ID44- THE LSTS OPEN-SOURCE COMMUNICATION AND AUTONOMY SOFTWARE: ENABLING NETWORKED VEHICLE SYSTEMS TO FIND, TRACK, AND SAMPLE DYNAMIC FEATURES OF THE OCEAN

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This paper discusses how the LSTS open-source communication and autonomy software (http://www.lsts.pt/toolchain) will enable networked vehicle systems to find, track, and sample dynamic features of the ocean. The software toolchain includes the following components:

· Ripples – Web application including a communications hub and tools for remote visualization, tasking, and supervision enabling remote collaborative planning and execution control, as well as outreach and education activities.

· Neptus – Distributed off-board command and control framework supporting planning, execution control, and post-mission analysis for networked vehicle systems.

· IMC – Protocol for networked vehicle systems operating in communications challenged environments. There is a discovery mechanism using different broadcasting mechanisms to identify end-points exposed in the network (over UDP, TCP, HTTP, acoustic modem, Iridium, etc.) The links among devices are dynamically created during execution.

· Dune – Onboard software framework providing logging, communications, navigation, and control functions for all supported vehicles, with a small memory and computational footprint to run virtually on any POSIX-compliant system.

· TREX – Onboard deliberative planning software enabling autonomous decision-making without human intervention integrated with the LSTS-UP tool chain.

· EUROPTus – Shipboard mixed-initiative planning and execution controller for multi-vehicle oceanographic field experiments and Neptus front-end.

These components endow a dynamic set of physical assets with system level properties targeted at adaptive volume observation and sampling of interacting ocean processes. The approach builds on experience in large ocean experiments with multi-vehicle systems and on advances in: 1) standardized vehicle onboard software, including autonomy software; 2) delay and disruptive tolerant networking communications; 3) adaptive sampling of ocean features; 4) mixed initiative planning and execution control; 5) inter-operability protocols for heterogeneous vehicles; and, 8) visualization software for integrated situational awareness and planning and control.

The LSTS vehicles and software toolchain will, for the first time, allow effective inter-disciplinary study of fronts and other oceanographic features of high mobility at fine spatial and temporal scales. Field trials are being performed with the LSTS unmanned vehicle systems (http://www.lsts.pt/vehicles/): AUVs in several configurations equipped with several types of sensors (CTD, fluorometer, holographic camera, turbidity, O2, cameras, and micro-turbulence), WiFi and satellite communications, acoustic modems, and battery packs enabling up to 36h endurance; fixed-wing UAVs capable of up to 1h of flight time equipped with several types of video cameras (including IR), WiFi, and capable of bent Line of Sight (LOS) communications; and, multi-copters/vertical takeoff and landing (VTOL) equipped with WiFi communications and cameras, and capable of bent LOS, of deploying drifters, and of collecting water samples.

ID45- GALWAY BAY SHALLOW-WATER OBSERVATORY: INSTALLATION, COMMISSIONING AND RESEARCH OPPORTUNITIES

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Abstract – The Galway Bay shallow-water observatory was installed in August 2015 and officially launched in July 2016. The observatory is located within the Galway Bay Marine and Renewable Energy Test Site at a depth of around 23m. The infrastructure has a core suite of scientific sensors monitoring a variety of marine parameters as well as providing dedicated scientific ports (sockets) for marine research projects.

Keywords – 'Marine' 'Research' 'Science' 'R&D' 'Technology' 'Subsea' 'Observatory' 'Galway' 'Ireland' 'EMSO'

I. CONTEXT AND OVERVIEW

The Galway Bay shallow-water observatory is part of a collaborative project between the Sustainable Energy Authority of Ireland (SEAI), the Marine Institute (MI), University College Cork (Marine Renewable Energy Ireland - MaREI), SmartBay Ireland and Dublin City University (DCU) to upgrade existing facilities at the Galway Bay marine and renewable test site. The overall project was funded by Science Foundation Ireland (SFI)*.

The Marine Institute had 4 main objectives to ensure a successful installation and completion of an operational marine observatory; 1) To procure and install main system components, 2) To apply for all relevant permissions (foreshore, planning, road-opening licence), 3) To procure and commission all onshore infrastructure (ductwork and shore station) and 4) to ensure integration of the entire system.

The culmination of the above steps led to the deployment of the Cable End Equipment (CEE) in August 2015 (fig. 2). The CEE is constructed of titanium housing (fig. 1) and is 1.78m in length and has a diameter of 0.48m. It contains 17 science ports, 4 fibre ports and 1 video port (a full list of CEE port functions can be viewed in Table 1).

The installation of the observatory also required terrestrial works (mainly civil) and included the cable landing site at a local pier, terrestrial duct work taking the cable ~1k underground to a specialised and fully equipped shore station. The shore station is located at a local second-level school and represents a successful partnership between the MI and the school. The dedicated shore facility was completely renovated and fitted out with a climate controlled server room. The shallow-water observatory has a core suite of environmental monitoring sensors for provision of long-term marine data at the site. The sensor and instrumentation payload includes a CTD (salinity and temperature), ADCP (water current velocities throughout the water column), Hydrophone (underwater noise monitoring), Flurometer (measuring the intensity of fluorescence, used chiefly in biochemical analysis), HDTV (HD video footage), Lights, Turbidity sensor, Nutrient Monitoring sensor, Dissolved O2 & CO2 sensor, pH sensor as well as dedicated ports for scientific research projects (see table 1).

In 2016 the Marine Institute launched a SmartBay National Infrastructure Access Programme (NIAP)6. The goal of NIAP is to continue the expansion of the observatory user base to encompass research teams, Small & Medium Enterprises (SME's) and Multinational Companies (MNC's), nationally and internationally, and demonstrate significant socio-economic impact through the growth of an associated industry base that commercialises research outputs, or uses the technologies to enhance productivity. This fund provides awards up to a maximum of €25K per application to research teams through a national competitive process, which is open to all higher education institutions on the island of Ireland.

II. FIGURES AND TABLES

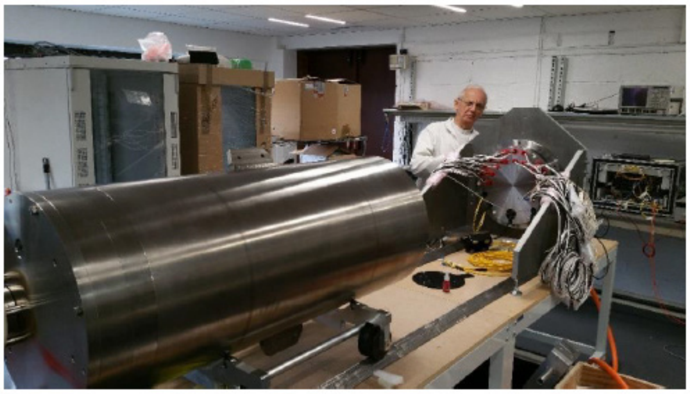

Fig 1. Above: Construction of the Cable End Equipment (CEE).

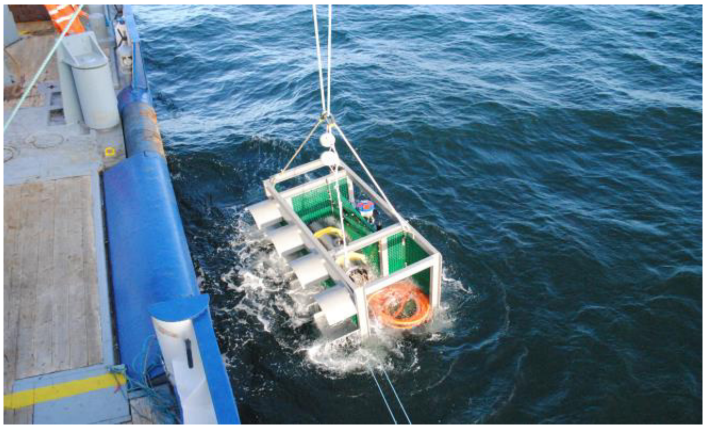

Fig 2. Above: Deployment of the CEE, installed horizontally in the centre of the observatory frame on which the sensors and instrumentation are also housed (note attached ADCP on centre right of frame)

CEE Port #	Communications	Function
EX1	CWDM	Sea Station
EX2	CWDM	Acoustic Array
EX3	CWDM	Science Port
EX4	CWDM	Science Port
S1	Ethernet	Hydrophone
S2	Ethernet	Science Port
S3	Ethernet	Science Port
S4	Ethernet	Science Port
S5	Ethernet	Science Port
S6	Serial	CTD/$D0_2$
S7	Serial	Turb/Fluor
S8	Serial	Science Port
S9	Serial	Science Port
S10	Serial	Vemco
S11	Serial	Science Port
S12	Serial	ADCP
S13	Serial	Science Port
S14	Serial	Lights
S15	Serial	Lights
S16	Serial	Science Port
S17	Serial	Science Port
V1	Coaxial+ Serial	HDTV
SR	-	Ground Reference
U	-	Uplink

Table 1. Above: List of observatory ports, communication type and their function

III. CONCLUSIONS

In 2012 Harnessing Our Ocean Wealth (HOOW)5 set out the Irish Government's Vision, high-level goals, and key 'Enabling' actions to put in place the appropriate policy, governance and business climate to enable Ireland's marine potential to be realised. HOOW states that creating an infrastructure to support the blue economy is critical to the success of Ireland's integrated marine plan; Galway Bay's shallow-water observatory is a prime example of how this can be achieved. The observatory infrastructure has placed Ireland in a position where it can be one of the founding member countries of the EMSO-ERIC (European Multidisciplinary Seafloor and Water Column Observatory – European Research Infrastructure Consortium)3. This will be the legal entity charged with the coordination of open ocean fixed-point observatory infrastructures in Europe1.

The MI has also been successful in a number of European proposals associated with the shallow-water observatory, including EMSODEV2, which is in the process of designing a state-of-the-art, standardized multidisciplinary EMSO Generic Instrument Module (EGIM), a harmonized observation system which will align and standardise data from all European observatories. H2020 observatory involvement also extends to JERICOnext4 whose objectives include; supporting European coastal research communities, enabling free and open access to data, enhance the readiness of new observing platform networks by increasing the performance of sensors, and to showcase the adequacy of developed observing technologies.

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