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Deliverable title	**Documentation associated to the capacity building**
Description	Report on the training provided for each set of local stakeholders responsible for the new sea level measuring equipment. Stakeholder training includes both the maintenance of the equipment as well as the analysis of sea level variability
Work Package number	5
Work Package title	Coastal Resilience and Operational Services Demonstrator
Lead beneficiary	National Oceanography Centre
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Comments	Some capacity-building work is still in progress, so this deliverable report will be updated once all relevant work is complete

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EuroSea

Executive summary

WP5's Coastal Resilience and Operational Services demonstrator aimed to deliver capacity-building work in a developing country (Colombia) to enable local stakeholders to install a state-of-the-art sea level monitoring system independently. In practice, the WP5 team met this objective and has additionally delivered capacity-building work in tide gauge installation in 2 other countries (Spain and Italy), in order to support the longevity of the EuroSea tide gauge systems. As planned, training material was delivered in relation to the maintenance of these systems in all 3 locations. All installation procedures were fully-documented to support the tide gauge operators in case the systems are to be relocated, refurbished or decommissioned at a future data (for example, in the event of port redevelopment works).

Training in the use of quality control software and the OSPAC (Operational Services at the Service of Ports and Cities) tool is planned (but pending) and this deliverable will be updated once that work is complete.

1. Introduction

WP5 aimed to demonstrate an end-to-end solution for sea level observing and forecasting, in what was termed Coastal Resilience and Operational Services demonstrator. Commencing with the design and deployment of innovative prototype sea level monitoring systems by NOC, the collected observations would then be assimilated (alongside downscaled ocean analyses and model forecasts) into a bespoke operational monitoring software tool for coastal ports and cities produced by PdE and Nologin. The software tool, known as OSPAC, (Operational Services at the Service of Ports and Cities), would provide an alert-based monitoring and forecasting system for stakeholders in 3 target locations.

The geographical focus of the Coastal Resilience and Operational Services demonstrator was to be the Mediterranean Sea, in order to address 2 key problems: the first being the vulnerability of the region to sea level extremes, swell waves, seiching, tsunamis and long-term sea level rise and the second being the sparsity of observational systems particularly on the north African Mediterranean coast. The rationale was to trial the demonstrator in Barcelona (Spain) and Taranto (Italy), using one of these prototype tide gauge installations as a training opportunity to upskill stakeholders from a 3rd location (originally Alexandria, Egypt) to install the 3rd tide gauge independently. Due to difficulties in obtaining local permissions in Alexandria, this 3rd location was subsequently changed by grant amendment to Buenaventura, Colombia.

The prototype sea level monitoring systems are designed to be largely maintenance-free, but even so it is advisable to conduct regular, cursory checks to ensure optimal performance and promote their longevity. Consequently, a further planned capacity-building activity was to train local stakeholders in tide gauge maintenance at each location.

An additional grant amendment to the planned work of the Coastal Resilience and Operational Services demonstrator was necessitated by an indefinite strike by staff at the Spanish Consulate in the UK, which meant that NOC engineers could not obtain appropriate work permits to install the tide gauge in Barcelona. Instead, a Spanish company (SIDMAR Estudios y Servicios Oceanográficos S.L.) was appointed to complete the installation under the supervision of NOC engineers. This introduced a further capacity-building requirement to upskill SIDMAR engineers in the installation of the prototype equipment.

The final capacity-building element of WP5 relates to the incorporation of near real-time quality control software within the OSPAC software. Since OSPAC was to provide an alert-based monitoring and forecasting systems, it was essential to incorporate near real time data quality control functionality in order to prevent the occurrence of false alarms. This was to be achieved by incorporating existing quality control software known as SELENE (SEa LEvel NEar-real time quality control processing) into the OSPAC software, whilst also updating it to provide additional functionality. Each set of local stakeholders would then be trained in the use of the automated quality control software as well as in the use of OSPAC itself.

Thus, there are 3 components to the capacity-building work of WP5:

1. Training in tide gauge installation
2. Training in tide gauge maintenance
3. Training in the use of automated quality control software and the OSPAC tool

This deliverable report describes these training elements, collectively, although it should be noted that the 3rd training component is partially incomplete. This is because the tide gauge installations planned for Task 5.1.1 were delayed considerably by multiple factors including the global COVID-19 pandemic, issues relating to the UK departure from the European Union and the conflict in Ukraine. Consequently, new data streams were, until very recently, unavailable for integration within the OSPAC software.

2. Training in tide gauge installation

2.1. Training of SIDMAR and Colombian stakeholders

It was agreed that the training of a Colombian technician (Yosamy Garcia Sanmiguel from Dirección General Marítima, DIMAR) would be most efficiently conducted during the Barcelona tide gauge installation. This was to promote better learning outcomes for the Spanish-speaking Colombian technician by delivering the training in Barcelona, where the prototype tide gauge was almost identical to the system planned for Buenaventura, (whereas the Taranto system was structurally and functionally quite different).

Although, the Spanish tide gauge installation subcontractors (SIDMAR) were experienced in tide gauge installation, they were unfamiliar with the prototype system, so to ensure successful implementation, NOC engineers supplied a tide gauge installation training manual (see Appendices) in advance of the planned installation date. This was a comprehensive and illustrated step-by-step guide that would allow SIDMAR to familiarise themselves with the equipment and the installation procedure. The rationale was that SIDMAR engineers would then be able to proceed with the tide gauge installation whilst NOC engineers could co-ordinate the activity, troubleshoot any problems and upskill Yosamy in preparation for the Buenaventura tide gauge installation.

There were 3 sets of instrumentation in relation to the tide gauge for the Port of Barcelona:

1. The primary tide gauge comprised a solar-powered tide gauge equipped with multiple sea level sensors (2 x radar sensors and 1 Global Navigation Satellite System (GNSS) receiver enabled for Interferometric Reflectometry (GNSS-IR)), a barometer for measuring atmospheric pressure, data logging equipment, solar panels, a battery array and supporting steelwork. This equipment was almost identical to that of the proposed Buenaventura tide gauge, aside from a customisation of the solar panel and electronics cabinet framework, which aimed to maximise solar efficiency in each

location (Figure 1). This primary set of instrumentation was to be installed in Barcelona close to a nautical college (Figure 2)

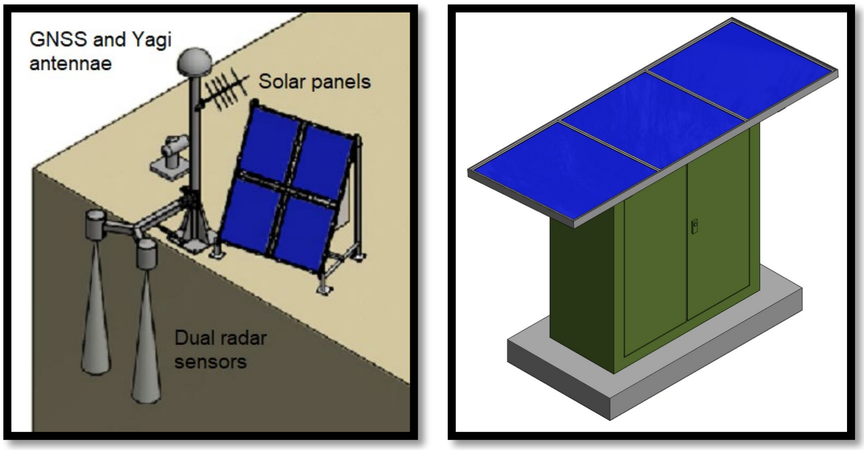


Figure 1. Tide gauge design for Barcelona (left panel) showing the solar panels framework positioned in front of the electronics cabinet. Solar panel framework for Buenaventura (right panel) positioned above the electronics cabinet to maximise solar efficiency. The GNSS, Yagi and radar sensor components are identical at both locations.

2. A low cost GNSS receiver for measuring significant wave height (SWH) via GNSS-IR, with supporting datalogging and data transmission equipment to be installed on a nearby lighthouse (Figure 2).
3. A Previstorm lighting detection system that had already been installed by the suppliers (INGESCO) and which required some slight modifications. The installation site of this was near to the airport, to allow sufficient distance (and therefore advance warning time) of the possibility of lightning strikes in the port.

Figure 2. Primary (nautical college) and secondary (lighthouse) locations of the Barcelona tide gauge equipment

The Barcelona training manual that was designed for SIDMAR engineers therefore included instructions on the installation procedure for all 3 components. An alternative version of the installation manual was developed for Yosamy and his colleagues in DIMAR, which was bespoke to the tide gauge equipment that was planned for Buenaventura. The DIMAR version of the manual was provided in both English and Spanish see Appendices).

The Barcelona tide gauge installation and in-person training took place between 04/04/23 and 07/04/23, with Steve Mack and Barry Martin from NOC co-ordinating the work, José María Cortés Crespo and Roberto Sevilla from SIDMAR implementing the tide gauge station and Yosamy García Sanmiguel from DIMAR undertaking training. Begoña Pérez Gómez (PdE) was also on site for a day to support the capacity-building work.

Days 1 and 2 of Yosamy's one-to-one training focused on the installation of the main steelwork, radar sensors, barometer and the supporting electronics equipment at the primary site (Figure 3).

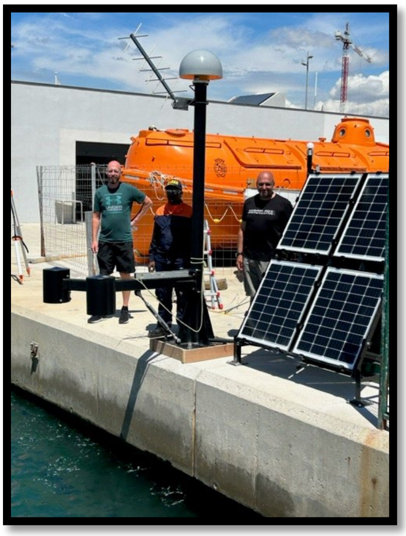


Figure 3. Engineers Barry Martin (NOC), Yosamy Garcia Sanmiguel (DIMAR) and Steve Mack (NOC) alongside the completed instrumentation at the primary Barcelona tide gauge site.

As part of this installation an optical level, tripod and levelling staff were supplied to the installation team, to facilitate the training of Yosamy in the optical levelling of the primary tide gauge site. This was a one-off exercise to be conducted during the initial tide gauge installation and involved measuring the height of a brass-domed benchmark (the tide gauge benchmark or TGBM) that had been installed on the quayside, near to the GNSS mast relative to a brass benchmark fitted to the radar arm of the main tide gauge stanchion. Once these heights are established, the ongoing monitoring of levelling is performed by the GNSS receiver. Since Yosamy would be required to replicate this in Buenaventura, he received one-the-job training to ensure that he developed these skills (Figure 4).

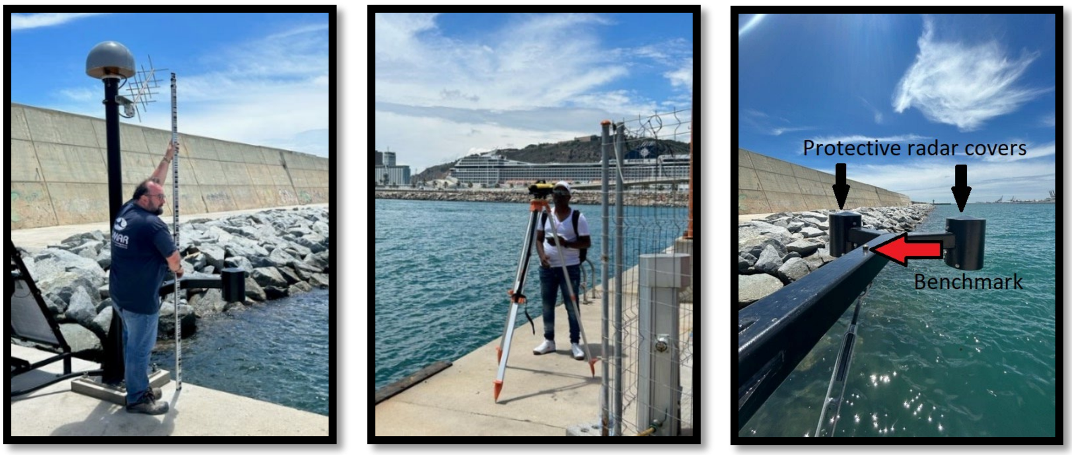


Figure 4. Jose Maria (SIDMAR) holds the levelling staff on the TGBM (left), whilst Yosamy estimates the TGBM height using the optical level (centre). The additional benchmark on the radar arm is shown (right)

Days 3 and 4 of the installation focused on the secondary instrumentation and on training Yosamy in the connection of electronics components and implementation of data flows. The entire procedure was documented in an installation report for distribution to all relevant parties (SIDMAR, PdE, DIMAR and Port of Barcelona). The installation guidance manual and the installation report can be referred to collectively, should the instrumentation need to be moved, refurbished or decommissioned in the future. The installation report is to be submitted under milestone MS24 (installation of documentation, including calibration sheets) and deliverable D5.9 (Operational monitoring systems available at the three sites), but it is also included in the appendices of this document for the sake of completeness.

2.2. Training of Taranto stakeholders

For Taranto, the proposed local operator of the tide gauge (the Euro-Mediterranean Center on Climate Change, CMCC) offered engineering support to assist with NOC's installation of the equipment. Consequently, NOC developed a further tide gauge installation training manual (see appendices) in advance of the planned installation date. Again, this was a comprehensive and illustrated step-by-step guide that would allow CMCC to familiarise themselves with the equipment and the installation procedure. Whilst the solar panel framework and supporting electronics resembled the Barcelona tide gauge closely (Figure 5), the tide gauge instrumentation and steelwork differed significantly.

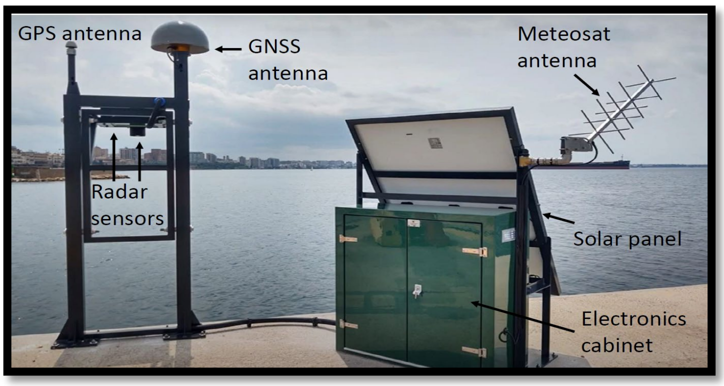


Figure 5. Completed Taranto tide gauge. The electronics cabinetry and solar panel frame are similar to that designed for Barcelona (Figure 1), but the radar instrumentation differed and required an alternative design for the supporting framework

In this case, local stakeholders had a strong interest in wave monitoring, so alongside a conventional water level radar sensor, a specialist wave-monitoring MIROS radar sensor had been incorporated into the design. In addition to water level height, this sensor would monitor the following wave parameters:

- Hm0 (significant wave height (m))
- Hmax (maximum wave height (m))
- Tm02 (mean zero up-crossing period (s))
- Tp (primary wave peak period (s))

This MIROS sensor was intended to collect wave data at the coast, whilst a Global Navigation Satellite System (GNSS) receiver enabled for wave monitoring via Interferometric Reflectometry (GNSS-IR) would acquire wave information across a wider nearshore area.

The tide gauge installation and in-person training took place in Taranto between 26/06/23 and 29/06/23. Leading the installation team from NOC were engineers Geoff Hargreaves and Barry Martin, whilst engineering support from CMCC was provided by Juan Francisco Martinez Osuna and Daniele Piazzolla.

As Juan and Daniele already had technical expertise, the training component was largely focused upon demonstrating the installation methodology and then implementing this as described in the training manual. The mechanical functionality of the bespoke 'A' frame (supporting the radar and GNSS sensors) was a key focus of the training work as the frame was designed to pivot from a normal operational mode (with sensors deployed over the sea surface) to a maintenance mode (with the sensors positioned over the quayside).

One deviation from the prescribed implementation methodology involved the repositioning of the Yagi antenna as it was noticed that, if aligned correctly and attached to the 'A' frame in its intended position, it might provide a source of interference with the Trimble Alloy GNSS receiver. Therefore, the Yagi antenna was instead attached to the solar panel frame with a stainless steel and brass coupling.

Daniele and Juan were also familiarised with the electronic components of the installation and an initial levelling exercise was also completed. The entire installation procedure was documented in an installation report, which can be used alongside the installation guidance manual if the tide gauge is to be moved, refurbished or decommissioned in the future. The installation report is to be submitted under milestone MS24 (installation of documentation, including calibration sheets) and deliverable D5.9 (Operational monitoring systems available at the three sites), but it is also included in the appendices to this document for the sake of completeness.

3. Training in tide gauge maintenance

These prototype tide gauges are designed to be largely maintenance free, but it is advisable nevertheless to conduct regular, cursory checks to ensure optimal performance and promote their longevity. Consequently, a further planned capacity-building activity was to train local stakeholders in tide gauge maintenance at each location. If time permits, such training can sometimes be completed during the installation process, but this was constrained by the limited availability of the local stakeholders. Therefore, the NOC produced a bespoke tide gauge maintenance manual for each EuroSea tide gauge, detailing the frequency and nature of the required checks. These are attached in the Appendices to this document.

4. Training in the use of automated quality control software and the OSPAC tool

4.1. Automated quality control software

As part of Task 5.2.3 OSPAC software development, Nologin was tasked with embedding the existing SELENE automated near real time quality control software within the OSPAC software, whilst also incorporating additional functionality. This additionality functionality included the incorporation of sea level trends from the GNSS-IR technique at each location and their use in datum control of the primary sea level measurement technology. On other words, these additional data streams would improve the early detection of datum shifts, spikes and other important data features.

Since the data streams associated with this deliverable were delayed considerably, the functionality could not be implemented in a live environment until the tide gauge installations were completed. These did not occur until April 2023 (Barcelona) and June 2023 (Taranto), whilst the Buenaventura installation is currently pending. So as not to lose momentum entirely, the new functionality was tested using the GNSS-IR technique on an existing location for which it was known to work (the REDMAR tide gauge at Barcelona). This allowed some development of the SELENE routines to take place in OSPAC, prior to completion of the tide gauge installations.

It is currently envisaged that there are 2 possible means of delivering the training in relation to the updated SELENE software:

1) Training can be conducted when the finalised version of the SELENE software is available (estimated for October 2023)
2) Training can be conducted using the present version of SELENE software, with subsequent updates documented and included within Github (see https://puertos-del-estado-medio-fisico.github.io/SELENE/).

4.2. OSPAC tool

The OSPAC tool has been implemented at the first of the three pilot sites (Barcelona) during a launch event that was held in Barcelona on 27th March 2023. During this event, specific training was given on sea level variability and its applications including:

- Visualization of total sea level in near-real time data.
- Visualization of forecasts of total sea level, as well as the tidal and storm surge components.
- Implications of sea level processes (especially the co-occurrence of waves and storm surges) for coastal flooding in the harbour and city of Barcelona, and how OSPAC can mitigate their impact (via the issuing of alerts.

In the fortnight following this launch event, more than 30 new users were registered for the OSPAC system. Further launch sessions will be held in respect of the Taranto and Buenaventura pilot sites, once the tool is operational for those locations and this deliverable will be updated accordingly. Please note that the functionality of the OSPAC tool is fully documented in a user manual, as described in deliverable D5.5 (final version of the software running operationally for the demonstration). User feedback and description of the demonstration will be provided in Deliverable D5.10 (Final report describing the demonstration and user feedback at European Sites) due to Month 45 of the project. Consequently, only a cursory mention of the capacity-building work in relation to the OSPAC tool is provided in this report.

Conclusion

The capacity-building element of this work package has been significant and has expanded beyond that which was envisaged originally. Face-to-face training in tide gauge installation was originally only intended to be provided to stakeholders from Alexandria and it was envisaged that this would necessitate the provision of one English language installation training manual (for Alexandria) and 3 tide gauge maintenance manuals (one for each locations). However, difficulties in obtaining work permits for NOC engineers in Spain resulted in the appointment of a subcontractor (SIDMAR), whose engineers also require familiarisation with the NOC's tide gauge technology. Consequently, technology training manuals and in-person training were also provided to the subcontractor SIDMAR. This was then replicated in Taranto and written installation training materials were also supplied to Colombian partners in 2 languages (English and Spanish).

Bespoke tide gauge maintenance manuals have also been supplied to all local stakeholders and will also be provided to Ocean Best Practices for their consideration.

The training element relating to the use of OSPAC is partially complete and described in deliverables D5.5[1] and D5.10[2]. Training in automated quality control software is planned but incomplete and this deliverable report will be updated in this respect in due course.

[1] https://doi.org/10.3289/eurosea_d5.5
[2] https://doi.org/10.3289/eurosea_d5.10

Appendices

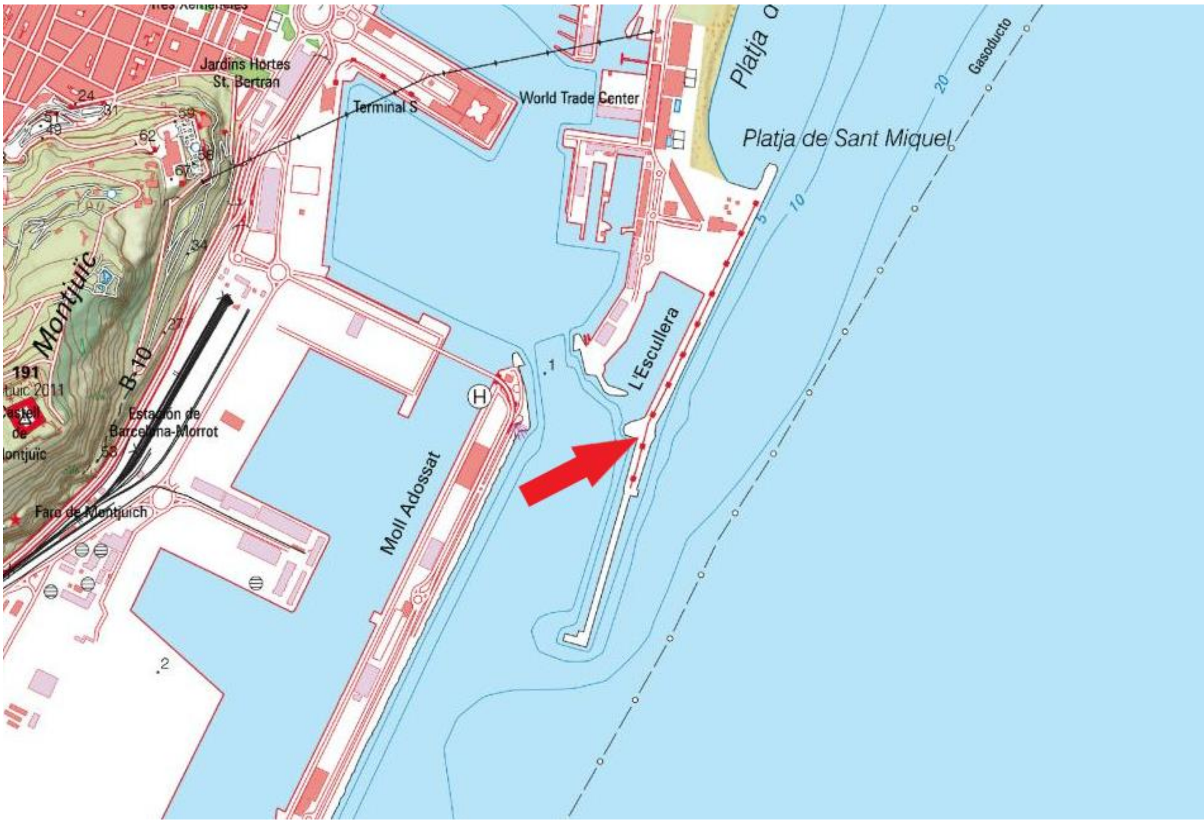
Tide gauge installation training manuals

The tide gauge installation training manuals provide step-by-step instructions to local stakeholders about how to install the EuroSea tide gauges. A bespoke manual is provided for each of the three tide gauges. (NB. Colombian editions are supplied in both English and Spanish versions):

- EuroSea Barcelona Tide Gauge Installation
- EuroSea Taranto Tide Gauge Installation
- EuroSea Colombia Tide Gauge Installation – English
- EuroSea Colombia Tide Gauge Installation – Spanish

EuroSea
Tide Gauge Installation Manual

Port of Barcelona



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EUROSEA Barcelona Tide Gauge Installation Instructions

The equipment for EUROSEA consists of:

- A steel Global Navigation Satellite System antenna monument, plus a steel arm extension for mounting dual radar water level sensors.
- A steel frame construction for mounting 4 solar panels to provide power to the system.
- A large fibreglass cabinet containing electronic equipment for logging data from the radar sensors and GNSS antenna.
- A small fibreglass cabinet containing GNSS logging equipment for mounting inside the lighthouse at the harbour entrance.
- A small GNSS antenna for mounting above the lighthouse.

1. Description

The tide gauge consists of dual radars co-located with a high specification GNSS system. The GNSS antenna attaches onto the same mast as the radars so that once the gauge is levelled; the GNSS can act as a correction for any subsequent shift in the radar data.

The tide gauge operates from batteries that are charged using renewable energy. A bank of six 38Ah batteries charge from an array of four 80W solar panels.

The GNSS mast specification causes it to behave as a monument. This should help to minimise movement in the structure that could affect both radar and GNSS signals, causing erroneous readings.

The solar panels and equipment cabinet are mounted onto a firm concrete base. The solar panels are oriented south to maximise solar collecting potential. Setting the solar panel elevation angle for optimum operation during the winter months of December and January, maximises the solar gathering potential for when there is the least amount of sunlight available, during the shorter winter days.

The system has a Meteosat transmitter and antenna, as well as 4G communication for data recovery.

2. Location

The tide gauge will be installed near to the Facultat de Nàutica de Barcelona, circled in red.

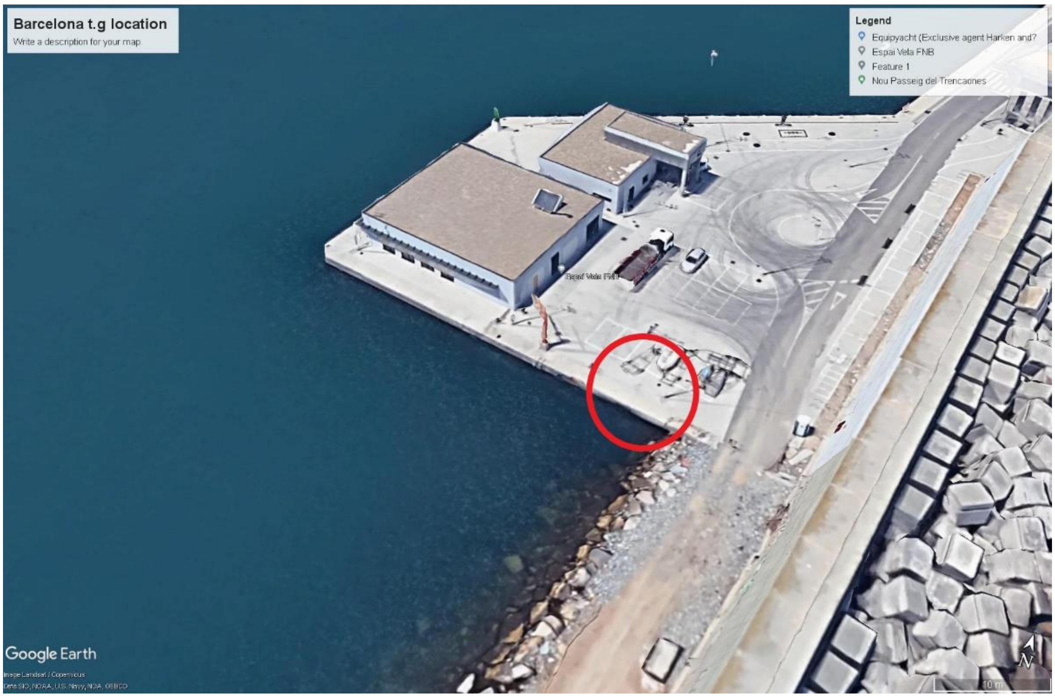


Figure 1 Installation location.

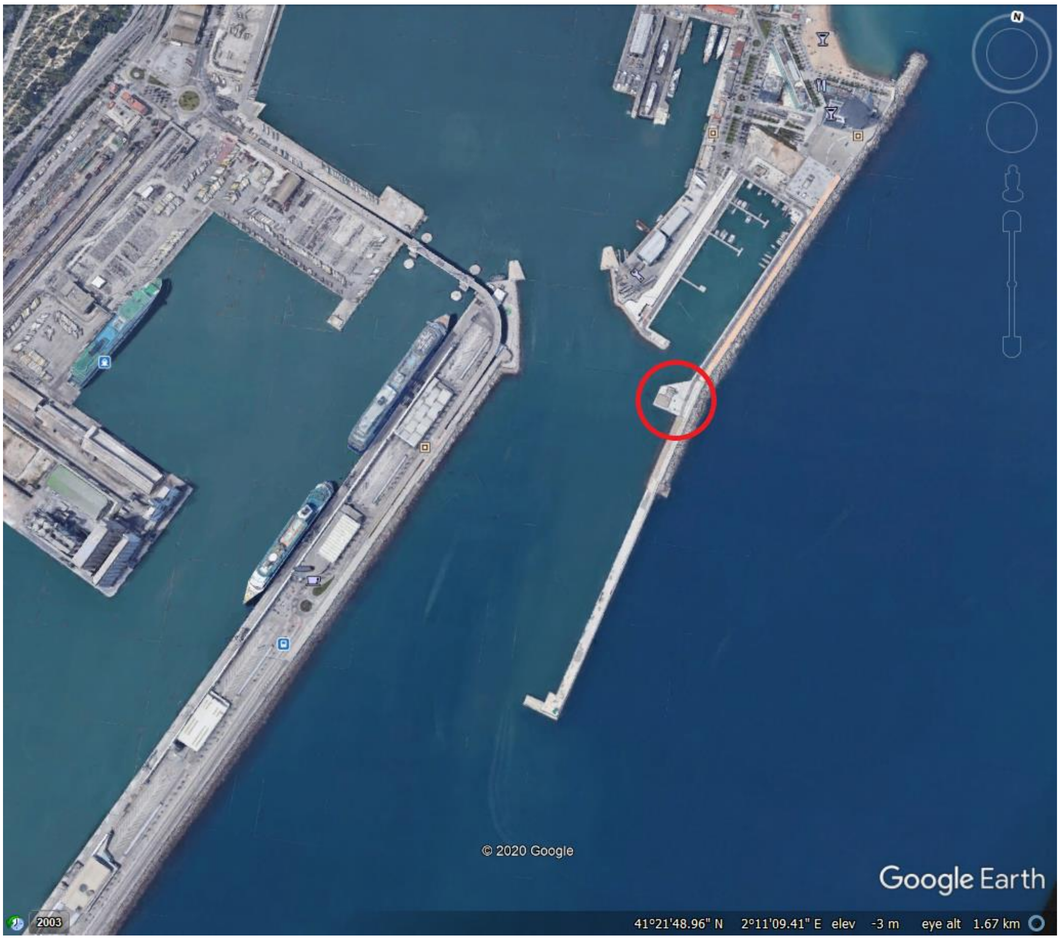


Figure 2 Harbour entrance.


Figure 3 Location of solar panels


Figure 4 Quayside for installation

The solar panel frame will be installed close to the end of the fencing, facing outwards towards the harbour. The equipment cabinet will be installed behind the solar panels (like in Figure 5). The GNSS monument must be installed on the right-hand side of the solar panel frame, looking seaward. This is to allow space for the radar arm to swing without hindrance. In addition to the GNSS antenna, a Yagi Meteosat antenna will be mounted on the mast.

The photographs below show a similar installation at Alfred Dock on the River Mersey in United Kingdom.

Figure 5 Photo showing the solar panel frame, equipment cabinet and Yagi antenna at Alfred Dock.

The following photographs show the GNSS monument and radar arm assembly. The radar arm is designed to swing to allow maintenance on the sensors and for ease of installation.

Figure 6 Radar arm swung inwards at Alfred Dock. Barcelona radar arm will swing inshore from the right side.

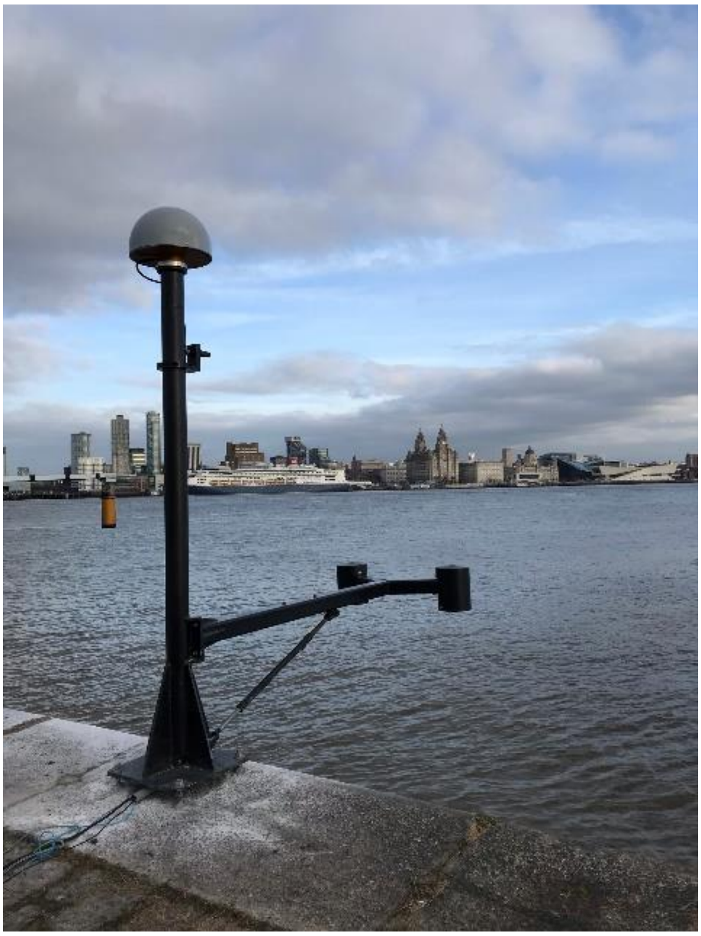


Figure 7 Radar arm in the outwards position.

In addition to the main GNSS tide gauge installation mentioned above, there will also be a small low cost GNSS system installed on the lighthouse at the harbour entrance.

Figure 8 Lighthouse at harbour entrance.

The antenna will be mounted above the light onto the tubular rail.

Figure 9 Rail where antenna will be mounted.

Figure 10 Radar antenna and mounting bracket.

3. Installation

The main installation will comprise of securing the solar panel frame, equipment cabinet and GNSS mast to the quayside. This will require drilling holes into the quayside concrete using an SDS type mains powered drill. Drill bits have been shipped out for this purpose. The drill (including an SDS chuck adapter) and power supply for it will need to be sourced locally.

Assemble the solar panel frame (all fasteners will be in-situ), including installing the Trimble GPS antenna and place it in the final installation location, near to the fencing. Mark out the footprint of the frame on the quayside, allowing some room for access if necessary. Be mindful of the requirements of the naval college when installing the steelwork to ensure they are not impacted by the installation.

The GNSS mast will be placed to the right of the solar panel frame. It will be placed approximately 0.5m – 1m away. The maximum limit on the spatial separation is determined by the antenna cables: 5m for the Yagi antenna and 7m for the GNSS antenna cable, which includes the antenna mast height of about 2.4m.

a. GNSS Mast

Mark out the location of the base of the GNSS mast and drill four 25mm holes to a depth of 200mm. Clear the dust from the holes using the blower device provided. Ensure the holes are drilled perfectly vertical.

Before installing the GNSS mast, read Section 3b on installing the GNSS antenna.

Move the GNSS mast into position and raise off the ground using pieces of wood from the shipping crates. The rope used for lashing the contents of the crate can be used to steady the mast. Pass the 300mm long, M24 galvanised studding through the base plate of the GNSS mast and check for alignment within the holes, so that they are vertical. Remove the studding, clear any dust from the holes and quarter fill with epoxy acrylate resin using the supplied applicator gun.

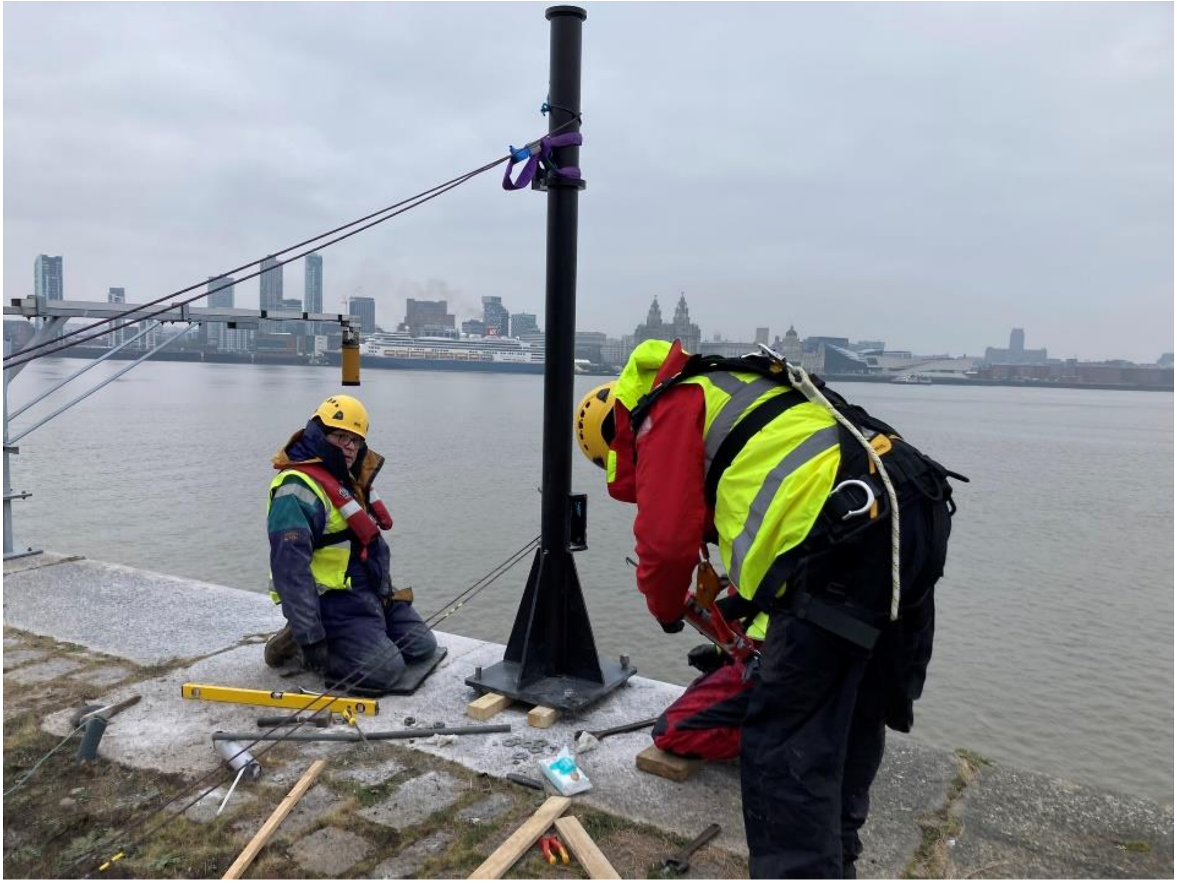


Figure 11 Installing bolts for GNSS mast.

Figure 12 GNSS mast anchor bolts.

Pass the 300mm long, M24 galvanised studding through the base plate of the GNSS mast, attaching a nut and washer below the bottom of the plate before it enters the hole and screw the rod into the hole, keeping the nut and washer just below the base plate. The galvanised studding can be wound into the hole by affixing two nuts to the top and locking them together (Figure 12).

Wind each stud down into the resin until it reaches the bottom of the hole by displacing the resin up to the top (Figure 12).

Loosely fit the top nut/washers to each stud and once the resin has hardened, adjust the bottom nuts until the mast is perfectly vertical (Figure 14).

Fit the cable conduit into the mast between the quayside and base of the mast, ensuring there is a pull-through piece of rope inside. Ensure the conduit bends slightly up inside the mast to just above the base level and is visible through the access hole. Secure the top nuts to prevent movement and check again for vertical alignment.

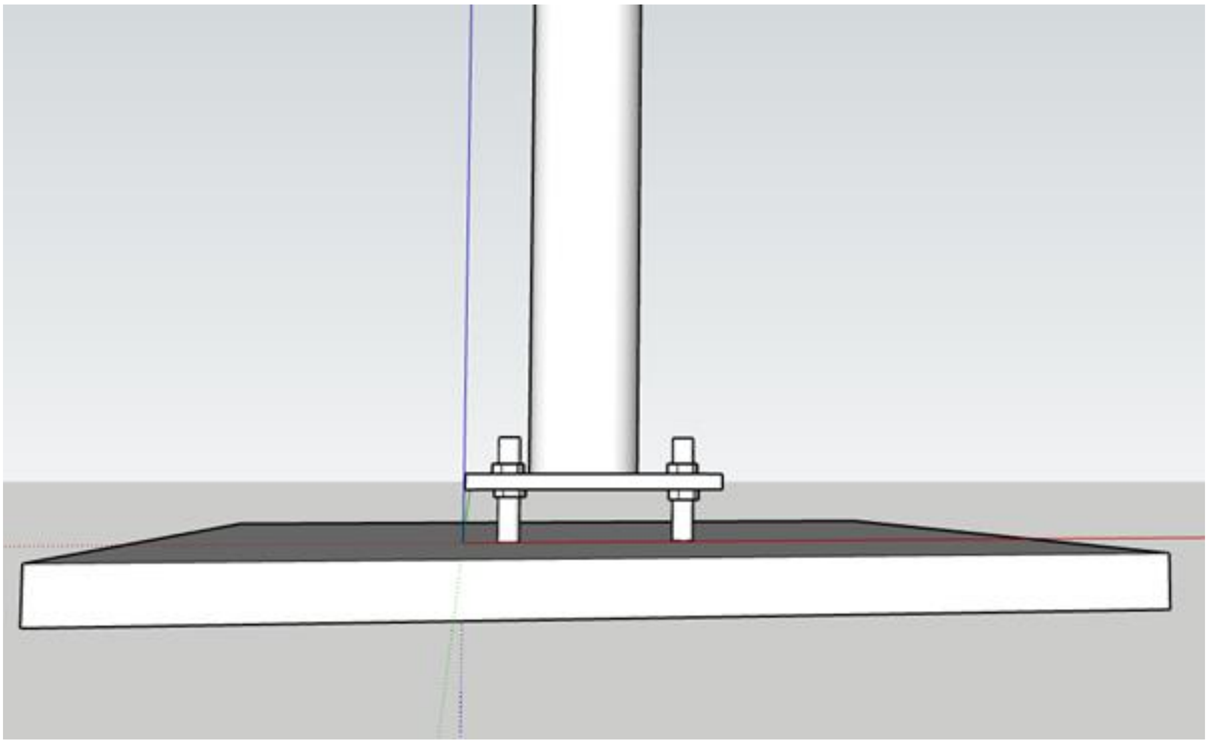


Figure 13 Installation of the GNSS mast to get perfectly vertical.

Figure 14 Levelling the GNSS mast with conduit in place.

b. GNSS antenna

The GNSS antenna can be fitted at this stage, or it can be fitted before the mast is erected. Once the mast is installed, a ladder or platform is required to fit the antenna on top of the monument. **It is easier to install the antenna onto the mast before it is lifted into position, but care must then be exercised to prevent damage to the antenna during installation of the mast.**

To install the antenna, locate the mounting stud and screw this fully into the antenna. Install the radome onto the antenna. Carefully offer the antenna up to the mast and gently rotate the antenna to fit the threaded stud into the top of the mast. It is probably easier if two people do this operation.

c. Solar panel frame and equipment cabinet

Secure the solar panel frame in place using the anchor bolts supplied. Depending upon access restrictions, it may be necessary to install the solar panels before securing the frame in place. The solar panels are held in place by adjustable clamps that are attached to the frame and are adjusted using a bolt (see Figure 22).

Position the green equipment cabinet in position and drill four fixing holes to secure it in place. Mark the location of the cabinet on the quayside, then remove it and apply a bead of frame sealant to the quayside such that the cabinet will sit on it once repositioned. To aid positioning of the cabinet, use wooden blocks to support the cabinet as it is moved into place, before lowering onto the bead of sealant. Fasten the cabinet to the quayside using the anchor bolts. A further bead of sealant may be placed around the exterior of the cabinet.

Run the conduit from the GNSS mast towards the cabinet and cut to size. Install conduit from the cabinet to the solar panel frame so that water ingress is prevented.

The cabinet is pre-drilled with two access points for conduit. Two conduit glands need installing into the cabinet. The larger diameter conduit will go to the GNSS mast and the other one to the solar panel frame.

Figure 15 Cable glands for conduit.

d. <u>Radar sensors</u>

Mount the radar arm onto the GNSS mast using the supplied bolts. Ensure the arm is swung inland and supported so that it is level whilst doing this (Figure 17). Use a spirit level to ensure the arm is level.

Install the radar sensors into the mounting clamps (Figure 16), and attach onto the radar arm, routing the cables from the sensor through the arm. Feed these cables into the main upright section of the mast and pull them through the conduit into the green cabinet. If the radar arm is level (check this using a spirit level), the bubble level on each radar sensor should be centred. Adjust as necessary until the radar arm and radar sensors are both level in all directions (Figure 17 and Figure 18).

Figure 16 Radar sensor attached to mounting clamp.

It is important that the radar sensor mounting plates are level when the radar arm is also level, since this will ensure that the radar beam travels vertically to the sea surface. Once deployed, the radar arm level will be checked.

Figure 17 Installing the radar sensors.

Figure 18 Radar sensor showing bubble level and adjustment screws.

e. Coaxial Cables

The GNSS antenna cable can now also be pulled through the conduit. Coaxial cables can be easily damaged when pulling them through conduit. Ensure the cable does not become kinked or twisted.

The GNSS cable will pass through the centre of the mast and emerge through the slot at the top, near to the antenna. Connect the cable to the antenna. The other end of the cable is fed into the green cabinet.

Assemble the Yagi antenna (the antenna elements and locations they fit into are numbered) and attach it to the antenna clamp (Figure 19).

Figure 19 Yagi antenna assembled.

Fit the clamp to the GNSS mast. Feed the Yagi antenna cable inside the GNSS mast and through the conduit so it enters the green cabinet. Connect the cable to the antenna.

Align the antenna according to Figure 20

- Elevation 42.1°
- Azimuth 182.1° Magnetic

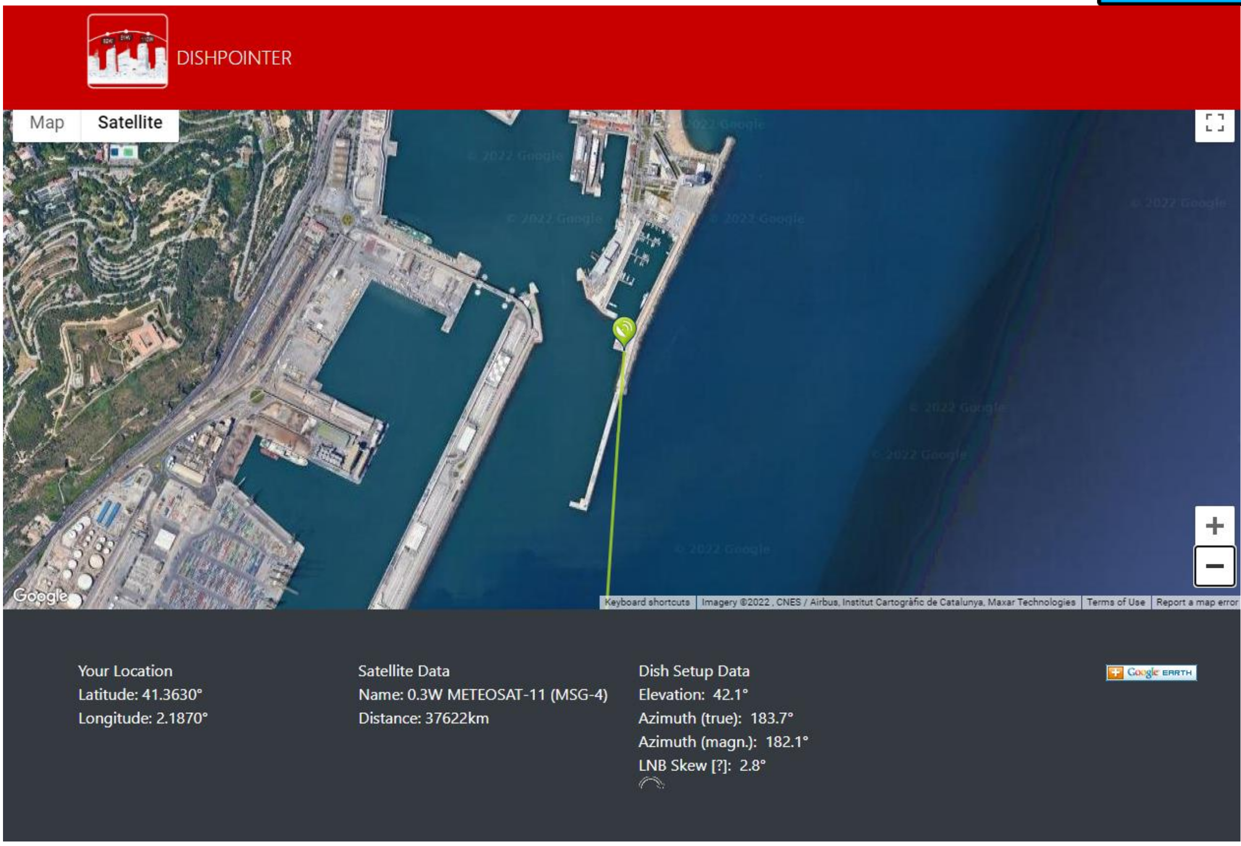


Figure 20 Meteosat antenna alignment.

f. <u>Solar Panels</u>

Connect the solar panels as two arrays in series, as shown in Figure 21. It doesn't matter whether the panels are connected in series horizontally or vertically (Figure 22). Feed the solar panel cables through conduit and into the green cabinet. Feed the Trimble GPS antenna cable into the green cabinet.

g. <u>Conduit</u>

To prevent water entering the green cabinet via the conduits, cables that are exposed to the elements must enter the conduit via a "swan neck loop". This is a loop created in the cable before it enters the conduit, where the lower level of the loop is below the entry level of the conduit. This will allow rainwater to run down the outside of the cable and drip from the lowest part of the loop before it enters the conduit. This also applies to cables entering the GNSS mast.

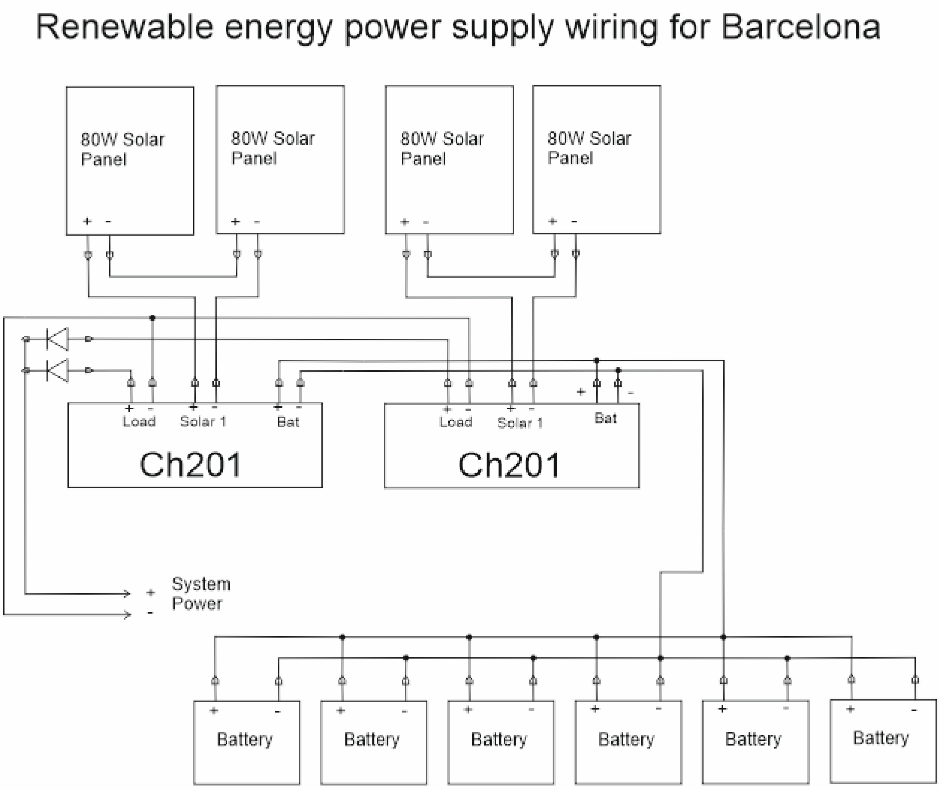


Figure 21 Solar panels and batteries.

Figure 22 Solar panel array.

h. Cables

Cables from the GNSS monument and solar panel frame are run through conduit to provide protection. Instrumentation connectivity has been kept as simple as possible and consists of routing cables through conduit and attaching it to connectors.

The radar sensors are shipped with cabling consisting of a yellow M12 connector at the radar end to a 3-wire unterminated end. This will require passing through cable glands and connecting to the terminal block inside the enclosure.

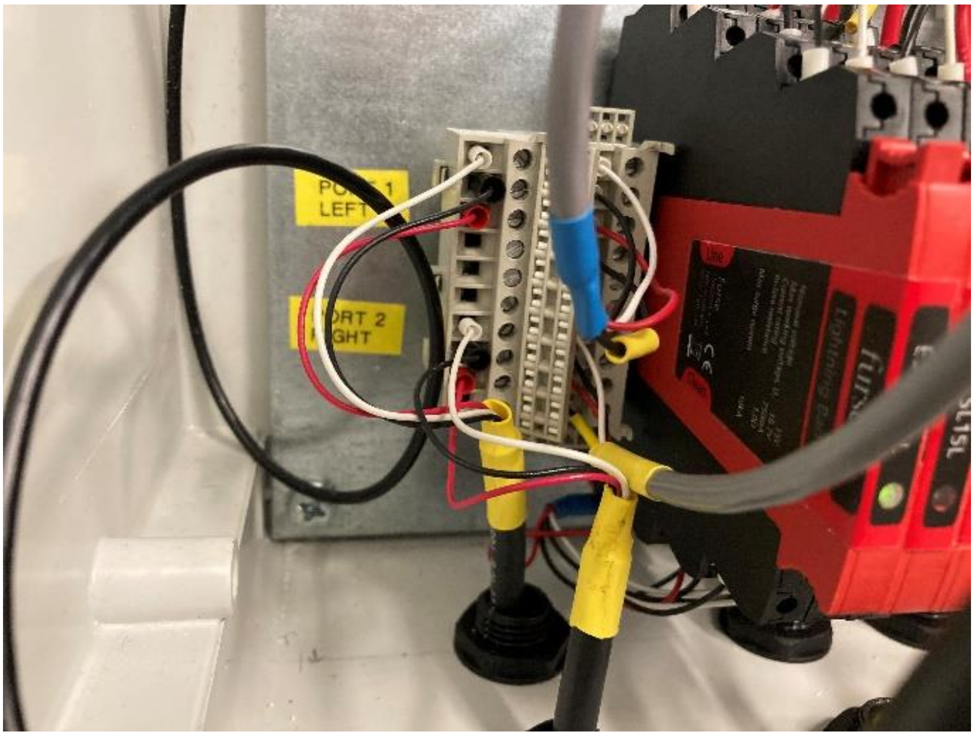


Figure 23 Radar sensor junction block.

The radar cables are connected to the matching colour on the junction block.

Red is +Ve

Black is -Ve

White is SDI-12 data.

When connecting the radar sensors to the terminal block, make a note of which radar sensor (left or right, when looking out towards the sea) is connected to which SDI-12 port. Ideally, the left-hand sensor should be connected to Port 1 (top) and the right-hand sensor connected to Port 2 (bottom) as in Figure 23.

The Yagi antenna cable is connected to the silver connector in Figure 24 after removing the ‘dummy load’ device. Do not confuse the Yagi antenna cable with the GNSS antenna cable. The Yagi antenna cable is more flexible than the GNSS one, even though it is the same size. The GNSS cable is labelled with LMR-400-DB along its length.

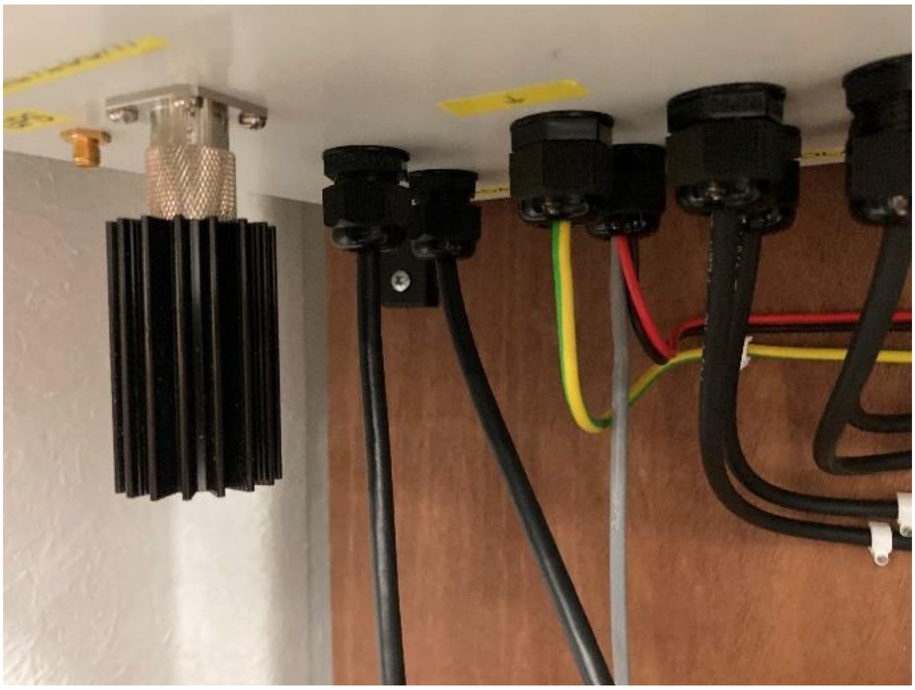


Figure 24 Meteosat Yagi antenna connector and radar cables.

The solar panel leads will be connected to the tail leads shown in Figure 25 during the commissioning of the tide gauge. **Do not connect them now.** Label the leads (array1, array2, etc.) to prevent mixing them up during commissioning.

Figure 25 Solar panel connector

The Trimble GPS antenna is connected to the gold coloured SMA connector adjacent to the Yagi antenna N type connector (Figure 24) on the left-hand cabinet (Figure 33).

The GNSS antenna cable is connected to the surge protector on the GNSS enclosure (Figure 26), right-hand cabinet (Figure 33).

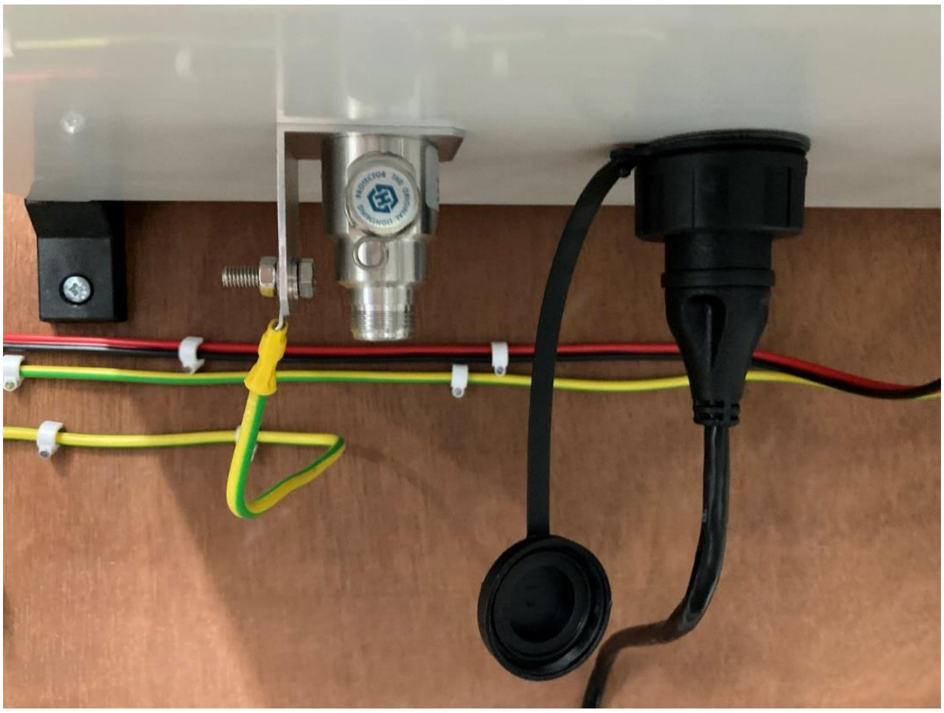


Figure 26 GNSS surge protector.

i. **Batteries**

Place the six lead crystal batteries inside the green cabinet. Using the supplied battery interconnection leads, wire the batteries in parallel (Figure 27). Locate the power leads for both enclosures and remove the blade fuses (Figure 28), noting the fuse rating for each enclosure. Connect the power leads, red to +ve and black to -ve. The power leads should be connected across the entire battery bank and not just one battery. This will ensure battery charging is performed optimally.

CAUTION: Care must be exercised when connecting the batteries to prevent shorting of the terminals. Shorting the battery terminals will cause a large current to flow, potentially creating sparks and could damage the battery.

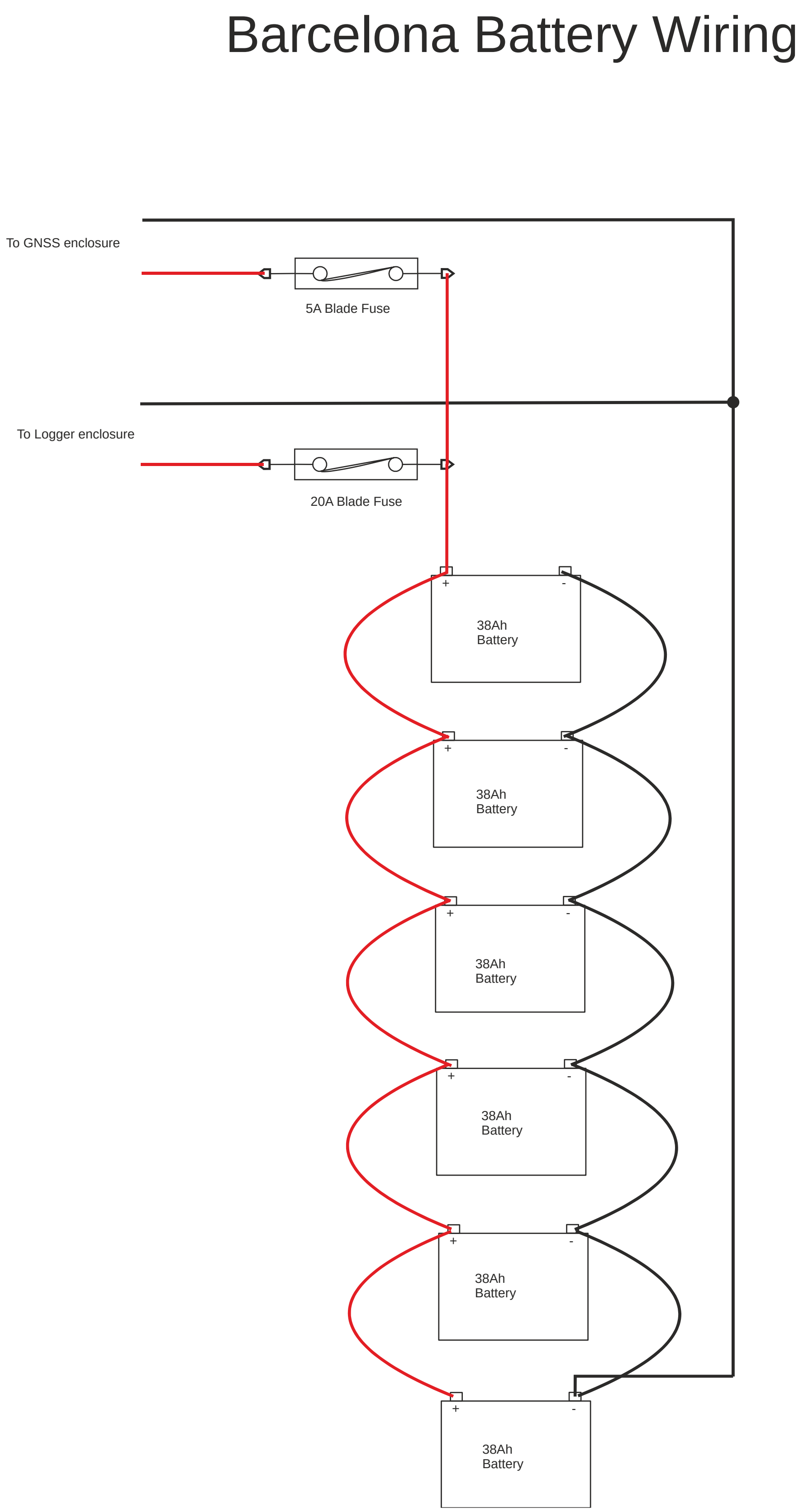


Figure 27 Battery connections.

Figure 28 Battery bank blade fuses.

j. Testing and commisioning the tide gauge

Open all of the fused circuit breakers inside both equipment enclosures.

Figure 29 Logger enclosure fuses in open position.

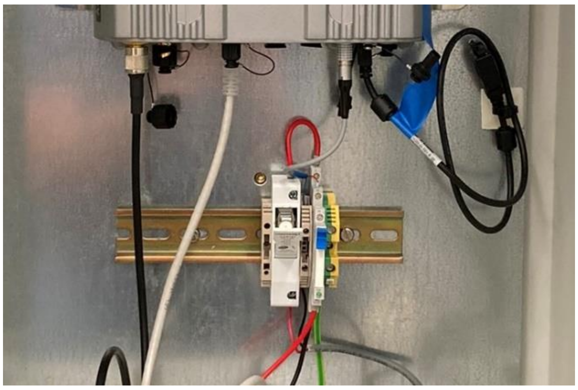


Figure 30 GNSS enclosure fuse in open position.

Connect the solar panel cables to the tail end connectors (Figure 25). Take care not to mix up the positive and negative solar panel leads from different arrays.

Insert the blade fuses back into the holders, ensuring the correct rated fuse is used. Refer to Figure 27 for reference.

Close fuses S1 and S2. This will apply the solar panel power output to the CH201 charge controller (

Figure 31 Solar charge controllers.). The CHG LED should start flashing green if the solar panels are producing enough energy to charge the batteries (Figure 32). The CH201 is fitted with a small silver switch to isolate power to the load. Ensure this is set to the ON position on both units.

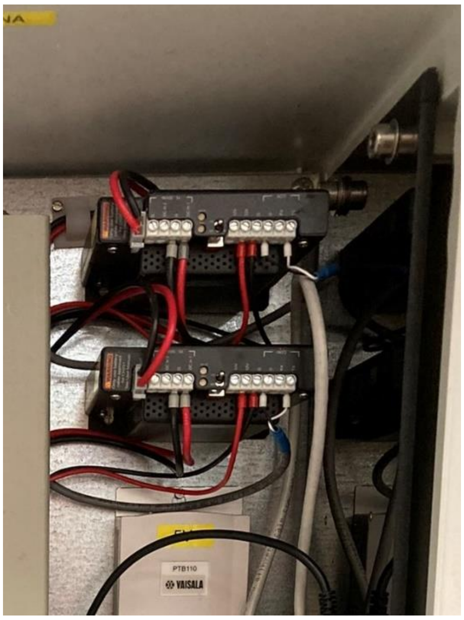


Figure 31 Solar charge controllers.

Table 7-7: CHG LED

Condition	Color/state
No valid charge source	Off
Valid charge source and charging battery	Flashing green
Valid charge source but battery discharging	Flashing orange
Regulator fault detected	Flashing red
Waiting for new operating system (Downloading an operating system (p. 31))	Solid red
Transferring operating system	Solid green

Table 7-8: CK BAT LED

Condition	Color/state
Battery voltage > 11.5 V	Off
10.5 V ≤ battery voltage ≤ 11.5 V	Flashing orange
Battery fault detected OR battery voltage < 10.5 V	Flashing red

Figure 32 CH201 LED status.

Close fuse PWR to power up the tide gauge. The system will now power up and begin operating.

Close the fuse in the GNSS enclosure to power up the Trimble GNSS system. The display will illuminate and the receiver should begin finding satellites and display this number on the screen.

Figure 33 Equipment cabinet.

The radar sensors will power up and a number will eventually be displayed on the LCD display corresponding to the distance from the sensor to the surface below it, either the quayside if the radar arm is swung landward or the sea surface in normal operation. Check this is working OK, and the number displayed looks reasonable.

Using a DVM, if available, measure and record the solar panel and battery voltages on the terminal block, located on the right-hand side of the enclosure (Figure 34), taking care not to short the terminals.

The data being logged by the Satlink3 logger can be checked by downloading the LinkComm app from Apple App store or Google Play store for smartphones, or for a laptop by visiting https://www.otthydromet.com/en/Ott/p-sutron-linkcomm-software/LINKCOMM

The Satlink3 has built-in Wi-Fi. To connect, press the silver button and a blue light will flash. Search for the Wi-Fi hotspot created and connect to it. Open the LinkComm app and connect to the logger. If using the laptop software, ensure Station Wi-fi is selected as the connection type. Laptops can also connect using a micro-USB cable. In this case, select USB as the connection type.

The data being logged by the Satlink3 can now be viewed.

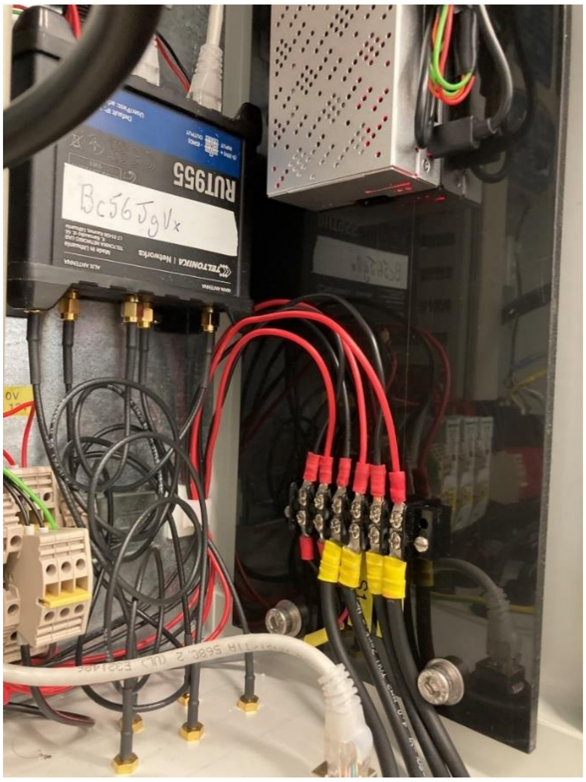


Figure 34 Battery and solar terminal block.

4. Finalising the installation

Install the radar sensor protective covers (Figure 35).

Figure 35 Radar protective cover.

Attach the turnbuckle to the radar arm and secure in place. Once the extended length of the turnbuckle is known, the seaward end of the threaded rod can be wrapped in Denzo tape to protect against corrosion. This may require temporarily swinging the arm seaward to determine the extension length required.

Swing the radar arm outwards so it extends over the sea. Fit securing bolts to the radar arm hinge point. Attach the landward end of the turnbuckle to the anchoring point.

Check the radar arm to ensure it is level when extended out over the sea. If the radar arm and sensors were levelled properly in section 3d, the radar sensors should be level once the radar arm is level. This can be checked by swinging the arm inland and checking the levels again.

Adjust the turnbuckle to get the arm level, then fasten up the bolts securing the radar arm hinge to the GNSS mast.

Check the level of the arm again and if OK, tighten the turnbuckle and wrap the threaded rod of the turnbuckle in Denzo tape.

Check the operation of the installation, especially all the cables running from the GNSS mast to the green cabinet. If everything is OK, proceed onto apply the Fosroc cementitious grout to the base of the mast.

5. Cementitious Grout

To add extra stability to the GNSS mast installation, a cementitious grout is poured beneath the mast base.

A casting mould has been shipped out and needs to be placed around the base of the monument. Seal the base of the mould to the quayside using silicon sealant and allow to set.

Mix up the Fosroc grout in the tub supplied using the mixing paddle to the right consistency. The grout is quite runny as it needs to flow beneath the base of the monument to provide support.

Pour the grout in so that it fills the mould up to the bottom of the base of the GNSS mast (Figure 36). Ensure that the grout level does not overflow into the conduit inside the mast.

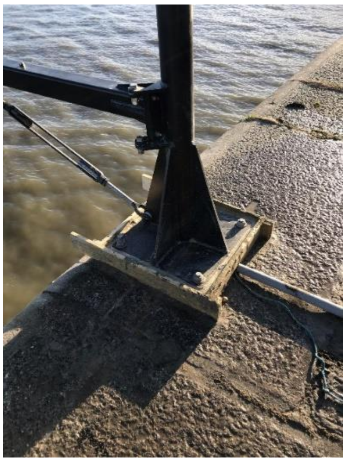


Figure 36 Mould filled with cementitious grout.

Figure 37 Finished installation with grout base.

Leave the grout to set and harden. Remove the wooden mould and clean the area.

6. Surveying

A brass domed benchmark (supplied) should be installed on the quayside, near to the monument for survey levelling purposes.

The height difference measurement between the quayside benchmark and the radar arm benchmark must be recorded. A survey level, staff and tripod have been shipped out for this purpose.

A benchmark is established near to the lighthouse (**Error! Reference source not found.**) at the harbour entrance. A survey should be undertaken between this benchmark and the tide gauge benchmark to establish a value for this newly installed benchmark, referencing existing survey data (Figure 39). The existing benchmark was surveyed using GNSS techniques to the geoid.

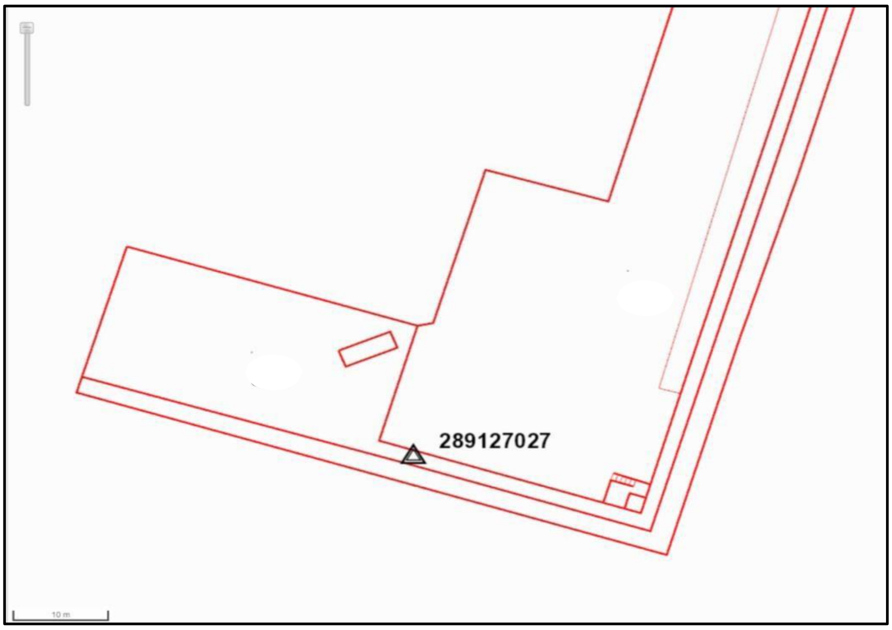


Figure 38 Harbour benchmark location.

Port de Barcelona — FITXA DE VÈRTEX TOPOGRÀFIC

Informació general

Codi:	289127027
Ubicació:	Port de Barcelona
Data d'última revisió:	Maig 2017
Xarxa:	Xarxa Topogràfica APB (3a rev.)

Descripció:

Clau d'anivellació ICC tipus INSTN1, d'acer inoxidable amb la cabota formada per un tronc de piràmide de 4cm de diàmetre superior i 3cm de diàmetre inferior, situat damunt d' un mur emergent.

Coordenades

Sistema de referència:	ETRS89		
Projecció:	UTM Fus 31	Hemisferi N	
X Projectada (X):	431831.600 m	σ:	0.003 m
Y Projectada (Y):	4578801.900 m	σ:	0.004 m
Factor d'escala (K):	0.99965719		
Longitud (λ):	2° 11' 6.11202" E	σ:	0.00013"
Latitud (ϕ):	41° 21' 28.21139" N	σ:	0.00013"
Cota ortomètrica (H):	5.020 m	σ:	0.007 m
Model de geoide:	EGM08D595	N:	48.991 m
Cota el·lipsoïdal (h):	54.011 m	σ:	0.007 m

Fotografia

Figure 39 Harbour benchmark survey information.

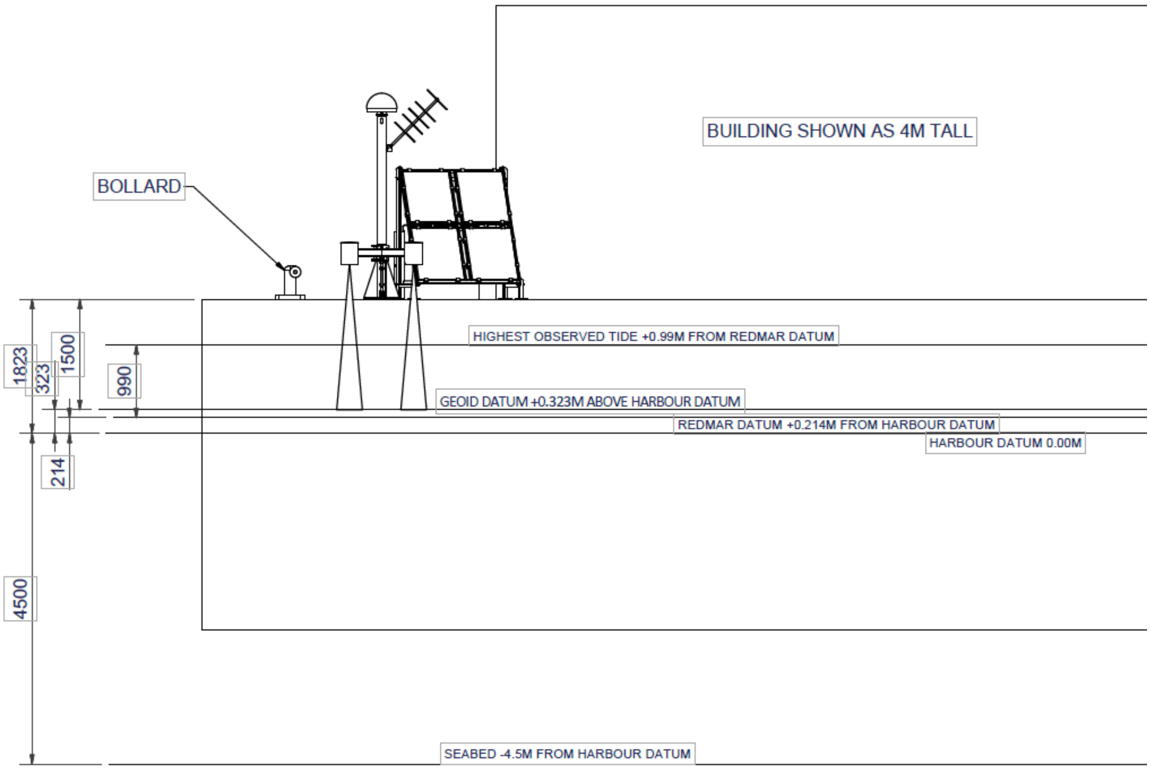


Figure 40 Sea level datums for Barcelona.

7. Low Cost GNSS

A low cost GNSS system will be installed on the lighthouse (Figure 8) to perform GNSS-IR wave measurements. The antenna (Figure 10) is to be mounted onto the rail above the lamp (Figure 9). The cable must be routed such that it does not block the lamp output.

The best route for running the cable must be determined during installation, but it is anticipated it will run along the top rail and drop down one of the metal beads (Figure 9) that separates the glass panes of the lighthouse. The cable will be secured using cable ties, sticky pads, and silicon sealant.

At floor level of the light room, the cable will follow the contour of the building until it reaches the point opposite the cable duct that provides access to the lighthouse interior (Figure 41).

Figure 41 Lighthouse cable access point.

At this point, the cable will pass through a yellow rubber cable protector placed on the floor and travel up to the access point (Figure 42).

The line in red indicates a possible route for the cable and the yellow indicates the position of the rubber cable guard.

Care should be taken to secure the antenna cable as best as possible to prevent a trip hazard from forming.

Figure 42 Rubber cable protector.

The cable will run through existing trunking (Figure 43) until it reaches one of the enclosures identified in the photograph (Figure 44). These enclosures are no longer required and will be removed by the port electrician in preparation for the GNSS enclosure to be installed.

Figure 43 Trunking carrying cables from light platform.

Figure 44 Existing equipment enclosures that will be removed.

The GNSS enclosure is smaller than the existing enclosures and therefore will be mounted onto a black backplate and then attached to the rails.

The GNSS system will be powered from the existing battery array that powers the warning light.

Figure 45 Low cost GNSS.

Figure 46 Lighthouse battery bank.

The low cost GNSS will be connected to the existing battery bank via the power cable shown in Figure 47. The cable incorporates a blade fuse sited close to the battery terminals.

Figure 47 Low cost GNSS items.

8. **Previstorm Lightning Detector**

Visit the location of the Previstorm lightning detector (ask permission from the port) and swap out the Ingesco supplied 4G modem with our Teltonika RUT955 modem. Arrange for Ingesco to collect their modem.

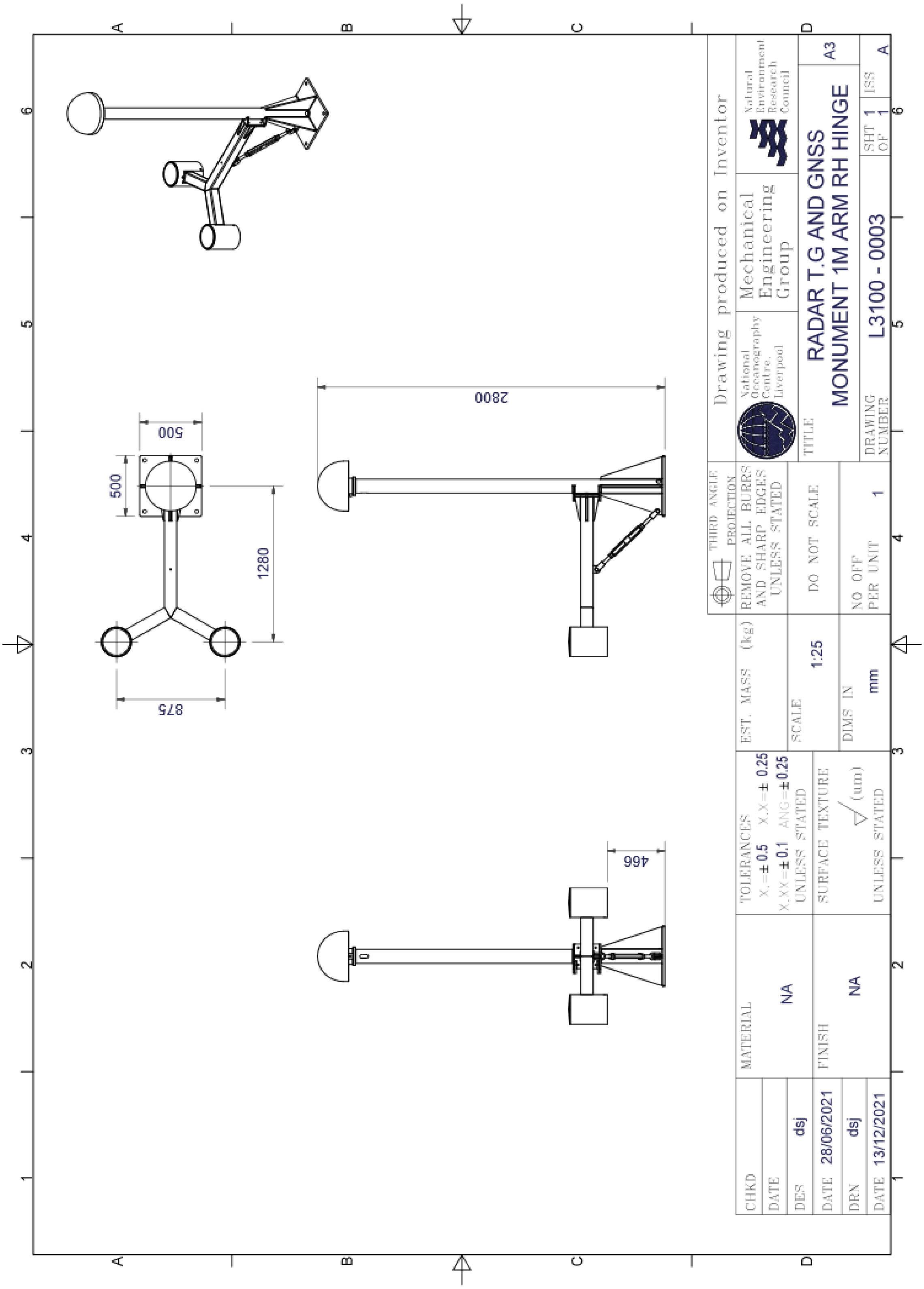
Figure 48 4G Modem RUT955 for lightning detector.

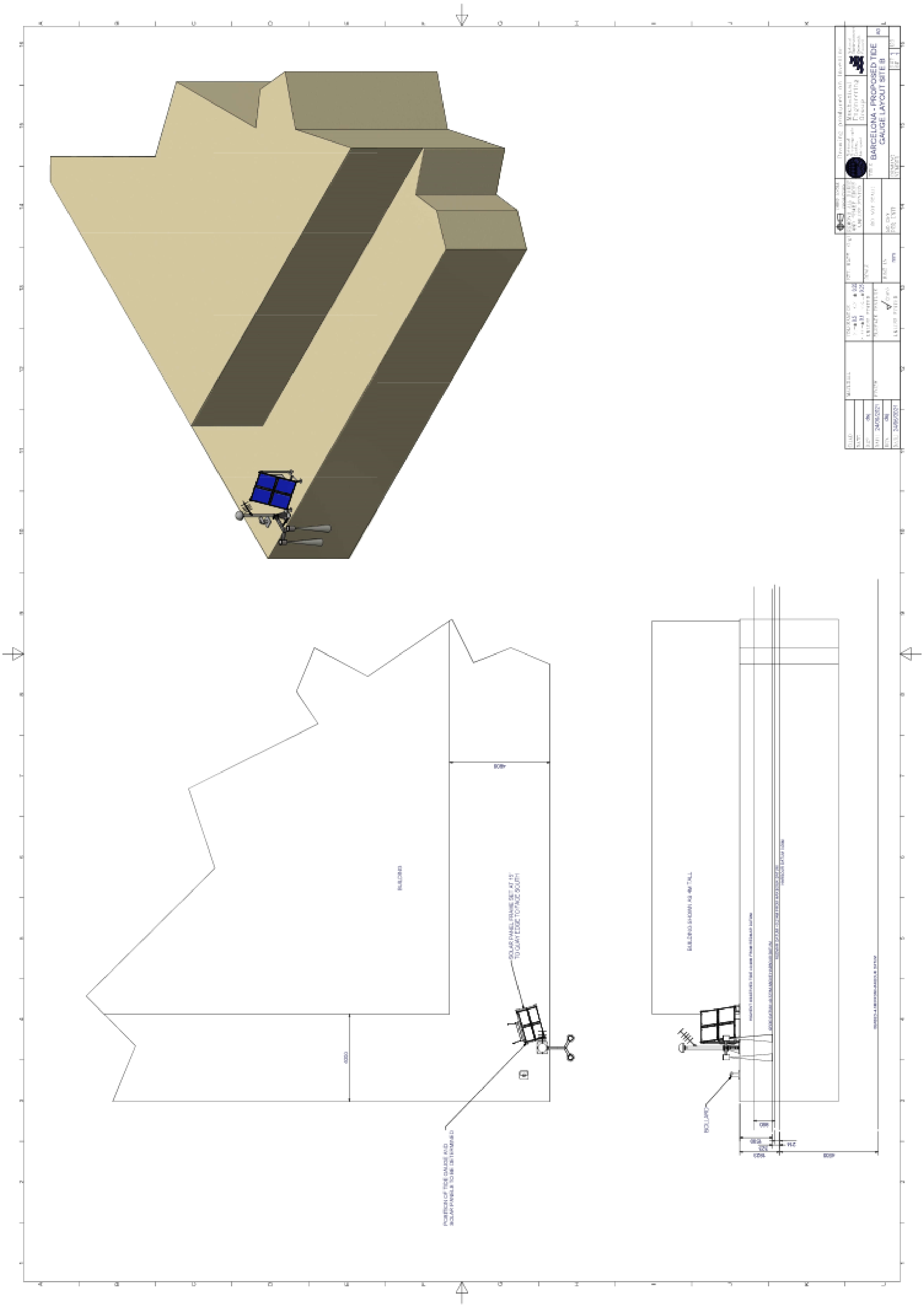
9. **Final checks**

Before leaving the tide gauge site after installation is finished, complete the following checks:

- Ensure the system is powered up correctly using the procedure described in this document.
- Use LinkComm to check for data being logged by the Satlink3.
- Contact Begoña Pérez Gómez at Puertos del Estado (bego@puerto.es), to check for data arriving onto OSPAC.
- Check the IOC website for data transmitted via satellite being published on their website. http://www.ioc-sealevelmonitoring.org/station.php?code=barc2
- Login to the Trimble GNSS (see APPENDIX 2) and check that data is being logged. If not, enable logging or request Simon Williams to remotely access the system and enable it.

APPENDIX 1 – MECHANICAL DESIGN




BARCELONA - PROPOSED TIDE
GAUGE LAYOUT SITE B

APPENDIX 2 – LOGIN INFORMATION

Tide Gauge RUT955
IP Address: 192.168.1.1
Username: admin
Password: EuroSBarca22
Wi-Fi SSID: RUT955_259A
Wi-Fi Password: Bc56JgVx

Tide Gauge Raspberry Pi
IP Address: 192.168.1.246
Username: pi
Password: EuroSBarca22
Anydesk number: 465 580 702
Password: EuroSBarca22

Lo-cost GNSS EMLID
IP Address: 192.168.1.116
Username: reach
Password: emlidreach

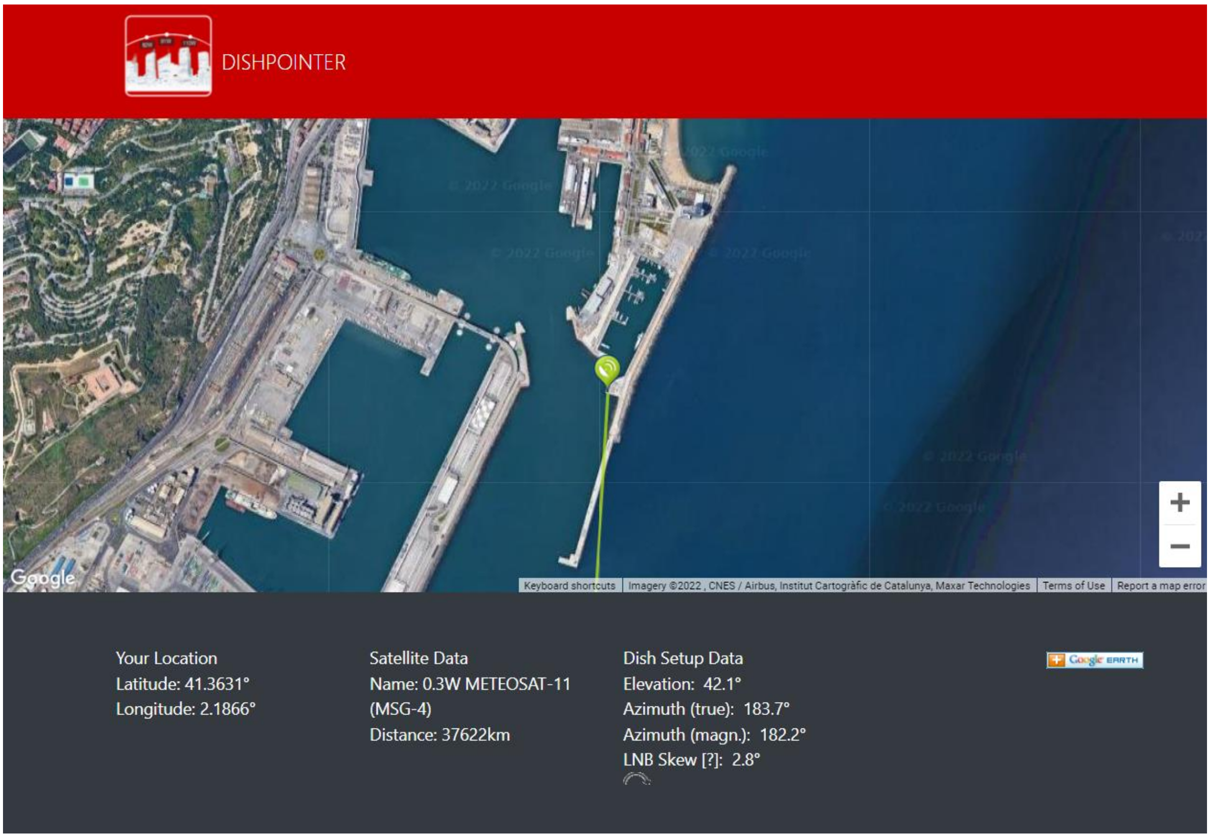
Previstorm RUT955
IP Address: 192.168.1.1
Username: admin
Password:
Wi-Fi SSID: RUT955_
Wi-Fi Password:

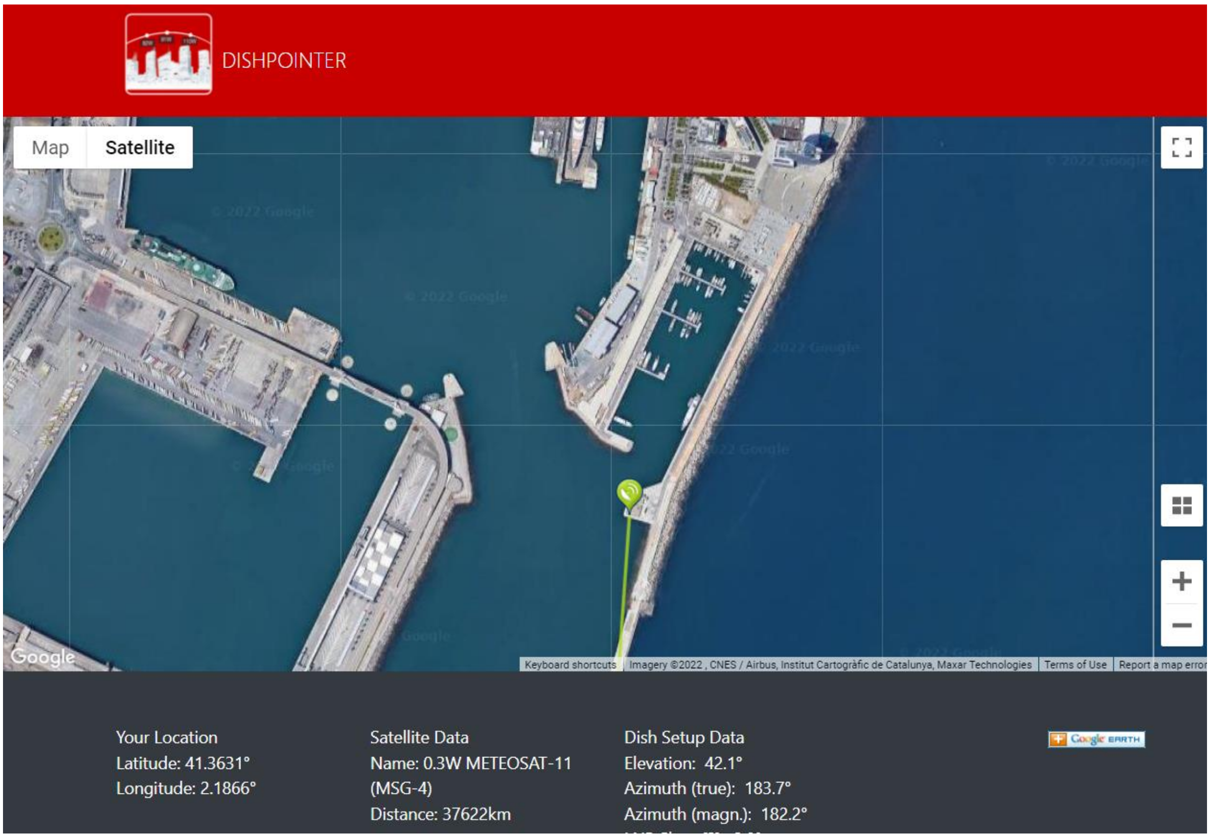
Trimble Alloy:
IP Address: 192.168.1.70
Username: admin
Password: 6050r40076!
Wi-Fi Access Point SSID: 6050R40076
Wi-Fi Password:

Lo-cost GNSS RUT955
IP Address: 192.168.1.1
Username: admin
Password: EuroSBarca22
Wi-Fi SSID: RUT955_F360
Wi-Fi Password: Rr5g3TWk

Lo-cost GNSS Raspberry Pi
IP Address: 192.168.1.244
Username: pi
Password: EuroSBarca22
Anydesk number: 519 768 864
Password: EuroSBarca22

APPENDIX 3 - SATELLITE TRANSMISSIONS





APPENDIX 4 – MATERIAL SAFETY DATA SHEETS

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EuroSea
Tide Gauge Installation Manual

Port of Taranto

Geoff Hargreaves
National Oceanography Centre

EUROSEA Taranto Tide Gauge Installation Instructions

The equipment for EUROSEA consists of:

- An aluminium A frame with mounting points for GNSS, GPS and Meteosat Yagi antennas.
- An aluminium right angle swinging frame for mounting the Nile and Miros radar sensors.
- A freestanding steel frame construction for mounting a 400W solar panel to provide power to the system.
- A large fibreglass cabinet containing electronic equipment for logging data from the radar sensors and GNSS antenna.

1. Description

The tide gauge consists of dual radars, from different suppliers, using different technologies, co-located with a high specification GNSS system. The GNSS antenna attaches onto the same mast as the radars so that once the gauge is levelled; the GNSS can act as a correction for any subsequent shift in the radar data.

The tide gauge operates from sealed lead acid batteries that are charged using renewable energy. A bank of eight 38Ah batteries are charged from a single 400W solar panel.

The A frame acts as a monument to provide a solid mounting point for the GNSS antenna. This should help to minimise movement in the structure that could affect both radar and GNSS signals, causing erroneous readings.

The solar panels and equipment cabinet are mounted onto the concrete quayside. The solar panels are oriented south to maximise solar collecting potential. The solar panel elevation angle is optimised for operation during the winter months of December and January. This maximises the solar gathering potential, during the shorter winter days, when there is the least amount of sunlight available.

The system has a Meteosat transmitter and antenna, as well as 4G mobile communication for data recovery.

2. Location

The tide gauge will be installed in the Port of Taranto, indicated by the red arrow in Figure 1, Figure 2 and Figure 3.

Figure 1 Taranto. Tide gauge location indicated by red arrow.

Figure 2 Tide gauge location.

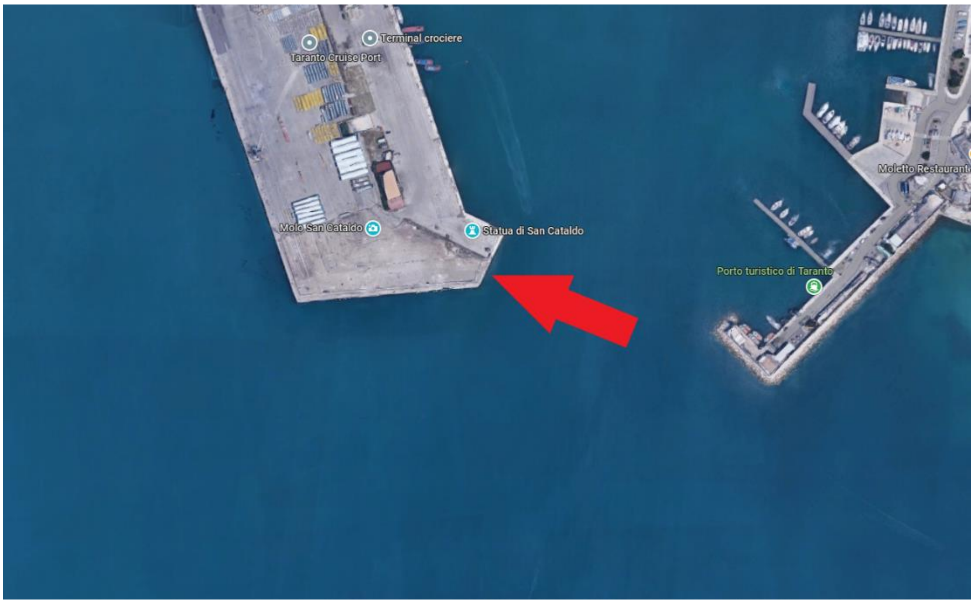


Figure 3 Tide gauge location in Port of Taranto.

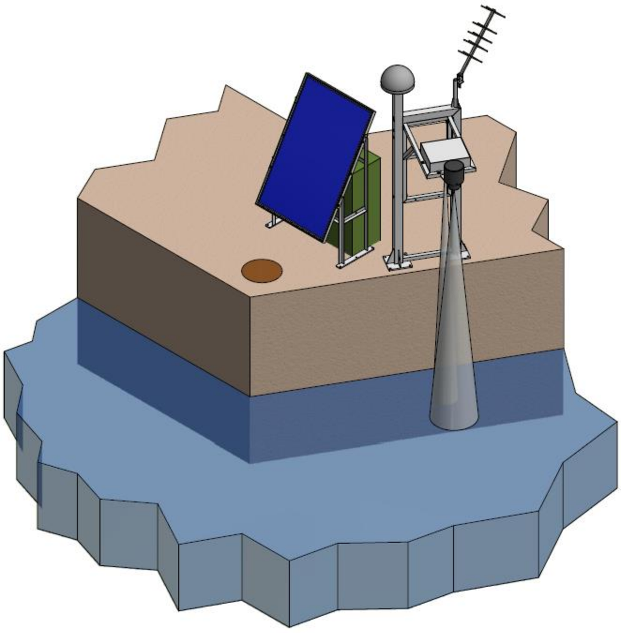


Figure 4 Proposed layout of installation.

The proposed installation layout is shown in Figure 4, but this will need confirming at the time of installation. There is a degree of flexibility in the siting of the installation on the designated quayside. Local factors need considering when choosing the location to ensure the installation will not become obstructed (solar panels are shaded from the sunlight) or damaged (radar arm is hit ships berthing alongside or mooring ropes).

The solar panel frame will be installed close to the quay edge, facing south, looking outwards towards the harbour. The equipment cabinet will be installed behind the solar panel frame.

The installation of the solar panel frame and the radar mounting A frame/swing arm assembly, should be undertaken to prevent the frame from casting a shadow on the solar panel during the day. This could be done by arranging he installation as in Figure 5 or by placing the solar panel and cabinet further back from the radar arm.

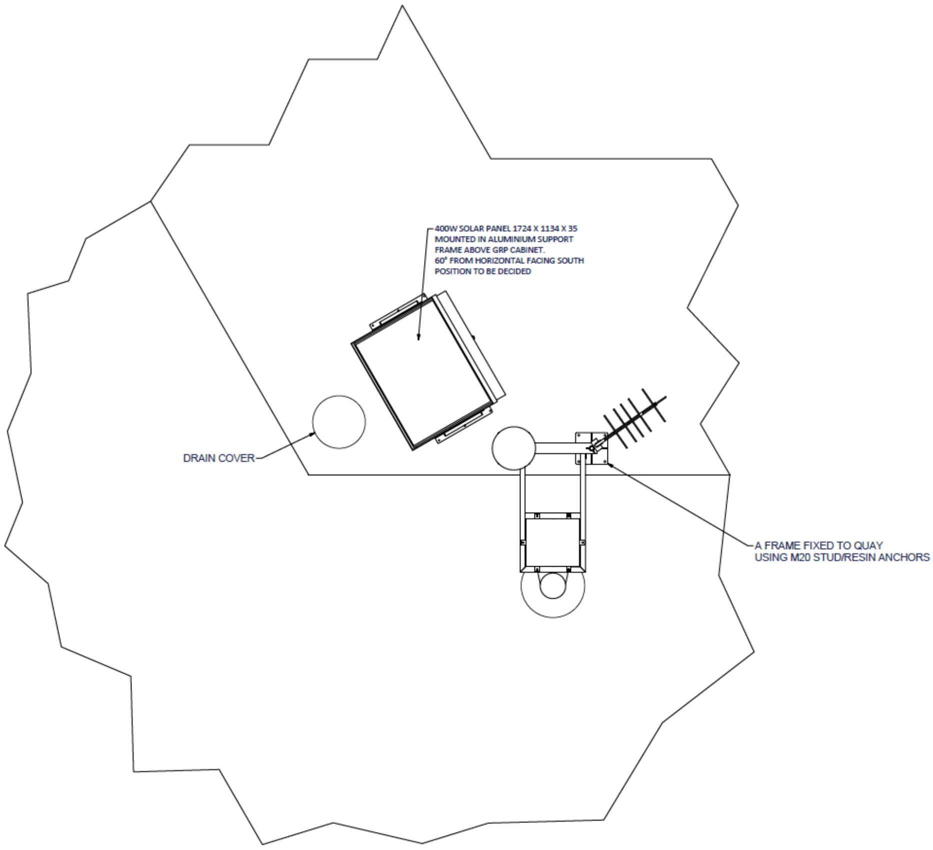


Figure 5 Suggested installation arrangement.

3. <u>Installation</u>

The main installation will comprise of securing the solar panel frame, equipment cabinet and GNSS A frame to the quayside. This will require drilling holes into the quayside concrete using an SDS type mains powered drill. Drill bits have been shipped out for this purpose. **An SDS drill and power supply for it will need to be sourced locally through a hire arrangement or by borrowing from the port. Acquiring a cordless drill driver will also be useful to facilitate opening of the shipping crate.**

Assemble the solar panel frame (all fasteners will be in-situ and the solar panel is pre-fitted in the frame), and place it in the final installation location, near to the quay edge. Mark out the footprint of the frame on the quayside, allowing some room for access to the solar panel.

The GNSS A frame will ideally be placed to the left of the solar panel frame, as in Figure 4. It will be placed as close as possible. The maximum limit on spatial separation is about 12m which is determined by the length of the shortest cables: 15m for the Yagi antenna and 15m for the Miros radar cable. The cables need routing inside the A frame for about 3m.

a. GNSS A Frame

Mark out the location of the base of the GNSS A frame and drill eight 20mm holes, deep enough to accommodate the M20 anchor bolt fixings. Clear the dust from the holes using the blower device provided. Ensure the holes are drilled perfectly vertical.

Before installing the GNSS A frame, read Section 3b on installing the GNSS antenna.

Place a bed of acrylate resin on the quayside beneath where the frame foot will stand and put some into the drill holes to help bond the anchor bolts.

Move the GNSS A frame into position and fix to the quayside with the anchor bolts. Tighten the bolts in turn uniformly, checking for vertical alignment. Tighten bolts as necessary to ensure the structure is perfectly vertical, checking with a spirit level. The bed of resin will provide support beneath the foot plates of the upright stanchions and allow some adjustment to correct for small alignment issues.

The alignment operation must be completed quickly before the resin hardens, preventing further adjustment.

Ensure the frame uprights are vertical and the horizontal section is level before leaving the resin to set.

Locate the A frame swinging radar arm (Figure 6) and associated fixings. The radar arm pivots about the point indicated by the red arrow. The pivoting action is to assist in the installation and maintenance of the sensors.

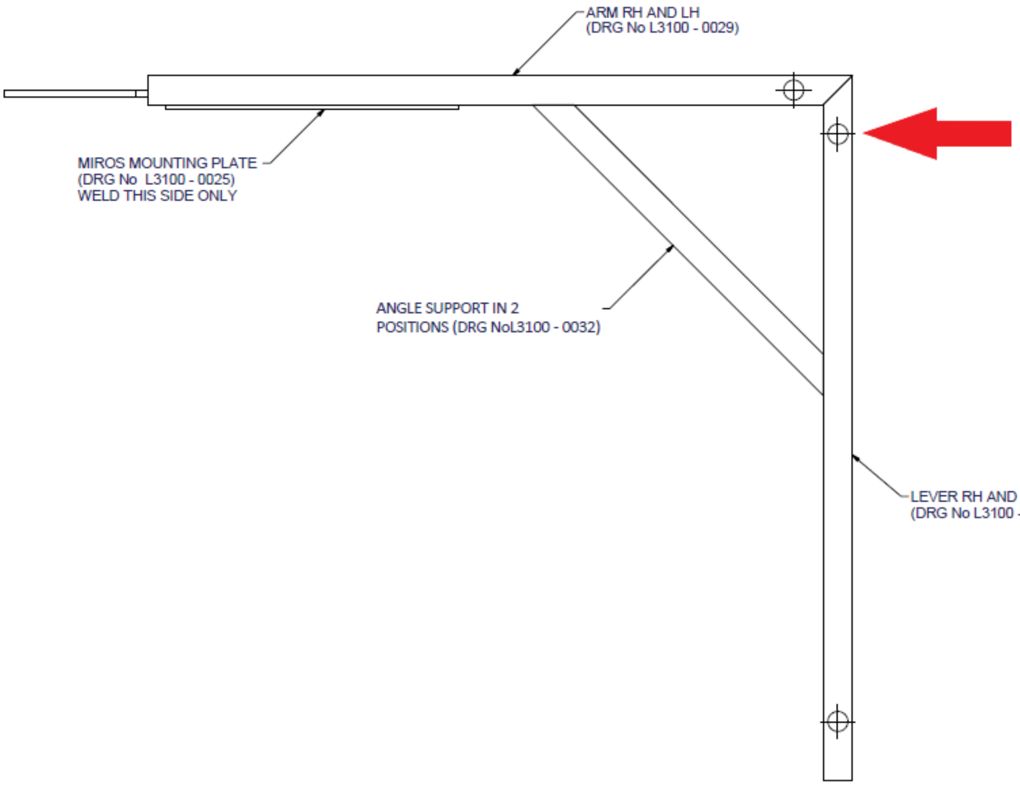


Figure 6 A frame radar swinging arm.

Once the resin has hardened, offer the swing arm frame up to the main A frame and insert the two pivot point bolts into the arm at the places identified in Figure 7. Secure in place so that the arm can rotate but is not loose.

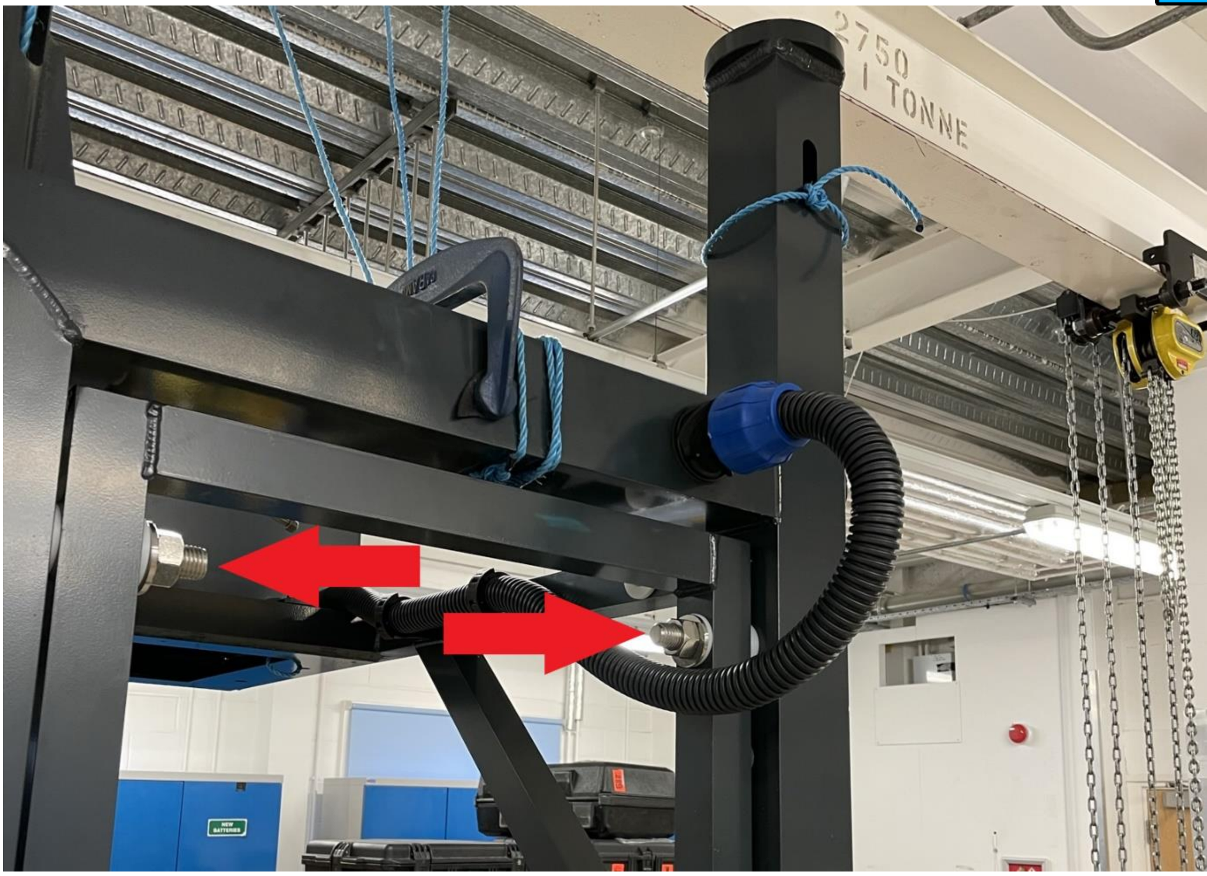


Figure 7 A frame swing arm installed.

Insert the securing bolts into the appropriate holes on the A frame to prevent it from swinging. The holes identified by the red arrows (Figure 8) lock the arm in the normal operating position. The hole identified by the green arrow, and a similar one on the opposite side, which is not visible in the image, permits the arm to be locked in the maintenance position, with the sensors accessible from the quayside.

Figure 8 Swing arm frame installed and locked.

b. GNSS antenna

The GNSS antenna can be fitted at this stage, or it can be fitted before the A frame is erected. Once the A frame is installed, a ladder or platform is required to fit the antenna on top of the monument. **It is easier to install the antenna onto the mast before it is lifted into position, but care must then be exercised to prevent damage to the antenna during installation of the mast.**

To install the antenna, locate the mounting stud and screw this fully into the antenna. Install the radome onto the antenna. Carefully offer the antenna up to the A frame mounting location (Figure 9) and gently rotate the antenna to fit the threaded stud into the top of the A frame. Rotate the antenna until it is flush with the plate. It is probably easier if two people do this operation.

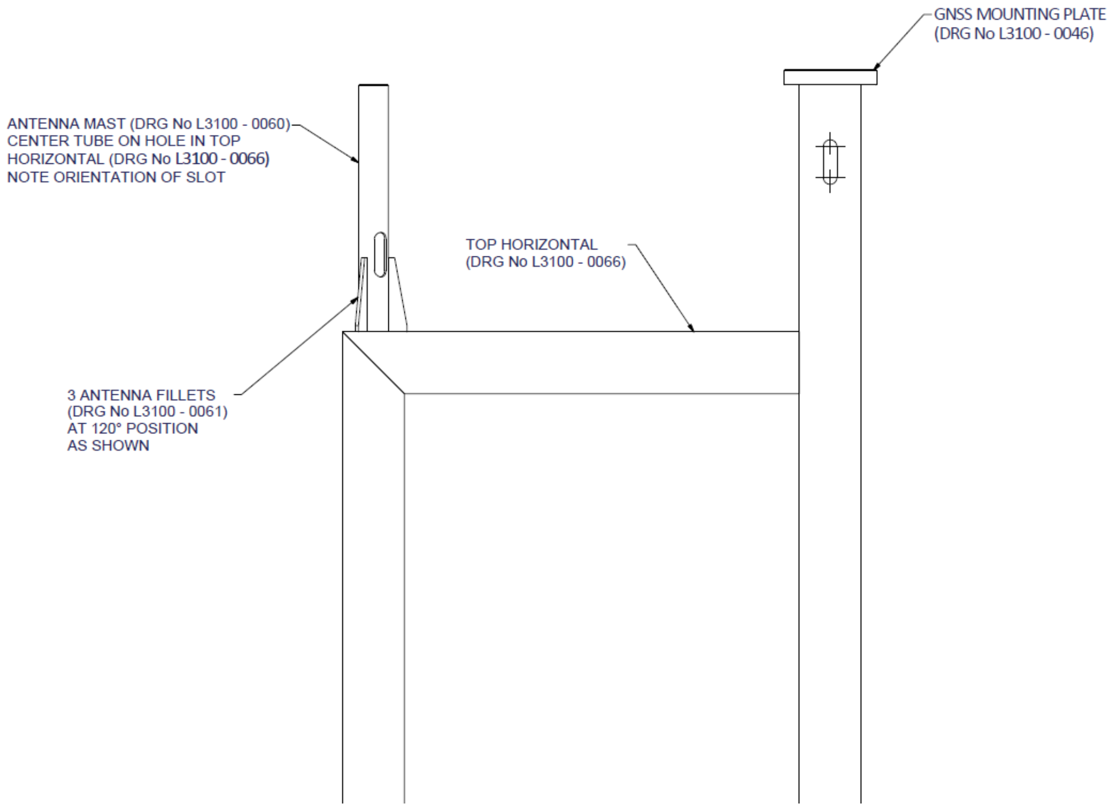


Figure 9 GNSS A frame

c. Trimble GPS antenna

The Trimble GPS antenna can be installed at the same time as the GNSS antenna. The two antennas are located at opposite ends of the A frame. Attach the Trimble GPS antenna onto the mounting adapter (Figure 10) and attach onto the A frame antenna mast (Figure 9). The GPS antenna cable will need fitting to the antenna at this point since it connects to the antenna by passing through the centre of the metalwork. A slot in antenna mast permits cable access to assist with routing. Secure any excess antenna cable to prevent damage occurring.

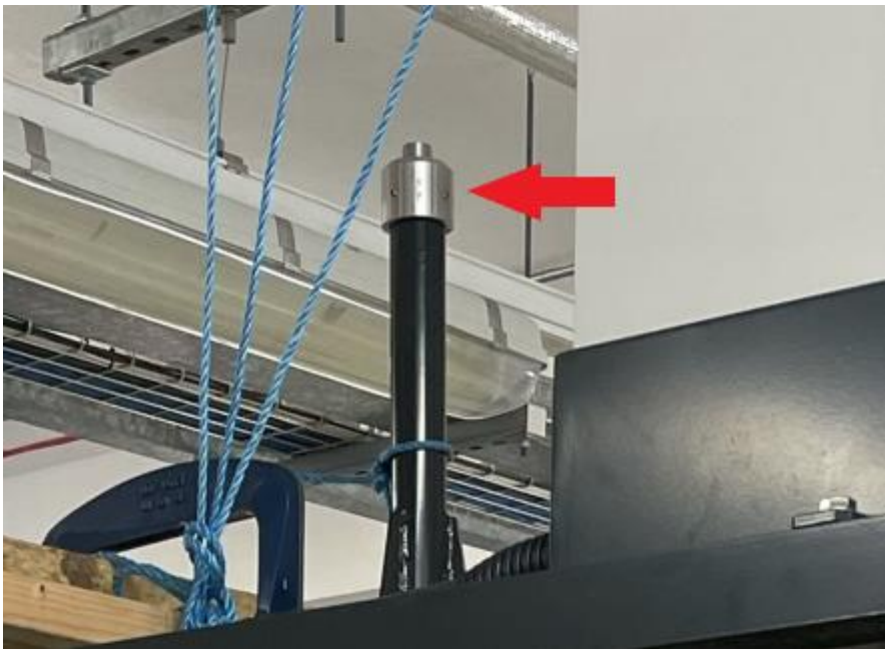


Figure 10 GPS antenna mounting adapter.

d. Solar panel frame and equipment cabinet

Assemble the solar panel frame. The solar panel is shipped pre-fitted in the mounting frame. The solar panel cables are pre-fitted to the panel. Drill fixing holes in the quayside and secure the solar panel frame in place using the anchor bolts supplied. Take care to ensure the panel is not damaged during installation.

Position the green equipment cabinet in position behind the solar panel frame and drill four fixing holes, one in each corner, to secure it in place. Mark the location of the cabinet on the quayside with a marker pen, then remove it and apply a bead of frame sealant to the quayside so that the cabinet will sit on it once repositioned. To aid positioning of the cabinet, use wooden blocks to support the cabinet as it is moved into place, before lowering it onto the bead of sealant. Fasten the cabinet to the quayside using the anchor bolts. A further bead of sealant may be placed around the exterior of the cabinet.

Install the conduit and connector from the cabinet towards the GNSS A frame so that water ingress into the cabinet is prevented.

Install the conduit and connector from the solar panel ensuring the solar panel cables enter the cabinet (Figure 11). **Do not connect them to the system.**

Figure 11 Rear of solar panel showing conduit access to cabinet for solar panel cables.

e. <u>Radar sensors</u>

The radar sensors can be fitted to the swing arm by allowing the arm to swing inshore. Remove the bolts indicated by the red arrows in Figure 8. Rotate the arm so that the section that normally protrudes out over the sea can drop down and swing in towards the quayside. Align the holes in the arm with the holes in the A frame (green arrow in Figure 8) and insert the locking bolt to secure it.

Locate the Nile radar. It should already be installed inside its installation housing. Install the housing onto the swing frame, ensuring the radar display will point inland once the arm is deployed seaward (Figure 12).

The red arrow (Figure 12) indicates the screws that can adjust the level of the radar, to obtain a perfectly vertical beam to the sea surface. This has been set in the laboratory and should not require adjustment during installation if the A frame is vertical.

Figure 12 Nile radar fitted to swing arm.

Install the Miros radar onto the radar arm, in the opening behind the Nile radar (Figure 13).

Figure 13 Radar mounting locations.

Attach the earth cable to the M8 earth bolt (Figure 14) and route the Nile and Miros cables through the conduit and into the upright frame.

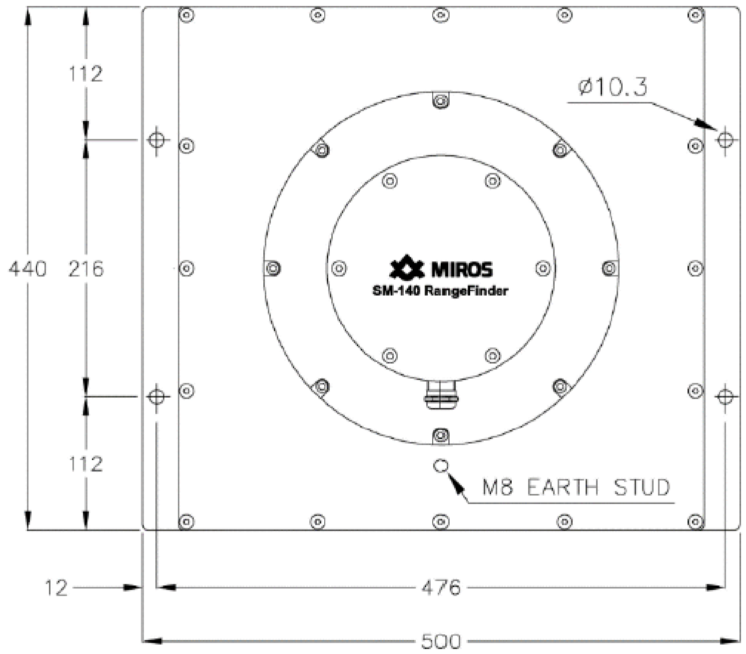


Figure 14 Miros radar.

The radar and earth bonding cables pass through the conduit on the swing arm and into the main A frame (Figure 15).

Figure 15 Swing arm cable conduit .

Remove the cable access cover (Figure 16) to assist in routing the cables into the A frame. The earth bonding cable is fastened to the brass bolt to establish an earth connection between the swing arm and A frame. The radar cables will pass down inside the upright stanchion and out through the cable access point at the bottom. Feed these into the conduit to the cabinet and pull them through so they enter the green cabinet.

Figure 16 Cable access cover in A frame.

The GPS antenna cable is similarly passed through the A frame to exit at the bottom of the stanchion.

Once all cables are installed and routed from the A frame into the green cabinet, fit the metal protective cover over the Miros radar and the black plastic cover over the Nile radar.

f. Coaxial Cables

The GPS and GNSS antenna cables can now also be pulled through the conduit between the A frame and equipment cabinet. Coaxial cables can be easily damaged when pulling them through conduit. Ensure the cable does not become kinked or twisted, especially the thinner GPS cable.

It may be better to pass the GNSS cable through the conduit towards the A frame from the cabinet. This will result in less cable being pulled through the conduit. The GNSS cable is 30m long.

The GNSS cable will pass through the centre of the stanchion and emerge through the slot at the top, near to the antenna. Connect the cable to the antenna. The other end of the cable is fed into the green cabinet.

Assemble the Yagi antenna (the antenna elements and locations they fit into are numbered) and attach it to the antenna clamp (Figure 17).

Figure 17 Yagi antenna assembled.

The Yagi antenna cable consists of 3 x 5m sections with coupling connectors. Depending upon the distance between the A frame and the cabinet, it may not be necessary to use all three sections. Use the shortest length of cable that is necessary for the installation. Connect the cable to the antenna and route it through conduit to enter the green cabinet.

Align the antenna according to Figure 19

- Elevation 39.8°
- Azimuth 201.4° Magnetic

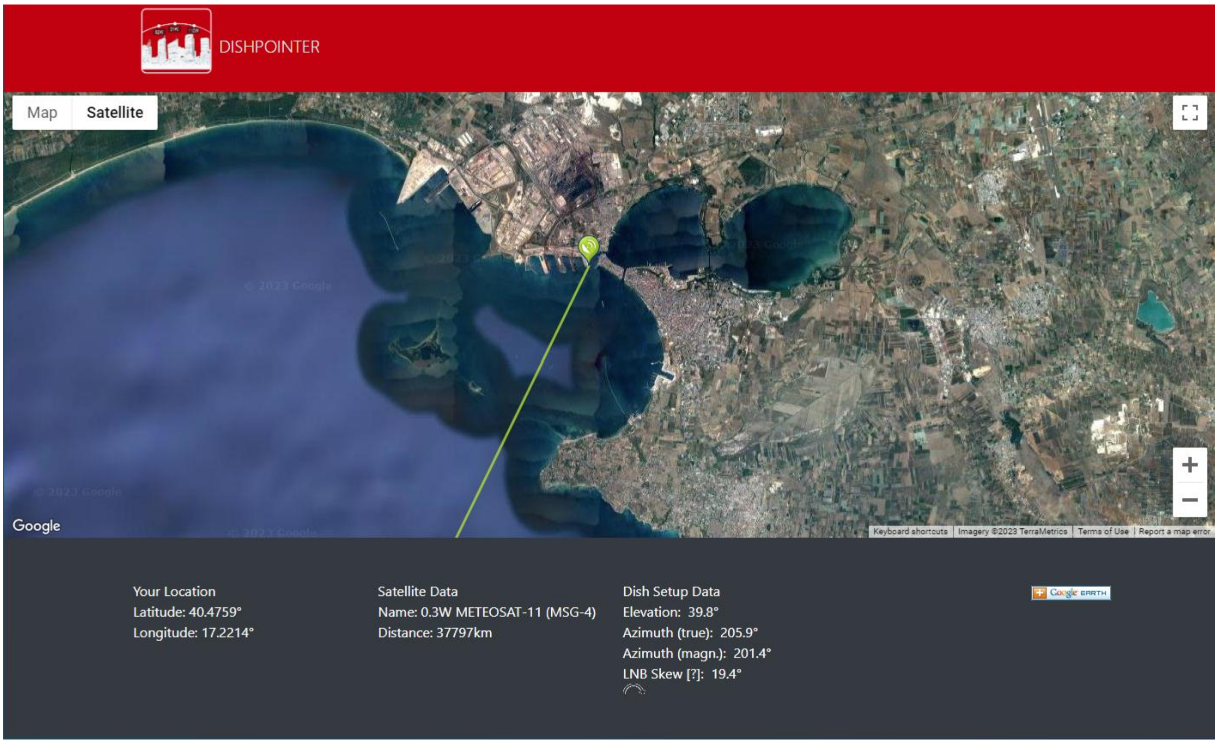


Figure 18 Meteosat satellite Yagi antenna alignment.

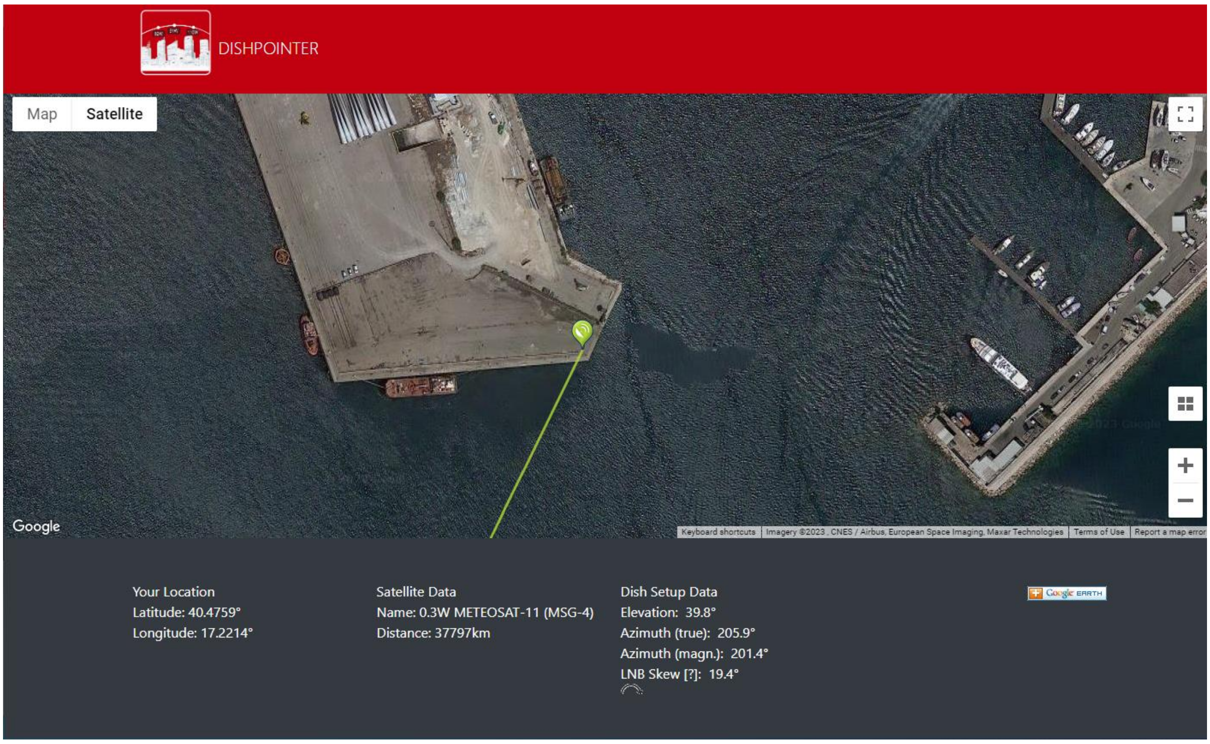


Figure 19 Yagi antenna alignment.

g. Benchmark

A brass reference benchmark is installed on one of the metal foot plates of the A frame.

Install a brass benchmark on the quayside, near to the base of the A frame containing the reference benchmark. This will enable a survey levelling exercise to be undertaken, of the tide gauge installation to a local datum.

Using survey equipment or a spirit level and tape measure, determine the height difference between the quayside benchmark and the reference benchmark used for establishing the sensor levels.

Note this value.

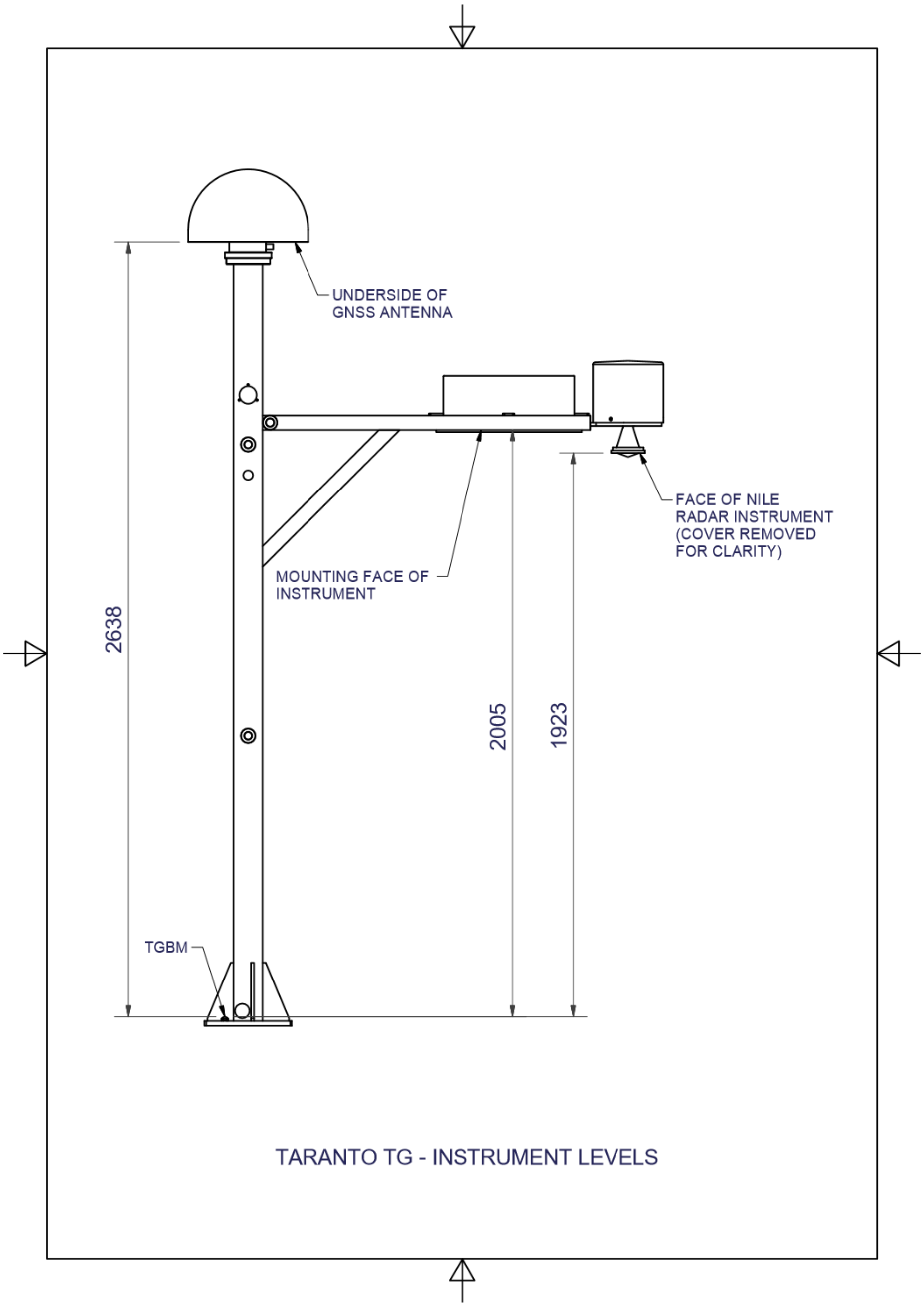


Figure 20 Instrument measuring levels relative to reference benchmark.

h. Cable connections

When all the cables are routed inside the cabinet, connecting to the system can commence.

Figure 21 Radar sensor connections.

The Nile radar cable (black cable in Figure 21) is connected to the DIN rail terminals as shown. The red and black cables connect to the same double height terminal, with black at the bottom and the white cable connects to the adjacent terminal at the top.

Red is +Ve

Black is -Ve

White is SDI-12 data.

The pre-wired cable inside the enclosure uses the same colour code to aid with correct wiring.

The Miros radar cable is cream coloured in Figure 21 and has more connections. The conductors are twisted pair cables, consisting of a coloured cable with a white cable. Do not untwist these as this could cause confusion between the numerous white cables.

The white cable of a twisted pair group represents the matching colour/white cable in a regular ethernet cable. E.g., in the white and orange twisted pair, the white cable represents the orange/white cable normally found in Cat5 or Cat6 type cables.

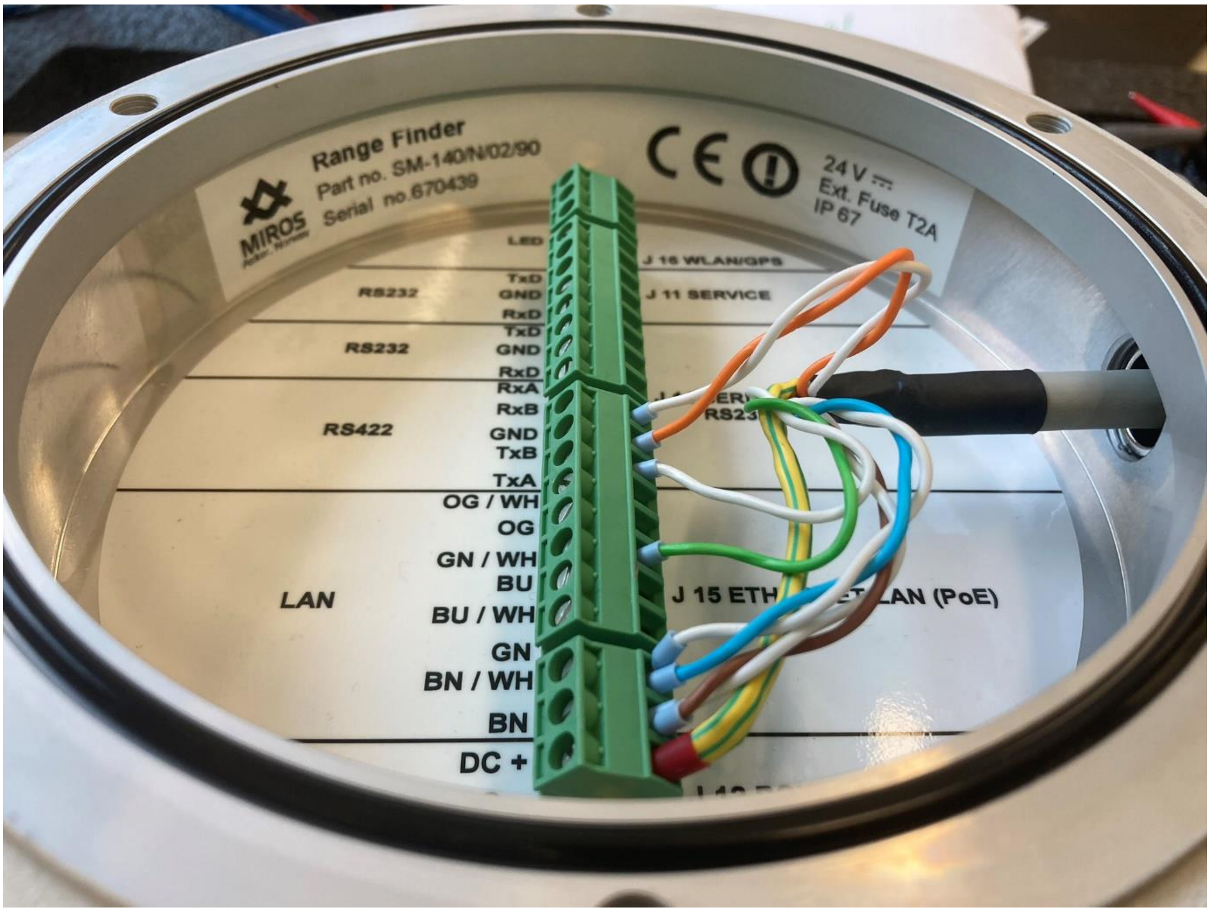


Figure 22 Miros radar cable connections.

Ensure the cables are connected to the system in the matching colour order.

The Yagi antenna cable is connected to the silver connector in Figure 23 after removing the ‘dummy load’ device. Do not confuse the Yagi antenna cable with the GNSS antenna cable. The Yagi antenna cable is more flexible than the GNSS one, even though it is the same size. The GNSS cable is labelled with LMR-400-DB along its length.

The Trimble GPS antenna is connected to the gold coloured SMA connector near to the Yagi antenna N type connector (Figure 23) on the left-hand cabinet (Figure 34).

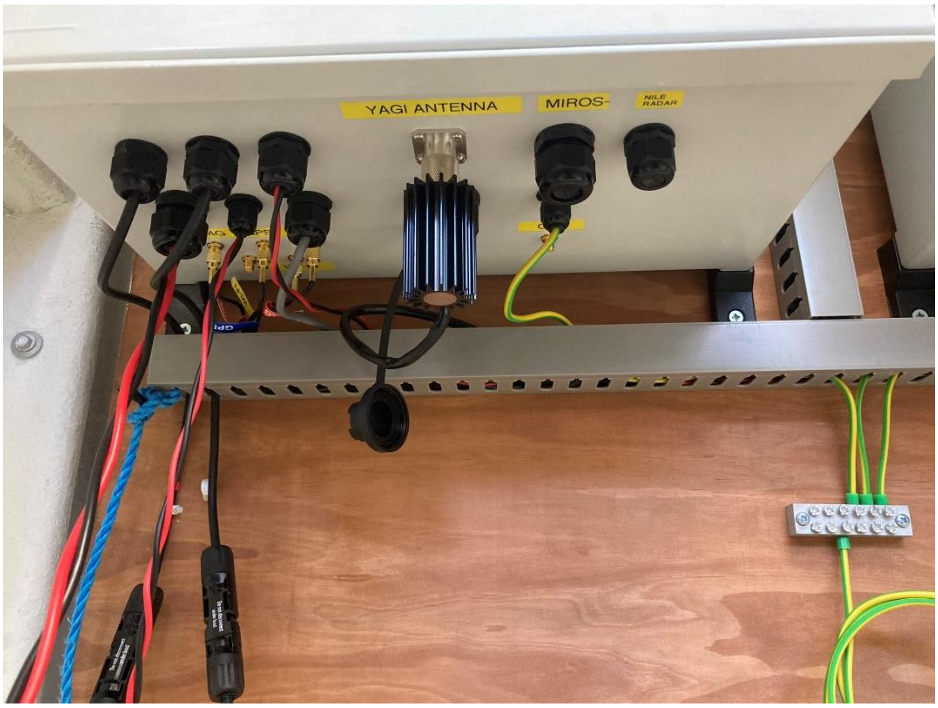


Figure 23 Meteosat Yagi antenna connector.

The solar panel leads will be connected to the tail leads shown in Figure 24 during the commissioning of the tide gauge. **Do not connect them now.**

Figure 24 Solar panel connector

The GNSS antenna cable is connected to the surge protector on the GNSS enclosure (Figure 25), right-hand cabinet (Figure 34).

Figure 25 GNSS surge protector.

i. Batteries

Place the eight lead crystal batteries inside the green cabinet. Using the supplied battery interconnection leads, wire the batteries in a series/parallel arrangement to create a 24V battery bank (Figure 26).

The suggested battery placement and connection scheme is shown in Figure 27.

Locate the power leads and remove the blade fuses noting the fuse rating for each lead.

Connect the power leads, red to +ve and black to -ve. The power leads should be connected across the entire battery bank and not just one battery. This will ensure battery charging is performed optimally.

CAUTION: Care must be exercised when connecting the batteries to prevent shorting of the terminals. Shorting the battery terminals will cause a large current to flow, potentially creating sparks and could damage the battery.

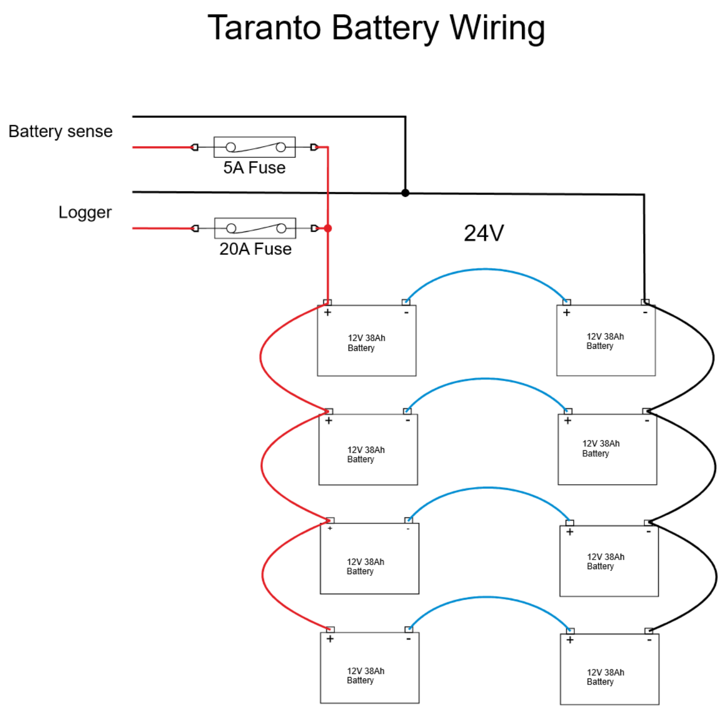


Figure 26 Battery connections.

Battery sense fuse value – 5A

Logger fuse value – 20A

Figure 27 Suggested battery layout.

4. **<u>Commisioning the tide gauge</u>**

a. Ensure all sensors, antennas, cables and connectors are fitted from the installation process.
b. Ensure the Yagi antenna is connected to the N type connector before continuing. **Powering the system up without the Yagi antenna or dummy load fitted will damage the Satlink3 transmitter.**
c. Install the Mobius 4G SIM card into the Teltonkia RUT955 router

Figure 28 SIM card location on RUT955 router.

Figure 29 Logger enclosure.

d. Open **all** of the fused circuit breakers inside both equipment enclosures.

Figure 30 Open the fused circuit breakers.

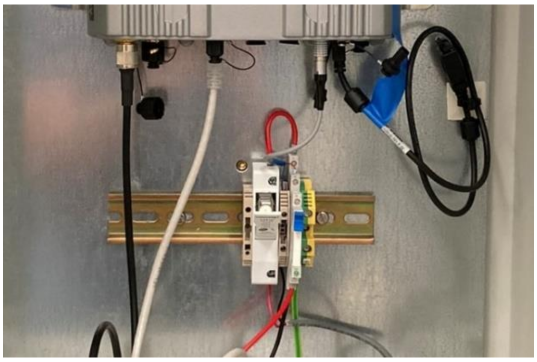


Figure 31 GNSS enclosure fuse in open position.

e. Ensure the circuit breaker switch is in the **OFF** position (Figure 30).
f. Insert the blade fuses into the holders, ensuring the correct rated fuse is used. Refer to Figure 26 for reference. The Morningstar solar charge controller should power up and the display will show values for battery voltage. Left of the display is the status LED. Figure 32 indicates expected LED response during power up. Below the display are three state-of-charge LEDs (Figure 33).

4.3 LED Indications

KEY:

G = green	G - Y - R = flashing sequentially
Y = yellow	G / Y = flashing together
R = red	G / Y - R = G and Y flashing together, alternating with R flash

4.3.1. Power-up

Normal power-up: Status LED flashes **G**, then SOC LEDS flash **G - Y - R**, then SOC LEDs indicate battery charge status with a single battery status LED.

Failed bootload: Status LED flashes **G**, then SOC LEDS flash **G - Y** and stop on solid **Y**.

4.3.2 Status LED

The Status LED indicates charging status and any existing solar input error conditions. The Status LED is on when charging during the day and off at night. The Status LED will flash red whenever an error condition(s) exists. Table 4.4 below, lists the Status LED indications.

Color	Indication	Operating State
None	Off (with heartbeat[1])	Night
Green	On Solid (with heartbeat[2])	Charging
Red	Flashing	Error
Red	On Solid (with heartbeat[2])	Critical Error

1. Heartbeat indication flickers the Status LED on briefly every 5 seconds
2. Heartbeat indication flickers the Status LED off briefly every 5 seconds

Table 4.4. Status LED Definitions

NOTES:

1) **R** flashing is generally a user addressable fault / error

2) **R** charging status LED ON with heartbeat blink OFF every 5 secs is a critical fault that generally requires service. See, **"Solid Charging Status LED with Self-test (R-Y-G) SOC Faults"**, in Section 5.2.

4.3.3 State-of-Charge LEDs

Battery SOC LED Indications are shown in Table 4-5 below:

Figure 32 Morningstar status LED.

Condition	Indication
Absorption	**G** flash - every sec
Float	**G** flash - every 2 secs
Start Equalization (push-button)	[G / Y / R] x2 - **G**- **G**
Stop Equalization (push-button)	[G / Y / R] x2 - **R** - **R**
Equalize	**G** flash - 2 / sec
SOC > 13.5V	**G** solid
13.5V > SOC > 13.0V	G / Y solid
13.0V > SOC > 12.5V	Y solid
SOC < 12.5V	Y / R solid
Low voltage disconnect warning	R flash - every sec
Low voltage disconnect	R solid

Table 4.5. Battery SOC LED Indications

Figure 33 Charge controller SOC LEDs.

g. Connect the solar panel leads to the connectors (Figure 24).

h. Close fuse circuit breaker S1 and set breaker switch to **ON.** This will apply the solar panel output to the charge controller. The charge controller will display the battery voltage, current and solar panel voltage. The status and SOC LEDs will indicate current charge controller performance.

i. Close fuse labelled PWR to power up the tide gauge. The system will now power up from the batteries and begin operating. If the system does not power on, note the status of the SOC LEDs. If the battery voltage is too low, the Low Voltage Disconnect will activate and the system power will be disabled until the batteries are sufficiently charged.

j. Close the fuse breaker labelled GNSS in the logger enclosure and the one inside the GNSS enclosure to power up the Trimble GNSS system. The Trimble GNSS display will illuminate and the receiver should begin acquiring satellites and display this information on the screen.

The system should now be operational.

Figure 34 Equipment cabinet showing the logger and GNSS enclosures.

The radar sensors will power up and a number will be displayed on the LCD display of the Nile radar corresponding to the distance from the sensor to a reflective surface, either a flat surface, if the radar arm is swung landward and something is placed in the path of the beam, or the sea surface in normal operation. Check this is working OK, and the number displayed looks reasonable.

Using a DVM, if available, measure and record the solar panel and battery voltages. These should correspond to the display on the charge controller.

The data being logged by the Satlink3 logger can be checked by downloading the LinkComm app from Apple App store or Google Play store for smartphones, or for a laptop by visiting https://www.otthydromet.com/en/Ott/p-sutron-linkcomm-software/LINKCOMM

The Satlink3 has built-in Wi-Fi. To connect, press the silver button and a blue light will flash. Search for the Wi-Fi hotspot created and connect to it. Open the LinkComm app and connect to the logger. If using the laptop software, ensure Station Wi-fi is selected as the connection type. Laptops can also connect using a micro-USB cable. In this case, select USB as the connection type.

The data being logged by the Satlink3 can now be viewed.

5. Finalising the installation

If not already done, remove the locking pins from the swing arm and rotate it so the sensors are now seaward and overlooking the sea.

If possible, check that the radar arm is level when in the deployed position.

Check the operation of the installation, especially all the cables running from the A frame to the green cabinet.

Check the data values from the radars look sensible. Measure the distance from the quayside height to the sea surface.

Radar height values to reference BM are:

- Nile radar height above reference BM – 1923mm
- Miros radar height above reference BM – 2005mm

Measurements produced by the radar sensors consist of the radar height reference value (see above) plus the distance from the quay edge to the sea surface, plus the height of the reference BM above the quay edge.

Once a typical radar value is known, make sure the Nile radar datum offset is sufficiently large to prevent negative values being recorded. The datum should be set to 10m below the radar measuring plane. To check this use LinkComm software, connect to the Satlink3 and click on the Measurements tab (Figure 35). Select RAD1 and scroll down to the 'Use equation' section (Figure 36).

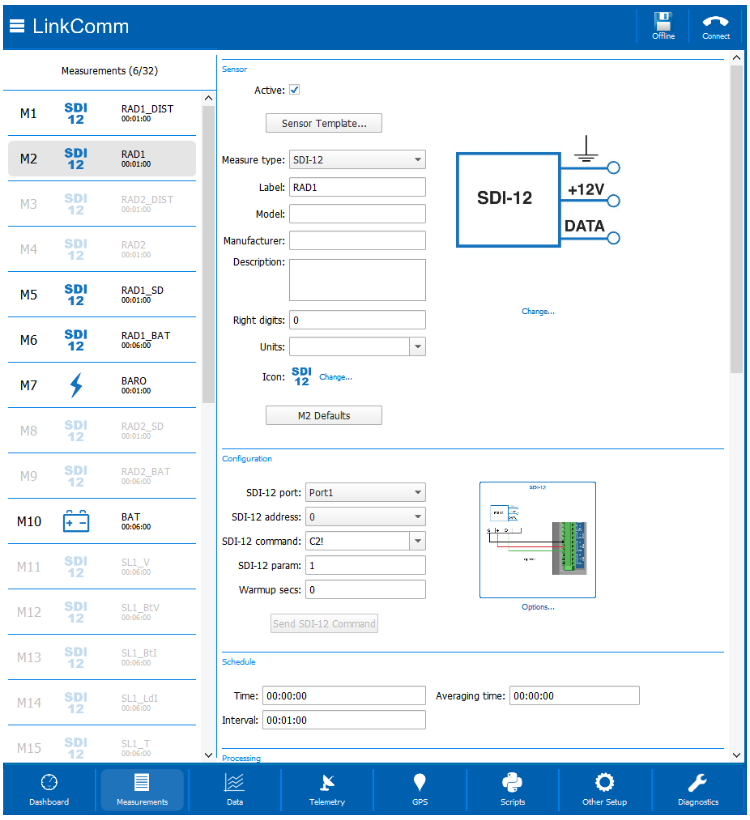


Figure 35 LinkComm measurements section.

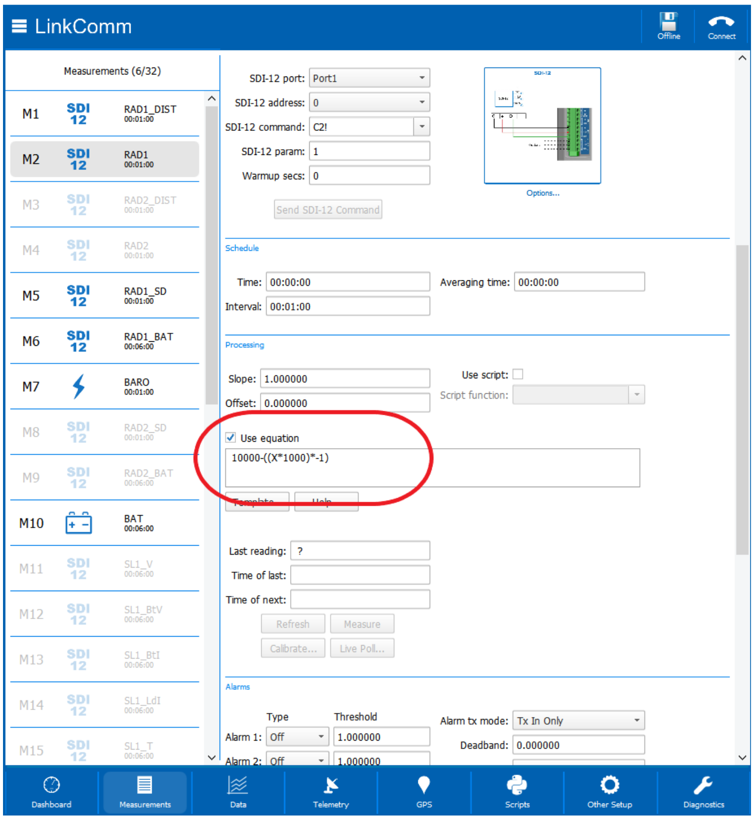


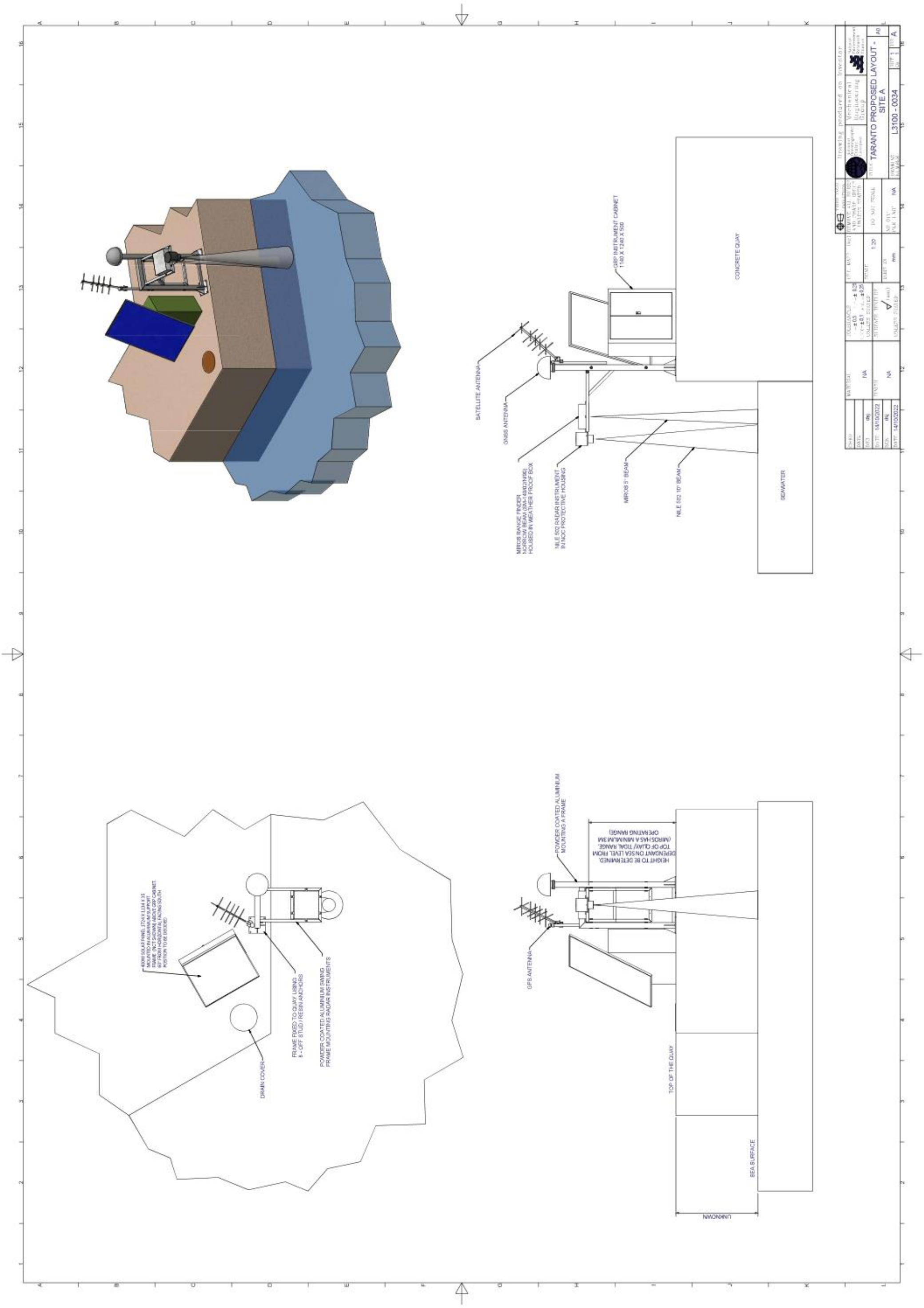
Figure 36 LinkComm sensor settings.

6. Final checks

Before leaving the tide gauge site after installation is finished, complete the following checks:

- Ensure the system is powered up correctly using the procedure described in this document.
- Use LinkComm to check for data being logged by the Satlink3.
- Contact Begoña Pérez Gómez at Puertos del Estado (bego@puerto.es), to check for data arriving onto OSPAC.
- Check the IOC website for data transmitted via satellite being published on their website.
- Login to the Trimble GNSS (see APPENDIX 2) and check that data is being logged. If not, enable logging or request Simon Williams to remotely access the system and enable it.

APPENDIX 1 – MECHANICAL DESIGN



APPENDIX 2 – LOGIN INFORMATION

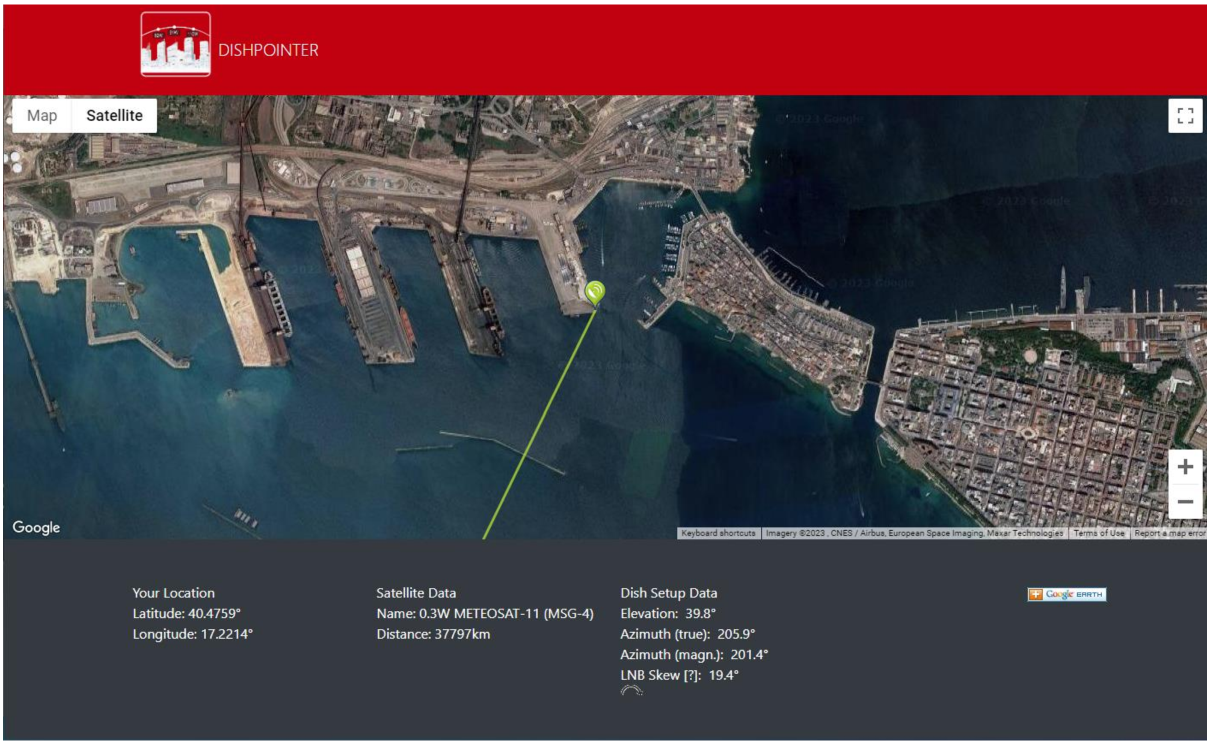
Tide Gauge RUT955
IP Address: 192.168.1.1
Username: admin
Password: EuroSTaran23
Wi-Fi SSID: RUT955_3B38
Wi-Fi Password: c7L3Ypi2

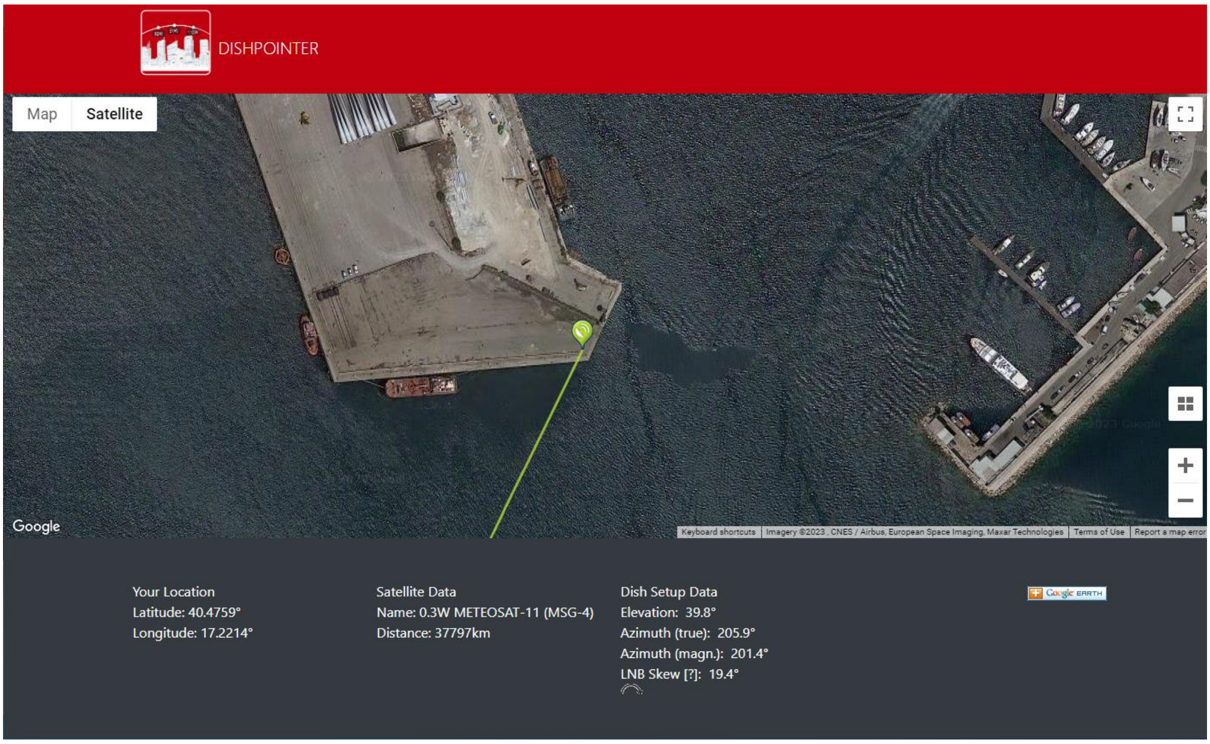
Tide Gauge Raspberry Pi
IP Address: 192.168.1.246
Username: pi
Password: EuroSTaran23

Anydesk number: 543 410 338
Password: EuroSTaran23

Trimble Alloy:
IP Address: 192.168.1.70
Username: admin
Password: 6105r40056!
Wi-Fi Access Point SSID: 6105R40056
Wi-Fi Password: 6105r40056!

APPENDIX 3 - SATELLITE TRANSMISSIONS





EuroSea
Tide Gauge Installation Manual

Buenaventura

Geoff Hargreaves
National Oceanography Centre

EUROSEA Colombia Tide Gauge Installation

The equipment for EUROSEA consists of:

- A steel Global Navigation Satellite System antenna monument, plus a steel arm extension for mounting dual radar water level sensors.
- A steel frame construction for mounting 3 solar panels to provide power to the system.
- A large fibreglass cabinet containing electronic equipment for logging data from the radar sensors and GNSS antenna.

1. Description

The tide gauge consists of dual radars co-located with a high specification GNSS system. The GNSS antenna attaches onto the same mast as the radars so that once the gauge is levelled; the GNSS can act as a correction for any subsequent shift in the radar data.

The tide gauge operates from batteries that are charged using renewable energy. A bank of four 38Ah batteries charge from an array of three 80W solar panels.

The GNSS mast specification causes it to behave as a monument. This should help to minimise movement in the structure that could affect both radar and GNSS signals, causing erroneous readings.

The equipment cabinet is to be mounted onto a firm concrete base, with the solar panel frame affixed to the cabinet. The solar panels (and thus the cabinet) are oriented south to maximise solar energy collecting potential. The solar panel elevation angle has been set for optimum operation during the spring/autumn months due to the latitude of the installation site. The sun passes overhead from North to South as the season changes from summer to winter, and from South to North during the transition from winter to summer.

The system has a GOES transmitter and Yagi antenna, as well as 4G communication for data recovery. The Yagi antenna is sited alongside the green cabinet.

2. Location

The tide gauge will be installed on the site of Hotel Maguipi, near Buenaventura. The red circle in Figure 3 and Figure 4 indicates the location of the GNSS mast and the yellow circle indicates the location of the equipment cabinet and solar panels.

Figure 1 Hotel Maguipi.

Figure 2 Buenaventura, Colombia.

Figure 3 Location of GNSS mast and equipment cabinet at Hotel Maguipi.

Figure 4 GNSS mast installation site circled in red.

The equipment cabinet will be installed onto a firm base, such as a cast concrete slab and the solar panels are mounted into a metal frame located above the cabinet (Figure 5).

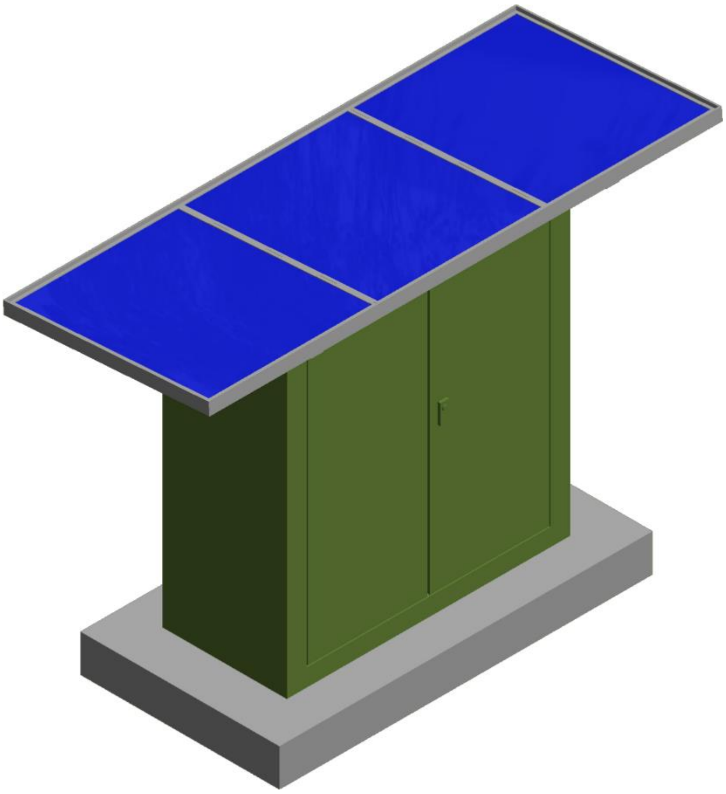


Figure 5 Image of equipment cabinet installed onto a concrete base, with solar panels mounted on top.

The following photographs show the GNSS monument and radar arm assembly installed at Birkenhead, which is similar to that being installed in Buenaventura. The radar arm is designed to swing to allow maintenance on the sensors and for ease of installation. The arm is designed to swing to the left or right, depending upon the installation site.

Figure 6 Radar arm swung inwards at Alfred Dock, Birkenhead, UK.

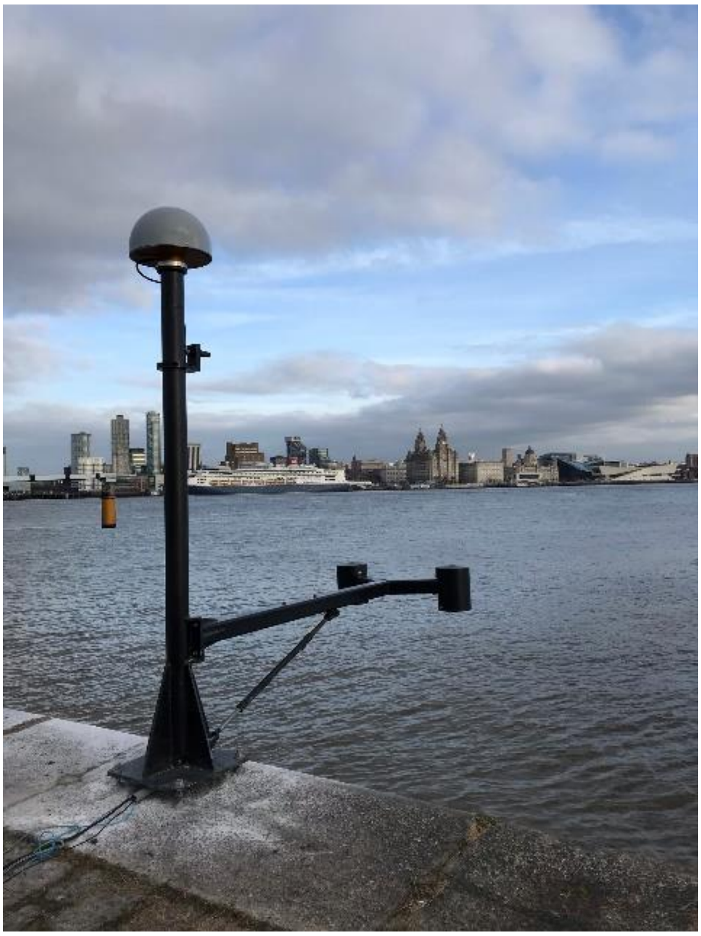


Figure 7 Radar arm in the outwards position.

3. Installation

The main installation will comprise of establishing a solid concrete base for the equipment cabinet to be secured to and installing the GNSS mast near to the cliff edge. Suitable installation hardware (not supplied) will be required to secure the GNSS mast and equipment cabinet in place. The type of hardware fixings required will depend upon the composition of the ground at the installation site. The recommended method for installing onto concrete or stone quayside is described in this document.

The maximum limit of the cable run between the GNSS mast and equipment cabinet is 70m, which includes the antenna mast height of about 2.8m.

Sections of conduit are supplied to facilitate cable access to the GNSS mast and equipment cabinet. Two sizes are supplied, together with connectors. Access holes will need drilling into the equipment cabinet during installation to permit cable entry from the GNSS mast.

Additional conduit will be required for routing cables the entire length between the mast and cabinet. The conduit used will be dependent upon local requirements and the route taken.

a. GNSS Mast

Mark out the location of the base of the GNSS mast and drill four 25mm holes to a depth of approximately 200mm. Clear the dust from the holes using the blower device provided. Ensure the holes are drilled perfectly vertical.

Before installing the GNSS mast, read Section 3b on installing the GNSS antenna.

Move the GNSS mast into position and raise off the ground using pieces of wood. Wood sections from the shipping crates may be used. Rope can be used to steady the mast, to prevent it toppling into the sea.

Using 300mm long M24 galvanised threaded rod, pass these through the base plate of the GNSS mast and check for alignment within the holes, so that they are vertical. Remove the threaded rod, clear any dust from the holes and quarter fill with the epoxy acrylate resin using the supplied applicator gun. The resin is a two-part mix, with the mixing occurring in the application nozzle. The resin hardens quickly in hot conditions, so this process will need to be completed quickly.

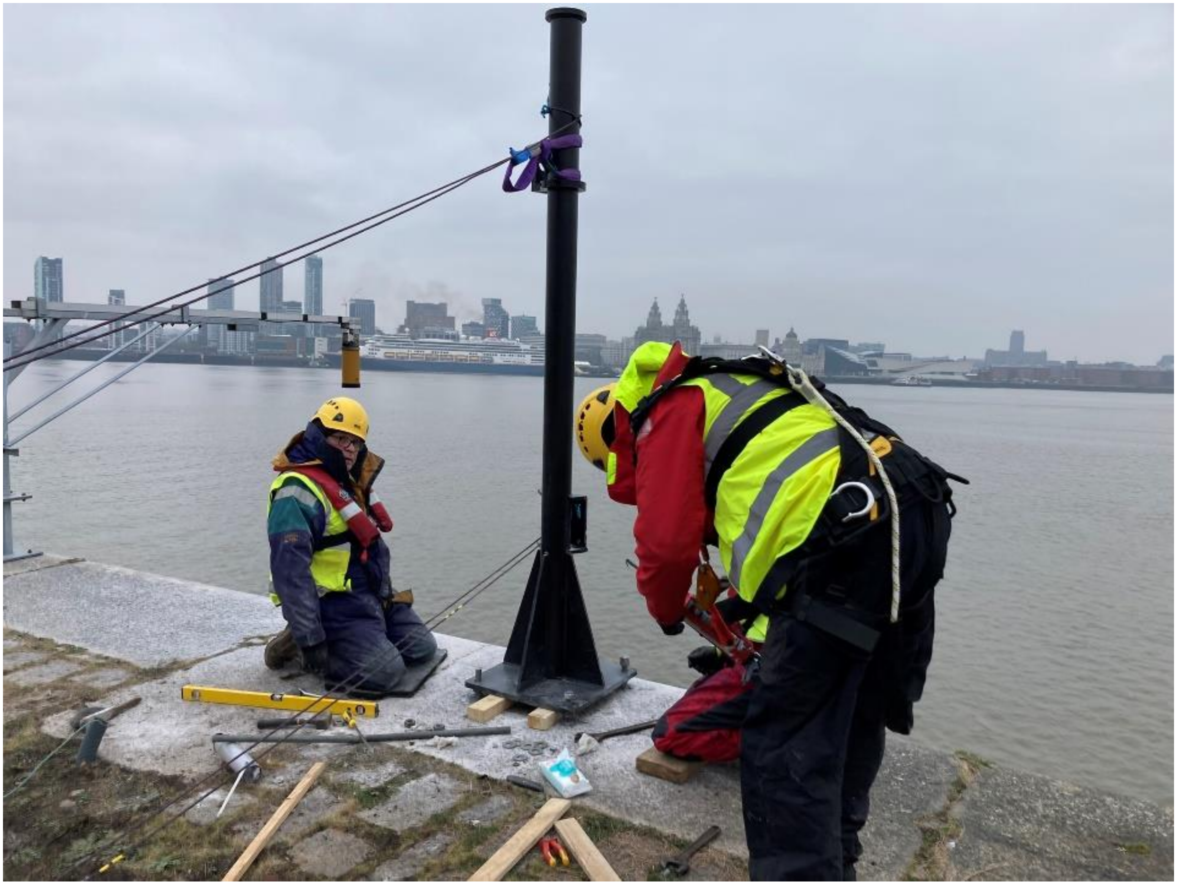


Figure 8 Installing bolts for GNSS mast.

Figure 9 GNSS mast anchor bolts.

Pass the 300mm long, M24 galvanised threaded rod through the base plate of the GNSS mast, attaching a nut and washer below the bottom of the plate before it enters the hole and screw the rod into the hole, keeping the nut and washer just below the base plate. The galvanised threaded rod can be wound into the hole by affixing two nuts to the top and locking them together (Figure 9).

Wind each rod down into the resin until it reaches the bottom of the hole by displacing the resin up to the top (Figure 9). Wipe away any excess resin.

Loosely fit the top nut/washers to each threaded rod and once the resin has hardened, adjust the bottom nuts until the mast is perfectly vertical (Figure 11). Secure the top nuts to prevent movement and check again for vertical alignment.

Apply the cementitious grout to the void below the GNSS mast. **See Section 6 for more information.**

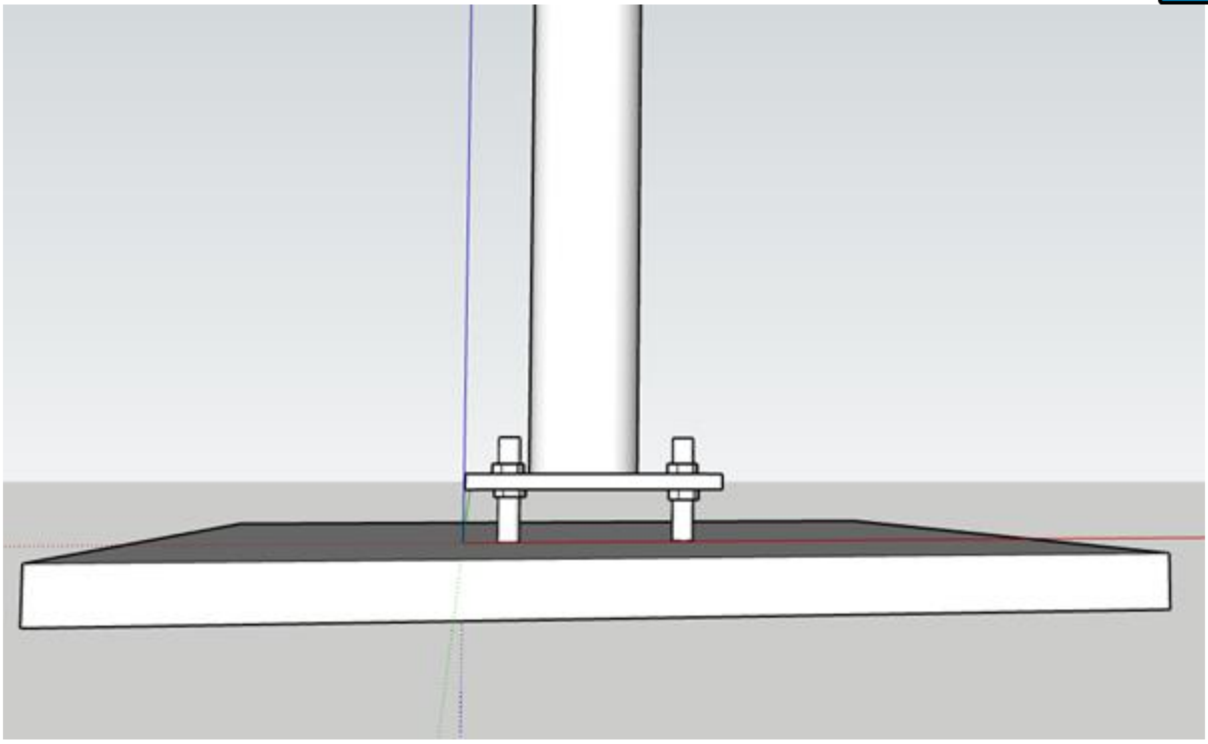


Figure 10 Installation of the GNSS mast to get perfectly vertical.

Figure 11 Levelling the GNSS mast.

b. GNSS antenna

The GNSS antenna can be fitted at this stage, or it can be fitted before the mast is erected. Once the mast is installed, a ladder or platform is required to fit the antenna on top of the monument. **It is easier to install the antenna onto the mast before it is lifted into position, but care must then be exercised to prevent damage to the antenna during installation of the mast.**

To install the antenna, locate the mounting stud and screw this fully into the antenna. Install the radome onto the antenna. Carefully offer the antenna up to the mast and gently rotate the antenna to fit the threaded stud into the top of the mast. It is easier and safer if two people do this operation, especially when installing the antenna with the mast already in place, since there is less chance of the antenna falling into the sea.

c. Equipment cabinet

Ensure the equipment cabinet is installed onto a solid flat surface, such as a bespoke cast concrete base. Place the green equipment cabinet in position and drill a fixing hole in each corner of the base to secure it in place. Further fixing holes may be used along the sides. Mark the location of the cabinet on the base with a marker pen. Remove the cabinet and apply a bead of frame sealant to the concrete surface so that the cabinet will sit on it once repositioned. This will help to seal the base of the cabinet to prevent water ingress. To aid positioning of the cabinet onto the bead of silicon, use wooden blocks to support the cabinet as it is moved into place, before lowering onto the bead of sealant. Fasten the cabinet to the concrete base using the anchor bolts. Aluminium angle strips are supplied, which should be fitted between the cabinet fibreglass and fasteners, to ensure a strong and secure fixing to the base (Figure 40). A further bead of sealant may be placed around the exterior of the cabinet where it contacts the concrete base.

Install conduit from the cabinet towards the GNSS mast so that water ingress into the cabinet is prevented. Drill a suitable sized hole in the cabinet, in the best location for the cable run from the GNSS mast and fit the connector and conduit in place (as in Figure 12). **Additional conduit is required to complete the full distance between GNSS mast and cabinet.**

Figure 12 Cable glands for conduit. Location of the entry holes are to be determined during installation.

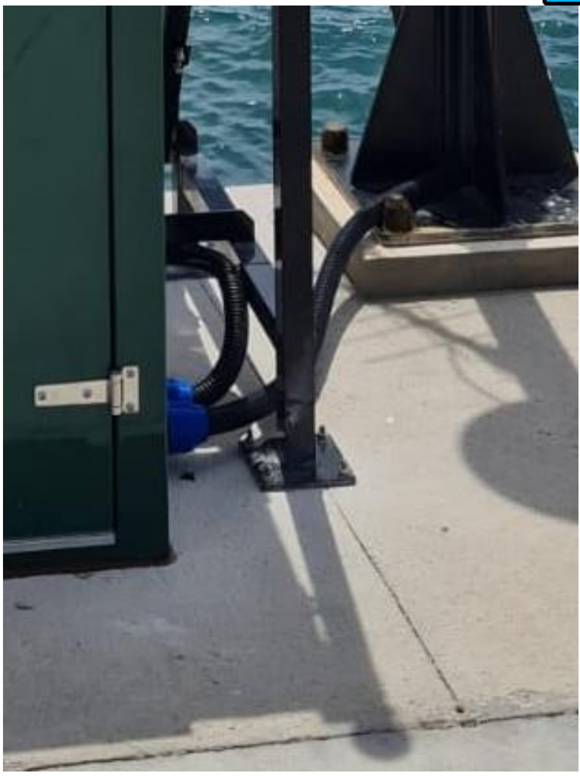


Figure 13 Conduit from cabinet to GNSS mast.

Install the solar panel frame onto the top of the cabinet. The frame is secured in place using bolts that pass through the frame and into the side of the cabinet. A black rectangular support piece is used to provide strength where the solar panel bolts enter the cabinet (Figure 14).

Figure 14 Solar panel frame support piece.

The solar panel cables are pre-fed though conduit (Figure 15) that will connect to the cabinet on the left-hand side, near the top. Cut the cable ties securing the conduit to the frame (Figure 34) for shipping and feed the cables through the hole in the cabinet, securing the conduit connector in place (Figure 16). Attach the conduit to the solar panel frame, as shown in Figure 15.


Figure 15 Solar panel cable conduit.


Figure 16 Solar panel cable entry.

d. Radar arm and sensors

Mount the radar arm onto the GNSS mast using the supplied bolts. Ensure the arm is swung inland and supported so that it is level whilst doing this (Figure 17 and Figure 23)). Use a spirit level to ensure the arm is level.


Figure 17 Radar arm fitted and swung inland.

Figure 18 Levelling the radar arm.

The arm is designed to swing to the left or right, depending upon whichever direction works best at the installation location.

Figure 19 Radar arm mounting bolts.

Figure 20 Radar arm mounting bolts.

Install the radar sensors into the mounting clamps (Figure 21) and attach onto the radar arm (Figure 22), routing the cables from the sensor through the arm. Feed these cables into the main upright section of the mast and pull them through the conduit into the green cabinet. If the radar arm is level (check this by using a spirit level), the bubble level on each radar sensor should be centred. Adjust as necessary until the radar arm and radar sensors are level in all directions (Figure 23 and Figure 24).

Figure 21 Radar sensor attached to mounting clamp.

Figure 22 Radar sensor fitted to radar arm.

It is important that the radar sensor mounting plates are level when the radar arm is also level, since this will ensure that the radar beam travels vertically to the sea surface. These have already been levelled prior to shipping but must be checked. Once deployed, the radar arm level will be checked again.

Figure 23 Installing the radar sensors.

Figure 24 Radar sensor showing bubble level and adjustment screws.

Figure 25 Levelling the radar arm.

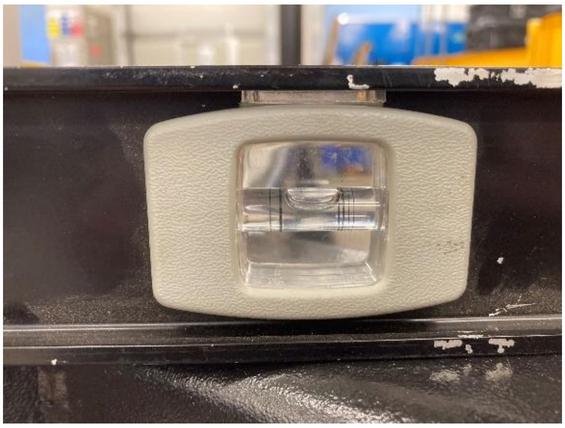


Figure 26 Levelling the radar arm.

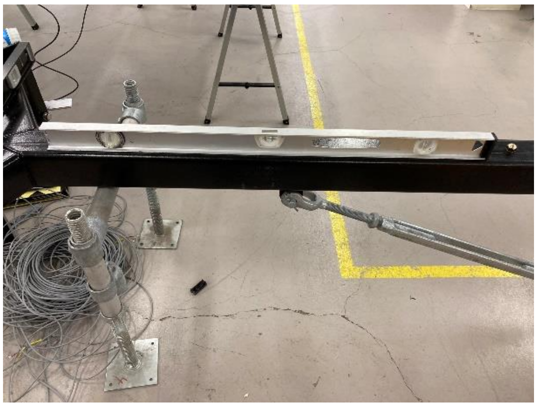


Figure 27 Levelling the radar arm.

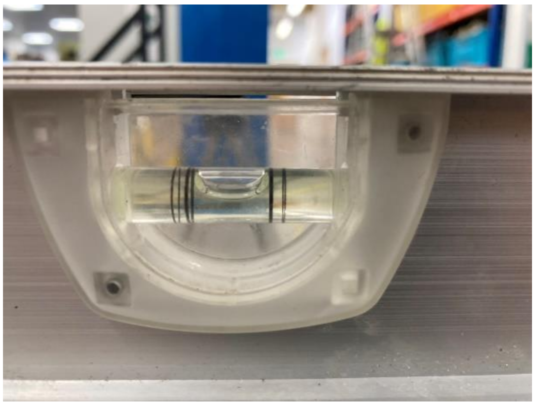


Figure 28 Levelling the radar arm.

e. <u>Coaxial Cables</u>

The GNSS antenna cable can now also be pulled through the conduit between the GNSS mast and equipment cabinet. Coaxial cables can be easily damaged when pulling them through conduit. Ensure the cable does not become kinked or twisted.

The GNSS cable will pass through the centre of the mast and emerge through the slot at the top, near to the antenna. Connect the cable to the antenna. The other end of the cable is fed into the green cabinet.

Assemble the Yagi antenna (the antenna elements and locations they fit into, are numbered) and attach it to the antenna clamp (Figure 29).

Figure 29 Yagi antenna assembled.

Locate the scaffold pole and fit it into the clamp that is mounted at the end of the solar panel frame (red arrow in Figure 30). Locate the coaxial cable for the antenna.

Connect the cable to the antenna and route it through conduit to enter the green cabinet. Ensure water cannot enter the conduit from exposed cables by creating a loop in the cable before it enters the conduit.

Figure 30 Yagi antenna mast (yellow arrow) and mast clamp (red arrow).

Figure 31 Yagi antenna mast attachment point.

Align the antenna according to Figure 32

- Elevation 84.9°
- Azimuth 157.6° Magnetic

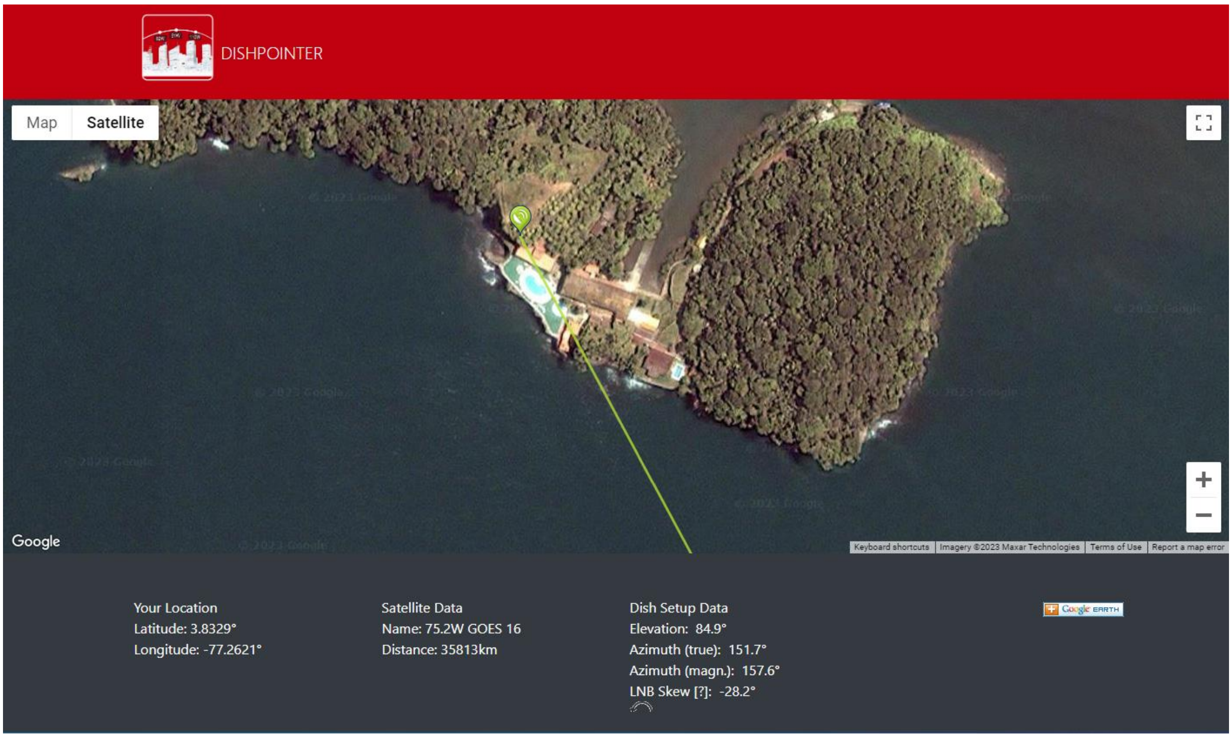


Figure 32 GOES satellite Yagi antenna alignment.

f. Solar Panels

The solar panels are shipped pre-fitted in the mounting frame (Figure 30). The three solar panels are connected in the following arrangement: two in series and one standalone (Figure 33). The solar panel cables are pre-fitted to the panels and are labelled S1 and S2 (Figure 34). **Do not connect the solar panels to the main system.**

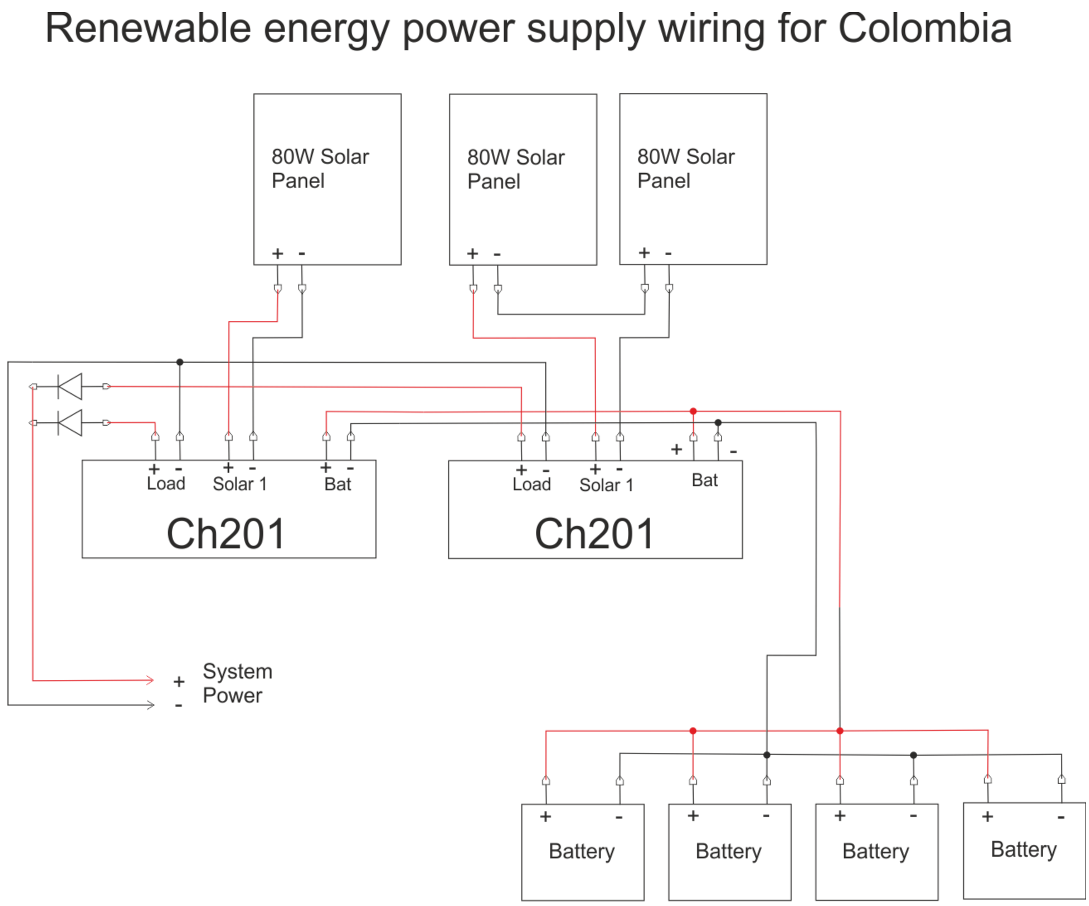


Figure 33 Solar panels and batteries.

Figure 34 Solar panel cables.

g. <u>Conduit</u>

All cables entering the green cabinet do so via conduit. To prevent water entering the green cabinet via the conduits, cables that are exposed to the weather must enter the conduit via a “swan neck loop”. This is a loop created in the cable before it enters the conduit, where the lower level of the loop is below the entry level of the conduit. This will allow rainwater to run down the outside of the cable and drip from the lowest part of the loop before it enters the conduit. This also applies to cables entering the GNSS mast.

h. <u>Cables</u>

Cables from the GNSS monument and solar panel frame are run through conduit to provide protection from the weather and wildlife. Instrumentation connectivity has been kept as simple as possible and consists of routing cables through conduit and attaching it to the appropriate connector.

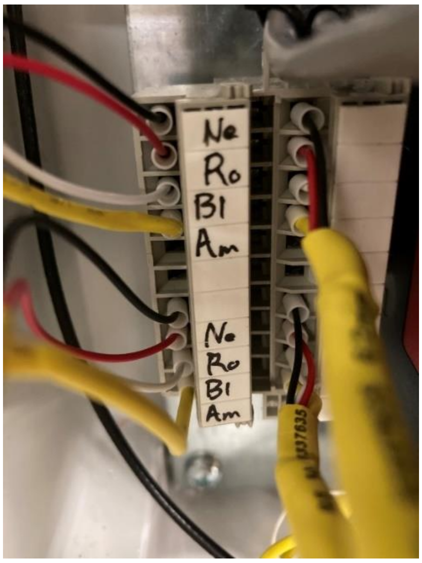


Figure 35 Radar sensor junction block.

Figure 36 Meteosat Yagi antenna connector and radar cables.

Pass the grey radar sensor cables through the cable glands on the bottom of the enclosure (red arrow in Figure 36) and connect them to the terminal block. The radar cables are connected to the corresponding colour on the terminal block (Figure 35).

Red is +Ve

Black is -Ve

White is SDI-12 data.

Yellow is shield.

When connecting the radar sensors to the terminal block, make a note of which radar sensor (left-hand or right-hand, when viewed looking out towards the sea) is connected to the upper and lower section of the terminal block. Ideally, the left-hand sensor should be connected to the top and the right-hand sensor connected to the bottom, as in Figure 35.

The Yagi antenna cable is connected to the silver connector in Figure 36 after removing the black 'dummy load' device. Do not confuse the Yagi antenna cable with the GNSS antenna cable. The GNSS cable is labelled with LMR-400-DB along its length.

The solar panel leads will be connected to the tail leads shown in Figure 37 during the commissioning of the tide gauge. **<u>Do not connect them now.</u>**

Figure 37 Solar panel connector

The Trimble bullet GPS antenna (Figure 38) is connected to the gold coloured SMA connector adjacent to the Yagi antenna N type connector (green arrow in Figure 36) on the left-hand enclosure in the green cabinet.

Figure 38 Trimble bullet GPS antenna.

The GNSS antenna cable is connected to the surge protector on the GNSS enclosure (Figure 39), right-hand cabinet.

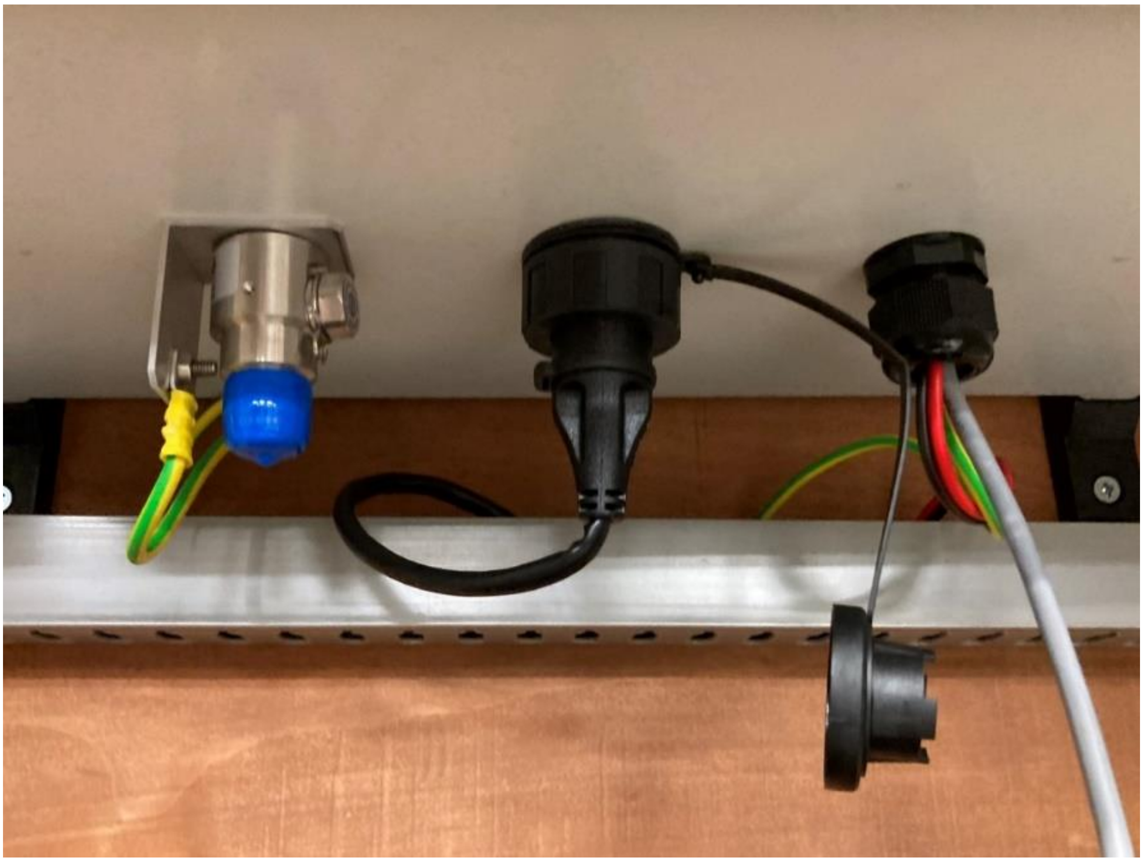


Figure 39 GNSS surge protector.

i. **Batteries**

Place the four lead crystal batteries inside the green cabinet (Figure 40). Using the supplied battery interconnection leads, wire the batteries in parallel (Figure 41). Locate the power leads for both enclosures and **remove the mini blade fuses**, noting the fuse rating for each enclosure. Connect the power leads, red to +ve and black to -ve. The power leads should be connected across the entire battery bank and not just one battery (Figure 41). This will ensure battery charging is performed optimally.

CAUTION: Care must be exercised when connecting the batteries to prevent shorting of the terminals. Shorting the battery terminals will cause a large current to flow, potentially creating sparks and it could damage the batteries.

Figure 40 Lead crystal batteries showing power leads connected across the battery bank.

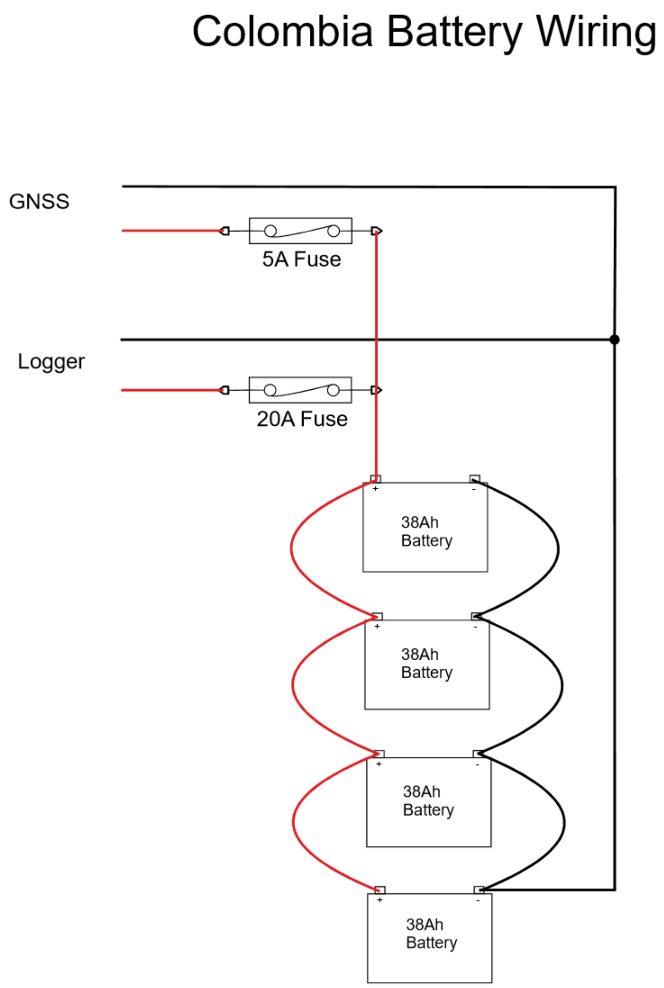


Figure 41 Battery connections.

4. **<u>Commisioning the tide gauge</u>**
   a. Ensure all sensors, antennas, cables and connectors are fitted following the installation process.
   b. Ensure the Yagi antenna is connected to the N type connector (Figure 36) before continuing. **Powering the system up without the Yagi antenna or dummy load fitted, will result in damage to the Satlink3 transmitter.**
   c. Install the Mobius 4G SIM card into the Teltonkia RUT955 router

Figure 42 SIM card location on RUT955 router.

Figure 43 Logger enclosure.

   d. Open **ALL** of the fused circuit breakers inside both equipment enclosures (Figure 44 and Figure 45).

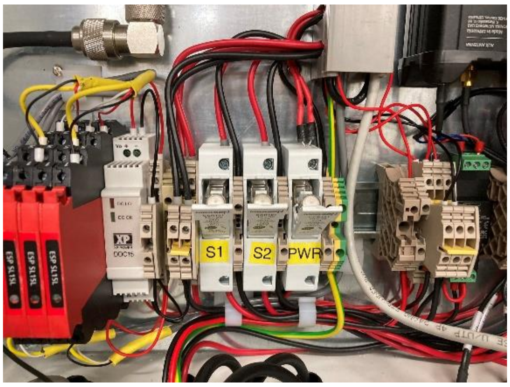


Figure 44 Logger enclosure fuses in open position.

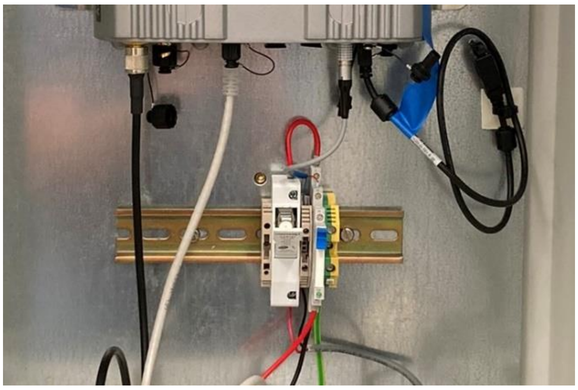


Figure 45 GNSS enclosure fuse in open position.

   e. Connect the solar panel cables to the tail end connectors (Figure 46). Take care not to mix up the positive and negative solar panel leads from different arrays. The leads are labelled S1 and S2.

Figure 46 Solar panel leads connected to system.

f. Insert the mini blade fuses into the holders, ensuring the correct rated fuse is used. Refer to Figure 41 for reference.

g. Close fused breakers S1 and S2 inside the left-hand enclosure. This will apply the solar panel output voltage to the CH201 charge controller (Figure 47). The CHG LED will start flashing green if the solar panels are producing enough energy to charge the batteries (Figure 48). The CH201 is fitted with a small silver switch to isolate power to the load. Ensure this is set to the **ON** position on both units.

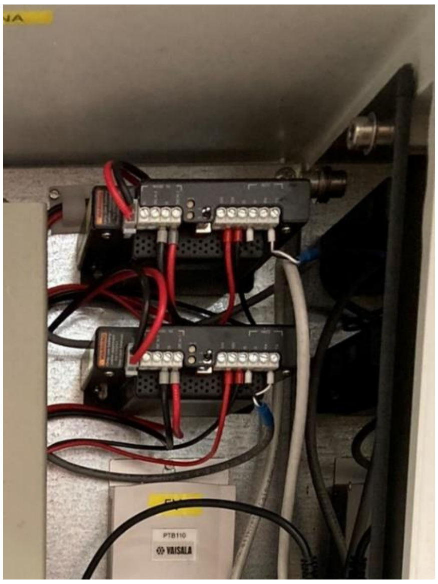


Figure 47 Solar charge controllers.

Table 7-7: CHG LED

Condition	Color/state
No valid charge source	Off
Valid charge source and charging battery	Flashing green
Valid charge source but battery discharging	Flashing orange
Regulator fault detected	Flashing red
Waiting for new operating system (Downloading an operating system (p. 31))	Solid red
Transferring operating system	Solid green

Table 7-8: CK BAT LED

Condition	Color/state
Battery voltage > 11.5 V	Off
10.5 V ≤ battery voltage ≤ 11.5 V	Flashing orange
Battery fault detected OR battery voltage < 10.5 V	Flashing red

Figure 48 CH201 LED status.

h. Close fused breaker labelled **PWR** to power up the tide gauge. The system will now power up and begin operating.

i. The radar sensors will power up and a number will eventually be displayed on the LCD display corresponding to the distance from the sensor to the surface below it, either the cliff top if the radar arm is swung landward or the sea surface during normal operation. Check this is working OK, and the number displayed looks reasonable. It should be providing a reading that is the distance to the concrete floor level (assuming the radar arm is swung inland).

j. Close the fused breaker in the GNSS enclosure to power up the Trimble GNSS system. The display will illuminate and the receiver should begin finding satellites and display this number on the screen (Figure 49).

Figure 49 Trimble Alloy GNSS operating display.

k. The system will now be operational.

5. **Finalising the installation**

Using a Digital Voltage Meter, if available, measure and record the solar panel and battery voltages on the terminal block, located on the right-hand side of the enclosure (Figure 50), taking care not to short the terminals. The solar panel output voltage will vary according the amount of sunlight, but it typically around 20V.

Figure 50 Battery and solar terminal block.

The data being logged by the Satlink3 logger can be checked by downloading the LinkComm app from Apple App store or Google Play store for smartphones, or for a laptop by visiting https://www.otthydromet.com/en/Ott/p-sutron-linkcomm-software/LINKCOMM

The Satlink3 has built-in Wi-Fi. To connect, press the silver button on the front of the Satlink3 logger and a blue light will flash. Search for the Wi-Fi hotspot created and connect to it. Open the LinkComm app and connect to the logger. If using the laptop software, ensure Station Wi-fi is selected as the connection type. Laptops can also connect using a micro-USB cable. In this case, select USB as the connection type.

The data being logged by the Satlink3 can now be viewed.

Install the radar sensor protective covers (Figure 51) over the radar sensors and secure onto the radar arms.

Figure 51 Radar protective cover.

Attach the turnbuckle to the radar arm and secure in place with the split pin. Once the extended length of the turnbuckle is known, the seaward end of the threaded rod can be wrapped in Denzo tape to protect against corrosion. This may require temporarily swinging the arm seaward to determine the extension length required.

Figure 52 Turnbuckle attached to the radar arm.

Swing the radar arm outwards so it extends over the sea. Fit securing bolts to the radar arm hinge point (Figure 20). Attach the landward end of the turnbuckle to the anchoring point on the GNSS mast.

Check the radar arm to ensure it is level when extended out over the sea. If the radar arm and sensors were levelled properly in section 3d, the radar sensors should be level once the radar arm is level. This can be checked by swinging the arm inland and checking the levels again.

Adjust the turnbuckle to get the arm level and ensure it is secured. Apply Denzo tape to the turnbuckle and anchor bolts where they pass through the GNSS mast foot plate.

Figure 53 Denzo tape applied to turnbuckle and bolts.

Check the operation of the installation, especially all the cables running from the GNSS mast to the green cabinet.

6. Cementitious Grout

To add extra stability to the GNSS mast installation, a cementitious grout is poured beneath the mast base.

A casting mould has been shipped out and needs to be placed around the base of the monument. Seal the base of the mould to the quayside using silicon sealant and allow to set.

Mix up the Fosroc grout in the tub supplied using the mixing paddle to the correct consistency. The grout is quite runny when mixed as it needs to flow beneath the base of the monument to provide support.

Pour the grout in so that it fills the mould up to the bottom of the base of the GNSS mast (Figure 54).

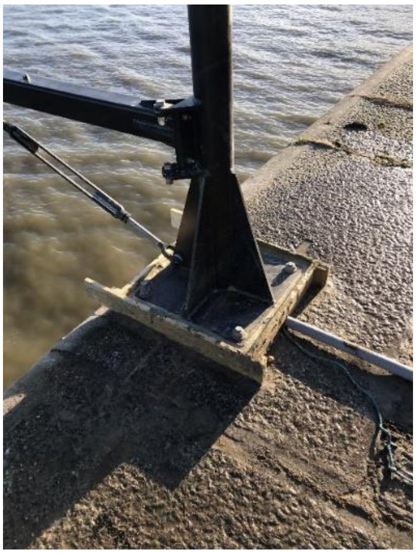


Figure 54 Mould filled with cementitious grout.

Figure 55 Finished installation with grout base.

Leave the grout to set and harden. Remove the wooden mould and clean the area.

This task should ideally be undertaken once the mast is vertical and before attaching the radar arm.

7. Surveying

A brass domed benchmark (supplied) should be installed on the cliff top, near to the monument for survey levelling purposes.

The height difference measurement between the cliff top benchmark and the radar arm benchmark must be recorded. A survey level, staff and tripod will be required for this purpose.

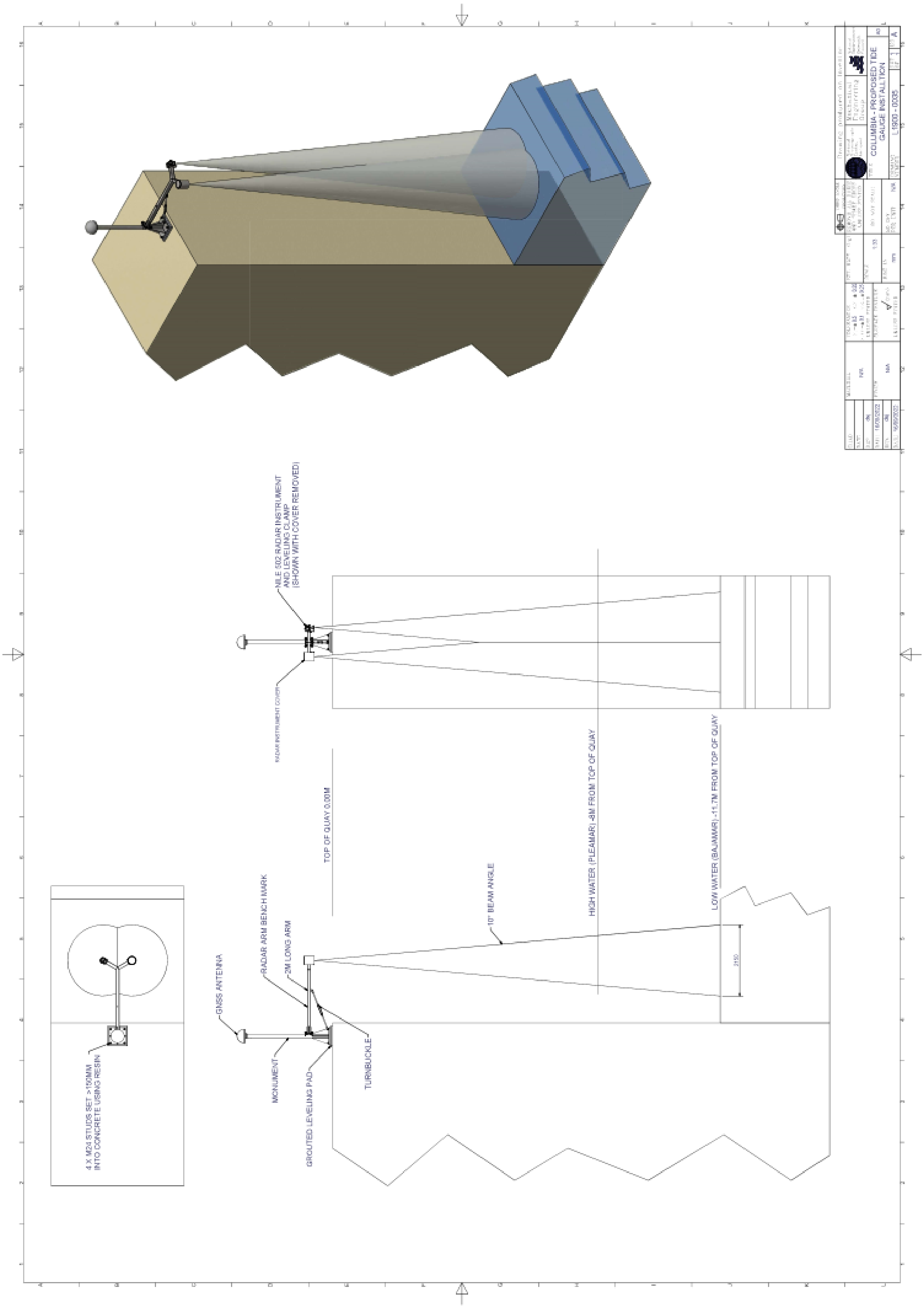
8. Final checks

Before leaving the tide gauge site after installation is finished, complete the following checks:

- Ensure the system is powered up correctly using the procedure described in this document.
- Use LinkComm to check for data being logged by the Satlink3.
- Check for an internet connection by connecting to the Teltonika RUT955 4G router Wi-Fi hotspot. (See APPENDIX 2)
- Contact Begoña Pérez Gómez at Puertos del Estado (bego@puerto.es), to check for data arriving onto OSPAC.
- Check the IOC website for data transmitted via satellite being published on their website (or contact NOC to verify this).

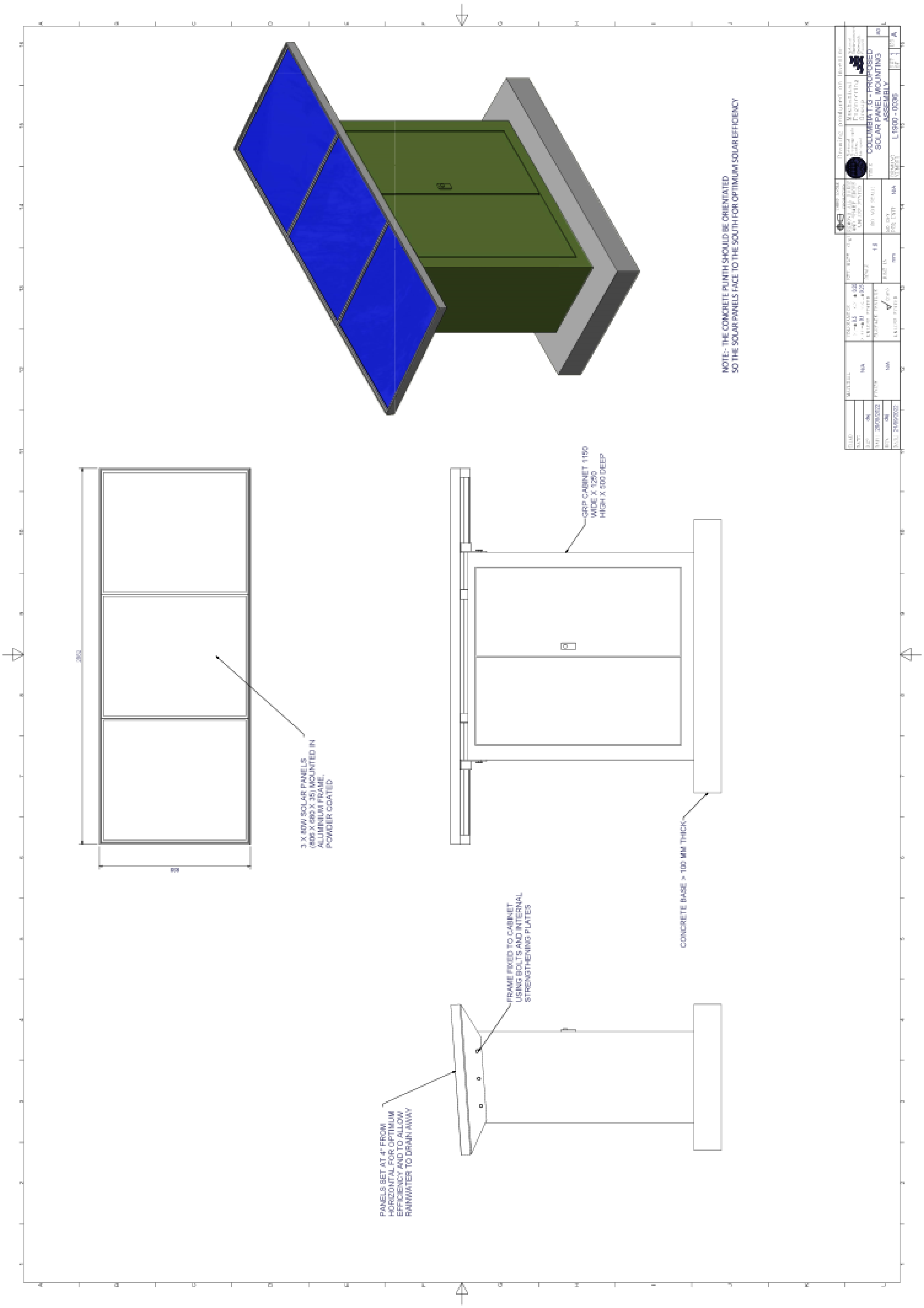
- Login to the Trimble GNSS (see APPENDIX 2) and check that data is being logged. If not, enable logging or request Simon Williams (NOC) to remotely access the system and enable it.

APPENDIX 1 – MECHANICAL DESIGN



EuroSea

National Oceanography Centre



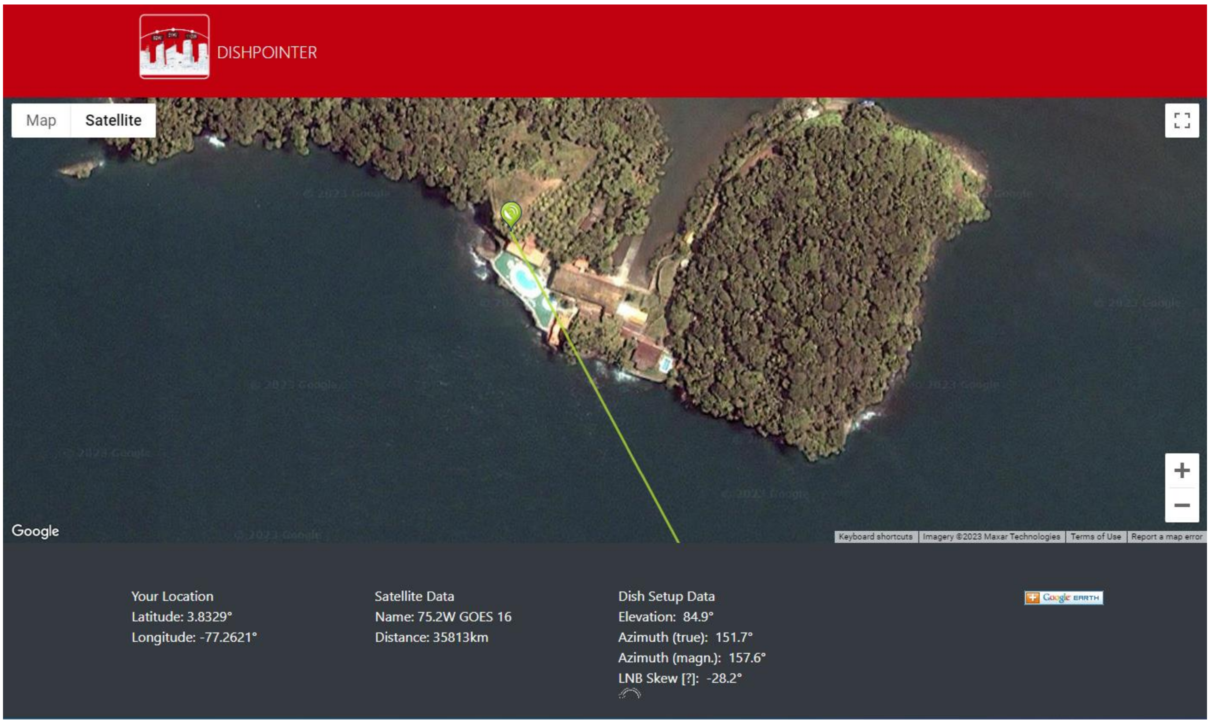
APPENDIX 2 – LOGIN INFORMATION

Tide Gauge RUT955
IP Address: 192.168.1.1
Username: admin
Password: EuroSColom22
Wi-Fi SSID: RUT955_3EC8
Wi-Fi Password: Pi3h4B9A

Tide Gauge Raspberry Pi
IP Address: 192.168.1.246
Username: stma
Password: EuroSColom22
Anydesk number: 502 608 620
Password: EuroSColom22

Trimble Alloy:
Username: admin
Password: 6042r40073!
Wi-Fi Access Point SSID: 6042R40073
Wi-Fi Password: 6042r40073!
IP Address: 192.168.142.1 Wi-Fi
IP Address: 192.168.1.70 Ethernet

APPENDIX 3 - SATELLITE TRANSMISSIONS



EuroSea
Manual de instalación del mareógrafo

Buenaventura

Geoff Hargreaves
Centro Nacional de Oceanografía

Proyecto EuroSea: Instalación de mareógrafos enColombia

El equipamiento de EUROSEA consta de:

- Un monumento de antena de acero del Sistema Global de Navegación por Satélite (GNSS en inglés), además de una extensión de brazo de acero para montar sensores de nivel de agua de radar duales.
- Una construcción de marco de acero para montar 3 paneles solares para proporcionar energía al sistema.
- Un gabinete de fibra de vidrio grande que contiene equipos electrónicos para registrar datos de los sensores de radar y la antena GNSS.

1. Descripción

El mareógrafo consiste en radares duales ubicados junto con un sistema GNSS de alta especificación. La antena GNSS se conecta al mismo mástil que los radares para que una vez nivelado el medidor; el GNSS puede actuar como una corrección para cualquier cambio posterior en los datos del radar.

El mareógrafo funciona con baterías que se cargan utilizando energía renovable. Un banco de cuatro baterías de 38Ah se carga desde una matriz de tres paneles solares de 80W.

La especificación del mástil GNSS hace que se comporte como un monumento. Esto debería ayudar a minimizar el movimiento en la estructura que podría afectar a las señales de radar y a las GNSS, causando lecturas erróneas.

El gabinete del equipo debe montarse sobre una base de concreto firme, con el marco del panel solar fijado al gabinete. Los paneles solares (y por lo tanto el gabinete) están orientados al sur para maximizar el potencial de recolección de energía solar. El ángulo de elevación del panel solar se ha establecido para un funcionamiento óptimo durante los meses de primavera / otoño debido a la latitud del sitio de instalación. El sol pasa por encima de Norte a Sur a medida que la estación cambia de verano a invierno, y de Sur a Norte durante la transición de invierno a verano.

El sistema tiene un transmisor GOES y una antena Yagi, así como comunicación 4G para la recuperación de datos. La antena Yagi está situada junto al gabinete verde.

2. Ubicación

El mareógrafo se instalará en el sitio del Hotel Maguipi, cerca de Buenaventura. El círculo rojo en la Figura Figura 34 indica la ubicación del Figura 4

Figura 1 Hotel Maguipi.

Figura 2 Buenaventura, Colombia.

Figura 3 Ubicación del mástil GNSS y el gabinete de equipos en el Hotel Maguipi.

Figura 4 Sitio de instalación del mástil GNSS rodeado en rojo.

El gabinete del equipo se instalará sobre una base firme, como una losa de concreto fundido y los paneles solares se montan en un marco de metal ubicado sobre el gabineteFigura 55).

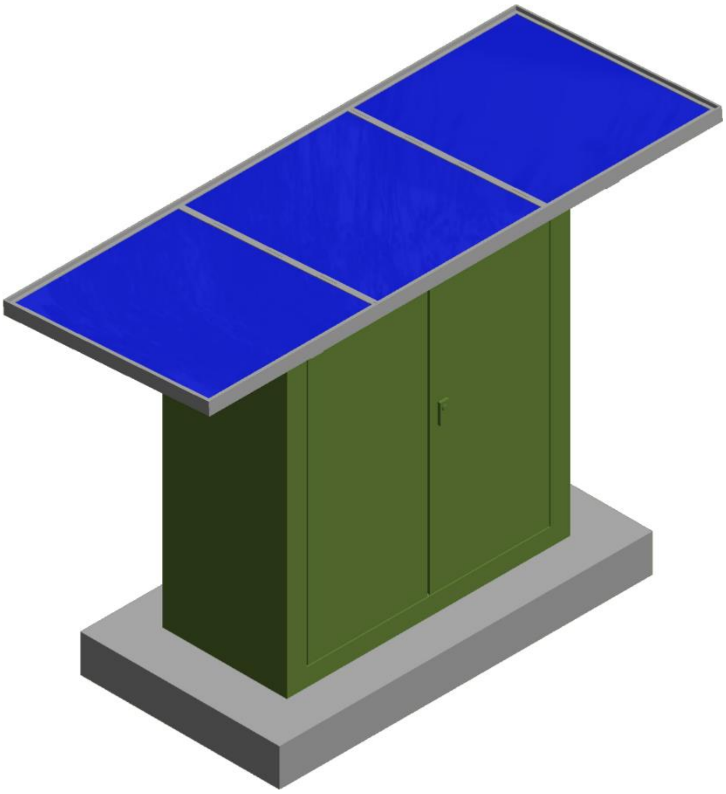


Figura 5 Imagen del armario del equipo instalado sobre unabase concreta, con paneles solares montados en la parte superior.

Las siguientes fotografías muestran el monumento GNSS y el conjunto del brazo de radar instalado en Birkenhead, que es similar al que se está instalando en Buenaventura. El brazo del radar está diseñado para oscilar para permitir el mantenimiento de los sensores y facilitar la instalación. El brazo está diseñado para girar hacia la izquierda o hacia la derecha, dependiendo del sitio de instalación.

Figura 6 El brazo del radar giró hacia adentro en Alfred Dock, Birkenhead, Reino Unido.

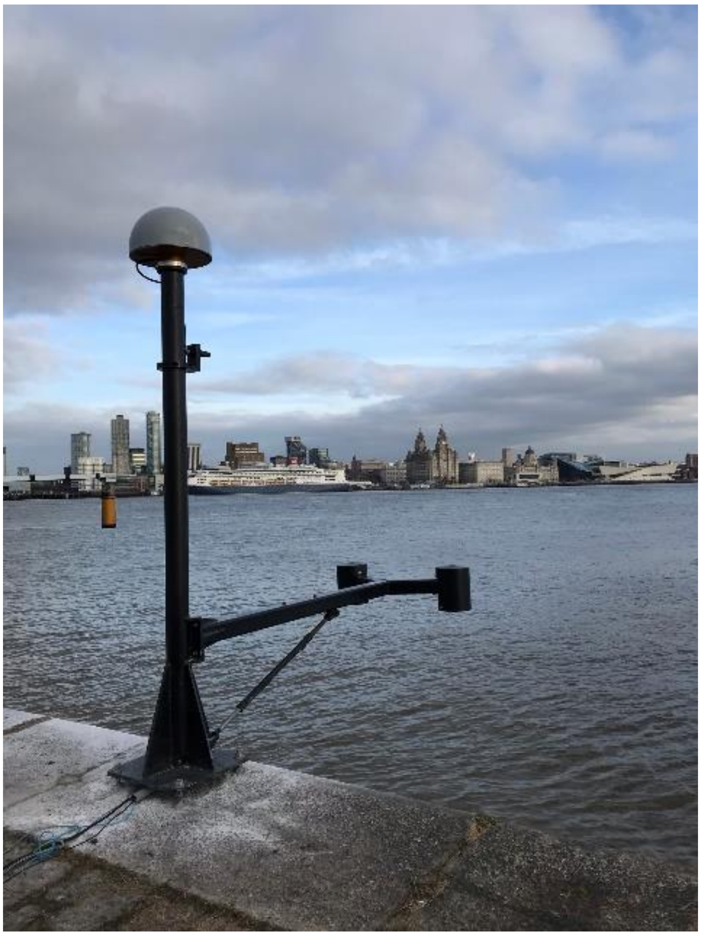


Figura 7 Brazo de radar en posición exterior.

3. Instalación

La instalación principal consistirá en establecer una base de hormigón sólido para el gabinete del equipo e instalar el mástil GNSS cerca del borde del acantilado o risco. Se requerirá equipamiento de instalación (no suministrado) para asegurar el mástil GNSS y el gabinete en su lugar. El tipo de fijaciones requeridas dependerá de la composición del terreno en el sitio de instalación. El método recomendado para la instalación sobre hormigón o piedra se describe en este documento.

El límite máximo del tendido de cable entre el mástil GNSS y el gabinete del equipo es de 70 m, esto incluye la altura del mástil de la antena de aproximadamente 2.8m.

Se suministran secciones de conducto para facilitar el acceso del cable al mástil GNSS y al gabinete del equipo. Se suministran dos tamaños, junto con conectores. Los orificios de acceso necesitarán ser perforados a un lado del gabinete del equipo durante la instalación para permitir la entrada del cable desde el mástil GNSS.

Se requerirá un conducto adicional para enrutar los cables entre el mástil y el gabinete. El sistema utilizado dependerá de los requisitos locales y de la ruta tomada.

a. Mástil GNSS

Marque la ubicación de la base del mástil GNSS y perfore cuatro agujeros de 25 mm a una profundidad de aproximadamente 200 mm. Limpie el polvo de los orificios utilizando el dispositivo soplador suministrado. Asegúrese de que los orificios estén perforados verticalmente.

Antes de instalar el mástil GNSS, lea la Sección 3b sobre la instalación de la antena GNSS.

Mueva el mástil GNSS a su posición y levante del suelo utilizando trozos de madera. Se pueden utilizar secciones de madera de las cajas de envío. Cuerdas se pueden utilizar para estabilizar el mástil, para evitar que se caiga en el mar.

Utilizando varilla roscada galvanizada M24 de 300 mm de longitud, páselos a través de la placa base del mástil GNSS y verifique la alineación dentro de los orificios, de modo que quede en posición vertical. Retire la varilla roscada, elimine el polvo de los orificios y llene ¼ del orificio con la resina epóxica acrílica utilizando la pistola suministrada. La resina es una mezcla de dos partes, con la mezcla que se produce en la boquilla dela pistola suministrada. . La resina se endurece rápidamente en condiciones de calor, por lo que este proceso deberá completarse rápidamente.

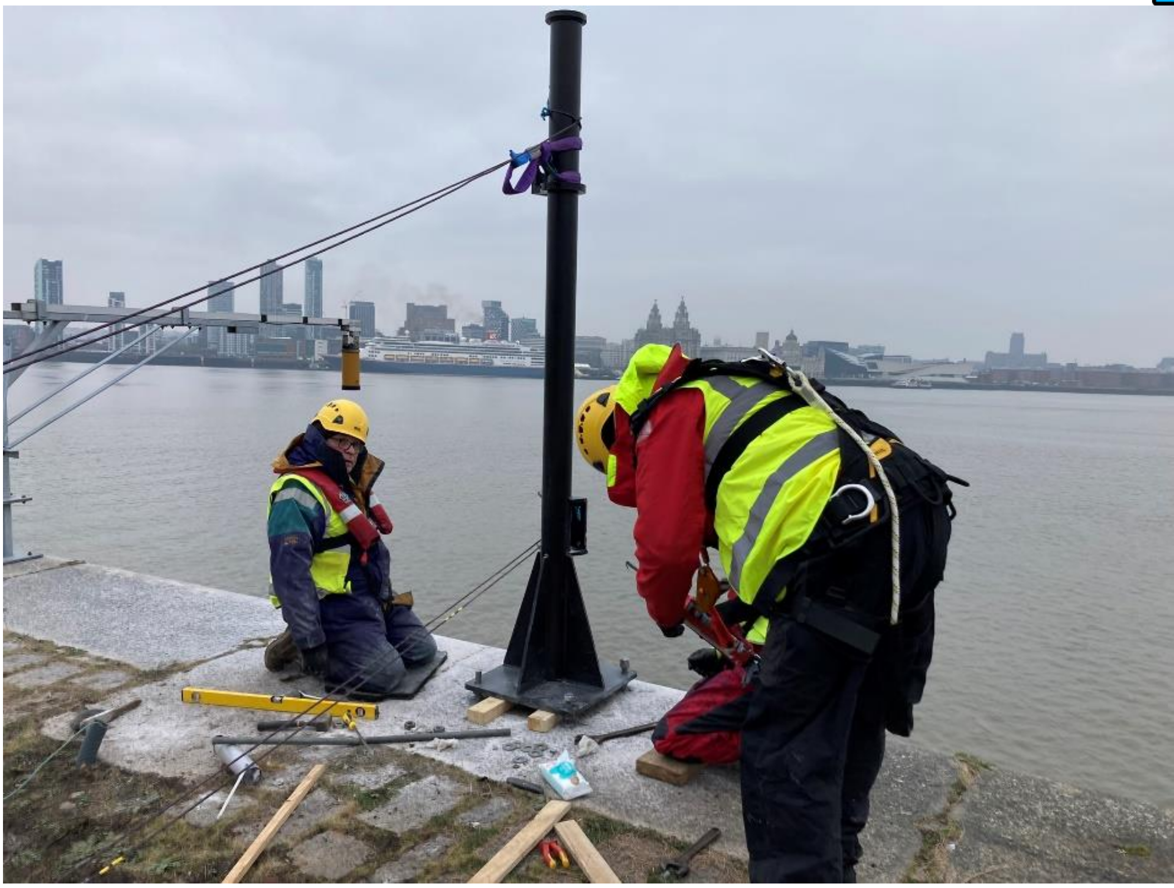


Figura 8 Instalación de pernos para mástil GNSS.

Figura 9 Pernos de anclaje del mástil GNSS.

Pase la varilla roscada galvanizada M24 de 300 mm de largo a través de la placa base del mástil GNSS, fijando una tuerca y una arandela debajo de la parte inferior de la placa antes de que entre en el orificio y atornille la varilla en el agujero, manteniendo la tuerca y la arandela justo debajo de la placa base. La varilla roscada galvanizada se puede fijar en el orificio fijando dos tuercas a la parte superior y bloqueándolas (Figura 9).

Mueva cada varilla hacia abajo en la resina hasta que llegue al fondo del orificio desplazando la resina hasta la parte superior (Figura 9). Limpie cualquier exceso de resina.

Ajuste la tuerca/arandelas superiores a cada varilla roscada y una vez que la resina se haya endurecido, ajuste las tuercas inferiores hasta que el mástil esté perfectamente vertical (Figura 11). Asegure las tuercas superiores para evitar el movimiento y verifique nuevamente la alineación vertical.

Aplique la lechada al vacío debajo del mástil GNSS. **Consulte la Sección 6 para obtener más información.**

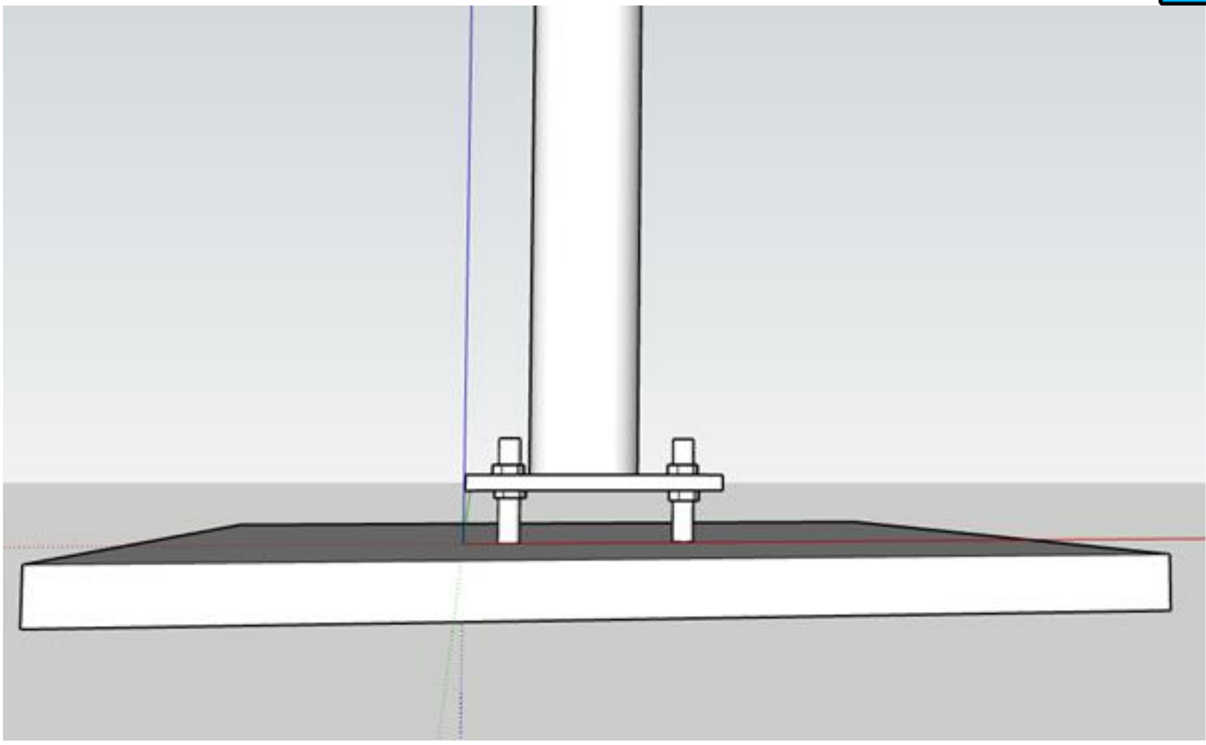


Figura 10 Instalación del mástil GNSS para quedar perfectamente vertical.

Figura 11 Nivelación del mástil GNSS.

b. Antena GNSS

La antena GNSS se puede instalar en esta etapa, o se puede instalar antes de que sea erguido el mástil. Unavez instalado el mástil, se requiere una escalera o plataforma para colocar la antena en la parte superior del monumento. **Es más fácil colocar** la antena en el mástil **antes** de **que este sea colocado en posición, pero se debe tener cuidado para evitar daños a la antena durante la** instalación **del mástil.**

Para instalar la antena, ubique el perno de montaje y atorníllelo completamente en la antena. Instale el radomo en la antena. Ofrezca cuidadosamente la antena hasta el mástil y gire suavemente la antena para que encaje en el perno roscado en la parte superior del mástil. Es más fácil y seguro si dos personas hacen esta operación, especialmente cuando se instala la antena con el mástil ya en su lugar, ya que hay menos posibilidades de que la antena caiga al mar.

c. Gabinete del equipo

Asegúrese de que el gabinete del equipo esté instalado en una superficie plana sólida, como una base de concreto fundido hecho a la medida. Coloque el gabinete verde en su posición y perfore un orificio de fijación en cada esquina de la base para asegurarlo en su lugar. Se pueden usar orificios de fijación adicionales a lo largo de los lados. Marque la ubicación del gabinete en la base con un rotulador. Mueva el gabinete y apliquesellador de marco a la superficie de concreto para que el gabinete se asiente sobre él una vez reposicionado. Esto ayudará a sellar la base del gabinete para evitar la entrada de agua. Para ayudar a colocar el gabinete sobre el silicón, use bloques de madera para sostener el gabinete a medida que se mueve en su lugar, antes de bajarlo sobre el sellador. Sujete el gabinete a la base de concreto usando los pernos de anclaje. Se suministran tiras angulares de aluminio, que deben instalarse entre la fibra de vidrio del armario y los elementos de sujeción, para garantizar una fijación fuerte y segura a la base (figura Figura 40 Se puede colocar una cuenta adicional de sellador alrededor del exterior del gabinete donde entra en contacto con la base de concreto.

Instale el conducto desde el gabinete hasta el mástil GNSS para evitar la entrada de agua en el gabinete. Perfore un orificio del tamaño adecuado en el gabinete, en la mejor ubicación para que el cable salga del mástil GNSS y coloque el conector y el conducto en su lugar (como en la Figura Figura 12 **Se requiere un conducto adicional para completar la distancia completa entre el mástil GNSS y el gabinete.**

Figura 12 Prensaestopas para conducto. La ubicación de los orificios de entrada debe determinarse durante la instalación.

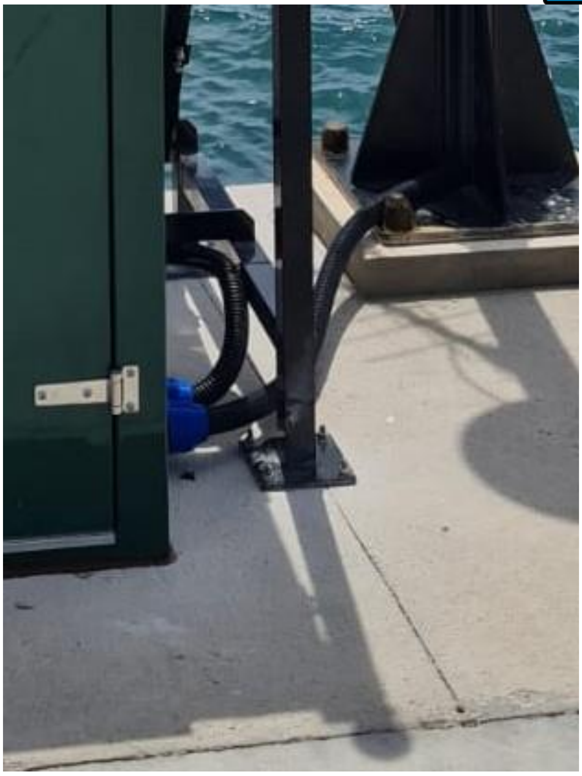


Figura 13 Conducto desde el gabinete hasta el mástil GNSS.

Instale el panel solar en la parte superior del gabinete. El panel solar se asegura en su lugar mediante pernos que pasan a través del marco y hacia el costado del gabinete. Se utiliza una pieza de soporte rectangular negra para proporcionar resistencia donde los pernos del panel solar entran en el gabinete (Figura 14).

Figura 14 Pieza de soporte del marco del panel solar.

Los cables del panel solar pasan a través de conductos (Figura 15) que se conectarán al gabinete en el lado izquierdo, cerca de la parte superior. Corte las bridas que sujetan el conducto al panel solar (Figura 34Figura 34 los cables a través del orificio del gabinete, asegurando el conector del conducto en su lugar (Figura 16Figura 16 Conecte el conducto al marco del panel solar, como se muestra en la Figura 15.

Figura 15 Conducto del cable del panel solar.

Figura 16 Entrada del cable del panel solar.

d. <u>Brazo de radar y sensores</u>

Monte el brazo del radar en el mástil GNSS utilizando los pernos suministrados. Asegúrese de que el brazo esté balanceado hacia el muelle/tierra adentro/interior y apoyado de manera que esté nivelado mientras monta el brazo del radar al mástil(Figura Figura 17Figura Figura 23)). Use un nivel de burbuja para asegurarse de que el brazo esté nivelado.

Figura 17 Brazo de radar instalado y balanceado tierra adentro.

Figura 18 Nivelación del brazo del radar.

El brazo está diseñado para girar hacia la izquierda o hacia la derecha, dependiendo de la dirección que funcione mejor en el lugar de instalación.

Figura 19 Pernos de montaje del brazo de radar.

Figura 20 Pernos de montaje del brazo de radar.

Coloque los sensores de radar en la abrazadera de montaje (Figura 21Figura 21 (Figura Figura 22), haciendo pasar los cables del sensor a través del brazo. Alimente estos cables en la sección recta principal del mástil y tire de ellos a través del conducto hacia el gabinete verde. Si el brazo del radar está nivelado (verifique esto usando un nivel de burbuja), el nivel de burbuja en cada sensor de radar debe estar centrado. Ajuste según sea necesario hasta que el brazo del radar y los sensores de radar estén nivelados en todas las direcciones (Figura 23 y Figura 24).

Figura 21 Sensor de radar conectado a la abrazadera de montaje.

Figura 22 Sensor de radar instalado en el brazo del radar.

Es importante que las placas de montaje del sensor del radar estén niveladas cuando el brazo del radar también esté nivelado, ya que esto asegurará que el haz de radar viaje verticalmente a la superficie del mar. Estos ya han sido nivelados antes del envío, pero deben verificarse. Una vez desplegado, el nivelado del brazo del radar debera ser comprobrado de nuevo.

Figura 23 Instalación de los sensores de radar.

Figura 24 Sensor de radar que muestra el nivel de burbuja y los tornillos de ajuste.

Figura 25 Nivelación del brazo del radar.

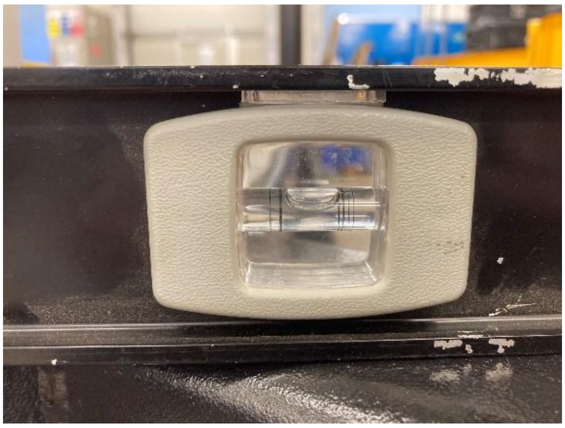


Figura 26 Nivelación del brazo del radar.

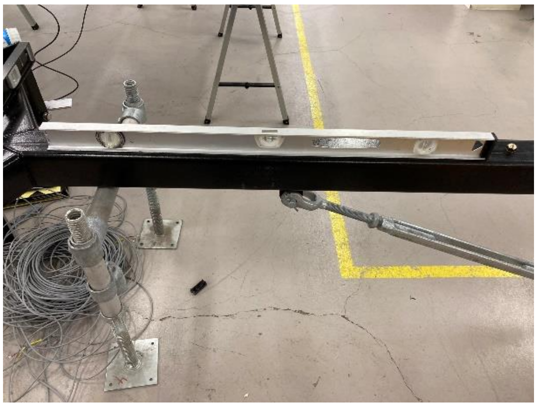


Figura 27 Nivelación del brazo del radar.

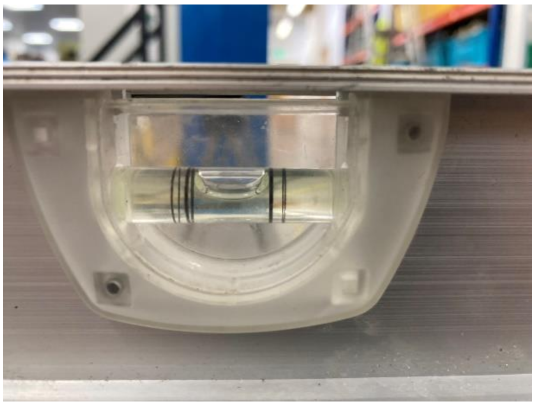


Figura 28 Nivelación del brazo del radar.

e. Cables coaxiales

El cable de antena GNSS ahora se puede tirar a través del conducto entre el mástil GNSS y el gabinete del equipo. Los cables coaxiales pueden dañarse fácilmente al tirar de ellos a través del conducto. Asegúrese de que el cable no se pliegue o se tuerza.

El cable GNSS pasará por el centro del mástil y emergerá a través de la ranura en la parte superior, cerca de la antena. Conecte el cable a la antena. El otro extremo del cable se introduce en el gabinete verde.

Ensamble la antena Yagi (los elementos de antena y las ubicaciones en las que encajan están numerados) y conéctela a la abrazadera de la antena (Figura Figura 29

Figura 29 Antena Yagi montada.

Localice el poste del andamio y colóquelo en la abrazadera que está montada en el extremo del marco del panel solar (flecha roja en la Figura 30). Localice el cable coaxial de la antena.

Conecte el cable a la antena y diríjalo a través del conducto para ingresar al gabinete verde. Asegúrese de que el agua no pueda ingresar al conducto desde los cables expuestos creando un bucle en el cable antes de que ingrese al conducto.

Figura 30 Mástil de antena Yagi (flecha amarilla) y abrazadera de mástil (flecha roja).

Figura 31 Punto de fijación del mástil de antena Yagi.

Alinee la antena de acuerdo con laFigura 32

- Elevación 84.9°
- Acimut 157.6° Magnético

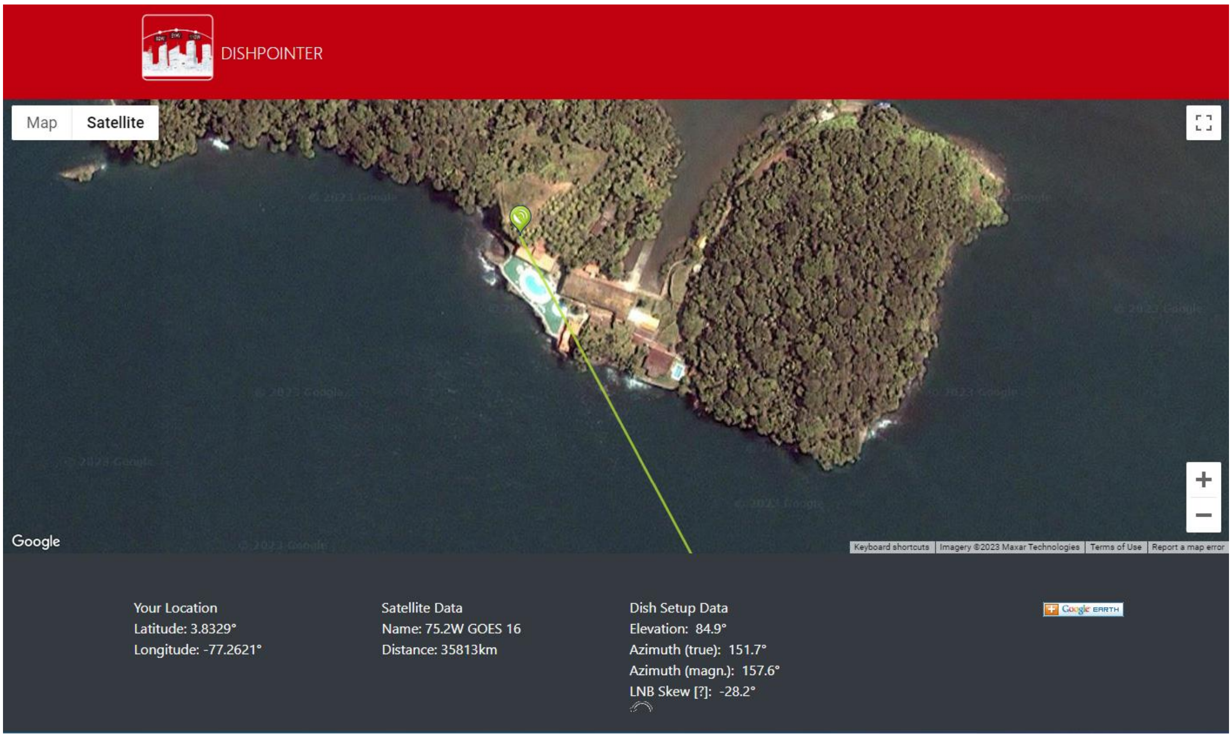


Figura 32 Alineación de la antena Yagi del satélite GOES.

f. Paneles solares

Los paneles solares se envían preinstalados en el marco de montaje (Figura 30). Los tres paneles solares están conectados en la siguiente disposición: dos en serie y uno independiente (Figura 33). Los cables del panel solar están preinstalados en los paneles y están etiquetados como S1 y S2 (Figura 34). **No conecte el panel solars al sistema principal.**

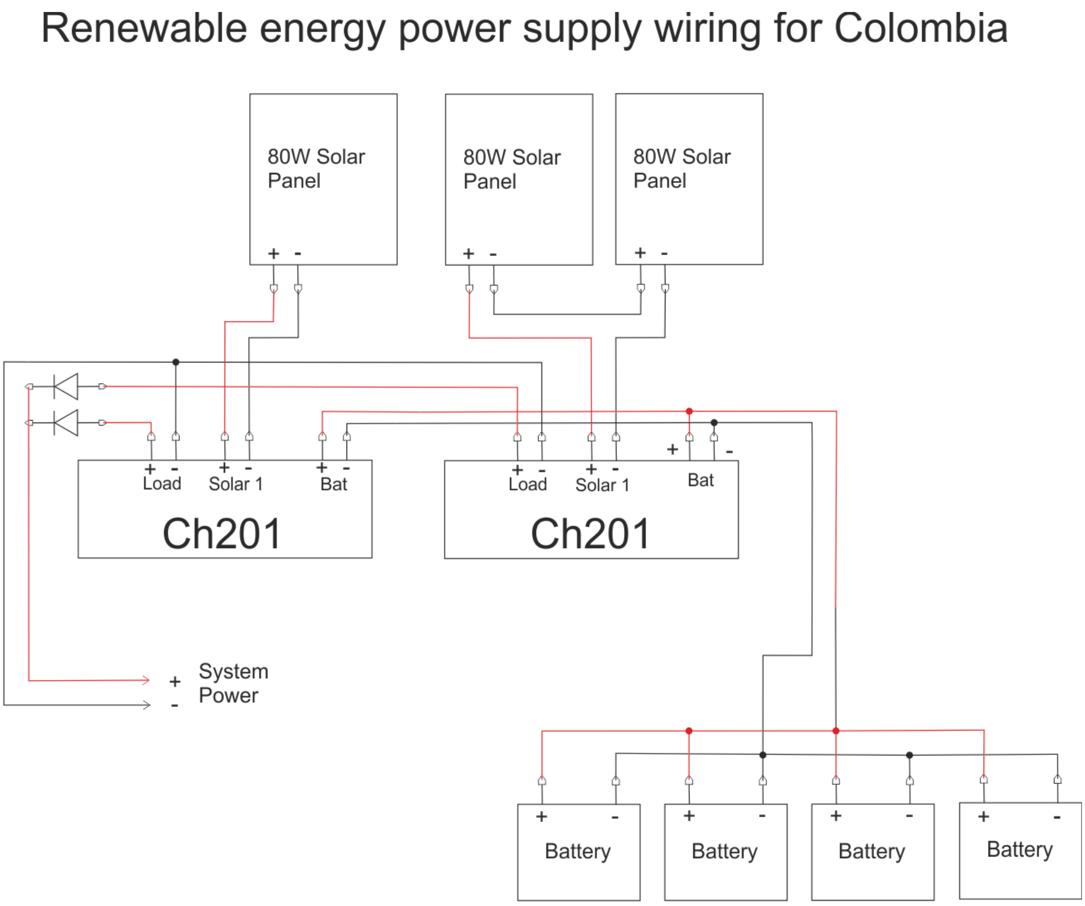


Figura 33 Paneles solares y baterías.

Figura 34 Cables de paneles solares.

g. Conducto

Todos los cables que entran en el gabinete verde lo hacen a través de un conducto. Para evitar que el agua entre en el gabinete verde a través de los conductos, los cables que están expuestos a la intemperie deben ingresar al conducto a través de un "lazo de cuello de cisne". Este es un bucle creado en el cable antes de que entre en el conducto, donde el nivel inferior del bucle está por debajo del nivel de entrada del conducto. Esto permitirá que el agua de lluvia corra por el exterior del cable y gotee desde la parte más baja del bucle antes de que entre en el conducto. Esto también se aplica a los cables que entran en el mástil GNSS.

h. Cables

Los cables del monumento GNSS y el panel solar se pasan a través de conductos para proporcionar protección contra el clima y la vida silvestre. La conectividad de la instrumentación se ha mantenido lo más simple posible y consiste en enrutar los cables a través del conducto y conectarlo al conector correcto.

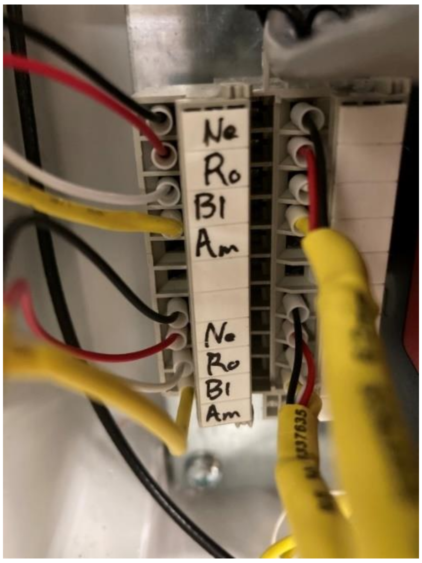


Figura 35 Bloque de unión del sensor de radar.

Figura 36 Conector de antena Meteosat Yagi y cables de radar.

Pase los cables grises del sensor de radar a través de la entrada en la parte inferior de la carcasa (flecha roja en la Figura 36 Conector de antena) y conéctelos al bloque de terminales. Los cables del radar están conectados al color correspondiente en el bloque de terminales (Figura 35).

El rojo es +Ve (positivo)

El negro es -Ve (negativo)

El blanco son datos SDI-12.

El amarillo es shield (protección/blindaje)

Al conectar los sensores de radar al bloque de terminales, tome nota de qué sensor de radar (izquierdo o derecho, cuando se ve mirando hacia el mar) está conectado a la sección superior e inferior del bloque de terminales. Idealmente, el sensor de la izquierda debe estar conectado a la parte superior y el sensor de la derecha conectado a la parte inferior, como en la Figura 35.

El cable de antena Yagi está conectado al conector plateado de la Figura 36 Conector de antena después de retirar el dispositivo negro de «carga ficticia».No confunda el cable de antena Yagi con el cable de antena GNSS.   El cable GNSS está etiquetado con LMR-400-DB en su longitud.

Los cables del panel solar se conectarán a los cables de cola que se muestran en la Figura 37 durante la puesta en marcha del mareógrafo. **No los conecte ahora.**

Figura 37 Conector del panel solar

La antena GPS de bala Trimble (Figura 38) está conectada al conector SMA de color dorado adyacente al conector tipo N de la antena YagiFigura 38Figura 36Figura 36 Conector de antena izquierdo en el gabinete verde.

Figura 38 Antena GPS de bala Trimble.

El cable de antena GNSS está conectado al protector contra sobretensiones en la carcasa GNSS (Figura 39), gabinete derecho.

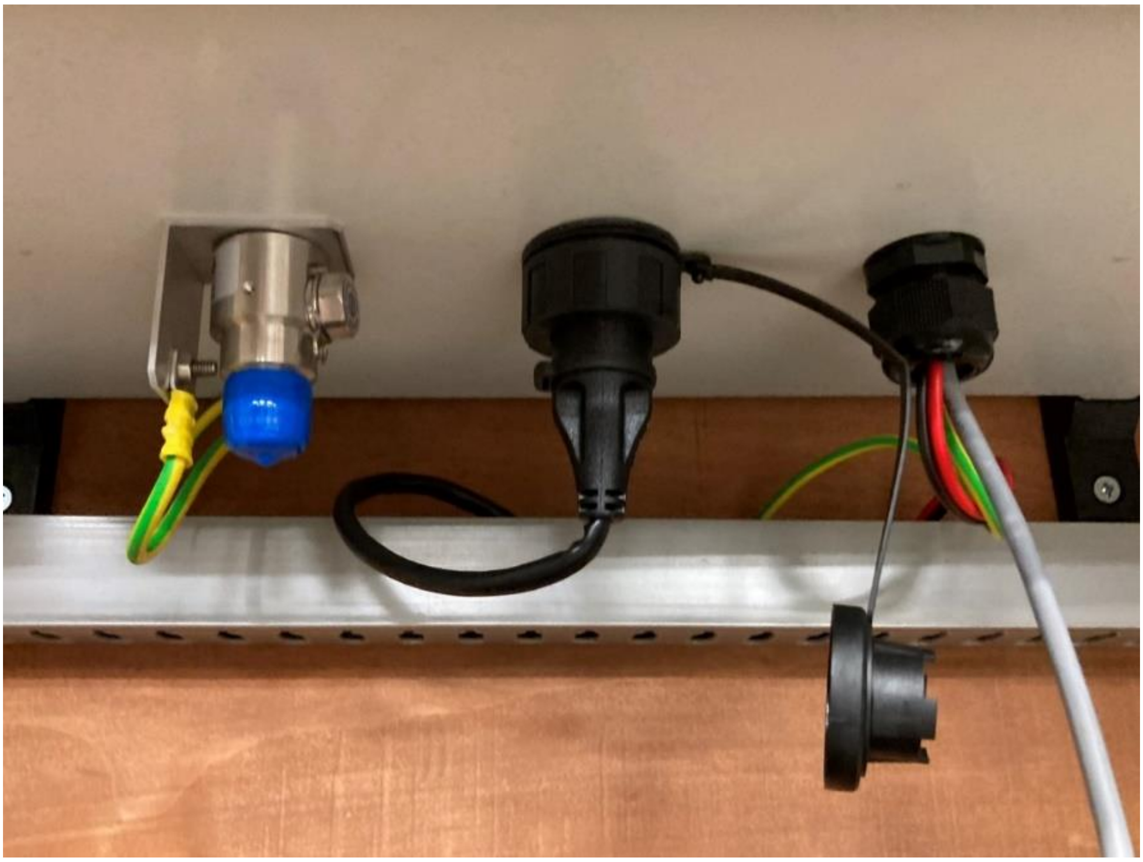


Figura 39 Protector contra sobretensiones GNSS.

i. **Baterías**

Coloque las cuatro baterías de cristal de plomo dentro del gabinete verde (Figura 40). Utilizando los cables de interconexión de baterías suministrados, conecte las baterías en paralelo (Figura 41). Localice los cables de alimentación para ambos gabinetes y **retire los fusibles mini tipo cuchilla**, anotando la clasificación de fusibles para cada gabinete. Conecte los cables de alimentación, rojo a +ve y negro a -ve. Los cables de alimentación deben conectarsea través de todo el banco de baterías y no sólo a una batería (Figura 41). Esto asegurará que la carga de la batería se realice de manera óptima.

PRECAUCIÓN: Se debe tener cuidado al conectar las baterías para evitar cortocircuitos en los terminales. El cortocircuito de los terminales de la batería hará que fluya una gran corriente, creando chispas y podría dañar las baterías.

Figura 40 Baterías de cristal de plomo que muestran los cables de alimentación conectados a través del banco de baterías.

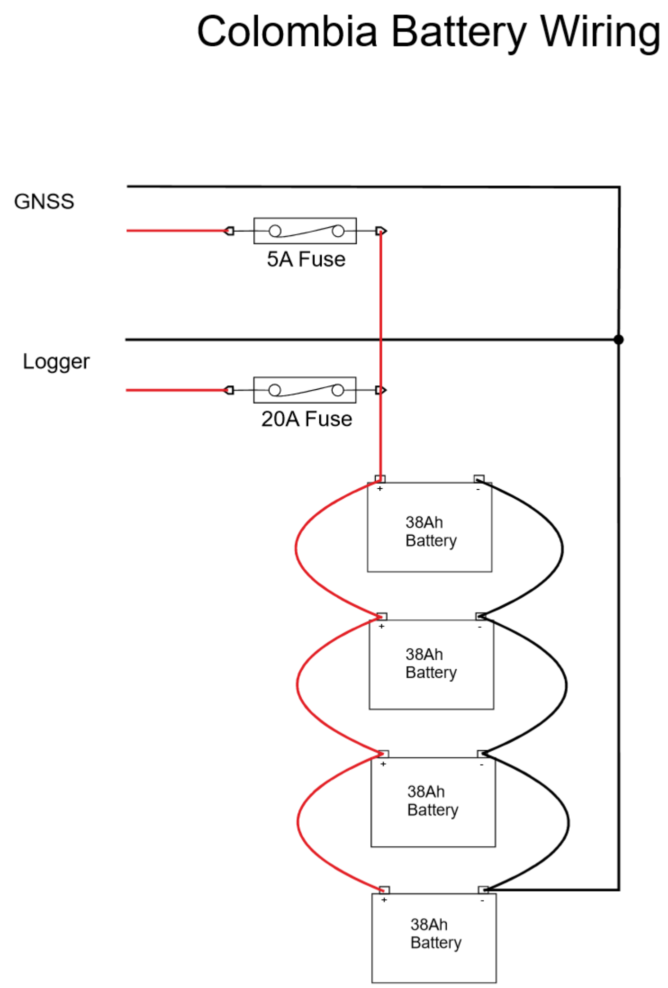


Figura 41 Conexiones de baterías.

4. **Puesta en marcha del mareógrafo**

   a. Asegúrese de que todos los sensores, antenas, cables y conectores estén conectados durante el proceso de instalación.

   b. Asegúrese de que la antena Yagi esté conectada al conector de tipo N (Figura 36 Conector de antena) antes de continuar. **Encender el sistema sin la antena Yagi o la carga ficticia instalada, se dañará el transmisor Satlink3.**

   c. Instale la tarjeta SIM Mobius 4G en el router Teltonkia RUT955

Figura 42 Ubicación de la tarjeta SIM en el router RUT955.

Figura 43 Recinto del registrador.

   d. Abra **TODOS los** disyuntores dentro de ambos gabinetes (Figura Figura 44Figura Figura 45

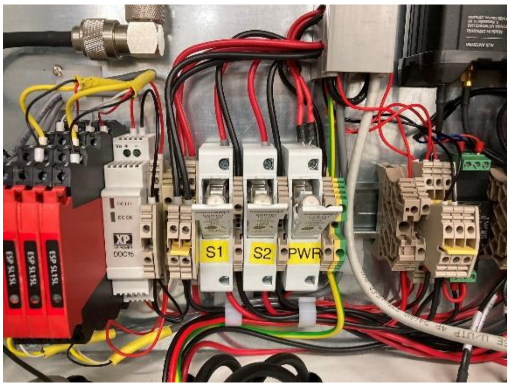


Figura 44 Fusibles de la carcasa del registrador en posición abierta.

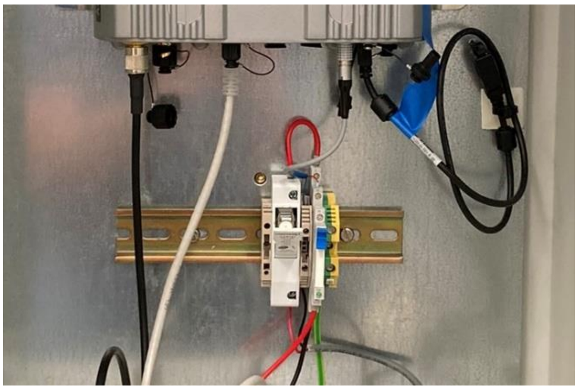


Figura 45 Fusible de la carcasa GNSS en posición abierta.

   e. Conecte los cables del panel solar a los conectores del extremo trasero (Figura 46). Tenga cuidado de no mezclar los cables positivos y negativos del panel solar de diferentes matrices. Los cables están etiquetados como S1 y S2.

Figura 46 Cables del panel solar conectados al sistema.

f. Inserte los fusibles mini tipo cuchilla en los soportes, asegurándose de que se utiliza el fusiblecorrecto. Consulte la Figura 41 como referencia.
g. Cierre los interruptores de fusible S1 y S2 dentro de la carcasa izquierda. Esto aplicará el voltaje de salida del panel solar Figura 4747).El LED CHG comenzará a parpadear en verde si los paneles solares producen suficiente energía para cargar las baterías (Figura 48). El CH201 está equipado con un pequeño interruptor plateado para aislar la potencia de la carga. Asegúrese de que esté configurado en la posición **ON** en ambas unidades.

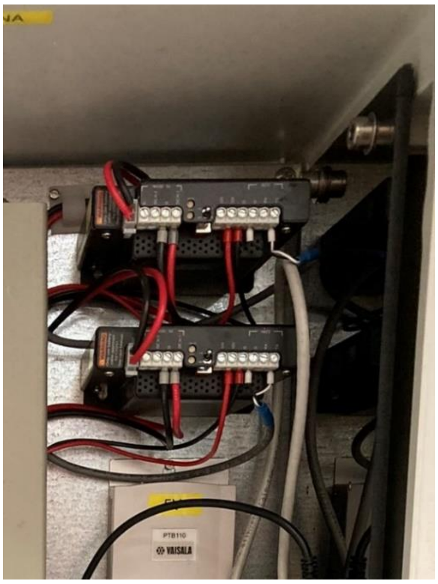


Figura 47 Controladores de carga solar.

Table 7-7: CHG LED

Condition	Color/state
No valid charge source	Off
Valid charge source and charging battery	Flashing green
Valid charge source but battery discharging	Flashing orange
Regulator fault detected	Flashing red
Waiting for new operating system (Downloading an operating system (p. 31))	Solid red
Transferring operating system	Solid green

Table 7-8: CK BAT LED

Condition	Color/state
Battery voltage > 11.5 V	Off
10.5 V ≤ battery voltage ≤ 11.5 V	Flashing orange
Battery fault detected OR battery voltage < 10.5 V	Flashing red

Figura 48 Estado del LED CH201.

h. Cierre el interruptor etiquetado PWR para encender el mareógrafo. El sistema ahora se pondrá en marcha y comenzará a funcionar.
i. Los sensores de radar se encenderán y eventualmente se mostrará un número en la pantalla LCD correspondiente a la distancia desde el sensor a la superficie debajo de él, ya sea la cima del acantilado si el brazo del radar se balancea hacia tierra o la superficie del mar durante el funcionamiento normal. Compruebe que esto funciona correctamente y que el número que se muestra parece razonable. Debe

proporcionar una lectura que sea la distancia al nivel del piso de concreto (suponiendo que el brazo del radar se balancee hacia el interior).

j. Cierre el interruptor en la carcasa GNSS para encender el sistema GNSS de Trimble. La pantalla se iluminará y el receptor debería comenzar a encontrar satélites y mostrar este número en la pantalla (Figura 49).

Figura 49 Pantalla operativa GNSS de aleación Trimble .

k. El sistema ya estará operativo.

5. <u>Finalización de la instalación</u>

Usando un medidor de voltaje digital, si está disponible, mida y registre los voltajes del panel solar y la batería en el bloque de terminales, ubicado en el lado derecho del gabinete (Figura 50), teniendo cuidado de no cortocircuitar los terminales. El voltaje de salida del panel solar variará según la cantidad de luz solar, pero generalmente alrededor de 20V.

Figura 50 Batería y bloque de terminales solares.

Los datos registrados por el registrador Satlink3 se pueden verificar descargando la aplicación LinkComm desde Apple App Store o Google Play Store para teléfonos inteligentes, o para una computadora portátil mediante https://www.otthydromet.com/en/Ott/p-sutron-linkcomm-software/LINKCOMM

El Satlink3 tiene Wi-Fi incorporado. Para conectarse, presione el botón plateado en la parte del registrador Satlink3 y una luz azul parpadeará. Busque el punto de acceso Wi-Fi creado y conéctese a él. Abra la aplicación LinkComm y conéctese al registrador. Si utiliza el software del portátil, asegúrese de que Station Wi-fi esté seleccionado como tipo de conexión. Las computadoras portátiles también se pueden conectar mediante un cable micro-USB. En este caso, seleccione USB como tipo de conexión.

Los datos registrados por el Satlink3 ahora se pueden ver.

Instale las cubiertas protectoras del sensor de radar (Figura 51) sobre los sensores de radar y asegúrelas en los brazos del radar.

Figura 51 Cubierta protectora del radar.

Fije el tensor al brazo del radar y asegúrelo en su lugar con el pasador dividido. Una vez que se conoce la longitud extendida del tensor, el extremo hacia el mar de la varilla roscada se puede envolver en cinta Denzo para proteger contra la corrosión. Esto puede requerir balancear temporalmente el brazo hacia el mar para determinar la longitud de extensión requerida.

Figura 52 Tensor conectado al brazo del radar.

Mueva el brazo del radar hacia afuerapara que se extienda sobre el mar. Ajuste los pernos de sujeción al punto de bisagra del brazo del radar (Figura 20). Fije el extremo hacia tierra del tensor al punto de anclaje en el mástil GNSS.

Verifique el brazo del radar para asegurarse de que esté nivelado cuando se extienda sobre el mar. Si el brazo del radar y los sensores se nivelaron correctamente en la sección 3d, los sensores del radar deben estar nivelados una vez que el brazo del radar esté nivelado. Esto se puede comprobar balanceando el brazo hacia el interior y comprobando los niveles de nuevo.

Ajuste el tensor para nivelar el brazo y asegurarse de que esté asegurado. Aplique cinta Denzo al tensor y los pernos de anclaje donde pasan a través de la placa del pie del mástil GNSS.

Figura 53 Cinta Denzo aplicada al tensor y pernos.

Compruebe el funcionamiento de la instalación, especialmente todos los cables que van desde el mástil GNSS hasta el armario verde.

6. Lechada cementicia

Para agregar estabilidad adicional a la instalación del mástil GNSS, se vierte una lechada cementicia debajo de la base del mástil.

Se ha enviado un molde de fundición que debe colocarse alrededor de la base del monumento. Sellar la base del molde al muelle con sellador de silicona y dejar cuajar.

Mezclar la lechada Fosroc en la bañera suministrada con la paleta mezcladora para obtener la consistencia correcta. La lechada es bastante líquida cuando se mezcla, ya que necesita fluir debajo de la base del monumento para proporcionar soporte.

Vierta la lechada para que llene el molde hasta el fondo de la base del mástil GNSS (Figura 54).

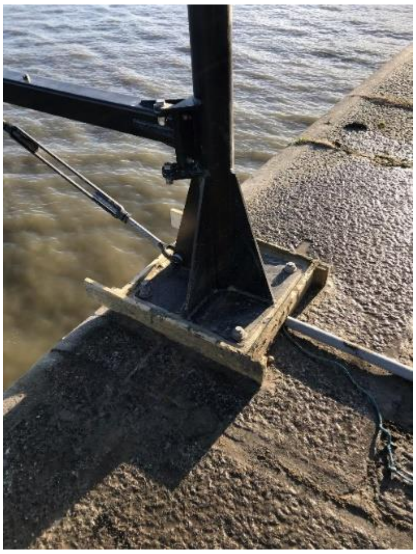


Figura 54 Moho relleno de lechada cementosa.

Figura 55 Instalación terminada con base de lechada.

Deja que la lechada se asiente y endurezca. Mueva el molde de madera y limpie el área.

Idealmente, esta tarea debe llevarse a cabo una vez que el mástil esté vertical y antes de colocar el brazo del radar.

7. Topografía

Se debe instalar un punto de referencia abovedado de latón (suministrado) en la cima del acantilado, cerca del monumento para fines de nivelación topográfica.

Deberá registrarse la medición de la diferencia de altura entre el punto de referencia de la cima del acantilado y el punto de referencia del brazo del radar.Para ello se necesitará nivel topográfico , personal y trípode .

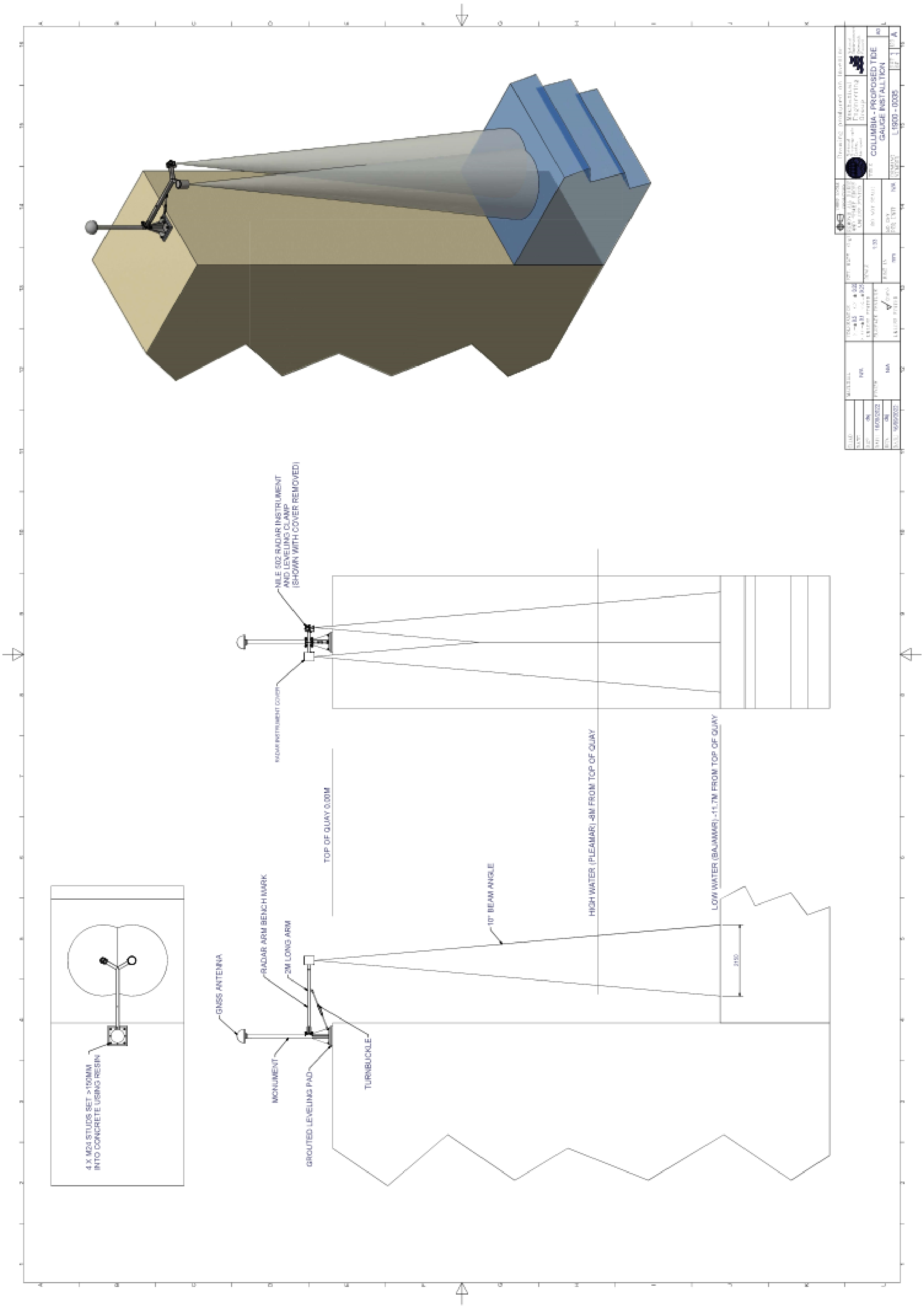
8. Comprobaciones finales

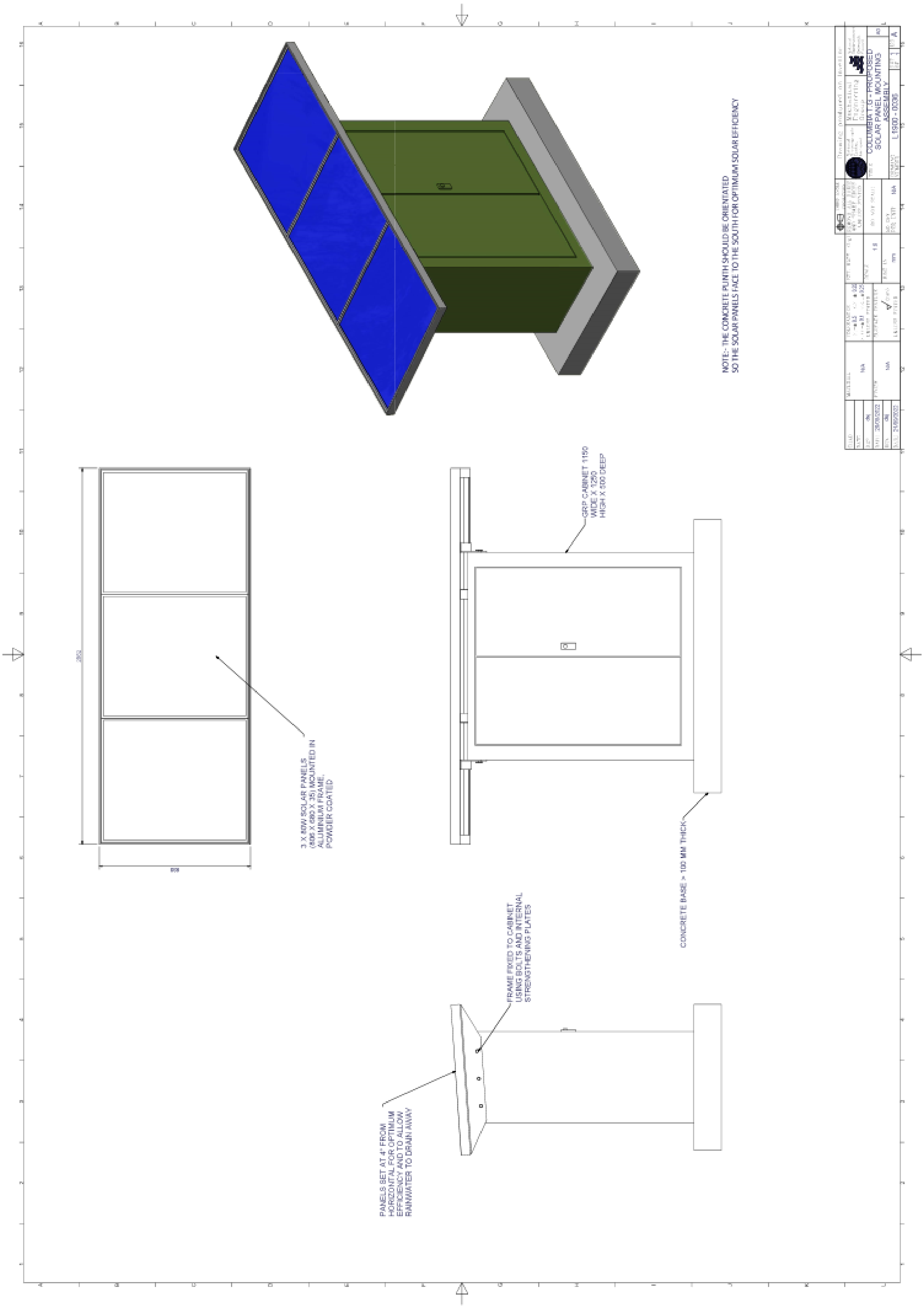
Antes de abandonar el sitio del mareógrafo una vez finalizada la instalación, complete las siguientes comprobaciones:

- Asegúrese de que el sistema esté encendido correctamente mediante el procedimiento descrito en este documento.
- Utilice LinkComm para comprobar si el Satlink3 registra los datos.
- Compruebe si hay una conexión a Internet conectándose al punto de acceso Wi-Fi del enrutador Teltonika RUT955 4G. (Ver APÉNDICE 2)
- Póngase en contacto con Begoña Pérez Gómez en Puertos del Estado (bego@puerto.es), para verificar los datos que llegan a OSPAC.
- Consulte el sitio web del COI para ver los datos transmitidos vía satélite que se publican en su sitio web (o comuníquese con NOC para verificarlo).

- Inicie sesión en el GNSS de Trimble (consulte el APÉNDICE 2) y compruebe que se están registrando los datos. Si no es así, habilite el registro o solicite a Simon Williams (NOC) que acceda de forma remota al sistema y habilítelo.

APÉNDICE 1 – DISEÑO MECÁNICO




NOTE:- THE CONCRETE PLINTH SHOULD BE ORIENTATED SO THE SOLAR PANELS FACE TO THE SOUTH FOR OPTIMUM SOLAR EFFICIENCY
GRP CABINET 1150 WIDE X 1250 HIGH X 500 DEEP
CONCRETE BASE > 100 MM THICK
FRAME FIXED TO CABINET USING BOLTS AND INTERNAL STRENGTHENING PLATES
PANELS SET AT 4° FROM HORIZONTAL FOR OPTIMUM EFFICIENCY AND TO ALLOW RAINWATER TO DRAIN AWAY
COLUMBIA 1.0 - PROPOSED SOLAR PANEL MOUNTING ASSEMBLY

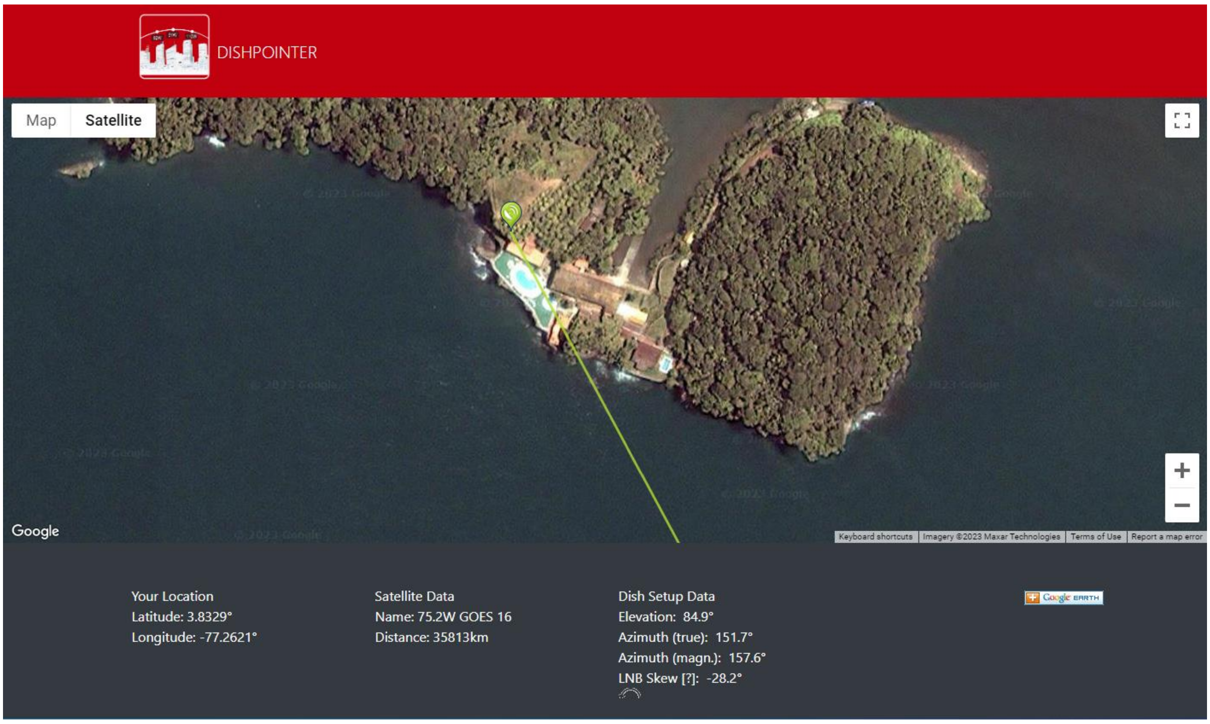
APÉNDICE 2 – INFORMACIÓN DE INICIO DE SESIÓN

Mareógrafo RUT955
Dirección IP: 192.168.1.1
Nombre de usuario: admin
Contraseña: EuroSColom22
Wi-Fi SSID: RUT955_3EC8
Contraseña de Wi-Fi: Pi3h4B9A

Mareógrafo Raspberry Pi
Dirección IP: 192.168.1.246
Nombre de usuario: stma
Contraseña: EuroSColom22
Número de escritorio: 502 608 620
Contraseña: EuroSColom22

Aleación Trimble:
Nombre de usuario: admin
Contraseña: 6042r40073!
Punto de acceso Wi-Fi SSID: 6042R40073
Contraseña de Wi-Fi: 6042r40073!
Dirección IP: 192.168.142.1 Wi-Fi
Dirección IP: 192.168.1.70 Ethernet

APÉNDICE 3 - TRANSMISIONES POR SATÉLITE



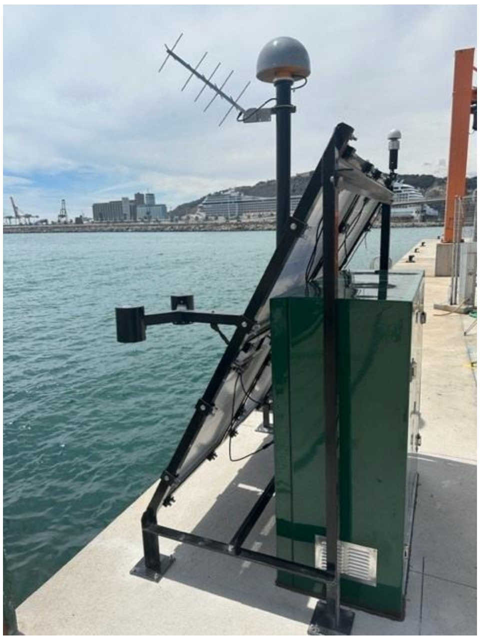
Tide gauge installation reports

The tide gauge installation reports summarise the equipment that was installed at each location, the installation procedures that were implemented and the data flows from each tide gauge. At present, only 2 tide gauges are in situ. The Buenaventura installation report will be provided in due course.

- Installation Report Barcelona
- Installation Report Taranto

Tide Gauge Installation Report

Port of Barcelona



Version 1.0 – 01/08/23

Angela Hibbert, Geoff Hargreaves, Steve Mack, Barry Martin, Begoña Pérez Gómez, Simon Williams

1. Executive Summary

Coastal inundation poses a significant threat globally, particularly to major population centres, infrastructure and economic activity that are concentrated within the coastal zone. Being situated in Mediterranean Sea, the Port of Barcelona is vulnerable to storm surges driven by atmospheric pressure and surface winds from extratropical cyclones, generating large swell waves that can adversely impact shipping. Safe operations of a nearby industrial energy plant can also be compromised by lightning strikes associated with these weather systems. Further hazards are posed to the port by tsunamis, and the longer-term impacts of sea level rise.

Tide gauges can capture this whole spectrum of sea level variability, but financial constraints dictate that they are often maintained to lower standards than the stringent accuracy requirements demanded by the IOC-UNESCO's Global Sea Level Observing System (GLOSS) for monitoring sea level rise. In addition, a sparsity of Global Navigation Satellite System (GNSS) receivers at the coast means that there are large uncertainties in rates of land motion at tide gauges, which also hampers the estimation of long-term sea level trends.

Funded by the EuroSea project (European Union Horizon 2020 research and innovation programme grant agreement No 862626), a new standard of low-cost and largely maintenance-free tide gauge system was designed for the port of Barcelona. The tide gauge system is renewably powered, offers high-frequency sampling for tsunami monitoring purposes and uses dual telemetry mechanisms for resilience, both of which are low cost or cost-free. It measures sea level, vertical land motion, atmospheric pressure, wave activity and electrostatic field strength (for detection of possible lightning strikes). The tide gauge design exploits a new technique known as GNSS Interferometric Reflectometry (GNSS-IR), which allows the measurement of mean sea level whilst simultaneously measuring vertical land movement and can be used at tide gauges to produce continuous levelling information without the extra cost of conventional levelling. The tide gauge transmits data in near-real time to the IOC's Sea Level Station Monitoring Facility and to the internet browser-based Oceanographic Services for Ports and Cities (OSPAC) monitoring and forecasting tool that was jointly developed by Puertos del Estado and Nologin, to help ports to minimise risks and improve environmental management.

2. Scope and Implementation

Locations covered: Port of Barcelona, Spain, 41.362977 N, 2.187024 E

Tide Gauge Implementers: Dr Angela Hibbert (NOC)
Geoff Hargreaves (NOC)
Dave Jones (NOC)
Steve Mack (NOC)
Barry Martin (NOC)
Jeff Pugh (NOC)
Simon Williams (NOC)
José María Cortés Crespo (SIDMAR)
Roberto Sevilla (SIDMAR)
Yosamy García Sanmiguel (DIMAR)
Begoña Pérez Gómez (Puertos del Estado)

Tide Gauge Local Contacts: Javier Romo Garcia (Port of Barcelona)
Joaquim Cortes (Port of Barcelona)

Beneficiaries: Port of Barcelona
Dirección General Marítima (DIMAR)
Puertos del Estado (PdE)

In-state visits/meetings: Two in-state visits were conducted over the project:

- 06/04/22-08/04/22: Visit by Dave Jones (NOC) to agree the location of the tide gauge installation.
- 04/04/23-07/04/23: Visit by Steve Mack (NOC), Barry Martin (NOC) José María Cortés Crespo (SIDMAR), Roberto Sevilla (SIDMAR), Yosamy García Sanmiguel (DIMAR) and Begoña Pérez Gómez (PdE) to install tide gauge equipment.

Key outputs: The main outputs of this work were:

- Installation at Port of Barcelona of a solar-powered tide gauge equipped with dual sea level sensors (2 x radar sensors and 1 Global Navigation Satellite System (GNSS) receiver enabled for Interferometric Reflectometry (GNSS-IR)), a barometer, a low cost GNSS receiver for measuring significant wave height (SWH) via GNSS-IR, a Previstorm lighting detection system, data logging equipment, solar panels, a battery array and dual data telemetry systems (a satellite-linked data transmission system and a Global System for Mobile Communications (GSM)-based system). This system has low maintenance requirements and low running costs to ensure the longevity of the gauge.
- Data streams for sea level, atmospheric pressure, SWH and electrostatic field strength for incorporation into OSPAC software.
- Provision of training in tide gauge installation to Yosamy Garcia Sanmiguel (DIMAR) to facilitate the subsequent Buenaventura tide gauge installation.

3. Engagement and Delivery

The monitoring requirements of local stakeholders were identified during discussions between the Port of Barcelona representatives, Puertos del Estado and the NOC during Spring 2020. These were as follows:

- High frequency sampling (1min) and low latency of data transmission for sea level data to facilitate tsunami warning
- Warnings of potential lightning strikes in order to improve safe operations (and timely shutdowns) of a nearby energy centre
- Atmospheric pressure observations to reduce the effects of atmospheric noise in tidal predictions
- Observations of wave activity outside the harbour area to support navigation
- Highly accurate observations of mean sea level and vertical land motion to understand the impacts of climate change
- Minimal maintenance requirements

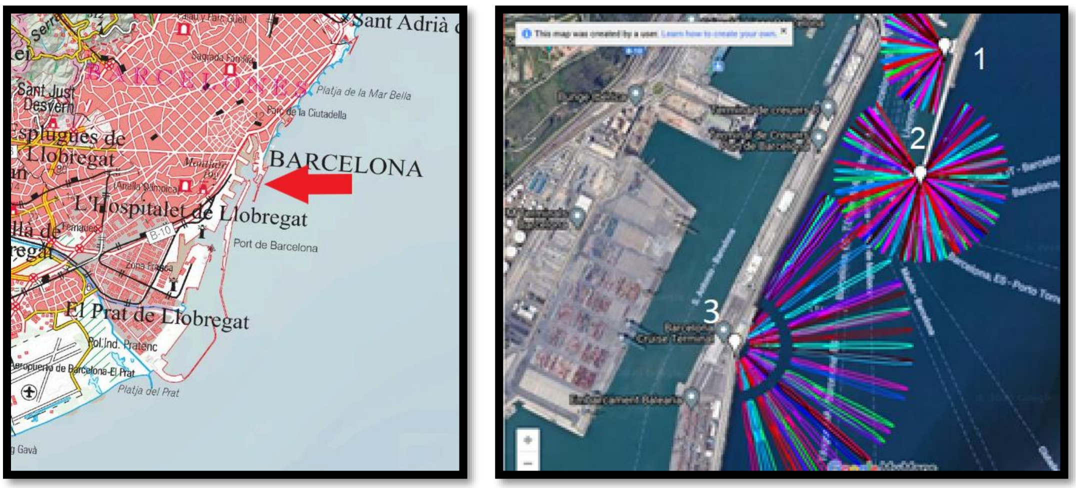


Figure 1. Potential area for Barcelona tide gauge shown by red arrow (left) and specific sites shown by white markers (right). Radial lines denote the area of the sea surface that can be 'seen' by GNSS-IR technology at each location.

Monitoring locations that were of interest to local stakeholders were also identified, but the implementation of COVID-19 lockdown restrictions prevented NOC engineers from undertaking the customary preliminary site surveys to finalise suitable tide gauge locations.

The evaluation of possible tide gauge sites was therefore largely conducted via a series of videoconferences between the NOC, PdE and the Port of Barcelona, based upon satellite imagery and photographs and videos of potential sites supplied by the Port Authority. This allowed potentially suitable locations to be narrowed to 3 sites (Figure 1).

These sites were further down-selected based upon local knowledge of the spatial impact of extreme wave conditions (with potential for causing damage to the monitoring equipment) and it was settled that the principal monitoring system would be located at site 1 (adjacent to a nautical college), where there is less exposure to environmental extremes. It was agreed that a secondary monitoring scheme would be located at site 2 and would comprise a low-cost GNSS-IR system to observe SWH outside the harbour wall from the upper level of a lighthouse. These locations are shown in Figures 1 & 2.

Figure 2. Principal tide gauge site (Site 1) adjacent to the Nautical College and the secondary site at the lighthouse (Site 2) for the low-cost GNSS system

Once the location was finalised, the tide gauge design (Figure 3) and functionality were agreed with key stakeholders as follows:

1. A steel monument to support a geodetic quality GNSS antenna and a Yagi satellite communications antenna

2. A pivoting steel arm attached to (1) with mounting points for dual radar water level sensors and bespoke protective steep caps for each sensor

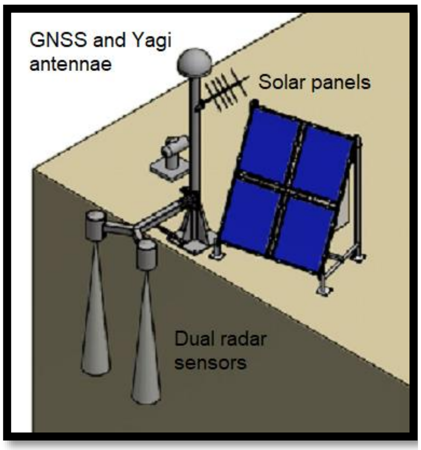


Figure 3 Agreed tide gauge design for Barcelona

3. A steel frame to support 4 X 80W solar panels to power the system

4. A Trimble Alloy GNSS receiver to monitor vertical land motion and sea level, collecting carrier phase and range of visible satellites, plus signal to noise ratio at 5 sec intervals.

5. 2 x YSI WaterLog Nile 502 radar water level sensors with manufacturer's reported accuracy of +/- 2mm, recording 1 sec samples averaged across 1 min.

6. A Meteosat YAGI antenna to transmit data free of charge at 6 min intervals to the Global Telecommunications System (GTS) and the IOC-UNESCO Sea Level Station Monitoring Facility

7. A Vaisala PTB110 Barometer sampling at 6 min intervals

8. A freestanding fibreglass electronics cabinet to be located directly behind the solar panel array and containing: (a) a SUTRON Satlink3 datalogger with GSM capability to transmit sea level data at 1 min intervals for tsunami warning purposes via a roaming SIM card, (b) supporting electronics and telemetry equipment and (c) 6 x 35Ah lead crystal batteries

9. A small fibreglass cabinet containing GNSS datalogging and telemetry equipment to be mounted inside the lighthouse at the harbour entrance.

10. A low-cost Emlid REACH M2 GNSS antenna to be mounted on the lighthouse, powered by an existing array of batteries. This would measure SWH outside the harbour wall, where large swell waves can adversely impact navigation.

11. An INGESCO Previstorm Thunderstorm Warning System to detect potential lightning strikes and to be located at sufficient distance from the port energy centre to allow advance notification.

NOC engineers subsequently procured the instrumentation and manufactured, assembled and tested the supporting steelwork in a laboratory environment for a period of 4 weeks (Figure 4).

Figure 4 Laboratory-based assembly and testing of tide gauge steelwork and instrumentation

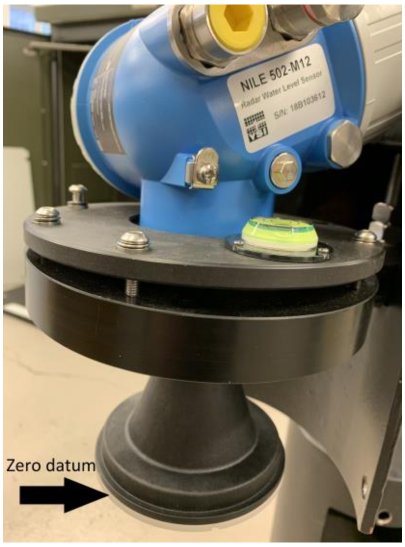


Figure 5. Nile Radar sensor

These tests included the calibration of the radar sensors, for which a zero datum (or zero recording point) is situated at the bottom of a black plastic flange (Figure 5). To evaluate the accuracy of measurement, the radar sensor was tested in the laboratory using a fixed target of a metal sheet to simulate the water surface below. The radar was then moved back and forth, over a range of 400 mm, to 2200 mm and the distances recorded by the instrument were compared with the known distances to the target. The results are recorded in Table 1, which can be found in Appendix 1 and indicate that there is a range of errors (between 1mm and 6mm) in the radar sensor measurements that must be considered when processing the data. These are within the accepted +/- 10 mm tolerances for GLOSS tide gauges.

Testing of the barometer, solar power functionality, battery charge and data transmission via satellite were all successfully concluded and the equipment was packaged in preparation for shipping by early spring 2022.

In the meantime, INGESO engineers had been able to install the Previstorm lightning detection sensor during July 2021, providing a real-time data feed to port operators as an interim measure, prior to the tide gauge installation and the incorporation of all parameters into the OSPAC system. This sensor was located close to the airport at:

Av. De l'estany de la Messeguera - Carrer de Cal Coracero
ZAL Prat
08820 El Prat de Llobregat

Following the removal of COVID-19-related travel restrictions in the UK, the NOC's Chief Mechanical Engineer Dave Jones visited the site between 06/04/22-08/04/22 and finalised the precise location of the tide gauge with port representatives and officials from the neighbouring Nautical College.

It was anticipated that the tide gauge installation would be completed shortly afterwards, but an indefinite strike by staff at the Spanish Consulate in the UK meant that NOC engineers could not obtain appropriate work permits to install the tide gauge. As a result, the NOC and PdE identified a Spanish company that had the required skills to install the tide gauge under the supervision of the NOC. The organisation in question (SIDMAR Estudios y Servicios Oceanográficos S.L.) maintains the Spanish REDMAR tide gauge network on behalf of PdE. Agreement of the funding body was officially sought and was granted in early February 2023. A further delay occurred while the NOC obtained fiscal representation in the European Union (necessitated by the departure of the UK from the European Union), to allow the shipping of the tide gauge from the UK to Spain.

Between the 4th and 7th of April 2023, NOC engineers Steve Mack and Barry Martin supervised the installation of the tide gauge by engineers from SIDMAR

(José María Cortés Crespo and Roberto Sevilla), whilst also training Yosamy García Sanmiguel (DIMAR) in installation methods. Begoña Pérez Gómez (PdE) attended to facilitate the process.

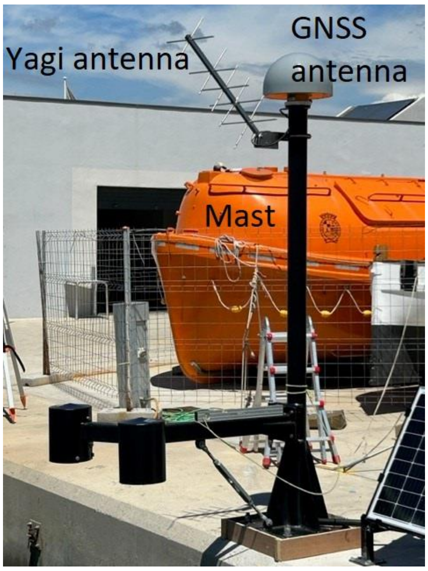


Figure 6. GNSS mast

On arrival at the port, a request was made from the Nautical College to once again review the intended location of the tide gauge. This delayed progress for several hours, but confirmation was ultimately received and the installation went ahead as planned.

The steel monument consists of a metal mast, which accommodates the GNSS antenna and radome and the Yagi antenna (Figure 6). The intended position of the GNSS monument was marked out on the quayside and four holes drilled to accommodate the base plate. The mast was moved into position and elevated, allowing epoxy acrylate resin to be applied to drilled holes. The base plate was then bolted to the quayside and once the resin had set, the nuts to the base plate were adjusted until the mast was perfectly vertical and the base plate was entirely level. A cable conduit was fitted between the quayside and base plate of the mast and secured in place. The GNSS radome and antenna were then fixed to the top of the steel monument.

The solar panel frame was assembled, the Trimble GPS antenna was attached (Figure 7) and the footprint of the frame was marked out on the quayside. The solar panels were fixed to the frame using adjustable clamps and the frame was then fixed to the quayside using anchor bolts.

The position of the large green fibreglass electronics cabinet was marked out, to the rear of the solar panel frame, and four fixing holes were drilled into the quayside. A bead of frame sealant was applied to the quayside and the cabinet was lowered onto the bead of sealant. The cabinet was then fastened to the quayside using anchor bolts and a further bead of sealant was placed around the exterior of the cabinet.

Figure 7. Solar panel frame and electronics cabinet

Lengths of cable conduit were installed on the quayside from the GNSS mast to the electronics cabinet and from the cabinet to the solar panel frame. To add extra stability to the GNSS mast installation, a cementitious grout was poured beneath the mast base using a casting mould which was placed around the base of the monument.

The pivoting steel radar arm (Figure 7) was mounted onto the GNSS mast, with the arm swung inwards over the quayside, to ensure that it was supported whilst being attached and was positioned so that it was perfectly level. The radar sensors were then inserted into the mounting clamps and attached to the radar arm. The electrical cables were routed from each sensor through the arm into the upright section of the mast and then through the conduit into the electronics cabinet. Each radar sensor mounting plate was equipped with an in-built spirit level to ensure that each sensor was correctly positioned so that the radar beam follows a vertical path to the sea surface, thereby minimising instrumental errors.

The GNSS antenna cable was then also pulled through the cable conduit into the mast, emerging through the uppermost end and was connected to the antenna. The other end of the cable was connected to the electronics green cabinet. The Yagi antenna was assembled and attached to the dedicated clamp, which was then attached to the GNSS mast. The Yagi antenna cable was fed down through the GNSS mast and along the conduit, emerging in the electronics cabinet and the cable was connected to the antenna. The Yagi antenna was then aligned with an elevation angle of 42.1° and an azimuth of 182.1° Magnetic

Figure 7. Pivoting radar arm with protective covers and brass benchmark

The solar panels were connected as two arrays in series, and the solar power cables were threaded along the conduit into the electronics cabinet. The cable for the smaller Trimble GPS antenna was also fed into the electronics cabinet. All cables entering the electronics cabinet and GNSS mast were installed in a “swan neck loop” arrangement, to minimise rainwater ingress into the cabinet and mast.

The 6 lead crystal batteries were installed within the electronics cabinet and were wired in parallel (Figure 8). All remaining connections were made within the electronics cabinet and the system was powered-up and sanity checks were completed to ensure that data were being logged correctly by the datalogger. The protective covers were fitted to the radar sensors (Figure 7) and the turnbuckle to the radar arm was secured in place. The seaward end of the turnbuckle rod was wrapped in Denzo tape to protect against corrosion. The radar arm was then swung outwards over the sea surface and securing bolts were fitted to the radar arm hinge point. The landward end of the turnbuckle was then attached to the anchoring point and wrapped in Denzo tape. Final checks were made to ensure than the radar arm and sensors remained level and cementitious grout was applied beneath the base of the mast to ensure stability.

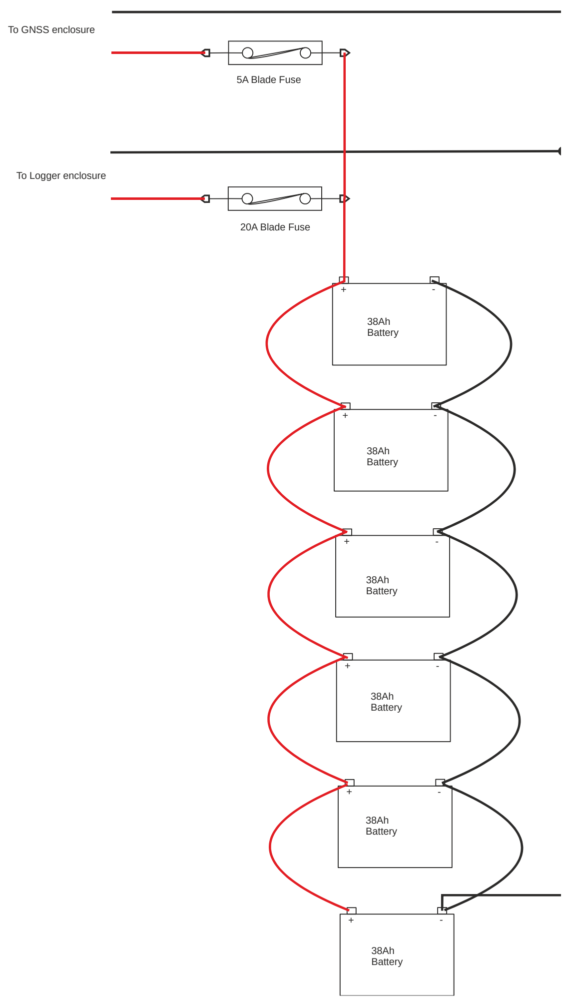


Figure 8. Battery connections at Barcelona tide gauge

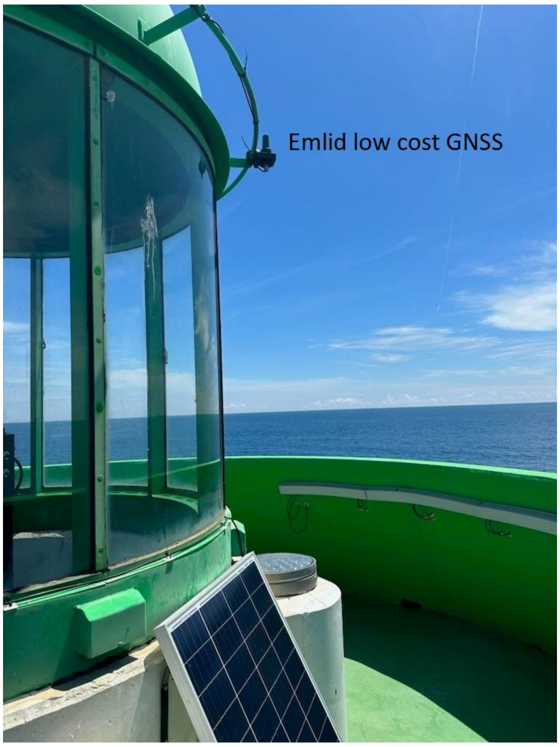


Figure 9. Low cost GNSS and solar panel mounted on the lighthouse at Site 2

During the installation, local permissions were revoked to connect the Emlid low cost GNSS system to an existing array of batteries in the lighthouse. Consequently, an additional 100W solar panel and 38Ah battery had to be sources locally by the project partners SIDMAR.

The low cost GNSS antenna was mounted onto an external rail above the main lighthouse lamp and the power cable was run horizontally along this rail and then vertically down one of the metal beads that separates the glass panes of the lighthouse (Figure 9). The cable was secured using cable ties, sticky pads, and silicon sealant and was routed in such a way that it did not block the lamp output. The cable was passed through existing conduit to the interior of the building, then through a rubber cable protector placed on the floor and through further trunking leading to the internal wall of the building. A second smaller electronics cabinet was mounted onto a backplate connected to wall-mounted rails. The solar panel was installed on the lighthouse lantern gallery, below the lantern window, facing due south at an elevation angle of approximately 60°, which is the optimised angle for winter performance. The solar panel cable follows the same route inside the building as the GNSS antenna cable. The battery was placed on the floor near to the existing batteries used by the lantern and the cable was routed into the GNSS enclosure.

The location of the Previstorm lightning detector was attended and an Ingesco-supplied 4G modem was swapped for a Teltonika RUT955 modem and the data connections were tested.

As part of this installation an optical level, tripod and levelling staff were supplied to the installation team, allowing them to level-in the tide gauge. A brass domed benchmark (the tide gauge benchmark or TGBM) was installed on the quayside, near to the GNSS mast. The height difference was recorded between this TGBM and a brass benchmark fitted to the radar arm (Figure 7). The benchmark heights relative to the tide gauge components are provided in Figure 10.

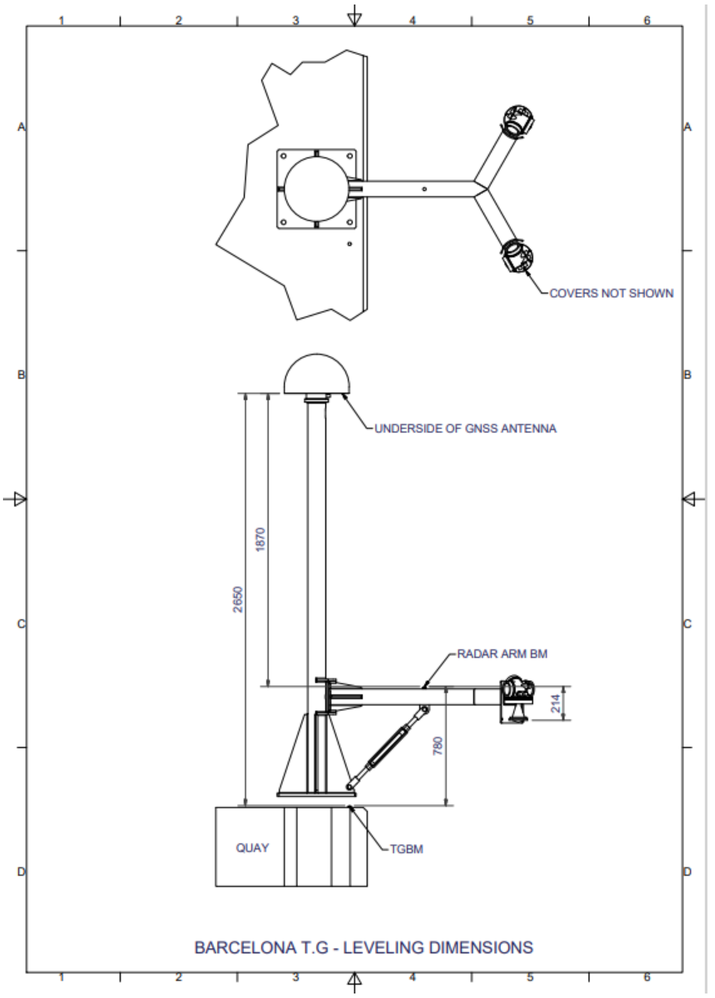


Figure 10. Tide gauge benchmark heights

Sea level datums for the tide gauge site were estimated, based upon information provided for the nearby REDMAR tide gauge. These are supplied in Figure 12.

A levelling survey will be needed to identify the height of the TGBM to another benchmark that exists near to the lighthouse (Figure 11) at the harbour entrance. The heights of this benchmark had already been established (Figure 13)

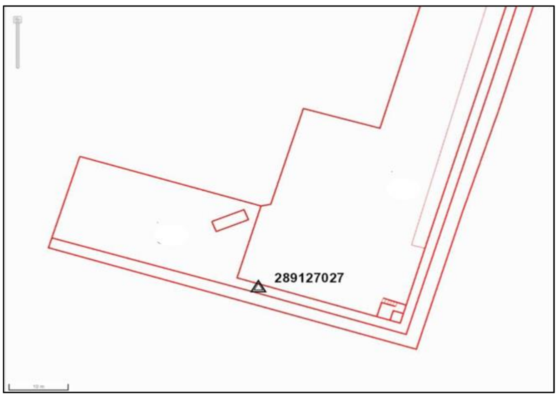


Figure 11. Harbour benchmark location

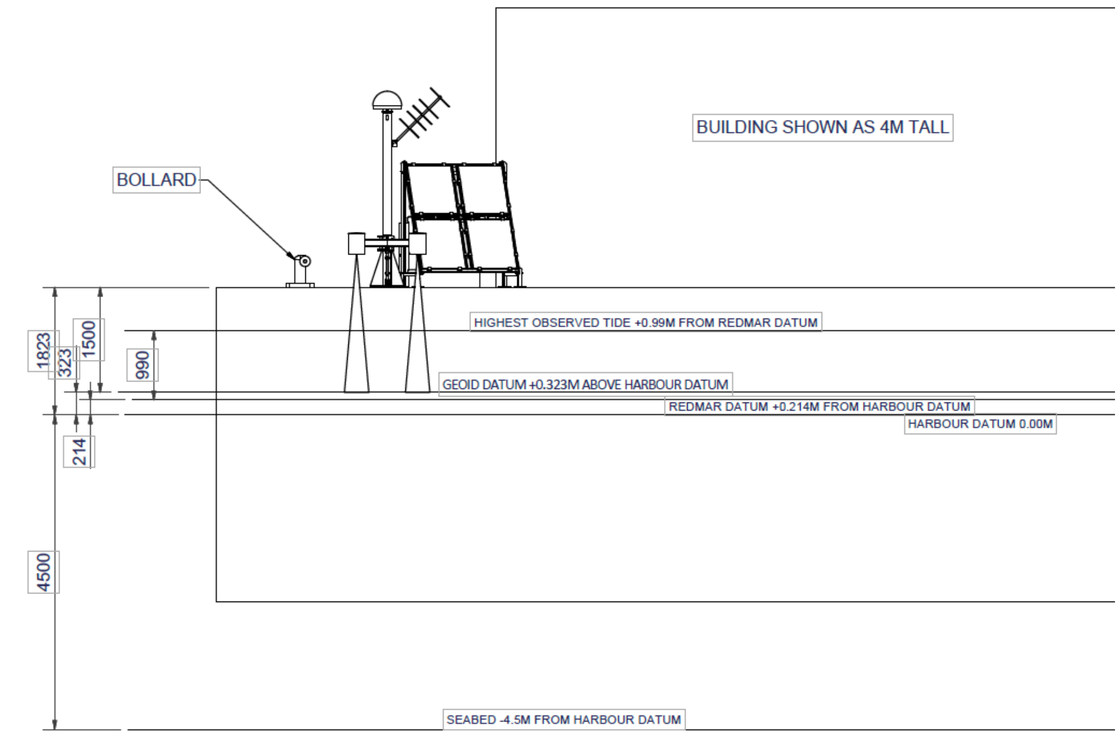


Figure 12. Sea level datums at Barcelona

Port de Barcelona

FITXA DE VÈRTEX TOPOGRÀFIC

Informació general

Codi:	289127027
Ubicació:	Port de Barcelona
Data d'última revisió:	Maig 2017
Xarxa:	Xarxa Topogràfica APB (3a rev.)

Descripció:
Clau d'anivellació ICC tipus INSTN1, d'acer inoxidable amb la cabota formada per un tronc de piràmide de 4cm de diàmetre superior i 3cm de diàmetre inferior, situat damunt d' un mur emergent.

Coordenades

Sistema de referència:	ETRS89		
Projecció:	UTM Fus 31	Hemisferi N	
X Projectada (X):	431831.600 m	σ:	0.003 m
Y Projectada (Y):	4578801.900 m	σ:	0.004 m
Factor d'escala (K):	0.99965719		
Longitud (λ):	2° 11' 6.11202" E	σ:	0.00013"
Latitud (ϕ):	41° 21' 28.21139" N	σ:	0.00013"
Cota ortomètrica (H):	5.020 m	σ:	0.007 m
Model de geoide:	EGM08D595	N:	48.991 m
Cota el·lipsoidal (h):	54.011 m	σ:	0.007 m

Fotografia

Figure 13. Heights of benchmark adjacent to lighthouse

The following final checks were completed before leaving the site:

- The system was powering-up correctly
- Data were being logged by the Satlink3 datalogger

- Data were being transmitted and received by the IOC Sea Level Station Monitoring Facility via satellite at http://www.ioc-sealevelmonitoring.org/station.php?code=barc2
- Data were being logged by the Trimble Alloy GNSS receiver.

4. Data Streams

The following data streams were implemented for this site:

- 1 min averages of sea level from dual radar sensors transmitted via a KPN roaming SIM card at 1 min intervals to the PdE ftp site (enoc.puertos.es) with a 10 sec latency for incorporation into the OSPAC software. Data are time stamped at 10 sec past the minute to which they relate. 40 sec should be subtracted from time stamps to accurately represent the midpoint of the averaging period. The SIM card contract also relates to the provision of atmospheric pressure data (below) and will expire on 20/09/2024
- 1 min averages of sea level from dual radar sensors transmitted every 6 mins via a free Meteosat satellite communications system to the Global Telecommunications System (GTS) from where they are accessed by the IOC sea Level Station Monitoring Facility (IOC SLSMF) and are made publicly available (Figure 14) [SEA LEVEL STATION MONITORING FACILITY (ioc-sealevelmonitoring.org)](http://ioc-sealevelmonitoring.org). This telemetry method has a maximum latency

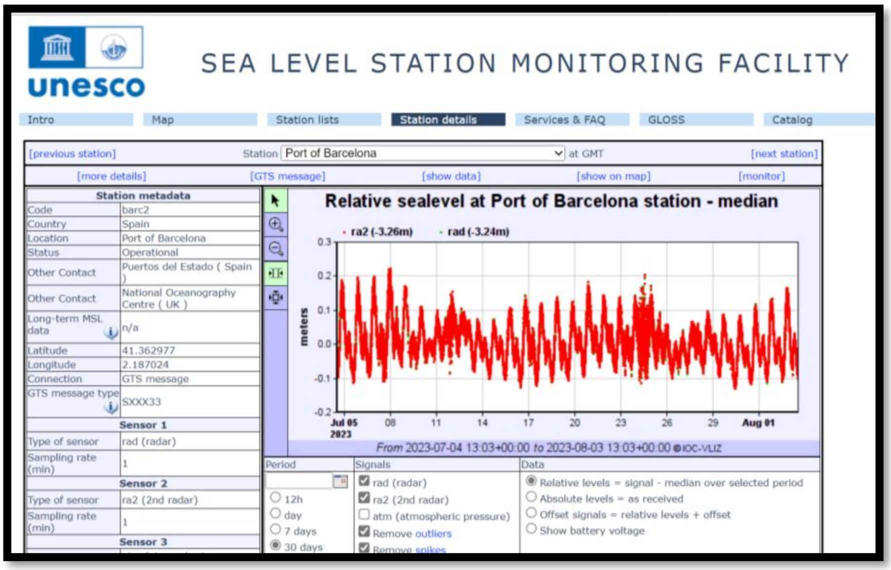


Figure 14. Sea level data received at IOC SLSMF for Port of Barcelona

of 6 min. Data are time stamped one minute later than the minute to which they relate. Therefore, 90 sec should be subtracted from time stamps to accurately represent the midpoint of the averaging period to which they relate.

- 6 min samples of atmospheric pressure transmitted via a KPN roaming SIM card at 1 min intervals (i.e. the barometer reading will be constant for 6 transmissions) to the PdE ftp site (enoc.puertos.es) with a 10 sec latency for incorporation into the OSPAC software. Data are timestamped at 10 sec past the sampling time.

- 6 min samples of atmospheric pressure transmitted via a free Meteosat satellite communications system to the Global Telecommunications System (GTS) from where they are accessed by the IOCSLSMF and are made publicly available (Figure 15) [SEA LEVEL STATION MONITORING FACILITY (ioc-sealevelmonitoring.org)](ioc-sealevelmonitoring.org). This telemetry method has a latency of ~10 sec. Data are timestamped at 1 minute after the sample was taken.

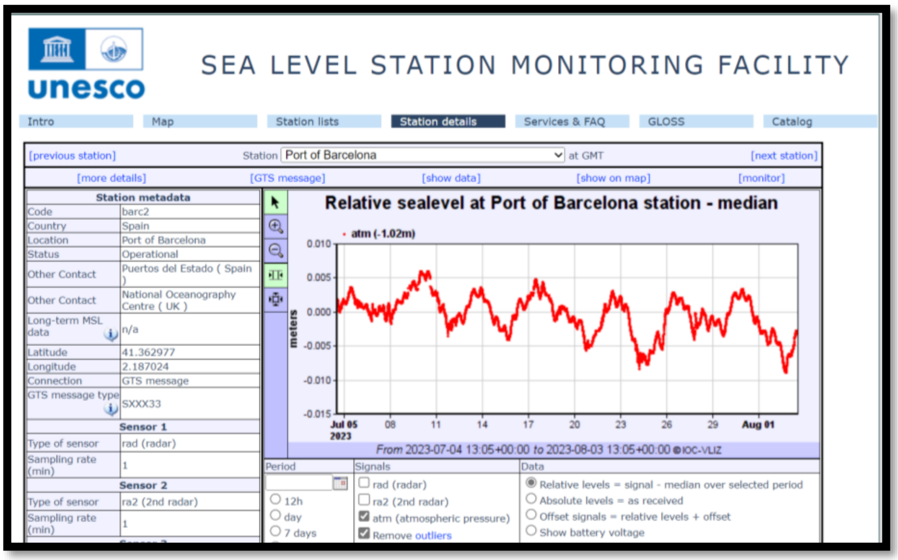


Figure 15. Atmospheric pressure data received at IOC SLSMF for Port of Barcelona

Consequently 60 seconds must be subtracted from the time stamps.

- Previstorm data (consisting of 1 sec samples of electrical field activity, V/m) are transmitted via a KPN roaming SIM card at 1 min intervals to the PdE ftp site (enoc.puertos.es) with a negligible (<1sec) latency for incorporation into the OSPAC software. The SIM card contract will expire on 20/09/2024.

  Data are also accessible via a dedicated laptop in the Port of Barcelona, which uses a software platform plugin known as Previstorm® Viewer for Windows^{TM}.

- RINEX 3 data files from the Trimble Alloy GNSS receiver are transmitted every 15 mins to the NOC via FTP. They contain observations of carrier phase and range, plus signal-to-noise ratio at 5 sec intervals from each satellite that is in view of the receiver. On a daily basis, the 15 min files are combined to produce a daily file of 30 second data which is sent via ftp to the SONEL data portal ([GPS Barcelona Tide Gauge 2 (sonel.org)](sonel.org), SONEL station code 4586, IGS site reference BCTG).

Figure 16. Vertical land motion at SONEL for the Port of Barcelona tide gauge

- The 15 min data files from the Trimble Alloy GNSS receiver are processed in near real-time using the interferometric reflectometry (IR) technique, to produce sea level heights at 15 minute intervals. The latency is around 1 hour. These data are transmitted to the PdE ftp site (enoc.puertos.es) for incorporation into the OSPAC software. These data have been shown to display good agreement with sea level data from the conventional Nile radar sensors (Figure 17).

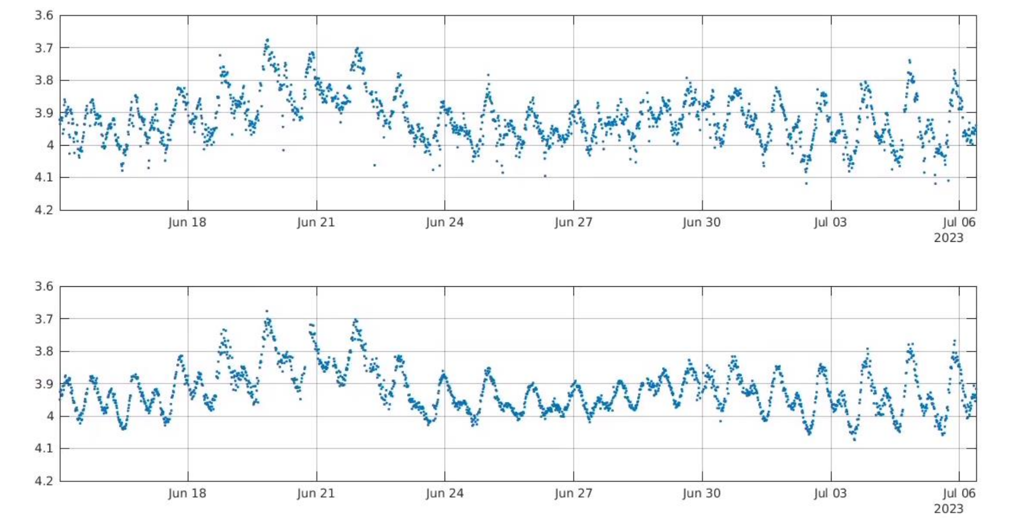


Figure 17. Sea level from GNSS-IR (top) and conventional radar sensor (bottom) at Barcelona Site 1

- 1 sec samples of carrier phase and range, plus signal-to-noise ratio are transmitted via a KPN roaming SIM card at hourly intervals to the NOC in the form of RINEX 3 data. These are currently processed manually every few days, using the IR technique, to produce hourly estimates of SWH. The results are currently in a calibration phase. Agreement between these observations and those of an offshore wave buoy has been shown to be very good (Figure 18). The NOC plans to refine this to produce a near real-time SWH product to support OSPAC in Autumn 2023. The SIM card

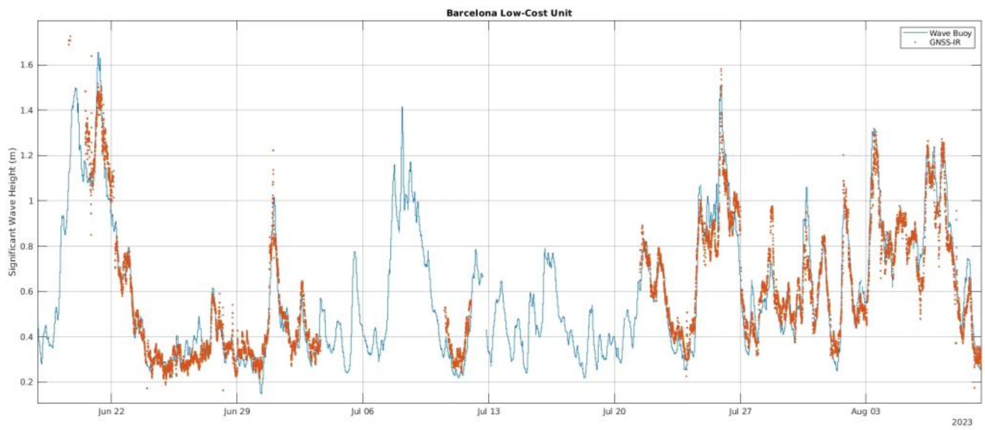


Figure 18. Comparison of SWH from GNSS-IR at lighthouse and an offshore wave buoy maintained by Puertos del Estado

contract will expire on 20/09/2024

Date telemetry contracts:

3 KPN roaming SIM card contracts for 1GB each per month are in place with Mobius Networks for the following:

- 1 min sea level and atmospheric pressure data transmissions
- Previstorm lightning detection data transmissions
- Low-cost GNSS-IR SWH data transmissions

The contracts will expire on 20/09/2024 and the details are as follows:

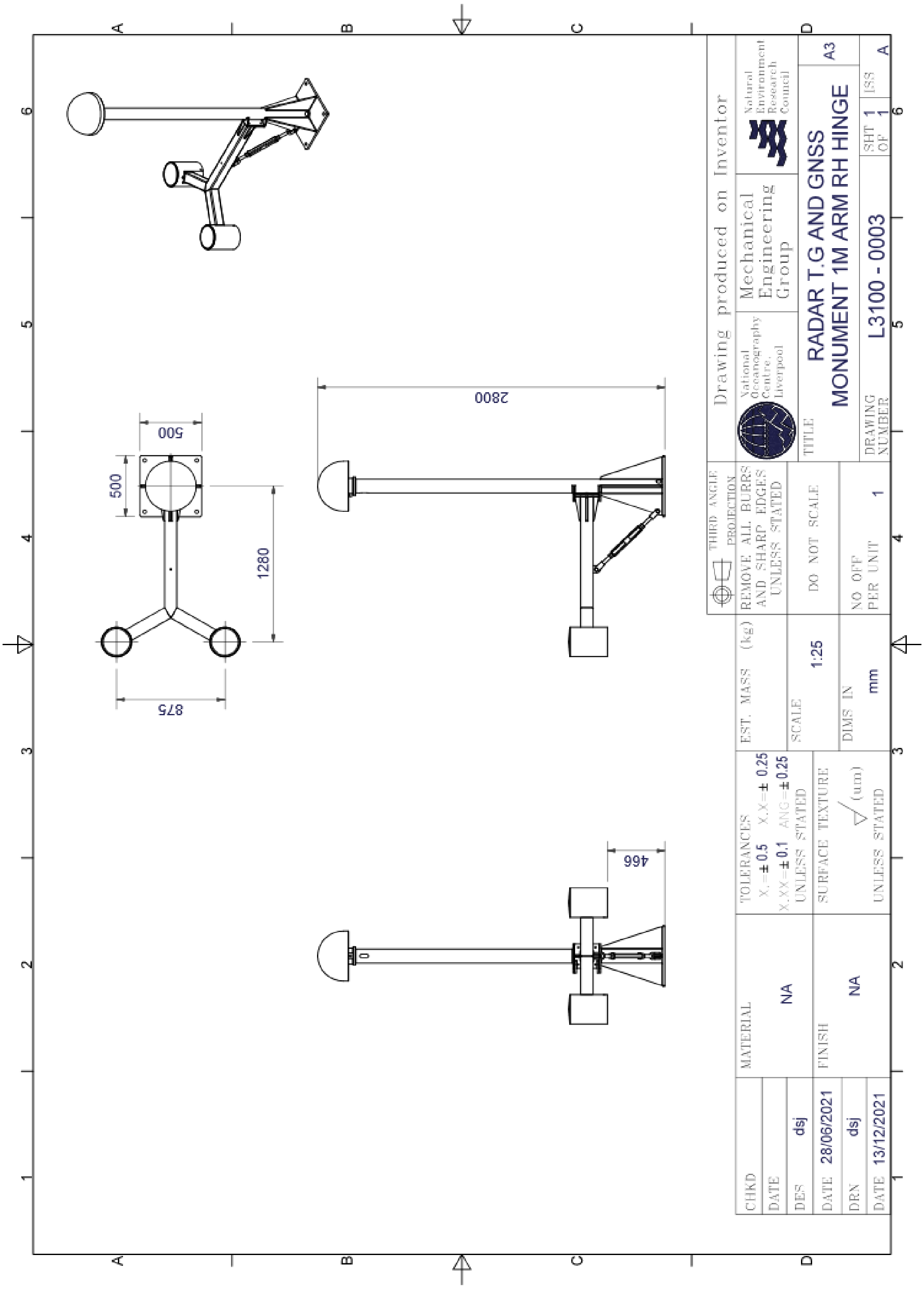
Telephone Number	SIM Number	IMSI
204080823477557	8931082322074940286	3197045379425
204080823477556	8931082322074940278	3197045379369
204080823477555	8931082322074940260	3197045379363

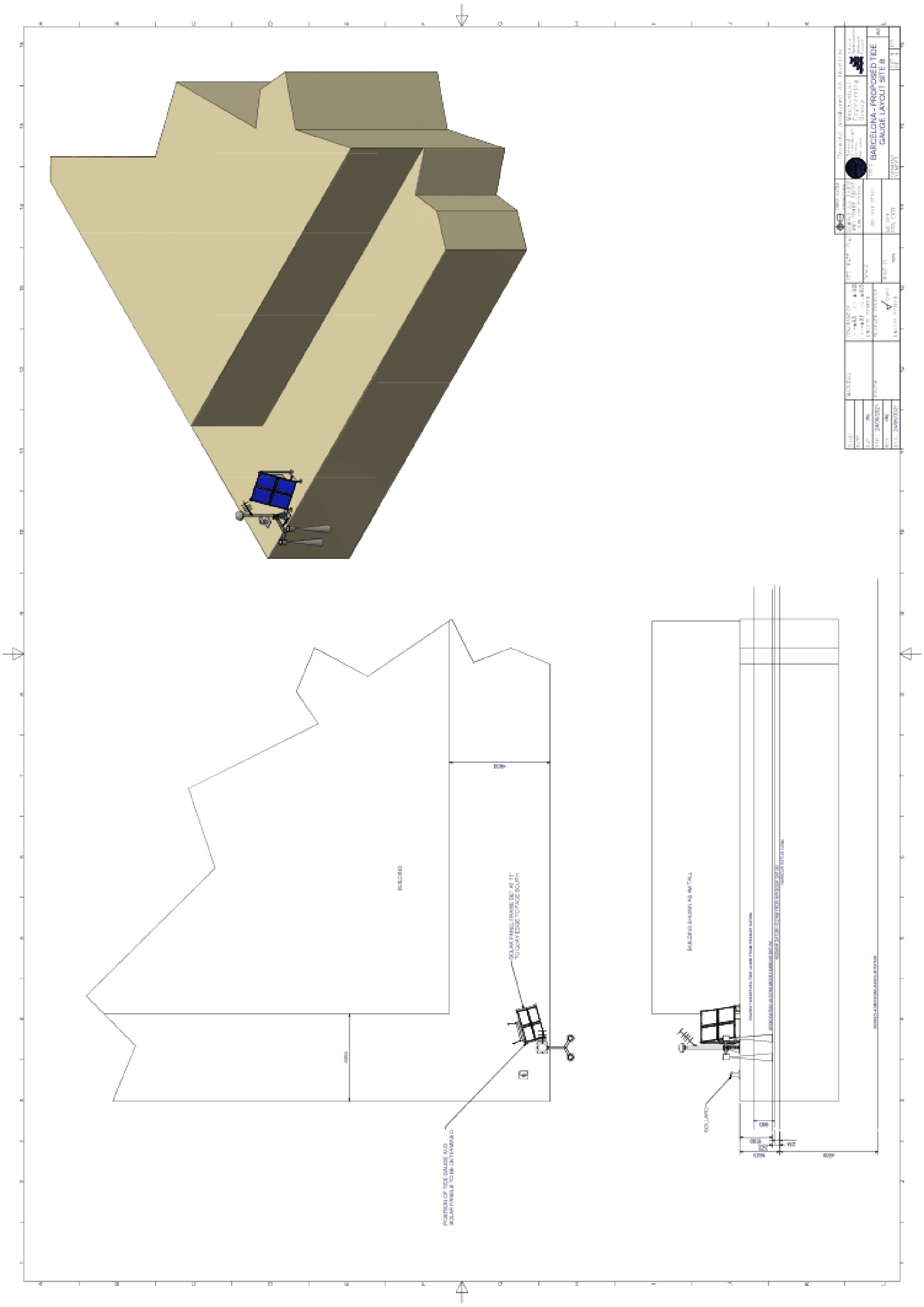
5. Appendices

Appendix 1. Radar Calibration Data

Site	Barcelona		
S/No.	21F105518		
Approx.	mm Waterlog Display	(Tape Measure mm)	Difference Measured (mm)
Distance	Radar Displayed Output	Measured Distance	Vs WaterLog
400	400	401	-1
500	500	498	2
1000	1000	998	2
1500	1500	1497	3
2000	2000	1996	4
2200	2200	2196	4
Site	Barcelona		
S/No.	21F105519		
Approx.	mm Waterlog Display	(Tape Measure mm)	Difference Measured (mm)
Distance	Radar Displayed Output	Measured Distance	Vs WaterLog
400	400	399	1
500	500	497	3
1000	1000	996	4
1500	1500	1494	6
2000	2000	1993	7
2200	2200	2194	6

Appendix 2. Technical Designs




BARCELONA - PROPOSED TIDE GAUGE LAYOUT SITE B

Appendix 3. Login Information

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IP Address: 192.168.1.1
Username: admin
Password: EuroSBarca22
Wi-Fi SSID: RUT955_259A
Wi-Fi Password: Bc56JgVx

Trimble Alloy:
IP Address: 192.168.1.70
Username: admin
Password: 6050r40076!
Wi-Fi Access Point SSID:
6050R40076
Wi-Fi Password:

Tide Gauge Raspberry Pi
IP Address: 192.168.1.246
Username: pi
Password: EuroSBarca22
Anydesk number: 465 580 702
Password: EuroSBarca22

Lo-cost GNSS RUT955
IP Address: 192.168.1.1
Username: admin
Password: EuroSBarca22
Wi-Fi SSID: RUT955_F360
Wi-Fi Password: Rr5g3TWk

Lo-cost GNSS EMLID
IP Address: 192.168.1.116
Username: reach
Password: emlidreach

Lo-cost GNSS Raspberry Pi
IP Address: 192.168.1.244
Username: pi
Password: EuroSBarca22
Anydesk number: 519 768 864
Password: EuroSBarca22

Previstorm RUT955
IP Address: 192.168.1.1
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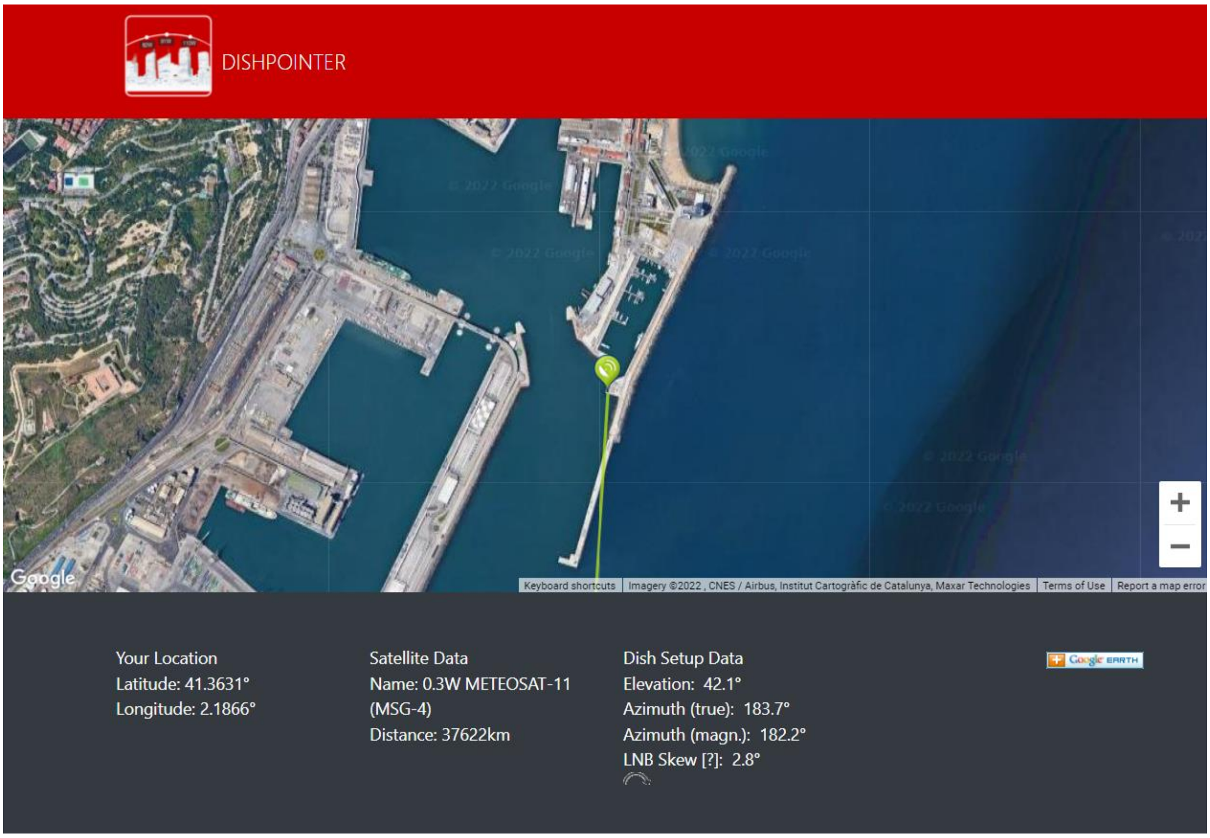
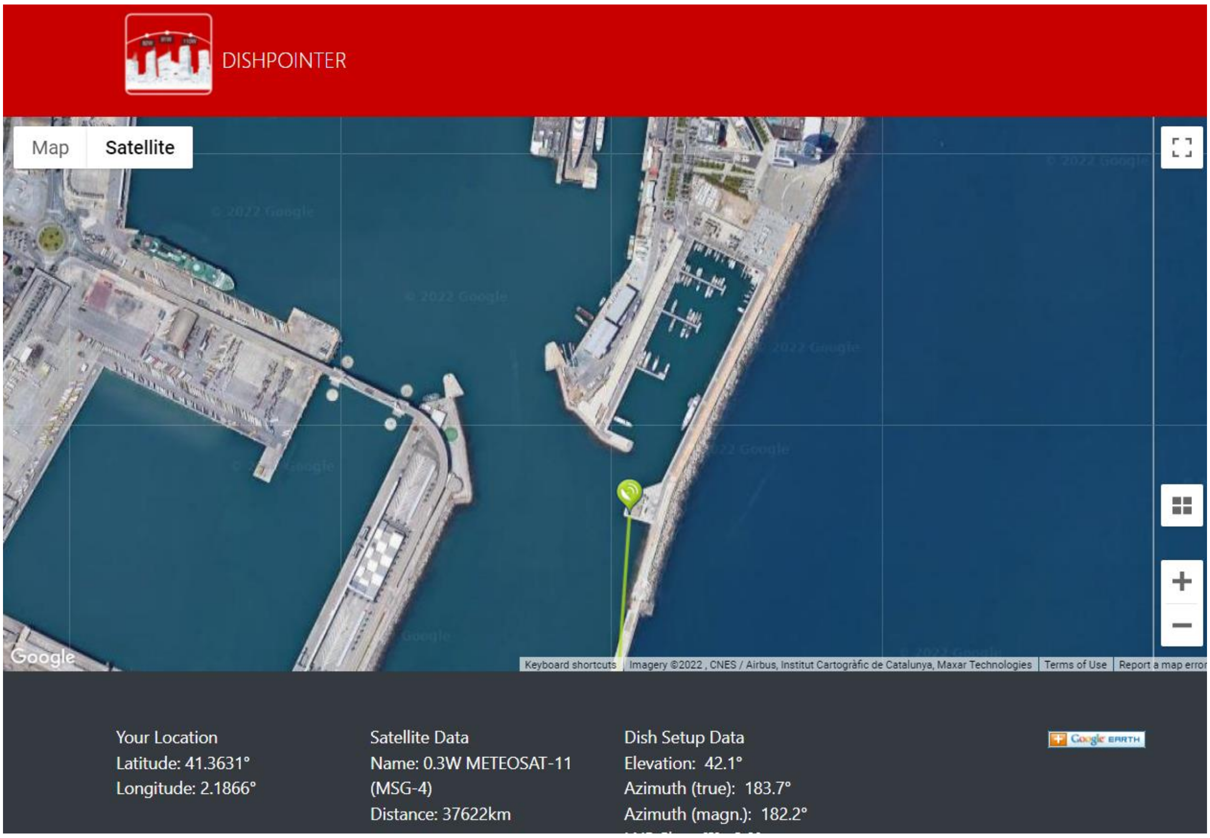
Password: EuroSBarca22
Wi-Fi SSID: RUT955_ FEC4
Wi-Fi Password: y2U7WqEi

Appendix 4. Satellite Transmissions





Tide Gauge Installation Report

Port of Taranto

Version 1.0 – 01/08/23

Angela Hibbert, Geoff Hargreaves, Steve Mack, Barry Martin, Begoña Pérez Gómez, Simon Williams

1. Executive Summary

Coastal inundation poses a significant threat globally, particularly to major population centres, infrastructure and economic activity that are concentrated within the coastal zone. Being situated in Mediterranean Sea, the Port of Taranto is vulnerable to storm surges driven by atmospheric pressure and surface winds from extratropical cyclones Large swell waves are a particular problem in this location and can adversely impact shipping. Further hazards are posed to the port by tsunamis, and the longer-term impacts of sea level rise.

Tide gauges can capture this whole spectrum of sea level variability, but financial constraints dictate that they are often maintained to lower standards than the stringent accuracy requirements demanded by the IOC-UNESCO's Global Sea Level Observing System (GLOSS) for monitoring sea level rise. In addition, a sparsity of Global Navigation Satellite System (GNSS) receivers at the coast means that there are large uncertainties in rates of land motion at tide gauges, which also hampers the estimation of long-term sea level trends.

Funded by the EuroSea project (European Union Horizon 2020 research and innovation programme grant agreement No 862626), a new standard of low-cost and largely maintenance-free tide gauge system was designed for the port of Taranto. The tide gauge system is renewably powered, offers high-frequency sampling for tsunami monitoring purposes and uses dual telemetry mechanisms for resilience, both of which are low cost or cost-free. It measures sea level, vertical land motion, atmospheric pressure and a variety of wave parameters both at the coast in in the nearshore area. The tide gauge design exploits a new technique known as GNSS Interferometric Reflectometry (GNSS-IR), which allows the measurement of mean sea level whilst simultaneously measuring vertical land movement and can be used at tide gauges to produce continuous levelling information without the extra cost of conventional levelling. The tide gauge transmits data in near-real time to the IOC's Sea Level Station Monitoring Facility and to the internet browser-based Oceanographic Services for Ports and Cities (OSPAC) monitoring and forecasting tool that was jointly developed by Puertos del Estado and Nologin, to help ports to minimise risks and improve environmental management.

2. Scope and Implementation

Locations covered: Port of Taranto, Italy, 40.475903 N, 17.221476 E

Tide Gauge Implementers: Dr Angela Hibbert (NOC)
Geoff Hargreaves (NOC)
Dave Jones (NOC)
Steve Mack (NOC)
Barry Martin (NOC)
Jeff Pugh (NOC)
Simon Williams (NOC)
Juan Francisco Martinez Osuna (CMCC)
Daniele Piazzolla (CMCC)
Viviana Piermattei (CMCC)
Begoña Pérez Gómez (Puertos del Estado)

Tide Gauge Local Contacts: Juan Francisco Martinez Osuna (CMCC)
Daniele Piazzolla (CMCC)
Viviana Piermattei (CMCC)
Maria Santoro (Port of Taranto)
Gennaro Ruggieri (Port of Taranto)
Gianluca Semitaio (Port of Taranto)
Serena Tinelli (Port of Taranto)

Beneficiaries: Port of Taranto
Euro-Mediterranean Center on Climate Change (CMCC)
Puertos del Estado (PdE)

In-state visits/meetings: One in-state visit was conducted over the project:
26/06/23-29/06/23: Visit by Geoff Hargreaves (NOC), Barry Martin (NOC), Juan Francisco Martinez Osuna (CMCC) and Daniele Piazzolla (CMCC) to install tide gauge equipment.

Key outputs: The main outputs of this work were:

- Installation at Port of Taranto of a solar-powered tide gauge equipped with dual sea level sensors (1 x conventional radar sensors, plus 1 x MIROS wave monitoring radar sensor), a Global Navigation Satellite System (GNSS) receiver enabled for monitoring vertical land motion, plus sea level and wave monitoring via Interferometric Reflectometry (GNSS-IR)), a barometer, data logging equipment, solar panels, a battery array and dual data telemetry systems (a satellite-linked data transmission system and a Global System for Mobile Communications (GSM)-based system. This system has low maintenance requirements and low running costs to ensure the longevity of the gauge.
- Data streams for sea level, atmospheric pressure, SWH and other wave parameters for incorporation into OSPAC software.

3. Engagement and Delivery

The monitoring requirements of local stakeholders were identified during a videoconference discussion between the Port of Taranto representatives, CMCC and the NOC on 26/02/21. These were as follows:

- High frequency sampling (1min) and low latency of data transmission for sea level data to facilitate tsunami warning
- Atmospheric pressure observations to reduce the effects of atmospheric noise in tidal predictions
- Observations of wave activity at the coast and in the nearshore area
- Highly accurate observations of mean sea level and vertical land motion to understand the impacts of climate change
- Minimal maintenance requirements

Potential monitoring locations that were of interest to local stakeholders were also identified, but the implementation of COVID-19 lockdown restrictions prevented NOC engineers from undertaking the customary preliminary site surveys to finalise suitable tide gauge locations. It was therefore agreed that colleagues at CMCC and the port authority would obtain photographs and videos of potential sites so that NOC engineers could assess the suitability of each location. Unfortunately, following the initial videoconference on 26/02/21, contact between the NOC and local stakeholders could not be re-established until 27/09/22. It was explained that this was initially due to COVID-19 restrictions within Italy and was subsequently caused by site security issues linked to the conflict in Ukraine. Once contact was re-established, a suitable location was identified on a newly-constructed quay (Figure 1).

Figure 1. Agreed site for Taranto tide gauge installation, indicated by red arrows

Once the location was agreed, the tide gauge design (Figure 2) and specification was finalised and functionality were agreed with key stakeholders as follows:

1. An aluminium ‘A’ frame with mounting points for a geodetic quality GNSS antenna, a Trimble GPS and a Yagi satellite communications antenna

2. An aluminium right-angle swinging frame attached to (1) with mounting points for the 2 radar sensors and a bespoke protective cap for the conventional Nile radar sensor

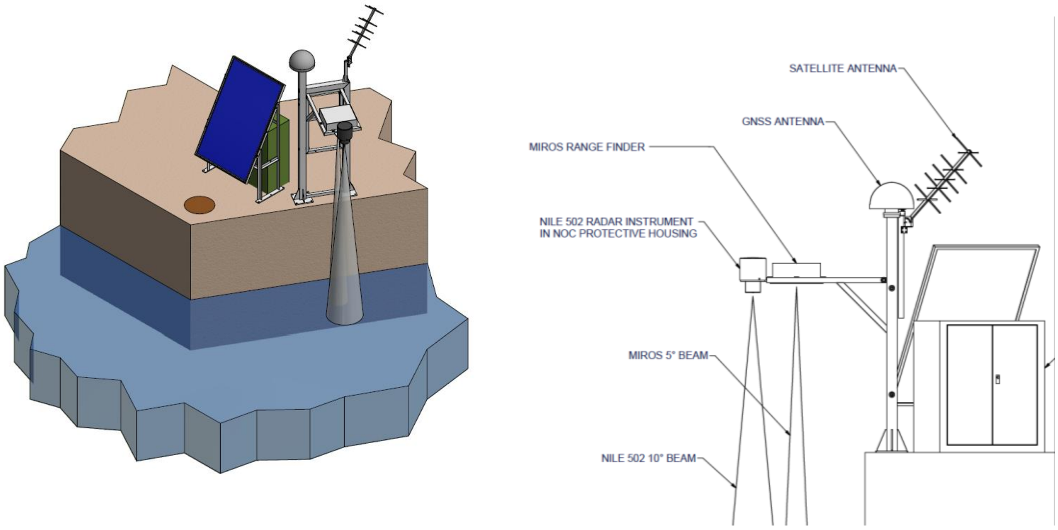


Figure 2. 3-D (left) and 2-D (right) representation of the agreed tide gauge design for Taranto

1. A steel frame to support 1 x 400W solar panel to power the system

2. A Trimble Alloy GNSS receiver to monitor vertical land motion and sea level at the coast, as well as SWH across the nearshore area. To this end the instrument would collect carrier phase and range of visible satellites, plus signal to noise ratio at 5 sec intervals.

3. 1 x YSI WaterLog Nile 502 radar water level sensors with manufacturer's reported accuracy of +/- 2mm, recording 1 sec samples averaged across 1 min.

4. 1 x MIROS RangeFinder narrow beam (5°) radar sensor monitoring sea level and wave parameters, with a manufacturer's reported accuracy of +/- 1mm (for sea level). To record 1 sec sea level samples averaged across 1 min and to transmit at 1 min intervals, wave parameters at the coast averaged across a 20 min period.

5. A Meteosat YAGI antenna to transmit data free of charge at 6 min intervals to the Global Telecommunications System (GTS) and the IOC-UNESCO Sea Level Station Monitoring Facility

6. A Vaisala PTB110 Barometer sampling at 1 min intervals

7. A freestanding fibreglass electronics cabinet to be located directly behind the solar panel array and containing: (a) a SUTRON Satlink3 datalogger with GSM capability to transmit sea level data at 1 min intervals for tsunami warning purposes via a roaming SIM card, (b) supporting electronics and telemetry equipment and (c) 8 x 35Ah lead crystal batteries

NOC engineers subsequently procured the instrumentation and manufactured, assembled and tested the supporting steelwork in a laboratory environment for a period of 4 weeks (Figure 3).

Figure 3 Laboratory-based assembly and testing of tide gauge steelwork and instrumentation

These tests included the calibration of the radar sensors. For the Nile radar, a zero datum (or zero recording point) is situated at the bottom of a black plastic flange (Figure 4). To evaluate the accuracy of measurement, the radar sensor was tested in the laboratory using a fixed target of a metal sheet to simulate the water surface below. The radar was then moved back and forth in 100 mm steps, over a range of 400 mm, to 2200 mm and the distances recorded by the instrument were compared with the known distances to the target. The results are recorded in Table 1, which can be found in Appendix1, and indicate that within the expected in situ measurement range, there is a +/-2mm error in the radar sensor measurements. This is consistent with the manufacturer's reported accuracy and is within the +/-10mm limit demanded by GLOSS.

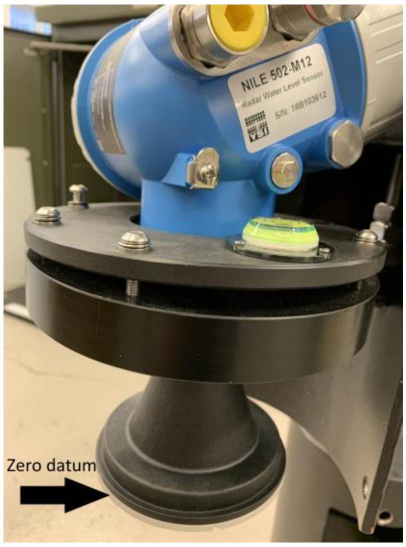


Figure 4. Nile Radar sensor

Testing of the barometer, solar power functionality, battery charge and data transmission via satellite were all successfully concluded and the equipment was packaged in preparation for shipping by January 2023.

It was anticipated that the tide gauge installation would be completed shortly afterwards, but a delay of around 6 weeks resulted whilst the NOC obtained fiscal representation in the European Union (necessitated by the departure of the UK from the European Union), to allow the shipping of the tide gauge from the UK to Italy. The installation was further delayed by the length of time taken for the port to issue the final ordinance allowing the equipment to be fitted.

Between the 26th and 29th of June 2023, NOC engineers Geoff Hargreaves and Barry Martin completed the installation of the tide gauge alongside Juan Francisco Martinez Osuna and Daniele Piazzolla of CMCC.

On arrival at the port, the final location of the equipment was determined, with the solar panel located close to the quay edge and oriented south (to maximise solar collecting potential) overlooking the harbor and away from objects that could cast a shadow. The solar panel elevation angle had already been optimised for operation during the winter months of December and January, ensuring sufficient energy gathering during the shorter winter days, when there is reduced availability of sunlight. The ‘A’ frame was to be located a few metres away (with a maximum separation of 15 m) where it would not shade the solar panel and where the radar arm could not be damaged by vessels or mooring ropes.

Figure 5. Installation of the solar panel frame and electronics cabinet.

The solar panel frame was assembled and the footprint of the frame was marked out on the quayside and holes were drilled to accommodate the base plates. The frame was then fixed to the quayside using anchor bolts.
The position of the large green fibreglass electronics cabinet was marked out on the quayside, to the rear of the solar panel frame, and four fixing holes were drilled into the quayside. A bead of frame sealant was applied to the quayside and the cabinet was lowered onto the bead of sealant. The cabinet was then fastened to the quayside using anchor bolts and a further bead of sealant was placed around the exterior of the cabinet (Figure 5). The solar panel and its housing were then bolted to the solar panel stand.

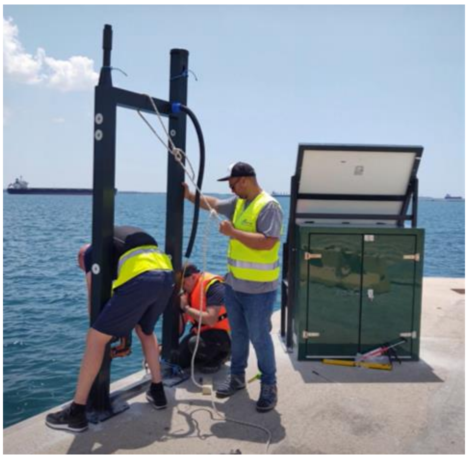


Figure 6. Installation of the ‘A’ frame.

The intended position of the aluminium ‘A’ frame was marked out on the quayside and eight holes drilled to accommodate the base plates. The drilled holes were checked to be of equal depth and perfectly vertical. A bed of acrylate resin was applied to the quayside and to the drilled holes to help bond the anchor bolts. The ‘A’ Frame was moved into position and fixed to the quayside with the anchor bolts (Figure 6). The bolts were tightened as necessary and the structure was checked to be perfectly vertical before the resin hardened.

Figure 7. Attachment of the swing arm

Once the resin beneath the 'A' frame had hardened, the swinging arm frame was attached to the main 'A' frame (Figure 7), securing it in place with two pivot point bolts at the places such that it could rotate but was not loose. Securing bolts were inserted into the appropriate holes on the 'A' frame to place the frame into 'maintenance position', with the sensor mounts accessible from the quayside.

The GNSS radome and antenna were fixed to the top of the steel monument and the Trimble GPS antenna was fixed to the opposite end of the A frame using a mounting adapter (Figure 8). The GPS antenna cable was connected to the antenna and was routed to the interior of the 'A' frame via a purpose-built slot in the framework. Lengths of cable conduit were installed on the quayside from the 'A' frame to the electronics cabinet and from the cabinet to the solar panel frame.

Figure 8. 'A' frame with GPS antenna (left) and GNSS antenna (right)

The Nile radar and attached protective housing were attached to the swing frame housing and the inbuilt spirit level to the housing was checked to be level, ensuring a perfectly vertical beam to the sea surface. The MIROS RangeFinder radar was fitted to the swing frame. The radar and earth bonding cables were routed through the conduit on the swing arm and into the main A frame and connections were made to the electronics cabinet. The GPS antenna cable was routed through the 'A' frame to exit at the base. The protective covers to the MIROS radar and Nile radar were then fitted and the swing arm was locked into 'normal operating position' with the sensors pointing vertically towards the sea surface (Figure 9).

The GPS and GNSS antenna cables were then routed through the conduit between the 'A' frame and equipment cabinet and connections made.

Figure 9. Radars mounted on the swing frame

The Yagi antenna was assembled and attached to the antenna clamp, but it was noticed that, if aligned correctly and attached to the ‘A’ frame in its intended position, it might provide a source of interference with the Trimble Alloy GNSS receiver. Therefore, the Yagi antenna was attached to the solar panel frame with a stainless steel and brass coupling (Figure 10). The Yagi antenna cable was fed down the panel frame and into the electronics cabinet and the cable was connected to the antenna. The Yagi antenna was then aligned with an elevation angle of 39.8° Azimuth and 201.4° Magnetic.

Figure 10. Yagi antenna with steel and brass coupling

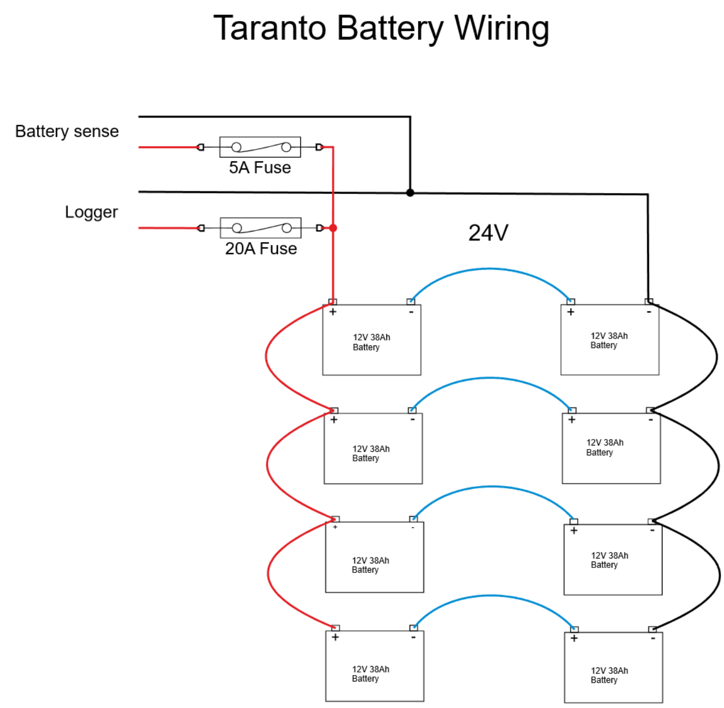


Figure 11. Battery connections at Taranto tide gauge

All cables entering the electronics cabinet and GNSS mast were installed in a “swan neck loop” arrangement, to minimise rainwater ingress into the cabinet and mast.

The 8 lead crystal batteries were installed within the electronics cabinet and were wired in parallel (Figure 11). All remaining connections were made within the electronics cabinet and the system was powered-up and sanity checks were completed to ensure that data were being logged correctly by the datalogger.

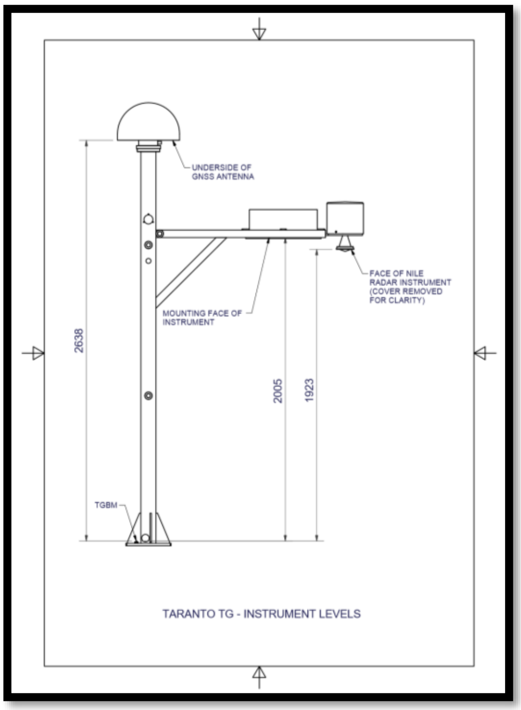


Figure 12. Height of tide gauge components relative to the 'A' frame benchmark (left) and installed benchmarks (right)

As part of this installation an optical level, tripod and levelling staff were supplied to the installation team, allowing them to level-in the tide gauge. A brass domed benchmark was installed on the quayside, near to the GNSS mast (Figure 12). This benchmark was found to be 0.0256m below the height of a brass benchmark (the tide gauge benchmark or TGBM) that was fitted to the metal foot plate of the 'A' frame (Figures 7 and 12). The 'A' frame benchmark height relative to the tide gauge components is provided in Figure 12.

The following final checks were completed before leaving the site:

- The system was powering-up correctly
- Data were being logged by the Satlink3 datalogger
- MIROS radar were being transmitted
- Remote data access via AnyDesk was working
- Data were being transmitted and received by the IOC Sea Level Station Monitoring Facility via satellite at http://www.ioc-sealevelmonitoring.org/station.php?code=tara1
- Data were being logged by the Trimble Alloy GNSS receiver

The fully-installed tide gauge is shown in Figure 13.

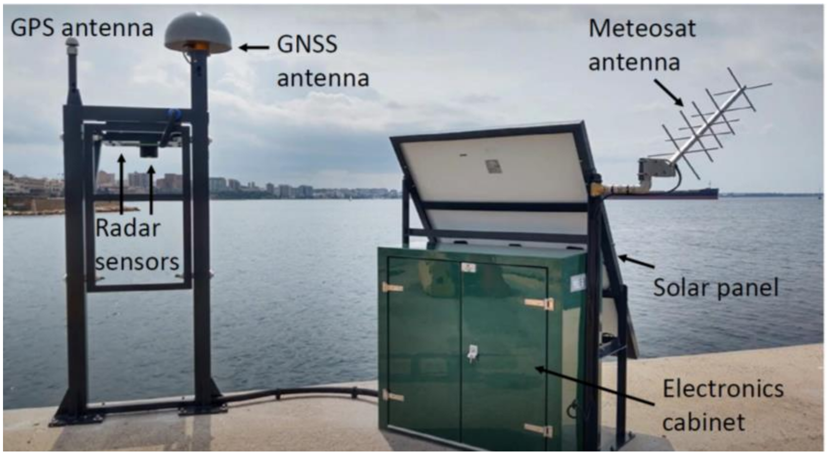


Figure 13. Completed Taranto tide gauge

4. Data Streams

The following data streams have been implemented for this site:

- 1 min averages of sea level from a Nile radar sensor are transmitted via a KPN roaming SIM card at 1 min to the PdE ftp site (enoc.puertos.es) with a 10 sec latency for incorporation into the OSPAC software. Data are time stamped at 10 sec past the minute to which they relate. 40 sec should be subtracted from time stamps to accurately represent the midpoint of the averaging period. The SIM card contract also relates to the provision of atmospheric pressure data (below) and will expire on 28/02/25
- 1 min averages of sea level from the Nile radar sensor are transmitted via a free Meteosat satellite communications system to the Global Telecommunications System (GTS) from where they are accessed by the IOC sea Level Station Monitoring Facility (IOC SLSMF) and are made publicly available (Figure 14) [SEA LEVEL STATION MONITORING FACILITY (ioc-sealevelmonitoring.org)](ioc-sealevelmonitoring.org).This telemetry method has a maximum latency of 6 min. Data are time stamped at 1 minute past the minute to which they relate. 90 sec should be subtracted from time stamps to accurately represent the midpoint of the averaging period.

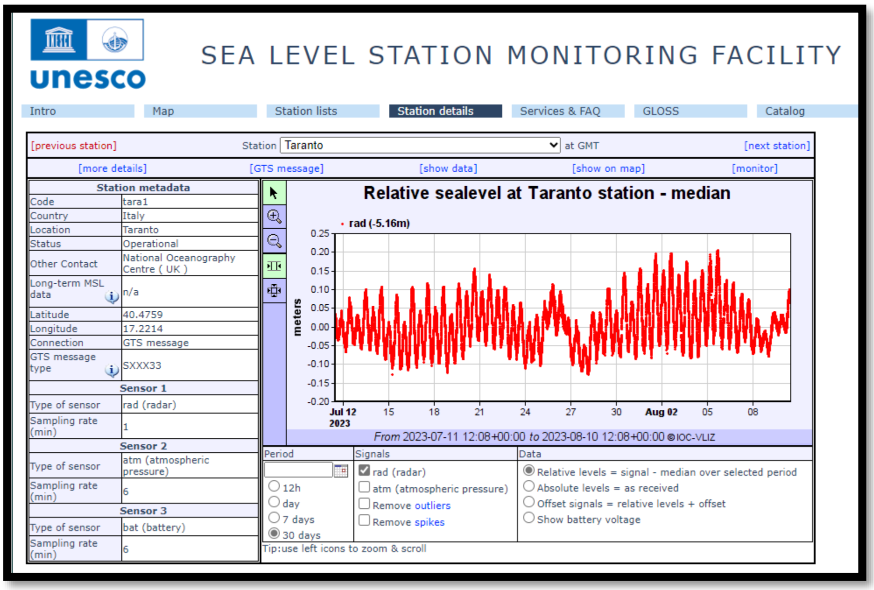


Figure 14. Sea level data received at IOC SLSMF for Port of Taranto

- 1 min samples of atmospheric pressure are transmitted via a KPN roaming SIM card at 1 min intervals to the PdE ftp site (enoc.puertos.es) with a 10 sec latency for incorporation into the OSPAC software. Data are timestamped at 10 sec past the sampling time.

- 1 min samples of atmospheric pressure are transmitted via a free Meteosat satellite communications system to the Global Telecommunications System (GTS) every 6 min from where they are accessed by the IOCSLSMF and made publicly available (Figure 15) [SEA LEVEL STATION MONITORING FACILITY (ioc-sealevelmonitoring.org)](ioc-sealevelmonitoring.org). This telemetry method has a maximum latency of 6 min. Data are timestamped

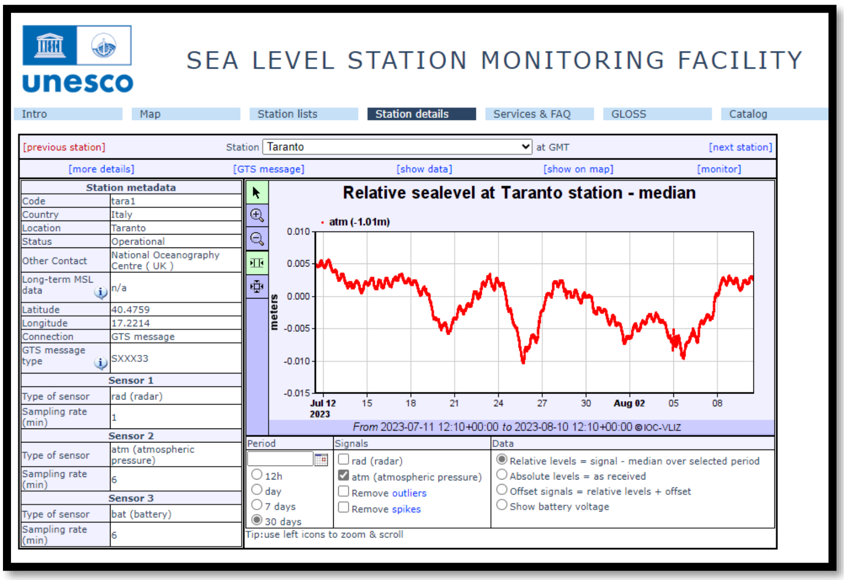


Figure 15. Atmospheric pressure data received at IOC SLSMF for Port of Taranto

at 60 secs after the sample was taken, so this must be deducted from each time stamp.

- Using the MIROS RangeFinder, every 1 min the following wave spectral parameters are computed for 2Hz raw data across a 20 min-time window:
    - Water level (m)
    - Hm0 (significant wave height (m))
    - Hmax (maximum wave height (m))
    - Tm02 (mean zero up-crossing period (s))
    - Tp (primary wave peak period (s))

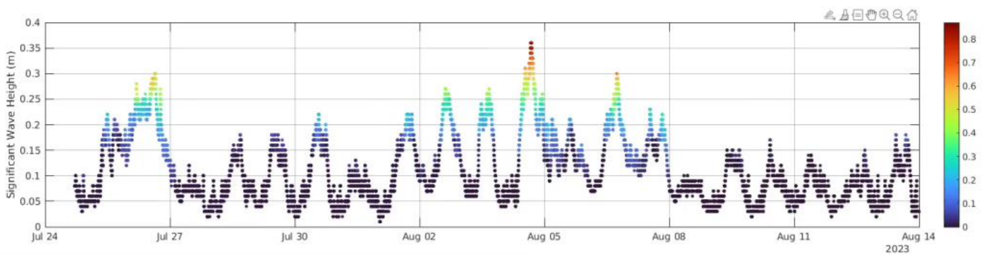


Figure 16. Significant wave height at the tide gauge in Taranto

An example of the data is shown in Figure 16. These data are transmitted via the KPN roaming SIM card to the PdE ftp site (enoc.puertos.es) with negligible latency for incorporation into the OSPAC software. Data are time stamped at 10 sec past the minute to which they relate. 610 sec should be subtracted from time stamps to accurately represent the midpoint of the averaging period.

- RINEX 3 data files from the Trimble Alloy GNSS receiver are transmitted every 15 mins to the NOC via FTP. They contain observations of carrier phase and range, plus signal-to-noise ratio at 5 sec intervals from each satellite that is in view of the receiver. On a daily basis, the 15 min files are combined to produce a daily file of 30 second data which is sent via ftp to the SONEL data portal (GPS Taranto tide gauge (sonel.org), SONEL

Figure 16. Vertical land motion at SONEL for the Port of Barcelona tide gauge

station code 4587, IGS site reference TRTG).

- The 15 min data files from the Trimble Alloy GNSS receiver are processed in near real-time using the interferometric reflectometry (IR) technique, to produce sea level heights at 15 minute intervals. The latency is around 1 hour. These data are transmitted to the PdE ftp site (enoc.puertos.es) for incorporation into the OSPAC software. These data have been shown to display good agreement with sea level data from the conventional Nile radar sensors (Figure 17).

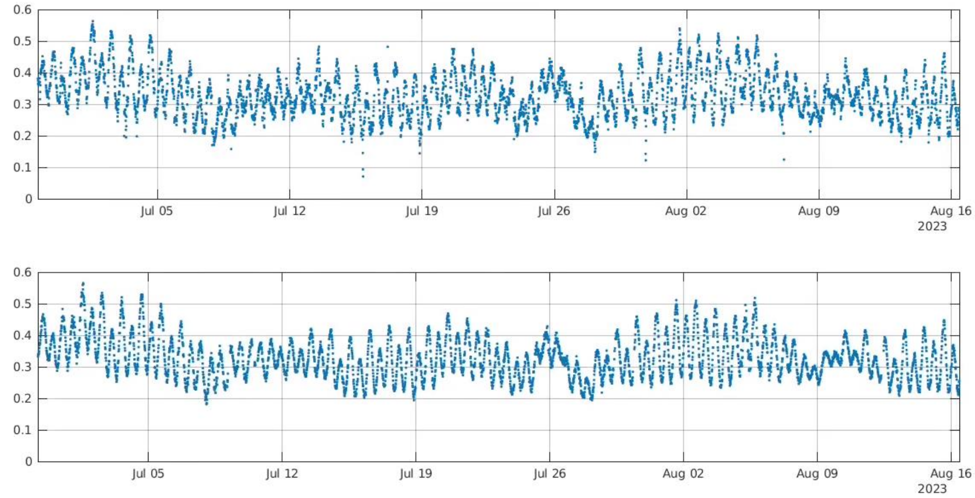


Figure 17. Sea level from GNSS-IR (top) and conventional radar sensor (bottom) at Taranto

- The 15 min data files from the Trimble Alloy GNSS receiver are currently processed manually every few days using the interferometric reflectometry (IR) technique, to produce hourly estimates of SWH across the nearshore area. The results are currently in a calibration phase. Agreement between these observations and those of an offshore wave buoy and/or the MIROS radar sensors have been shown to be very good (Figure 18). The NOC plans to refine this to produce a near real-time SWH product to support OSPAC in Autumn 2023.

Date telemetry contracts:

A KPN roaming SIM card contract for 1GB per month is in place with Mobius Networks for the following:

- 1 min sea level and atmospheric pressure data transmissions
- 1 min MIROS sea level and wave data transmissions

The contract will expire on 28/02/25 and the details are as follows:

Telephone Number	SIM Number	Contract Start	IMSI
204080823556790	8931082522108704315	01/02/2023	3197045690915

5. Appendices

Appendix 1. Radar Calibration Data

Distance to Target (mm)	Radar Displayed Output (mm)	Measured Distance (Tape Measure mm)	Satlink3 Output (mm)	Offset (mm)
400	400	405	N/C	+5
500	500	504	N/C	+4
600	600	604	N/C	+2
700	700	702	N/C	+2
800	800	802	N/C	+2
900	900	902	N/C	+2
1000	1000	1002	N/C	+2
1100	1100	1101	N/C	+2
1200	1200	1202	N/C	+2
1300	1300	1301	N/C	+1
1400	1400	1400	N/C	0
1500	1500	1499	N/C	-1
1600	1600	1599	N/C	-1
1700	1700	1699	N/C	-1
1800	1800	1799	N/C	-1
1900	1900	1899	N/C	-1
2000	2000	1998	N/C	-2
2100	2100	2098	N/C	-2
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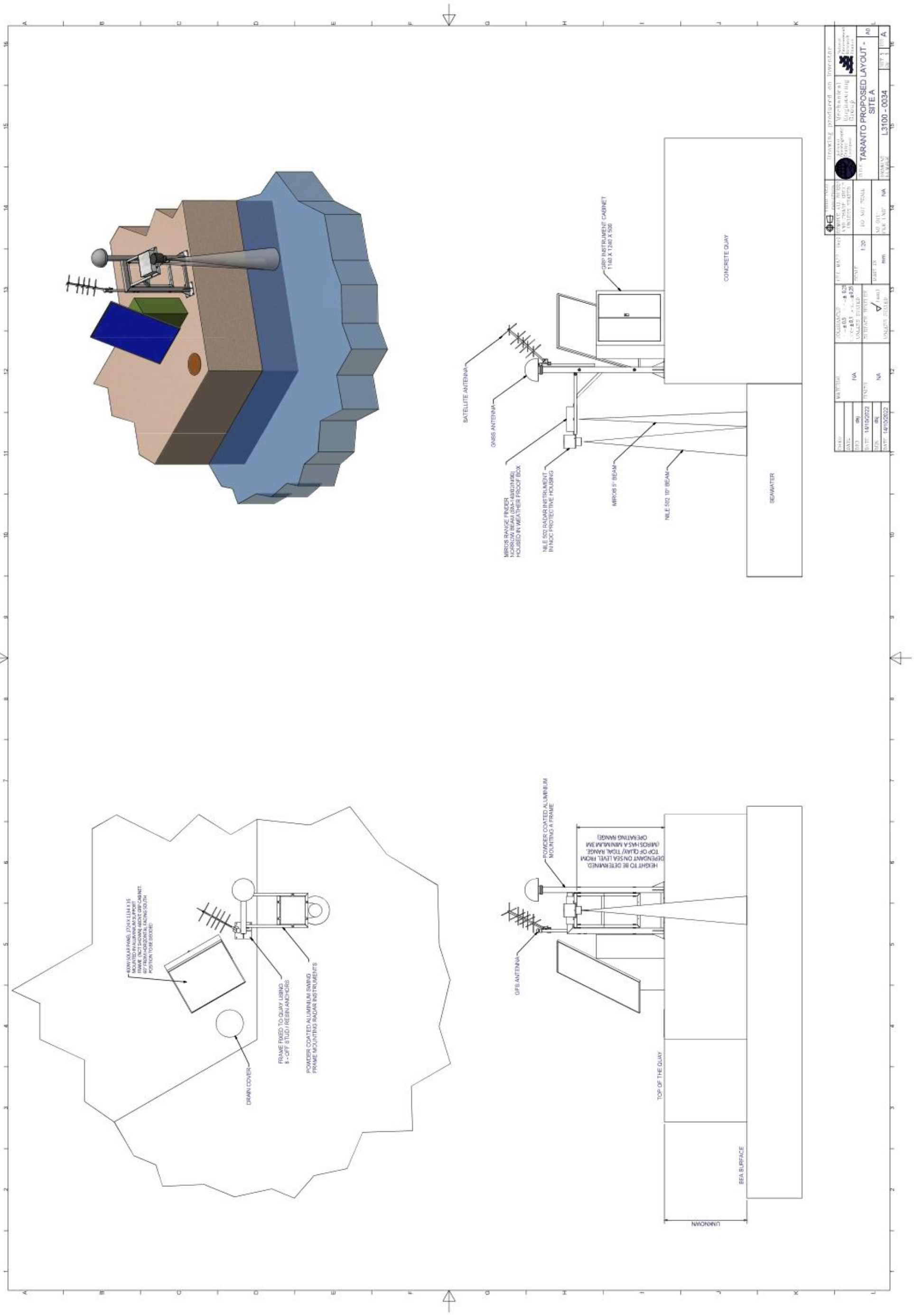
Appendix 2. Technical Designs



Appendix 3. Login Information

Tide Gauge RUT955
IP Address: 192.168.1.1
Username: admin
Password: EuroSTaran23
Wi-Fi SSID: RUT955_3B38
Wi-Fi Password: c7L3Ypi2

Trimble Alloy:
IP Address: 192.168.1.70
Username: admin
Password: 6105r40056!
Wi-Fi Access Point SSID:
6105R40056
Wi-Fi Password: 6105r40056!

Tide Gauge Raspberry Pi
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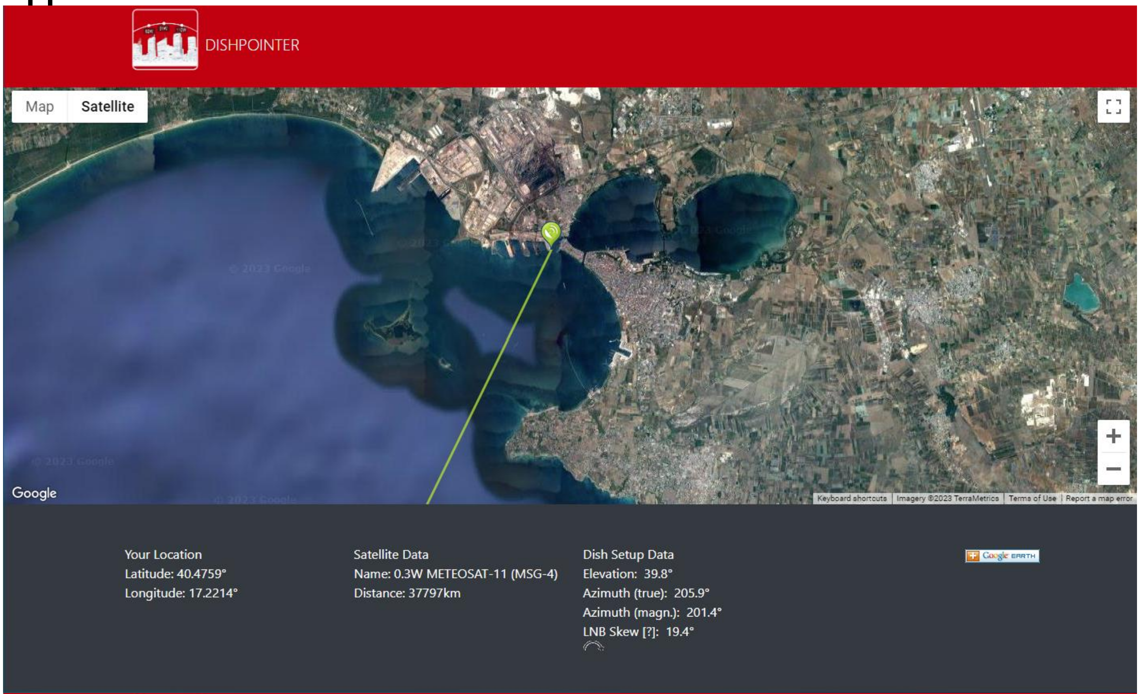
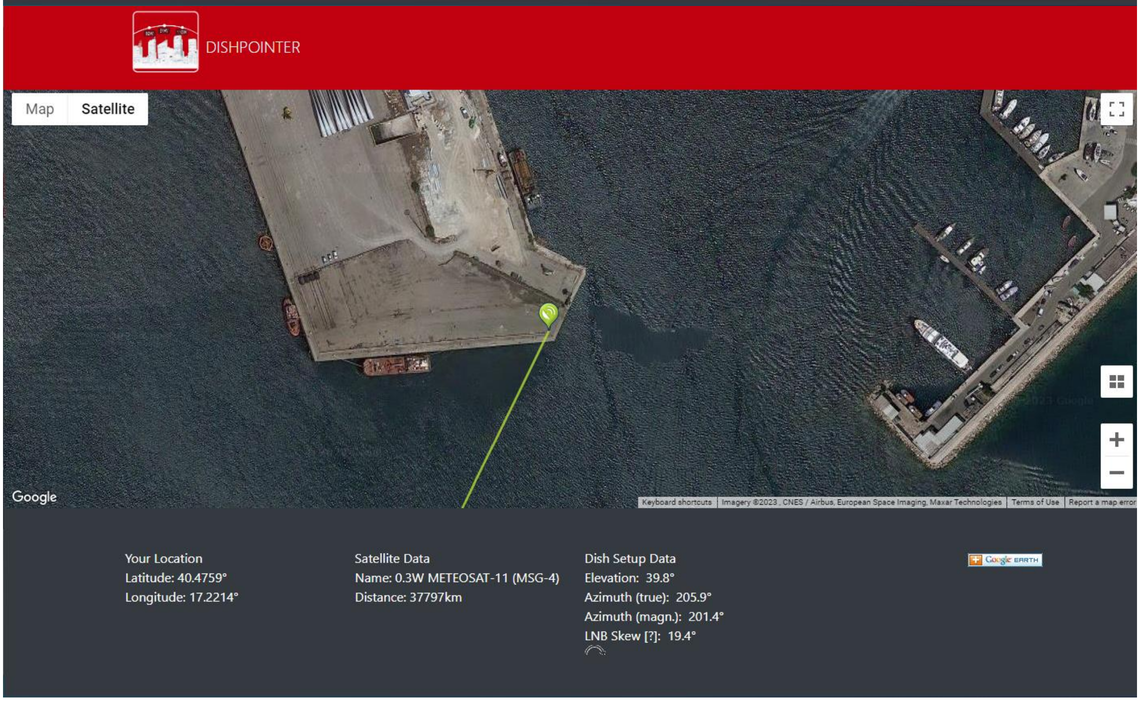
Username: pi
Password: EuroSTaran23

Anydesk number: 543 410 338
Password: EuroSItaly23

Appendix 4. Satellite Transmissions



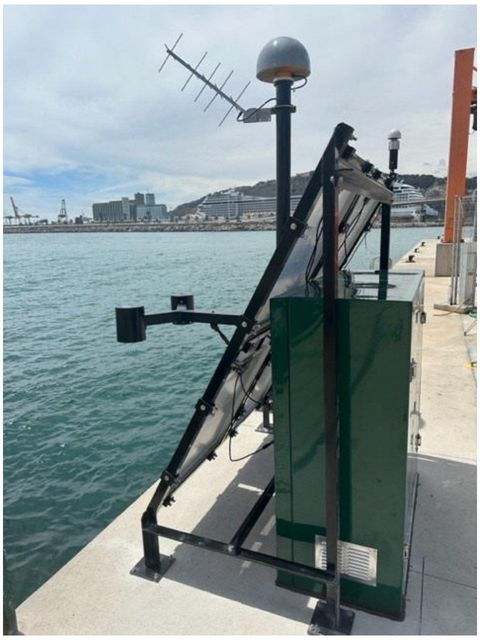


Tide gauge maintenance manuals

Tide gauge maintenance manuals are provided for each EuroSea tide gauge. They summarise the regular checks that should be undertaken to keep the system in a state of good repair and provide information regarding data streams that is essential for troubleshooting. NB. Colombian editions are supplied in both English and Spanish Versions, but the Spanish version is currently in draft as it is undergoing proof-reading and will be updated with a final version in due course.

- EuroSea Tide Gauge Maintenance Manual Barcelona
- EuroSea Tide Gauge Maintenance Manual Taranto
- EuroSea Tide Gauge Maintenance Manual Buenaventura - English
- EuroSea Tide Gauge Maintenance Manual Buenaventura - Spanish

Barcelona Tide Gauge Maintenance Manual



v1.0

Jeff Pugh, Geoff Hargreaves and Angela Hibbert
11/08/23

Contents

1. Introduction

Tide gauges are exposed to hostile monitoring conditions, which can give rise to numerous problems that adversely affect tide gauge operation. These can be largely mitigated if tide gauge operators undertake regular maintenance, which forms an essential part of a tide gauge operator's role.

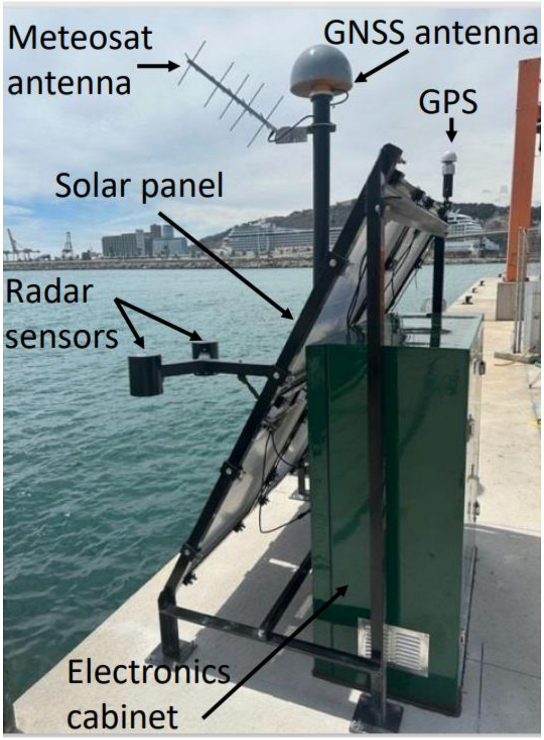


Figure 1. Main tide gauge components at the primary Barcelona tide gauge site

Short inspection visits to visually assess equipment for signs of deterioration should be undertaken on a quarterly basis. Additional inspection visits are advisable after an extreme weather event. During a visual inspection, tide gauge operators should examine all visible components for signs of deterioration, such as corrosion of metalwork, UV degradation of protective coatings, exposed, frayed and loose cables, biofouling, evidence of vandalism etc. For the primary tide gauge site at Barcelona (Figure 1), key components to be checked include supporting frames, antennae, solar panels, sensors and cabling. For the secondary instrumentation at the lighthouse (Figure 2), the main components to be checked are the low-cost GNSS receiver, solar panel, cabling and electronics cabinet.

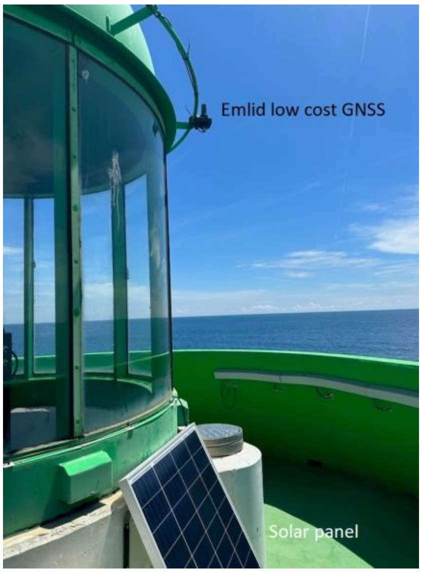


Figure 2. Instruments at the secondary site in Barcelona

Inspection visits should be interspersed with longer servicing and maintenance visits on a 6-monthly or annual basis. These longer visits allow for removal and cleaning of pressure sensors (if fitted), downloading of data and checking the correct functioning of sensors.

This combined visual inspection and maintenance regime will allow the operator to detect damage and potential problems at an early stage and prevent further degradation.

The operator should also maintain regular contact with port and harbour authorities, so that they are aware of any potential site development work or changes in port operations that might adversely affect the operation of the tide gauge.

Operators are encouraged to take photographs during visits in order to maintain a visual record of the condition of the equipment. It is also important to keep a written record of the dates and times of any maintenance visit and the checks and procedures performed on each occasion, as this will help data users to understand any anomalies in tide gauge records.

2. Maintenance Procedures by Tide Gauge Component

2.1 Supporting Structures and Fittings

The steelwork structure should be visually checked for physical damage such as vessel impacts and breakages, corrosion, biofouling and rodent activity (see Figure 3). If there is evidence of degradation, appropriate action can then be taken (e.g.

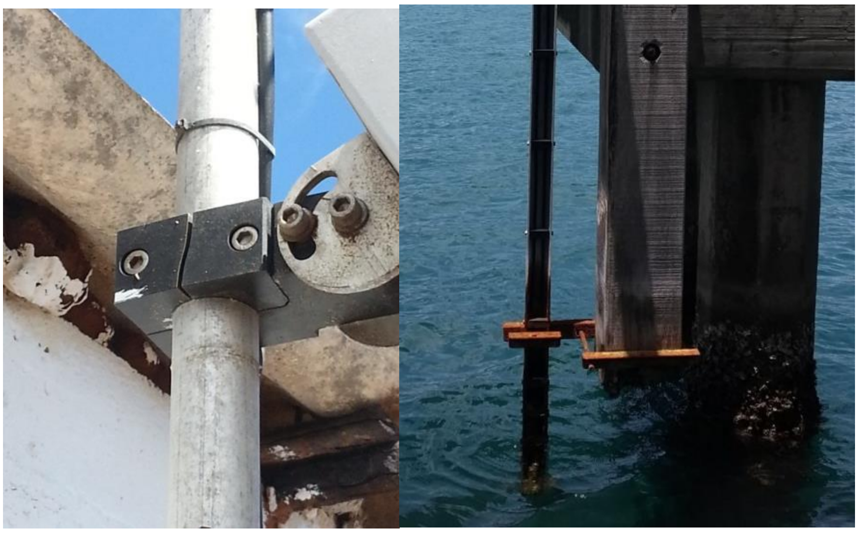


Figure 3. (a) Cracked bracket and (b) rotten wooden support

steelwork repairs, application of anti-corrosion paint or replacements of broken fittings). If rodent damage or activity is found, metal grills can be placed across openings in supporting steelwork, radar arm and electronics cabinet. The condition of the pier/jetty/wharf should also be noted and the site owners consulted about plans for maintenance and repair.

2.2 Meteosat Antenna

Yagi data transmission antennae are typically very reliable but can be susceptible to physical damage from debris, severe weather, bird damage or other impacts to individual elements. A Yagi antenna uses 4 active elements (see Figure 4) to transmit the data signal to a satellite, whilst the remaining elements are used to focus and guide the transmitted signal.

The antenna can remain operational even if a number of elements are damaged or broken, but this will result in a degraded signal transmission. Therefore, the tide gauge operator should check that sufficient elements remain intact and if not, the antenna should be replaced. In colder climates, ice build-up can also affect the performance of the antenna and in some cases this causes a temporary short circuit, this can be removed by cleaning off the ice build-up. Antenna fixings should also be checked to ensure that they are secure as antennae can be loosened by storm damage and high winds. Cabling to the antenna should be checked for degradation and nicks in the outer sheath. These can be repaired with self-amalgamating electrical tape, which should be covered with PVC tape to prevent UV degradation.

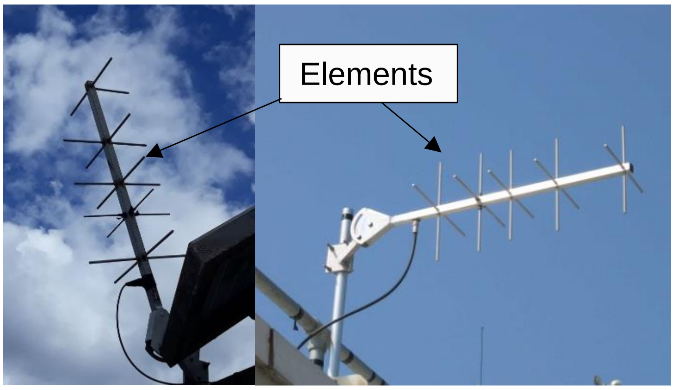
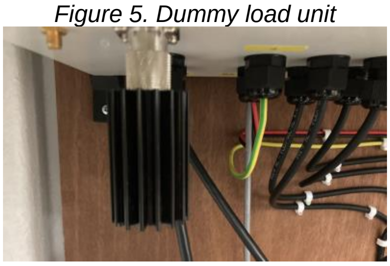


Figure 4. (left) and (right) Yagi antennae

The antenna's elevation and azimuth should be checked at each visit to ensure the correct elevation of 42.1° and an azimuth of 182.1° Magnetic. A tide gauge setup sheet and a pictorial diagram showing the correct values is provided in Appendix A.

Figure 5. Dummy load unit



Should the Yagi antenna fail, the dummy load unit (Figure 5) that was supplied with the tide gauge can be connected in place of the antenna to allow fault diagnosis. Prior to connecting the dummy load, the tide gauge operator should monitor data transmission attempts by observing the light emitting diodes (LEDs) on the data logger, which are illuminated during data transmission. There are two possible failures:

1. A short circuit

   This will result in a shorter transmission time than normal and can be confirmed by connecting the dummy load in place of the antenna, If the antenna or cable is faulty and a dummy load is fitted a normal transmission length should then observed.

2. An open circuit

   In the case of an open circuit, the transmitter will prevent the transmission entirely, so the LEDs will not illuminate. Again, the use of the dummy load should result in a normal transmission time.

In addition, the data logger can also supply diagnostic information relating to the status of the last transmission e.g. if it was successful or not (Figure 6). This can be accessed via one of the options under the transmission menu and can be used helped with the diagnostics.

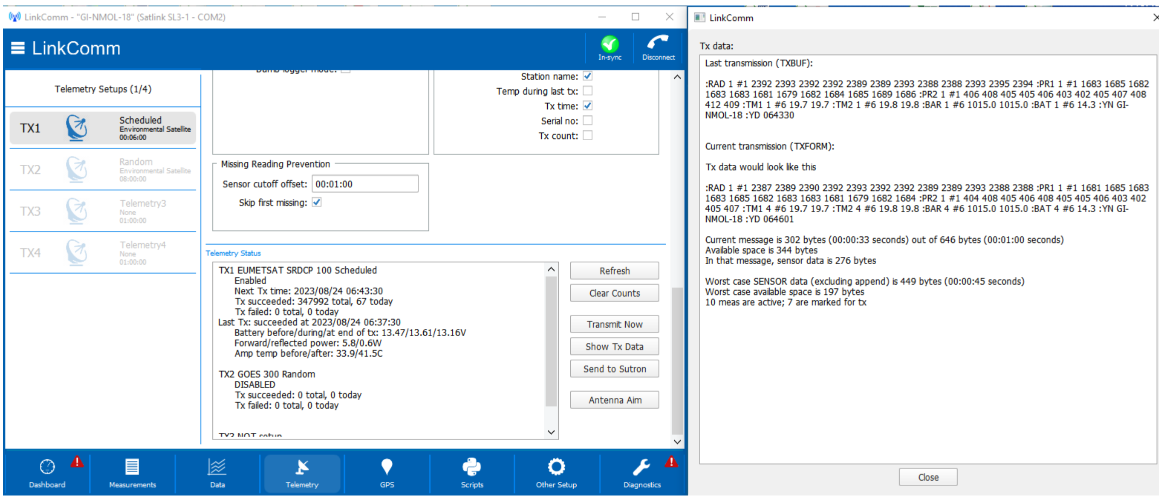


Figure 6. Diagnostic information displayed by Sutron Satlink3 data logger

2.3 GPS & GNSS Antennae

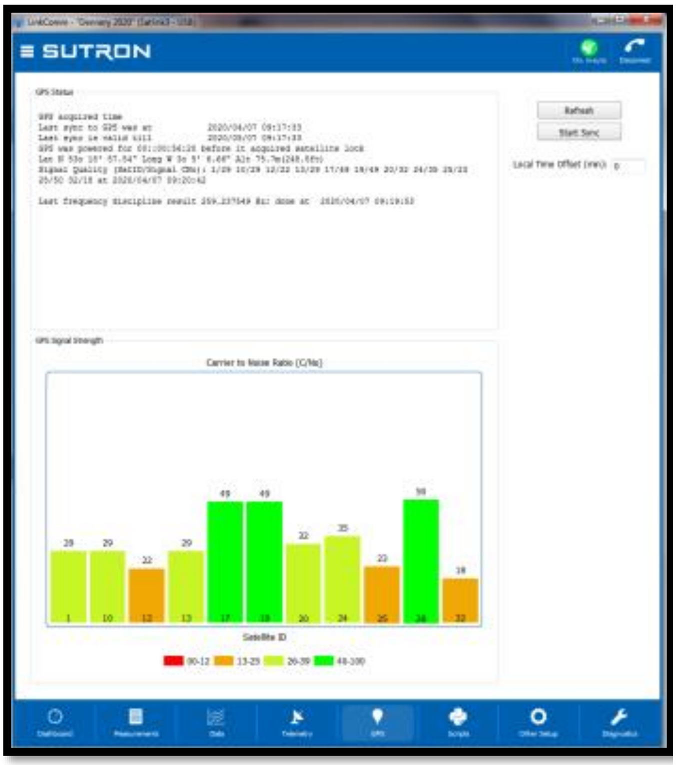
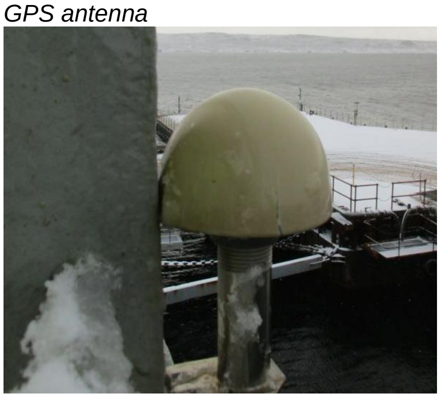


Figure 7. Satellite status displayed by Sutron Satlink3 data logger

The tide gauge is supplied with a small Trimble bullet-style GPS antenna (shown in Figure 1). This has been specifically chosen for its improved immunity to other radio frequency (RF) signals, which results in reliable performance in hostile RF-jamming environments. The datalogging and transmission systems use the GPS antenna to obtain an up-to-date GPS time fix every 12 hours, which is sufficient to keep the inbuilt clock correctly synchronised, ensuring that data are transmitted within the dedicated time frame allocated to each tide gauge location for satellite transmission. The operation and performance of the GPS can also be monitored using the in-built datalogger diagnostics to confirm correct operation, as described in the manufacturer's

Figure 8. Cracking to outer casing of a GPS antenna



datalogger manuals provided. The output (Figure 7) shows the satellites in view and how many are being used at any one time.

GPS antennae are very reliable, but over extended periods of time, the outer casing may perish due to degradation by UV radiation, resulting in cracking and water ingress (Figure 8). Replacements are widely available and easily procured.

Figure 9. Trimble Alloy GNSS receiver and radome

The geodetic quality Trimble Alloy GNSS receiver (Figure 9) is likewise reliable and is fitted with a protective cover (a 'radome') to prevent general wear, damage by wildlife and the build-up of debris. It should be also be checked for evidence of degradation. Since radomes alter the antenna's absolute phase centre, if a radome is replaced, the operator must ensure that the correct antenna/dome corrections are applied.

2.4 Solar Panels

Figure 10. Solar panel array for the primary tide gauge site (left) and the solar panel for the low-cost GNSS (right)

The solar panels (Figure 10) are the main power source to the tide gauge during the day. They additionally supply charge to the array of internal batteries that will power the gauge during the hours of darkness. Panels are usually resilient and are designed for a 25-year operational lifespan, before a deterioration in power generation becomes notable. However, it is helpful to periodically clean the panel with a damp cloth, particularly in environments where it is dusty or where there is bird activity. This will ensure a constant supply of power to the electronic components. The operator should check that the solar panel remains securely fixed and that cabling is in a good state of repair. If the panel is loose, it should be secured and the angle rechecked.

2.5 Radar Sensor

Figure 11. Damaged radar horn (left) and cracked sensor housing (right)

Figure 12. Levelling bubble on Nile radar housing

Since they are mounted above the water line, radar sensors tend to be more susceptible than underwater sensors to physical damage from ropes, vessels, environmental impacts and vandalism. A visual inspection should be made of the sensor, checking for external damage (Figure 11) and possible moisture ingress. It is also important to check that the sensor position has not moved since the last visit. For the Nile radar sensors, a levelling bubble is fitted to the radar housings (Figure 12), allowing the operator to ensure that this is still in alignment. The cables should be checked for degradation and physical damage (nicks, abrasions, rodent damage etc.) to the outer coating. Any damage should be repaired with self-amalgamating tape and then covered with a further layer of PVC tape to protect against water ingress and UV deterioration. If fitted with an LCD screen, this can be used to confirm normal operation of the radar sensor.

2.6 Electronics Cabinet

Figure 13. Outer (green) and inner (white) electronics cabinets

The large green electronics cabinet (Figure 13) houses two inner electronics cabinets, to provide weatherproofing and prevention of physical damage to the inner electronics components. The inner cabinets are accessed with the use of a key. All cabinets should be checked for signs of water ingress.

The electronics cabinet contains the data logger and lead crystal battery together with other electronics components. It is good practice to download data on a 3-monthly to 6-monthly basis (see Appendix B).

The lead crystal batteries have a typical lifespan of 3-5 years, but the voltage can be

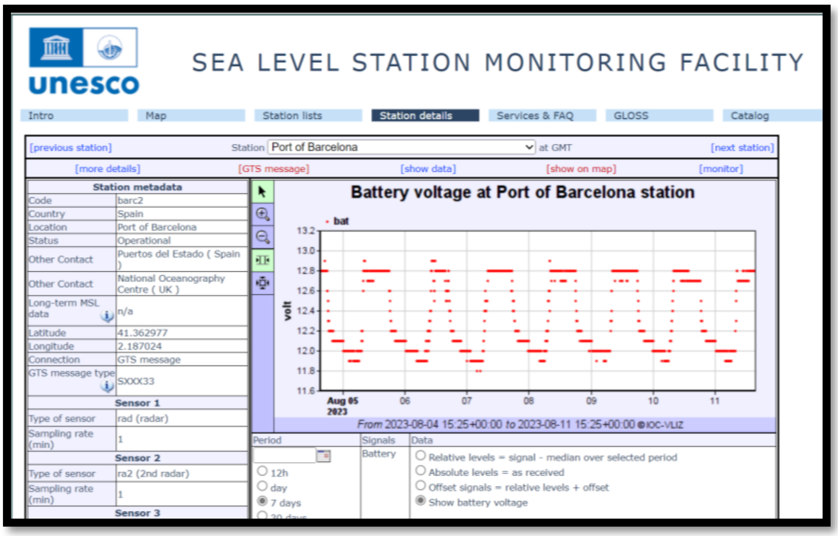


Figure 14. Battery voltage display at IOC SLSMF website for Barcelona tide gauge

monitored daily via the IOC Sea Level Station Monitoring Facility (IOC SLSMF) website ([SEA LEVEL STATION MONITORING FACILITY (ioc-sealevelmonitoring.org)](ioc-sealevelmonitoring.org), Figure 14). Signs that the battery is coming to the end of its life might include failures during the early morning/night or inability of the battery to recover its charge during the day, achieving a level of only 10 volts or below.

2.7 Datalogger

The OTT Sutron Satlink3 datalogger (Figure 15) is capable of logging the data internally and has an integrated Meteosat transmitter to relay the data via satellite network. Data can be downloaded directly from the dataloggers via a serial/USB lead, or via Wi-Fi, and it is recommended that tide gauge operators undertake this as part of a maintenance protocol as direct download ensures that a complete tide gauge record is obtained and avoids data gaps that might arise in the IOC SLSMF web portal record through satellite communications problems. An example data download process is provided in Appendix B

Figure 15. Sutron Satlink 3 datalogger

2.8 Lead Crystal Batteries

Figure 16. Non-spillable lead crystal battery

The tide gauge is supplied with 6 high quality 'non-spillable' lead crystal batteries (Figure 16) which are designed to operate in extreme temperatures whilst providing excellent deep discharge performance. These batteries should operate for around 3-5 years depending on the environment.

The battery will normally receive a full charge during the day via the solar panel and will then use that energy to power the tide gauge during the hours of darkness. Each time a transmission is made the battery has to supply up to 4 amps for that period. If the battery charge dwindles, transmissions start to fail during the night when the gauge is relying on the battery only. It is therefore essential to monitor battery voltage via the IOC SLSMF website. The battery should be replaced if it falls below 10 volts after it has received a full charge during the day.

2.9 Fuse/Surge Protection Devices

Figure 17. Fuses and surge protectors

The cabinet contains a number of protection devices mounted on the DIN rail and include surge and lightning protectors as well as inline fuses (Figure 17). The inline fuse allows power to be isolated from the logger or battery or both, to allow maintenance to be carried out. The surge and lightning protectors have been provided for each of the externally mounted sensors, to protect the data logger in the event of a lightning strike. Replacement fuses and surge/lightning protectors have been supplied.

2.10 Solar Charge Controller

The power to the electronics and battery is provided by the solar panels. To provide and regulate a 12V supply to the battery, two Campbell Scientific solar charge controllers (Figure 18) are used. These units transform the higher solar panel voltages to provide a regulated 12V supply to the logger and sensors. In addition to this, the controller is able to intelligently monitor and charge the battery to keep it in optimum condition.

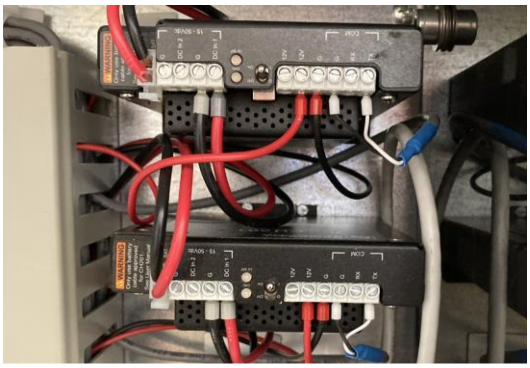


Figure 18. Solar charge controllers

The controllers have a couple of diagnostic LED's which can be used by the operator to determine the charging status and battery status which can help in the diagnosing of faults. The Campbell Scientific CH201 manual should be checked for further information on these diagnostic LEDs.

2.11 Previstorm

The Previstorm Thunderstorm Warning System should be checked externally for evidence of damage and degradation. Repairs and faults should be reported to the manufacturer Ingesco Lightning Solutions Tel: +34 937 360300

3. Schedule of Maintenance Tasks

3.1 Daily Tasks

- Check the data at the IOC's Sea Level Station Monitoring Facility data portal (http://www.ioc-sealevelmonitoring.org/) for missing messages and Meteosat transmissions for message corruption.

3.2 Quarterly Tasks

- Download data from the Satlink3. Although data are transmitted in near real-time to the IOC Sea Level Station Monitoring Facility, it is good practice to download the data every 3 to 4 months before they are overwritten. This will allow the infilling of data gaps that have resulted from a failed satellite transmission.
- Quick visual inspection of the tide gauge, cables, antennae and solar panel for any damage.

3.3 Annual Tasks

- Thorough inspection of the tide gauge, cables, antennae and solar panel for any damage. Time should be taken to closely inspect all the component parts and cables checking for wear or damage. It may be necessary to use a stepladder to inspect the upper components.

4.Levelling

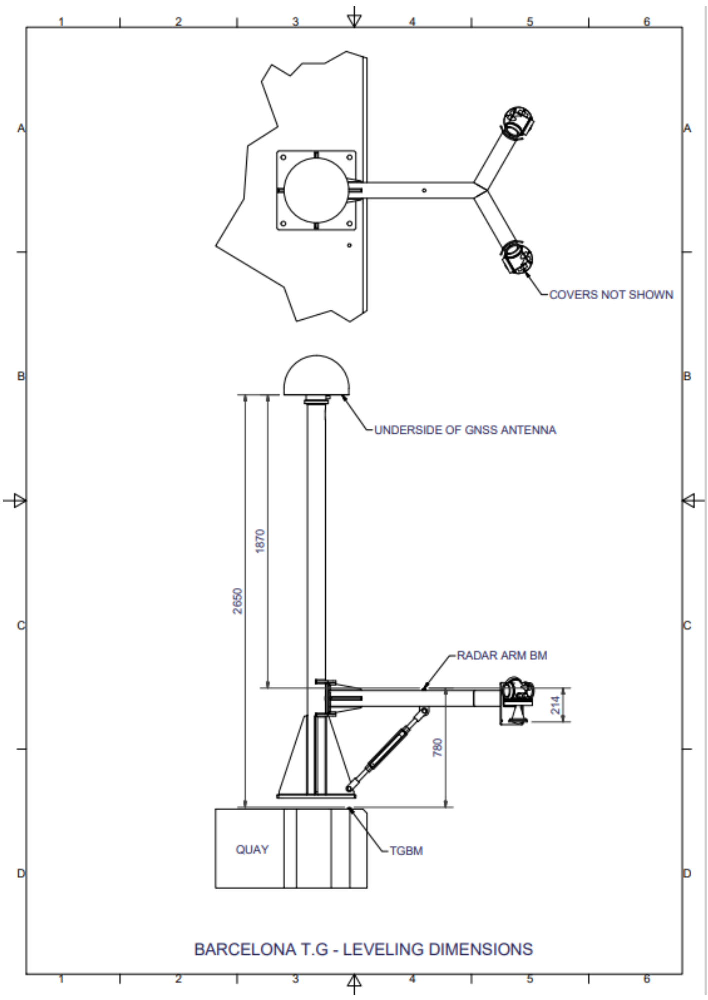


Figure 18. Tide gauge benchmark heights

Levelling is an important part of the installation process as it allows the tide gauge and its sensors to be tied in into known stable benchmarks situated nearby.

As part of this installation a benchmark (the tide gauge benchmark or TGBM) was installed on the quayside, near to the GNSS mast. The height difference was recorded between this TGBM and a brass benchmark fitted to the radar arm (Figure 18).

Ongoing monitoring of levelling at the primary site is done by comparing time series of vertical land motion from the GNSS receiver with sea level time series derived from the same instrument via the GNSS interferometric reflectometry (GNSS-IR) technique. This removes the need for ongoing manual levelling exercises.

Appendix A

Quick start data sheet

The quick-start data sheets (below) provide a summary of all relevant information about the tide gauge and can be used as part of the site maintenance procedures to check the antenna's elevation and azimuth, the timeslot address, channel and time. Information on the sensors/loggers such as serial numbers and wiring information are also included in case they have to be removed and reconnected.

Quick Start Data Sheet – Eurosea Barcelona Tide Gauge

Latitude: 41.362977
Longitude: 2.187024

Xylem Nile 502 Radar Sensor:

s/n - 21F105518.
Communication interface – SDI-12.
SDI-12 device address: 0
Max measuring range – 30m.
Cable assembly, Turck Banner, WKC 12T-15/S618.

Cable colours:			
	Black	GND	Pin 11
	Red	+12V	Pin 8
	White	SDI-12 data	Pin 1

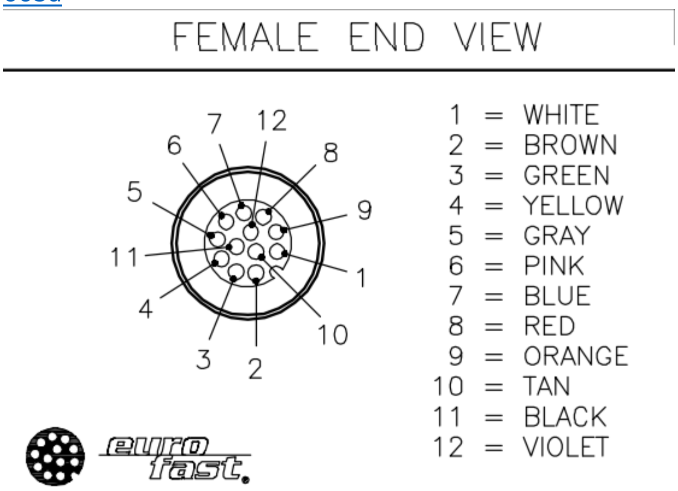
Xylem Nile 502 Radar Sensor:

s/n - 21F105519.
Communication interface – SDI-12.
SDI-12 device address: 0
Max measuring range – 30m.
Cable assembly, Turck Banner, WKC 12T-15/S618.

Cable colours:			
	Black	GND	Pin 11
	Red	+12V	Pin 8
	White	SDI-12 data	Pin 1

Turck Banner WKC 12T-*/S618:

12 core, 2A, Black PVC Cable, Shielded, Female Right Angled M12 connector, * indicates length of cable (m).
https://www.turck.us/en/product/0000002b0001a4120007003a



Vaisala Barometer PTB110:

Model: PTB110 1A0AB
S/N T2130675 0-5V (500-1100 hPa)
Spot Reading every 6 minutes.
Satlink3 calculation 500+(((1100-500)/5)*X) hPa.

Sensor	Cable	Satlink3	Pin No.
VOUT	White	A	36
Supply	Red	Prot +12V	21
GND	Black	GND	22
AGND	Green	Analogue GND	37

SATLINK3 SL3-1 V2:	**D**ata logger with integrated transmitter S/N 2105534
Antenna Pointing Data:	Azimuth (true) = 183.7°, Azimuth (magnetic) = 182.2°, Elevation = 42.1°
EUMETSAT Transmission Slot:	00:00:30 plus 6 minutes thereafter
DCP ID:	1825C776
DCP Name:	SP/PORT_BARC
Channel:	225
Baud Rate:	1200
Transmission Time Slot Length:	15 seconds
Satellite:	METEOSAT-11
Online Antenna Pointing Help:	http://www.dishpointer.com/
Configuration file:	EUROSEA_BARCELONA

Trimble GNSS:

Trimble Alloy Receiver s/n: 6050R40076
Trimble Choke Ring Antenna s/n: 5104338210
Trimble Antenna Radome s/n: 3278
Antenna Measurement Method: bottom of antenna mount
Firmware Version 6.15
Core Engine Version 5.55

Position
- Lat: 41° 21’ 46.64699” N
- Lon: 02° 11’ 13.26218” E
- Height 52.912m
- Datum: WGS-84

Measurements, 5 seconds, positions 5 minutes, continuous 15 minutes.

Low cost GNSS:

Emlid REACH M2 GNSS receiver s/n: 8243E56B8A7BD3D3
Antenna: Tallysman HC871
Part number: 33-HC871-28

Lo-cost GNSS EMLID

IP Address: 192.168.1.116
Username: reach
Password: emlidreach

Teltonika RUT955 Modem:

Tide Gauge
s/n: 1111260073
IP Address: 192.168.1.1
Username: admin
Password: EuroSBarca22
Wi-Fi SSID: RUT955_259A
Wi-Fi Password: Bc56JgVx

Lo-cost GNSS
s/n: 1112895837
IP Address: 192.168.1.1
Username: admin
Password: EuroSBarca22
Wi-Fi SSID: RUT955_F360
Wi-Fi Password: Rr5g3TWk

Previstorm Lightning Detector
s/n: 1110197319
IP Address: 192.168.1.1
Username: admin
Password: EuroSBarca22
Wi-Fi SSID: RUT955_FEC4
Wi-Fi Password: y2U7WqEi

AnyDesk Access:

Tide Gauge
Desk number: 465 580 702
Password: EuroSBarca22

Low cost GNSS
Desk number: 519 768 864
Password: EuroSBarca22

Previstorm
Desk number: 869145776
Password: uzHm*:9)+y

Raspberry Pi:

Tide Gauge
IP Address: 192.168.1.246
Username: pi
Password: EuroSBarca22

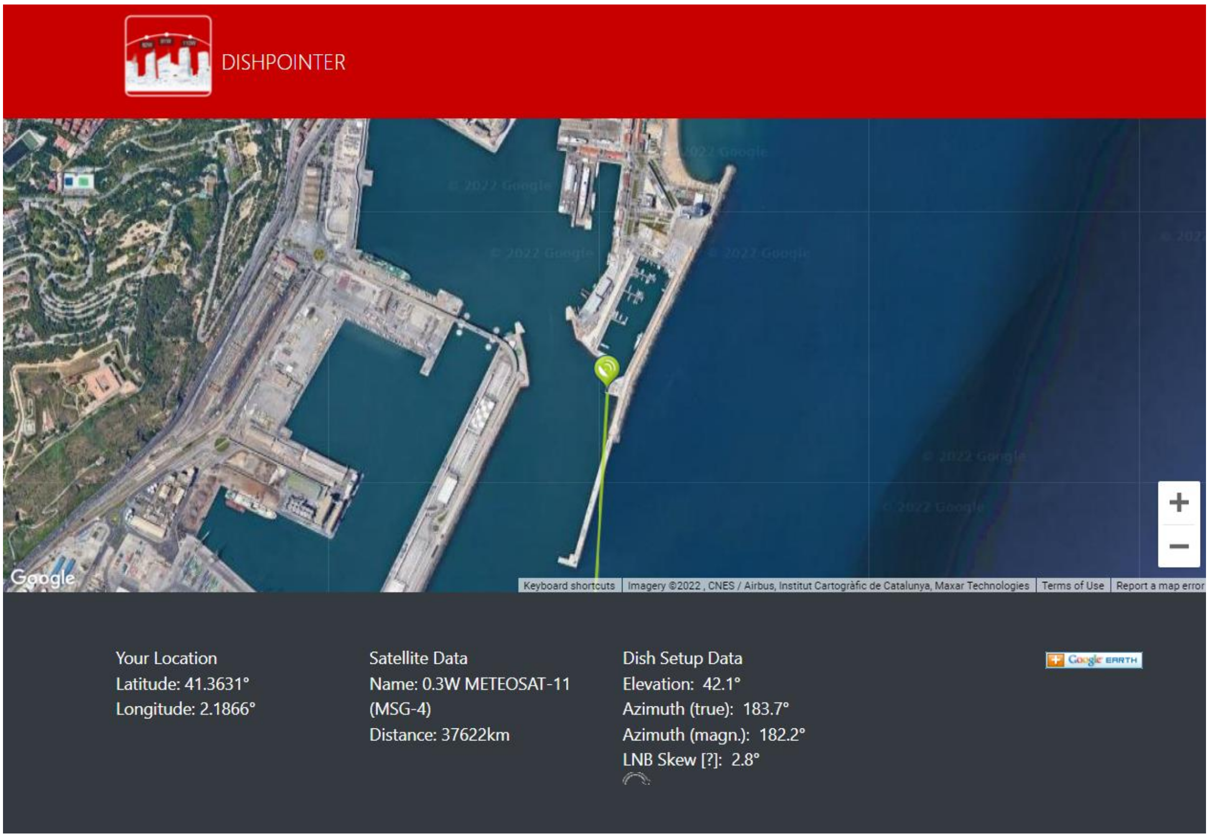
Lo-cost GNSS
IP Address: 192.168.1.244
Username: pi
Password: EuroSBarca22

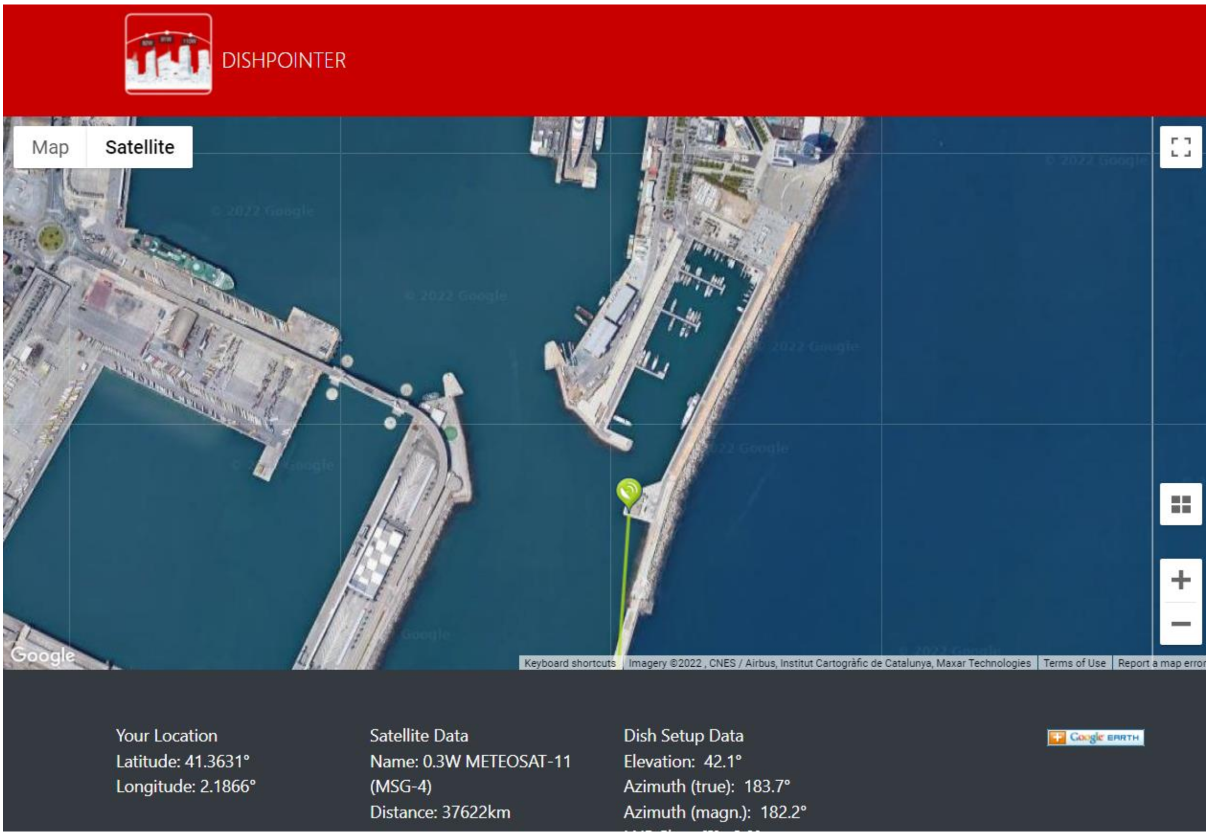
Previstorm
IP Address: 192.168.1.112
Username: pi

	Password: EuroSBarca22
Solar Charge Controller:	Campbell Scientific CH201 s/n: 1169 SDI-12 device address: 3 Input voltage range: 15V to 50V Max Charge Current: 10A
	Campbell Scientific CH201 s/n: 1263 SDI-12 device address: 4 Input voltage range: 15V to 50V Max Charge Current: 10A
Solar Panels:	Phaesun Sun Plus 80 Number of panels: 4 Power output: 80W per panel System voltage: 12V Open circuit voltage: 22.3V
Batteries:	NX Lead Crystal Model No: AMC9007 Capacity (C20): 38Ah Voltage: 12V Number of batteries: 6

National Oceanography Centre (NOC) Contacts Geoff Hargreaves (gwh@noc.ac.uk) Angela Hibbert (anhi@noc.ac.k)
Telephone support - Switch Board +44 151 795 4800 Fax: +44 151 795 4801

Satellite transmissions - Meteosat antenna azimuth and elevation:





Appendix B. Instructions for downloading from the OTT Sutron Satlink3 Datalogger

There are two methods for transferring the data stored on the Satlink3, onto its attached USB stick.

Method 1:

The OTT Satlink3 can automatically transfer data to an inserted USB stick. The logger monitors the USB port and when a USB stick is inserted, the data are automatically downloaded to the USB stick. The datalogger will only download data that has not been previously downloaded via the USB. This means that the logger will not transfer the entire stored dataset, only the new data.

Method 2:

This method requires a connection from a computer to the Satlink3 via Wi-Fi, a USB or serial lead. Using the provided LinkComm software, the selected data can be downloaded using various user specified options. These options can be found under the data tab menu and allow the user to specify weekly, monthly, six monthly, or the entire stored data set to be downloaded. The software can also be used to display the downloaded data in either a graphical or tabular form providing a quick method for data checking.

Taranto Tide Gauge Maintenance Manual

v1.0

Jeff Pugh, Geoff Hargreaves and Angela Hibbert

11/08/23

Contents

1. Introduction

Tide gauges are exposed to hostile monitoring conditions, which can give rise to numerous problems that adversely affect tide gauge operation. These can be largely mitigated if tide gauge operators undertake regular maintenance, which forms an essential part of a tide gauge operator's role.

Short inspection visits to visually assess equipment for signs of deterioration should be undertaken on a quarterly basis. Additional inspection visits are advisable after an extreme weather event. During a visual inspection, tide gauge operators should

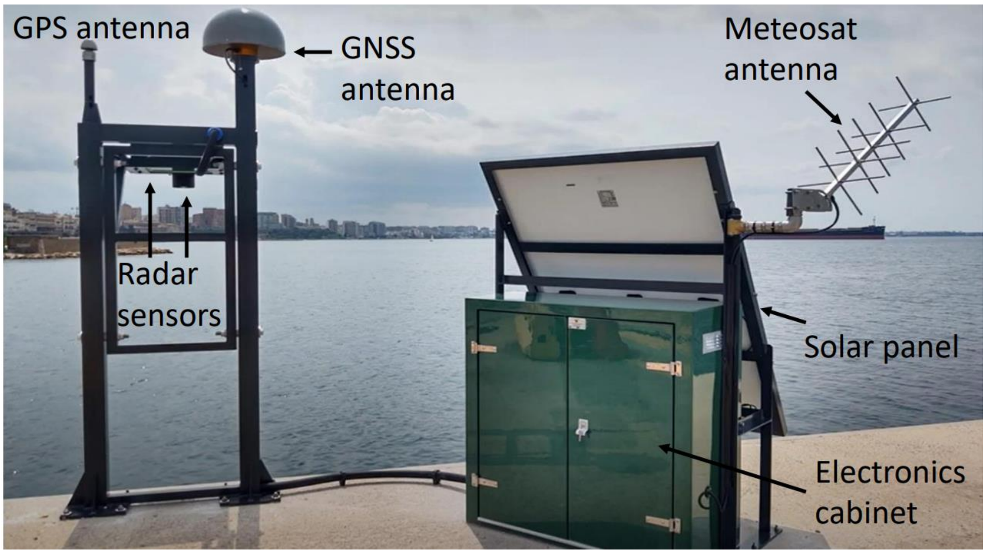


Figure 1. Main tide gauge components

examine all visible components for signs of deterioration, such as corrosion of metalwork, UV degradation of protective coatings, exposed, frayed and loose cables, biofouling, evidence of vandalism etc. Key components to be checked include supporting structures, antennae, solar panels, sensors and cabling (Figure 1).

Inspection visits should be interspersed with longer servicing and maintenance visits on a 6-monthly or annual basis. These longer visits allow for downloading of data and checking the correct functioning of sensors.

This combined visual inspection and maintenance regime will allow the operator to detect damage and potential problems at an early stage and prevent further degradation.

The operator should also maintain regular contact with port and harbour authorities, so that they are aware of any potential site development work or changes in port operations that might adversely affect the operation of the tide gauge.

Operators are encouraged to take photographs during visits in order to maintain a visual record of the condition of the equipment. It is also important to keep a written record of the dates and times of any maintenance visit and the checks and procedures performed on each occasion, as this will help data users to understand any anomalies in tide gauge records.

2. Maintenance Procedures by Tide Gauge Component

2.1 Supporting Structures and Fittings

The steelwork structure should be visually checked for physical damage such as vessel impacts and breakages, corrosion, biofouling and rodent activity (see Figure 2). If there is evidence of degradation, appropriate action can then be taken (e.g. steelwork repairs, application of anti-corrosion paint or replacements of broken fittings). If rodent damage or activity is found, metal grills can be placed across openings in supporting steelwork, radar arm and electronics cabinet. The condition of the pier/jetty/wharf should also be noted and the site owners consulted about plans for maintenance and repair.

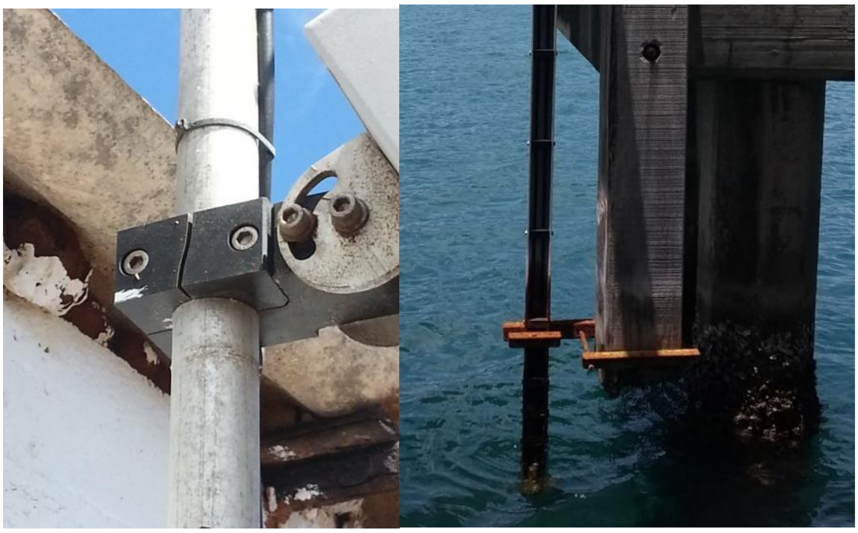


Figure 2. (a) Cracked bracket and (b) rotten wooden support

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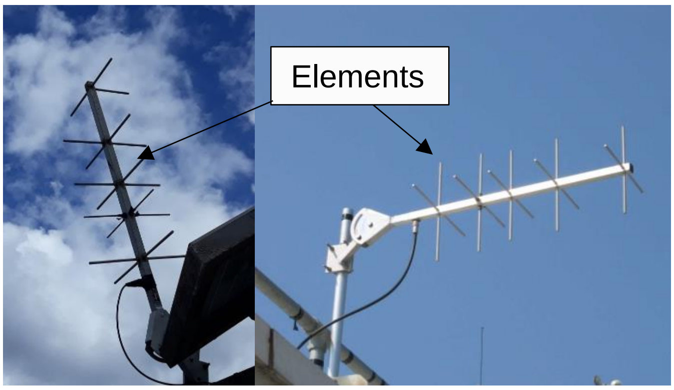

Figure 3. (left) and (right) Yagi antennae

antenna should be replaced. In colder climates, ice build-up can also affect the performance of the antenna and in some cases this creates a temporary short circuit, this can be removed by cleaning off the ice build-up. Antenna fixings should also be checked to ensure that they are secure as antennae can be loosened by storm damage and high winds. Cabling to the antenna should be checked for degradation and nicks in the outer sheath. These can be repaired with self-amalgamating electrical tape, which should be covered with PVC tape to prevent UV degradation.

Figure 4. Dummy load unit

The antenna's elevation and azimuth should be checked at each visit to ensure the correct orientation (39.8° Azimuth and 201.4° Magnetic). A tide gauge setup sheet and a pictorial diagram showing the correct values is provided in Appendix B.

Should the Yagi antenna fail, the dummy load unit (Figure 4) that was supplied with the tide gauge can be connected in place of the antenna to allow fault diagnosis. Prior to connecting the dummy load, the tide gauge operator should monitor data transmission attempts by observing the light emitting diodes (LEDs) on the data logger, which are illuminated during data transmission. There are two possible failures:

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   In the case of an open circuit, the transmitter will prevent the transmission entirely, so the LEDs will not illuminate. Again, the use of the dummy load should result in a normal transmission time.

In addition, the data logger can also supply diagnostic information relating to the status of the last transmission e.g. if it was successful or not (Figure 5). This can be accessed via one of the options under the transmission menu and can be used helped with the diagnostics.

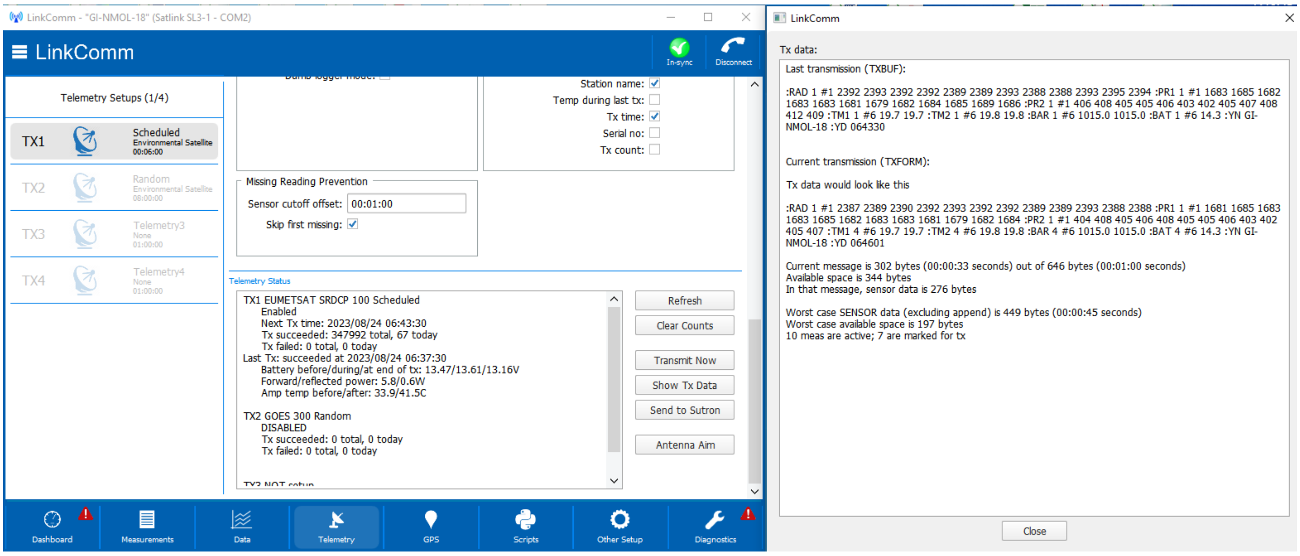


Figure 5. Diagnostic information displayed by Sutron Satlink3 data logger

2.3 GPS & GNSS Antennae

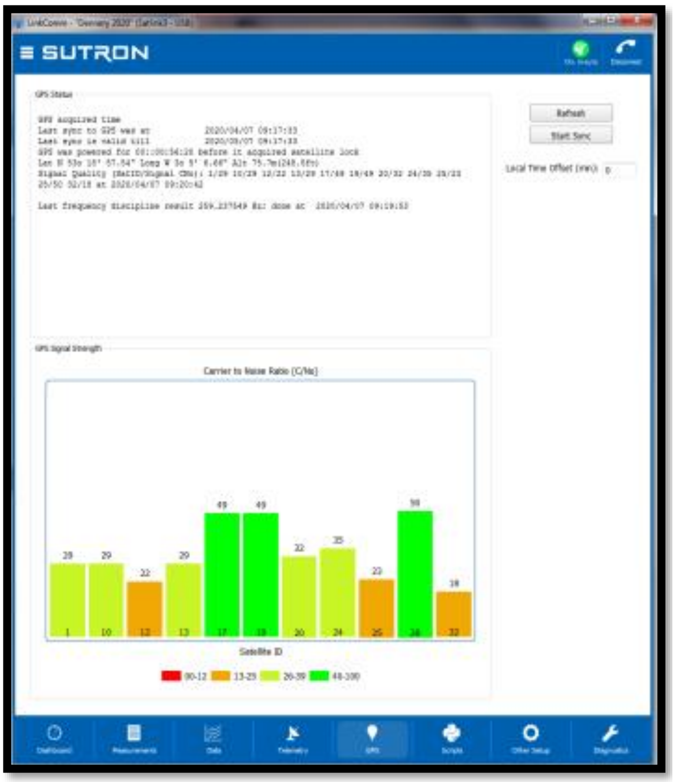


Figure 6. Satellite status displayed by Sutron Satlink3 data logger

The tide gauge is supplied with a small Trimble bullet-style GPS antenna (shown in Figure 1). This has been specifically chosen for its improved immunity to other radio frequency (RF) signals, which results in reliable performance in hostile RF-jamming environments. The datalogging and transmission systems use the GPS antenna to obtain an up-to-date GPS time fix every 12 hours, which is sufficient to keep the inbuilt clock correctly synchronised, ensuring that data are transmitted within the dedicated time frame allocated to each tide gauge location for satellite transmission. The operation and performance of the GPS can also be monitored using the in-built datalogger diagnostics to confirm correct operation, as described in the manufacturer's datalogger manuals provided. The output (Figure 6) shows the satellites in view and how many are being used at any one time.


Figure 7. Cracking to outer casing of a GPS antenna

GPS antennae are very reliable, but over extended periods of time, the outer casing may perish due to degradation by UV radiation, resulting in cracking and water ingress (Figure 7). Replacements are widely available and easily procured.


Figure 8. Trimble Alloy GNSS receiver and radome

The geodetic quality Trimble Alloy GNSS receiver (Figure 8) is likewise reliable and is fitted with a protective cover (a 'radome') to prevent general wear, damage by wildlife and the build-up of debris. It should be also be checked for evidence of degradation. Since radomes alter the antenna's absolute phase centre, if a radome is replaced, the operator must ensure that the correct antenna/dome corrections are applied.

2.4 Solar Panel


Figure 9. Solar panel

The solar panel (Figure 9) is the main power source to the tide gauge during the day and additionally supplies charge to the array of internal batteries in order to power the gauge during the hours of darkness. Panels are usually resilient and are designed for a 25-year operational lifespan, before exhibiting significant deterioration in power generation. However, it is helpful to periodically clean the panel with a damp cloth, particularly in environments where it is dusty or there is bird activity. This will ensure a constant supply of power to the electronic components. The operator should check that the solar panel remains securely fixed and that cabling in a good state of repair. If the panel is loose, it should be secured and the angle rechecked.

2.5 Radar Sensor

Since they are mounted above the water line, radar sensors tend to be more susceptible than underwater sensors to physical damage from ropes, vessels, environmental impacts and vandalism. A visual inspection should be made of the sensor, checking for external damage (Figure 10) and possible moisture ingress. It is also important to check that the sensor position has not moved since the last visit. For the Nile radar sensor, a levelling bubble is fitted to the radar housing (Figure 11), allowing the operator to ensure that this in still in alignment. The cables should be checked for degradation and physical damage (nicks, abrasions, rodent damage etc.) to the outer coating. Any damage should be repaired with self-amalgamating tape and then covered with further layer of PVC tape to protect against water ingress and UV deterioration. If fitted with an LCD screen, this can be used to confirm normal operation of the radar sensor.

Figure 10. Damaged radar horn (left) and cracked sensor housing (right)

Figure 11. Levelling bubble on Nile radar

2.6 Electronics Cabinet

The large green electronics cabinet (Figure 12) houses 2 inner electronics cabinets, to provide weatherproofing and prevention of physical damage to the inner electronics

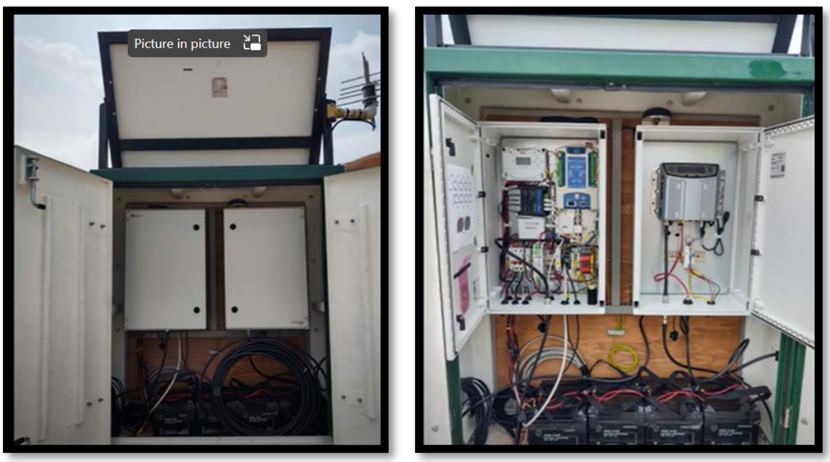


Figure 12. Outer (green) and inner (white) electronics cabinets

components. The inner cabinets are accessed with the use of a key. All cabinets should be checked for signs of water ingress.

The electronics cabinet contains the data logger and lead crystal battery together with other electronics components. It is good practice to download data on a 3-monthly to 6-monthly basis (see Appendix B).

2.7 Datalogger

The OTT Sutron Satlink3 datalogger (Figure 13) is capable of logging the data internally and has integrated Meteosat transmitters to relay the data via satellite network. Data can be downloaded directly from the dataloggers via a serial/USB lead or WiFi and it is recommended that tide gauge operators undertake this as part of a maintenance protocol as direct download ensures that a complete tide gauge record is obtained and avoids data gaps that might arise in the IOC SLSMF web portal record through satellite communications problems. An example data download process is provided in Appendix B

Figure 13. Sutron Satlink 3 datalogger

2.8 Lead Crystal Batteries

The tide gauge is supplied with 8 high quality 'non-spillable' lead crystal batteries (Figure 14) which are designed to operate in extreme temperatures whilst providing excellent deep discharge performance. These batteries should operate for around 3-5 years depending on the environment.

Figure 14. Non-spillable lead crystal battery

The battery will normally receive a full charge during the day via the solar panel and will then use that energy to power the tide gauge during the hours of darkness. Each time a transmission is made the battery has to supply up to 4 amps for that period. If the battery charge dwindles, transmissions start to fail during the night when the gauge is relying on the battery only. The battery should be replaced if it falls below 10 volts after it has received a full charge during the day.

2.9 Fuse/Surge Protection Devices

The cabinet contains a number of protection devices mounted on the DIN rail and include surge and lightning protectors as well as inline fuses (Figure 15). The inline

Figure 15. Surge protectors

fuse allows power to be isolated from the logger or battery or both, to allow maintenance to be carried out. The surge and lightning protectors have been provided for each of the externally mounted sensors, to protect the data logger in the event of a lightning strike.. Replacement fuses and surge/lightning protectors have been supplied.

2.10 Solar Charge Controller

The power to the electronics and battery is provided by the solar panel. To provide and regulate a 24V supply to the batteries, a Morningstar ProStar solar charge controller (Figure 16) is used. This unit transforms the higher solar panel voltages to provide a regulated 24V supply to the MIROS radar sensor. The supply then passes through a DC-DC converter to create a 12V supply to the datalogger and other sensors. In addition to this, the controller is able to intelligently monitor and charge the battery to keep it in optimum condition.

Figure 16. Solar charge controller

The controller has a number of diagnostic LED’s which can be used by the operator to determine the charging status and battery status which can help in the diagnosing of faults. The Morningstar ProStar manual should be checked for further information on these diagnostic LEDs.

3. Schedule of Maintenance Tasks

3.1 Daily Tasks

- Check the data at the IOC's Sea Level Station Monitoring Facility data portal (http://www.ioc-sealevelmonitoring.org/) for missing messages and Meteosat transmissions for message corruption.

3.2 Quarterly Tasks

- Download data from the Satlink3. Although data are transmitted in near real-time to the IOC Sea Level Station Monitoring Facility, it is good practice to download the data every 3 to 4 months before they are overwritten. This will allow the infilling of data gaps that have resulted from a failed satellite transmission.
- Quick visual inspection of the tide gauge, cables, antenna's and solar panel for any damage.

3.3 Annual Tasks

- Thorough inspection of the tide gauge, cables, antennae and solar panel for any damage. Time should be taken to closely inspect all the component parts and cables checking for wear or damage. It may be necessary to use a stepladder to inspect the upper components.

4.Levelling

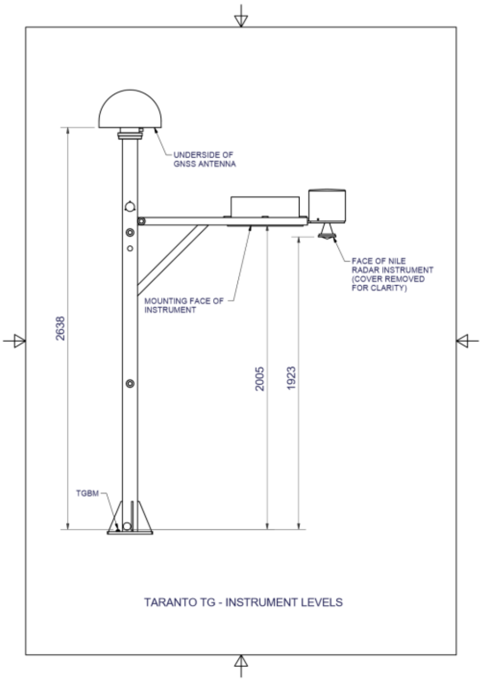


Figure 17. Height of tide gauge components relative to the ‘A’ frame benchmark

Levelling is an important part of the installation process as it allows the tide gauge and its sensors to be tied in into known stable benchmarks situated nearby.

A brass domed benchmark was installed on the quayside, near to the GNSS mast. This benchmark was found to be 0.0256m below the height of a brass benchmark (the tide gauge benchmark or TGBM) that was fitted to the metal foot plate of the ‘A’ frame (Figure 17).

Ongoing monitoring of levelling is done by comparing time series of vertical land motion from the GNSS receiver with sea level time series derived from the same instrument via the GNSS interferometric reflectometry (GNSS-IR) technique. This removes the need for ongoing manual levelling exercises.

Appendices

Appendix A Quick start data sheet

The quick-start data sheets (below) provide a summary of all relevant information about the tide gauge and can be used as part of the site maintenance procedures to check the antenna's elevation and azimuth, the timeslot address, channel and time. Information on the sensor's/loggers such as serial numbers and wiring information are also included in case they have to be removed and reconnected.

Quick Start Data Sheet – Eurosea Taranto Tide Gauge

Latitude: 40.5759
Longitude: 17.2214

Xylem Nile 502 Radar Sensor:

s/n - 21J102935.
Communication interface – SDI-12.
SDI-12 device address: 0
Max measuring range: 30m.
Cable colours:

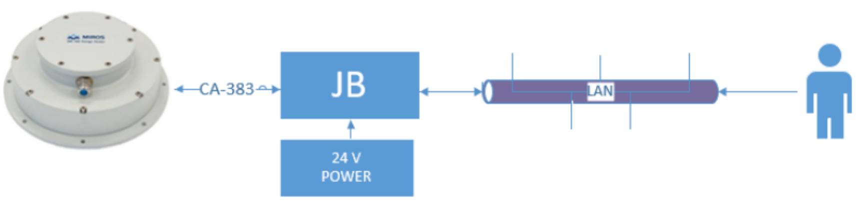
Black	GND
Red	+12V
White	SDI-12 data

Miros SM-140 Radar Sensor:

SM140/N/02/90
s/n: 670439

Communication interface:	TCP/IP over Cat5E or better.
Max measuring range:	95m.
Cable colours:	Cat5E twisted pair colours.

External connection - LAN



Internal connector	Pos no	CA-383 cable (LAN) Standard LAN cable color coding	User end/Junction box (JB) Note! Cable must be spilt
J15	1	OG/WH	RJ45 pin 1
	2	OG	RJ45 pin 2
	3	GN/WH	RJ45 pin 3
	6	GN	RJ45 pin 6
J12	1	BU & BU/WH	+24 V power supply
	2	BN & BN/WH	0 V (GND) power supply
	3	Outer screen	Outer screen

Table 3: External connection - LAN

Vaisala Barometer PTB110:

Model: PTB110 1A0AB
S/N T2130674 0-5V (500-1100 hPa)
Spot Reading every 1 minute.
Satlink3 calculation 500+(((1100-500)/5)*X) hPa.

Sensor	Cable	Satlink3	Pin No.
VOUT	White	A	36
Supply	Red	Prot +12V	21
GND	Black	GND	22
AGND	Green	Analogue GND	37

SATLINK3 SL3-1 V2: **D**ata logger with integrated transmitter
S/N 2015621
Antenna Pointing Data: Azimuth (true) = 205.9°, Azimuth (magnetic) = 201.4°, Elevation = 39.8°
EUMETSAT Transmission Slot: 00:01:15 plus 6 minutes thereafter
DCP ID: 182B9362
DCP Name: IY/CMCC 1
Channel: 225
Baud Rate: 1200
Transmission Time Slot Length: 15 seconds
Satellite: METEOSAT-11
Online Antenna Pointing Help: http://www.dishpointer.com/
Configuration file: EUROSEA_TARANTO

Trimble GNSS:

Trimble Alloy Receiver s/n: 6105R40056
Trimble Choke Ring Antenna s/n: 5104338211
Trimble Antenna Radome s/n: 3324
Antenna Measurement Method: bottom of antenna mount
Firmware Version 6.15
Core Engine Version 5.55
Position Lat: 40° 28’ 33.328” N
Lon: 17° 13’ 17.422” E
Height: 49.162m
Datum: WGS-84
Measurements, 5 seconds, positions 5 minutes, continuous 15 minutes.

Teltonika RUT955 Modem:

Tide Gauge
s/n: 1118493377
IP Address: 192.168.1.1
Username: admin
Password: EuroSTaran23
Wi-Fi SSID: RUT955_3B38
Wi-Fi Password: c7L3Ypi2

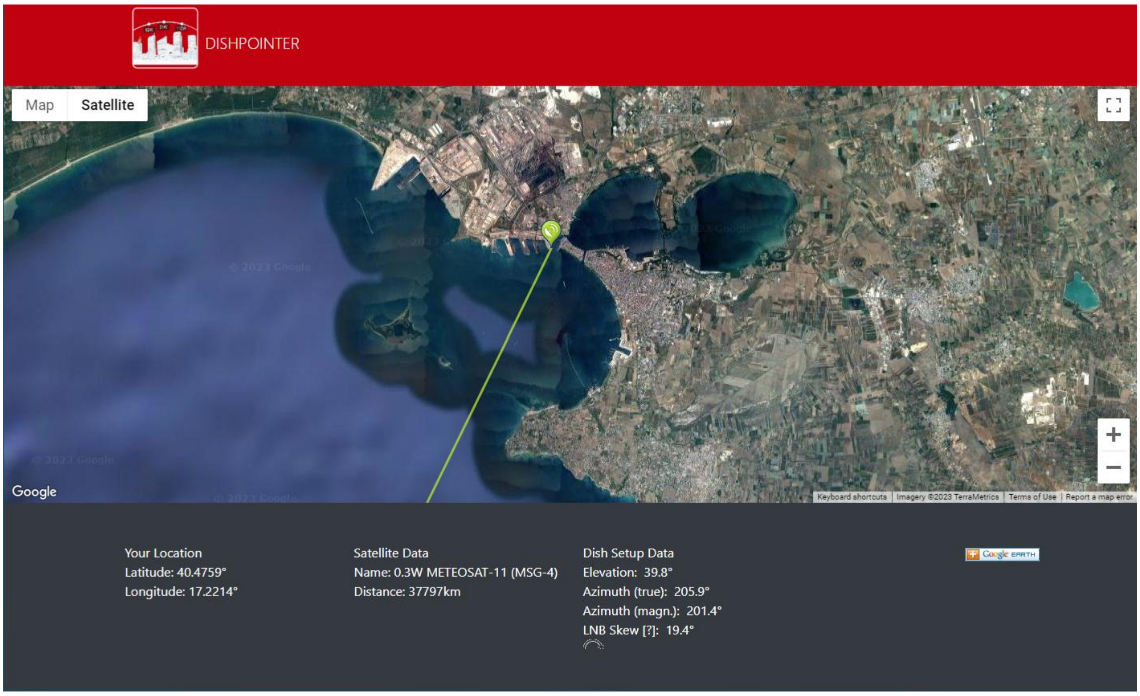
AnyDesk Access:

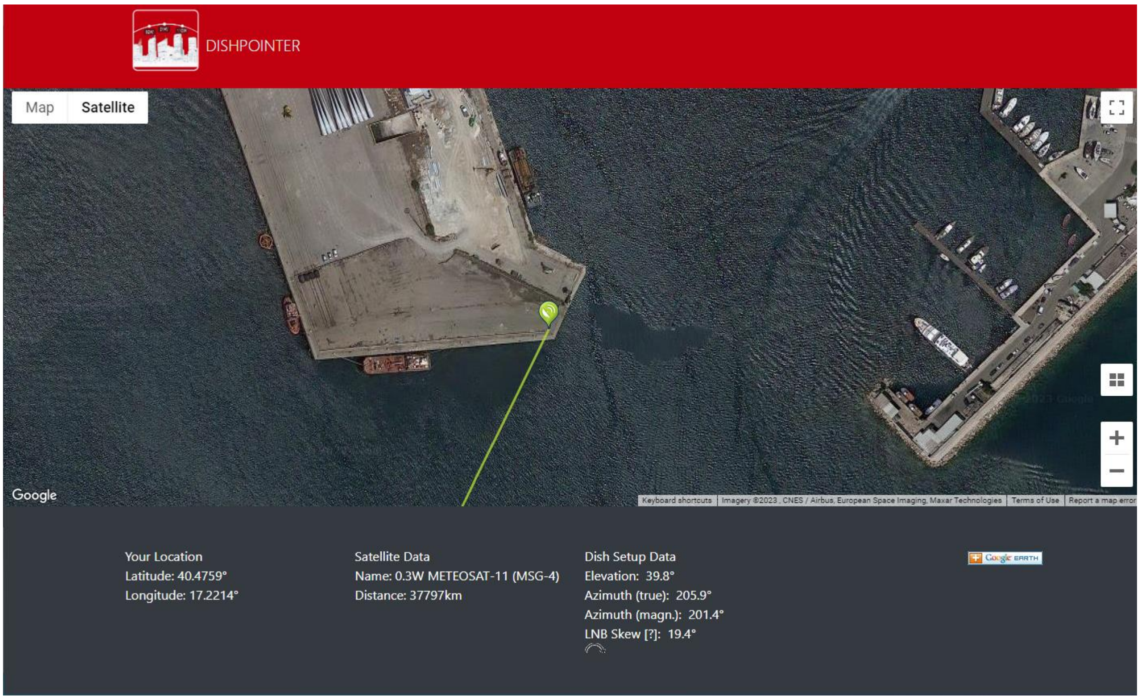
Tide Gauge
Desk number: 543 410 338

	Password: EuroSItaly23
Solar Charge Controller:	Morningstar PS-30M Maximum input voltage: 60V Maximum Charge Current: 30A Nominal Battery Voltage: 24V
Solar Panels:	Suntec Mono Perc Half Cell 400W Number of panels: 1 Power output: 400W per panel System voltage: 24V Open circuit voltage: 37.04V
Batteries:	NX Lead Crystal Model No: AMC9007 Capacity (C20): 38Ah Voltage: 12V configured as a 24V power bank. Number of batteries: 8

National Oceanography Centre (NOC) Contacts Geoff Hargreaves (gwh@noc.ac.uk) Angela Hibbert (anhi@noc.ac.k)
Telephone support - Switch Board +44 151 795 4800 Fax: +44 151 795 4801

Satellite transmissions - Meteosat antenna azimuth and elevation





Appendix B. Instructions for downloading from the OTT Sutron Satlink3 Datalogger

There are two methods for transferring the data stored on the Satlink3, onto its attached USB stick.

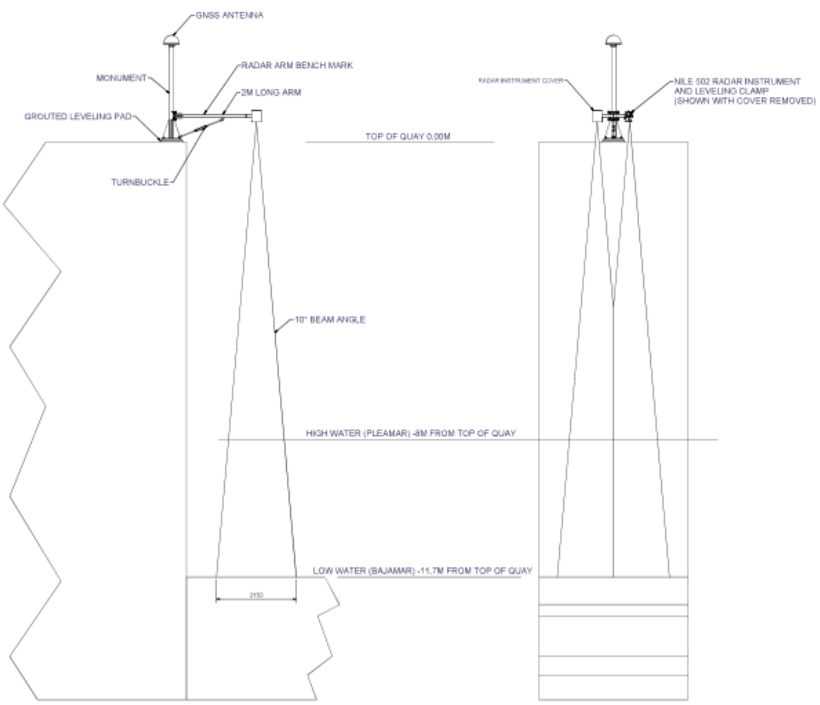
Method 1:

The OTT Satlink3 has the ability to automatically store data to an inserted USB stick. The logger monitors the USB port and when a USB stick is inserted the data are automatically downloaded to the USB stick. The datalogger will only download data that has not been previously downloaded via the USB. This means that the logger will not transfer the entire stored dataset, only the new data.

Method 2:

This method requires a connection from a computer to the Satlink3 via a USB, WiFi or serial lead. Using the provided LinkComm software, the selected data can be downloaded using various user specified options. These options can be found under the data tab menu and allows the user to specify weekly, monthly, six monthly, or the entire stored data set to be downloaded. The software can also be used to display the downloaded data in either a graphical or tabular form providing a quick method for data checking.

Buenaventura Tide Gauge Maintenance Manual



v1.0

Jeff Pugh, Geoff Hargreaves and Angela Hibbert

11/08/23

Contents

1. Introduction

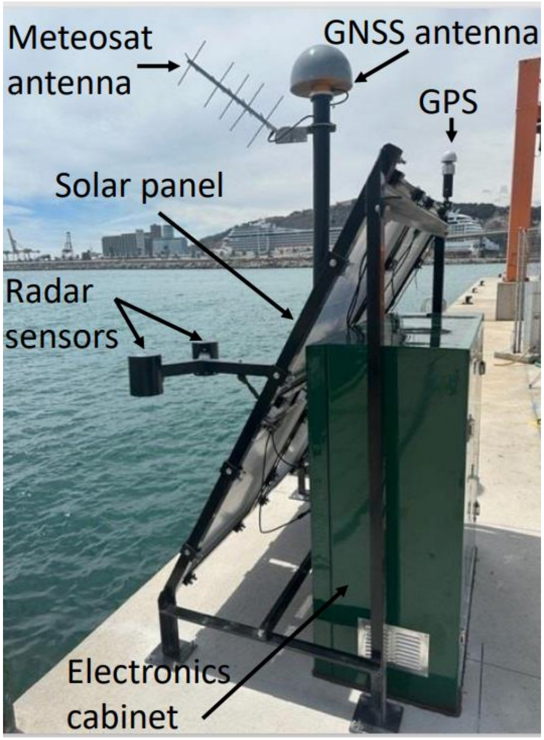


Figure 1. Main tide gauge components at the Barcelona tide gauge site

Tide gauges are exposed to hostile monitoring conditions, which can give rise to numerous problems that adversely affect tide gauge operation. These can be largely mitigated if tide gauge operators undertake regular maintenance, which forms an essential part of a tide gauge operator's role.

Short inspection visits to visually assess equipment for signs of deterioration should be undertaken on a quarterly basis. Additional inspection visits are advisable after an extreme weather event. During a visual inspection, tide gauge operators should examine all visible components for signs of deterioration, such as corrosion of metalwork, UV degradation of protective coatings, exposed, frayed and loose cables, biofouling, evidence of vandalism etc. The Buenaventura tide gauge is almost identical to the installation that was completed with the help of Yosamy Garcia Sanmiguel from DIMAR at Barcelona (Figure 1), differing only in the mounting of the solar panel, which is fitted to the top of the electronics cabinet. The key components to be checked include supporting frames, antennae, solar panels, sensors and cabling.

Inspection visits should be interspersed with longer servicing and maintenance visits on a 6 monthly or annual basis. These longer visits allow for downloading of data and checking the correct functioning of sensors.

This combined visual inspection and maintenance regime will allow the operator to detect damage and potential problems at an early stage and prevent further degradation.

The operator should also maintain regular contact with port and harbour authorities, so that they are aware of any potential site development work or changes in port operations that might adversely affect the operation of the tide gauge.

Operators are encouraged to take photographs during visits in order to maintain a visual record of the condition of the equipment. It is also important to keep a written record of the dates and times of any maintenance visit and the checks and procedures performed on each occasion, as this will help data users to understand any anomalies in tide gauge records.

2. Maintenance Procedures by Tide Gauge Component

2.1 Supporting Structures and Fittings

The steelwork structure should be visually checked for physical damage such as vessel impacts and breakages, corrosion, biofouling and rodent activity (see Figure 2). If there is evidence of degradation, appropriate action can then be taken (e.g. steelwork repairs, application of anti-corrosion paint or replacements of broken fittings). If rodent damage or activity is found, metal grills can be placed across openings in supporting steelwork, radar arm and electronics cabinet. The condition of the pier/jetty/wharf should also be noted and the site owners consulted about plans for maintenance and repair.

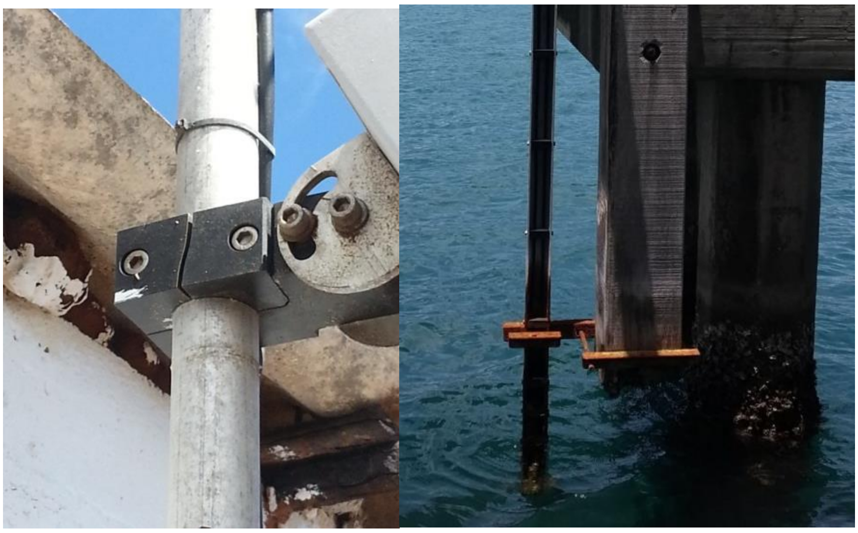


Figure 2. (a) Cracked bracket and (b) rotten wooden support

2.2 Meteosat Antenna

Yagi data transmission antennae are typically very reliable but can be susceptible to physical damage from debris, severe weather, bird damage or other impacts to individual elements. A Yagi antenna uses 4 active elements (see Figure 3) to transmit the data signal to a satellite, whilst the remaining elements are used to focus and guide the transmitted signal.

The antenna can remain operational even if a number of elements are damaged or broken, but this will result in a degraded signal transmission. Therefore, the tide gauge operator should check that sufficient elements remain intact and if not, the antenna should be replaced. In colder climates, ice build-up can also affect the performance of the antenna and in some cases this a temporary short circuit, this can be removed by cleaning off the ice build-up. Antenna fixings should also be checked to ensure that they are secure as antennae can be loosened by storm damage and high winds. Cabling to the antenna should be checked for degradation and nicks in the outer sheath. These can be repaired with self-amalgamating electrical tape, which should be covered with PVC tape to prevent UV degradation.

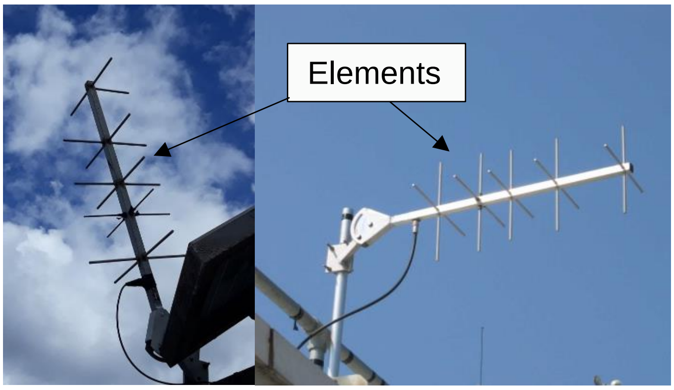
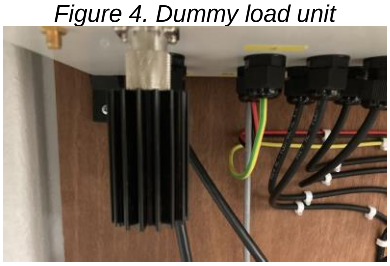


Figure 3. (left) and (right) Yagi antennae

The antenna's elevation and azimuth should be checked at each visit to ensure the correct elevation of 84.9° and an azimuth of 157.6° Magnetic. A tide gauge setup sheet and a pictorial diagram showing the correct values is provided in Appendix A.

Should the Yagi antenna fail, the dummy load unit (Figure 4) that was supplied with the tide gauge be connected in place of the antenna to allow fault diagnosis. Prior to connecting the dummy load, the tide gauge operator should monitor data transmission attempts by observing the light emitting diodes (LEDs) on the data logger, which are illuminated during data transmission. There are two possible failures:

Figure 4. Dummy load unit


1. A short circuit

   This will result in a shorter transmission time than normal and can be confirmed by connecting the dummy load in place of the antenna, If the antenna or cable is faulty and a dummy load is fitted a normal transmission length should then be observed.

2. An open circuit

   In the case of an open circuit, the transmitter will prevent the transmission entirely, so the LEDs will not illuminate. Again, the use of the dummy load should result in a normal transmission time.

In addition, the data logger can also supply diagnostic information relating to the status of the last transmission e.g. if it was successful or not (Figure 5). This can be accessed via one of the options under the transmission menu and can be used helped with the diagnostics.

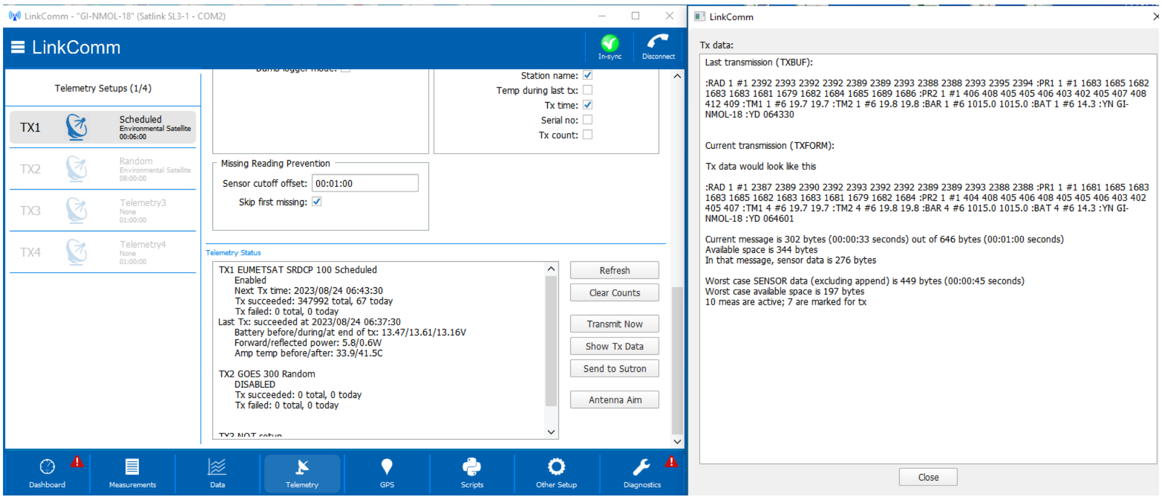


Figure 5. Diagnostic information displayed by Sutron Satlink3 data logger

2.3 GPS & GNSS Antennae

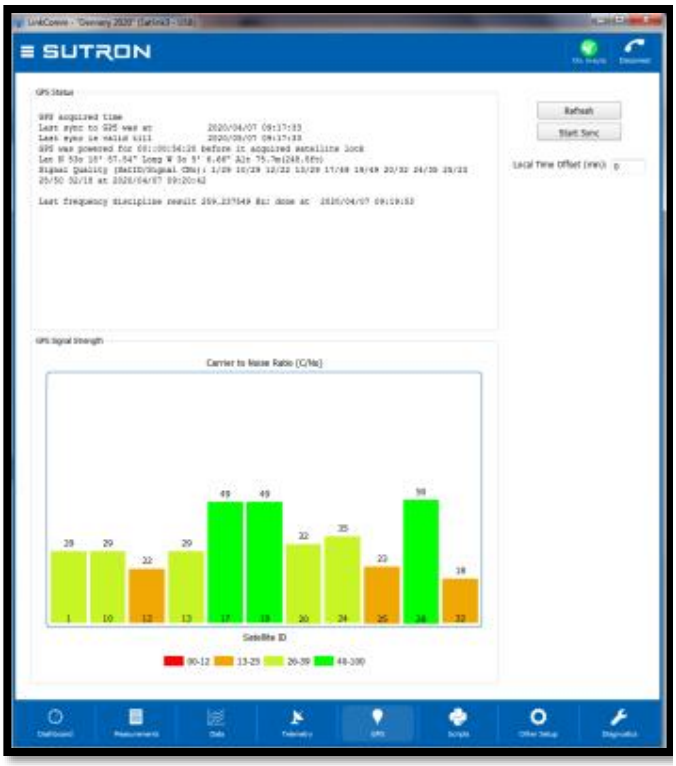
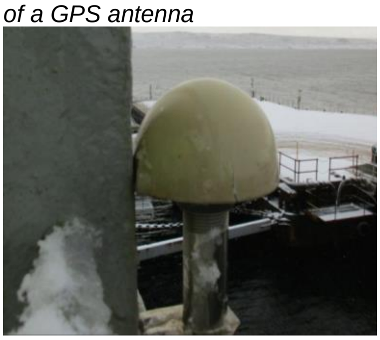


Figure 6. Satellite status displayed by Sutron Satlink3 data logger

The tide gauge is supplied with a small Trimble bullet-style GPS antenna (shown in Figure 1). This has been specifically chosen for its improved immunity to other radio frequency (RF) signals, which results in reliable performance in hostile RF-jamming environments. The datalogging and transmission systems use the GPS antenna to obtain an up-to-date GPS time fix every 12 hours, which is sufficient to keep the inbuilt clock correctly synchronised, ensuring that data are transmitted within the dedicated time frame allocated to each tide gauge location for satellite transmission. The operation and performance of the GPS can also be monitored using the in-built datalogger diagnostics to confirm correct operation, as described in the manufacturer’s datalogger manuals provided. The output (Figure 6) shows the satellites in view and how many are being used at any one time.

Figure 7. Cracking to outer casing of a GPS antenna



GPS antennae are very reliable, but over extended periods of time, the outer casing may perish due to degradation by UV radiation, resulting in cracking and water ingress (Figure 7). Replacements are widely available and easily procured.

Figure 8. Trimble Alloy GNSS receiver and radome

The geodetic quality Trimble Alloy GNSS receiver (Figure 8) is likewise reliable and is fitted with a protective cover (a 'radome') to prevent general wear, damage by wildlife and the build-up of debris. It should also be checked for evidence of degradation. Since radomes alter the antenna's absolute phase centre, if a radome is replaced, the operator must ensure that the correct antenna/dome corrections are applied.

2.4 Solar Panels

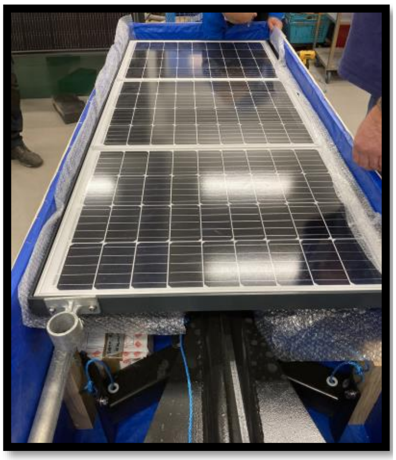


Figure 9. Solar panel array for Buenaventura tide gauge

The solar panels (Figure 9) are the main power source to the tide gauge during the day. They additionally supply charge to the array of internal batteries in order to power the gauge during the hours of darkness. Panels are usually resilient and are designed for a 25-year operational lifespan, before a deterioration in power generation becomes notable. However, it is helpful to periodically clean the panel with a damp cloth, particularly in environments where it is dusty or there is bird activity. This will ensure a constant supply of power to the electronic components. The operator should check that the solar panel remains securely fixed and that cabling in a good state of repair. If the panel is loose, it should be secured and the angle rechecked.

2.5 Radar Sensor

Since they are mounted above the water line, radar sensors tend to be more susceptible than underwater sensors to physical damage from ropes, vessels, environmental impacts and vandalism. A visual inspection should be made of the sensor, checking for external

Figure 10. Damaged radar horn (left) and cracked sensor housing (right)

damage (Figure 10) and possible moisture ingress. It is also important to check that the sensor position has not moved since the last visit. For the Nile radar sensors, a levelling bubble is fitted to the radar housings (Figure 11), allowing the operator to ensure that this in still in alignment. The cables should be checked for degradation and physical damage (nicks, abrasions, rodent damage etc.) to the outer coating. Any damage should be repaired with self-amalgamating tape and then covered with further layer of PVC tape to protect against water ingress and UV deterioration. If fitted with an LCD screen, this can be used to confirm normal operation of the radar sensor.

Figure 11. Levelling bubble on Nile radar housing

2.6 Electronics Cabinet

Figure 12. Outer (green) and inner (white) electronics cabinets

The large green electronics cabinet (Figure 12) houses two inner electronics cabinets, to provide weatherproofing and prevention of physical damage to the inner electronics components. The inner cabinets are accessed with the use of a key. All cabinets should be checked for signs of water ingress.

The electronics cabinet contains the data logger and lead crystal battery together with other electronics components. It is good practice to download data on a 3-monthly to 6-monthly basis (see Appendix B). The lead crystal batteries have a typical lifespan of 3-5 years, but the voltage can be monitored daily via the IOC Sea Level Station Monitoring Facility (IOC SLSMF) website (SEA LEVEL STATION MONITORING FACILITY (ioc-

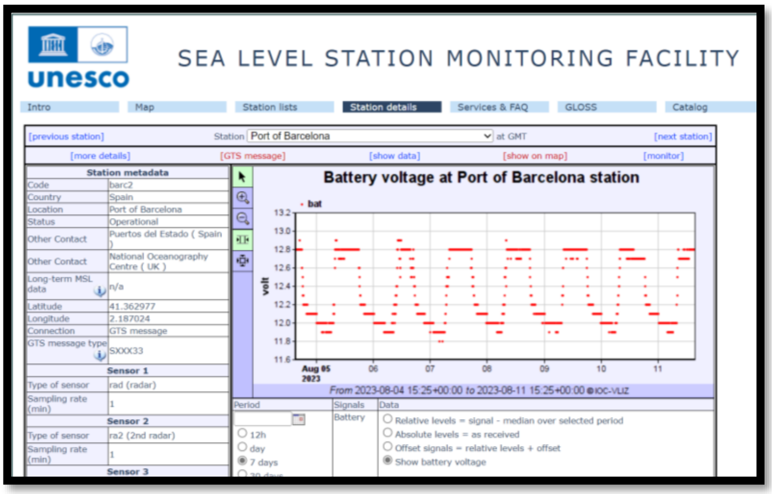


Figure 13. Battery voltage display at IOC SLSMF website for an example (Barcelona) tide gauge

sealevelmonitoring.org), Figure 13). Signs that the battery is coming to the end of its life might include failures during the early morning/night or inability of the battery to recover its charge during the day, achieving a level of only 10 volts or below.

2.7 Datalogger

The OTT Sutron Satlink3 datalogger (Figure 14) is capable of logging the data internally and has integrated Meteosat transmitters to relay the data via satellite network. Data can be downloaded directly from the dataloggers via a serial/USB lead (or WiFi) and it is recommended that tide gauge operators undertake this as part of a maintenance protocol as direct download ensures that a complete tide gauge record is obtained and avoids data gaps that might arise in the IOC SLSMF web portal record through satellite communications problems. An example data download process is provided in Appendix B

Figure 14. Sutron Satlink 3 datalogger

2.8 Lead Crystal Batteries

The tide gauge is supplied with 4 high quality ‘non-spillable’ lead crystal batteries (Figure 15) which are designed to operate in extreme temperatures whilst providing excellent deep discharge performance. These batteries should operate for around 3-5 years depending on the environment.

The battery will normally receive a full charge during the day via the solar panel and will then use that energy to power the tide gauge during the hours of darkness. Each time a transmission is made the battery has to supply up to 4 amps for that period. If the battery charge dwindles, transmissions start to fail during the night when the gauge is relying on the battery only. It is therefore essential to monitor battery voltage via the IOC SLSMF website. The battery should be replaced if it falls below 10 volts after it has received a full charge during the day.

Figure 15. Non-spillable lead crystal battery

2.9 Fuse/Surge Protection Devices

The cabinet contains a number of protection devices mounted on the DIN rail and include surge and lightning protectors as well as inline fuses (Figure 16). The inline fuse allows power to be isolated from the logger or battery or both, to allow maintenance to be carried out. The surge and lightning protectors have been provided for each of the externally mounted sensors, to protect the data logger in the event of a lightning strike.

Figure 16. Fuses and surge protectors

2.10 Solar Charge Controller

The power to the electronics and battery is provided by the solar panels. To provide and regulate a 12V supply to the battery, two Campbell Scientific solar charge controllers (Figure 18) are used. These units transform the higher solar panel voltages to provide a regulated 12V supply to the logger and sensors. In addition to this, the controller is able to intelligently monitor and charge the battery to keep it in optimum condition.

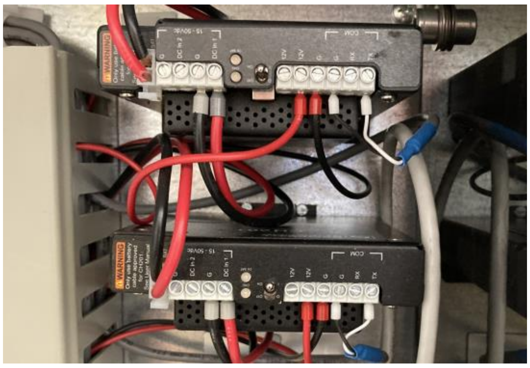


Figure 18. Solar charge controllers

The controllers have a couple of diagnostic LED’s which can be used by the operator to determine the charging status and battery status which can help in the diagnosing of faults. The Campbell Scientific CH201 manual should be checked for further information on these diagnostic LEDs.

3. Schedule of Maintenance Tasks

3.1 Daily Tasks

- Check the data at the IOC's Sea Level Station Monitoring Facility data portal (http://www.ioc-sealevelmonitoring.org/) for missing messages and GOES transmissions for message corruption.

3.2 Quarterly Tasks

- Download data from the Satlink3. Although data are transmitted in near real-time to the IOC Sea Level Station Monitoring Facility, it is good practice to download the data every 3 to 4 months before they are overwritten. This will allow the infilling of data gaps that have resulted from a failed satellite transmission.
- Quick visual inspection of the tide gauge, cables, antennae and solar panel for any damage.

3.3 Annual Tasks

- Thorough inspection of the tide gauge, cables, antennae and solar panel for any damage. Time should be taken to closely inspect all the component parts and cables checking for wear or damage. It may be necessary to use a stepladder to inspect the upper components.

4.Levelling

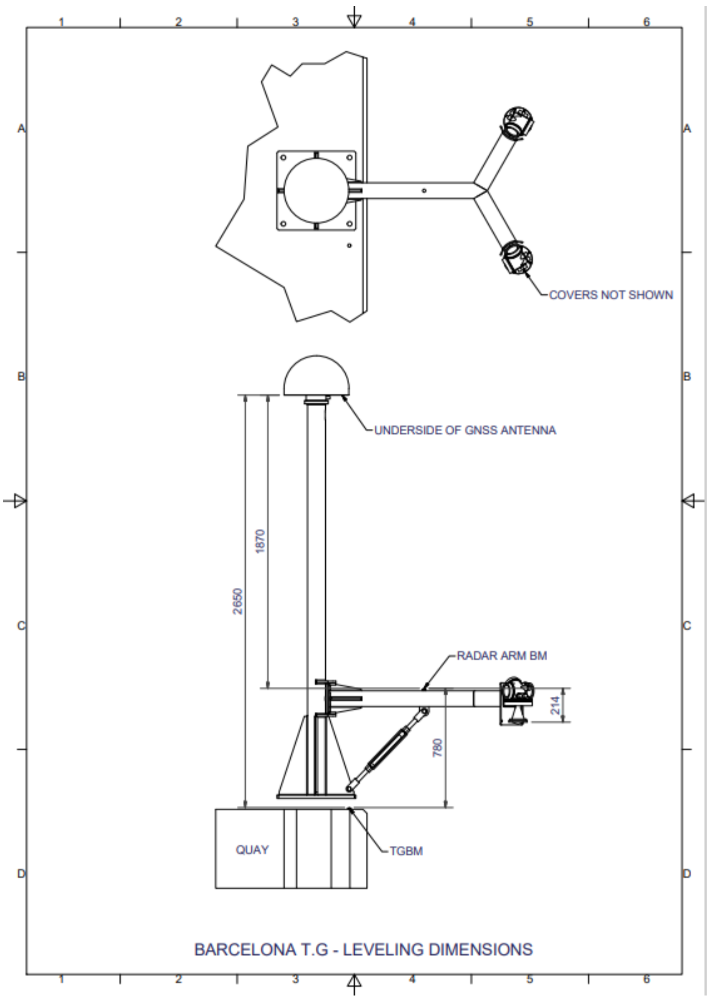


Figure 18. Example tide gauge benchmark heights (for Barcelona)

Levelling is an important part of the installation process as it allows the tide gauge and its sensors to be tied in into known stable benchmarks situated nearby.

As part of this installation a brass domed benchmark (the tide gauge benchmark or TGBM) should have been installed on the quayside, near to the GNSS mast. The height difference should be recorded between this TGBM and a brass benchmark fitted to the radar arm (Figure 18).

Ongoing monitoring of levelling at the primary site is done by comparing time series of vertical land motion from the GNSS receiver with sea level time series derived from the same instrument via the GNSS interferometric reflectometry (GNSS-IR) technique. This removes the need for ongoing manual levelling exercises.

Appendix A

Quick start data sheet

The quick-start data sheets (below) provide a summary of all relevant information about the tide gauge and can be used as part of the site maintenance procedures to check the antenna’s elevation and azimuth, the timeslot address, channel and time. Information on the sensors/loggers such as serial numbers and wiring information are also included in case they have to be removed and reconnected.

Quick Start Data Sheet – Eurosea Colombia Tide Gauge

Latitude: 3.832559
Longitude: -77.262154

Xylem Nile 502 Radar Sensor:

s/n - 21J102933.
Communication interface – SDI-12.
SDI-12 device address: 0
Max measuring range – 30m.

Cable colours:		
	Black	GND
	Red	+12V
	White	SDI-12 data

Xylem Nile 502 Radar Sensor:

s/n - 21J102934.
Communication interface – SDI-12.
SDI-12 device address: 0
Max measuring range – 30m.

Cable colours:		
	Black	GND
	Red	+12V
	White	SDI-12 data

Vaisala Barometer PTB110:

Model: PTB110 1A0AB
S/N T2130676 0-5V (500-1100 hPa)
Spot Reading every 6 minutes.
Satlink3 calculation 500+(((1100-500)/5)*X) hPa.

Sensor	**Cable**	**Satlink3**	**Pin No.**
VOUT	White	A	36
Supply	Red	Prot +12V	21
GND	Black	GND	22
AGND	Green	Analogue GND	37

SATLINK3 SL3-1 V2: Data logger with integrated transmitter
S/N 2105620

Antenna Pointing Data: Azimuth (true) = 151.7°, Azimuth (magnetic) = 157.6°, Elevation = 84.9°

EUMETSAT Transmission Slot: 00:01:40 plus 5 minutes thereafter

DCP ID: 6B004E92

Channel:	211
Baud Rate:	300
Transmission Time Slot Length:	5 seconds
Satellite:	GOES-16
Online Antenna Pointing Help:	http://www.dishpointer.com/
Configuration file:	EUROSEA_COLOMBIA
Trimble GNSS:	Trimble Alloy Receiver s/n: 6042R40073 Trimble Choke Ring Antenna s/n: 5104338219 Trimble Antenna Radome s/n: 3353 Antenna Measurement Method: bottom of antenna mount Firmware Version 6.15 Core Engine Version 5.55 Measurements, 5 seconds, positions 5 minutes, continuous 15 minutes.
Teltonika RUT955 Modem:	**Tide Gauge** s/n: 1116487429 IP Address: 192.168.1.1 Username: admin Password: EuroSColom22 Wi-Fi SSID: RUT955_3EC8 Wi-Fi Password: Pi3h4B9A
AnyDesk Access:	**Tide Gauge** Desk number: 502 608 620 Password: EuroSColom22
Raspberry Pi:	**Tide Gauge** IP Address: 192.168.1.xxx Username: stma Password: EuroSColom22
Solar Charge Controller:	Campbell Scientific CH201 s/n: 1171 SDI-12 device address: 3 Input voltage range: 15V to 50V Max Charge Current: 10A Campbell Scientific CH201 s/n: 1246 SDI-12 device address: 3 Input voltage range: 15V to 50V Max Charge Current: 10A

Solar Panels:

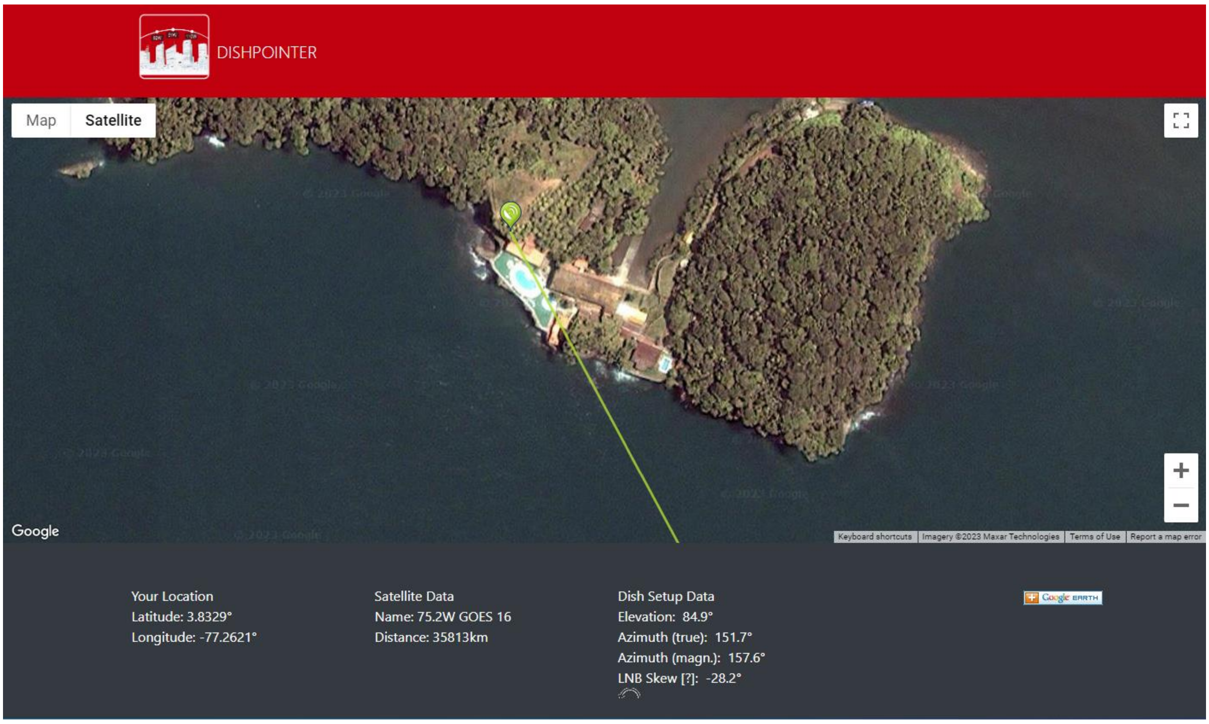
Phaesun Sun Plus 80
Number of panels: 3
Power output: 80W per panel
System voltage: 12V
Open circuit voltage: 22.3V

Batteries:

NX Lead Crystal
Model No: AMC9007
Capacity (C20): 38Ah
Voltage: 12V
Number of batteries: 4

National Oceanography Centre (NOC) Contacts Geoff Hargreaves (gwh@noc.ac.uk) Angela Hibbert (anhi@noc.ac.k)
Telephone support - Switch Board +44 151 795 4800 Fax: +44 151 795 4801

Satellite transmissions - Meteosat antenna azimuth and elevation:



Appendix B. Instructions for downloading from the OTT Sutron Satlink3 Datalogger

There are two methods for transferring the data stored on the Satlink3, onto its attached USB stick.

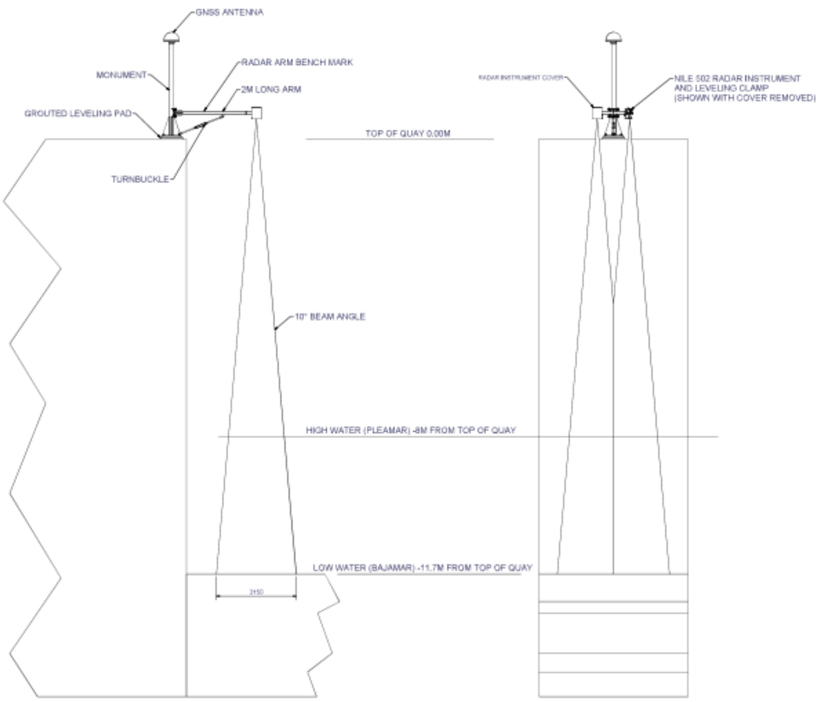
Method 1:

The OTT Satlink3 has the ability to automatically store data to an inserted USB stick. The logger monitors the USB port and when a USB stick is inserted the data are automatically downloaded to the USB stick. The datalogger will only download data that has not been previously downloaded via the USB. This means that the logger will not transfer the entire stored dataset, only the new data.

Method 2:

This method requires a connection from a computer to the Satlink3 via a USB, WiFi or serial lead. Using the provided LinkComm software, the selected data can be downloaded using various user specified options. These options can be found under the data tab menu and allows the user to specify weekly, monthly, six monthly, or the entire stored data set to be downloaded. The software can also be used to display the downloaded data in either a graphical or tabular form providing a quick method for data checking.

Manual de mantenimiento del mareógrafo de Buenaventura



v1.0

Contenido

1. Introducción

Los mareógrafos son expuesto a condiciones de monitoreo hostiles, que pueden dar lugar a numerosos problemas que afectan negativamente el funcionamiento del mareógrafo. ÉsimoLos EEE pueden mitigarse en gran medida si los operadores de mareógrafos se comprometen regular mantenimiento, que formas una parte esencial de un Operador de mareógrafos's rol.

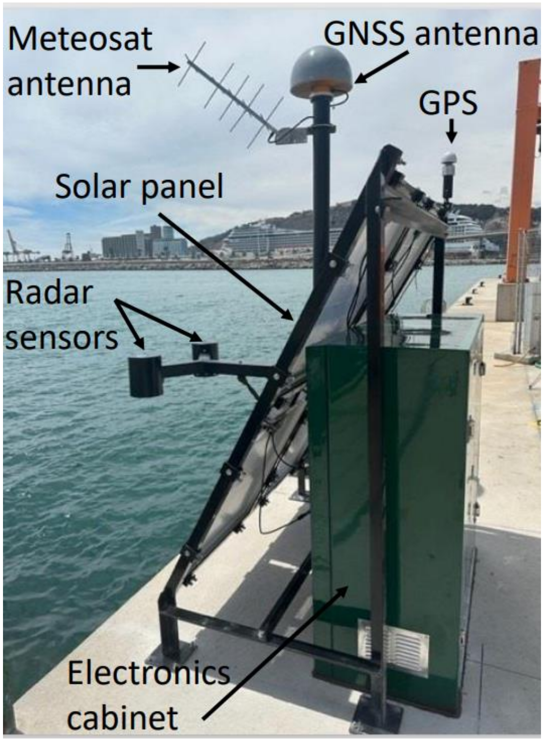


Figura 1. Principales componentes del mareógrafo en el sitio del mareógrafo de Barcelona

Deben realizarse trimestralmente breves visitas de inspección para evaluar visualmente el equipo en busca de signos de deterioro. Se recomiendan visitas de inspección adicionales después de un evento climático extremo. Durante una inspección visual, los operadores de mareógrafos deben examinar todos los componentes visibles en busca de signos de deterioro, como corrosión de la carpintería metálica, degradación UV de los recubrimientos protectores, cables expuestos, deshilachados y sueltos, bioincrustaciones, evidencia de vandalismo, etc. El mareógrafo de Buenaventura es casi idéntico a la instalación que se completó con la ayuda de Yosamy García Sanmiguel de DIMAR en Barcelona (Figura 1), diferenciándose solo en el montaje del panel solar, que se instala en la parte superior del gabinete electrónico. Loscomponentes que deben comprobarse incluyen marcos de soporte, antenas, paneles olares, ensores y c.

Las visitas de inspección deben intercalarse con visitas de servicio y mantenimiento más largas sobre una base de 6 meses o años. Estas visitas más largas permiten descargar datos y comprobar el correcto funcionamiento de los sensores.

Este régimen combinado de inspección visual y mantenimiento permitirá al operador detectar daños y problemas potenciales en una etapa temprana y evitar una mayor degradación.

El operador también debe mantener un contacto regular con las autoridades portuarias y portuarias, de modo que estén al tanto de cualquier posible trabajo de desarrollo del sitio o cambios en las operaciones portuarias que puedan afectar negativamente al funcionamiento del mareógrafo.

Se alienta a los operadores a tomar fotografías durante las visitas para mantener un registro visual de la condición del equipo. También es importante mantener un registro escrito de las fechas y horas de cualquier visita de mantenimiento y las comprobaciones y procedimientos realizados en cada ocasión, ya que esto ayudará a los usuarios de datos a comprender cualquier anomalía en los registros de mareógrafos.

2. Procedimientos de mantenimiento por componente del mareógrafo

2.1 Estructuras de soporte y accesorios

La estructura de acero debe ser revisada visualmente por daños físicos como impactos de buques y Roturas, corrosión, Bioincrustación y actividad de roedores (ver Figura 2). Si hay evidencia de degradación, se pueden tomar las medidas apropiadas

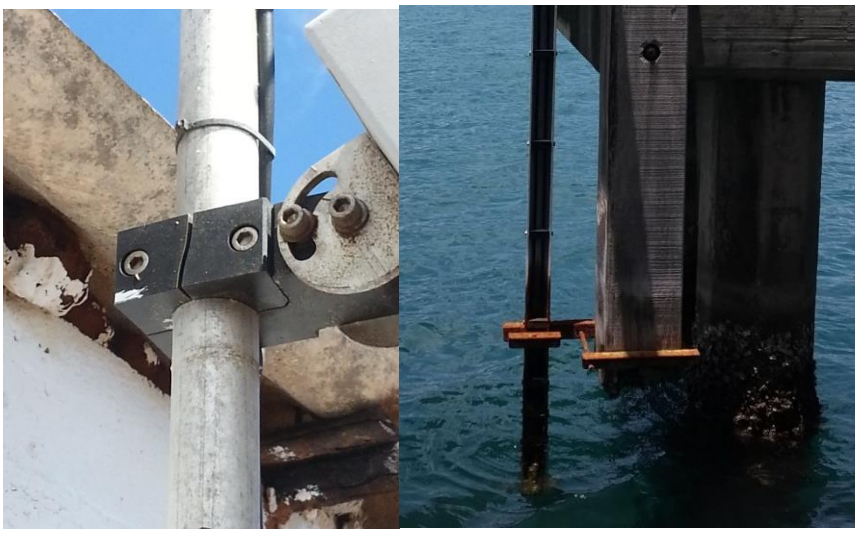


Figura 2. a) Soporte agrietado y b) soporte de madera podrida

(por ejemplo, reparaciones de acero, aplicación de pintura anticorrosiva o reemplazos de accesorios rotos). If Se encuentra daño o actividad de roedores, parrilla de metals enlatar ser lugard A través de aberturas en el apoyo a la siderurgia, Brazo de radar y electrónica gabinete. El Estado del muelle/embarcadero/muelle También se debe tener en cuenta y los propietarios del sitio consultados sobre los planes para mantenimiento y reparar.

2.2 Antena Meteosat

Las antenas de transmisión de datos Yagi suelen ser muy confiables, pero pueden ser susceptibles a daños físicos por escombros, clima severo, daños a las aves u otros impactos en elementos individuales. Una antena Yagi utiliza 4 elementos activos (véase la figura 3) para transmitir la señal de datos a un satélite, mientras que los elementos restantes se utilizan para enfocar y guiar la señal transmitida.

La antena puede permanecer en funcionamientoal Incluso si varios elementos están dañados o rotos, esto resultará en una transmisión de señal degradada. Por lo tanto, el operador del mareógrafo debe verificar que suficientes elementos permanezcan intactos y, de no ser así, la antena debe ser reemplazada. En climas más fríos, iConstrucción CE-subir lata Además afectar el rendimiento de la antena y en alguno casos Este es un cortocircuito, esto se puede eliminar limpiando la acumulación de hielo-hacia arriba. Las fijaciones de la antena también deben revisarse para asegurarse de que estén seguras, ya que las antenas pueden aflojarse por daños causados por tormentas y vientos fuertes. Cableado a la antena debe comprobarse la degradación y muescas en El exterior vaina. Estos pueden ser reparado con autoamalgamación eléctrico cinta, que debería ser cubierto con cinta de PVC para evitar la degradación UV.

Figura 3. (izquierda) y (derecha) Antenas Yagi

Se debe verificar la elevación y el acimut de la antenaEd en cada visita para garantizar la correcta elevación Elemento n acimut de 157.6°Magnético. Un mareógrafo hoja de configuración y un Diagrama pictórico que muestra los valores correctos se proporciona en Apéndice Un.

¿Debería el Yagi fallo de antena, el dUnidad de carga ummy (Figura 4) que fue Suministrado con el mareógrafo estar conectado en lugar de la antena para permitir el diagnóstico de fallas. Antes de conectar la carga ficticia, el operador del mareógrafo debe monitorear los intentos de transmisión de datos observando los diodos emisores de luz (LED) en el registrador de datos, que se iluminan durante la transmisión de datos. Hay Dos posible Fallas:

Figura 4. Unidad de carga ficticia

1. Un circuito hort

   Esto dará como resultado un tiempo de transmisión más corto de lo normal y se puede confirmar conectando la carga ficticia en lugar de la antena, si la antena o el cable están defectuosos y se instala una carga ficticia, se observará una longitud de transmisión normal.

2. Un circuito debolígrafo

   En el caso de un circuito abierto, el transmisor evitará la transmisión por completo, por lo que los LED no se iluminarán. Una vez más, el uso de la carga ficticia debería resultar en un tiempo de transmisión normal.

Además, el registrador de datos también puede proporcionar información de diagnóstico relacionada con el estado de la última transmisión, por ejemplo, si fue exitosa o no (Figura 5). Se puede acceder a esto a través de una de las opciones en el menú de transmisión y se puede utilizar para ayudar con el diagnóstico.

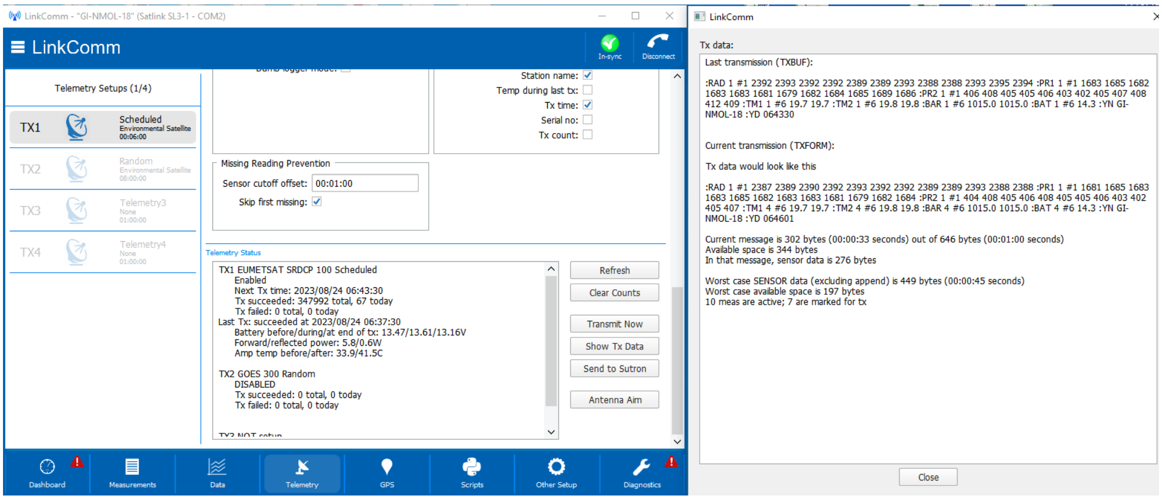


Figura 5. Información de diagnóstico mostrada por el registrador de datos Sutron Satlink3

2.3 GPS y GNSS Antenae

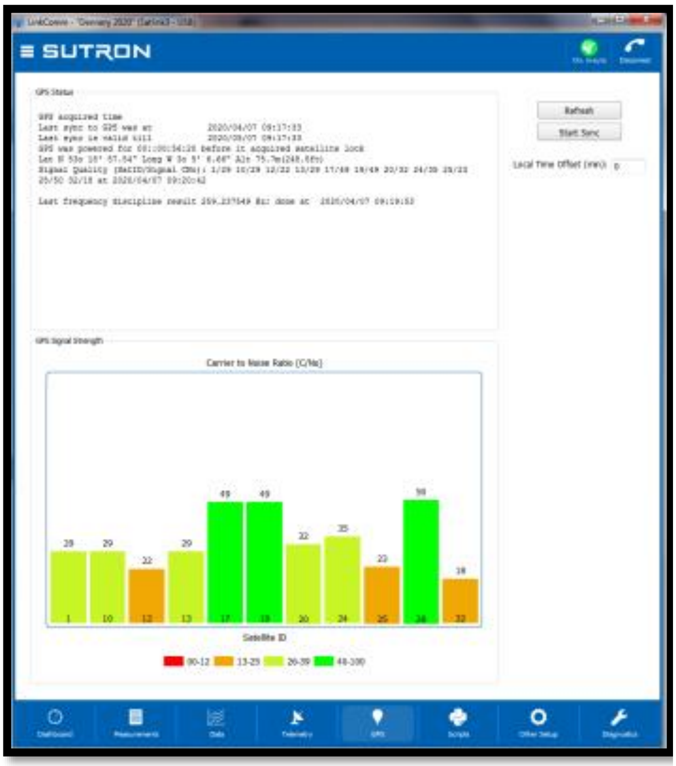


Figura 6. Estado del satélite mostrado por el registrador de datos Sutron Satlink3

El mareógrafo se suministra con un pequeño Bala de Trimble-estilo GPS antena (mostrado en la Figura 1). Éste ha sido elegido específicamente para su mejorard inmunidad a otros radiofrecuencia (RF) señales cuál resultados en un rendimiento fiable en RF hostil-entornos de interferencia. El datosRegistro y los sistemas de transmisión utilizan la antena GPS para obtener un-Para-fecha GPS hora fija cada 12 horas, que es suficiente para mantener el Incorporado reloj correctamente SincronizadoAsegurar Esos datos se transmiten dentro del marco temporal específico asignado a cada ubicación del mareógrafo para la transmisión por satélite. El funcionamiento y el rendimiento del GPS también se pueden monitorear utilizando el Datos incorporadosDiagnóstico del registrador para confirmar el funcionamiento correcto, como se describe en el Se proporcionan manuales de

Figura 7. Agrietamiento de la carcasa exterior de una antena GPS

datalogger. El resultado (Figura 6) mostrars los satélites a la vista y cuántos se están utilizando en un momento dado.

Las antenas GPS son muy confiable, pero más Durante largos períodos de tiempo, la carcasa exterior puede perecer debido a la degradación por Radiación UV, lo que resulta en agrietamiento y agua ingreso (Figura 7). Los reemplazos están ampliamente disponibles y se pueden obtener fácilmente.

Figura 8. Receptor GNSS y radomo Trimble Alloy

El receptor GNSS de aleación Trimble de calidad geodésica (Figura 8) también es fiable y está equipado con una cubierta protectora (un "radomo") para evitar el desgaste general, el daño a la vida silvestre y la acumulación de escombros. También debe verificarse en busca de evidencia de degradación. Dado que los radomos alteran el centro de fase absoluto de la antena, si se reemplaza un radomo , el operador debe asegurarse de que se aplican las correcciones correctas de antena/domo.

2.4 Panel solars

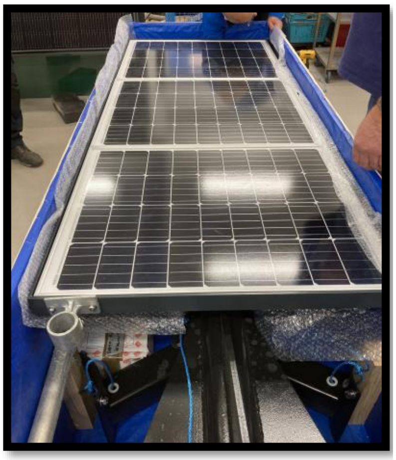


Figura 9. Matriz de paneles olares para mareógrafo de Buenaventura

El panel solars (Figura 9) son La fuente de alimentación principal al mareógrafo durante el día. Ellos adicionalmente supply Cargo al matriz de Masa internalES con el fin de Encienda el medidor durante las horas de oscuridad. Los paneles suelen ser resistentes y están diseñados para un 25-año de vida útilenvergaduraantes un Deterioro en la generación de energía se vuelve notable. Sin embargo Es útil limpiar periódicamente el panel con un paño húmedo, particularmente en Entornos donde está polvoriento o hay actividad de aves. Esto asegurará un suministro constante de energía a los componentes electrónicos. El operador should comprobar que el panel solar permanece Fijo de forma segura y que Cableado en buen estado. Si el panel es suelto Debe estar asegurado y el ángulo reComprobado.

2.5 Radar Sensor

Figura 10. Bocina de radar dañada (izquierda) y carcasa del sensor agrietada (derecha)

Dado que están montados sobre la línea de flotación, los sensores de radar tienden a ser más susceptible que los sensores submarinos a daños físicos causados por cuerdas, embarcaciones, impactos ambientales y vandalismo. Se debe hacer una inspección visual del sensor, Comprobación de aspectos externos daño (Figura 10) y Posible entrada de humedad. También es importante comprobar que el sensor posición no se ha movido desde la última visita. Para el sensor de radar del Nilos, Una burbuja niveladora Is Equipadas al radar carcasas (Figura 11), permitiendo al operador garantizar que esto todavía está alineado. Los cables deben ser revisados para degradación y daño físico (muescas, abrasiones, daños en roedores etc.) al revestimiento exterior. Cualquier daño debe repararse con sduende-acinta de malgamación y entonces cubierto con capa adicional de Cinta de PVC Para proteger contra la entrada de agua y el deterioro UV. Si está equipado con una pantalla LCD, esto se puede utilizar para confirmar el funcionamiento normal del sensor de radar.

Figura 11. Burbuja de nivelación en la carcasa del radar del Nilo

2.6 Gabinete electrónico

Figura 12. Armarios exteriores (verdes) e interiores (blancos) eLectronics

El verde grande Gabinete electrónico (Figura 12) casas Dos Armarios electrónicos internos, para proporcionar Impermeabilización y Prevención de daño físico a los componentes electrónicos internos. TEl interior gabinetes son Se accede con el uso de una clave. Todo Los gabinetes deben ser revisados para signos de Entrada de agua.

El gabinete electrónico contiene el registrador de datos y batería de cristal de plomo junto con otros componentes electrónicos. Eso es una buena práctica descargar datos en un 3 meses a 6-Mensualmente (véase el apéndice B). El masa de cristal de plomoIES jave una vida útil típica de 3-5 añospero el voltaje enlatar ser monitoreado diariamente Vía el COI Instalación de Monitoreo de Estaciones a Nivel del Mar (IOC SLSMF) sitio web (INSTALACIÓN DE MONITOREO DE ESTACIONES A NIVEL DEL MAR (ioc-sealevelmonitoring.org), Figura 13). Ssignifica que la batería está llegando al final de su vida útil podría incluir fallarUres durante la madrugada/noche o incapacidad de la batería Para recuperar su carga durante el día, alcanzando un nivel de sólo 10 voltios o menos.

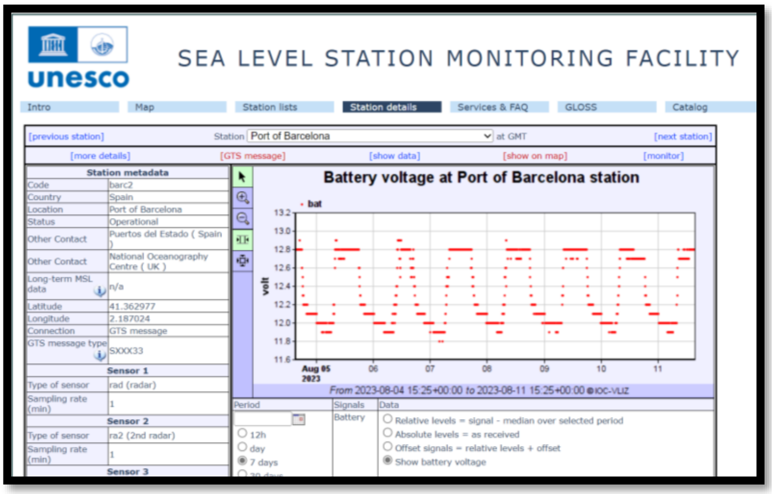


Figura 13. Visualización del voltaje de la batería en el sitio web de IOC SLSMF para un ejemplo (Barcelona) mareógrafo

2.7 Datalogger

El OTT Sutron Satlink3 datalogger (Figura 14) es Capaz de registrar los datos internamente y HAs Transmisores Meteosat integrados para transmitir los datos a través de la red satelital. Los datos se pueden descargar directamente desde los registradores de datos a través de un cable serie / USB (o WiFi) y se recomienda que los operadores de mareógrafos realicen esto como parte de un protocolo de mantenimiento, ya que la descarga directa garantiza que se obtenga un registro completo del mareógrafo y evite las lagunas de datos que podrían surgir en el registro del portal web SLSMF de la COI a través de problemas de comunicaciones por satélite. En el Apéndice se proporciona un ejemplo de proceso de descarga de datos B

Figura 14. Registrador de datos

2.8 Masa de cristal de plomo

El mareógrafo se suministra con 4 masas de cristal de plomo "no derramables" de alta calidad (Figura 15) que están diseñadas para funcionar a temperaturas extremas conun excelente rendimiento de descarga profunda. Estas baterías deben funcionar durante unos 3-5 años, dependiendo del entorno.

La batería normalmente recibirá una carga completa durante el día a través del panel solar y luego usará esa energía para poder El mareógrafo Durante las horas de oscuridad. Cada vez que una transmisión se hace La batería tiene que abastecerse a 4 amperios para ese período. Si la batería La carga disminuye, Transmisións Comience a fallar durante la noche cuando el medidor depende solo de la batería. Por lo tanto, es esencial monitorear voltaje de la batería a través del COI Sitio web de SLSMF. La batería debe ser reemplazada si cae por debajo 10 voltios después de que haya recibido una carga completa durante el día.

Figura 15. Batería de cristal de plomo no derramable

2.9 Dispositivos de protección de fusible/sobretensión

El gabinete contiene una serie de dispositivos de protección montado en el carril DIN e incluyen protección contra sobretensiones y rayosOrs así como fusible en líneas (Figura 16). El en línea El fusible permite aislar la energía del registrador o de la batería o de ambos, para permitir que se lleve a cabo el mantenimiento. El surge y lightning Protectores han sido proporcionadosd para cada uno de los externosLy sensores montados, para proteger el registrador de datos en el caso de un Rayo.

Figura 16. Fusibles y protectores contra sobretensiones

2.10 Controlador de carga solar

La energía de la electrónica y la batería es proporcionada por los paneles solares. Para proporcionar y regular un suministro de 12V a la batería, se utilizan dos controladores de carga solar Campbell Scientific (Figura 18). Estas unidades transforman los voltajes más altos del panel solar para proporcionar un suministro regulado de 12V al registrador y los sensores. Además de esto, el controlador es capaz de monitorear y

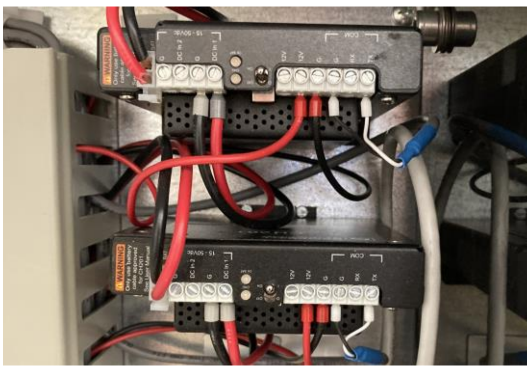


Figura 18. Controlador de carga solars

cargar inteligentemente la batería para mantenerla en condiciones óptimas.

Los controladores tienen un par de LED de diagnóstico que pueden ser utilizados por el operador para determinar el estado de carga y el estado de la batería, lo que puede ayudar en el diagnóstico de fallas. Se debe consultar el manual de Campbell Scientific CH201 para obtener más información sobre estos LED de diagnóstico.

3. Programación de tareas de mantenimiento

3.1 Tareas diarias

- Verifique los datos en el portal de datos (http://www.ioc-sealevelmonitoring.org/) de la Instalación de Monitoreo de la Estación del Nivel del Mar del COI para ver si faltan mensajes y transmisiones GOES para la corrupción de mensajes.

3.2 Tareas trimestrales

- Descargar datos del Satlink3. Aunque los datos se transmiten casi en tiempo real a la Instalación de Monitoreo de la Estación del Nivel del Mar de la COI, es una buena práctica descargar los datos cada 3 o 4 meses antes de sobrescribirlos. Esto permitirá llenar las lagunas de datos que han resultado de una transmisión satelital fallida.
- Inspección rápida del mareógrafo, cables, antenay panel solar para detectar cualquier daño.

3.3 Tareas anuales

- Inspección exhaustiva del mareógrafo, cables, antenae y panel solar para detectar cualquier daño. Se debe tomar tiempo para inspeccionar de cerca todos los componentes y cables para verificar si haydaños o daños. Puede ser necesario utilizar una escalera de mano para inspeccionar los componentes superiores.

4.Nivelación

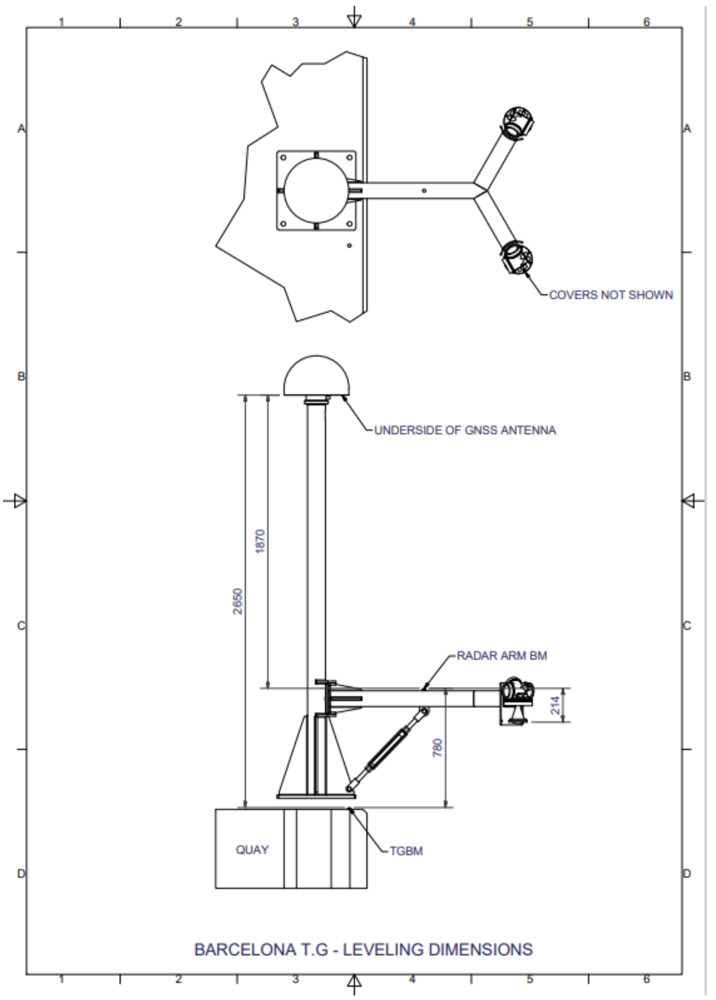


Figura 18. Ejemplo de alturas de referencia de mareógrafos (para

La nivelación es una parte importante del proceso de instalación, ya que permites el tIde gauge y su sensores Para estar atado a Benchmark estable conocidos situado cerca.

Como parte de esta instalación, se debería haber instalado un punto de referencia abovedado de latón (el punto de referencia del mareógrafo o TGBM) en el muelle, cerca del mástil GNSS. La diferencia de altura debe registrarse entre este TGBM y un punto de referencia de latón instalado en el brazo del radar (Figura 18).

El monitoreo continuo de la nivelación en el sitio primario se realiza comparando series temporales de movimiento vertical de la tierra desde el receptor GNSS con series temporales del nivel del mar derivadas del mismo instrumento a través de la técnica de reflectometría interferométrica GNSS (GNSS-IR). Esto elimina la necesidad de ejercicios manuales continuos de nivelación.

Appendix A

Hoja de datos de inicio rápido

Las hojas de datos quick-start (abajo) proporcionan un resumen de toda la información relevante sobre el mareógrafo y se pueden utilizar como parte de los procedimientos de mantenimiento del sitio para verificar la elevación y el acimut de la antena, la dirección del intervalo de tiempo, el canal y la hora. La información sobre los sensores / registradores, como los números de serie y la información de cableado, también se incluyen en caso de que tengan que retirarse y volver a conectarse.

Hoja de datos de inicio rápido – Eurosea Colombia Mareógrafo

Latitud: 3.832559
Longitud: -77.262154

Sensor de radar Xylem Nile 502: s / n - 21J102933.
Interfaz de comunicación – SDI-12.
Dirección del dispositivo SDI-12: 0
Rango máximo de medición – 30m.
Colores del cable: BlackGND
Rojo+12V
Datos WhiteSDI-12

Sensor de radar Xylem Nile 502: s / n - 21J102934.
Interfaz de comunicación – SDI-12.
Dirección del dispositivo SDI-12: 0
Rango máximo de medición – 30m.
Colores del cable: BlackGND
Rojo+12V
Datos WhiteSDI-12

Barómetro de Vaisala PTB110: Modelo: PTB110 1A0AB
S/N T2130676 0-5V (500-1100 hPa)
Lectura puntual cada 6 minutos.
Cálculo de Satlink3 500+(((1100-500)/5)*X) hPa.

Sensor	**Cable**	**Satlink3**	**Pin No.**
VOUT	White	A	36
Suministro	Red	Prot+12V	21
GND	Black	GND	22
AGND	Green	Analogue GND	37

SATLINK3 SL3-1 V2: Registrador D ata con transmisor integrado
S/N 2105620

Datos de apuntamiento de la antena: Azimut (verdadero) = 151.7°, Azimut (magnético) = 157.6°, Elevación = 84.9°

Ranura de transmisión EUMETSAT: 00:01:40 más 5 minutos a partir de entonces
ID de DCP: 6B004E92
Canal: 211
Velocidad en baudios: 300
Duración del intervalo de tiempo de transmisión: 5 segundos
Satélite: GOES-16
Ayuda para apuntar antenas en línea: http://www.dishpointer.com/
Archivo de configuración: EUROSEA_COLOMBIA

Trimble GNSS:
Receptor de aleación Trimble s / n: 6042R40073
Trimble Choke Ring Antenna s/n: 5104338219
Antena Trimble Radome s/n: 3353
Método de medición de antena: parte inferior del soporte de antena
Versión de firmware 6.15
Core Engine versión 5.55
Medidas, 5 segundos, posiciones 5 minutos, continuo 15 minutos.

Teltonika RUT955 Módem:
mareógrafo
s/n: 1116487429
Dirección IP: 192.168.1.1
Nombre de usuario: admin
Contraseña: EuroSColom22
Wi-Fi SSID: RUT955_3EC8
Contraseña de Wi-Fi: Pi3h4B9A

Acceso AnyDesk:
Mareógrafo
Número de escritorio: 502 608 620
Contraseña: EuroSColom22

Raspberry Pi:
Mareógrafo
Dirección IP: 192.168.1.xxx
Nombre de usuario: stma
Contraseña: EuroSColom22

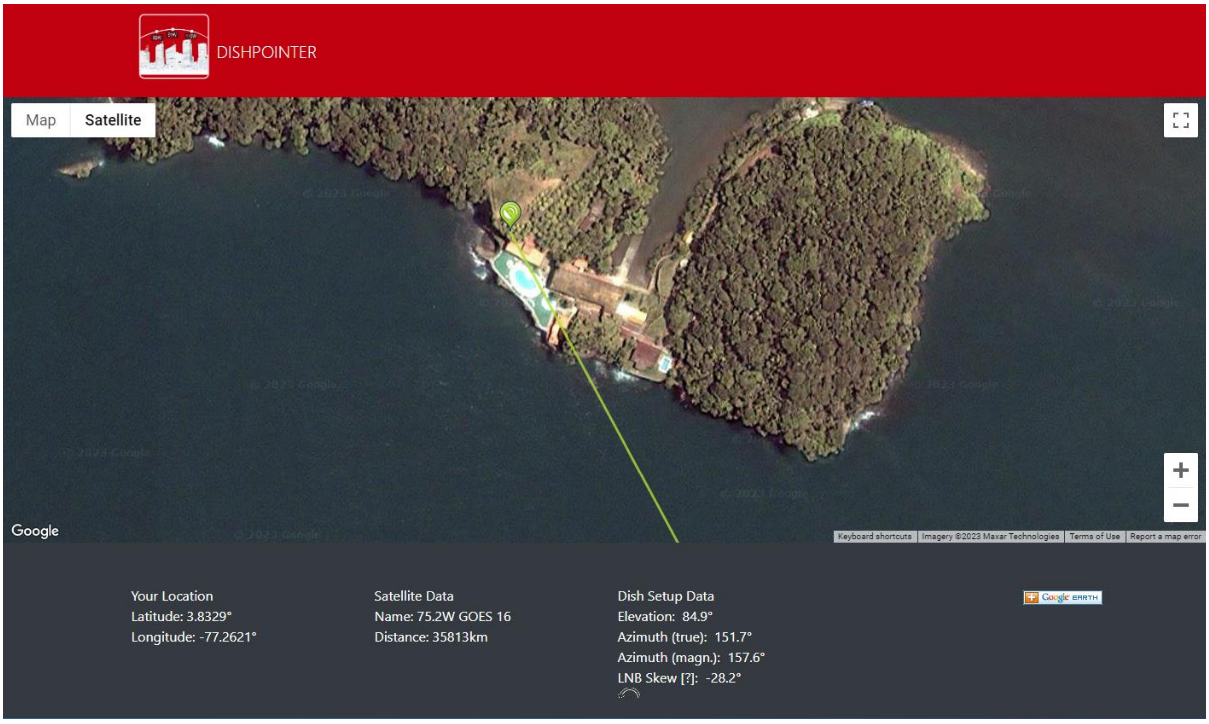
Controlador de carga solar:
Campbell Scientific CH201
s/n: 1171
Dirección del dispositivo SDI-12: 3
Rango de voltaje de entrada: 15V a 50V
Corriente de carga máxima: 10A

Campbell Scientific CH201
S/N: 1246
Dirección del dispositivo SDI-12: 3
Rango de voltaje de entrada: 15V a 50V

	Corriente de carga máxima: 10A
Paneles solares:	Phaesun Sun Plus 80 Número de paneles: 3 Potencia de salida: 80W por panel Voltaje del sistema: 12V Voltaje de circuito abierto: 22.3V
Baterías:	NX Lead Crystal Nº de modelo: AMC9007 Capacidad (C20): 38Ah Voltaje: 12V Número de baterías: 4

Centro Nacional de Oceanografía (NOC) Contactos Geoff Hargreaves (gwh@noc.ac.uk) Angela Hibbert (anhi@noc.ac.k)
Asistencia telefónica - Cuadro +44 151 795 4800 Fax: +44 151 795 4801

Transmisiones satelitales - Acimut y elevación de la antena Meteosat:



Apéndice B. Instrucciones para lacarga propia desde el registrador de datos OTT Sutron Satlink3

Hay dos métodos para transferir los datos almacenados en el Satlink3, a su memoria USB conectada.

Método 1:

El OTT Satlink3 tiene la capacidad de almacenar automáticamente datos en una memoria USB insertada. El registrador monitorea el puerto USB y cuando se inserta una memoria USB, los datos se descargan automáticamente en la memoria USB. El registrador de datos solo descargará datos que no se hayan descargado previamente a través del USB. Esto significa que el registrador no transferirá todo el conjunto de datos almacenado, solo los nuevos datos.

Método 2:

Este método requiere una conexión desde un ordenador al Satlink3 a través de un cable USB, WiFi o serie. Utilizando el software LinkComm proporcionado, los datos seleccionados se pueden descargar utilizando varias opciones especificadas por el usuario. Estas opciones se pueden encontrar en el menú de la pestaña de datos y permiten al usuario especificar semanalmente, mensualmente, semestralmente o todo el conjunto de datos almacenados para descargar. El software también se puede utilizar para mostrar los datos descargados en forma gráfica o tabular, proporcionando un método rápido para la verificación de datos.