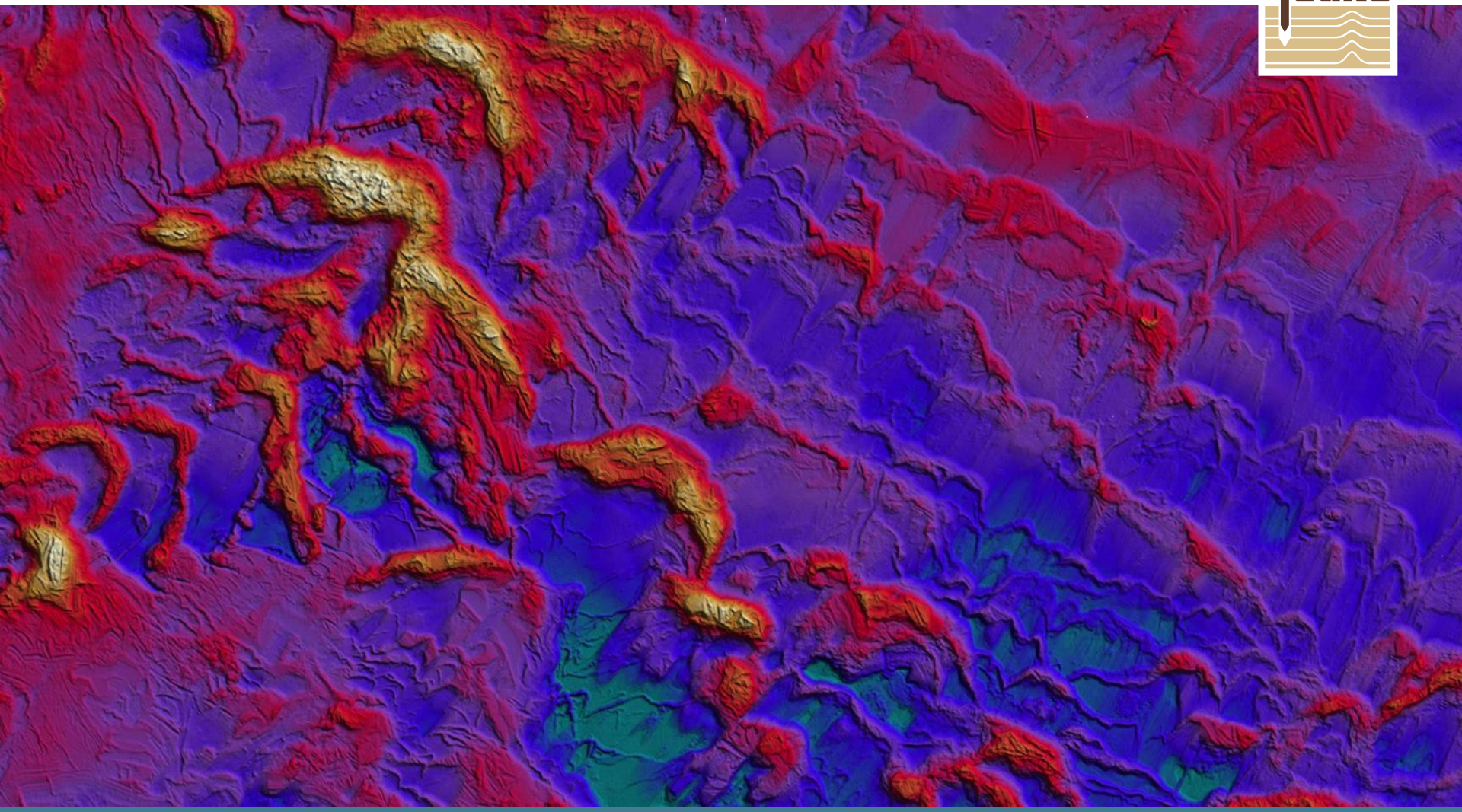


Integrated mapping solution

SDB Day - Satellite Derived Bathymetry Technology and User Forum

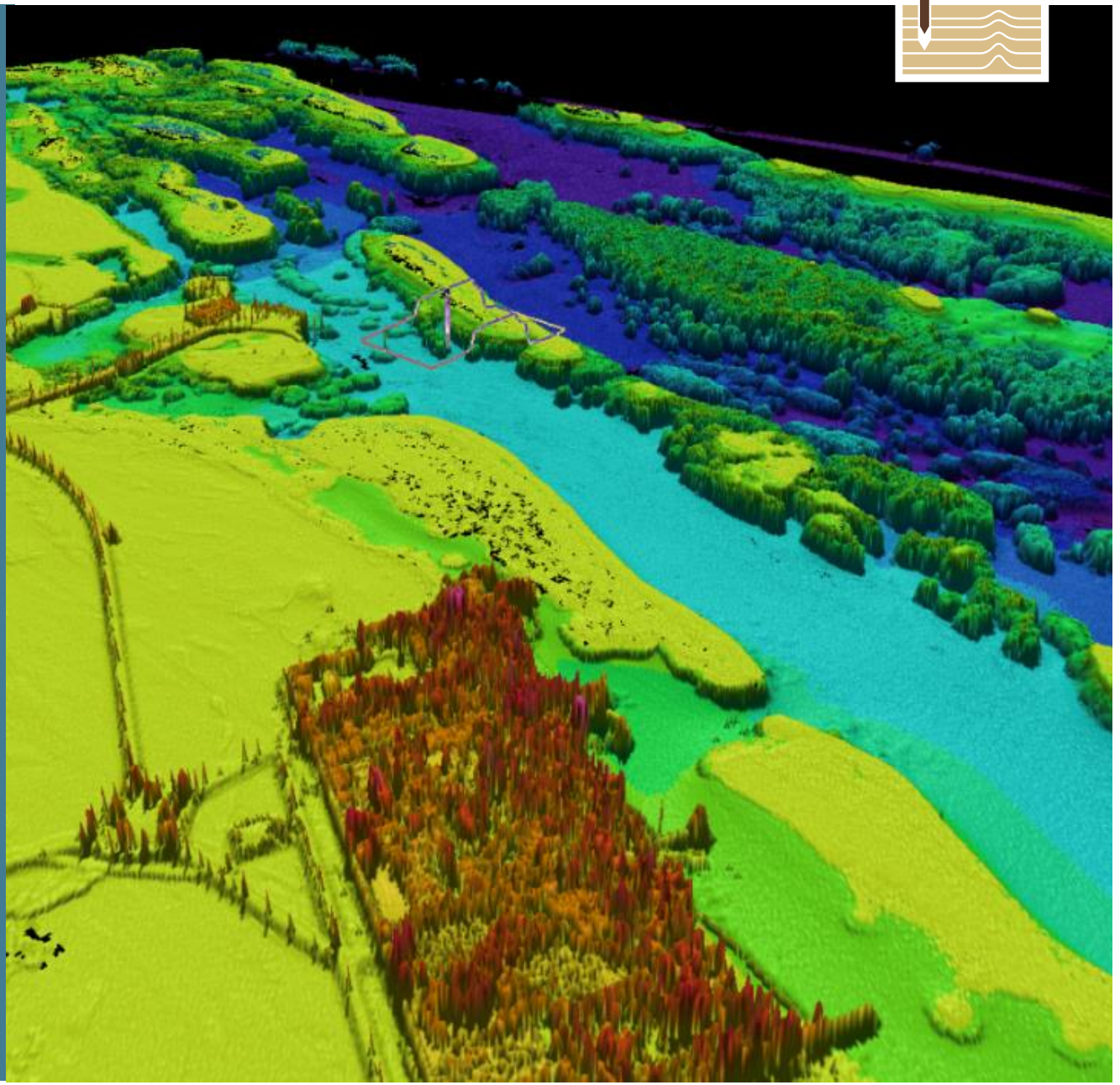
Dr Marco Filippone

Agenda:

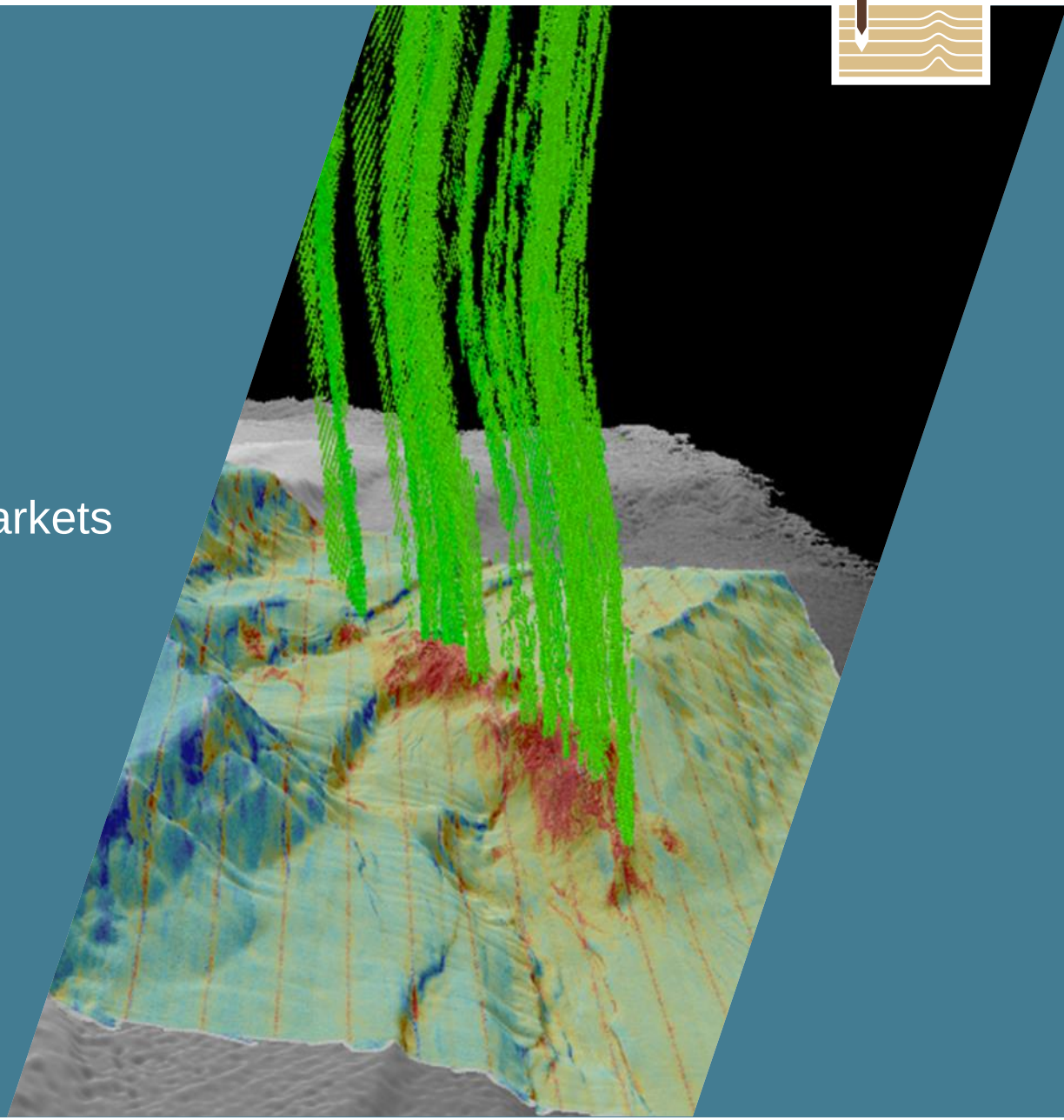
- Introduction (User´s needs)
- Today´s technologies (active - passive sensors)
- Integrated solution
- Conclusion

EXTRA

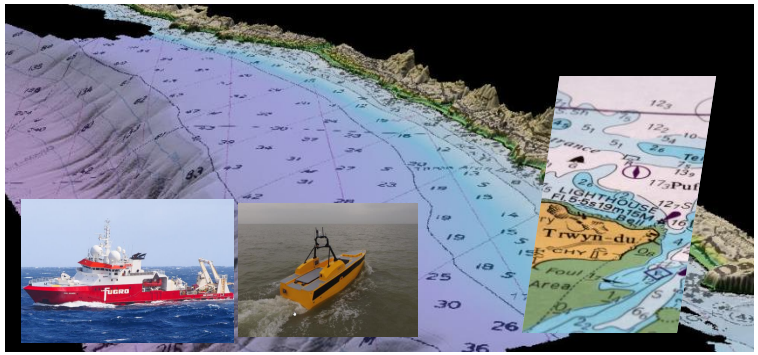
Future of Hydrography



Fugro Capabilities – Our Markets



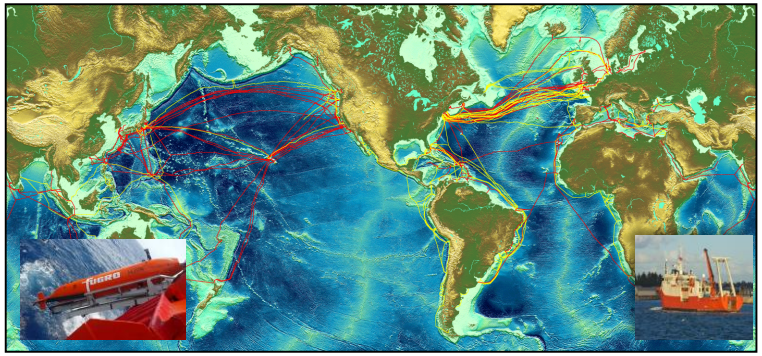
Fugro Capabilities - Our Markets



Hydrographic Surveying (Charting)

Engineering & Construction Support

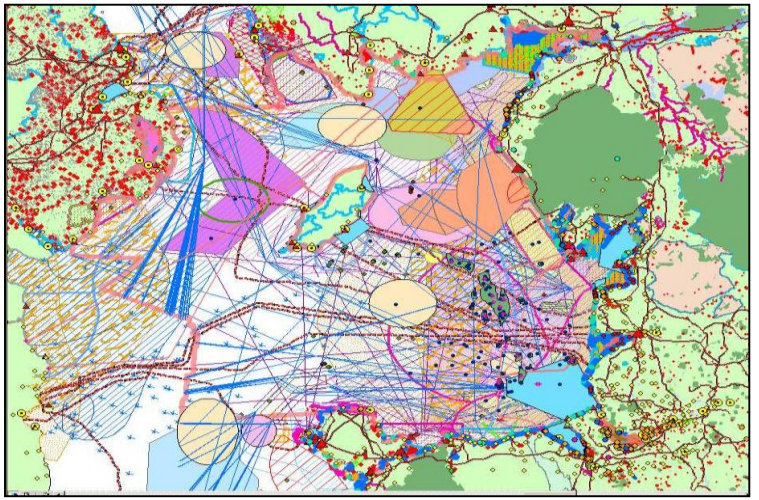
Coastal Zone Management



Marine Route Surveys

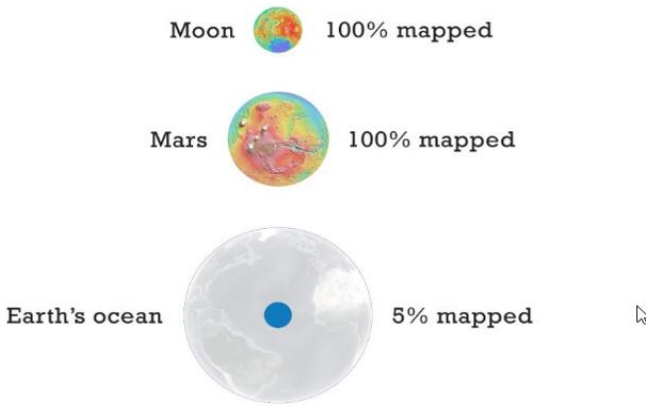
Introduction

- Emphasis on nearshore surveys and the coastal hinterland has increased over the past few years.
- 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.



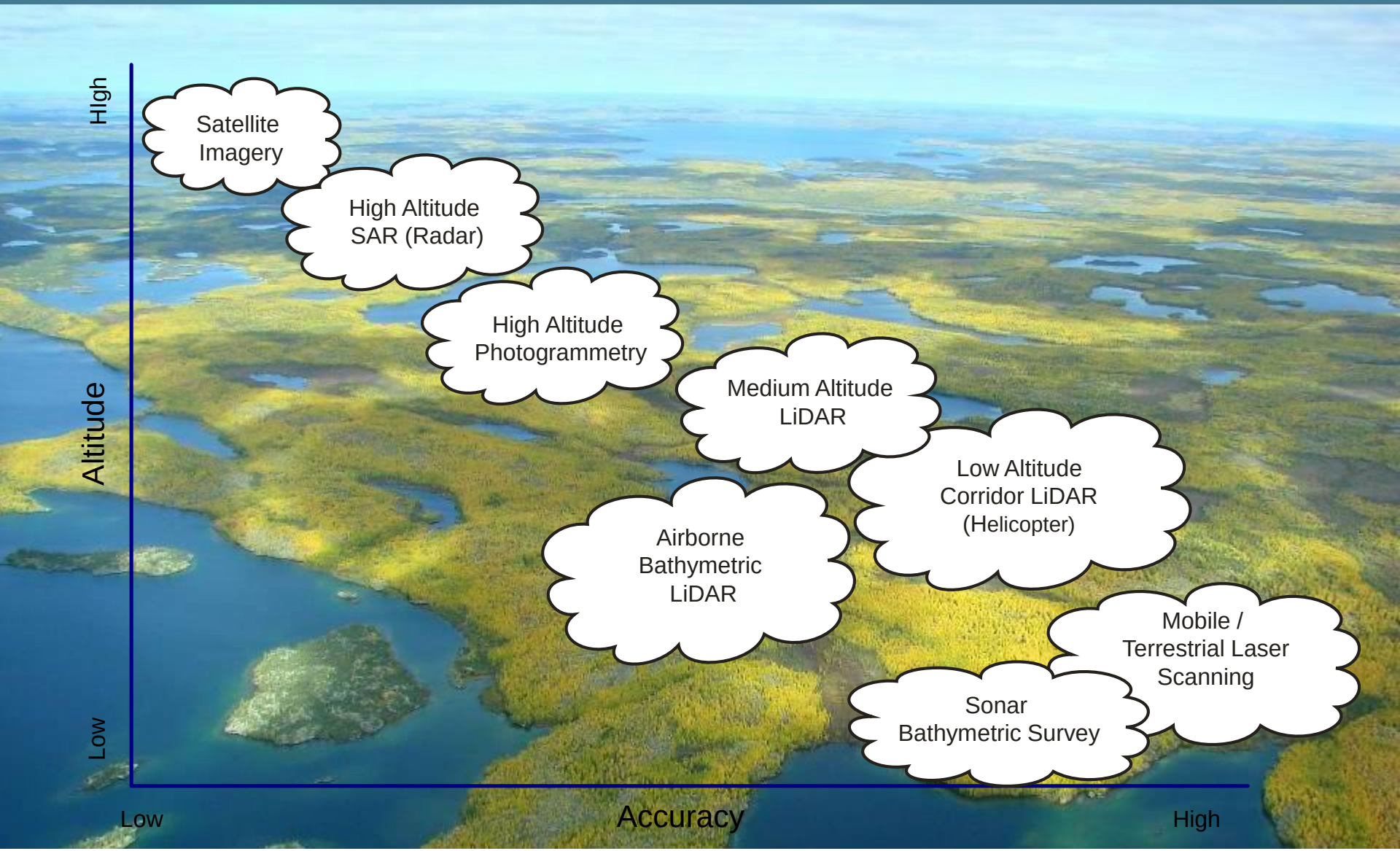
Introduction

In the coming years we can expect:



- Exponential adoption of autonomous systems
- Economics work to increase mapping programs
- Crowd sourcing of hydrography
- High-end platforms will continue to adopt new complimentary sensors:
  - LIDAR
  - Environmental
  - GeoChemistry
  - Multi Spectral
  - …
- New emphasis on processing automation and turning data into actionable knowledge

Today´s technology for nearshore mapping - Remote Sensing

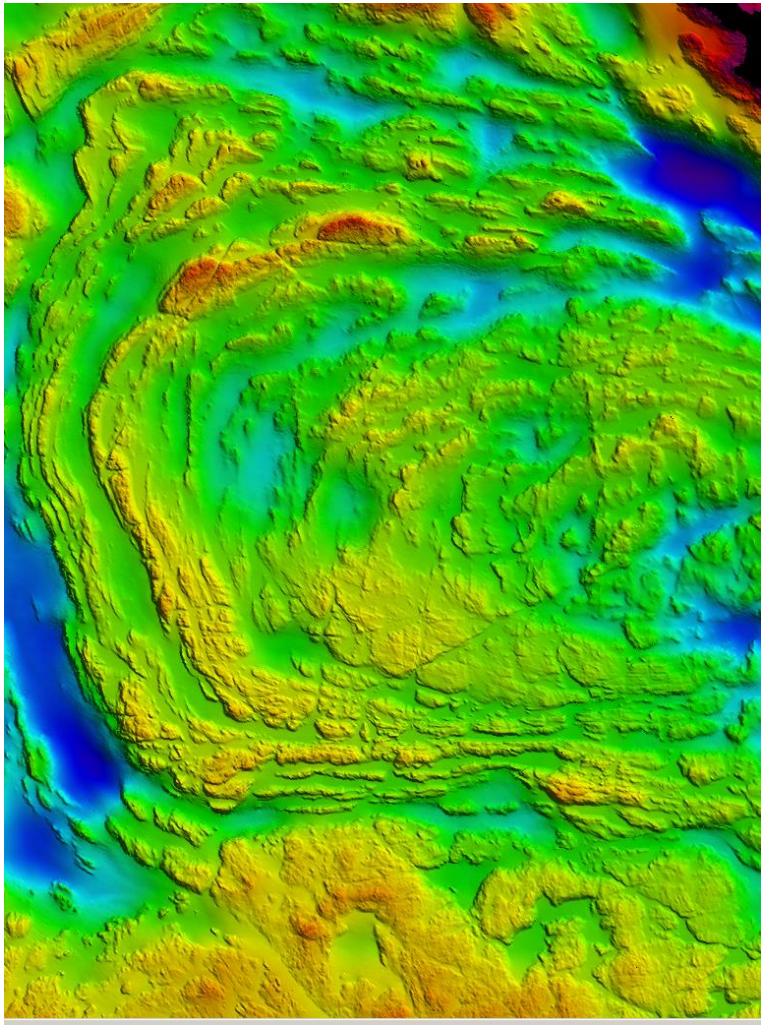


Today´s technology for nearshore mapping - Costs

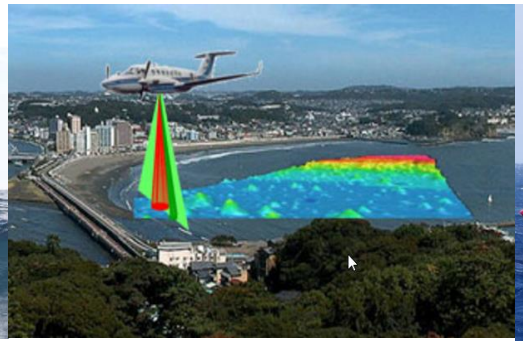
Where possible, the most cost effective approaches to mapping nearshore, high-impact coastlines – notwithstanding absolute accuracy standards - are:

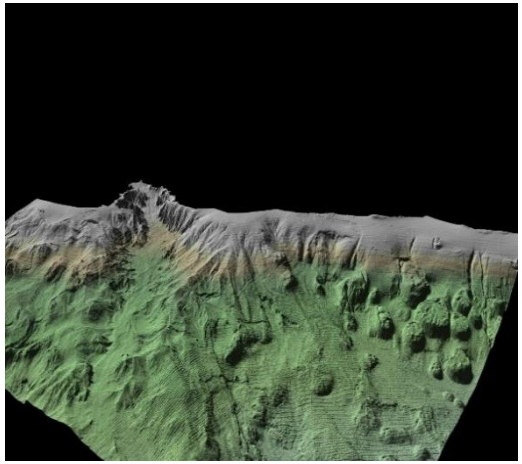
- Remote sensing for coastal waters (€)
  - Satellite Derived Bathymetry – SDB
  - Airborne and high-resolution satellite based multispectral imagery
  - Satellite Altimetry**
- Airborne active sensor techniques (€€)
  - High-resolution RGB Photography
  - Hyperspectral Imagery
  - Topographic Lidar
  - Topo-Bathymetric Lidar
  - Bathymetric Lidar
- Traditional acoustic hydrographic survey techniques (€€€)
  - MBES, MPES, SBES, SSS etc.

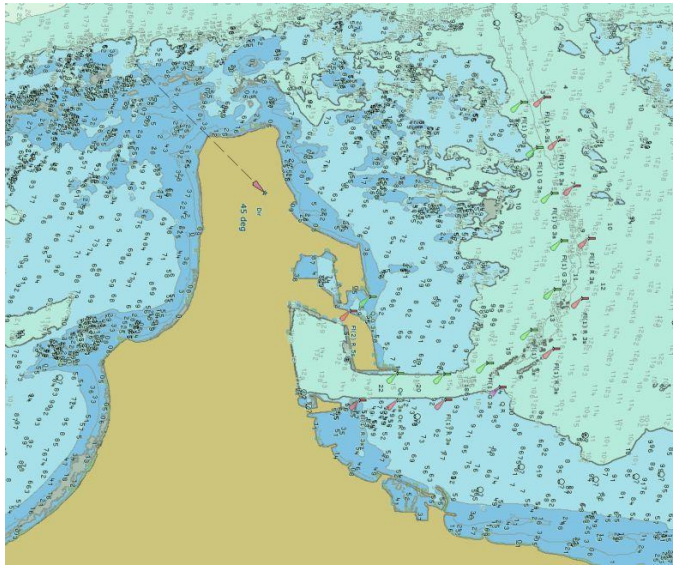
All of the above are affected in different ways by metocean conditions in the nearshore environment: water clarity, seabed color and rugosity, platform dynamics and operational parameter windows etc.

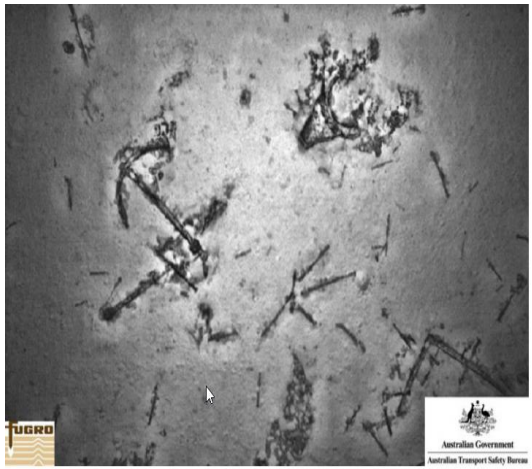


Today´s technology for nearshore mapping (active)

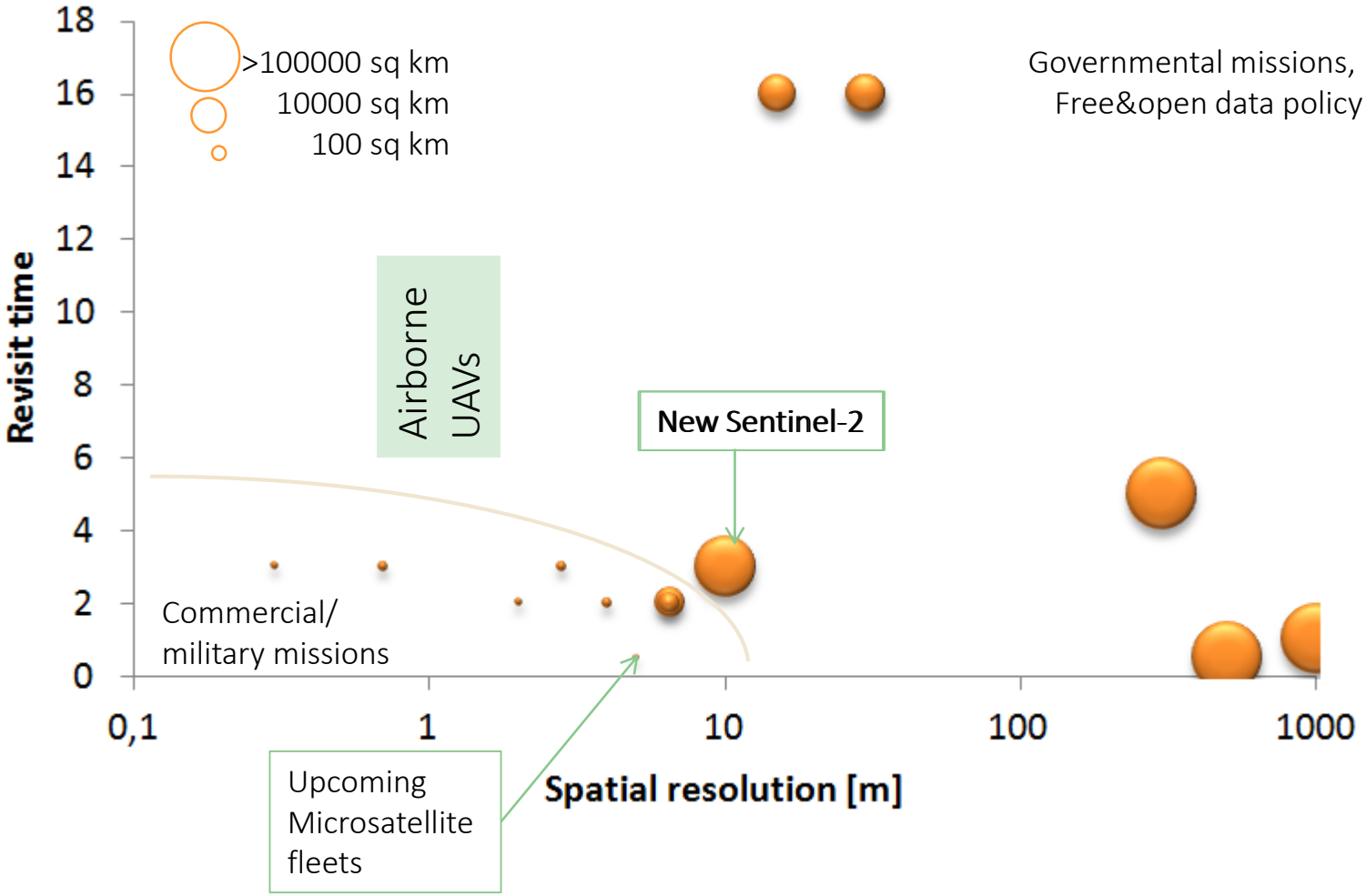








Optical satellite sensors (passive)



Different SDB Approaches

	(Semi-) Empirical	Physical
Dependency on in-situ data	High	Low
Uncertainties Uncertainties forecast/trace	High No	Lower Yes
Productivity & efficiency Coverage	Lower Lower	High High
Method & Development costs	Relating brightness or ratios to water quality parameters - easy **Low development costs**	Resolving the light transfer - complex High development costs

Integrated solution rationale - why an integrated approach?

- Small scale / large area deliverables can be generated in a timely manner
- By integrating a survey campaign, the survey team can take advantage of the results of initial remote sensing data:
  - to hone the extent of survey required by the next level of technology in the campaign
  - to highlight the presence of potential hazards and obstructions
  - to maximize efficiency in all phases of the campaign and improve cost-effectiveness
  - to accelerate the detection of major chart discrepancies
- Such an approach promotes efficiency in all levels of survey planning
- Given the extent and geographic disparity of nationals waters, a 'base-layer' of SDB can accelerate the acquisition of modern data coverage:
  - …. from unacceptably long and protracted survey programs
  - …. to acceptably manageable timelines
  - …. within acceptable budget constraints
  - …. with discernable progress possible for all recipients.

Integrated solution rationale

If we apply an integrated approach….

- SDB can provide cost-effective initial coverage of a suitable, clear, shallow-water area
- We can take the initial results and do, at least :

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 defense / monitoring
3. Use 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 of satellite imagery to extract even more habitat info from the coastal zone

SDB Vs. Direct measure Tests Comparison Results

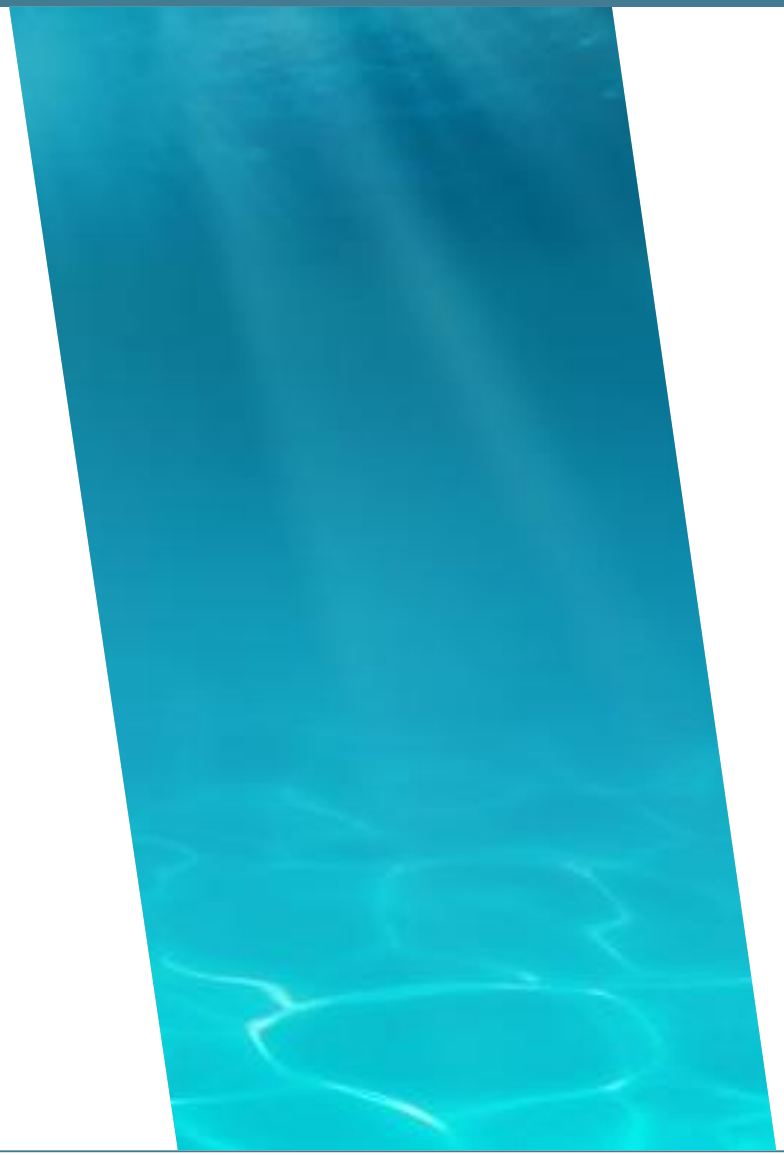
- Agencies have independently compared results of one or two overlapping surveys in discrete regions … often over very limited areas

- We undertook a wider study of four very disparate areas, with differing coastal conditions, between the complementary and more typical (in terms of coverage and domain) mainly ALB datasets and SDB datasets

SDB Vs. Direct measure Tests Comparison Results

- SDB is an acceptable product when either budgets are tight or the area of interest is very remote or access is restricted, or when chart quality accuracy in the hydro product is un-necessary. Considerable data and information can be generated for a very low cost per unit area and QHSE considerations are almost negligible as no personnel are necessary in the area of interest. Absolute accuracy might not meet current charting requirements but relative accuracy is good for reconnaissance and change detection;

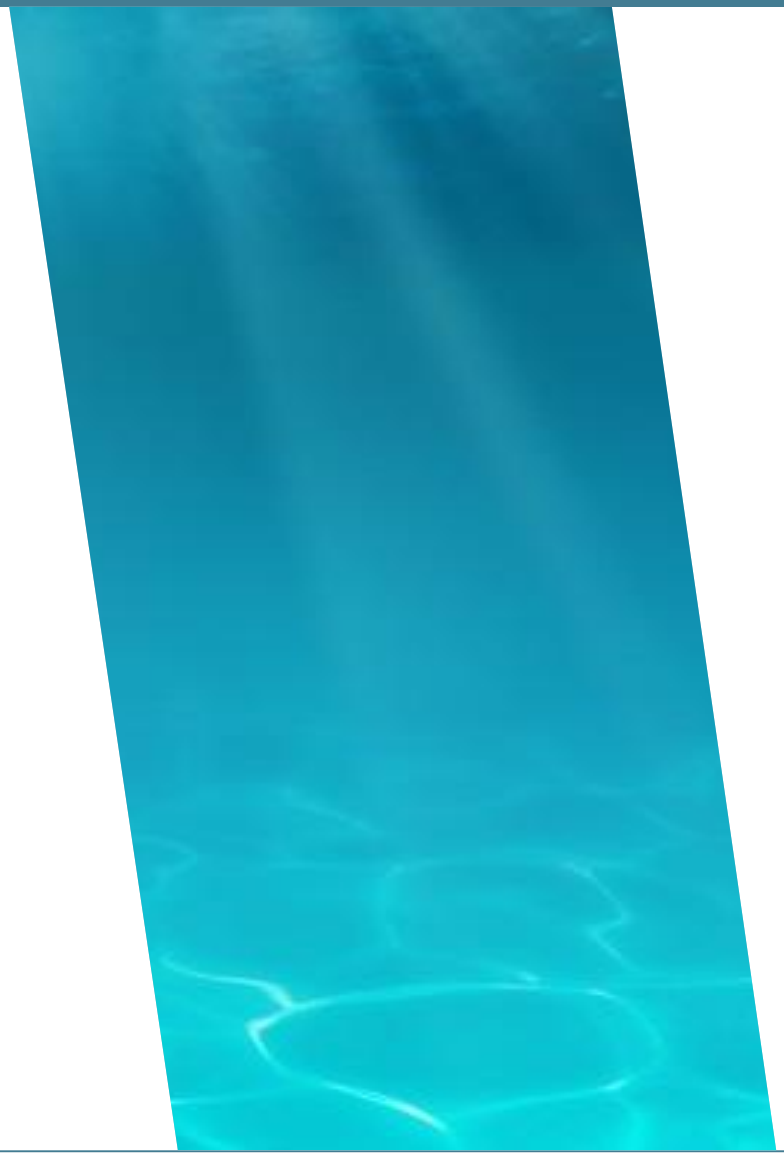
- As a planning tool for very poorly charted areas SDB can provide invaluable forecast on the bathymetry likely to be encountered during the follow-on active sensor survey, or in the case where no data is possible due to historic turbidity in the imagery, a good indicator as to which technology has to be used to attain higher accuracy or higher resolution data (i.e. ALB is unlikely to work very well if SDB returns no data extraction).



SDB Vs. Direct measure Tests Comparison Results

- The historic record of imagery grows daily, such that at least two decades of useable imagery from rapidly improving sources can be used to determine long term trends and change detection in the coastal fringe – hugely useful in the CZM market.

- Physics-based SDB ‘conditions’ the raw satellite imagery through an algorithmic workflow to provide much more repeatable results compared to any semi-empirical approach. It also has the added benefit of providing a reliable reflectance product for seabed classification products, something impossible with a semi-empirical approach (‘Cookbook’).



Conclusion

- Alternative solutions to the nearshore mapping of many areas are feasible
- They will not always attain navigational charting standards
- These solutions can also benefit non-charting (but related) agencies
- An open minded approach can better serve a broader stakeholder group

- Fugro-EOMAP's partnership:
  1. We are aiming to combine Fugro's considerable hydrographic survey expertise with EOMAP's innovative satellite imagery technologies
  2. We are committed to ensuring that shallow and hazardous coastal waterways can be surveyed safely and even more efficiently

- There are ways and means of improving initial results from SDB with iterative processes utilizing ALB full waveform algorithms and a ground-truth approach
- There are ways and means of improving final coverage and data density which agrees within a reasonable tolerance
- Key is to quantify what we have and apply appropriate risk to the data usage

Future of Hydrography

Dr Marco Filippone

Fugro Germany Marine GmbH

Chief Hydrographer

m.filippone@fugro.com