NSHC 31st Conference
Amsterdam, the Netherlands
25-27 June 2014

Evaluation report
Agenda Item C.3, ver2
submitted by NSHC RWG Chair (NL)

Evaluation report to the 31st conference of the North Sea Hydrographic Commission of the current state of optical and radar remote sensing techniques

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Assignment

NSHC Conclusion no. 97, made in Norway in 2012 during NSHC30, is: "*Given the current situation and expectations for the future development of airborne and satellite bathymetry a need for closer cooperation between organizations was identified. It was agreed that the Resurvey Working Group's scope could be an appropriate activity of the NSHC though further consideration and investigation would be required in order to identify the most suitable and appropriate way to proceed.*"

State of the art

Airborne derived bathymetry (LIDAR) and Satellite derived bathymetry (SDB) open new perspectives to hydrographic surveying, not only to improve the state of global hydrographic survey coverage and the diminishing levels of resources, but also in the frame of Blue Economic development in littoral areas. But when it comes for HOs to use those techniques to fulfil their obligations or to convince decision makers, it becomes essential to define their respective level of trust and state of maturity compared to traditional survey techniques.

LIDAR is a remote sensing technology based on distance measurement by illuminating a target with a laser and analysing the reflected light. It is usually operated in shallow waters areas and its accuracy mostly depends on water turbidity. Various sensor systems exist, each of them with their own sensitivity and characteristics. This technique plays an important role in coastal surveying by its cost-efficiency (1400€/km2 vs. 3000€/km2 with MBES) and time efficiency (few hours vs. few days) compared to traditional surveys in the same kind of waters. The gain is even more obvious when it comes to steep and rugged coastlines. Regarding survey accuracy, LIDAR systems can now reach IHO S-44 order 1-b on a regular basis. Moreover, the recent combination of topographic and bathymetric lasers allows such systems to reach order 1-a in optimal environmental conditions. Nowadays, major coastal mapping projects, such as the JECMaP project proposal, are drawn upon a wide use of this technology. Additionnally, this technology tends to be efficient at designing littoral monitoring strategies, like in France for some parts of its North Sea coast. Nevertheless, it remains necessary to address the use of LIDAR with care as some systems may appear less accurate than they should be, especially in turbid waters.

Over the past decade, there have been significant advances in the methods used to derive bathymetry from multispectral satellite imagery. Satellite Derived Bathymetry (SDB) has the potential to make substantial improvements to otherwise inadequate charts, and to provide useful hydrographic data for other purposes in areas where existing charting is based on little or no hydrographic surveying. For such areas, there is often little prospect of conventional surveys being conducted in the reasonable future.

Two SDB techniques can be identified:
1. Synthetic Aperture Radar (SAR) amplitude images[1];
2. optical observation with optical Earth Observation Sensors (EOS)[2].

Thanks to the introduction in the Eighties of EOS and the properties of clear waters, light penetration could be further modelled against in-situ measurements to yield morphological information of the seabed. The latest improvement consists of feeding environmental parameters into the systems, which reduces the need of in-situ observations. Various water column parameters can be obtained from EOS if the reflection of light from the seafloor is detected by the sensor. For instance, EOS can reveal biological parameters, like the extent of seagrasses; macro-algae and associated substrates; main species differentiation; density of seafloor cover; biomass; the nature of coral reefs; and can discriminate between living and dead coral. Moreover, EOS can reveal physical parameters, such as total suspended matter, and chemical parameters, such as the presence of various organisms (photosynthesizing organisms, and cyanobacteria) that allow to assess water quality.

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[1] See e.g. http://www.sarusersmanual.com/ManualPDF/NOAASARManual_CH12_pg277-304.pdf
[2] See e.g. Stumpf, Holderied, Sinclair: *Determination of water depth with high-resolution satellite imagery over variable bottom types*, (2003), Limnol. Oceanogr., 48(1 part 2), pp. 547 - 556.

In this context, EOS can serve as a comprehensive maritime environmental sensor package, rather than a single-focus hydrographic tool.

The assessment of uncertainties to SDB bathymetry data is difficult and highly variable, which makes the technique difficult to use for nautical chart production according to the IHO S-44 standard. And cloud cover could result in the need of many repeates satellite tracks before a full picture can be built up.

Application
Current shipborne hydrographic data gathering operations rely on labour-intensive relatively slow on-site operations. LIDAR is able to cover large areas more quickly, whilst being able to gather topographic, bathymetric and intertidal data simultaneously but is limited by depth and water clarity. LIDAR usually requires complex logistic support and organisational requirements to be in place, just like shipborne surveys.

SDB has the ability to quckly get a first impression of a larger area, e.g. for rapid environmental assesments in a military or disaster management setting. Another potential application could be to use SDB as a planning tool for shipborne bathymetric surveys, in relatively clear waters. And a comparison of two images could lead to an impression of the dynamics of an area, and subsequently a decision on a resurvey.

Especially EOS-based SDB can potentially deliver a wide variety of maritime spatial and topographic data, sometimes in a very short timeframe, and in certain circumstances without the need for any in situ support. More importantly, it easily provides the bathymetric 'alerts' in shallow waters.

Conclusion
LIDAR and SDB could be useful for shallow parts of the North Sea that have clear water. LIDAR is in a more mature state and is available for operational use in such areas. However, it is recommended to follow SDB innovations, as it is still under development: a vertical precision of 10 to 20% of the water depth between 5 and 20 metres should be achievable and could probably be improved with upgraded SDB models in the near future.

Requested actions from NSHC31
The WG requests the 31st conference of the NSHC to:
1. note this evaluation report, and comment on the report as appropriate;
2. support the conclusion;
3. use the information on a national level (resurvey decisions) and a European level (project design).

Annex 1: SDB References & Bibliography

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