**Passive and Active: Remote Survey Solutions for the Nearshore; an Integrated Approach**

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ABSTRACT

Emphasis on nearshore, shallow water surveys and the immediate coastal hinterland has increased over the past few years. This has been generated by concerns over various issues, including: sea level rise due to climate change and directly-attributable man-made issues such as land subsidence through extraction of valuable mineral and water resources; growth of, and reliance on, a seaborne Blue Economy delivering goods as efficiently as possible; concerns over erosion or damage to nearshore ecosystems necessitating additional focus on habitat mapping and environmental surveys in general; and an increasing percentage of the world's human population residing in close proximity to the coast which places extra emphasis on baselining and monitoring of this specific margin. At the same time, economic pressures on a great many of the world's advanced and developing nations alike bring the need for cost-effective methods of garnering geospatial data in the nearshore into sharp focus. Clearly, mapping of the land-sea interface requires the adoption of a broader approach to hydrographic surveying techniques and technologies to augment that already well surveyed with traditional methodology.

**Bio:**

Don Ventura is a Charge IHO Category A Surveyor with Fugro and has been engaged in hydrography for almost 30 years. His experience includes 22 years service as a hydrographic survey officer in the British Royal Navy, 3 years exchange with the US Navy at NAVOCEANO, 3 years employed with SAIC and 8 years with Fugro Pelagos Incorporated. Currently employed in the International Business Development and Marketing role, Don enjoys the opportunity to engage with the world's leading hydrographic institutions, agencies and industry peers.

## INTRODUCTION: THE LAND-SEA INTERFACE

Emphasis on nearshore surveys and the coastal hinterland has increased over the past few years. This interest has been generated by concerns over various issues, including:

- sea level rise due to climate change
- directly-attributable man-made issues such as land subsidence through extraction of valuable mineral and water resources;
- growth of, and reliance on, a seaborne Blue Economy delivering goods as efficiently as possible;
- concerns over erosion or damage to nearshore ecosystems necessitating additional focus on habitat mapping and environmental surveys in general
- an increasing percentage of the world's human population residing in close proximity to the coast which places extra emphasis monitoring of this margin

Critical to the efficiency and safety with which the bulk of the world's Blue Economy actually arrives at the global marketplace; which of course is overwhelmingly terrestrial, is the creation and maintenance of a reliable set of data which supports this sea-to-land transition; in other words the coastal environment. This is but one, albeit major, facet of global economic and geo-political drivers which are increasingly reliant on nearshore data for major aspects of their success, efficiency, smart management and end-client wellbeing; there are many other such stakeholders in the nearshore realm. As surveyors and cartographers are all too well aware of however, this interface happens to be the most navigationally hazardous, technically challenging and cost-inefficient realm in which either terrestrial or hydrographic surveyors can acquire their data. It is therefore of paramount importance that a sound understanding of the ways and means to combat these challenges and still acquire data fit-for-purpose and to international standards is attained.

One of the main challenges facing progress towards a more inclusive and holistic approach to geospatial data capture and product design lies in the legacy approach to survey specification itself. The realm of the nautical cartographer and terrestrial mapper have for many generations been dealt with completely separately; encouraging the design of a survey polygon which fulfils the needs of not only these two realms but is inclusive enough to be of interest to other potential stakeholders is something that even the more progressive agencies still have to work hard to envisage. Traditional hydrographic survey polygons have always their inshore limits set where the cartographer perceives that the hydrographic surveyor can neither meet safe nor efficient operational progress; often a charted contour suffices as a guide to the survey limit. This is not necessarily what the cartographer wants; the challenge is to encourage the design of a survey polygon that is based on need, not assumed technological capability. The rapid advances in a variety of technologies renders this old approach obsolete and offers the cartographer an opportunity to fully capture all necessary data for update or renewal purposes of the final product or data layers. In such a way the land-sea interface is no longer the obstruction it once was to seamless data and this critical boundary is much better charted for all users.

## STAKEHOLDERS

A recent and very effective IHO presentation, on a single slide of waterspace managers and interested parties, demonstrated how the management of a typical nearshore environment could very quickly become an extremely complicated matrix of overlapping areas of interest, prioritization and management considerations.

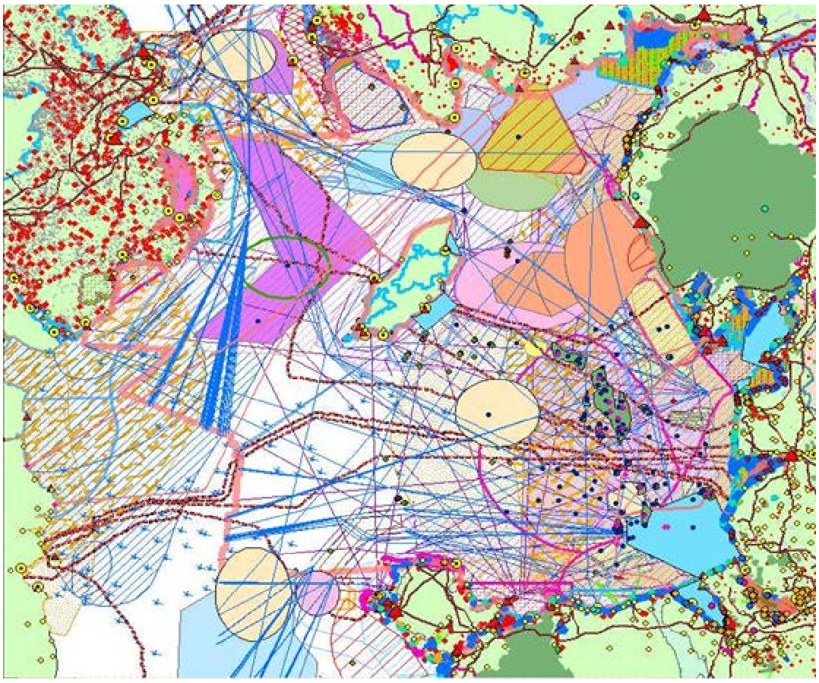

**Figure 1: Irish Sea waterspace management  issues with only 15 stakeholders represented (Source: DEFRA)**

Conversely, it also highlights the typical grouping of potential stakeholders interested in the collection of nearshore data over and above the traditional main recipients (the national charting and mapping agencies).  Inclusion of one or more of these parties in the deliberation stages of a nearshore/coastal hydrographic surveys can induce additional funding resource for a project, making the feasibility more affordable for the national government as a whole and amortising costs between the stakeholders.  Such stakeholders might include but are not exclusive to the following:

- Cadastral (land usage and ownership) surveyors
- Nearshore oil and gas industry
- Tourism
- Aquaculture
- Cultural agencies
- Conservation and natural resource groups
- Renewable energy industry
- National security and defence agencies
- Cable route surveys for O&G, telecommunications and power
- Fishing agencies
- Recreation industry
- Nearshore mineral extraction activities (e.g. beach renourishment; sediment mining)
- Coastal engineering (construction etc.)

## INTEGRATED GEOSPATIAL DATA ACQUISITION

Modern survey companies have excellent tools at their disposal to ensure that various types of geospatial data can be collected by different technologies and to varying degrees of accuracy and data density on a single common spatial reference frame.  Providing the translation parameters are known to refer the common dataset to a different datum or reference frame preferred by each stakeholder, a single product can satisfy the needs of all recipients. This has been delivered on more than one occasion to a growing number of hydrographic agencies whose requirement to fulfil the needs to the nautical chart and terrestrial map products can be met with the one survey dataset.

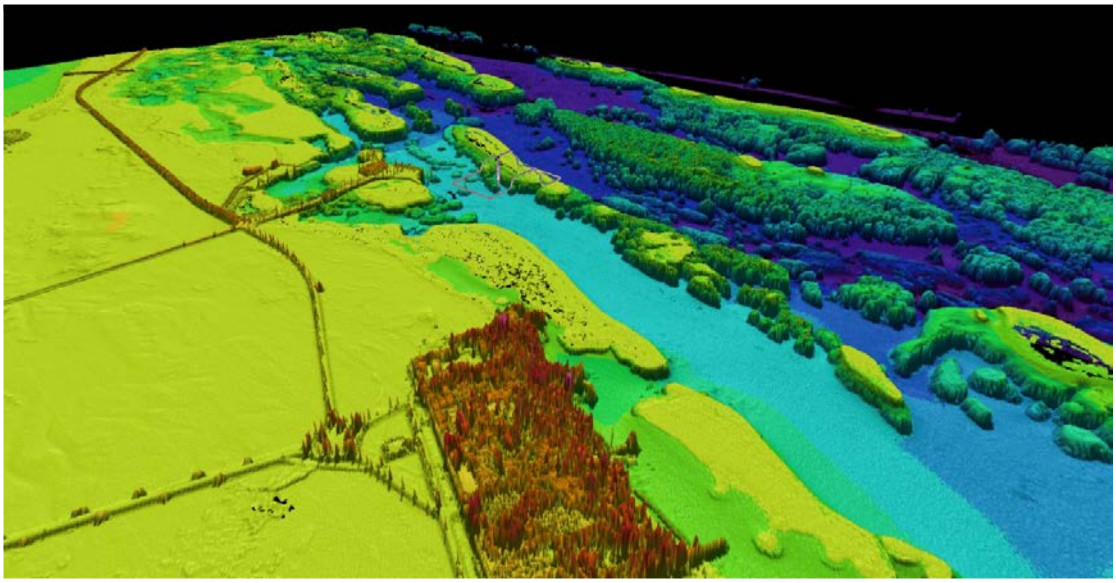

**Figure 2: Charting agencies are increasingly looking for datasets which seamlessly integrate the land-sea interface; this image includes coastal topography, complex nearshore reef structures and deeper navigable channels fused into one deliverable**

Data collected from non-surveying third parties (so-called 'crowd sourcing'), although usually collected using active sensors, needs to be very carefully assessed against other more rigorously appraised data. The veracity of data therefore depends not just on the mode of collection but very much who has collected it.

## TOOLS OF THE TRADE

Current technology allows the hydrographic survey industry to meet the demands of efficient data capture on the land-sea interface with a combination of technologies and techniques; these include sensors fitted to both airborne and waterborne platforms that cover a much broader band of the energy spectrum than previously employed. Data can be acquired from a number of sources; these can be broadly grouped into active and passive sensors. Active sensors provide a degree of control input and accuracy verification which is not available to passive sensor data acquisition, but are generally more expensive to run, process and deliver information from. Active sensors might include but are not limited to the following:

- Multi-beam and single-beam echosounders
- Sidescan (interferrometric) sonars
- Bathymetric and topographic LiDAR systems
- Horizontal laser linescanning systems (deployed from both boats and terrestrial vehicles)
- Magnetometers
- Gravity meters
- Shore-based Doppler radar
- Airborne Synthetic Aperture Radar

Passive sensors tend to be cheaper to operate and obtain data from, but the lack of additional sensory input (including a human element of assimilation, particularly in assessing the environmental conditions present when the data was acquired), means that a heightened risk of use is involved without alternative means of data validation. For this reason it is always preferable to augment any passive data with overlapping 'active' data for which accuracy and resolution have been very carefully monitored and deliberated. Passive sensors might include but are not limited to the following:

- Aerial cameras (visible spectrum)
- Hyperspectral imagers
- Multispectral imagers
- Satellite imagery and Derived Bathymetry

These are just some of the main active and passive sensors available with which to determine the nearshore and onshore environment. All of the above however are affected in different ways by metocean conditions in the nearshore environment: water clarity, seabed colour and rugosity, platform dynamics and operational parameter windows etc.

Associated with the costs involved in collecting and processing data that has to be relied upon heavily for its inherent fiducial properties, is the perennial question “Can we trust the cheapest option on data acquisition?” This is typically supplied, on a sliding scale, from large, remotely sensed area data acquisition such as satellite imagery, down to fiducial measurements made in the field with trained personnel using single point, high accurate and calibrated instrumentation. In the case of the emerging utility of Satellite derived bathymetry, the answer is ‘yes’, providing a number of pragmatic steps are taken, most notable the incorporation of the data type to an integrated data capture approach. SDB can provide very effective cost-effective and initial coverage of a suitable, clear-water nearshore area. We can then take these initial results and do at least three things:

1. Use the data to provide reconnaissance information for follow-on, more easily quantifiable survey techniques (put an otherwise poorly charted area in focus)
2. Conduct more discrete, higher-resolution surveys of the most critical areas for development or coastal defence/monitoring
3. Use the active sensor data to refine the original SDB results to create a better-defined, integrated product which can start to attain accuracies acceptable to a wider stakeholder group

We can also start to recognize the benefits of well-developed algorithms for satellite imagery to extract even more habitat info from the coastal zone. In such a way we can begin to design more cost-effective, regional survey programs by harnessing the traits of the most low-cost data acquisition and add increasingly reliable and attributable data as specific locations and infrastructure dictate. This approach steers away for the traditional, sensor- or technology-reliant survey planning paradigms towards an integrated or layered approach that meets the needs of more stakeholders and provides more coverage per unit cost yet still satisfies the critical, high-fidelity data collection only in areas that need it most.

## DATA LAYERS - PRESENT AND NEAR-FUTURE

Current data layers which typically need to be populated are based on the structure of paper, raster and electronic nautical charts (ENCs); most of these seek to comply with IHO standards for nautical charting and suggested structures as laid down in IHO Publications S-4, S-52, S-

57 and the new S-100 standards. These layers of information follow historic protocols for the prioritization and hierarchy of data essential to the mariner to assist in the safe conduct of navigation within the charted area. A similar methodology has always been employed to provide structure to the hydrographic tasking for surveyors to follow when collecting hydrographic data. Whilst this is not necessarily deficient in fulfilling the needs of the nautical cartographer in the design and build of the databases necessary to create a modern chart folio, it does not address the needs of a number of interested secondary stakeholders for whom data collection could be vital and, in increasingly tight fiscal circumstances, necessary for more holistic governmental budgetary propriety. Inclusion of a number of additional stakeholders during the planning and consulting phase of a coastal hydrographic survey will not only assist in the overall budgeting equation, it will most likely adjust the initial survey area and data collection parameters so that a more inclusive data collection mission is fulfilled for the benefit of all stakeholders.

Some examples of additional or heightened priority on a typical hydrographic survey can be simply illustrated by exploring the needs of a few topical stakeholders. These are not listed below in any particular order or level of importance and are not exclusive but serve to demonstrate how the typical outlines of a hydrographic survey can become more inclusive.

| Stakeholder | Interests | Prime Deliverables |
|---|---|---|
| Charting Agency | Nautical Charting | Bathymetry; Navigational Aids; Tidal Information; Seabed Composition |
| Aquaculture | Marine Habitat; Biomass | Seabed Composition; vegetative growth; water column information; water quality; tides, human impact in vicinity; bathymetry |
| Coastal Engineering | Ports and Coastal Infrastructure | High-resolution geospatial structural surveys; land-sea interface; tidal datums and levels; change detection modelling; bathymetry; immediate nearshore topography |
| Habitat Mapping | Coastal environmental protection | Land-sea interface; backscatter, hyperspectral and/or reflectance imagery above and below water; ground truth sampling for definitive soil/seabed classification |
| Cadastral/Land Utilization | Land usage; boundary information | Tidal datum and associated levels; legal boundary definition and baseline establishment; hyperspectral imagery defining land/seabed type and current usage/vegetative layers present; bare earth deliverables; land usage maps |
| Ports and Coastal Cities | Port and terrestrial Transport infrastructure | Bathymetry; coastal topography; cadastral and bare earth |

| | | |
|---|---|---|
| | | deliverables; high-resolution geospatial structural surveys |

It is the evolution of this conceptual approach to coastal survey planning which this paper seeks to foster and to make the reader take heed of the necessity of incorporating the requirements of the greater Blue Economy stakeholder community into the vital hydrographic survey planning necessary to support the 'to market' land-sea interface.

## CONCLUSION

Within the last three decades there has been a huge increase in our collective reliance on the sea as a means of transportation; as a source of energy of various types; as a source of food and nutrients; and as the carrier medium for the globally vital Blue Economy input to the world's overall trade volume. As seaborne trade, goods and services has increased, so has the importance of overcoming the historic shortfalls in effective geospatial data collection across the land-sea interface. Growth both in trade and the size of vessels now carrying this trade has been alarming, particularly in the last 10-15 years, which has placed increasing pressure on the existing infrastructure and logistic operations of even the largest port complexes. Other major stakeholder dependents on critical coastal geospatial information has increased markedly with global population growth but continuing trends towards reliance of the coastal margins of the world. These groups have entirely different data needs to that typically decimated into a graphic, nautical chart format. Hydrographic surveys need to be planned therefore to support this level of business, to overcome the traditional land-sea boundary issues and to meet the needs of a greater number of stakeholders. This can be achieved with appropriate use of today's technology and utilized more effectively by the cartographer with a greater awareness of potential stakeholder investment and adoption of a more holistic survey planning paradigm.

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