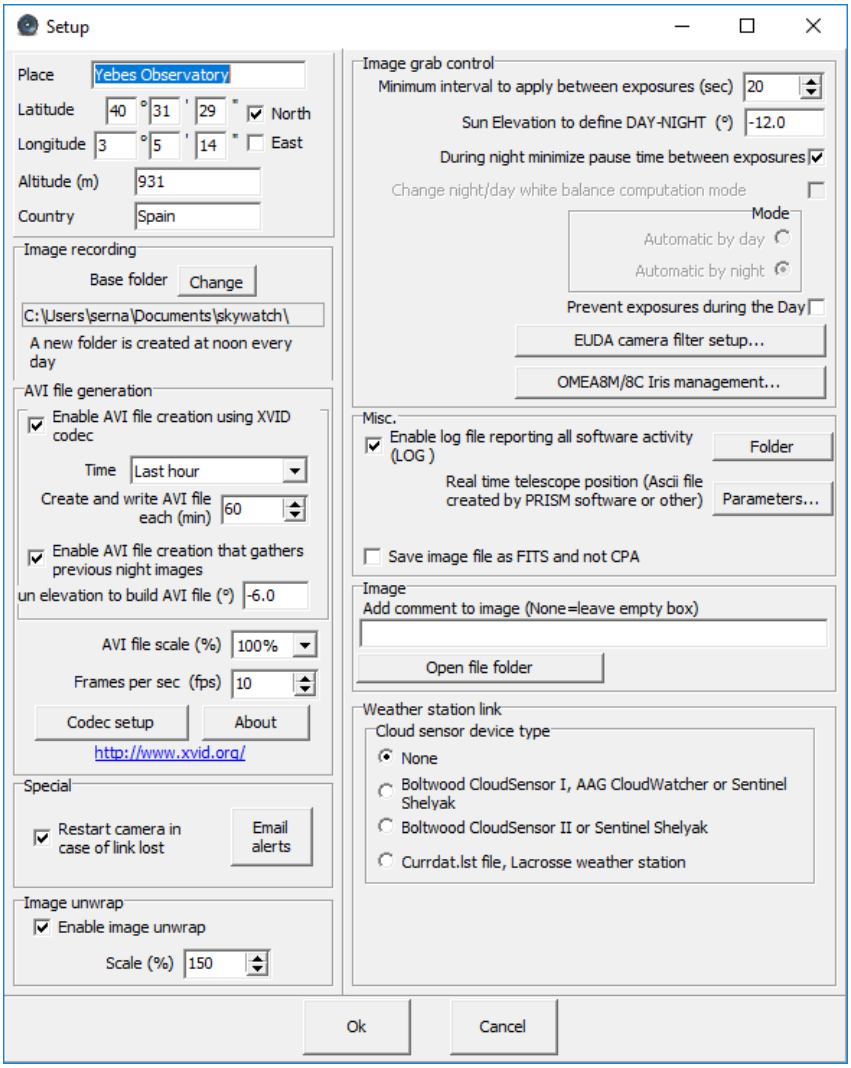


Figure 26: Test image.

Setup:


Camera setup
Camera type
Simulation camera (no physical camera)
OMEA AllSky Camera (Imaging Source based)
OMEA Cooled (Moravian based)
EUDA Camera EUDA (Atik 383L+ based)
EUDA camera (Moravian based)
EUDA camera (Apogee based)
ALPHEA (All models)
OMEA camera 3M/3C, 5M/5C, 6M,6C
OMEA camera 8M/8C
OMEA 5M/5C camera (QHY base)
Camera parameters
USB Bandwidth Allocation (%)
50
Select among available cameras
ZWO ASI294MC Pro (20181203)
Ok
Cancel


Heating control
+20.3 °C
46.9 %
8.5 °C
Heating
Auto mode
Hot side Temperature : +21.2 °C
Internal Humidity : 1.2 %
CCD/CMOS Temperature : +25.0 °C


Setup
Place
Yebes Observatory
Latitude
40 ° 31 ' 29 " North
Longitude
3 ° 5 ' 14 " East
Altitude (m)
931
Country
Spain
Image recording
Base folder
Change
C:\Users\serna\Documents\skywatch\
A new folder is created at noon every day
AVI file generation
Enable AVI file creation using XVID codec
Time
Last hour
Create and write AVI file each (min)
60
Enable AVI file creation that gathers previous night images
un elevation to build AVI file (°)
-6.0
AVI file scale (%)
100%
Frames per sec (fps)
10
Codec setup
About
http://www.xvid.org/
Special
Restart camera in case of link lost
Email alerts
Image unwrap
Enable image unwrap
Scale (%)
150
Image grab control
Minimum interval to apply between exposures (sec)
20
Sun Elevation to define DAY-NIGHT (°)
-12.0
During night minimize pause time between exposures
Change night/day white balance computation mode
Mode
Automatic by day
Automatic by night
Prevent exposures during the Day
EUDA camera filter setup...
OMEA8M/8C Iris management...
Misc.
Enable log file reporting all software activity (LOG)
Folder
Real time telescope position (Ascii file created by PRISM software or other)
Parameters...
Save image file as FITS and not CPA
Image
Add comment to image (None=leave empty box)
Open file folder
Weather station link
Cloud sensor device type
None
Boltwood CloudSensor I, AAG CloudWatcher or Sentinel Shelyak
Boltwood CloudSensor II or Sentinel Shelyak
Currdat.lst file, Lacrosse weather station
Ok
Cancel

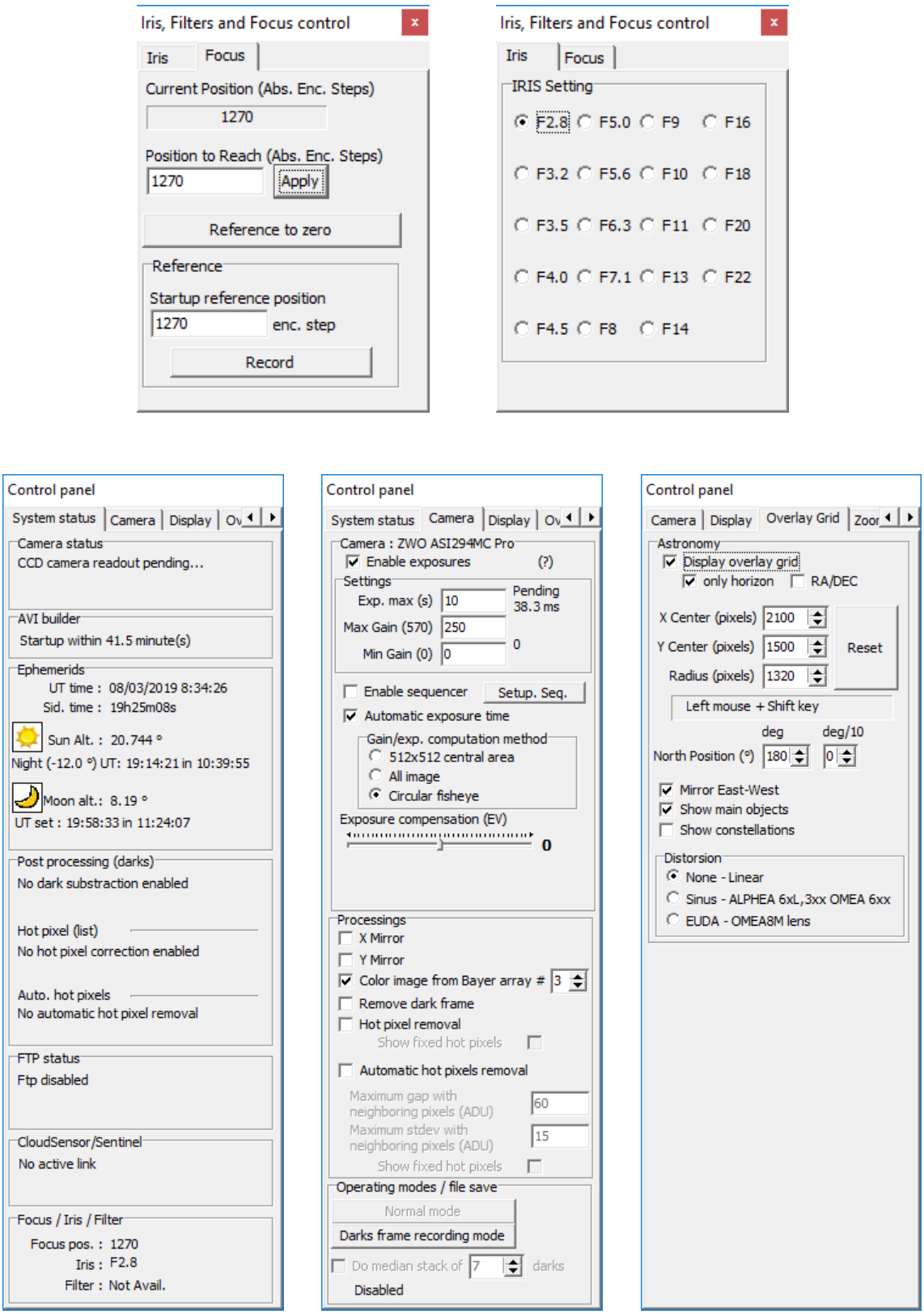


Figure 27: Test setting.

1.5.6. Camera exposure time and gain

Manual mode

The users enter the exposure time and gain as they wish. No adjustment is made by the software.

Automatic mode

The software manages the exposure time with focusing on the camera gain. It is up to the users to set the maximum gain and maximum exposure time they want to use. The software can use a calculation area of 512x512 pixels at the center of the whole image, all the image or circular fisheye, with the aim to adjust the gain / exposure time to get a signal level located at half the camera dynamic range. When the settings are changed, regarding which area will be used, a red shape appears on the image during some minutes as a reminder of the selected area.

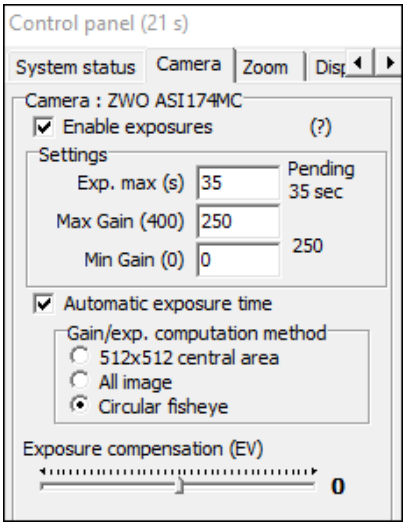


Figure 28: Exposure settings.

When determining the maximum exposure time, the user shall bear in mind that **the minimum exposure time is 32 µs** (0.000032 s) and the maximum exposure time will depend on when the stars will start to leave traces due to earth rotation.

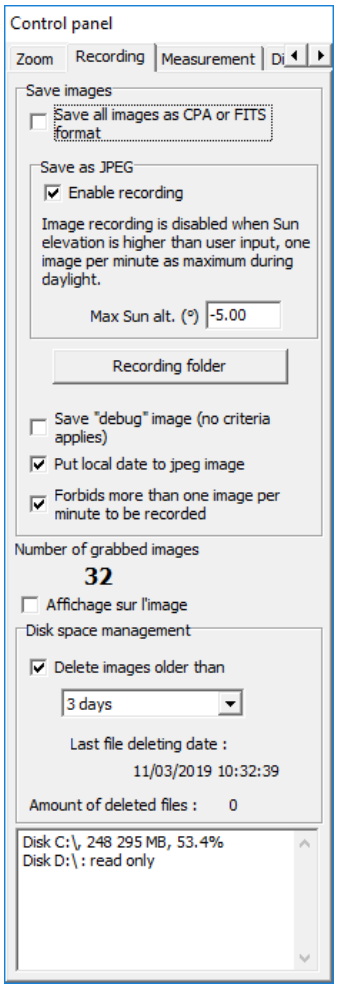
Note:

- User manual (page 27): Maximum recommended exposure is 30s OMEA 8x.
- Log report: Min exposure: 32 µs, max exposure 33m 20s (this is what the camera can do intrinsically (FPGA firmware), the software can clip this).
- Summary of specifications (Figure 5): From 32 µs to one hour exposure (All-sky mode, typically 20s to 75 s).

1.5.7. Storage of files produced by the camera control software

The software stores all the files it produces into a directory that is specific to the user.

This directory (and subdirectories) is created automatically by the software. C:\Users\[Login name]\Documents\skywatch, where [login name] is the name used to log into your windows session.



Enable recording:
disabled when sun elevation
is higher than specified value.
Open recording folder Tab

Figure 29: Recording settings.

1.5.8. Boldwood cloud sensor link with camera control software

If you own a cloud monitor from Cyanogen, it is possible to display, at the top right of the image, some weather information. In the main Setup Panel, enter appropriate information. The software uses simply the output file generated by each measurement from cloud sensor. It does not use the COM or ActiveX interface. Enter the path of the generated file provided by the software that runs the cloud sensor.

The amount of information depends on the system that is measuring cloud cover.

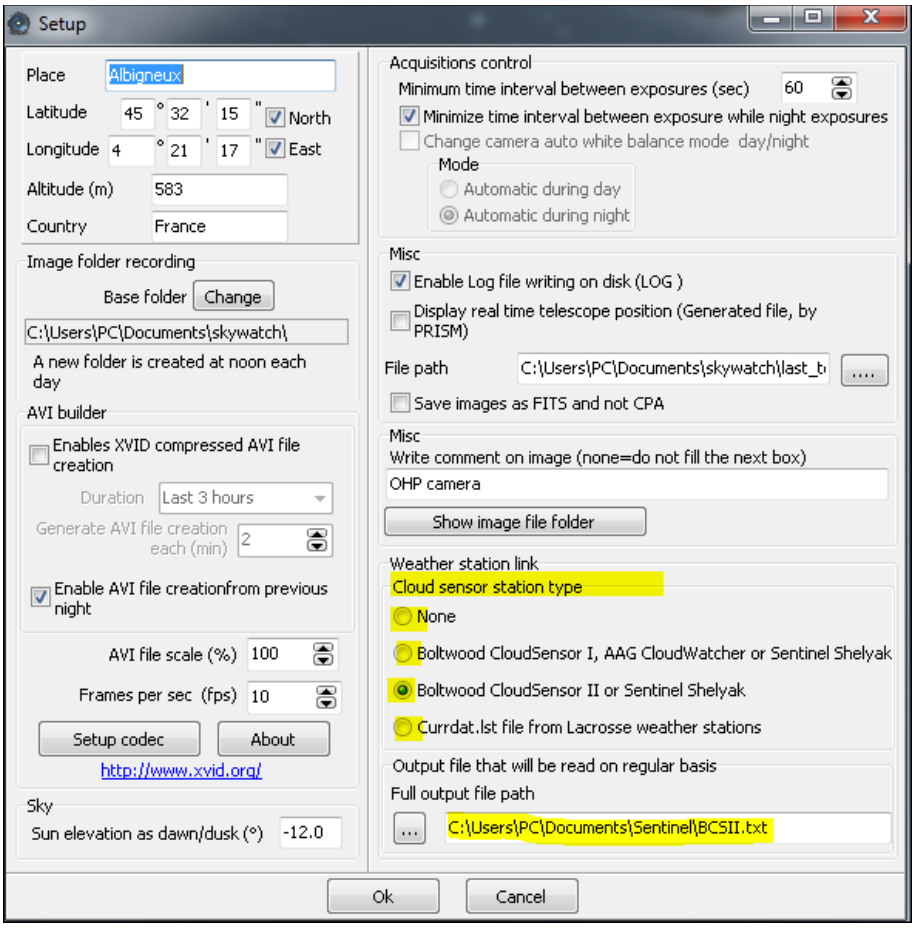


Figure 30: Boltwood cloud sensor integration.

1.6. Sphere condensation heater management

The **heating** of the sphere is achieved throughout a set of resistors placed under the sphere base. It can **defog or defrost the outside side of the acrylic sphere**.

The system is autonomous (works without link to PC and without user's supervision). It sets out the conditions when temperature and humidity levels enable occurrence of water condensation.

As soon as the temperature is below a certain value, and moisture above another value, the heating system is automatically activated. These levels are named temperature and humidity levels.

By default, factory set, the default threshold **temperature is set to +7°C and humidity level to 90%**. These thresholds may be inappropriate for a given site and can be adjusted by user input (RS 232 link to camera is mandatory to do so).

Similarly, the **heating power is set by default to 50%**, it can be changed according to site and circumstances (Figure 22).

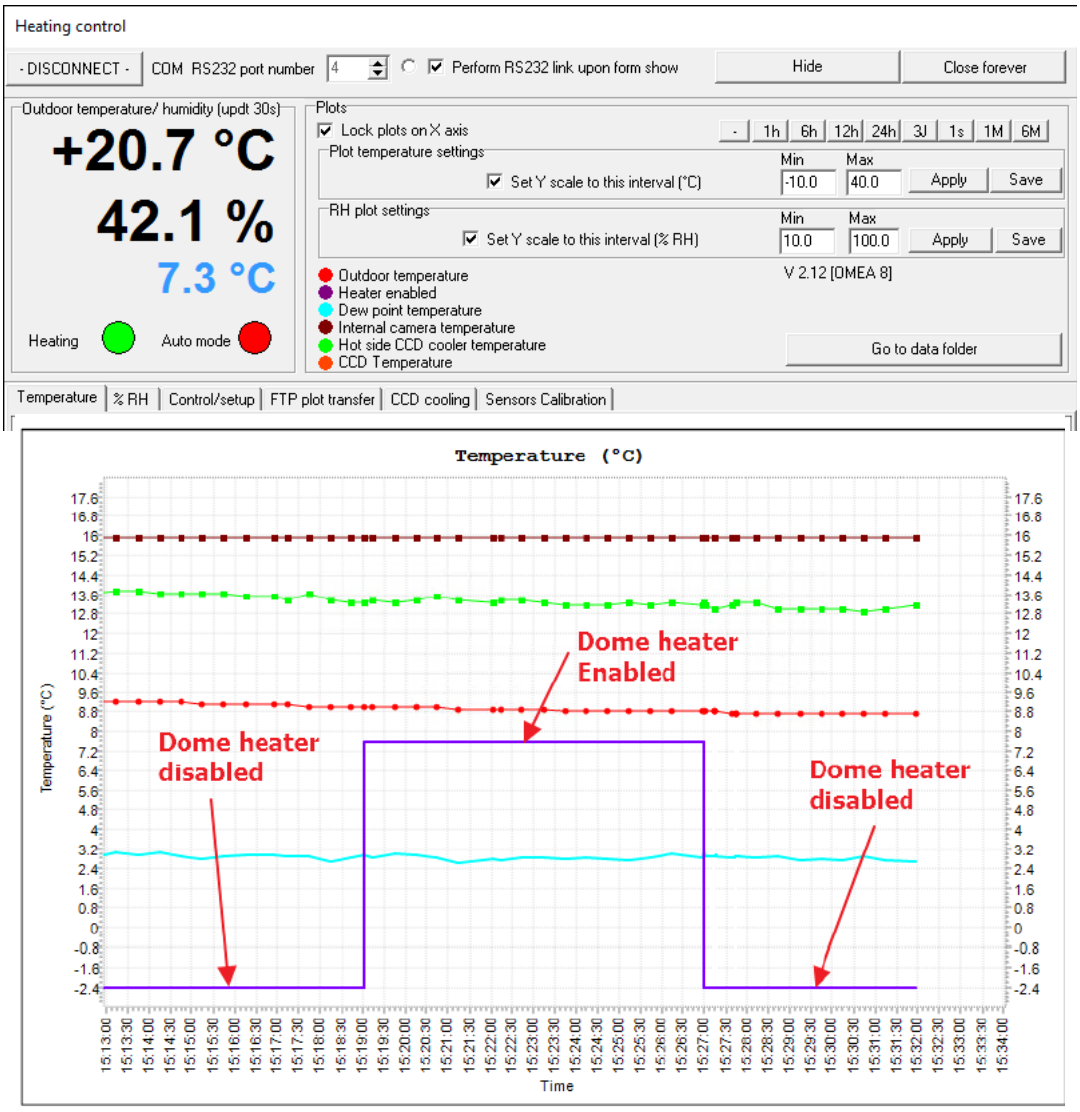


Fig. 80 *Heating plot (as purple) warning there is not unit bound to it*

Figure 31: Heating plot (as purple) warning there is not unit bound to it.
The red curve provides outdoor temperature, light blue curve is dew point.

The tab "% RH" provides access to humidity plot expressed as % RH (**Relative Humidity**). The internal humidity shall be kept **under 20% RH**. The camera embeds a desiccant (molecular sieve) inside it, to have the humidity as low as possible, **to prevent dew from forming in the inner side of the dome**. So do not dismount the backside of the camera if not needed, this would cancel out the effect of the desiccant, and humidity level would be higher than 20% RH.

1.7. Camera Maintenance

Sphere cleaning

Sphere cleaning must be achieved on regular basis. Rains can bring dust that is deposited on the sphere surface; it reduces the optical transmission and image quality.

The acrylic sphere outer and inner surface can be cleaned with water, then with a Kleenex moistened with washer fluid dedicated for window cleaning. The 8 screws can be removed to detach the sphere from the rest of the camera. Attention must be paid on these topics:

- The cable bringing power to the heaters should not be pinched during reassembly
- O-rings properly positioned in their grooves
- The distance between the sphere support and the camera body must be at least 0.7mm and constant around the perimeter.
- 8 screws must be put together with their washer and all tightened the same way.

Incorrect reassembly can cause loss of sealing, allowing rain to enter and de facto guarantees no longer apply. If you feel confident with dismounting sphere, please do not do it.

Camera internal desiccant replacement

Inside the camera, a small desiccant bag has been installed. This is molecular sieve that can set the level of humidity down to zero. Replacement of this bag, may happen once every 3 years. The inside camera relative humidity can be monitored, if above 60% inside the camera, this latter should be inspected for leaks.

- **Trouble shooting: Dew inside the dome**.

  This may happen after several years of operation, if the internal desiccant is exhausted. Please check the internal humidity figure. It should be less than 20%, above 60% dew can form easily. To replace the internal desiccant, please contact us to get the procedure.

2. Annexes

2.1. Camera model

The camera inside is the next one:

Model	ASI294
Manufacturer	ZWO Co., Ltd.

2.2. Optics model

$$f(x) := \begin{pmatrix} x \\ x^2 \\ x^3 \\ x^4 \\ x^5 \end{pmatrix}$$

$$cg := ajustlin(\Theta, Y, f)$$

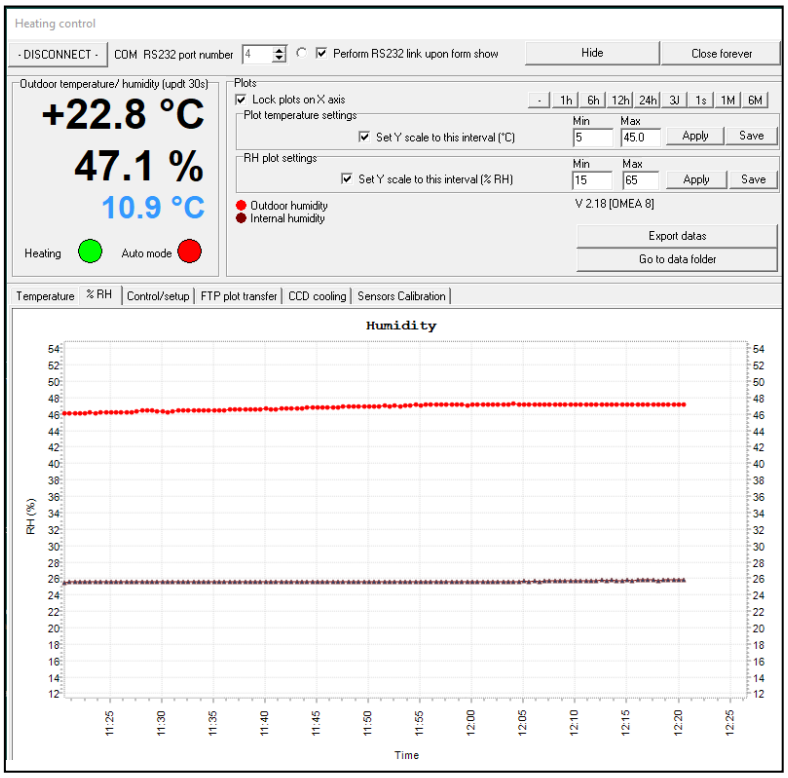
$$cg = \begin{pmatrix} 0.0129 \\ -3.3045 \times 10^{-5} \\ 1.2614 \times 10^{-6} \\ -2.3034 \times 10^{-8} \\ 1.2237 \times 10^{-10} \end{pmatrix}$$

Zenith angle to pixel coefs

$$FuncRes(\theta) := \sum_{i=1}^{5} \left(cg_{i-1} \cdot \theta^i \right) \cdot Rm$$

Up to the 5th order, distortion coefficients, Rm= 1137 pixels, teta as degrees.

2.3. Internal relative humidity values



HR value over 20% (around 26%). February, 2020.

The manufacturer was asked about this circumstance.

> Q: Why this value? Has sealing been lost? Is the internal desiccant working properly?
>
> A. Not nice but I would not touch anything. How long do you have the camera outside? We realized that acrylic dome let moisture to go thru a bit. Glass dome does not exhibit this issue. If you need to exchange the desiccant (this is a molecular sieve type).

Molecular sieves information

https://www.geejaychemicals.co.uk/molecularsieve.htm

Molecular sieves are desiccants with differing properties to those of silica gel. With the appearance of small opaque pinkish beads, molecular sieves are synthetically produced, highly porous crystalline metal-alumino silicates. They have many internal cavities that are linked by window openings of precise diameters. It is these diameters (measured in Ångstroms) that classify molecular sieves **- 3Å, 4Å, 5Å, and 10Å** (also known as **13X**). Adsorption occurs only of molecules with smaller diameters than these cavity openings. Larger molecules will be excluded from adsorption. Preferentially adsorbed are molecules of greater polarity.

This makes molecular sieves ideal for adsorption of water from air and liquids, as water molecules are both polar and very small. Molecular sieves will adsorb water molecules and other contaminants from liquids and gases down to very low levels - often just 1 part per million.

Examples of the applications of the differing molecular sieve grades are:

- **Grade 3Å**. Dries unsaturated gases and organic liquids (e.g methanol). Used to remove water from cleaning fluids in ultrasonic baths.
- **Grade 4Å**. Is a general dryer of liquids, natural gases. Also an excellent adsorber of carbon dioxide.
- **Grade 10Å (13X)**. Is used in air prepurification (due to its high water and carbon dioxide adsorption capacity) and also adsorbs sulphur compounds ('sweetens'). It will remove decomposition products following the quenching of arcing in electrical products.

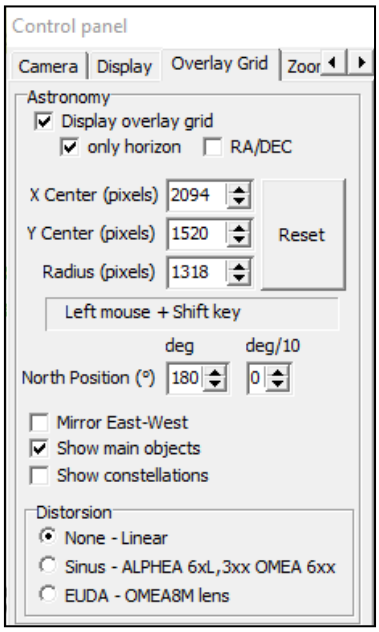
Molecular sieves properties as desiccants differ from silica gel in a number of ways:

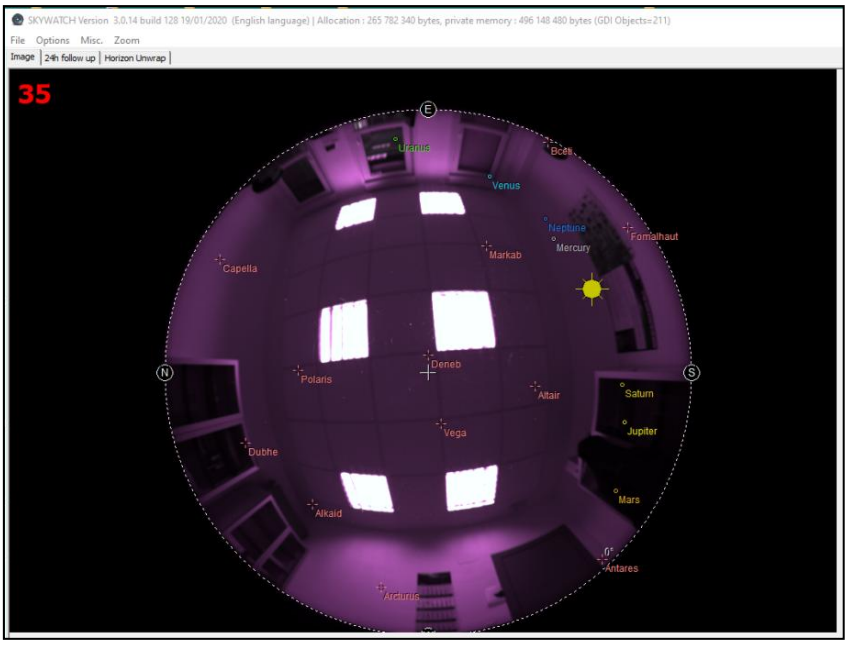
1. They absorb water vapor more rapidly than silica gel.
2. They will reduce water vapour to much lower levels than silica gel, making their use essential when a very dry product or atmosphere is required.
3. They perform more effectively as moisture adsorbers at higher temperatures (greater than 25°C) than silica gel does.

2.4. Overlay grid

Image size is 4144px x 2822px, then its centre would be at (2072px, 1411px), but the grid is centred at (2094px, 1302px). As a result, part of the grid is out of the image ⇨ Not all the FoV is being covered by the camera.

The manufacturer argues that it is not very important, sensor inside the camera is not XY adjusted, and they have very limited degree of freedom to compensate for that.





OMEA 8C, All Sky Camera
Observatorio de Yebes, March 2019

BOLTWOOD II CLOUD SENSOR

Reception report: specifications and setup instructions

YLARA Project

YLARA-BS-50-I01 (CDT Technical Report 2019-07)

J.M. Serna Puente, B. Vaquero Jiménez

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January 22nd, 2019

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Applicable and reference documents

[1] Boltwood Cloud Sensor User´s manual. Boltwood Systems Corporation and Diffraction Limited.August 21, 2012.

[2] http://diffractionlimited.com/product/boltwood-cloud-sensor-ii/

1. Boltwood II cloud sensor

1.1. Introduction

The Cloud Sensor II senses how clear the sky is, measures the ambient air temperature, wind speed, humidity, detects wetness (snow and rain) and detects daylight.

It must be mounted outdoor in a location that provides a clear view of the sky. A cable runs from the sensor head to the indoors, and connects to the supplied **adaptor box**. This adaptor box has a wall plug **power supply connector**, a **USB port for connection to a computer**, and another connector that may be used to request an **emergency dome closure**.

The supplied **Clarity II software operates under Windows 2000** and beyond, and provides a visible and audible alerting interface. It also has a single line file interface and a COM (ActiveX) interface to allow the Cloud Sensor II to input to observatory automation software.

The design of the Cloud Sensor II emphasizes monitoring weather phenomena that affect your astronomical observations and the safety of your astronomical equipment. To do this it does overlap some of the capabilities of a weather station – but with a change in emphasis.

The sensor head must be installed out of doors in a location where it has an unobstructed view of the sky.

It will not work through a glass window. Its field of view is in the shape of a cone with an included **angle of approximately 80°**. There is some **sensitivity out to 120°**. Any substantial obstruction in that field of view will reduce the sensitivity and accuracy of the sensor head.

Figure 1: Boltwood II cloud sensor.

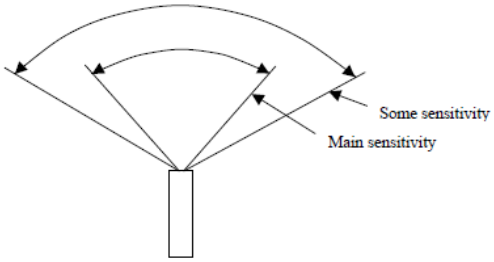

Figure 2: Sensor visibility.

Here are some of the intended uses of the Cloud Sensor II and the Clarity II software.

a) Identify sky conditions before starting an observing session or opening a remote observatory.
b) Warn a user who is indoors and/or asleep, when the skies become observable.
c) Warn the user that conditions have changed from observable, and that further imaging will not succeed.
d) Warn the user that conditions have become very cloudy or windy or there is daylight, and that the observatory should be closed soon.
e) Warn the user that conditions have become wet or very windy or there is bright daylight, and the observatory should be closed immediately.
f) Automatically close an observatory when conditions become very windy, very cloudy or wet, or very bright even if the user is not at the computer to see the warning, or the computer is not functioning.

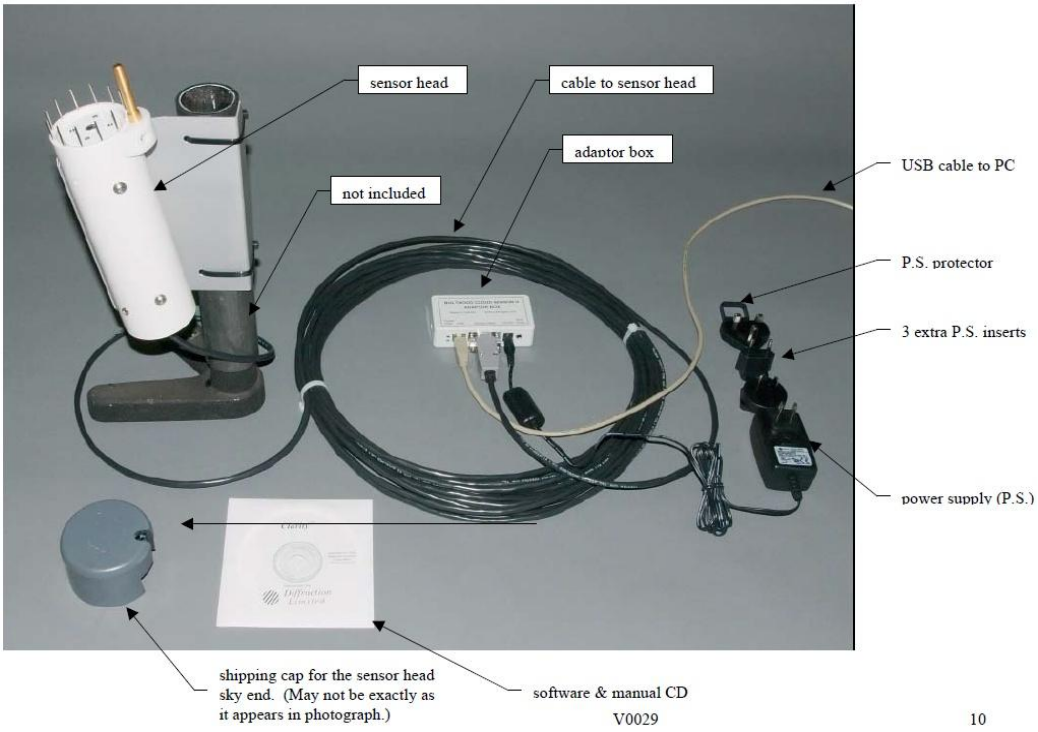

Figure 3: Cloud sensor components.

Part list

- The sensor head (plastic double tube unit with electronic innards), attached anemometer (gold finger), and attached bracket.
- A cap over the sensor head protecting the anti-bird wires (11 sharp wires at the sky end). This protector should be kept in case if you ever need to ship the sensor [or return it to us]."Paperboard"
- Adaptor box.
- Universal 24 VDC power supply with AC plug adaptors for different countries
- Cable to the sensor head, length of 30 meter.
- 2 meter USB A/B cable used to go from the adaptor box to the PC.
- Software and user manual CD.

1.2. Operation principles

The Cloud Sensor II **detects the presence of clouds in an indirect manner**.

What it really does is measure the sky temperature by sensing the infrared radiation from the sky in the 8 to 14 micron wavelength range.

It uses a **thermopile** to do this. It then compares this reading to the ambient temperature at the bottom of the sensor head. A clear sky is at least 20°C (36°F) colder than the ambient temperature near the ground. A fully overcast sky with **low clouds** (**the kind that rain usually comes from**) usually will be close to the same temperature as the ambient temperature.

Very high thin clouds composed of ice crystals (cirrus) are by their nature quite cold and therefore **may not be detected by the Cloud Sensor II**. Unfortunately, this might fool you into thinking that you can observe when you cannot. This might waste a bit of your time but on the positive side these clouds do not produce rain.

There are some unusual meteorological situations where rain clouds can be high above ground and therefore cold. If so there will be a warning only after the rain begins to fall.

While these limitations due to the physics of the atmosphere are unfortunate, you should find the Cloud Sensor II a very useful adjunct to your astronomical observing, just as we do.

The thermopile for measuring sky temperature is inside the little round can on the sky end of the sensor head. You can see the filter aperture that lets the infrared radiation enter the device. This device also contains a thermistor, which is used to measure the temperature of the case around the thermopile. This is used in the calculations for the sky temperature measured by the thermopile.

1.3. Auxiliary sensors

Ambient temperature and humidity

At the other end of the sensor head, near the cable connector, is a device that measures the humidity and the ambient temperature. The dew point temperature is calculated from those two values. This device is covered with a somewhat delicate white insect and dirt-proof cover.

Wetness or rain sensor

Around the thermopile device there is a white disk that is the wetness detector. It senses individual drops of rain striking it. It also senses whether there is a film of water on it or not. This sensor is also able to detect snow and ice. **The thermopile cannot see through any form of water**. This means that any wetness must be removed quickly. This is done by three methods. First, the sky end of the sensor head is normally heated to 8°C (15°F) or more above the ambient temperature to prevent the formation dew or frost. Second, when the rain stops but the wetness sensor is wet, the sensor head is heated to 60°C (140°F) until it is dry. For older firmware the temperature was 70°C (158°F). Third, the **sensor** head is installed at a **tilt** from the vertical position by the attached bracket so water runs off of the sensor head.

Anemometer

The gold finger sticking up from the sensor head is the anemometer. It has adequate accuracy for our purposes but is less accurate than other designs. It also is omni directional – it does not sense the direction of the wind. This one has no moving parts, no holes to get blocked, no transducers to fail, and is reliable under winter conditions. These were the reasons for choosing this design.

The gold finger has a fixed power heater at the bottom and a temperature sensor at the tip of the finger.

By measuring the amount the finger is cooled by the wind, the wind speed is estimated. The gold plating helps it work in full sunlight by reducing heating by the sun. It is most accurate at the low wind speeds where observing is possible.

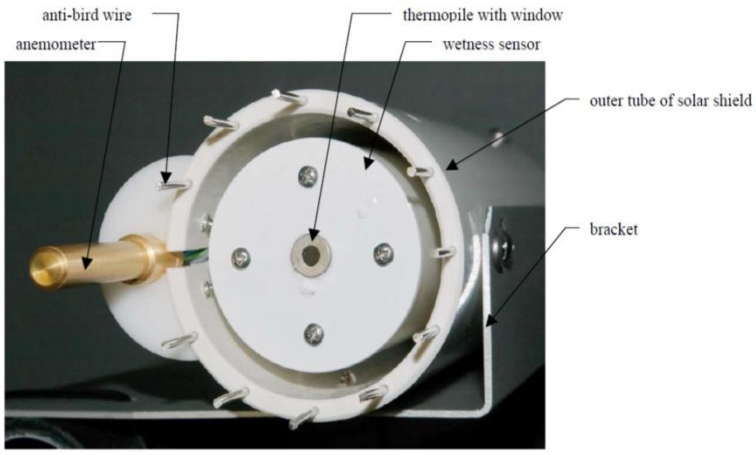

Figure 4: Auxiliary sensors (top).

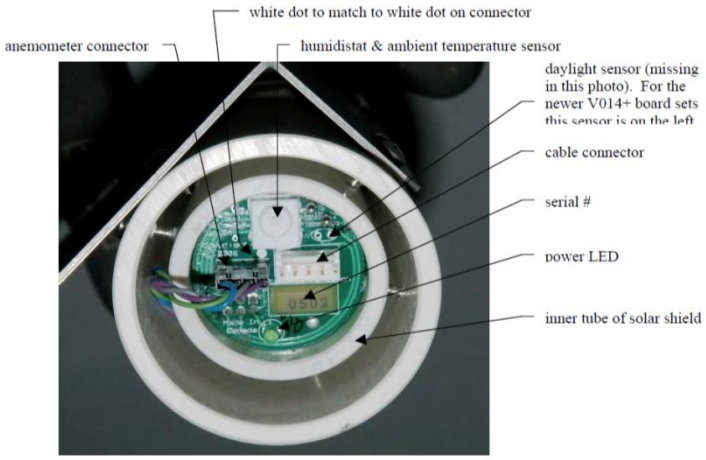

Figure 5: Auxiliary sensors (bottom).

1.4. Graphical user interface

From top to bottom on the left the items in the window are:

- Caption Gives the Clarity II version number.
- Cloud State Large text field showing the current cloudiness state.
- Wind State Large text field showing the current wind state.
- Wetness State Large text field showing the current wetness state. Note that a report of Snow or Snowed occurs if the ambient temp. is below freezing.
- Daylight State Large text field showing the current daylight brightness state.
- Error Message Large text field that normally is blank but may contain an error message.

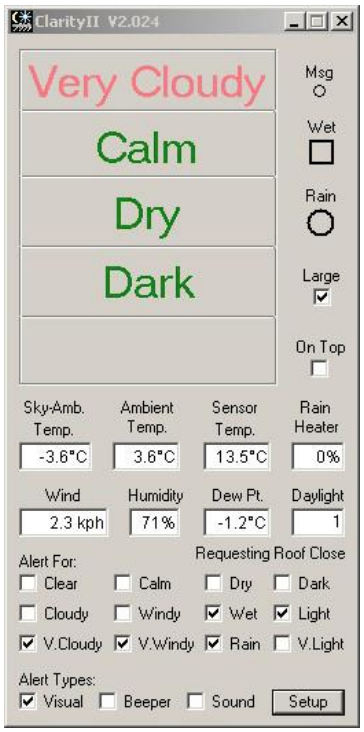

Figure 6: GUI.

Then down the right side:

- Msg has a little circle to the right of it that flashes green for every message received from the sensor head – normally every 2.1 seconds. It turns red when communications with the sensor head are lost.
- Wet Square this is dark cyan if the sensor was wet in the last 2.1 seconds. It is a light cyan if the sensor was wet in the last minute. This condition is also possible under extreme dewing or frosting conditions. It easily occurs if the Cloud Sensor II has been off and has just been turned on. The normal anti-dew heating that is done will not have taken effect yet.
- Rain circle This is dark blue if a rain drop struck the sensor in the last 2.1 seconds. It is a light blue if a rain drop struck the sensor in the last minute.
- Large User settable. When checked the full window is shown. When unchecked all of the fields below “On Top” are not shown as is shown immediately above.
- On Top User settable. If this is checked the Clarity window will stay “on top” and not be hidden by other windows. If it is on top and then minimized, the minimization will occur. If this was checked, the window had been minimized, and a visual alert occurs, the window will be immediately displayed on top. To stop this behavior uncheck the visual alert.

1.5. System setup

1.5.1. Software, Clarity II

The pen drive supplied contains the Clarity II software, the USB drivers, this manual, and the program TestClarityII.

Clarity II requires Windows 2000 or higher. **Linux** software is available from third parties; however we provide **no technical support** for operation through any software package except Clarity II under Windows.

By today's standards, its RAM requirements are modest – under 10 MB. It requires about 50 MB on hard disk for its log files. In a dual monitor system, the Clarity II windows must be placed on the first monitor due to Microsoft Visual Basic limitations. Note that only one Cloud Sensor II can be installed on a computer.

Install the Clarity II software (**check for updates that are posted on www.diffractionlimited.com**). The Clarity II installer will also install Cloud Sensor Graph II, an optional program for graphing the cloud sensor data.

1.5.2. Power supply, adaptor box and drivers

The **power supply** works on **90-230 VAC 50-60 Hz**. It has been provided with 4 different plug inserts. There might be a protective piece of plastic where the AC plug insert goes. Remove this open square protector, if it is there. Install the correct AC plug insert for your area into the power supply. The power supply automatically adapts to the local voltage and frequency no matter which insert is used.

Note that the power supply provided is a **24VDC** regulated unit and that is a higher voltage than most similar units. Do not mix it up with other similar supplies that have the same plug. Do not substitute an unregulated power supply for the one that comes with the Cloud Sensor II. Do not substitute a noisy power supply either. Noise will stop the wetness or rain detector from working properly. The center contact of the 24V plug is positive.

Leave the sensor head unconnected for now. Plug the power supply into the adaptor box and to AC power. The green power LED should come on in a few seconds. Plug the USB cable into the box and your computer.

Drivers must be installed for the USB interface. On modern systems such as **Windows 10**, if you have an internet connection the drivers will be **installed automatically** via download from Windows Update.

For older operating systems such as Windows XP you may have to install the drivers manually. FTDI drivers are very widely used, so they may already be on your system. It may be advisable to upgrade them. You can download the latest FTDI virtual COM port drivers from:

http://www.ftdichip.com/Drivers/VCP.htm

1.5.3. Cloud sensor familiarization

Please follow these steps and test the Cloud Sensor II conveniently indoors before installing the sensor head out of doors:

a) Unplug the wall plug power supply. This precaution is necessary in case you mis-register the rectangular connector at the rear of the sensor head. Connect the cable to both the sensor head and to the adaptor box. The cable is supplied in a coil held together with cable ties. Enough slack has been left at each end such that you probably do not need to cut the ties at this time.
Remove the protective cap from the sensor head. Be careful. The anti-bird wires are sharp and are easily bent. Store the cap or block where it can be found in future years. Check that the anemometer cable is correctly plugged in on the sensor head. This cable runs from the bottom of the gold finger straight down between the plastic tubes. At the bottom end there is a black rectangular connector with a white dot on it. It might have come loose during shipping. If so, match the white dot with the white dot on the circular circuit board at the bottom end. Plug the connector onto the pins of the black strip of 4 pins.

b) If not connected, reconnect the adaptor box to the computer's USB port used during the driver installation above. The "Roof Close" jack on the adaptor box is not used during this familiarization but will function in your proper installation. If the sensor head is not yet near room temperature, leave it until it is. It does not matter in what order you plug things together or run the software, except as concerns the alignment of connectors noted above.

c) Run the Clarity II software. You may get the message, "Could not find any previous settings in registry - using defaults". This is normal if Clarity II has never been run before.

d) Click the Setup button at the bottom of the large version of the Clarity II window. This will bring up the Setup window.

e) Enter the COM port number from the driver installation into the "Port" field and click OK. The yellow LED on the adaptor box should start to flicker. If all is well, after less than 60 seconds the circle just to the right of Msg in the Clarity II window will flash green every 2.1 seconds meaning that the computer is receiving signals from the sensor head. If the circle remains red or you get "No Msg's" continuously, check all of the Cloud Sensor II hardware connections and make sure that you have the COM port number correct.

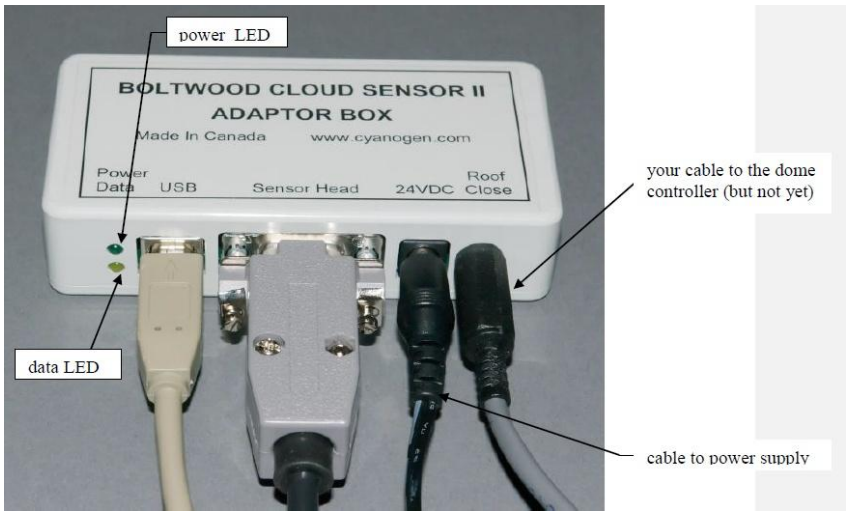

Figure 7: Adaptor box connections.

f) Familiarize yourself with the adaptor box LED behaviour, software, and the various readings and alerts. After a few seconds, the seven fields near the top of the window should contain numbers. Aim the sensor head at something that is at room temperature and the top left hand number should be near zero. If it reads 999.9, wait a couple of minutes for the sensor to heat up a bit and try again. Aim it at your skin and the number should read either a few degrees positive or 999.9 (it won't show your true temperature because it quickly saturates for positive temperatures, indicating 999.9). Aim it at something taken from your freezer and the number should be quite negative.

   During all of this, the next number field should be showing the air temperature in the room and after many minutes of warm up, the Wind field should be indicating near 0. After a few minutes the next field should indicate a temperature that is about 10ºC above the Ambient Temp. If this is true, simulate some "rain" with a sprinkle of water on the white disk at the sky end of the sensor head. After a while the sensor head should heat until the water evaporates. The heater will then shut off.

   NOTE that the sensor head could heat up to a HOT 70°C.

1.6. Installation

1.6.1. Location

The sensor head must be installed out of doors in a location where it has an unobstructed view of the sky. It will not work through a glass window. Its field of view is in the shape of a cone with an included angle of approximately 80°. There is some sensitivity out to 120°. Any substantial obstruction in that field of view will reduce the sensitivity and accuracy of the sensor head.

The sensor head is installed with a tilt of 10° (due to its bracket) from the vertical. This tilt allows water to run off of the surface of the wetness sensor. Otherwise it would take a lot of heating to evaporate that water. It would be better to lean 10° **into the direction from which the prevailing**

winds blow. This will allow, in most situations, the sensor head to detect a change in the weather slightly earlier than otherwise.

There is a daylight sensor at the bottom end of the head. It is quite sensitive but it does need to see some daylight reflected off of the objects and surfaces below for it to work. This would be a problem only if you deliberately block it or mount it over a black pit.

The sensor head is quite robust but it must not be installed in a polluted, dirty, salt water, or corrosive environment. Do not place the sensor head anywhere that you would not leave your telescope mirrors and lenses open at. Your telescope's expensive mirror, lens coatings and mechanics are only occasionally exposed - the sensor head is always exposed and therefore more vulnerable.

You should consider the need for maintenance when you chose your position.

Because the rain or wetness sensor and the wind probe can get very hot (70°C), locate the sensor head such that no one can casually touch it.

1.6.2. Mounting

The sensor head bracket is designed to be mounted onto a vertical pipe or metal or wood post. One way to mount it would be to fasten a piece of aluminum channel or angle to the edge of your roof. An even **better location** would be on a pole or post positioned **over vegetation**. In this way the ambient temperature sensor will not be affected by the heat from your roof or driveway during and after a hot, sunny day.

There are two mounting holes on the bracket that will take cable ties or #10 screws. If necessary, drill more holes in the bracket. If you use cable ties, make sure that they are sunlight or UV proof (black ones), and that the bracket will not slip down your pole as the temperature changes. A few layers of weatherproof tape just under the bracket on the pole can be used to do this.

Make the pole long enough to keep the sensor head well above any snowdrifts. The connector at the end of the cable will corrode if it is left in a puddle of water, especially if it has power on it. If the snow drifts as high as the bottom of the sensor head, this can happen.

Before leaving the sensor head, please press down gently on the white rain sensor (NOT on the thermopile window and avoid the anti-bird wires), and make sure that the electronics assembly is fully seated in the double tube unit. The white disk surface should be about 1/8" or 3 mm. below the edge of the large white tube. If the electronics assembly moved during shipping, the silicone grease water seal just under the rain or wetness sensor could have opened up and cause problems during violent rain storms.

1.6.3. Roof cable

The cable has been sent to you in a coil without twists in it. To keep it that way you need to cut the two white cable ties, and then unroll the cable - instead of just holding the bundle and pulling at one end. If you should ever need to move the cable elsewhere, make sure that you roll it up properly. At one end make a circle 12" (30 cm) in diameter out of one turn of the cable and tape it. Now "roll" this circle of cable down the length of the cable gathering it up.

For those who do not already have a convenient hole through an exterior wall for the cable, drill a 15 or 16 mm (5/8") diameter hole through the wall, making very sure not to drill through any electrical wires or plumbing pipes. To thread the cable, start with the cable inside. Push a straightened-out metal coat hanger with the hook at the outside end, from outside to inside. Tape the rectangular connector and 10 cm (4") of cable to the coat hanger. Pull on the coat hanger. You might need a second person inside to unroll the cable and to make sure that the cable does not snarl. If you are alone, unroll the cable inside first before pulling it through the wall. Note that the end of the cable with the small rectangular connector goes to the sensor head.

If you must use a smaller hole (large enough for the cable itself but without the connector), you can disassemble the rectangular connector using a very small screwdriver and a lot of care. First push the 5 wires into the connector slightly. This disengages the retaining tabs on the clips. Then you depress the retaining tab of the clip for each pin. They are visible in each of the rectangular small holes on the longer side. With the retaining tab depressed you gently pull on the wire and the clip will come out.

Before reassembling the connector you might need to use a small knife to bend each retaining tab upward slightly. The pinout for the rectangular connector is:

Pin Number	Twisted Pair	Wire	Signal
1	1	Red	Data-
2	1	Green	Data+
3	2	Yellow	+24V Power
4	2	Black	Power Return
5		Bare	Shield

Figure 8: Connector pinout.

Figure 9: Sensor head installation example.

Make sure that the power supply is unplugged before the next step. This precaution is necessary in case you accidentally misregister the rectangular connector at the rear of the sensor head, which could damage the sensor head if power is present. Plug the rectangular connector on the cable into the white connector on the bottom end of the sensor head. Strain-relieve the cable below and close to the head. Tie the cable against a flat or convex surface - not the inside of an angle or U channel.

Fasten the cable to the building or post. If you need cable ties, you should be able to find them in the electrical section of a hardware store. Use the black version (which should be labeled UV or sunlight resistant).

Support the cable well enough so that it will not flex in the wind. While the cable is rated to -40°C, it will be stiffer at low temperatures; you do not want to risk cracking the insulation if it is flexed or handled. Put a drip loop into the cable before it enters the building so that water running down the cable cannot run into the hole in the wall.

Bring the cable indoors to near your computer. Plug the sensor head cable into the adaptor box, plug in the power supply, connect the USB cable to the computer, and you are done. Normally the **Cloud Sensor II is left powered on at all times; this is important for keeping the sensor clear of water and ice**.

The adaptor box and power supply are intended to be used at room temperature near your computer. The **power supply is rated for 0°C to 40°C**. The **adaptor box is rated for 0°C to 70°C**. This means that you should avoid operating the power supply in an unheated observatory in very cold winter conditions or in very hot summer conditions.

1.7. Maintenance

Cloud Sensor II is designed to be **low maintenance**. We especially avoided having any moving parts (such as in a conventional anemometer). We built in a bird deterrent, and powerful heater to remove rain, ice, and snow.

In extreme winter conditions, the sensor head could develop a cap of snow beyond the reach of the heater. You would have to brush that off by hand if it happens.

If you get cloudy or very cloudy readings when you know it is clear, inspect the sensor head top end for an obstruction such as a hollowed out snow cap, leaf, or bird droppings.

Over a long period of time the window to the thermopile in the sensor head can accumulate dirt although the rain usually washes it clean. The window is a silicon wafer with coatings on it. Gently clean it as you would clean an optical surface. Blow off any grit with compressed air or a blower bulb first. Unlike an optical lens, the thermopile is hermetically sealed so you do not have to worry about an excess of fluid. Just don't immerse the sensor head.

Allowable cleaning agents are Kodak lens cleaning fluid (distilled water with a little alcohol and mild detergent) and 70% to 100% isopropyl alcohol.

See user's manual for information related with birds, insects, leaves and debris.

Unfortunately, many good mounting locations will also attract lightning.

The Cloud Sensor II has lightning protection in the sensor head and in the adaptor box. These should protect against the surge from nearby lightning hits. They will not protect against a very close or direct hit (nothing simple or inexpensive will). We do not warranty the sensor head against lightning damage, nor damage to your building or other equipment due to lightning that the cable might conduct inside, because it is beyond our control. In high frequency lightning areas an optical isolation device on the USB interface between the adaptor box and the computer is strongly recommended.

If the sensor head is vulnerable, place a properly grounded lightning rod nearby and higher than the sensor head. Also provide a heavy grounding wire from either the sensor head aluminum bracket, or the metal pole you mount the sensor head on, directly down to a ground rod. A few loops in the cable near to the cable entrance to the building will also help keep a direct stroke of lightning out of the building.

2. Annexes

2.1. First setup

First setup, January 2019. (just to check the device works after the reception)

Boltwood II Cloud Sensor
Observatorio de Yebes, January 2019