TA PROJECT REPORT

1. Project Information

Proposal reference number[1]	21/1001596
Project Acronym (ID)[2]	V-RUNAS
Title of the project[3]	Validation of a Real-time Underwater Noise Acquisition System
Host Research Infrastructure[4]	OBSEA (UPC)
Starting date - End date[5]	20/09/2021 – 23/02/2022
Name of Principal Investigator[6] Home Laboratory Address E-mail address Telephone	Ehsan Abdi Cyprus Subsea, 34A Paragogikotitas, 2326, Lakatamia, Cyprus e.abdi@cyprus-subsea.com +35797817638

2. Project objectives[7] (250 words max.)

The main objective of this project is the technical and scientific validation of the Real-time Underwater Noise Acquisition System (RUNAS) in coastal waters. This system aims to provide real-time underwater noise measurements compliant with the Marine Strategy Framework Directive (MSFD) indicator 11.2.1. The scientific and technical validation of the system has three main objectives:

Objective 1: "Robustness and Readiness": Assess the proper functionality of the equipment and monitor its stability and performance, including mechanical components, internal electronics and software.

Objective 2: "In-situ underwater noise algorithms": Validate the real-time underwater noise algorithms embedded within RUNAS and compare them with the Sound Pressure Level dataset produced by the reference hydrophones at OBSEA.

[1] Reference number assigned to the proposal by the TA-Office.

[2] User-project identifier used in the proposal.

[3] Title of the approved proposal. The length cannot exceed 255 characters

[4] Name of the installation/infrastructure accessed with this project. If more than one installations/infrastructures are used by the same project, please list them in the box.

[5] Specify starting and end date of the project (including eventual preparatory phase before the access).

[6] Fill in with the full contact of the Principal Investigator (user group leader).

[7] Write the short-term, medium and long-term objectives of the project. Use no more than 250 words.

Objective 3: "FAIR cyber-infrastructure": Setup and test a data management cyber-infrastructure following the FAIR principles (findable, accessible, interoperable and re-usable). Standard protocols and interfaces will be used to encourage the scientific use of the acquired data (e.g. calibration of underwater noise models, underwater noise impact on local fauna). This objective will be achieved by using Open Geospatial Consortium's standards for data and metadata archival and access (Sensor Observation Service, Sensor Modelling Language, Observations & Measurements) and combine them with tools that have a broad acceptance within the ocean observing community (e.g. ERDDAP).

3. Main achievements and difficulties encountered (250 words max.)[8]

The main outcome of this project was that for the first time, a system using off-the-shelf products and a commercially available hydrophone (namely icListen Kayak) were integrated and using the SWE Bridge interoperability framework. Furthermore, data acquired by the system has been successfully integrated in real-time in state-of-the art data services such as ERDDAP. Data has been processed according to the MSFD directive and is shared following the FAIR principles.

The system worked flawlessly during the whole deployment period: from 13th December 2021 until 3rd February 2022. The only difficulty was experimented during a communications outage at OBSEA, where the RUNAS system continued acquiring internally until the hard drive was full. This extreme and uncommon situation lead to some data loss. However, this situation can be easily solved in future deployments by placing a larger SD card on the junction box.

In the data analysis, data from both datasets (RUNAS dataset and a reference hydrophone at OBSEA) the 1/3 octave bands centered at 63 Hz and 125 Hz have a good correlation (98.18% and 96.69% respectively). However, the correlation at the 2000Hz 1/3 octave band is significantly lower: 78.96%. It is believed that the progressively decrease on the correlation is related to the higher self-noise of the OBSEA hydrophone, which leads to an artificial increment of the measured background noise as the 1/3 center frequency is incremented .

4. Dissemination of the results[9]

[8] Describe briefly the main achievements obtained and possible impacts, as well as possible difficulties encountered during the execution of the project. Use no more than 250 words.

[9] Describe any plan you have to disseminate and publish the results resulting from work carried out under the Transnational Access activity in JERICO -S3: scientific articles, books - or part of them -, patents, as well as reports and communication to scientific conferences, meetings and workshops. Highlight peer-reviewed publications. Note that any publications resulting from work carried out under the JERICO -S3 TA activity must acknowledge the support of the European Commission – H2020 Framework Programme, JERICO -S3 under grant agreement No. 871153.

Acoustic and processed Sound Pressure Levels (SPL) data from the experiment can be publicly access using the below links:

SPL: https://erddap.obsea.emso.eu/erddap/tabledap/OBSEA_kayak_hydrophone_spl_levels.html

WAVS: https://erddap.obsea.emso.eu/erddap/tabledap/OBSEA_kayak_hydrophone_wavs.html

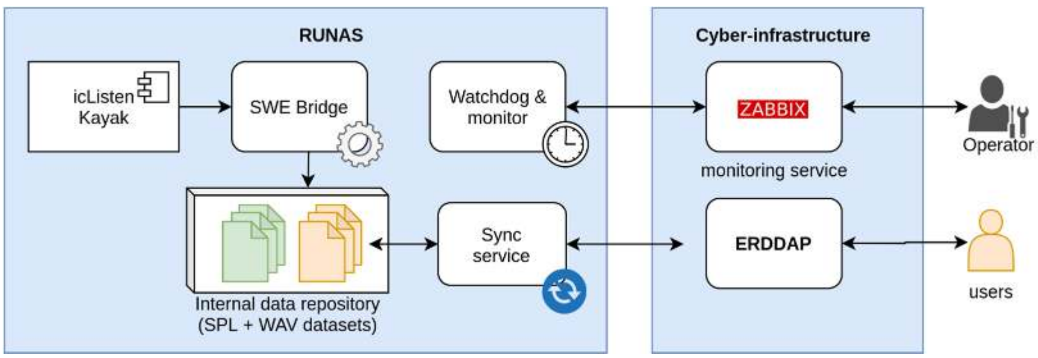
It is planned to disseminate the results of the deployment and the data analysis in an upcoming conference paper.

5. Technical and Scientific preliminary Outcomes (2 pages max.)[10]

[10] Describe in detail results and main findings of your experiment at the present stage.

RUNAS System Development: The first step to achieve the above, was to decode the proprietary streaming protocol of the Kayak hydrophone. Then, a machine-actionable description of the hydrophone was created using the SensorML metadata standard (part of the OGC's Sensor Web Enablement framework). The open-source software SWE Bridge takes this information and interfaces the icListen accordingly, processing the acoustic data in real-time, generating a SPL dataset and acoustic recordings.

Using this framework SPL data were reporting an MSFD compliant stream of data straight into ERDDAP, making it accessible to everyone in real-time. Additionally, a monitoring system (Zabbix) was setup to monitor the system, providing technical feedback to the operators to ensure the correct operation of the system. The overview of the RUNAS system and its associated cyber-infrastructure is shown in the following diagram:



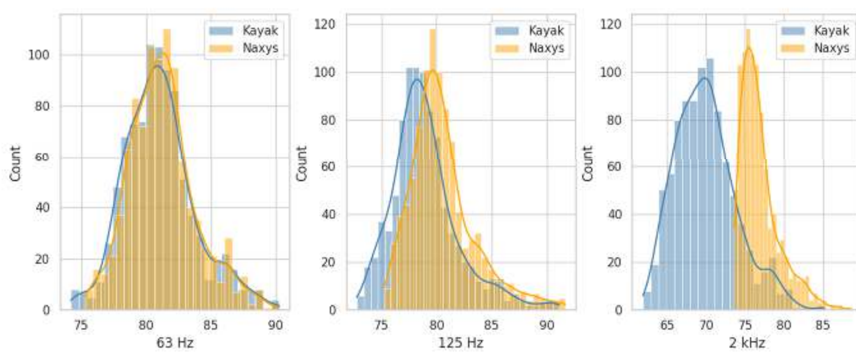
Deployment & recovery: The system was deployed on December 14th 2021 and recovered on 3rd Februrary 2022. In the following picture shows the RUNAS System deployed at OBSEA, including the Kayak hydrophone (center top) and the junction box (bottom left).

The Kayak hydrophone was situated approximately at 1.5 meters from the NAXYS hydrophone. The latter is the hydrophone permanently deployed at OBSEA, which will be used to validate the results from the RUNAS system.

The system proved reliable throughout the whole deployment, acquiring data continuously. The only data gap was during a communications outage at OBSEA, where data was logged internally until the RUNAS hard drive was full. For future deployments an increase of the internal space is recommended to extend the acquisition time during communications outages (although these events are quite uncommon).

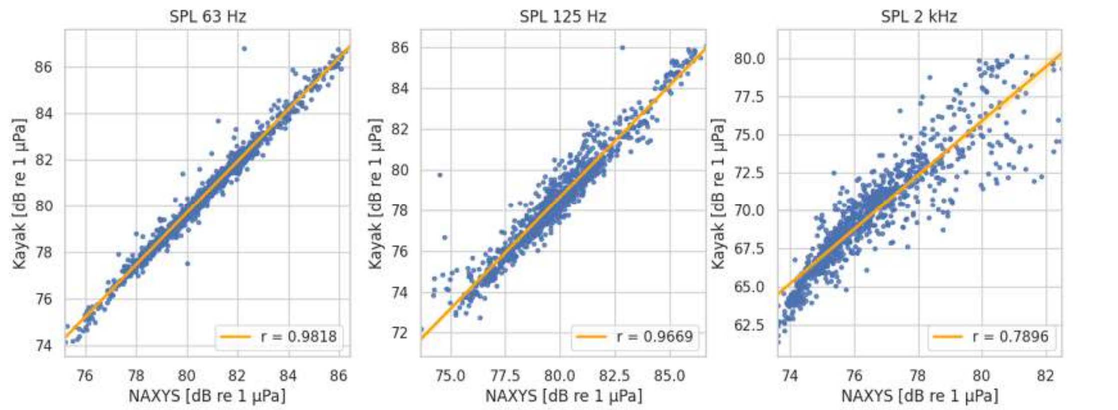
Data analysis: It has been detected that the self-noise of NAXYS hydrophone is significantly higher than the icListen kayak, leading to an artificial increase of the perceived background noise. The noise floor from the kayak dataset and the Naxys dataset increases as the 1/3 octave band center frequency. However, this effect is less apparent in the icListen kayak, due to its better self-noise characteristics.

The following plot shows the histogram and kernel density estimation (KDE) of the SPL measurements from both hydrophones at 1/3 octave bands centered at 63, 125 and 2000 Hz. It is possible to appreciate how the distance between the peaks of the different hydrophone distributions becomes greater as the frequency band center frequency increases. This phenomenon is believed to be associated with the increase of the bandwidth of the 1/3 octave band, thus introducing more self-noise power to the SPL calculation.



A part from the visual coherence between the histograms a correlation analysis has been performed using both datasets. However, in both datasets there are some outliers that do not have temporal coherence between datasets. Although it is difficult to assign a clear cause for these outliers, a hypothesis is the influence of biodiversity, such as fish and algae in the transducer proximity, producing air bubbles and impacts. These phenomena can produce locally significant changes in pressure, but they are rapidly attenuated as the distance increases. So, due to the distance between transducers these outliers are not captured in both datasets.

To minimize the influence of these outliers, the top 5% values from the distribution have been ignored in the correlation analysis (i.e. the values that conform the L95 percentile). Then, the correlation of SPL levels of both datasets can be observed in the following figure:



At the 63 and 125 Hz centered 1/3 octave bands the correlation is quite good (98.18 and 96.69% respectively). However, at 2kHz the correlation drops significantly until 78.96%, probably due to the different self-noise characteristics of both hydrophones.

Cyprus – 09/02/2022

_________________________________ __________________________________

_

Location and date Signature of principal investigator