Sensing and Surveillance Challenge

Sensing the Coastal Undersea Environment

1. Challenge topic

Sensing the Coastal Undersea Environment will address sensing and information management in subsurface coastal zones. Of primary interest are technology capabilities that **significantly extend the spatial scales, persistence, and feature diversity of undersea-environment monitoring**.

2. Background

Coastal environments are special resources, defining both the territorial extent and economic exclusion zones of the countries to which they correspond. They are home to fishing and aquaculture, offshore energy production, commerce, recreation, and transport, for example. In times of conflict, they are resource zones that include national borders and critical infrastructure whose protection is essential for the safety and security of its populace. Climate change has made them particularly vulnerable, threatening not only the marine environment, but the lives of the substantial fraction of the global population who lives in coastal regions.

Despite their importance, our understanding of these critical zones is limited, in part by the physical limitations of signal propagation in water, and in part because of the complexity of operating in the subsurface domain. For example, sensing and communications methods using RF and optical frequencies (typical in air) are attenuated, refracted, and scattered in water, so that ranges and data rates are severely limited. Thus, acoustic signals are used underwater, but improvements in range are at the expense of resolution and data bandwidth. Operationally, working in the marine environment has its own difficulties such as fouling and corrosion, energy and propulsion limitations, and logistical support of deployed equipment. **This Challenge call aims to promote advances in undersea sensing and communications**, with a goal of enabling new capabilities or system constructs that will address civilian economic, societal, and defence needs.

3. Technology Challenges

DIANA is seeking disruptive capabilities in the following two general areas:

3.1 *Sensing technologies that contribute to persistent monitoring of harbour-scale zones:*

By persistent, we refer to continuous (or high-revisit rate) sensing that would allow us to characterize the baseline conditions, observe and track natural and manmade changes and activities, detect anomalous behaviours, and generally provide a level of surveillance not typically found in the subsurface environment. We choose coastal waters at harbour scales (strictly as a guideline, consider areas up to of order 50 km sq.; up to 30 metre depths) so that the technology capabilities being developed will apply to ports, natural harbours, offshore fisheries, and other localized coastal regions of vital economic and security interest. Applications for such capabilities include but are not limited to incursion detection, subsurface infrastructure inspection, marine ecosystem monitoring, and effects of extreme weather events.

DIANA seeks advanced sensing technologies (acoustic, optical, gravimetric, magnetic, or other) to address any of the following applications:

- bottom mapping, with a goal of improving seabed characterization, object detection, waypoint navigation or any combination thereof;
- undersea structure characterization and/or inspection, with a focus on timely identification of threats to critical undersea infrastructure integrity;
- detection and characterization of mobile objects, both manmade and natural;
- indicators of ocean health, such as temperature/salinity/chemical sensing to support enhanced understanding of climate and anthropogenic effects.

Ideal submissions will address not only the specific sensing modality being proposed, but a system architecture and concept of operations for its optimal use. This challenge is not seeking to develop platforms for undersea operations, however, if the proposed sensing technology requires or is enabled by a specific platform (fixed or mobile), please indicate this. Note that inherent in the desire for persistent monitoring is the assumption of a high degree of autonomous operation.

3.2 Data collection / information products associated with marine environment characterization: Any persistent or frequent monitoring system will accrue large volumes of data that must be either collected and processed *in situ* or communicated via cables, buoys, or through the sea-air interface for subsequent processing. This aspect of the Challenge seeks novel methods, tools, or technologies for facilitating the exploitation of undersea sensing data to allow for close-to-continuous realization of sensor-data analytic products. Capabilities of interest could include, for example, data transport vessels and information-transfer docking stations, fibre or cable-based networks, undersea optical communication systems, or other high-data-rate transfer schemes. Similarly, submitters could propose novel methods for *in situ* data processing and onboard or in-sensor analytics, with opportunistic low-data-rate transmission and data prioritization schemes.

Finally, advances are also sought that enable a holistic "picture" of the undersea coastal environment. This could be achieved through, for example, the creation of high-quality underwater situational awareness from sparse data sets or from fusion of disparate sensing data (including from surface or air), with a goal of creating "patterns of life" visualizations of the coastal subsurface domain. Methods for immersive visualizations and scene filtering, such as via mixed-reality platforms, are also of interest, with a goal of displaying and engaging within the undersea domain with the same ease as is typical for surface observations.

Submitters may offer a single sensing scheme or data-processing capability, or any combination of capabilities described in sections 3.1 and 3.2.

4. Deliverables (6 months for phase one, with potential for an additional second phase of 6 months)
The challenge programme will be split across two phases of six months, with advancement to the second phase being a result of tangible and demonstrable progress in the first. Deliverables should show considerable progress and clear development potential at the end of phase one, with phase two outputs providing sufficient demonstration of capability to attract further progressive scale-up and development investment from entities other than DIANA.
Strong candidate proposals and their corresponding solutions will:

- Clearly address the problem(s) to be solved;
- Demonstrate new capabilities (or performance increases) that are disruptive;
- Make clear what technology developments are needed to deliver the innovation;
- Offer reliable, easy to maintain, robust, and (ideally) cost-effective solutions;
- Cite specific civilian or commercial applications and defence benefits, where known;
- Make effective use of the funding available to progress the technology proposed.

End-state capabilities could include improvements in sensor sensitivity, prolonged operation in the undersea environment, ruggedization or miniaturization of sensing components, data-transfer demonstrations commensurate with the problem scenario, or advanced visualizations using real or realistic-synthetic data. These are offered strictly as examples; it is assumed that each proposer will offer a unique capability to be demonstrated. By the end of the programme, the capability must contribute – plausibly and significantly – to the advancement of a solution and should be characterised by genuine innovation in the market. Existing commercial, off-the-shelf technologies will not be considered unless a novel modification is proposed.