The Shipborne European Common Automatic Weather Station (EUCAWS)

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ABSTRACT

Among the 3000 ships participating to the Voluntary Observing Ship programme recruited by National Meteorological Services, less than 1 in 10 is equipped with an Automatic Weather Station. Considering that automated measurement is more accurate and regular, automation of the national fleets is a real challenge to improve the quality and the density of marine observation. E-Surfmar, as Surface Marine Programme of the EUMETNET Composite Observing System, published in 2012 an invitation to tender in order to make available to its members a common system specially designed for ships.

The EUCAWS was specified to be highly flexible and adaptable to different kind of sensors. Its installation is rather easy as the interaction needed with ship equipments is limited to the absolute minimum (power supply). The station can be configured locally, but also remotely, by two dedicated software packages. Transmission of weather messages is ensured through Iridium Short-Burst Data mode (SBD), in a specific data format optimised and designed by E-Surfmar. The station can also be connected to the software TurboWin, to visualize automatic measurements and to complete weather observation by manual input.

After several phases of intensive tests in laboratories and on ships, coordinated between Météo-France, DWD, and KNMI, the EUCAWS prototypes have been validated in March 2016. First series were purchased and some stations are already operating. E-Surfmar also proposes an adoption program to its participants who want to develop their own network.

1. INTRODUCTION

Among the 3000 ships participating to the Voluntary Observing Ship programme recruited by National Meteorological Services, less than one in ten is equipped with an Automatic Weather Station (source: WMO Pub. 47). Considering that automated measurement is more accurate and regular, automation of the national fleets is a real challenge to improve the quality and the density of marine observation.

The EUCAWS station (European Common Automatic Weather Station) is a new European station specifically designed for ships. It is the result of a rather long coordination project started in 2008. At that time, Automatic Weather Station for ships did not really exist on the market; several European countries expressed needs to develop and modernise their national networks of observing ships, while also being wary of the pitfalls of insufficient specifications for such a novel endeavour.

From this idea of pooling together resources in order to draft stringent requirements between countries came the idea of sharing the cost of development for a future product. The grouping of European NMS[1], EUMETNET, provides a framework to organise co-operative programmes between its Members in the various fields of basic meteorological activities. Its surface marine service, E-Surfmar, took on this challenge of organizing and coordinating the initial work of drafting common specifications, and then published in 2012 an invitation to tender (ITT). The long delay between initial specifications and ITT had to do with finding proper administrative and contractual instruments for such a pan-European call involving several national institutions under the umbrella of EUMETNET (all being entities operating under different national laws). After this, the company was selected to develop the EUCAWS station. The development phase lasted until end 2014; the year 2015 was mainly dedicated to the acceptance and verification of the prototypes; finally in 2016 the verification of regular service was completed.

The present paper is organized as follows. Section 2 presents the EUCAWS Automatic Weather Station with its interfaces, the data acquisition, and the data transmission. Section 3 discusses the validation process, with the distinct phases. Section 4 describes the implementation of the network in Europe.

[1] NMS : National Meteorological Service

2. DESCRIPTION OF THE EUCAWS STATION

2.1. Synoptic Scheme

The principal components of the new Shipborne Automatic Weather Station are as follows (see Figure 1).

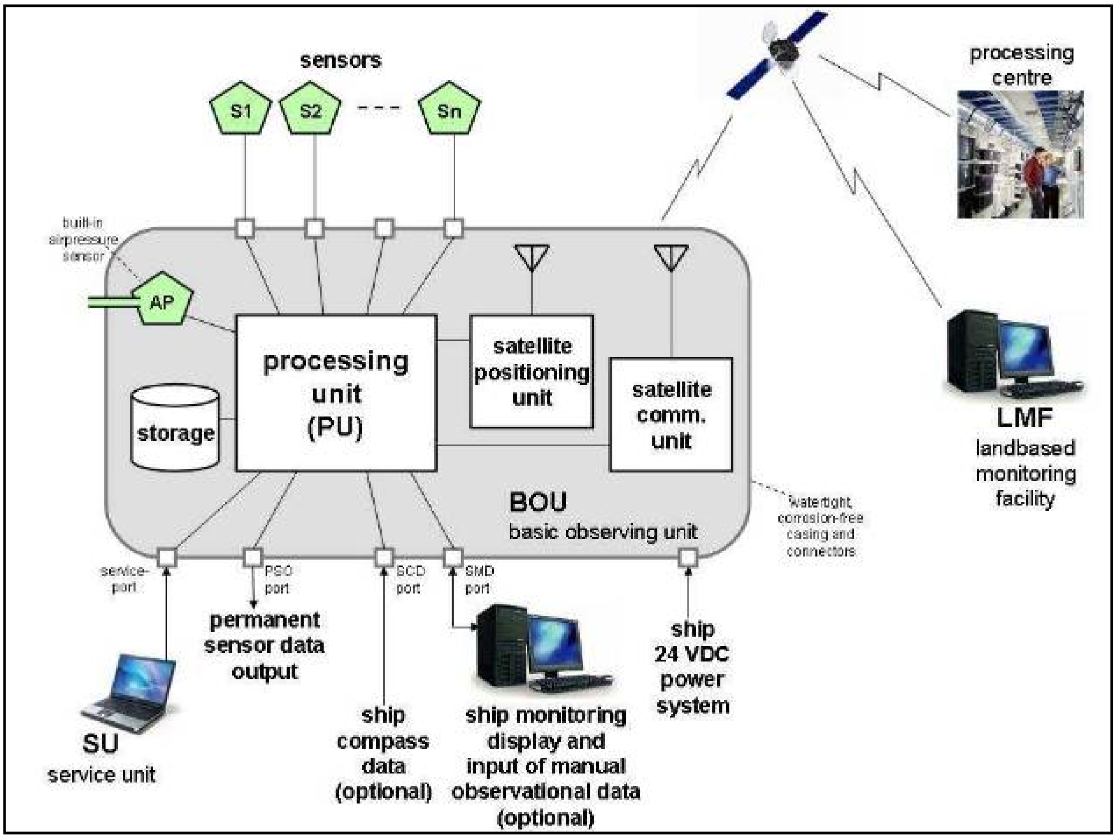

Figure 1: Synoptic Scheme of the EUCAWS station

The station collects the measured data on board of a ship and sends them to the mainland for further processing. The main elements of the station are:

- A Processing Unit, including all necessary software to process the sensor data. It is composed of several electronic boards with specific functions: main board, power board, acquisition boards;
- A Satellite Positioning system to obtain position data, providing global coverage, and time reference data. A GPS receiver has been chosen here.
- A Satellite Communication system for two-way communication with the processing centre on the mainland, providing global coverage. An Iridium modem was selected, in order to ensure low coast and reliable communication.

The station is powered by 24V of the ship, and can operate between 18 and 30V.

For each meteorological parameter that has to be observed by the EUCAWS, a sensor must be installed and connected to the station.

The Service Unit (SU) enables a PMO[2] or NMS technician to check and configure the station on board the ship. It consists of a software program, to be installed on a portable computer, which can be connected to the service port of the station by cable.

The Land based Monitoring Facility (LMF) enables NMS staff and technicians ashore to check and configure an S-AWS remotely. The LMF consists of a software program to be installed on a computer on the mainland (i.e. where the NMS is located), that can communicate with the S-AWS via its Satellite Communication system unit.

An optional Ship Monitoring Display (SMD) which displays to the crew the current measurements of the station and that may also serve to enter manual observation data. In that case the software used is TurboWin+, running on a dedicated computer connected to the station.

An optional Permanent Sensor Output (PSO) is available on the station, to provide to the ship 1 second data, for crew own need.

2.2. Integration

The enclosure of the EUCAWS station is a plastic cabinet which measures 54 x 45 x 25 cm and weighs 16 kg (see Figure 2).

Figure 2: EUCAWS cabinet

For each input and output of the station, a dedicated marine connector is available. An external switch is also present on the bottom of the box. On the top of the box, an air pressure outlet is fixed. That system connected to the barometer inside reduces the effects of the wind on pressure measurement. Handles are fixed on the box to help NMS staff to carry the station. Antennas for GPS and Iridium are outside on the metallic interface that allows an easy fixation to the ship rails (see Figure 3).

[2] PMO : Port Meteorological Officer

Figure 3: Metallic interface to fix the station on the ship rails

Inside the enclosure (see Figure 4), the electronic boards are located in a rack: main board, power board, analogue board, digital board and Iridium board.

Figure 4: Inside the EUCAWS

A circuit breaker is located inside to protect the electronic boards from surges. In addition, a connection module allows connecting the sensor inputs. It also contains electronic fuses for each channel.

The station is IP67, and complies with the standards specified for maritime equipment in the category 'Exposed', as referred to in European standard EN-IEC-60945, 4th edition, 2002-08.

2.3. Data acquisition

The meteorological parameters acquired by the EUCAWS station are the 5 main parameters commonly measured on ships: pressure, temperature, humidity, wind, and sea surface temperature. Navigational and clock data are provided by the GPS (compulsory to locate the station). Optionally, the gyrocompass of the ship can be connected to improve the quality of the true wind computation, especially when the ship is moving slowly.

In addition, visual observations entered by observers via the TurboWin+ software are also acquired by the EUCAWS if provided.

The list of sensors that can be interfaced to the EUCAWS is presented in Figure 5. Mostly, the frequency of acquisition is 1Hz for the sensors, except for the wind, where the frequency is between 1 and 4 Hz, and for pressure, where it depends on the sensor.

Parameter	Sensor
Pressure	Vaisala PTB220 Vaisala PTB330 Vaisala PTB210
Temperature	PT100
Humidity	Any 0-1V sensor (ex: HMP110...)
Sea surface temperature	PT100
Wind	Any NMEA sensor (ex; Thies, Gill...) Note that Thies sensor can be heated by the station
Multisensor	E+E33 (temperature and humidity) PTU300 (pressure, temperature and humidity) Gill MetPak-II (Pressure, temperature, humidity and wind) Vaisala WXT520 (Pressure, temperature, humidity and wind)
GPS	Any NMEA GPS
Gyrocompass	Any NMEA gyrocompass
Visual observation	TurboWin+

Figure 5: List of sensors interfaced to the EUCAWS

The station has been specified to be highly adaptable to new sensors, or to the same sensors with different configuration (which is needed to cope with national practices). In total, the EUCAWS has 8 channels that can be set to three different configurations (8 digital input, 6 digital & 2 analogue, 4 digital & 4 analogue). Part of the software dedicated to sensors acquisition can be modified by E-Surfmar members.

2.4. Data transmission

Data are transmitted ashore to a processing centre through Iridium satellites. The transmission chain is presented in figure 6.

The processing centre receives emails to be decoded and converted into BUFR. A configuration interface allows NMS to allocate the call sign of the ship for each Iridium number, to activate or deactivate the transmission onto the GTS, and to select which parameter are sent to the GTS.

The format to transmit the data (called format #100) has been designed by E-Surfmar to optimise the compression of data and therefore the cost of transmission. Without visual observation a weather message contains only 30 bytes.

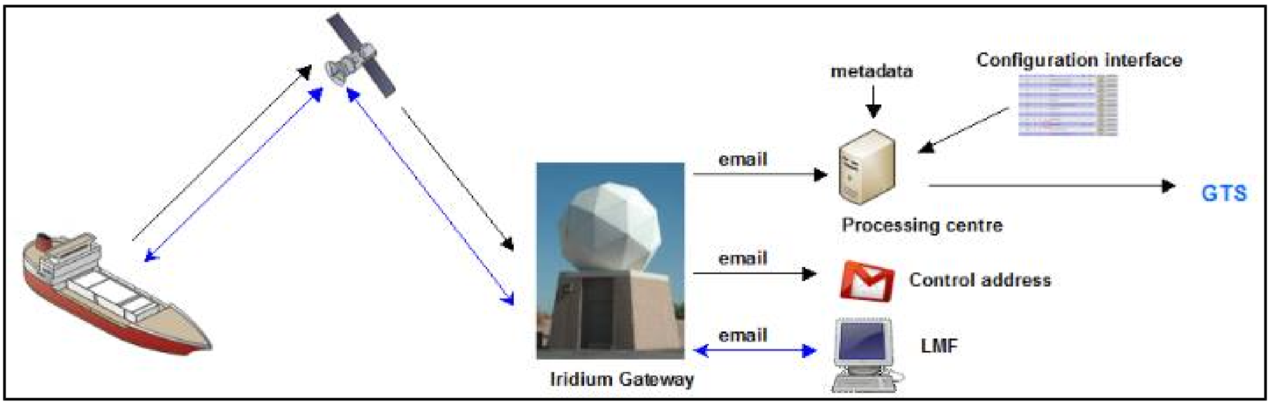

Figure 6: Transmission chain for EUCAWS messages

Frequency of transmission can be set to 5, 10, 15, 20, 30 minutes or 1 hour. Several transmission modes have been implemented:

- Enabled mode: to activate or not the transmission.
- Port mode: implies that no weather reports will be transmitted when the ship is not moving (speed < 0.5 knots).
- Area mode: 10 areas can be defined in order to select the frequency of transmission in each area.
- Trigger mode: the frequency at which weather reports are transmitted changes into a higher frequency than the nominal one, if a parameter is outside a defined range (ex: wind speed higher that 30m/s)

With the LMF software, some commands can be sent to the station to modify its configuration, to access the logbook or current measured values, to restart the station… In these cases, emails are sent to the Iridium provider and the commands are read and processed when the EUCAWS station checks its mailbox. The mailbox is checked after each transmission, and also daily at 12 UTC.

2.5. Station configuration and maintenance

EUCAWS stations can be configured locally thanks to the Service Unit (SU) software running on a laptop connected to the station. It allows the following actions (see figure 7):

- Configure the system: select which sensor on which channel, select transmission parameter and configure metadata (e.g. height of barometer…).
- Show logging data.
- Show outputs and inputs on the various ports (port analysis): current measuring values of all connected sensors, PSO output, SMD input and output, communication output.
- Installation of new software on the station, fall-back to older versions.
- Erase older versions of the software, logging data files, etc.
- Reboot the station

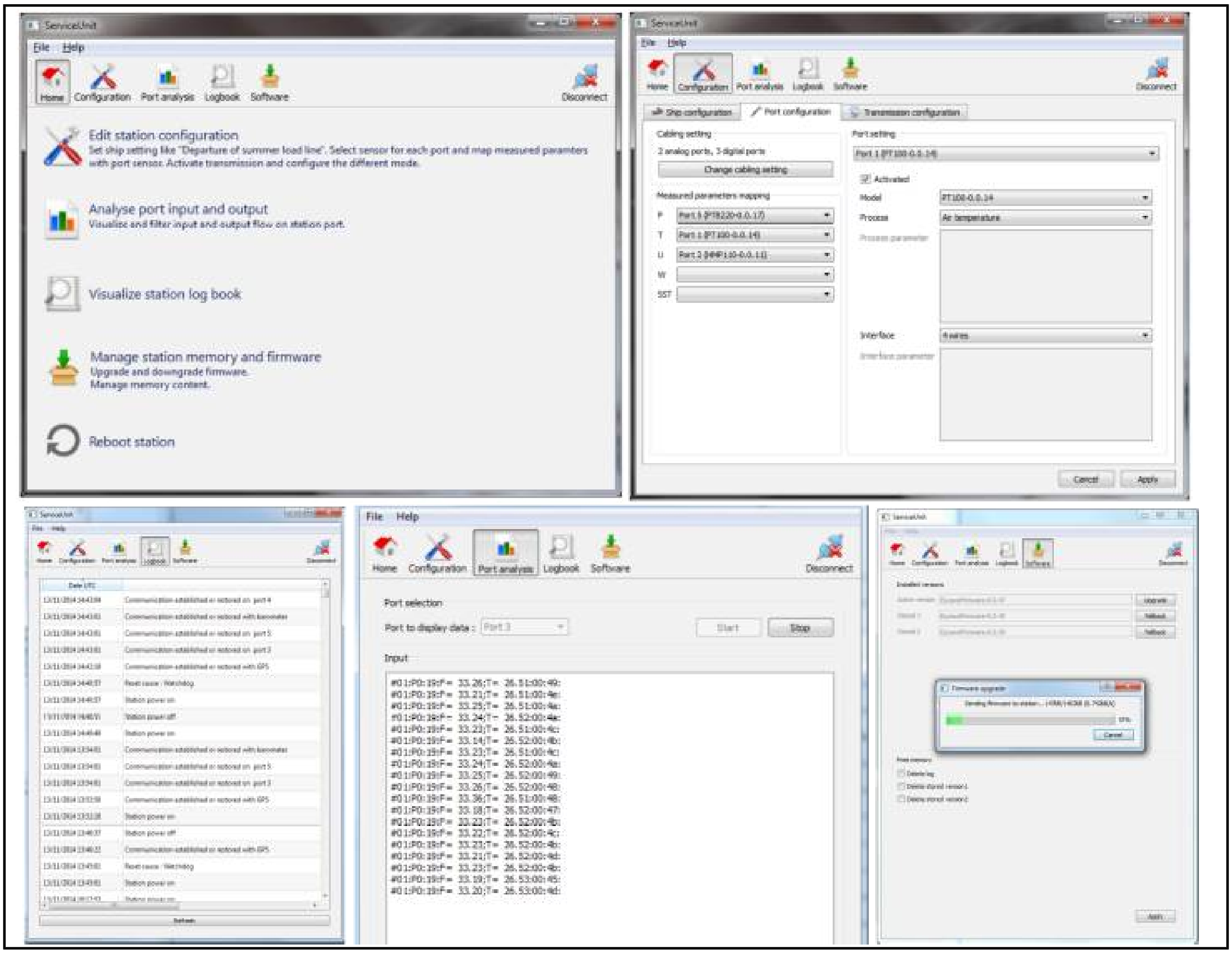

Figure 7: Service Unit views

Remotely, some actions can be done thanks to the Landbased Monitoring Facility (LMF) software (see figure 8):

- Show logging data. The 60 most recently added log event messages can be viewed.
- Show current PSO output telegram (current measuring values of all connected sensors).
- Configure the system: activate or deactivate a parameter, modification of transmission parameter, update of metadata.
- Fall-back to another version of the software
- Reboot the station

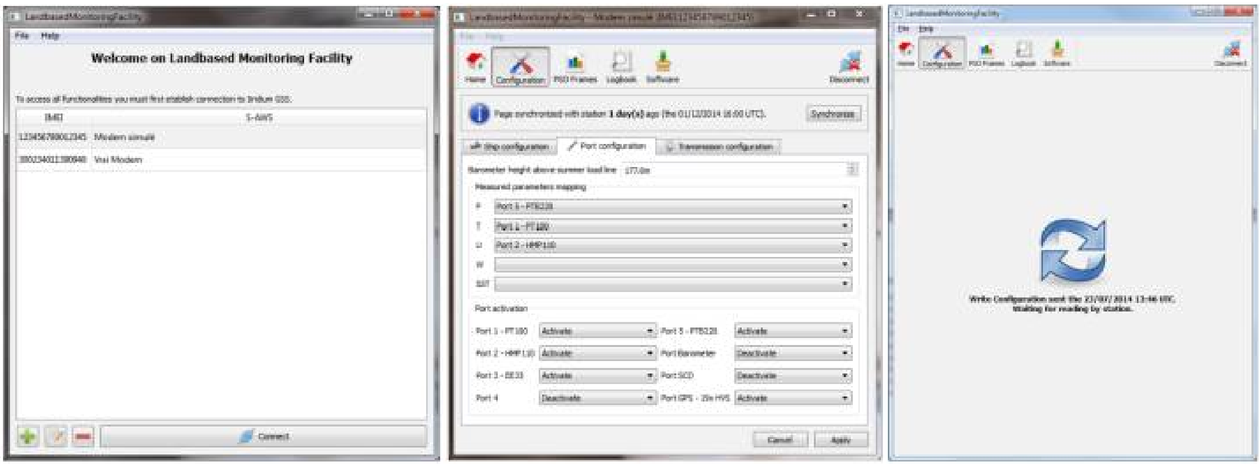

Figure 8: Landbased Monitoring Facility views

2.6. Local outputs

Two local outputs are available:

- The Ship Monitoring Display (SMD): 1-minute data are sent to the TurboWin+ software (see Figure 9). TurboWin+ is an adaptation of the TurboWin software, well known by ship observers, allowing coding a visual observation. Within the twenty minutes before the round hour, the crew can enter a visual observation that will be sent to the EUCAWS station. In that case, the visual data will be added to the automatic measurements at the next round hour, and sent in the weather message. The format of exchange for SMD input and output is two proprietary NMEA sentences defined by E-Surfmar.

Figure 9: TurboWin+

- The Permanent Sensor Output (PSO): 1 second data are sent in a proprietary NMEA sentence on a RS422 port (see Figure 10). These data can be used by the crew or scientists for their own needs.

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Figure 10: PSO output

3. VALIDATION OF THE PROTOTYPES

Three prototypes were ordered in 2013 to test the correct behaviour of the station. The acceptance of the prototypes was scheduled in several phases:

- A factory acceptance test was planned at the end of the development phase in December 2014.
- A site acceptance test in early 2015: One prototype was installed during one month on a ship
- A 6-month acceptance time period to test exhaustively each prototype: one at Météo-France, one at DWD and one at KNMI.

3.1. Factory Acceptance Test (FAT)

The Factory Acceptance Test was organised at the manufacturer's site between the 17 and 19 December 2014, with participants from KNMI, DWD and Météo-France.

Many basic tests were performed like the correct interface of all the sensors, power supply issues, transmission modes, behaviour of the SU and LMF, data format for the different outputs. It was also the opportunity to check the qualification report provided by an external company to guaranty the IEC-60945 compliance.

Except for a few minor issues, the prototypes were declared accepted. However some improvements on the integration were requested for the series. It was also the opportunity to establish a wish list of things not clearly enough specified in the tender to improve the station possibilities.

3.2. Site Acceptance Test (SAT)

From 27 January to 24 February 2015, one prototype was installed on the ferry Armorique, plying between France and England. That ship was already equipped with a BATOS weather station, thus allowing easy comparison of measurements.

Figure 11: EUCAWS installation on Armorique ferry

The tests carried out during the installation and the 4 weeks of SAT allowed pointing out several problems on the prototypes:

- Connectors were not sturdy enough to authorize only one position.
- PSO and SMD were not correctly logged.
- LMF worked partially.
- Too high pressure difference with BATOS station (and ECMWF model) during windy events (see figure 12).

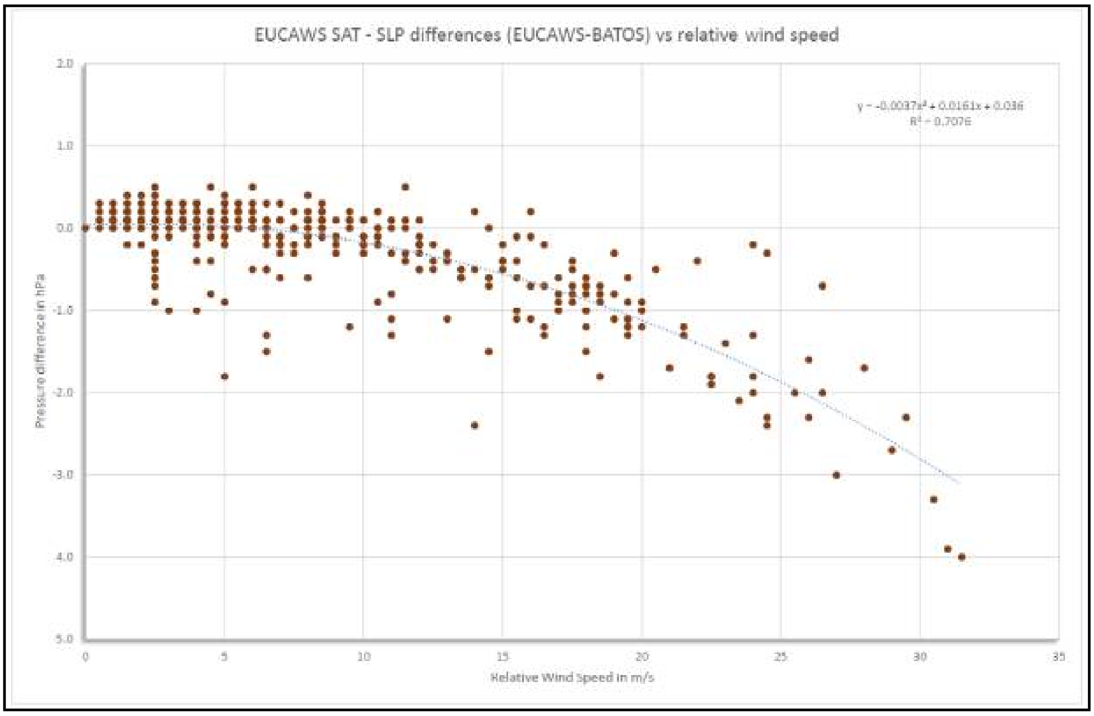

Figure 12: Difference between BATOS and EUCAWS measurement related to the wind speed

The first three issues were requested to be solved before the end of the SAT period. The last issue with pressure was tested more in detail during the next phase in DWD's wind tunnel, and we concluded that the position of the station on the metallic installation kit was too low.

After some software corrections and the retrofit of the prototypes with new connectors, the SAT was completed in June 2015.

3.3. Acceptance Period

A six month acceptance period was schedule in the tender to be able to check carefully all the specifications of the station and softwares. The three retrofitted prototypes were delivered at Meteo-France, DWD and KNMI in June 2015, after the SAT acceptance.

Two prototypes were installed on ships: DWD prototype on the ship Alkor between 10 July and 17 September and the KNMI prototype on the Lagarfoss between 23 September and 16 December. Météo-France prototype was not re-installed onboard a ship as during the previous phase and this allowed to have a station in the laboratory, which was useful to reproduce problems found at sea.

A list of 375 tests was performed in the laboratory and lead to corrections. However, the two periods at sea were again relevant to point out issues with the prototype:

- GPS time was jumping from few minutes from time to time
- The power board had a bad behaviour for an input voltage of 20V.
- A ground issue: insulation of the ground of the station was required so as not to perturb the ship's power network.

After some software adjustments, tests of the new GPS (GPS150 Dual Nav) and of the new power board, E-Surfmar accepted the prototypes on 7th March 2016.

4. IMPLEMENTATION

4.1. First installations

Since March 2017, the Eucaws stations are deployed by DWD and Météo-France. In September 2017, 14 stations are installed, transmitting data on the GTS. Some installations are presented below.

Figure 13: Installation on Alkor (DWD)

Figure 14: Installation on Montreal Express (DWD)

Figure 15: Installation on CMA-CGM Fort Sainte Marie (Météo-France)

4.2. Adoption scheme

The aim of this scheme is to assist E-Surfmar participants, National Meteorological Services or other partner institutes in participant countries, who wish to develop an AWS fleet.

This requires a commitment by the receiving institution, wishing to adopt a station provided by E-Surfmar, to then operate the station and maintain it. Once adopted, the station becomes part of the National fleet recruited by the receiving country. Support for the installation can be given by E-Surfmar members who already operate EUCAWS stations. The sensors to be installed are those from the institute in charge of the station. If these sensors cannot be interfaced yet with the EUCAWS, the E-Surfmar coordination team can help to develop the appropriated part of software. It is not in E-Surfmar remit to ensure calibration and maintenance of the instruments. However, E-Surfmar can provide the GTS transmission of the weather messages. Handling the monitoring of data transmitted, and switching on/off sensors, remains a responsibility of the receiving institute (note E-Surfmar has developed web-based tools for these tasks).

In the framework of this adoption scheme, Eucaws stations have been delivered recently to Spain

(AEMET), Portugal (IMPA), Croatia (DHMZ), Norway (Met.no), Sweden (SHMI) and soon to Iceland (IMO). The first adopted stations should be operational soon.

5. Conclusions and Perspectives

After nearly 8 years of project, with coordination between several participants in various European countries, the EUCAWS has reached a maturity sufficient for operational implementation. Very much similar to other European initiatives of technical collaboration, this common effort resulted in a product that meets all the constraints of a variety of participants; such characteristics are perfectly fitting for a scientific-class instrument, designed to be operated in harsh conditions, because it means that a variety of scenarios and technical obligations, as well as national standards, had to be taken into account in the design. This came at the expense of the realization timeline, for a longer timeframe was needed to achieve this development, as compared to national-only developments.

The EUCAWS project was also successful in making various groups work together, and develop capacity. For example, it was the first time that European Meteorological Services conducted a tender together. Putting together the efforts, the knowledge and testing capacities was highly productive to end with a better product, and also helped raise the bar in terms of practices in the contributing institutions.

The EUCAWS station has been designed specifically for observation on ships and has a flexible architecture to be adapted easily to national practices and sensors. It has been thought to enable an easy installation and easy maintenance, including remotely, which are important improvements as compared to previous systems.

The first stations start to be installed, and an adoption scheme has been established inside E-Surfmar. Current plans for EUCAWS are in the order of 300 stations between European countries. In addition, E-Surfmar hopes this will stimulate the will of other countries to participate, and hopefully develop their marine networks in the future. The benefits will extend to all users of weather and climate observations, since many parts of the world oceans remain unobserved in situ on a routine basis.

Acknowledgements

The EUCAWS development team is thankful to all E-Surfmar participants for their support, as well as to others in several countries, including ship operators, who have assisted with installations and testing of the first stations, as well as current operational implementation.