



# **NLA International–Seabed 2030**

## **Phase 2: Benefits Analysis Workstream Report**

### **Catalogue of Premium Models for Seabed Mapping Benefits Analysis**

**January 2022**



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## SECTION ONE: INTRODUCTION TO THE REPORT

### 1.1 CONTEXT

The Nippon Foundation-GEBCO Seabed 2030 Project's vision to map the world's oceans by 2030 is insightful and ambitious setting a challenging timeline to address the 80% of the oceans that have yet to be charted to the required gridded resolution. The "Wind in the Sails" (WITS) proposal supports the Seabed 2030 Project by providing empirical evidence to enable the development of a prioritised, targeted survey strategy. The aim of this three-phase project is to unite the global hydrographic community and operators within the marine and maritime domains around an agreed global seabed mapping priority list, underpinned by a robust evidence base that articulates the true need and value of mapping the seabed in its entirety to a defined gridded depth variable resolution.

WITS phases are: *(Bold text current phase highlights the current phase of activity, Phase 2)*

- Phase 1: Rapid evidence review and fast action priority list
- **Phase 2: Detailed modeling, benefit extrapolation and prioritisation of need**
- Phase 3: Release of interactive priority action map and revised strategy

### 1.2 'WIND IN THE SAILS' PHASE 2 TASK – DETAILED MODELLING, BENEFIT EXTRAPOLATION AND PRIORITISATION OF NEED

WITS Phase 2 work builds on top of the Phase 1 outputs and is informed by the community engagement survey findings. Phase 2 has 3 objectives, as described below:

Objective 3: Catalogue the premium models for seabed mapping benefit analysis (this report).

A collated catalogue of the various models used to calculate the environmental, social, and economic benefits to be derived from mapping currently uncharted areas of the seabed will be produced. Such benefit modelling has never been attempted on a global scale; it is anticipated that different models will have been used to quantify those differing benefits (environmental, social, and economic), and that varying types of seabed's (coastal, deep water within EEZs or on the High Seas, etc..) will also have been addressed in different ways. A taxonomy of global seabed mapping categories will be developed, and the best models found to articulate the benefits of mapping each identified seabed characteristic category will be identified.

Objective 4: Model potential global benefit.

Using the blended suite of shortlisted premium benefit calculation models as a guide, a globally recognised and supported priority list will be transposed into a framework for a potential global model that reflects all categories and seabed survey priority needs. Extrapolating the priorities and needs across pan-maritime stakeholders/sectors will result in a global first a never-before-attempted quantification of the environmental, social and economic benefits and bringing them together within one model.

Objective 5: Develop a final model to prioritise all areas of unmapped seabed.

With the global picture in place, further work will be required to develop an approach to prioritising areas for mapping interventions globally. This exercise will take the output from Objective 4 above as its starting point, but it is listed as a separate objective as considered work will need to be undertaken to develop a ranking model that draws in the disparate modelling functions into a coherent, quantifiable whole. For example, it may be necessary to develop separate rankings for the environmental, social, and economic benefits of each area (so that stakeholders with an individual interest in each of them can see those separately), and then develop a method to weight each of those scores in a headline 'score'.

### 1.3 Report Purpose & Structure

Phase 2 provides includes 2 reports, and both reports are products of the WITS benefits analysis workstream, where:

- Report 1 ([this report](#)) focusses on Phase 2 Objective 3, is a guidance report, and provides a catalogue of the premium models for seabed mapping benefit analysis.
- Report 2 (future report) target submission at the end of April 2022, focusses on Objectives 4 and 5, and provides a description of the proposed Seabed 2030 benefits analysis and prioritisation process and approach. It also includes a set of recommendations for Seabed 2030 consideration relating to Seabed 2030 benefits analysis and prioritisation matters.

Both **reports readership** potentially includes Seabed 2030 management, decision makers, and practitioners. The benefits analysis and prioritisation modeling are also developed with the same readership in mind (Seabed 2030 management, decision-makers, and practitioners), and additionally is produced with researchers and future donors / funding bodies in mind.

Report 1 structure is as follows:

- Section 1: 'Introduction to the Report' – providing Seabed 2030, and WITS context and provides the purpose and layout of the report.
- Section 2: 'Catalogue of the premium models for seabed mapping benefit analysis – summary of approach', provides a summary of approach / concise methodology for the Phase 2 Objective 3 task.
- Section 3: 'Seabed 2030 product scope parameters to be considered for the purposes of benefits analysis', identifies key parameters and scope of the Seabed 2030 product and benefits analysis constraints.
- Section 4: The catalogue of the premium models for seabed mapping benefit analysis. This section is presented as follows:
  - Three model search categories were adopted and on this basis ten (No.10) benefits analysis reference examples are identified and described.
  - For each example, key features are presented, including Benefit Model Source/Title, Website URL, Objectives, Scope, Highlights, with if applicable any associated Seabed 2030 Recommendation identified.

- Section 5: 'Collation of Recommendations', providing a table of recommendations for carry across into the WITS Phase 2 Objectives 4 and 5 work, and for potential inclusion in the WITS Phase 2 report 2.
- Section 6: WITS Phase 3 next steps.
- Annex 1: Task Lexicon - Definition of Terms.
- Annex 2: References.

## SECTION TWO: CATALOGUE THE PREMIUM MODELS FOR SEABED MAPPING BENEFIT ANALYSIS – SUMMARY OF APPROACH

This section presents a summary of approach / method adopted to cataloguing the premium models for seabed mapping analysis and delivering on Phase 2 Objective 3.

The Phase 2 Objective 3 delivery, throughout, draws on guidance from the wider WITS delivery team, and in particular insight from the WITS Phase 1 Seabed 2030 survey returns and findings analysis. This is supplemented with dedicated consultant research activities to achieve Phase 2 Objective 3 as described in section 2.1 below.

### 2.1 CATALOGUE THE PREMIUM MODELS FOR SEABED MAPPING BENEFIT ANALYSIS – SUMMARY OF APPROACH

The following step activities were undertaken to both achieve Objective 3 stage and inform future work towards Objectives 4 and 5:

**Step 1: Define the Seabed 2030 product scope parameters to be considered for the purpose of benefits analysis.**

Output: Section 3 of this report presents the proposed scope parameters to be adopted and to inform the benefits analysis logic.

**Step 2: Source a Lexicon best practice / industry adopted reference source for technical definitions and terminologies.**

Output: Annex 1 of this report documents the lexicon proposed adopted for the benefits analysis work. This will be added to throughout the Phase 2 task delivery, to reflect selected / adopted benefit analysis model definitions.

**Step 3: Source benchmark / informing methodologies and undertake a consultant review of their features to inform a tailored Seabed 2030 benefits analysis model.**

Output: Section 4 of this reports presents the benchmarking / informing methodologies review findings.

The models were selected based on 3 search criteria, including:

- (i) **Search Category 1: Previously executed seabed mapping studies that include benefits analysis activities, including:**
  - **USA: 3D Nation Study, USGS National Geospatial Program, 3D Elevation Program, and NOAA Office of Coast Survey, (2020),** and previously USA: National Enhanced Elevation Assessment, USGS, (2013 and signed into US law in Oct 2018).
  - **Australia: The value of Australian seabed mapping data to the blue economy,** October 2021, study by Deloitte commissioned by Geoscience Australia.



- **INFOMAR - Marine Mapping Study, Options Appraisal Report**, 30 June 2008 study by PWC.

Supplemented with wider useful informing practices and applications to inform Objectives 4 and 5 activities, including from:

- UK: (i) **Value Chains in Public Marine Data: A UK Case Study** - A joint OECD Working Paper in collaboration with the UK Marine Environmental Data and Information Network (MEDIN) and the Global Ocean Observing System (GOOS) in the Intergovernmental Oceanographic Commission of UNESCO. And (ii) the use of **UK HMG Green Book for Appraising Public Value**.
- **Atlantic Ocean Research Alliance (AORA) related seabed mapping** - Atlantic Mapping Framework Report.

(ii) **Search Category 2: Benefits analysis experience drawn from the wider geospatial sector**, e.g., where a number of key economic value of geospatial data studies have been commissioned by Federal Government Bodies to inform their geospatial data policy and related investment decisions. Examples reviewed include:

- **An Initial Analysis of the Potential Geospatial Economic Opportunity**, 2018, study by HMG Cabinet Office, supported by Boston Consulting Group. With subsequent supplementary work undertaken by Frontier Economics study for Cabinet Office: **Geospatial Data Market Study - Report for the Geospatial Commission**, September 2020, study by Frontier Economics commissioned by HMG Cabinet Office. **Geospatial Data Market Study - Report for the Geospatial Commission**, September 2020, study by Frontier Economics commissioned by HMG Cabinet Office.
- **Assessment of the Economic Value of the Geospatial Information Industry in Ireland**, February 2014, study by Indecon International Economic Consultants, commissioned by Ordnance Survey Ireland.

(iii) **Search Category 3: Benefits analysis experience drawn from the private / NGO sector**, e.g., where a number of key studies have been expedited by private sector entities to inform their own commercial activities. The benefits analysis approach adopted by Google is identified and reviewed, including reference to two useful studies commissioned by Google to inform their own geospatial services investment:

- **The economic impact of geospatial services: how consumers, businesses and society benefit from location-based information**, [September 2017, study by Alphabet, commissioned by Google].
- **What is the economic value of Geo services**, [January 2013, study by Oxera Consulting Ltd, commissioned by Google].

Also, case studies are highlighted for Seabed 2030 future reference where 'commercial' or 'free to use' global coverage data 'elevation' and 'mapping' products have been produced, maintained, rolled out and supported, including:

- **Airbus WorldDEM™**.
- **InterMap® NextMap®** product family.
- **MAXAR 3D** product family (noting MAXAR acquisition of Vricon, in July 2020).
- **AW3D** Product family

- **OpenStreetMap**, by Open Street Map Foundation

Whilst not reported on as detailed review, throughout this work the study team draws on best practice and industry norms, from key organizations with Blue Economy interests and concerns, including such as **EU DG Maritime Affairs and Fisheries**, **World Bank**, and **OECD**.

**Step 4: Produce this Phase 2 Report 1**, to document an evidence base towards and inform the WITS Phase 2 Objectives 4 and 5 work [Objective 4: Model potential global benefit, and Objective 5: Develop a final model to prioritize all areas of unmapped seabed]

**Next Step - Step 5: Proceed with the delivery of the WITS Phase 2 Objectives 4 and 5**, drawing on the outcomes and findings of Objective 3.



### SECTION THREE: SEABED 2030 PRODUCT SCOPE PARAMETERS TO BE CONSIDERED FOR THE PURPOSES OF BENEFITS ANALYSIS

This section identifies the Seabed 2030 'product' and 'scope' parameters to be considered for the purposes of benefits analysis'. This scope is also used to inform the taxonomy of global seabed mapping categories, to be updated during the Objective 4 and 5 activities and presented in the Phase 2 Report 2.

Parameters for scope include:

- A: Waters and maritime boundaries of interest
- B: Seabed 2030 Product Portfolio of Interest
- C: Seabed 2030 Product Currency / Maintenance
- D: Categorisation of Economic Sectors

And are detailed including where applicable at sub-element level below.

#### **A: Waters and maritime boundaries of interest**

**Sub-element 1.1: Waters of interest to this study and benefits analysis** focus are:

- #1: Internal Waters - Inland water bodies / Navigable waterways, etc.
- #2: Ports
- #3: Coast
- #4: Territorial Seas 12 nm
- #5: Contiguous Zone 24 nm
- #6: EEZ
- #7: Archipelagic Waters
- #8: High Seas

Where #1 through to #7 fall under national mandates, this study focus and the Seabed 2030 benefits analysis focus is #8: High Seas.

**Sub-element 1.2: Other maritime / marine area boundary driven concerns or interests**, include, where available the following: [Relevant authorities are identified where known].

- #1: Areas of Particular Environmental Interest [*Source: Relevant Authority - International Seabed Authority*]
- #2: Vulnerable marine ecosystem [*Source: Regional Fisheries Management Organizations or associations, competent national authorities by cascade*]
- #3: Particularly sensitive sea areas and areas to be avoided [*Source: Relevant Authority - IMO*]
- #4: Fisheries closures and fisheries restricted areas [*Source: Food and Agriculture Organization of the United Nations, Relevant Authority - IMO*]
- #5 Whale sanctuaries [*Source: Relevant Authority – International Whaling Commission*]
- #6 Infrastructure closures: Pipeline (e.g., oil, gas, etc.) and cable closures (e.g., telecommunications, grid, etc.) [*Source: Relevant Authority – IMO cascade competent national authorities*]

#7 World Heritage Sites, including those for their mixed cultural and natural outstanding value [Source: Relevant Authority – United Nations Educational, Scientific and Cultural Organization]

#8 Marine Protected Areas [Source: Relevant Authority – Aichi Biodiversity Targets. Regional seas conventions, and by cascade competent national authorities]

#9 Special Areas and Emissions Control Areas [Source: Relevant Authority - IMO]

#10: Others (TBD and may emerge as a result of the Seabed 2030 community engagement workshop on 8 February 2022). E.g., Offshore Mining delineated areas, other marine geological sites of interest, such as marine trenches, tectonic plates, and other sites of known geological interest / activity (that may drive benefits analysis and/or seabed mapping prioritisation e.g., support to tsunami forecasting)

### **Sub-element 1.3: Ocean Regions**

Ocean Regions to be adopted are as used in the WITS Phase 1 work, and are based on 12 ocean regions as follows:

#1: Arctic Ocean,

#2: Atlantic North,

#3: Atlantic South,

#4: Baltic Sea,

#5: Black Sea,

#6: Indian Ocean,

#7: Mediterranean Sea,

#8: Pacific North,

#9: Pacific South,

#10: South China Sea,

#11: Southern Ocean, and

#12: “Multiple” (Multi). The multiple category can be used to reflect preferences across multiple ocean regions (cross-cutting multiple regions apply).

**B: Seabed 2030 Product Portfolio of Interest**, include the following:

### **Sub-element 2.1: Seabed 2030 Actual / Concept Products**

#1: Seabed Grid

#2: Seabed 2030 Charts

Noting that the availability of acquired raw data, backscatter, and/or Seabed Features / Seabed Textures are excluded from this specific benefits analysis study (i.e., the focus is the post processed grid model).

### **Sub-element 2.2: GEBCO Products**

To inform this study, the General Bathymetric Chart of the Oceans (GEBCO) consists of an international group of experts who work on the development of a range of bathymetric data sets and data products, including:

- Gridded bathymetric data sets.

- GEBCO Digital Atlas, confirmed to consider Seabed 2030 as an input to the GEBCO Digital Atlas
- GEBCO world map, confirmed consider Seabed 2030 as an input to the GEBCO world map
- GEBCO Gazetteer of Undersea Feature Names

For the purpose of the benefits analysis, it is proposed to consider Seabed 2030 as:

- #1: An input to GEBCO gridded bathymetric data sets,
- #2: An input to GEBCO Digital Atlas, and
- #3: An input to GEBCO World Map can be considered.

Additional to the Seabed 2030 data products (grids and charts) and Seabed 2030 data holdings.

**Sub-element 2.3: Any other international data holdings in scope or to be considered** – at this stage this is proposed as ‘none’ or ‘not applicable’. This may be considered again during Objectives 4 and 5 work, pending consideration of sub-element 1.2 (*Other maritime / marine boundary driven concerns or interests*), above, and in particular any feedback from the Seabed 2030 community engagement workshop ~February 2022.

#1: None / Not Applicable

#### **Sub-element 2.4: Product Grids – depth and resolution parameters to be applied**

As defined by Seabed 2030, the following depth and resolution parameters will be adopted for the benefits analysis work.

The long-term target specification of 100m x 100m grid has been superseded. The initial efforts of Seabed 2030 are focusing on mapping the 93% of the ocean deeper than 200 meters, leaving national hydrographic agencies to cover waters closer to shore”.

Seabed 2030 progress tracking refers to the following parameters and it is these parameters that are adopted for the purpose of benefits analysis. The specification of target resolutions by varying depth are:

- #1: Depth range 0-1500 metres, grid cell size 100m x 100m
- #2: Depth range 1500-3000 metres, grid cell size 200m x 200m
- #3: Depth range 3000-5750 metres, grid cell size 400m x 400m
- #4: Depth range 5750-11000 metres, grid cell size 800m x 800m

Please note the Seabed 2030 ancillary reference to satellite altimetry providing a resolution in order of 5000m resolution / 5Km resolution, while of technical interest, is out of scope for the purposes of the benefits analysis.

#### **C. Seabed 2030 Product Currency / Maintenance**

Whilst in the longer-term Seabed 2030 may seek to maintain the Seabed 2030 product portfolio and undertake resurvey / data maintenance work, at this time and for the purposes of benefits analysis activities it is assumed that Seabed 2030 is a single event base-line survey without any associated update maintenance / resurvey specification applied.

#### **D. Categorisation of 'Economic' Sectors**

Sector categories are proposed aligned with the WITS Phase 1 work, and for consistency purposes / following maritime economic norms. Additionally, and to optimise the potential to leverage wider economic approaches and reference / routinely collated economic data, it is useful to be able to map across sectors to wider economic statistical categories. For example, World Bank / OECD / IMF together regularly collate and report international statistics on GDP, among others, and this cascades internationally, and nationally applying economic categories, such as:

An economy comprises 3 sectors:

#1: Sector: Public or 'State Sector'

#2: Sector: Private or 'Privately run business'

#3: Sector: Voluntary or 'Not for Profit'

[Explainer: Economic Value, based on GDP applies the formula  $GDP = C + G + I + NX$

Where,

- C is Consumption
- G is Government spending
- I is Investment, and
- NX is Net Exports]

Economic sectors include:

Three Sector Model, is categorised as follows:

#1: Primary sector [Raw Materials] – Involves the retrieval and production of raw materials such as for our interest minerals, fishing, and oil and gas.

#2: Secondary sector [Manufacturing] – Involves the transformation of raw or intermediate materials into goods, e.g., in this instance includes fisheries processing to food products.

#3: Tertiary sector [Services] – Involves supplying services to customers, e.g., banking, and accounting, etc. and in this instance can include blue financing.

Additional Sectors:

#4: Quaternary sector [Information Services]– And is where knowledge-based services are accounted for (e.g., Seabed 2030 can be considered a quaternary sector entity as a provider of data for....).

#5: Quinary sector [Human services] – activities centered on human-based services such as hospitality (e.g., and in this instance includes tourism).

Maritime Economy / Blue Economy / Ocean Economy can be considered cross-cutting.

An 'industry' can be considered a collection of organisations within a specific sector where they are typically involved in a specific internal sector activity, e.g., an oil company may be extracting oil – oil can be considered a primary sector industry, as can forestry and also in this instance marine fishing, and extraction of crude petroleum and natural gas (offshore).

This logic can be seen in the OECD list of ocean economic activities for internationally comparable statistics, where 14 categories are adopted, as follows: **(Bold can be potentially considered applicable to Seabed 2030)**. Statistic code references are used to inform and build up the OECD economic view.

Ref ID	Ocean Specific Description
1	<b>Marine fishing</b>
2	<b>Marine aquaculture</b>
3	Maritime passenger transport
4	Maritime freight transport
5	<b>Offshore extraction of crude petroleum and natural gas</b>
6	<b>Maritime and seabed mining</b>
7	<b>Offshore industry support activities</b>
8	Processing and preserving of marine fish, crustaceans, and molluscs
9	<b>Maritime ship, boat, and floating structure building</b>
10	Maritime manufacturing, repair, and installation
11	<b>Offshore wind &amp; marine renewable energy</b>
12	<b>Maritime ports and support activities for maritime transport</b>
13	<b>Ocean scientific research &amp; development</b>
14	<b>Marine &amp; coastal tourism</b>

EU blue economy studies also treat sectors as ‘Established’ and ‘Emerging’. For instance, EU identifies the following Established Blue Economy Sector, with their Sub-sectors.

Sector	Sub-sector
Marine Living Resources	Primary production
	Processing of fish products
	Distribution of fish products
Marine non-living resources	Oil and gas
	Other minerals
Marine renewable energy	Offshore wind energy
Port Activities	Cargo and warehousing
	Port and water projects
Ship Building and Repair	Ship building
	Equipment and machinery
Maritime Transport	Passenger transport
	Freight transport
	Services for transport
Coastal Tourism	Accommodation
	Transport
	Other expenditure

For the purposes of benefits analysis, it is not critical to adopt an international cascade of sector logic, but it will aid Seabed 2030 when convincing International Organisations, National Government, and donor funders to invest, where a business case or ‘value proposition’ can be aligned with international practices and norms.

For the purposes of benefits analysis it is more important to identify tangible use cases, that can be used to evidence the benefits and costs. This will be addressed in the Seabed 2030 community engagement workshop on 8<sup>th</sup> February 2022.

## SECTION FOUR: The catalogue of the premium models for seabed mapping benefit analysis

This section presents the catalogue of the premium models for seabed mapping benefit analysis, and is presented as follows:

- Section 4.1 Presents a list of premium models for seabed mapping benefit analysis.
- Section 4.2 Presents the key features of the individual premium benefits analysis models – which is developed from a perspective of informing the potential use of each model for Seabed 2030 benefits analysis.

### 4.1 List of premium models for seabed mapping benefit analysis

This section presents a list of the premium models for seabed mapping benefit analysis, as identified, and considered by the WITS benefits analysis workstream.

As detailed in Section 2 above, the benefits analysis models identified were based on 3 areas of search:

**Search Category 1: Previously executed seabed mapping studies that include benefits analysis activities.** The list of premium benefits models include:

- **USA: 3D Nation Study**, USGS National Geospatial Program, 3D Elevation Program, and NOAA Office of Coast Survey, (2020) see here: <https://my.usgs.gov/confluence/display/3DNationStudyElevation> Requirements and Benefits Study Benefits. And also its previous study, **USA: National Enhanced Elevation Assessment, USGS**, (2013 and signed into US law in Oct 2018), see here: [https://www.usgs.gov/3d-elevation-program/national-enhanced-elevation-assessment?qt-science\\_support\\_page\\_related\\_con=4#qt-science\\_support\\_page\\_related\\_con](https://www.usgs.gov/3d-elevation-program/national-enhanced-elevation-assessment?qt-science_support_page_related_con=4#qt-science_support_page_related_con) – and also see here: <https://www.usgs.gov/3d-elevation-program/program-benefits-and-uses> where the ‘National Enhanced Elevation Assessment (NEEA)’ was conducted to document national level requirements for enhanced elevation data, estimate the benefits and costs of meeting those requirements, and evaluate multiple national enhanced elevation program scenarios. See here: <https://www.dewberry.com/services/geospatial-mapping-and-survey/national-enhanced-elevation-assessment-final-report> for the final report
- **Australia: The value of Australian seabed mapping data to the blue economy**, October 2021, study by Deloitte commissioned by Geoscience Australia. See here: <https://www2.deloitte.com/au/en/pages/economics/articles/value-of-australian-seabed-mapping-data-to-blue-economy.html>
- **Ireland: Price Waterhouse Coopers (2008). INFOMAR Marine Mapping Study. Options Appraisal Report: Final Report 30 June 2008.** Marine Institute, Ireland. See here: <https://oar.marine.ie/handle/10793/1652>

Supplemented with wider useful informing practices and applications to inform Objectives 4 and 5 activities, including from:

- **UK: (i) Value Chains in Public Marine Data: A UK Case Study - A joint OECD Working Paper** in collaboration with the UK Marine Environmental Data and Information Network (MEDIN) and



the Global Ocean Observing System (GOOS) in the Intergovernmental Oceanographic Commission of UNESCO. And (ii) the use of **UK HMG Green Book for Appraising Public Value**.

- **Atlantic Ocean Research Alliance (AORA)** related seabed mapping - Atlantic Mapping Framework

**Search Category 2: Benefits analysis experience drawn from the wider geospatial sector**, e.g., where a number of key economic value of geospatial data studies have been commissioned by Federal Government Bodies to inform their geospatial data policy and related investment decisions. The list of premium benefits models include:

- **An Initial Analysis of the Potential Geospatial Economic Opportunity**, 2018, study by HMG Cabinet Office, supported by Boston Consulting Group. With subsequent supplementary work undertaken by Frontier Economics study for Cabinet Office: **Geospatial Data Market Study - Report for the Geospatial Commission**, September 2020, study by Frontier Economics commissioned by HMG Cabinet Office. Geospatial Data Market Study - Report for the Geospatial Commission, September 2020, study by Frontier Economics commissioned by HMG Cabinet Office.
- **Assessment of the Economic Value of the Geospatial Information Industry in Ireland**, February 2014, study by Indecon International Economic Consultants, commissioned by Ordnance Survey Ireland.

**Search Category 3: Benefits analysis experience drawn from the private / NGO sector**, e.g., where a number of key studies have been expedited by private sector entities to inform their own commercial activities. The benefits analysis approach adopted by Google is identified and reviewed, including reference to two useful studies commissioned by Google to inform their own geospatial services investment:

- **The economic impact of geospatial services: how consumers, businesses and society benefit from location-based information**, [September 2017, study by Alphabeta, commissioned by Google].
- **What is the economic value of Geo services**, [January 2013, study by Oxera Consulting Ltd, commissioned by Google].

Also, case studies are highlighted for Seabed 2030 future reference where 'commercial' or 'free to use' global coverage data 'elevation' and 'mapping' products have been produced, maintained, rolled out and supported, including: *Please note, benefits analysis / business planning details are not in the public domain, for the commercial entities listed below, but are known to exist based on the consultant's previous geospatial industry roles.*

- European case study – **Airbus WorldDEM™**.
- USA private sector case study – **InterMap® NextMap®** product family.
- USA private sector case study – **MAXAR 3D** product family (noting MAXAR acquisition of Vricon, in July 2020).
- Japan Case Study – **AW3D** Product family - Japan Case Study – AW3D Product family, W3D is a service jointly developed and sold by RESTEC and NTT DATA Corporation see here: <https://www.restec.or.jp/en/solution/aw3d.html> and product details here: <https://www.aw3d.jp/en/products/>

- **OpenStreetMap**, by Open Street Map Foundation, , see here:  
<https://www.openstreetmap.org/#map=6/54.910/-3.432>

Section 4.2 below provides further description details for each model and case study.

#### 4.2 Premium benefits analysis model key features tables – providing on overview of key features of each considered model to inform the potential use of each model for Seabed 2030 benefits analysis.

This section presents the key features for each benefits model listed in Section 3.1 above. A common table, one table per benefits analysis model is used. These details will inform the potential application of each model or elements from each model for the proposed Seabed 2030 benefits analysis (informing the Phase 2 objectives 4 and 5 next step activities).

To ease reader review, this section adopts the 3 search categories applied in Section 4.1 above by subsection.

##### 4.2.1 Premium Models Search Category 1: consultant desk study identified previously executed seabed mapping benefits studies.

Benefits Model Key Features Tables are provided for the following previously executed seabed mapping benefits studies:

**USA 3D Elevation Programme: Including the National Enhanced Elevation Assessment, USGS, (2013 and signed into US law in Oct 2018), and USA: 3D Nation Study, USGS National Geospatial Program, 3D Elevation Program, and NOAA Office of Coast Survey, (2020)**

<b>Benefit Model Source/Title</b>	<b>USA 3D Elevation Programme: Including the National Enhanced Elevation Assessment, USGS, (2013 and signed into US law in Oct 2018), and USA: 3D Nation Study, USGS National Geospatial Program, 3D Elevation Program, and NOAA Office of Coast Survey, (2020)</b>
<b>Website URL</b>	<p><b>USA 3D Elevation Programme:</b> <a href="https://www.usgs.gov/3d-elevation-program">https://www.usgs.gov/3d-elevation-program</a></p> <p><b>USA: 3D Nation Study,</b> USGS National Geospatial Program, 3D Elevation Program, and NOAA Office of Coast Survey, (2020), Requirements and Benefits Study Benefits. And also its previous study, <b>USA: National Enhanced Elevation Assessment, USGS,</b> (2013 and signed into US law in Oct 2018), see here: <a href="https://www.usgs.gov/3d-elevation-program/national-enhanced-elevation-assessment?qt-science_support_page_related_con=4#qt-science_support_page_related_con">https://www.usgs.gov/3d-elevation-program/national-enhanced-elevation-assessment?qt-science_support_page_related_con=4#qt-science_support_page_related_con</a> – and also see here: <a href="https://www.usgs.gov/3d-elevation-program/program-benefits-and-uses">https://www.usgs.gov/3d-elevation-program/program-benefits-and-uses</a> where the ‘National Enhanced Elevation Assessment (NEEA)’ was conducted to document national level requirements for enhanced elevation data, estimate the benefits and costs of meeting those requirements, and evaluate multiple national enhanced elevation program scenarios.</p>
<b>Objectives</b>	The <b>National Enhanced Elevation Assessment (NEEA)</b> was performed to document USA national requirements for improved elevation data, estimate the benefits and costs of meeting these requirements, and evaluate multiple national enhanced program implementation scenarios. The study was sponsored by member agencies of the National Digital Elevation Program and was completed December 2011. Study participants included 34 federal agencies, 50 states, and selected local governments and tribes, as well as private and not-for-profit organizations. An analysis of the results showed that an improved national program has the potential to generate \$1.2-billion to

	<p>\$13-billion in new benefits each year once fully operational. The report was developed by Dewberry under contract to the USGS.</p> <p><b>NEEA directly informed the USA national 3D Elevation programme (3DEP). The first full year of 3DEP production began in 2016 and at the end of fiscal year 2021, 84% of the Nation has available or in progress elevation data that meet 3DEP specifications for high accuracy and resolution.</b></p> <p><b>The 3D Nation Study is a more recent study (WIP) and is documenting topographic, coastal, &amp; bathymetric 3D elevation data requirements and benefits across a multitude of geographies, as represented by the graphic further below.</b></p>
<b>Scope</b>	<p>The <b>NEEA assessment</b> was conducted under USGS' Geospatial Products and Services Contract 2 (GPSC2) with Dewberry, headquartered in Fairfax, Virginia. <b>USGS tasked Dewberry to conduct a study to develop and refine requirements and to identify implementation alternatives and associated benefits and costs for a National Enhanced Elevation Data Program that meets federal, state, and other national Business Uses and needs.</b> The study's findings <b>established a baseline understanding of national Business Uses for, and the associated benefits from, enhanced national elevation data.</b> The report findings help improve the responsiveness of USGS and partner agency programs and <b>informed the design of an enhanced future program that balanced requirements, benefits, and costs at a national scale.</b> The <b>first task was to comprehensively document and validate federal, state, local, and tribal government and nongovernmental (not-for-profit and private business) needs for enhanced elevation data.</b> The needs, as well as cost and benefit information, were documented for each participating organisation.</p> <p>The <b>3D Nation Study</b> is more recent study (WIP) is documenting topographic, coastal, &amp; bathymetric 3D elevation data requirements and benefits across a multitude of geographies, as represented by the graphic further below.</p>
<b>Highlights</b>	<p><b>3D Elevation Programme</b> - The study team wish to highlight five items from the 3D Elevation Programme. The first 4 items concern the NEEA methodology and approach, and the fifth item the more recent 3D Nation Study.</p> <p><b>Item 1 – NEEA methodology - A three-step initial stakeholder engagement process was adopted</b> including:</p> <ul style="list-style-type: none"> <li>• an online questionnaire</li> <li>• follow-on workshops and interviews with key managers to complete and consolidate responses, and</li> <li>• validation of this information for participating organisations.</li> </ul> <p>Engagement was across federal, state, local, tribal, and nongovernmental organisations (engagement was extensive).</p> <p><b>Follow-on tasks undertaken by consultants</b> included:</p> <ul style="list-style-type: none"> <li>• <b>Analysis of Business Use and benefits information to develop the proposed standardized national dataset options that will address key the identified Business Uses.</b></li> <li>• <b>Evaluation of emerging technology trends and technical limitations to provide a high-level technical approach and costs for implementing a national program</b></li> </ul>

over a 4-7 year timeframe; identifying also where radar may be an alternative to LiDAR; and identifying current bathymetric LiDAR technologies.

- **Assessment of the feasibility, cost, and performance of data infrastructure alternatives** for services such as ingesting and managing a range of minimally processed LiDAR data from federal and state agencies, generating customized derivative products, and delivering high volumes of data.
- **Evaluation and comparison of alternative programme scenarios based on their expected ability to produce the optimised dataset options in terms of costs, risks, operational efficiency, and other feasibility issues.**

**Item 2: The cost benefits analysis was comprehensive and was based on a set of 27 predefined business use case, as presented in the graphic below.**

Table 4.1. The 27 pre-defined Business Use (BU) numbers and names

1. Natural resources conservation	15. Sea level rise and subsidence
2. Water supply and quality	16. Wildfire management, planning and response
3. River & stream resource management	17. Homeland security, law enforcement, and disaster response
4. Coastal zone management	18. Land navigation and safety
5. Forest resources management	19. Marine navigation and safety
6. Rangeland management	20. Aviation navigation and safety
7. Wildlife and habitat management	21. Infrastructure and construction management
8. Agriculture and precision farming	22. Urban and regional planning
9. Geologic resource assessment and hazard mitigation	23. Health and human services
10. Resource mining	24. Real estate/banking/mortgage/insurance
11. Renewable energy resources	25. Education K-12 and beyond
12. Oil and gas resources	26. Recreation
13. Cultural resources preservation and management	27. Telecommunications
14. Flood risk management	

**Each use case identified the following benefit categories:**

- **Operational Benefits**
- **\$ Benefits**
- **Customer Service Benefits**
- **Public/Social Benefits**
- **Environmental Benefits**
- **Strategic/Political Benefits**

For example, one of seven coastal zone management use cases, determined **“Topographic and bathymetric LiDAR data will improve USGS’ ability to map, and model predicted and actual results of hurricane tidal surges, tsunamis, coastal erosion, and the effects of sea level rise and subsidence in coastal zones that cause billions of dollars annually in property damages.” (Potentially US\$ Billions Benefits and classified Major Benefit).**

**Marine navigation and safety use cases directly evidences the use of seabed mapping and is a useful use case study reference for Seabed 2030.** (Use Case is Navigation and Underwater Recovery).

**Item 3 – NEEA assessed 5 elevation product specifications,** as presented in the graphic below. Please note the benefits use cases and cost benefits analysis considered the

different resolutions products and acquisition approaches LiDAR / IFSAR (Interferometric Synthetic Aperture Radar)/ Imagery (Photogrammetry) etc.

Table 4.2. The five pre-defined topographic data Quality Levels (QLs)

Elevation Quality Levels (QL)	Source	Horizontal Resolution Terms			Vertical Accuracy Terms	
		Point Density	Nominal Pulse Spacing (NPS)	DEM Post Spacing	Vertical RMSEz	Equivalent Contour Accuracy
QL 1	LiDAR	8 pts/m <sup>2</sup>	0.35 m	1/27 arc-sec ~1 meter	9.25 cm	1-ft
QL 2	LiDAR	2 pts/m <sup>2</sup>	0.7 m	1/27 arc-sec ~1 meter	9.25 cm	1-ft
QL 3	LiDAR	1 – 0.25 pts/m <sup>2</sup>	1 – 2 m	1/9 arc-sec ~3 meters	≤18.5 cm	2-ft
QL 4	Imagery	0.04 pts/m <sup>2</sup>	5 m	1/3 arc-sec ~10 meters	46.3 cm – 139 cm	5 – 15 ft
QL 5	IFSAR	0.04 pts/m <sup>2</sup>	5 m	1/3 arc-sec ~10 meters	92.7 cm – 185 cm	10 – 20 ft

It is not the technologies that are emphasised here, but that different approaches can be considered in the use cases and cost benefit analysis. **This provides a candidate approach for Seabed 2030 to adopt should Seabed 2030 wish to compare different acquisition technology approaches.**

**Item 4 – NEEA concluded that the 3DEP can conservatively provide new benefits of \$690 million per year and has the potential to generate \$13 billion per year in new benefits through applications that span the economy (Dewberry, 2012).** The shared lidar, IfSAR, and derived elevation datasets would foster cooperation and improve decision-making among all levels of government and other stakeholders.

The NEEA study identified more than 600 requirements for enhanced (3D) elevation data to address mission-critical information requirements of 34 Federal agencies, all 50 States, and a sample of private sector companies and Tribal and local governments.

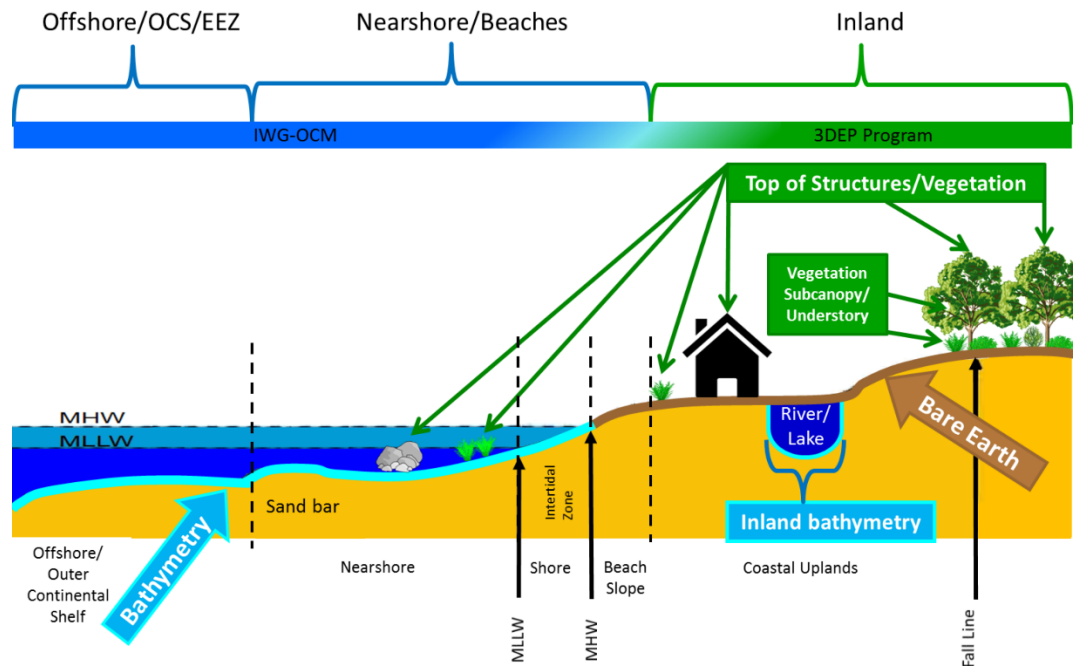
**Of direct relevance to seabed 2030, the NEEA study concludes that seabed mapping is critical for:**

- Navigation
- Underwater recovery
- Forecasting weather, tsunami, and storm surge events.
- Climate change projections; and
- Identifying the outlines of where living marine resources exist.
- Seabed mapping provides the means to uncover the history of our fallen lost at sea and
- A framework for seabed mineral discovery.
- Accurate ocean depths are instrumental in connecting the world through safe navigation and transoceanic communication cables, and
- Critical to emergency response on the high seas.

**Even if these benefits are difficult to quantify, they certainly should be considered as “Major.”**

**Item 5: 3D Nation Study** – this study is WIP and appears to be in validation of findings phase (TBC). **The study will document topographic, coastal, & bathymetric 3D**

elevation data requirements and benefits across a multitude of geographies, as represented in the graphic below.



As with NEEA, the 3D Nation Study approach / methodology is robust and comprehensive and is anticipated to document and evidence details that will be transferrable for use by Seabed 2030 benefits analysis approach.

In particular, the 3D Nation Study engagement questionnaire questions on benefits are useful applying benefits scale category (major, moderate, minor, none, don't know) and requesting participants to complete scenario based evidence for each benefit scenario, e.g., providing details on the numbers of hours saved, numbers of dollars saved, etc.

The questionnaire addresses instances; inland bathymetry, near shore, and offshore use cases. Questionnaire Part 3.4 (Page 111 of 144) and provides detailed engagement questions on offshore scenarios and use cases. These are directly relevant to Seabed 2030.

Benefits are defined as:

- Operational Benefits Time savings, Cost savings or cost reduction (i.e., savings on purchases), Cost avoidance Increased revenues to the organisation, Mission-driven performance improvements
- Customer Service Benefits, Value added to products or services, Improved response or Timeliness, Improved customer experience
- Societal Benefits, Education, or outreach
- Environmental benefits
- Public safety, including life and property



Seabed 2030 Recommendation	<p>USA NEEA offers a comprehensive engagement approach to both identify benefit use cases, and a comprehensive approach to cost benefit analysis, including comparing cost benefits analysis for different technical approaches, and follows a use case based assessment approach.</p> <p>Of direct relevance to seabed 2030, the NEEA study concludes that seabed mapping is critical for:</p> <ul style="list-style-type: none"> <li>• Navigation</li> <li>• Underwater recovery</li> <li>• Forecasting weather, tsunami, and storm surge events.</li> <li>• Climate change projections; and</li> <li>• Identifying the outlines of where living marine resources exist.</li> <li>• Seabed mapping provides the means to uncover the history of our fallen lost at sea and</li> <li>• A framework for seabed mineral discovery.</li> <li>• Accurate ocean depths are instrumental in connecting the world through safe navigation and transoceanic communication cables, and</li> <li>• Critical to emergency response on the high seas.</li> </ul> <p>And concludes that “even if these benefits are difficult to quantify, they certainly should be considered as “Major”.”</p> <p>As with NEEA the <b>3D Nation Study approach / methodology is robust and comprehensive</b> and is anticipated to document and evidence details that will be transferrable for use by Seabed 2030 benefits analysis approach.</p> <p>In particular, the engagement questionnaire questions on benefits are useful applying benefits scale category (major, moderate, minor, none, don’t know) and requesting participants to complete scenario based evidence for benefits, based on numbers of hours saved, numbers of dollars saved, etc.</p> <p>The questionnaire addresses instances inland bathymetry, near shore, and offshore use cases. Questionnaire Part 3.4 (Page 111 of 144) provides detailed engagement questions on offshore scenarios and use cases. These are directly relevant to Seabed 2030.</p>
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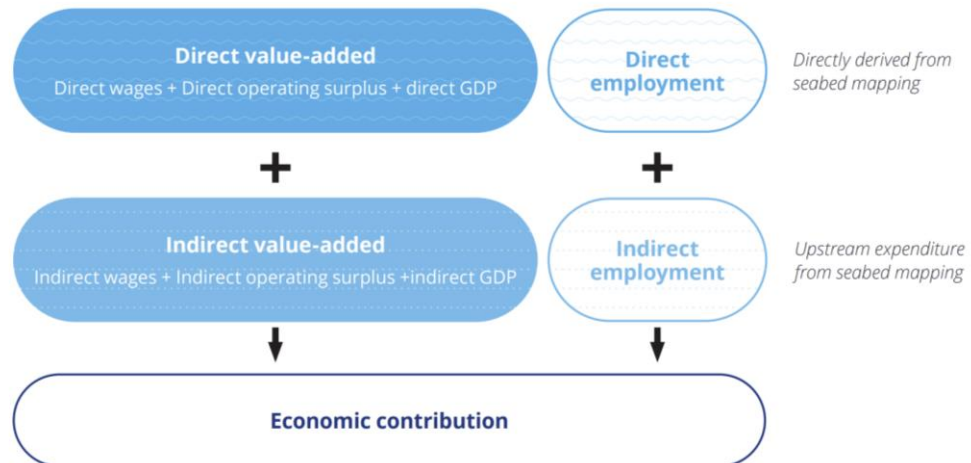
**Australia: The value of Australian seabed mapping data to the blue economy, October 2021, study by Deloitte commissioned by Geoscience Australia.**

<b>Benefit Model Source/Title</b>	Australia: The value of Australian seabed mapping data to the blue economy, October 2021, study by Deloitte commissioned by Geoscience Australia.
<b>Website URL</b>	See here: <a href="https://www2.deloitte.com/au/en/pages/economics/articles/value-of-australian-seabed-mapping-data-to-blue-economy.html">https://www2.deloitte.com/au/en/pages/economics/articles/value-of-australian-seabed-mapping-data-to-blue-economy.html</a>
<b>Objectives</b>	Geoscience Australia recognised that Seabed mapping data is essential to the establishment and operation of many marine industries that significantly contribute to Australia’s economic growth. In order to showcase the value of this data to the Australian economy, Deloitte Access Economics was commissioned by Geoscience

	Australia to analyse the role of seabed mapping in the Australian economy, including its supply chain and employment effects.
<b>Scope</b>	<p>This report seeks to present the current economic and environmental significance of seabed mapping data in Australia and the potential economic benefits that could be unlocked with investment in a national seabed mapping program. The report:</p> <ul style="list-style-type: none"> <li>• Defines seabed mapping in the Australian context and explores how the industry has developed over time.</li> <li>• Discusses how seabed mapping is used to create economic value.</li> <li>• Defines the industries producing seabed mapping data in Australia.</li> <li>• Defines the boundaries of the key industries and businesses that use seabed mapping data.</li> <li>• Presents the economic contribution of seabed mapping data facilitated through key industry users and data production activities.</li> <li>• Presents the broader social and environmental benefits seabed mapping contributes to Australia.</li> <li>• Presents 'what's next' for the seabed mapping industry and how a growing data pipeline, increased adoption rate and new applications of data can further increase the value seabed mapping data contributes to the Australian economy.</li> </ul>
<b>Highlights</b>	<p>The study team wish to highlight six items from the Ausbed methodology and approach to Seabed mapping economic value assessment, and prioritisation, with each item set out below:</p> <p><b>Item 1 Key findings:</b> As reported on the report website "Seabed mapping data enables economic activity in commercial fishing, tourism, national defence, water transport, oil exploration, search and rescue, and marine research and environmental protection by using the data for navigation, exploration, and research. <b>The application of this data in these fields directly contributed \$9 billion to the Australian economy and employed over 56,000 FTEs in 2018-19.</b> This direct contribution is larger than the size of the rental and hiring services sector.</p> <p>Australia's blue economy is an area with strong potential for economic growth; however, <b>three quarters of the Australian seabed is yet to be mapped to an adequate resolution to assist businesses and governments in decision making. This data deficit is constraining economic activity and should be addressed to enable Australia's blue economy to thrive.</b></p> <p>To assist in filling this gap and opening up the availability of collected data to end-users, Australian seabed mapping stakeholders have <b>identified the need for a national mapping program, to centrally manage and distribute existing and new seabed mapping data products.</b></p> <p><b>As new high-resolution data becomes available, it is expected to unlock new activity as end-users can effectively plan and strategize around this new fundamental information – highlighting seabed mapping data as a key to the future growth of the blue economy."</b></p> <p><b>Item 2: The economic value assessment methodology adopted is comprehensive.</b> Highlights include:</p>

- Two industry community engagement surveys were used focussing on users and producers, (i) *data user survey* and (ii) *data producer survey*
- Economic Contribution analysis included both direct value-added and indirect value added elements – as presented in the graphic below

Figure 6.1 Economic contribution analysis



Source: Deloitte Access Economics

And reported the following key results:

- Activities directly involved in **producing seabed mapping data directly contributed \$51 million to the Australian economy in 2018-19 and created 500 jobs.**
- The **direct economic contribution of seabed mapping data use was \$9 billion in 2018-19.**
- The **use of seabed mapping data also directly contributed over 56,000 jobs (FTEs) to the Australian economy in 2018-19.**
- The **use of seabed mapping data creates demand for upstream activities, contributing a further \$7 billion in indirect value added to the economy in 2018-19.**
- In addition to these figures, there was \$37 billion of unlocked economic activities in 2018-19 that were enabled by the use of seabed mapping data during establishment.

Note consideration of direct, indirect, and upstream activities.

Economic Value by sub-sector was analysed and reported, with subsectors including: *Partaking in seabed mapping data use*

- Defence
- Tourism Protection
- Water Transport
- Commercial Fishing
- Oil Exploration
- Search and Rescue

- Marine research and environmental protection

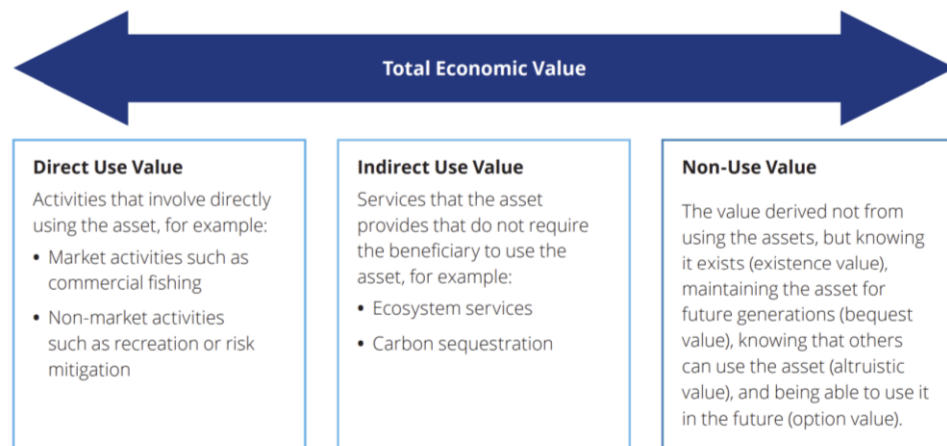
And, value-added by sub-sector whose activities are unlocked by seabed mapping data use:

- Oil and gas exploration
- Aquaculture

**Item 3 Broader impacts of seabed mapping were considered**, recognising that additional environmental, cultural, social and sovereignty benefits are delivered through Australia's seabed, economic benefits that go beyond the economic contribution in normal market activity.

This builds towards a Total Economic Value as presented in the graphic below:

Figure 7.1 Total economic value framework



Source: Deloitte Access Economics

Interesting context case studies are presented, including Great Barrier Reef, Shipwreck discovery, and the use of RV Investigator to extend Australia's maritime territory.

- Environmental Impacts consider environmental management and research and coastal protection and management
- Social and Cultural Impact considers traditional owner value, maritime safety and risk management, and shipwreck discovery and protection, and
- Sovereign rights are considered, where seabed mapping helps with the identification and enforcement of marine boundaries

**Item 4: The report Annex A presents the economic contribution methodology and Annex B presents the Economic Contribution Framework adopted.** This represents a candidate economic value assessment methodology that Seabed 2030 can apply and tailor for 'High Seas' context.

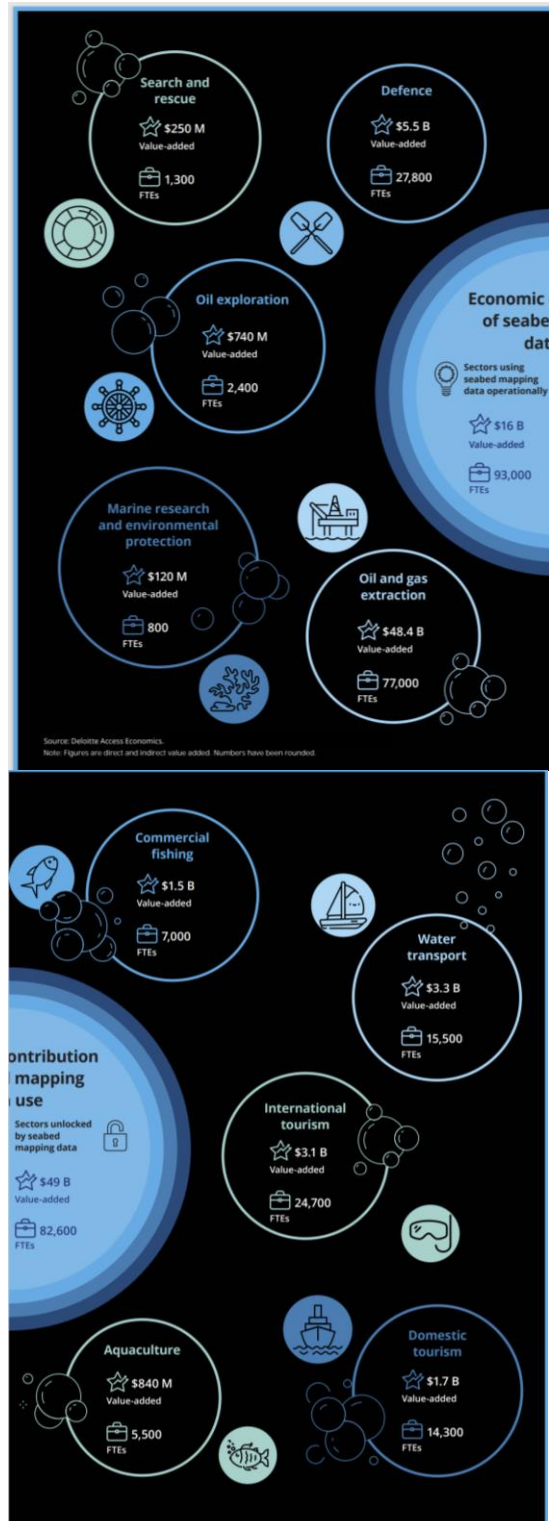
**Item 5: Use of AusSeabed Coordination Tool to address national priority rankings, based on 3 categories:**

- Urgent (1-2 years)
- Mid-term (2-5 years)

- Long-term (5-10 years)

The Ausbed team has provided Seabed 2030 has been provided with a draft storyboard of the Ausbed prioritisation workflow for ongoing reference / use.

**Item 6: The centre page graphic is compelling and visually useful way to present sub-sector economic values, please see a copy of the graphic below.**



<b>Seabed 2030 Recommendation</b>	<p>The Ausbed economic value methodology is comprehensive but is focussed on internal EEZ related use cases, benefits, costs, and economic value assessment. The report Annex A presents the economic contribution methodology and Annex B presents the Economic Contribution Framework adopted. This represents a candidate economic value assessment methodology that Seabed 2030 can apply and tailor for 'High Seas' context.</p> <p>Note: there is a need for Seabed 2030 to consider global as opposed to national economic value.</p> <p>The Ausbed prioritisation tool offers 3 priority ranking categories that could be used by Seabed 2030, including:</p> <ul style="list-style-type: none"> <li>• Urgent (1-2 years)</li> <li>• Mid-term (2-5 years)</li> <li>• Long-term (5-10 years)</li> </ul> <p>The Ausbed team has provided Seabed 2030 has been provided with a draft storyboard of the Ausbed prioritisation workflow for ongoing reference / use.</p> <p>The centre page graphic is compelling and a visually useful way to present sub-sector economic values and could be repurposed for Seabed 2030.</p>
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**Ireland: Price Waterhouse Coopers (2008). INFOMAR Marine Mapping Study. Options Appraisal Report: Final Report 30 June 2008. Marine Institute, Ireland.**

<b>Benefit Model Source/Title</b>	<b>Ireland: Price Waterhouse Coopers (2008). INFOMAR Marine Mapping Study. Options Appraisal Report: Final Report 30 June 2008. Marine Institute, Ireland.</b>
<b>Website URL</b>	See here: See here: <a href="https://oar.marine.ie/handle/10793/1652">https://oar.marine.ie/handle/10793/1652</a>
<b>Objectives</b>	<p>PWC terms of reference for the project were: To fulfil the NDP Value for Money reporting requirements for Large Capital Projects (&gt;€30 million), PricewaterhouseCoopers (PwC) were commissioned by the Department of Communications, Energy and National Resources (DCENR) to undertake a detailed appraisal of the INFOMAR project. The appraisal is to be carried out in line with the requirements of the 'Guidelines for the Appraisal and Management of Capital Expenditure Proposals in the Public Sector (February 2005)'.</p> <p>PWCs appraisal essentially provided a cost benefits analysis for the Infomar programme (3 options considered and compared).</p>
<b>Scope</b>	<p>The Integrated Mapping for the Sustainable Development of Ireland's Marine Resource (INFOMAR) programme is Ireland's national marine mapping programme.</p> <p>The focus of the INFOMAR programme is to create a range of integrated mapping products of the physical, chemical, and biological features of the seabed, in the near-shore (Zone 1, 0m to 50m) area and building on previous INSS offshore survey area (Zone II, 50m to 200m), to complete the mapping programme for the entirety of Ireland's off-shore waters. Against this background, and to fulfil the NDP Value for Money reporting requirements for Large Capital Projects (&gt;€30 million), PricewaterhouseCoopers (PwC) were commissioned by the Department of</p>

	<p>Communications, Energy and National Resources (DCENR) to undertake a detailed appraisal of the INFOMAR project. The methodology for undertaking the appraisal involved both primary and secondary research, including extensive consultation with stakeholders of the INFOMAR. A range of options for the INFOMAR programme were identified and appraised in financial and qualitative terms and are presented within this report.</p>
<b>Highlights</b>	<p>The study team wish to highlight six items from the PWC Infomar methodology, with each item set out below:</p> <p>Item 1: This specific Infomar report has been included in the review should Seabed 2030 wish to investigate and compare costs / benefits for different implementation options. The PWC report provides a comprehensive cost benefit analysis approach, methodology and working example that seabed 2030 could adopt and tailor for their purposes.</p> <p>Item 2: Building on from item 1, the PWC report presents a methodology that could be followed, addressing:</p> <ul style="list-style-type: none"> <li>• Summary Project Status Review</li> <li>• Assessment of a Project Needs and Objectives of the project.</li> <li>• Identification of Potential Constraints (to project success)</li> <li>• Identification of the main project options</li> <li>• Financial Cost calculation for options</li> <li>• Benefits assessment for options, including discussion of monetary and non-monetary factors</li> <li>• Risk Analysis and contingencies (for Options)</li> <li>• Cost Benefit Analysis; and</li> <li>• Presentation of a Preferred Option</li> </ul> <p>Infomar options descriptions included:</p> <ul style="list-style-type: none"> <li>• Option 1: Do minimum – continue the project for the remainder of the current funding period (i.e., until December 2008)</li> <li>• Option 2: Complete Priority Areas only – complete the mapping of the 26 priority bays and 3 priority coastal areas (Phase 1). This would also include implementation of other GSI/MI aspects of the overall Strategy as far as possible. It was anticipated this would be completed by 2016.</li> <li>• Option 3: INFOMAR Strategy in full – this includes mapping of phases 1 and 2 and the implementation of other GSI/MI components of the strategy across Programmes 1, 2 and 3. It was anticipated this would be completed by 2016</li> <li>• Option 4: INFOMAR Strategy in full, phased – this is similar to option 3 above, but only the Phase 1 mapping would be completed by 2016 and Phase 2 mapping would be completed by 2026. Other INFOMAR programmes would be implemented over the extended time period.</li> </ul> <p>Item 3: The Infomar methodology provides useful detail that Seabed 2030 will find helpful towards cost estimation, e.g., appendix 1 presents detailed cost estimations (by options) - noting 2008 currency of the report, the cost estimation approach is informative.</p>



	<p>The PWC Infomar process identified benefits (both direct and indirect), and were categorised as follows:</p> <ul style="list-style-type: none"> <li>• Commercial/ Resource Benefits (Indirect Benefits).</li> <li>• Knowledge Economy (Direct and Indirect Benefits).</li> <li>• Legislative requirements and obligations (Indirect Benefits); and</li> <li>• Environmental Benefits (Not Quantified).</li> </ul> <p>For example, commercial benefits identified include:</p> <p style="text-align: center;"><b>Table 7.1: Summary of commercial benefits</b></p> <table border="1"> <thead> <tr> <th>Industry</th><th>Benefit</th></tr> </thead> <tbody> <tr> <td>Fishing</td><td> <ul style="list-style-type: none"> <li>• Efficiencies</li> <li>• Reduction in gear loss</li> <li>• Ability to identify and protect fish spawning and nursery areas</li> </ul> </td></tr> <tr> <td>Aquaculture</td><td> <ul style="list-style-type: none"> <li>• Selection of appropriate sites for cultivation</li> </ul> </td></tr> <tr> <td>Biodiversity</td><td> <ul style="list-style-type: none"> <li>• Mapping/ identification of commercially exploitable species e.g. seaweed</li> </ul> </td></tr> <tr> <td>Energy</td><td> <ul style="list-style-type: none"> <li>• Suitable locations for wind farms</li> <li>• Off shore oil industry site studies</li> <li>• Cables and pipeline routes</li> <li>• Tidal energy</li> <li>• Wave Energy (still at R&amp;D stage)</li> </ul> </td></tr> <tr> <td>Aggregates</td><td> <ul style="list-style-type: none"> <li>• Potential commercial value of utilisation of marine aggregates</li> </ul> </td></tr> <tr> <td>Tourism/leisure</td><td> <ul style="list-style-type: none"> <li>• Development of sailing routes/ angling/ diving</li> </ul> </td></tr> </tbody> </table> <p>Item 5: The Infomar methodology provides a detailed Net Present Value (NPV) calculation reference case – see appendix 2.</p> <p>Item 6: The infomar methodology provides a candidate methodology for options review (e.g., in the case of Infomar considering low impact, medium impact and high impact option scenarios).</p> <p>Item 7: This methodology provides a Cost benefit analysis that can potentially inform the Seabed 2030 prioritisation approach.</p>	Industry	Benefit	Fishing	<ul style="list-style-type: none"> <li>• Efficiencies</li> <li>• Reduction in gear loss</li> <li>• Ability to identify and protect fish spawning and nursery areas</li> </ul>	Aquaculture	<ul style="list-style-type: none"> <li>• Selection of appropriate sites for cultivation</li> </ul>	Biodiversity	<ul style="list-style-type: none"> <li>• Mapping/ identification of commercially exploitable species e.g. seaweed</li> </ul>	Energy	<ul style="list-style-type: none"> <li>• Suitable locations for wind farms</li> <li>• Off shore oil industry site studies</li> <li>• Cables and pipeline routes</li> <li>• Tidal energy</li> <li>• Wave Energy (still at R&amp;D stage)</li> </ul>	Aggregates	<ul style="list-style-type: none"> <li>• Potential commercial value of utilisation of marine aggregates</li> </ul>	Tourism/leisure	<ul style="list-style-type: none"> <li>• Development of sailing routes/ angling/ diving</li> </ul>
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Aquaculture	<ul style="list-style-type: none"> <li>• Selection of appropriate sites for cultivation</li> </ul>														
Biodiversity	<ul style="list-style-type: none"> <li>• Mapping/ identification of commercially exploitable species e.g. seaweed</li> </ul>														
Energy	<ul style="list-style-type: none"> <li>• Suitable locations for wind farms</li> <li>• Off shore oil industry site studies</li> <li>• Cables and pipeline routes</li> <li>• Tidal energy</li> <li>• Wave Energy (still at R&amp;D stage)</li> </ul>														
Aggregates	<ul style="list-style-type: none"> <li>• Potential commercial value of utilisation of marine aggregates</li> </ul>														
Tourism/leisure	<ul style="list-style-type: none"> <li>• Development of sailing routes/ angling/ diving</li> </ul>														
<b>Seabed 2030 Recommendation</b>	<p>This specific PWC Infomar report has been included in the review should Seabed 2030 wish to investigate and compare costs / benefits for different implementation options. The PWC report provides a comprehensive cost benefit analysis approach, methodology and working example that seabed 2030 could adopt and tailor for their purposes. It could also potentially inform the Seabed 2030 prioritisation approach.</p>														

**Global Ocean Observing System (GOOS) in the Intergovernmental Oceanographic Commission of UNESCO.**

<b>Benefit Model Source/Title</b>	<p><b>UK: (i) Value Chains in Public Marine Data: A UK Case Study - A joint OECD Working Paper in collaboration with the UK Marine Environmental Data and Information Network (MEDIN) and the Global Ocean Observing System (GOOS) in the Intergovernmental Oceanographic Commission of UNESCO.</b></p> <p><b>And (ii) the use of UK HMG Green Book for Appraising Public Value.</b></p>
<b>Website URL</b>	<p>(i) <a href="https://www.oecd-ilibrary.org/science-and-technology/value-chains-in-public-marine-data_d8bbdcfa-en">https://www.oecd-ilibrary.org/science-and-technology/value-chains-in-public-marine-data_d8bbdcfa-en</a></p> <p>(ii) <a href="https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-government">https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-government</a></p>
<b>Objectives</b>	<p>This study applies a UK HMG methodology to assign public value for MEDIN, and the Green Book methodology brings together the Green Book approach to appraising public value with the UK HMG Cabinet Office, Infrastructure and Projects Authority (IPA) project assurance, and the latest commercial standards and procurement methodologies from the Crown Commercial Service (CCS).</p>
<b>Scope</b>	<p>The Value Chains in Public Marine Data Study provides a useful example of a cost-benefit analysis methodology applied to a key marine programme in this instance for the Marine Environmental Data and Information Network (MEDIN).</p> <p>The (2020 updated version) Green Book methodology brings together the Green Book approach to appraising public value with the Cabinet Office, Infrastructure and Projects Authority (IPA) project assurance, and the latest commercial standards and procurement methodologies from the Crown Commercial Service (CCS). It also supports Treasury spending scrutiny and approval processes. It is best practice methodology and should be used by those responsible for using public resources in developing proposals to scope, analyse, plan, procure and manage delivery to achieve best value</p>
<b>Highlights</b>	<p>The Value Chains in Public Marine Data Study uses a cost – benefit analysis methodology for MEDIN, with a copy of the final report available here: <a href="https://medin.org.uk/sites/medin/files/documents/MEDIN%20Cost%20Benefit%20Analysis_Final%20Report.pdf">https://medin.org.uk/sites/medin/files/documents/MEDIN%20Cost%20Benefit%20Analysis_Final%20Report.pdf</a></p> <p>The MEDIN cost benefit analysis study states, “As the benefits are not directly financial, other measurement tools must be used to provide evidence of the impact that MEDIN is having. The challenge here is in understanding the use of MEDIN and the benefits being received, quantifying them, and calculating a monetary value, to be compared against the financial and other costs associated with MEDIN. The study is designed to explicitly consider financial and time costs and savings within the assessment framework, but also considers more difficult to measure benefits qualitatively.</p> <p><i>Further, to undertake a cost benefit analysis, the following steps need to be taken:</i></p>

**1. Scope and Baseline** - Defining the scope of the analysis involves identifying the geographical boundary, beneficiaries, list of costs and benefits and the time scale over which the costs and benefits will be assessed. In the baseline, the counterfactual scenario (i.e., the case without the intervention) against which changes in the costs and benefits are measured is defined.

**2. Identify costs and benefits** - Identify the main costs and benefits related to the intervention. The Green Book recommends that “all relevant costs and benefits which may arise from an intervention should be valued and included in Social CBA unless it is not proportionate to do so.” (HM Treasury, 2018).

**3. Quantify, monetise, and measure costs and benefits** - The costs and benefits are then quantified and monetised. This allows for their comparison as they will be in the same unit of measure, money, to gain understanding of their relative scale.

**4. Compare costs and benefits** - In the CBA model, the annual costs and benefits over the assessment period are aggregated into present value (discounted) terms. The net present value (NPV) of an intervention is calculated as the difference between present value of the benefits (PVB) and the present value of the costs (PVC). A benefit to cost ratio (BCR) can also be produced which is calculated as the ratio between the PVB and the PVC.

**5. Sensitivity analysis** - Sensitivity analysis is a fundamental aspect of the assessment and is used to determine how various assumptions used can affect the overall results of the study. This can be important to provide credibility for the assessment.

**6. Reporting and interpretation** - Interpretation of the results of the analysis and ensuring that any limitations and caveats are clearly evidenced when reporting.”

**The above is based on UK HMG cost benefit analysis methodology as applied in the Green Book**, see here: <https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-government>. The Green Book itself presents a useful benchmarking methodology for Seabed 2030 reference, for appraising public value and is the UK HMG best practice adopted approach for major programmes and projects.

The (2020 updated version) Green Book methodology brings together the Green Book approach to appraising public value with the Cabinet Office, Infrastructure and Projects Authority (IPA) project assurance, and the latest commercial standards and procurement methodologies from the Crown Commercial Service (CCS). It also supports Treasury spending scrutiny and approval processes. It is best practice methodology and should be used by those responsible for using public resources in developing proposals to scope, analyse, plan, procure and manage delivery to achieve best value. Noter that the Green Book applies a ‘Five Case Model’ to policies, strategies, programmes, and projects which comprises five key dimension to appraising public value: **(i) The Strategic Case, (ii) The Economic Case, (iii) The Commercial Case, (iv) The Financial Case, and (v) the Management Case.**

And useful contextual cross references are made to wider studies, including:

	<p>(i) Integrated Ocean Observing System: NOAA 'benefits of ocean observing catalogue': see here: <a href="https://ioos.noaa.gov/ioos-in-action/benefits-of-ocean-observing-catalog/">https://ioos.noaa.gov/ioos-in-action/benefits-of-ocean-observing-catalog/</a></p> <p>(ii) Geo Blue Planet, see here: <a href="https://geoblueplanet.org/">https://geoblueplanet.org/</a> for which part of its mission is to raise awareness of the societal benefits of ocean observations at the public and policy levels.</p>
<b>Seabed 2030 Recommendation</b>	Benefits analysis methodology is informed by this report and its approach. Should Seabed 2030 adopt a cost benefit analysis approach this provides a best practice methodology that could be applied for Seabed 2030.

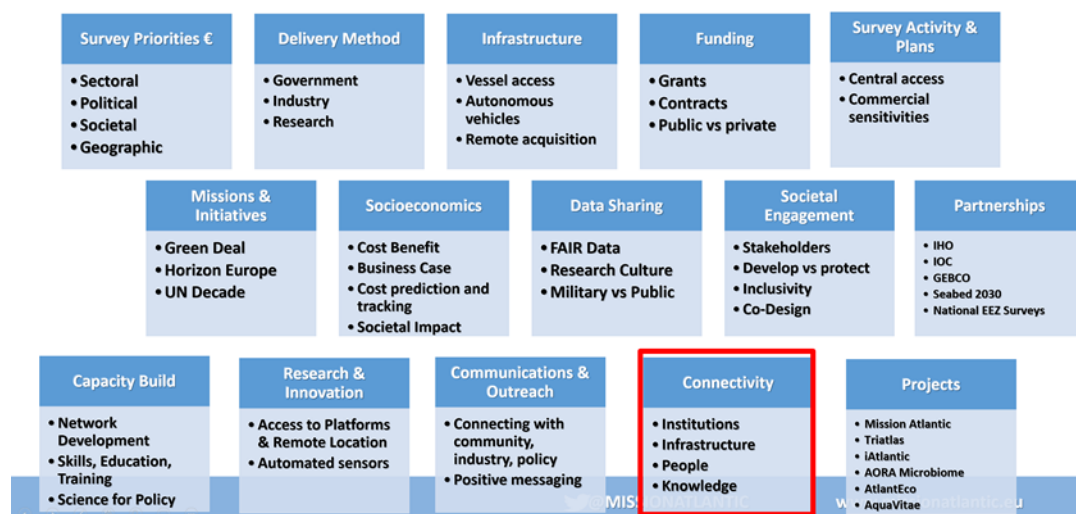
### Atlantic Ocean Research Alliance (AORA) related seabed mapping - Atlantic Mapping Framework

<b>Benefit Model Source/Title</b>	<b>Atlantic Ocean Research Alliance (AORA) Related Seabed Mapping - Atlantic Mapping Framework</b>
<b>Website URL</b>	<p>See here: <a href="https://www.infomar.ie/maps/story-maps/aora-mapping-atlantic">https://www.infomar.ie/maps/story-maps/aora-mapping-atlantic</a></p> <p>For AORA Roadmap document, see here: <a href="https://oar.marine.ie/handle/10793/1596?show=full">https://oar.marine.ie/handle/10793/1596?show=full</a></p>
<b>Objectives</b>	AORA has adopting a systematic approach with an underpinning strategic framework to realising seabed mapping of the Atlantic.
<b>Scope</b>	<p>The Atlantic Seabed Mapping International Work Group (Seabed Mapping Group) is conducted through the Atlantic Ocean Research Alliance (AORA) between Canada, the European Union, and the United States of America. The progress and vision towards achieving a baseline seabed and habitat map of the Atlantic Ocean, has been captured and a roadmap produced. The Seabed Mapping Group has, in the last five years, defined and tested all the necessary steps to map the previously uncharted seafloor of the Atlantic Ocean. With the onset of the UN Decade of Ocean Science for Sustainable Development, the Seabed Mapping Group calls on the international leaders to provide the resources and framework necessary to achieve this ambitious goal, in order to deliver on their commitment to the Galway and Belém Statements. The group recognises that creating an accurate fact based map of the Atlantic seafloor is essential for the sustainable use of our ocean and will greatly help us to achieve the UN Sustainable Development Goal.</p> <p>AORA is adopting a systematic approach to realising seabed mapping of the Atlantic. Through their Mission Atlantic WP4 Task 4.1 a strategic framework for Atlantic bathymetry and benthic habitat mapping to address key aspects of seabed mapping (addressing both bathymetry and benthic mapping). The highlights below identify 4 items of synergy and potential cooperation between AORA and Seabed 2030 with respect to benefits analysis and seabed mapping prioritisation planning methodologies.</p>
<b>Highlights</b>	The study team wish to highlight four areas of AORA methodology and approach to Seabed mapping planning, and investment decision-making, with each item set out below:

**Item 1:** AORA has adopted a systematic approach to realise seabed mapping of the Atlantic, and within the establish the following strategic framework to underpin its delivery.

• **Task 4.1 Strategic framework for Atlantic Bathymetry & Benthic Habitat Mapping for IEA (MI)**

- Assess and share Atlantic survey operational activities, strategies and plans, and develop an all Atlantic strategy to steer bathymetry and benthic habitat mapping activity, & data sharing, leveraging new data in support of IEA.



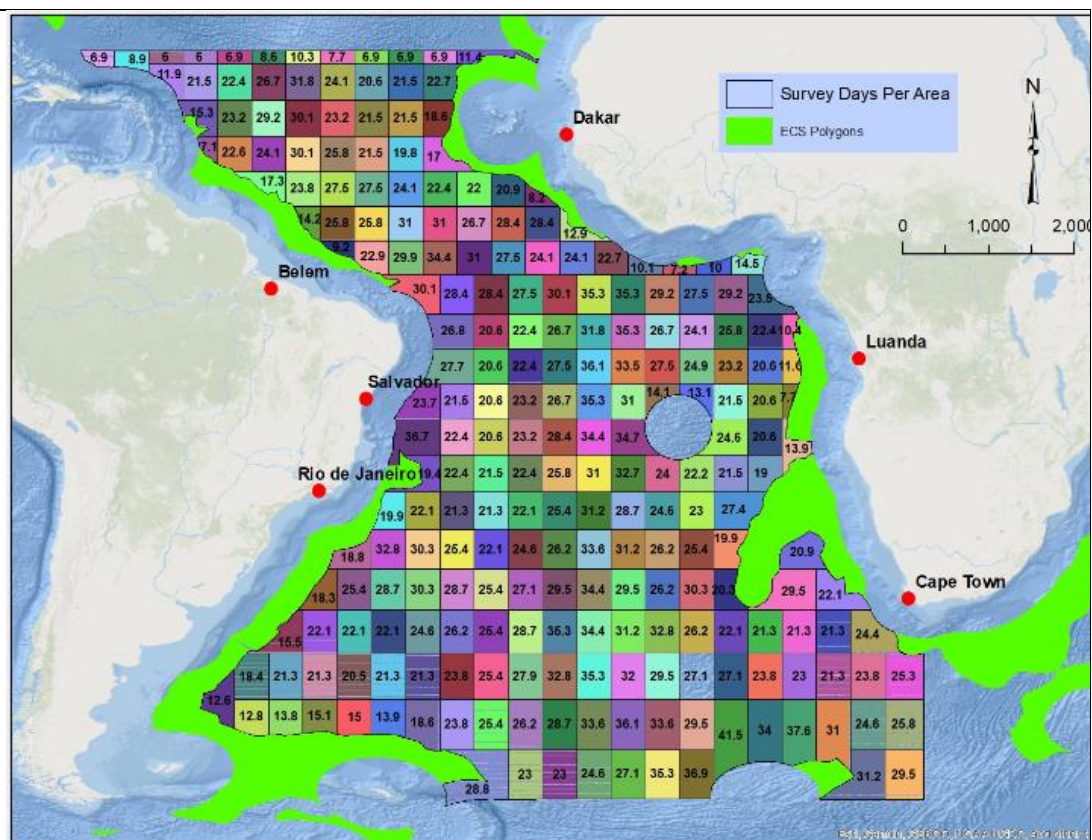
Please note six task areas that are directly applicable to the study:

- (i) Survey priorities
- (ii) Funding
- (iii) Survey activities and plans
- (iv) Socioeconomics (including cost benefit, business case, cost prediction and tracking and societal impact)
- (v) Partnership (which include Seabed 2030), and
- (vi) Communications and outreach

All of which present opportunities for cooperation with Seabed 2030 and to inform the benefits assessment and prioritisation approach for Seabed 2030

**Item 2:** Aligned with Seabed 2030 ‘high seas’ and the scope / purpose of this study, AORA has identified the following areas to be mapped outside of territorial waters





The map tiles identify the survey days per area and is a robust and easy to understand way to inform the cost elements of benefits analysis (economic assessment). If Seabed 2030 can develop a benefits analysis model that adopts a spatially orientated 'map tile' stakeholders will be able to rapidly search, and visualise benefits, and thereafter inform prioritisation using a visual range colour ramp key.

**Item 3:** The AORA Framework for Atlantic Bathymetry & Benthic Habitat Mapping next steps include:

1. Build south, across projects, & across disciplines
2. Collate Atlantic mapping initiatives, activities, priorities
3. Identify & expand Atlantic survey operational stakeholders & mapping
4. Collate published survey guidelines, SOPs, best practice data acquisition protocols.
5. Capture Atlantic mapping data workflows, (acquisition platform – processing - archiving – sharing)
6. Assess funding models & opportunities to drive the Atlantic Mapping Agenda
7. Continue acknowledging the collective effort & ambition of the Atlantic mapping community & supporters

Items 2, 3, 4, and 6 are recommended for Seabed 2030 to engage on to inform Seabed 2030 forward pathway with respect to the Atlantic geography.

**Item 4:** AORA is currently preparing a report titled and addressing the 'Atlantic Bathymetry and Benthic Mapping Framework' and is due for imminent release. This report will offer an opportunity for Seabed 2030 to engage and rapidly be informed on the planned way forward regarding seabed mapping for the Atlantic geography.

	<p>Noting section 5 of the report addresses:</p> <p>“Why Should We Invest in this and who should pay for it?</p> <ul style="list-style-type: none"> <li>o Cost Benefit Analysis / Approaches (ref side event)</li> <li>o Direct infrastructure &amp; funding to target priorities</li> <li>o Funding mechanisms, challenges, options”</li> </ul>
<b>Seabed 2030 Recommendation</b>	<p>Both Seabed 2030 benefits analysis and mapping prioritisation can be informed by the AORA systematic approach adopted towards the realisation of seabed mapping. It is recommended that Seabed 2030 engages and aligns with AORA Atlantic Bathymetry &amp; Benthic Habitat Mapping next steps activities.</p> <p>Seabed 2030 could adopt the AORA map tile approach for cost assessment (spatially orientated) and use this to build up and present a benefit assessment visualisation.</p> <p>AORA is imminently producing a report titled and addressing the ‘Atlantic Bathymetry and Benthic Mapping Framework’ which is directly relevant to seabed 2030 and will potentially be able to inform and guide Seabed 2030 work on benefits analysis and prioritisation.</p>



#### 4.2.2 Premium Models Search Category 3: Benefits analysis experience drawn from the wider geospatial public sector.

Benefits model key features tables are provided for the following premium benefits models as applied by federal government bodies to inform their geospatial data policy and related investment decisions.

#### **An Initial Analysis of the Potential Geospatial Economic Opportunity, 2018, study by HMG Cabinet Office.**

<b>Benefit Model Source/Title</b>	<p><b>An Initial Analysis of the Potential Geospatial Economic Opportunity, 2018, study by HMG Cabinet Office, supported by Boston Consulting Group.</b></p> <p>With subsequent supplementary work undertaken by Frontier Economics study for Cabinet Office: <b>Geospatial Data Market Study - Report for the Geospatial Commission, September 2020, study by Frontier Economics commissioned by HMG Cabinet Office.</b></p>
<b>Website URL</b>	<p>Geospatial Commission - An Initial Analysis of the Potential Geospatial Economic Opportunity document can be accessed here: <a href="https://www.gov.uk/government/news/government-launch-call-for-evidence-to-be-geospatial-world-leader">https://www.gov.uk/government/news/government-launch-call-for-evidence-to-be-geospatial-world-leader</a></p> <p>Also see blog release by research team, see here: <a href="https://quarterly.blog.gov.uk/2018/03/28/location-location-location-tapping-the-economic-potential-of-geospatial-data/">https://quarterly.blog.gov.uk/2018/03/28/location-location-location-tapping-the-economic-potential-of-geospatial-data/</a></p> <p>With subsequent supplementary work undertaken by Frontier Economics study for Cabinet Office: <b>Geospatial Data Market Study - Report for the Geospatial Commission, September 2020, study by Frontier Economics commissioned by HMG Cabinet Office.</b></p> <p>See here: <a href="https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/937025/Frontier_Economics_-_Geospatial_Data_Market_Study.pdf">https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/937025/Frontier Economics - Geospatial Data Market Study.pdf</a></p> <p>and here: <a href="https://www.gov.uk/government/publications/enhancing-the-uks-geospatial-ecosystem/frontier-economics-geospatial-data-market-study-report-executive-summary">https://www.gov.uk/government/publications/enhancing-the-uks-geospatial-ecosystem/frontier-economics-geospatial-data-market-study-report-executive-summary</a></p>
<b>Objectives</b>	<p>This document sets out the initial high-level analysis which contributed to the Government's announcement of the creation of a Geospatial Commission in the 2017 Autumn Budget. This study by HMG Cabinet Office provides the findings on the potential size of the (UK) economic opportunity from better use of geospatial data. The purpose of this work was to provide a 'size of the prize' estimate and an understanding of the kinds of interventions government will need to consider in order to unlock value.</p>
<b>Scope</b>	<p>This was one of the key studies that informed the development of the UK National Geospatial Strategy. Amongst other elements the study provided a provided a bottom-up economic analysis of the opportunities in the public and private sectors, relating to the better use and exploitation of geospatial data.</p>

<b>Highlights</b>	<p>This study was comprehensive and was completed by HMG Cabinet Office with consulting support from the Boston Consulting Group and further with input from a range of government departments, arm's length bodies and external geospatial data users.</p> <p>Amongst other elements the study provided a bottom-up economic analysis of the opportunities in the public and private sectors. There were many suggestions for how geospatial could be used more effectively, but it was critical to keep the approach grounded in evidence and analysis. Through extensive user engagement and case studies, we developed an economic case for reform that suggested a £6 billion to £11 billion per annum opportunity in the private sector alone. This valuation was done according to the Green Book, HM Treasury's guidance on policy, project and programme appraisal and evaluation, and was signed off by HMT. The economic case also allowed us to develop a number of actions for 'unlocking' this value, creating a potential plan of work for the new body. This then fed into our understanding of what capabilities would be needed.</p> <p>Boston Consulting reported, "Estimating the value of data is notoriously difficult given inherent uncertainty in the rate of development and diffusion of new technologies and their resulting impact. To provide Government with a potential "size of the prize" and an understanding of where in the economy this value might be realised, this analysis has taken a use case based approach. The analysis has focussed on the additional economic value that could be unlocked across the UK. In order to avoid double counting or economic transfers and to maintain consistency with HMT Green-book principles, the analysis focussed on productivity impacts:</p> <ul style="list-style-type: none"> <li>• Labour / time savings – e.g., reduced search time, reduced unplanned delay, process automation</li> <li>• Fuel savings – e.g., in route-optimisation</li> <li>• Material savings – e.g., reduced error rates in construction, avoided consumables</li> </ul> <p>The analysis did not look at the investment required or the funding model for these initiatives, this should be analysed with broader consultation of the public and private sector specific opportunities a future Commission or government agency might consider. These would be subject to individual business cases, regulatory assessments and other analysis as required. This analysis has used publicly available sources where possible. In particular, use has been made of three publicly available studies of the value of geospatial data in the New Zealand, Canada and Australia and the Shakespeare Report (2013) in the UK. While these studies had different purposes and were not necessarily focussed on how government might unlock additional value, they do provide useful input and context for this work.</p> <p>In order to estimate the potential impact, a three step approach was used:</p> <p><b>Identify use cases:</b> A range of known use cases were identified. This was done through interviews with government agencies, delivery bodies, external experts, and previous reports. Given the wide range of use cases an attempt was made to ensure that the set of case studies covered the widest possible range of sectors and focussed on areas that stakeholders perceived the most incremental value.</p> <p><b>Estimate potential impact:</b> For each of the use cases, the potential impact on GVA in a given sector of the economy was estimated. This was done using case studies of typical savings that had been achieved derived from experts or industry interviews.</p> <p><b>Estimate adoption rate:</b> The level of adoption today was estimated, and an assumption was then made about the incremental adoption that could be encouraged by government action was also made.</p>
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	<p>To promote consistency between the use cases, the assumption was made that the rate of adoption could be accelerated one category on the Rogers Curve (e.g., from early adopter to early majority). This approach is not exhaustive of all the potential use cases of geospatial data. In particular it is likely to understate the impact of use cases that have not yet been developed or that are not yet widely understood. Broader consultation than was possible during this work should help to surface further use cases.</p> <p>At the same time, the total impact on GVA in a given sector and the potential for increased adoption are inherently uncertain. Simplifying assumptions – such as the Rogers curve - were necessary in order to generate size of the prize estimates. As a result, the values are presented in overall aggregate.”</p> <p>The supplementary market study review work by Frontier Economics, identified key consideration of spill over use value, as follows “Like many other forms of data, the value of geospatial data is not limited to the data creator or data user. Value from using geospatial data can be subdivided into several different categories based on who the value accrues to:</p> <ul style="list-style-type: none"> <li>• <b>Direct use value:</b> where value accrues to users of geospatial data. This could include a sales and marketing firm using geospatial data to make better decisions and increasing profitability as a result.</li> <li>• <b>Use value:</b> where value is also derived by indirect beneficiaries who interact with direct users. This could include other firms in the supply chain of the direct user or the firm’s customers.</li> <li>• <b>Spill over use value:</b> value that accrues to others who are not a direct data user or indirect beneficiary. This could, for example, include lower levels of emissions that generate health benefits to individuals which result from optimisation of the end-to-end supply chain of the direct user.</li> </ul> <p><i>Noting that,</i> as the value from the geospatial data does not always accrue to the direct user of the data, there is a risk of underinvestment in geospatial technology and services.”</p>
<b>Seabed 2030 Recommendation</b>	<p>Seabed 2030 Recommendation: Any benefits analysis methodology can be informed by this report and its approach (<b>UK HMG Cabinet Office an Initial Analysis of the Potential Geospatial Economic Opportunity (Boston Consulting Group) and follow on study - Geospatial Data Market Study (Frontier Economics)</b>). The approach is comprehensive based on use cases, direct use value, use value and spill over use value.</p> <p>A similar approach based on use cases and estimating economic, environmental, and social value could be adopted by Seabed 2030.</p>

**Assessment of the Economic Value of the Geospatial Information Industry in Ireland, February 2014, study by Indecon International Economic Consultants, commissioned by Ordnance Survey Ireland.**

<b>Benefit Model Source/Title</b>	<b>Assessment of the Economic Value of the Geospatial Information Industry in Ireland, February 2014, study by Indecon International Economic Consultants, commissioned by Ordnance Survey Ireland.</b>
<b>Website URL</b>	<a href="https://osi.ie/wp-content/uploads/2016/02/Economic-Value-of-the-Geospatial-Information.pdf">https://osi.ie/wp-content/uploads/2016/02/Economic-Value-of-the-Geospatial-Information.pdf</a>
<b>Objectives</b>	The overall objective of the study / and referenced report was to establish the economic value of geospatial information in the Irish Economy and to consider the wider contribution of the industry.
<b>Scope</b>	<p>The study addresses:</p> <ul style="list-style-type: none"> <li>• Establishing the economic contribution of geospatial information sector to Ireland's economy; and</li> <li>• Wider user benefits.</li> </ul> <p>The study report represents an independent assessment of the economic value of geospatial information ('GI') in Ireland.</p>
<b>Highlights</b>	<p>The report has a well explained Geospatial economic value assessment methodology and approach with assumptions identified. This offers an example methodology for Seabed 2030 consideration.</p> <p>In summary, this study and report provide a useful methodology for Geospatial economic value assessment, as well as a clear outline of the user community geospatial applications.</p> <p>Of relevance to Seabed 2030: Section 2 – highlights the key issues of the economic impact and characteristics of the geospatial industry are examined, and Section 3 - user benefits of geospatial information are evaluated.</p> <p>Both sections 2 and 3 offer an optional approach to / useful reference inform a Seabed 2030 benefits analysis approach.</p> <p>The Indecon study based its economic value assessment on:</p> <ul style="list-style-type: none"> <li>(i) Assessment of Direct Economic Contribution, for which five inputs are considered: <ul style="list-style-type: none"> <li>a. Output / sales revenues</li> <li>b. Employment supported</li> <li>c. Wages and salaries</li> <li>d. Non-labour business expenditure</li> <li>e. Gross Value Added (GVA)</li> </ul> </li> <li>(ii) Assessment of Indirect and Economy-wide Impacts, and in particular, the following aspects of economy-wide impact are quantified at a sectoral level: Economy-wide output contribution; Economy-wide employment contribution; and Economy-wide value added/GDP contribution, with two types of multipliers applied: <ul style="list-style-type: none"> <li>a. Type I multipliers enable the estimation of the economy-wide impacts arising from the direct plus indirect impacts associated with changes in activity that occur in backward-linked industries due to an increase in demand from the (geospatial_ industry.</li> <li>b. Type II multipliers are an expansion of the Type I construct but include direct, indirect, and induced impacts. Induced impacts arise through the additional consumption that takes place as a result of</li> </ul> </li> </ul>

	<p>the additional employment incomes created through the indirect impacts. In other words, Type II multipliers include the household as an additional sector in the economic relationships that make up the input-output framework.</p>
<p><b>Seabed 2030 Recommendation</b></p>	<p><b>Benefits analysis methodology can be informed by this report and its approach (Economic Value of the Geospatial Information Industry in Ireland, Indecon Study), with an optional methodology for the assessment of direct and indirect economic value assessment.</b></p>

#### 4.2.3 Premium Models Search Category 3: Benefits analysis experience drawn from the private / NGO sector.

Benefits Model Key Features Tables are provided for the following studies expedited by the private sector entities to inform their own commercial activities.

<b>Benefit Model Source/Title</b>	<b>What is the economic value of Geo services, January 2013, study by Oxera Consulting Ltd, commissioned by Google.</b>
<b>Website URL</b>	<a href="https://www.oxera.com/about-us/media-centre/oxera-quantifies-the-benefits-of-geo-services-to-global-consumers-and-businesses-on-behalf-of-google/">https://www.oxera.com/about-us/media-centre/oxera-quantifies-the-benefits-of-geo-services-to-global-consumers-and-businesses-on-behalf-of-google/</a>
<b>Objectives</b>	The Oxera study provides a global geospatial services economic value assessment and was commissioned by Google.
<b>Scope</b>	The Oxera study provides a global geospatial services economic value assessment based on the consideration of direct effects, consumer effects, and wider economy effects.
<b>Highlights</b>	<p>The Oxera study and report provide an approach to and estimates the economic impacts of geo services globally on a per annum basis.</p> <p>Oxera use three economic thematic categories as the basis for their economic value estimation approach, identified here:</p> <ul style="list-style-type: none"> <li>• <b>Direct effects</b> – the footprint of the Geo services measured according to the revenue generated by firms developing and providing Geo services and the value that they add. Oxera method in the study to assign economic value based on direct effects and then how these scale up to provide a global assessment. The direct effect refers to the economic presence or footprint of those companies directly involved in producing Geo services and the value they create. The Oxera adopted approach uses bottom up measurements / assessments based on financial reporting (self-reported financial results and or / market capitalisation of Geo services companies). Oxera used Bloomberg to collate actual reported finance. The scale up to global – USA base figures were captured and then scaled up for countries only where a country had declared a R&amp;D expenditure (i.e., R&amp;D spend was used as an indicator of high-tech industry at national level).</li> <li>• <b>Consumer effects</b> – the benefits that accrue to consumers, businesses, and government from using geo services, over and above the value that may be paid for any services (i.e., The revenue accounted for under the direct effects category); the box below articulates the Oxera approach to consumer effects assessment.</li> </ul>

	<p><b>Key messages</b></p> <p>Geo services are wide in scope, as reflected in the range of uses that consumers have for them. These uses generate benefits for consumers in different ways. The fact that consumers benefit from Geo services is partly captured in the revenue impacts illustrated under the direct effects, showing that consumers are willing to pay to use these services. Moreover, consumers derive benefits from services that are not captured via revenues. This is apparent when considering that many Geo services are free at the point of use (eg, Michelin maps).</p> <p>Geo services are typically an intermediate good—ie, they are not typically valuable in themselves, but are instead used to help consumers engage in other activities. Thus, the benefit to consumers (described in economics terms as the 'consumer surplus') from Geo services is a derived consumer surplus, but this can still be significant. Some examples of the consumer welfare benefits that Geo services generate include:</p> <ul style="list-style-type: none"> <li>– <b>journey time and fuel savings from more efficient navigation</b>—this impact could be worth around \$22 billion per year to consumers;</li> <li>– <b>faster emergency response to cardiac arrests</b>—potentially saving 152 lives per year in the UK;</li> <li>– <b>educational benefit</b>—worth around \$12 billion per year to individuals.</li> </ul> <p>and</p> <ul style="list-style-type: none"> <li>• <b>Wider economic effects</b> – the benefits that accrue from Geo services improving efficiency elsewhere in the economy, by creating new products and services and creating cost savings that cannot be generated by other sectors. <i>Wider economic (or supply-side) effects of Geo services are those that help to change the overall productivity and potential output of the economy. They help to bring about changes in the overall productivity of the economy. In assessing these wider effects, the focus is on gross effects.</i></li> </ul>
<b>Seabed 2030 Recommendation</b>	<b>Benefits analysis methodology can be informed by this report and its approach. The Oxera (for Google) approach assesses economic value through consideration of (i) direct effects, (ii) indirect effects and (iii) wider economic effects. Seabed 2030 could adopt a similar approach.</b>

<b>Benefit Model Source/Title</b>	<b>The economic impact of geospatial services: how consumers, businesses and society benefit from location-based information, [September 2017, study by Alphabeta, commissioned by Google].</b>
<b>Website URL</b>	<a href="https://alphabeta.com/wp-content/uploads/2017/09/GeoSpatial-Report_Sept-2017.pdf">https://alphabeta.com/wp-content/uploads/2017/09/GeoSpatial-Report_Sept-2017.pdf</a>
<b>Objectives</b>	The Alphabeta study provides a global geospatial services economic value view <i>(focus location-based information for Google customer).</i>
<b>Scope</b>	Alphabeta "the economic impact of geospatial services: how consumers, businesses and society benefit from location-based information"  This report can be considered an updated view commissioned by Google compared to Oxera report presented above.



<b>Highlights</b>	<p>Alphabeta examine the value of Geospatial Services in three areas:</p> <p><b>Consumer benefits</b>, including:</p> <ul style="list-style-type: none"> <li>• Commuting efficiency: beating congestion</li> <li>• Fuel efficiency: saving money at the pump</li> <li>• Personal safety: safer routes and driving</li> <li>• Purchasing efficiency: faster shopping</li> </ul> <p><b>Business Benefits</b>, including:</p> <ul style="list-style-type: none"> <li>• New products and services</li> <li>• Productivity benefits for other sectors</li> <li>• Sales growth (particularly for small businesses)</li> <li>• Tourism spend</li> </ul> <p><b>Societal Benefits</b>, including:</p> <ul style="list-style-type: none"> <li>• Job creation</li> <li>• Traffic congestion</li> <li>• Urban planning</li> <li>• Civic engagement</li> <li>• Public Health</li> <li>• Safety &amp; emergency response</li> <li>• Disaster preparation and responsiveness</li> <li>• Environment and wildlife preservation</li> <li>• Knowledge creation and human capital development</li> </ul> <p>And analyse these benefits to provide an assessment on ‘Global Economic Impact of Geospatial Services.’</p>
<b>Seabed 2030 Recommendation</b>	<p>Benefits analysis methodology can be informed by this report and the approach taken by Google – Alphabeta study. Seabed 2030 could follow a similar global methodology - consider consumer, business, and societal resulting benefits from Seabed 2030.</p>

Additionally, there are synergies and insights to be drawn from wider ‘global elevation product’ and ‘mapping’ programmes. The consultant proposes Seabed 2030 could engage with the following five programmes / entities to draw lessons and insights towards the approach towards developing global coverage data products and services.

Five case studies are presented for Seabed 2030 future reference, including:

#### **Case study 1: Airbus WorldDEM™ (Europe)**

Company headquartered in Toulouse, France. Airbus Intelligence located in Germany leads on TerraSAR X / Tandem-X and WorldDEM™ product line.

Airbus is a global space technology and intelligence company. Airbus offers a range of satellite data products and services, including based on global coverage terrain / elevation data, based on Synthetic Aperture Radar Missions TerraSar-X / Tandem-X WorldDEM.

For WorldDEM™ product details see here: <https://www.intelligence-airbusds.com/en/8703-worlddem>



A public / private partnership financing model approach was taken by DLR and Airbus. For further details on the public/private partnership finance model see here:

[https://www.dlr.de/rd/en/Portaldata/28/Resources/dokumente/re/TerraSAR-X\\_PPP\\_engl.pdf](https://www.dlr.de/rd/en/Portaldata/28/Resources/dokumente/re/TerraSAR-X_PPP_engl.pdf)

**Seabed 2030 Recommendation: Seabed 2030 engage WorldDem™ product team at Airbus Intelligence to be informed on (i) the approach adopted (Public/Private Partnership finance model), to realising the WorldDEM™ product, and (ii) how Airbus has gone about presenting and supporting a global elevation product user community to identify synergy and insight from Airbus experience.**

### **Case Study 2: InterMap® NextMap® product family (USA)**

Company headquartered in Denver, Colorado, USA.

Intermap's desire is to help customers understand and make sense of the world around them and led Intermap to create a company that produces reliable, accurate datasets and decision-making tools for customers in the insurance, aviation, telecommunications, railway, and government markets — and anyone else who needs a more comprehensive understanding of our planet. Intermap has a long history of collecting, processing, analyzing, and delivering 3D terrain data, from all sources, to solve problems with speed, accuracy, recency, and global scale. Intermap's NextMap® product is based on jet aircraft mounted IFSAR based data acquisition, and associated processing and production flow line.

Intermap can be considered as the first commercial entity to invest in product and take to market a global coverage elevation data product / service offering.

For InterMap company details, see here: <https://www.intermap.com/>

For InterMap NextMap® product details see here: <https://www.intermap.com/nextmap>

**Seabed 2030 Recommendation: Seabed 2030 engage NextMap™ product team at InterMap to be informed on (i) the investment model adopted by InterMap to realise the NextMap® product, and (ii) how InterMap has gone about presenting and supporting a global elevation product user community to identify synergy and insight from InterMap experience.**

### **Case Study 3: MAXAR 3D product family (USA)**

Company headquartered in Westminster, Colorado, USA.

Maxar is a global space technology and intelligence company. MAXAR offer a range of satellite data products and services, including based on global coverage elevation data.

Of note MAXAR acquired the former Saab company, Vricon, in July 2020. This M&A action was viewed by the industry for MAXAR to consolidate the MAXAR elevation and associated technologies offer, noting the importance of providing data and SW tools are typically both required to enable users.

For MAXAR 3d data suite, see here: <https://www.maxar.com/products/3d-data-suite>

For VRICON explorer, see here: <https://www.maxar.com/products/vricon-explorer>

**Seabed 2030 Recommendation: Seabed 2030 engage MAXAR 3d data suite at MAXAR to be informed on (i) the investment model adopted by MAXAR to realise the 3d data suite product portfolio, and (ii) the context of combining data with user tools (e.g., Vricon explorer), to support target user community, and to identify any synergies and draw insight from MAXAR experience.**

#### **Case Study 4: AW3D Product family (Japan)**

The Remote Sensing Technology Center of Japan, (RESTEC), is headquartered in Tokyo, Japan.

AW3D is a full global 3D Map, 3D data that simulates the terrain, ground undulations, and the heights of trees and buildings on the Earth's surface all over the globe.

Unlike conventional 3D data obtained by analyzing satellite images of the Earth's surface, AW3D is able to produce and provide 3D data of any place on Earth with a short delivery time, made possible by combining the latest IT technologies, including Multi-View Stereo Processing—AW3D's unique image processing technology, as well as AI, big data, and cloud computing. With the future development of the space business, AW3D service will be able to provide even higher quality 3D data as the number of available satellites increases and satellite-mounted sensor functions improve.

Since commencing product distribution in 2014, AW3D has been utilized in 130 countries and 1,300 projects. Its use spans a number of fields from mapping, disaster management, resource development, urban development to infrastructure development. Service use has also begun in cutting-edge verticals such as 5G mobile phone networks and autonomous driving. AW3D will continue to evolve and contribute to customers' development of new businesses.

AW3D is a service jointly developed and sold by RESTEC and NTT DATA Corporation see here: <https://www.restec.or.jp/en/solution/aw3d.html>

For AW3D product details see here: <https://www.aw3d.jp/en/products/>

**Seabed 2030 Recommendation: Seabed 2030 engage RESTEC / NTT DATA Corporation to be informed on (i) the investment model adopted to realise the AW3D products and services, and (ii) how they see AW3D will evolve to contribute to customers' development of new businesses.**

**Seabed 2030 may also see interesting automation of workflow through engagement with AW3D companies**

### **Case Study 5 OpenStreetMap**

OpenStreetMap is an initiative to create and provide free geographic data, such as street maps, to anyone. The OpenStreetMap Foundation is an international not-for-profit organization supporting, but not controlling, the OpenStreetMap Project. It is dedicated to encouraging the growth, development, and distribution of free geospatial data and to providing geospatial data for anyone to use and share.

For OpenStreetMap, see here: <https://www.openstreetmap.org/#map=6/54.910/-3.432>

For OpenStreetMap Foundation, see here: <https://blog.osmfoundation.org/about/>

**Seabed 2030 Recommendation: Seabed 2030 engage with OpenStreetMap Foundation to be informed on (i) the investment model adopted to realise OSM, (ii) how they successfully leveraged citizen science approach, (iii) the challenges and opportunities and how to realise an open data offer at a global level of scale, and to identify any synergies and draw insight from the OSM experience.**

## SECTION FIVE: COLLATION OF RECOMMENDATIONS

This section provides a 'Collation of Recommendations' and consists of a table that captures recommendations drawn from the Phase 2 Objective 3 activities and as presented iteratively throughout this report. The intention is that this set of recommendations is available to support the WITS Phase 2 Objectives 4 and 5 work and is available for potential inclusion in the WITS Phase 2 Report 2.

Ref.ID	Recommendation
1.	<p>Seabed 2030 Recommendation for our next steps on the phase 2 project and for the end of February 2022: Through this study, NLAI propose to present three key components in the accompanying Phase 2 Report 2 (Objective 2 and 3):</p> <ul style="list-style-type: none"> <li>(i) Document a set of Seabed 2030 application case studies (use cases), and present these in a SeaBed 2030 Value Proposition Document, (<i>focus: SeaBed 2030 value proposition – High Seas application of grid data</i>).</li> <li>(ii) Present a proposed methodology for (i) a rapid economic value assessment and (ii) a detailed economic value assessment study for Seabed 2030 consideration. This will be discussed in the engagement workshop and presented in the phase 2 report 2 with methodology process diagrams, with accompanying description (key steps).</li> <li>(iii) Present a proposed methodology for a prioritisation methodology for Seabed 2030 consideration. This will be presented as a methodology process diagram, with guidance and description of key steps proposed. The methodology will include decision gates with weightings and matrices and include spatial / temporal features where deemed applicable.</li> </ul>
2.	<p>Seabed 2030 Recommendation: <b>3DEP: USA NEEA offers a comprehensive engagement approach to both identify benefit use cases, and a comprehensive approach to cost benefit analysis, including comparing cost benefits analysis for different technical approaches, and follows a use case based assessment approach.</b></p> <p><b>Of direct relevance to seabed 2030, the NEEA study concludes that seabed mapping is critical for:</b></p> <ul style="list-style-type: none"> <li>• Navigation</li> <li>• Underwater recovery</li> <li>• Forecasting weather, tsunamis, and storm surge events.</li> <li>• Climate change projections; and</li> <li>• Identifying the outlines of where living marine resources exist.</li> <li>• Seabed mapping provides the means to uncover the history of our fallen lost at sea and</li> <li>• A framework for seabed mineral discovery.</li> <li>• Accurate ocean depths are instrumental in connecting the world through safe navigation and transoceanic communication cables, and</li> <li>• Critical to emergency response on the high seas.</li> </ul> <p><b>And concludes that “even if these benefits are difficult to quantify, they certainly should be considered as “Major”.”</b></p>

	<p>As with NEEA the <b>3D Nation Study approach / methodology is robust and comprehensive</b> and is anticipated to document and evidence details that will be transferrable for use by Seabed 2030 benefits analysis approach.</p> <p>In particular, the engagement questionnaire questions on benefits are very useful applying benefits scale category (major, moderate, minor, none, don't know) and requesting participants to complete scenario-based evidence for benefits, based on numbers of hours saved, numbers of dollars saved, etc.</p> <p><b>The questionnaire addresses instances inland bathymetry, near shore, and offshore use cases. Questionnaire Part 3.4 (Page 111 of 144) provides detailed engagement questions on offshore scenarios and use cases. These are directly relevant to Seabed 2030.</b></p>
3.	<p>Seabed 2030 Recommendation: <b>The Ausbed economic value methodology is comprehensive but is focused on internal EEZ related use cases, benefits, costs, and economic value assessment.</b> The report Annex A presents the economic contribution methodology and Annex B presents the Economic Contribution Framework adopted. <b><u>This represents a candidate economic value assessment methodology that Seabed 2030 can apply and tailor for 'High Seas' context.</u></b></p> <p>Note there is a need for Seabed to consider <b>global</b> as opposed to national economic value.</p> <p>The Ausbed prioritisation tool offers 3 priority ranking categories that could be used by Seabed 2030, including:</p> <ul style="list-style-type: none"> <li>• Urgent (1-2 years)</li> <li>• Mid-term (2-5 years)</li> <li>• Long-term (5-10 years)</li> </ul> <p>The Ausbed team has provided Seabed 2030 has been provided with a draft storyboard of the Ausbed prioritisation workflow for ongoing reference / use.</p> <p>The centre page graphic is compelling and a visually useful way to present sub-sector economic values and could be repurposed for Seabed 2030.</p>
4.	<p>Seabed 2030 Recommendation: This specific PWC Infomar report has been included in the review <b>should Seabed 2030 wish to investigate and compare costs / benefits for different implementation options.</b> The PWC report provides a <b>comprehensive cost benefit analysis approach, methodology and working example that seabed 2030 could adopt and tailor for their purposes.</b> It could also potentially <b>inform the Seabed 2030 prioritisation approach.</b></p>
5.	<p>Seabed 2030 Recommendation: Both Seabed 2030 benefits analysis and mapping prioritisation can be informed by the <b>AORA systematic approach adopted towards the realisation of seabed mapping.</b> It is recommended that Seabed 2030 engages and aligns with AORA Atlantic Bathymetry &amp; Benthic Habitat Mapping next steps activities.</p> <p><b>Seabed 2030 could adopt the AORA map tile approach for cost assessment (spatially orientated) and use this to build up and present a benefit assessment visualisation.</b></p>

	<b>AORA is imminently producing a report titled and addressing the ‘Atlantic Bathymetry and Benthic Mapping Framework’ which is directly relevant to seabed 2030 and will potentially be able to inform and guide Seabed 2030 work on benefits analysis and prioritisation.</b>
6.	<p>Seabed 2030 Recommendation: Any benefits analysis methodology can be informed by this report and its approach (<b>UK HMG Cabinet Office an Initial Analysis of the Potential Geospatial Economic Opportunity (Boston Consulting Group) and follow on study - Geospatial Data Market Study (Frontier Economics)</b>). The approach is comprehensive based on use cases, direct use value, use value and spill over use value.</p> <p><b>A similar approach based on use cases and estimating economic, environmental, and social value could be adopted by Seabed 2030.</b></p>
7.	Seabed 2030 Recommendation: Any benefits analysis methodology can be informed by this report and its approach ( <b>Economic Value of the Geospatial Information Industry in Ireland, Indecon Study</b> ), with an optional methodology for the assessment of direct and indirect economic value assessment.
8.	Seabed 2030 Recommendation: Any benefits analysis methodology can be informed by this report and its approach. <b>The Oxera (for Google) approach assesses economic value</b> through consideration of (i) direct effects, (ii) indirect effects and (iii) wider economic effects. Seabed 2030 could adopt a similar approach.
9.	Seabed 2030 Recommendation: Any benefits analysis methodology can be informed by this report and the approach taken by Google – Alphabet study. Seabed 2030 could follow a similar global methodology - <b>consider consumer, business, and societal resulting benefits</b> from Seabed 2030.
10.	Seabed 2030 Recommendation: <b>Seabed 2030 engage WorldDEM™ product team at Airbus Intelligence</b> to be informed on (i) the approach adopted (Public/Private Partnership finance model), to realising the WorldDEM™ product, and (ii) how Airbus has gone about presenting and supporting a global elevation product user community to identify synergy and insight from Airbus experience.
11.	Seabed 2030 Recommendation: <b>Seabed 2030 engage NextMap™ product team at InterMap</b> to be informed on (i) the investment model adopted by InterMap to realise the NextMap® product, and (ii) how InterMap has gone about presenting and supporting a global elevation product user community to identify synergy and insight from InterMap experience.
12.	Seabed 2030 Recommendation: <b>Seabed 2030 engage MAXAR 3d data suite at MAXAR</b> to be informed on (i) the investment model adopted by MAXAR to realise the 3d data suite product portfolio, and (ii) the context of combining data with user tools (e.g., Vricon explorer), to support target user community, and to identify any synergies and draw insight from MAXAR experience.
13.	<p>Seabed 2030 Recommendation: <b>Seabed 2030 engage RESTEC / NTT DATA Corporation</b> to be informed on (i) the investment model adopted to realise the <b>AW3D products and services</b>, and (ii) how they see AW3D will evolve to contribute to customers' development of new businesses.</p> <p>Seabed 2030 may also see interesting automation of workflow through engagement with AW3D companies</p>
14.	Seabed 2030 Recommendation: <b>Seabed 2030 engage with OpenStreetMap Foundation</b> to be informed on (i) the investment model adopted to realise OSM, (ii) how they successfully leveraged citizen science approach, (iii) the challenges and opportunities

	and how to realise an open data offer at a global level of scale, and to identify any synergies and draw insight from the OSM experience.
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## SECTION SIX: WITS PHASE 2 NEXT STEPS

This report is the WITS Phase 2 Objective 3 report and provides a selection of Premium Models for Seabed Mapping Benefits Analysis.

The projects Phase 2 next steps are:

- To progress with the Phase 2 activities with a focus on:
  - Objective 4: Model potential global benefit,
  - Objective 5: Develop a final model to prioritise all areas of unmapped seabed, and
- Hold a Seabed 2030 community engagement workshop on the Phase 2 work to inform the Seabed 2030 benefits analysis and prioritisation model approaches, (Scheduled for 8 February 2022).

The project phase 2 work will close with the issue of the WITS Phase 2 report 2, which will focus on The Phase 2 Objective 4 and 5 and provide a description of the proposed Seabed 2030 benefits analysis and prioritisation process and approach. The report will also include a set of recommendations for Seabed 2030 consideration relating to Seabed 2030 benefits analysis and mapping area prioritisation.

## ANNEX 1: TASK LEXICON / DEFINITION OF TERMS

For domain orientated technical definitions please search the International Hydrographic Organization (IHO) Hydrographic Dictionary; please see here: <https://iho.int/en/hdwg>

Supplemented with additional terms defined for the purposes of this project in the table below.

Abbreviation	Term	Definition
AOI	Area of Interest	Also referred to as study area or area of interest (AOI)—that contains a geographic subset of the features in another, larger dataset. This is particularly useful for creating a new dataset, where the new dataset comprises the area within a geographic delineation.
AORA	Atlantic Ocean Research Alliance	Atlantic Ocean Research Alliance - The All-Atlantic Ocean Research Alliance is the result of science diplomacy efforts involving countries from both sides of the Atlantic Ocean which aims at enhancing marine research and innovation cooperation along and across the Atlantic Ocean, from the Arctic to Antarctica. See here: <a href="https://allatlanticocean.org/whoweare">https://allatlanticocean.org/whoweare</a>
AusSeabed	AusSeabed is a national seabed mapping coordination program (Australian Waters)	AusSeabed is a national seabed mapping coordination program. The program aims to serve the Australian community that relies on seabed data by coordinating collection efforts in Australian waters and improving data access. The AusSeabed program is a national collaborative initiative led by Geoscience Australia, but operated by Commonwealth, State and Territory entities, universities, and industry. It is open to all interested parties. See here: <a href="https://www.ausseabed.gov.au/home">https://www.ausseabed.gov.au/home</a>
CBA	Cost-Benefit Analysis	<p>Cost–benefit analysis (CBA), sometimes also called benefit–cost analysis, is a systematic approach to estimating the strengths and weaknesses of alternatives. It is used to determine options which provide the best approach to achieving benefits while preserving savings in, for example, transactions, activities, and functional business requirements. A CBA may be used to compare completed or potential courses of action, and to estimate or evaluate the value against the cost of a decision, project, or policy.</p> <p>CBA has two main applications: (i) To determine if an investment (or decision) is sound, ascertaining if – and by how much – its benefits outweigh its costs. (ii) To provide a basis for comparing investments (or decisions), comparing the total expected cost of each option with its total expected benefits.</p> <p>CBA is related to cost-effectiveness analysis. Benefits and costs in CBA are expressed in monetary terms and are adjusted for the time value of money; all flows of benefits and costs over</p>

		<p>time are expressed on a common basis in terms of their net present value, regardless of whether they are incurred at different times.</p> <p>UK Government Green Book methodology for cost benefit analysis, involves the following steps:</p> <ol style="list-style-type: none"> <li>1. Scope and Baseline</li> <li>2. Identify costs and benefits</li> <li>3. Quantify, monetise, and measure costs and benefits</li> <li>4. Compare costs and benefits</li> <li>5. Sensitivity analysis</li> <li>6. Reporting and interpretation</li> </ol> <p>See here: <a href="https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-government?msclkid=5026cc8dc09c11eca01c9eca2bf239f6">https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-government?msclkid=5026cc8dc09c11eca01c9eca2bf239f6</a></p>
COTS	Commercial Off-The-Shelf	Commercial off-the-shelf, e.g., software products commercially available
EEZ	Exclusive Economic Zone	An exclusive economic zone (EEZ), as prescribed by the 1982 United Nations Convention on the Law of the Sea, is an area of the sea in which a sovereign state has special rights regarding the exploration and use of marine resources, including energy production from water and wind. It stretches from the baseline out to 200 nautical miles (nm) from the coast of the state in question.
Economic Sectors	Economic Sectors	<p>Economic Sectors include:</p> <p>#1: Sector: Public or 'State Sector'.</p> <p>#2: Sector: Private or 'Privately run businesses'.</p> <p>#3: Sector: Voluntary or 'Not for Profit'.</p> <p>Also:</p> <p>#1: Primary sector [Raw Materials] – Involves the retrieval and production of raw materials such as for our interest minerals, fishing, and oil and gas.</p> <p>#2: Secondary sector [Manufacturing] – Involves the transformation of raw or intermediate materials into goods, e.g., in this instance includes fisheries processing to food products.</p> <p>#3: Tertiary sector [Services] – Involves supplying services to customers, e.g., banking, and accounting, etc. and in this instance can include blue financing.</p> <p>Additional Sectors:</p> <p>#4: Quaternary sector [Information Services]– And is where knowledge-based services are accounted for.</p> <p>#5: Quinary sector [Human services] – activities centered on human-based services such as hospitality (e.g., and in this instance includes tourism).</p> <p>Also:</p> <p>#1: Sector: Established sectors - Sectors with long-term proven contribution to the economy.</p>

		#2: Sector: Emerging sectors - new sectors showing high potential for future development.
Esri	Esri (Company) - Environmental Systems Research Institute	Esri is an international supplier of geographic information system software, web GIS and geodatabase management applications. The company is headquartered in Redlands, California. See here: <a href="https://www.esri.com/en-us/home">https://www.esri.com/en-us/home</a>
Economic Value Assessment	Economic Value Assessment	<p>The assessment of economic value associated with [Seabed mapping]. One example methodology through which economic value can be assessed involves:</p> <p>(i) Assessment of Direct Economic Contribution, (ii) Assessment of Indirect Economic Contribution, and (iii) Economy-wide (resulting) Impacts.</p> <p>At a sectoral level: Economy-wide output contribution; Economy-wide employment contribution; and Economy-wide value added/GDP contribution, with two types of multipliers can potentially be applied:</p> <ul style="list-style-type: none"> <li>- Type I multipliers enable the estimation of the economy-wide impacts arising from the direct plus indirect impacts associated with changes in activity that occur in backward-linked industries due to an increase in demand from the seabed mapping industry.</li> <li>- Type II multipliers are an expansion of the Type I construct but include direct, indirect, and induced impacts. Induced impacts arise through the additional consumption that takes place as a result of the additional employment incomes created through the indirect impacts. In other words, Type II multipliers include the household as an additional sector in the economic relationships that make up the input-output framework.</li> </ul>
EU	European Union	European Union - The European Union is a political and economic union of member states that are located primarily in Europe.
FGDC	Federal Geographic Data Committee (FGDC) [U.S. Government]	The Federal Geographic Data Committee (FGDC) is an organized structure of [U.S. Government] Federal geospatial professionals and constituents that provide executive, managerial, and advisory direction and oversight for geospatial decisions and initiatives across the Federal government. See here: <a href="https://www.fgdc.gov/">https://www.fgdc.gov/</a>
FTE(s)	Full Time Equivalent(s)	FTE is a unit of measurement equivalent to in business that indicates the amount of time that an employee or student is working. Full Time Equivalent(s) is used to represent headcount, e.g., 10 FTE are 10 Full Time Equivalent job positions/job posts. FTE is a unit of measurement equivalent to in business that indicates the amount of time that an employee or student is working.
GDPR	General Data Protection Regulation	The General Data Protection Regulation (EU) 2016/679 (GDPR) is a regulation in EU law on data protection and privacy in the European Union (EU) and the European Economic Area (EEA).

		<p>The GDPR is an important component of EU privacy law and of human rights law, in particular Article 8(1) of the Charter of Fundamental Rights of the European Union. It also addresses the transfer of personal data outside the EU and EEA areas. The GDPR's primary aim is to enhance individuals' control and rights over their personal data and to simplify the regulatory environment for international business. Superseding the Data Protection Directive 95/46/EC, the regulation contains provisions and requirements related to the processing of personal data of individuals (formally called data subjects in the GDPR) who are located in the EEA, and applies to any enterprise—regardless of its location and the data subjects' citizenship or residence—that is processing the personal information of individuals inside the EEA.</p> <p>For UK requirements see here:  <a href="https://www.gov.uk/government/publications/guide-to-the-general-data-protection-regulation?msclid=43017329c09511ec8e7885796010f289">https://www.gov.uk/government/publications/guide-to-the-general-data-protection-regulation?msclid=43017329c09511ec8e7885796010f289</a></p>
GEBCO	General Bathymetric Chart of the Oceans (GEBCO)	<p>The General Bathymetric Chart of the Oceans (GEBCO) is a publicly available bathymetric chart of the world's oceans. See here: <a href="https://www.gebco.net/">https://www.gebco.net/</a></p>
GIS	Geographic Information System	<p>Esri definition for GIS state: “A spatial system that creates, manages, analyses, and maps all types of data.”</p> <p>“A geographic information system (GIS) is a system that creates, manages, analyses, and maps all types of data. GIS connects data to a map, integrating location data (where things are) with all types of descriptive information (what things are like there). This provides a foundation for mapping and analysis that is used in science and almost every industry. GIS helps users understand patterns, relationships, and geographic context. The benefits include improved communication and efficiency as well as better management and decision making.” See here: <a href="https://www.esri.com/en-us/what-is-gis/overview">https://www.esri.com/en-us/what-is-gis/overview</a></p>
Industry	Industry	<p>An ‘industry’ can be considered a collection of organisations within a specific sector where they are typically involved in a specific internal sector activity, e.g., an oil company may be extracting oil – oil can be considered a primary sector industry, as can forestry and also in this instance marine fishing, and extraction of crude petroleum and natural gas (offshore).</p> <p>An industry is a group of companies that are related based on their primary business activities. In modern economies, there are dozens of industry classifications. Industry classifications are typically grouped into larger categories called sectors.</p>

		While a sector (see below) represents a large segment of an economy that includes many companies, an industry represents a narrower focus of the companies within a particular sector. Thus, industries are the result of breaking down a sector into more defined and specific groupings. On the other hand, sectors can represent a large grouping of companies that have similar business activities, and hence why economic analysis for benefit / value analysis purposes is ideally addressed at sector level.
INFOMAR	Integrated Mapping for the sustainable development of Ireland's marine resource	INFOMAR is a DECC funded joint programme between the Geological Survey Ireland and the Marine Institute, surveying Irelands unmapped marine territory and creating a range of integrated mapping products of the physical, chemical, and biological features of the seabed. See here: <a href="https://www.infomar.ie/">https://www.infomar.ie/</a>
IHO	International Hydrographic Organization (IHO)	The International Hydrographic Organization (IHO) is an intergovernmental organisation representing hydrography. See here: <a href="https://iho.int/en/">https://iho.int/en/</a>
IMO	International Maritime Organization	The International Maritime Organization is a specialised agency of the United Nations responsible for regulating shipping. See here: <a href="https://www.imo.org/en">https://www.imo.org/en</a>
LIDAR	Light Detection And Ranging	Light Detection And Ranging - a method for determining ranges (variable distance) by targeting an object or a surface with a laser and measuring the time for the reflected light to return to the receiver. It can also be used to make digital 3-D representations of areas on the earth's surface and ocean bottom by varying the wavelength of light. It has terrestrial, airborne, and mobile applications.
MIRO	MIRO (Brand)	MIRO – an online whiteboard and collaboration solution
MPA	Marine Protected Area	A marine protected area is a defined region designated and managed for the long-term conservation of marine resources, ecosystems services, or cultural heritage. For Guidelines for applying the IUCN protected area management categories to marine protected areas, see here: <a href="https://portals.iucn.org/library/node/48887">https://portals.iucn.org/library/node/48887</a> [2nd Edition]
NEEA	National Enhanced Elevation Assessment	National Enhanced Elevation Assessment. 'National Enhanced Elevation Assessment (NEEA)' was conducted to document national level requirements for enhanced elevation data, estimate the benefits and costs of meeting those requirements, and evaluate multiple national enhanced elevation program scenarios. For the NEEA final report See here: <a href="https://www.dewberry.com/services/geospatial-mapping-and-survey/national-enhanced-elevation-assessment-final-report">https://www.dewberry.com/services/geospatial-mapping-and-survey/national-enhanced-elevation-assessment-final-report</a>

NLAI	NLA International (Company)	NLA Internal (Company). See here: <a href="https://nlai.blue/">https://nlai.blue/</a>
NPV	Net Present Value	Net Present Value is the value in the present of a sum of money, in contrast to some future value it will have when it has been invested at compound interest.
N/A	Not Applicable	Not Applicable
OECD	The Organisation for Economic Co-operation and Development	The Organisation for Economic Co-operation and Development is an intergovernmental economic organisation with 38 member countries, founded in 1961 to stimulate economic progress and world trade.
OSM	OpenStreetMap	OpenStreetMap is a collaborative project to create a free editable geographic database of the world. The geodata underlying the maps is considered the primary output of the project. See here: <a href="https://www.openstreetmap.org/about?msclid=f1f7bfc1c09311ecab872fb810f3e417">https://www.openstreetmap.org/about?msclid=f1f7bfc1c09311ecab872fb810f3e417</a>
QC	Quality Control	Quality management review process/procedure.
Sector	Sector	<p>A 'sector' is an area of the economy in which businesses share the same or related business activity, product, or service. Sectors represent a large grouping of companies with similar business activities, such as the extraction of natural resources and agriculture.</p> <p>Dividing an economy into different sectors helps economists analyse the economic activity within those sectors. As a result, sector analysis provides an indication as to whether an economy is expanding or if areas of an economy are experiencing contraction. Further, Sectors are used by economists to classify economic activity by grouping companies that are engaged in similar business activities.</p> <p>While a sector represents a large segment of an economy that includes many companies, an industry (see above) represents a narrower focus of the companies within a particular sector. Thus, industries are the result of breaking down a sector into more defined and specific groupings. On the other hand, sectors can represent a large grouping of companies that have similar business activities, and hence why economic analysis for benefit / value analysis purposes is ideally addressed at sector level.</p>
SCT	Survey Coordination Tool	<p>Survey Coordination Tool (SCT) an AusSeabed Tool. The Survey Coordination Tool (SCT) is designed for the seabed mapping community to communicate their plans to survey as well as outline areas they have prioritised for survey. It also hosts the online form for submitting survey requests to the Australian Hydrographic Office (AHO) for consideration by the HydroScheme Industry Partnership Programme.</p> <p>See here: <a href="https://www.ausseabed.gov.au/survey-coordination-tool">https://www.ausseabed.gov.au/survey-coordination-tool</a></p>



TBC/TBD	To Be Confirmed / To Be Determined	To Be Confirmed / To Be Determined
TEV	Total Economic Value	Total Economic Value (TEV). Used in the quantification of economic value, where Total Economic Value = Total User Value + Total Non-user Value. Total User Value includes both direct use and indirect use.
TOR	Terms of Reference	Terms of Reference (TOR) define the purpose and structures of a project, committee, meeting, negotiation, or any similar collection of people who have agreed to work together to accomplish a shared goal.
UK HMG	United Kingdom Her Majesty's Government	United Kingdom Government
USA	United States of America	United States of America
Use Value	(Economic) Use Value	Where (economic) value accrues or is derived through Direct, Indirect or Spill Over, including: #Direct use value: Where value accrues to users of [geospatial data]. This could include a sales and marketing firm using [geospatial] data to make better decisions and increasing profitability as a result. #Use Value: where value is also derived by indirect beneficiaries who interact with direct users. This could include other firms in the supply chain of the direct user or the firm's customers. #Spillover Use Value: Value that accrues to others who are not a direct data user or indirect beneficiary. This could, for example, include lower levels of emissions that generate health benefits to individuals which result from optimisation of the end-to-end supply chain of the direct user.
USGS	United States Geological Survey	The United States Geological Survey, abbreviated USGS and formerly simply known as the Geological Survey, is a scientific agency of the United States government.
WITS	Wind In The Sails	Project Name 'Wind In The Sails.'
WG/WGs	Working Group (s)	A committee or group appointed to study and report on a particular question and make recommendations based on its findings.

## ANNEX 2: REFERENCES

[Ref 1] WITS Phase 2 Report 2 [WITS Phase 2 Report 2 - Proposed model for Seabed 2030 – Seabed Mapping Benefits Analysis and Prioritisation, April 2022].

[Ref2] USA 3D Elevation Programme: Including the National Enhanced Elevation Assessment, USGS, (2013 and signed into US law in Oct 2018), and USA: 3D Nation Study, USGS National Geospatial Program, 3D Elevation Program, and NOAA Office of Coast Survey, (2020).

USA 3D Elevation Programme: <https://www.usgs.gov/3d-elevation-program>

USA: 3D Nation Study, USGS National Geospatial Program, 3D Elevation Program, and NOAA Office of Coast Survey, (2020), Requirements and Benefits Study Benefits. And also its previous study, USA: National Enhanced Elevation Assessment, USGS, (2013 and signed into US law in Oct 2018), see here: [https://www.usgs.gov/3d-elevation-program/national-enhanced-elevation-assessment?qt-science\\_support\\_page\\_related\\_con=4#qt-science\\_support\\_page\\_related\\_con](https://www.usgs.gov/3d-elevation-program/national-enhanced-elevation-assessment?qt-science_support_page_related_con=4#qt-science_support_page_related_con)

– and also see here: <https://www.usgs.gov/3d-elevation-program/program-benefits-and-uses> where the ‘National Enhanced Elevation Assessment (NEEA)’ was conducted to document national level requirements for enhanced elevation data, estimate the benefits and costs of meeting those requirements, and evaluate multiple national enhanced elevation program scenarios. See here: <https://www.dewberry.com/services/geospatial-mapping-and-survey/national-enhanced-elevation-assessment-final-report> for the final report

[Ref3] The value of Australian seabed mapping data to the blue economy, October 2021, study by Deloitte commissioned by Geoscience Australia. See here: <https://www2.deloitte.com/au/en/pages/economics/articles/value-of-australian-seabed-mapping-data-to-blue-economy.html>

[Ref4] Ireland: Price Waterhouse Coopers (2008). INFOMAR Marine Mapping Study. Options Appraisal Report: Final Report 30 June 2008. Marine Institute, Ireland. See here: <https://oar.marine.ie/handle/10793/1652>

[Ref5] UK: (i) Value Chains in Public Marine Data: A UK Case Study - A joint OECD Working Paper in collaboration with the UK Marine Environmental Data and Information Network (MEDIN) and the Global Ocean Observing System (GOOS) in the Intergovernmental Oceanographic Commission of UNESCO. See here: [https://www.oecd-ilibrary.org/science-and-technology/value-chains-in-public-marine-data\\_d8bbdcfa-en](https://www.oecd-ilibrary.org/science-and-technology/value-chains-in-public-marine-data_d8bbdcfa-en)

For Value Chains in Public Marine Data Study adoption of cost – benefit analysis methodology for MEDIN, see a copy of the final report available here:

[https://medin.org.uk/sites/medin/files/documents/MEDIN%20Cost%20Benefit%20Analysis\\_Final%20Report.pdf](https://medin.org.uk/sites/medin/files/documents/MEDIN%20Cost%20Benefit%20Analysis_Final%20Report.pdf)

[Ref6] UK HMG Green Book for Appraising Public Value. See here: <https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-government>

[Ref7] Atlantic Ocean Research Alliance (AORA) Related Seabed Mapping - Atlantic Mapping Framework.

See here: <https://www.infomar.ie/maps/story-maps/aora-mapping-atlantic>

For AORA Roadmap document, see here: <https://oar.marine.ie/handle/10793/1596?show=full>

[Ref8] An Initial Analysis of the Potential Geospatial Economic Opportunity, 2018, study by HMG Cabinet Office, supported by Boston Consulting Group. See here: Geospatial Commission - An Initial Analysis of the Potential Geospatial Economic Opportunity document can be accessed here: <https://www.gov.uk/government/news/government-launch-call-for-evidence-to-be-geospatial-world-leader>

Also see blog release by research team, see here:

<https://quarterly.blog.gov.uk/2018/03/28/location-location-location-tapping-the-economic-potential-of-geospatial-data/>

[Ref9] Geospatial Data Market Study - Report for the Geospatial Commission, September 2020, study by Frontier Economics commissioned by HMG Cabinet Office. See here:

[https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/937025/Frontier\\_Economics\\_-\\_Geospatial\\_Data\\_Market\\_Study.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/937025/Frontier_Economics_-_Geospatial_Data_Market_Study.pdf), and here:

<https://www.gov.uk/government/publications/enhancing-the-uks-geospatial-ecosystem/frontier-economics-geospatial-data-market-study-report-executive-summary>

[Ref10] Assessment of the Economic Value of the Geospatial Information Industry in Ireland, February 2014, study by Indecon International Economic Consultants, commissioned by Ordnance Survey Ireland. See here: <https://osi.ie/wp-content/uploads/2016/02/Economic-Value-of-the-Geospatial-Information.pdf>

[Ref11] The economic impact of geospatial services: how consumers, businesses and society benefit from location-based information, [September 2017, study by Alphabet, commissioned by Google].

See here: [https://alphabet.com/wp-content/uploads/2017/09/GeoSpatial-Report\\_Sept-2017.pdf](https://alphabet.com/wp-content/uploads/2017/09/GeoSpatial-Report_Sept-2017.pdf)

[Ref12] What is the economic value of Geo services, January 2013, study by Oxera Consulting Ltd, commissioned by Google. See here: <https://www.oxera.com/about-us/media-centre/oxera-quantifies-the-benefits-of-geo-services-to-global-consumers-and-businesses-on-behalf-of-google/>

[Ref13] OECD (2016), The Ocean Economy in 2030, OECD Publishing, Paris, <https://doi.org/10.1787/9789264251724-en>.

[Ref14] The EU Blue Economy Report 2021, © European Union, 2021. See here:

[https://ec.europa.eu/oceans-and-fisheries/system/files/2021-05/the-eu-blue-economy-report-2021\\_en.pdf?msckid=58edc250c0ba11ec8360a56b8a86494a](https://ec.europa.eu/oceans-and-fisheries/system/files/2021-05/the-eu-blue-economy-report-2021_en.pdf?msckid=58edc250c0ba11ec8360a56b8a86494a)

[Ref15] AW3D Product family - Japan Case Study – AW3D Product family, W3D is a service jointly developed and sold by RESTEC and NTT DATA Corporation see here:

<https://www.restec.or.jp/en/solution/aw3d.html>

and for AW3D product details see here: <https://www.aw3d.jp/en/products/>

[Ref16] OpenStreetMap, by Open Street Map Foundation, see here:

<https://www.openstreetmap.org/#map=6/54.910/-3.432>

And for OpenStreetMap Foundation, see here: <https://blog.osmfoundation.org/about/>

[Ref17] Integrated Ocean Observing System: NOAA 'benefits of ocean observing catalogue': see here:

<https://ioos.noaa.gov/ioos-in-action/benefits-of-ocean-observing-catalog/>

[Ref18] Geo Blue Planet, see here: <https://geoblueplanet.org/>

[Ref19] Airbus WorldDEM™ product details see here: <https://www.intelligence-airbusds.com/en/8703-worlddem>

[Ref20] A public / private partnership financing model approach by DLR and Airbus. For further details on the public/private partnership finance model see here:

[https://www.dlr.de/rd/en/Portaldata/28/Resources/dokumente/re/TerraSAR-X\\_PPP\\_engl.pdf](https://www.dlr.de/rd/en/Portaldata/28/Resources/dokumente/re/TerraSAR-X_PPP_engl.pdf)

[Ref21] InterMap company details, see here: <https://www.intermap.com/>

[Ref22] InterMap NextMap® product details see here: <https://www.intermap.com/nextmap>

[Ref23] MAXAR 3d data suite, see here: <https://www.maxar.com/products/3d-data-suite>

[Ref24] VRICON explorer, see here: <https://www.maxar.com/products/vricon-explorer>

[Ref25] For domain orientated technical definitions please search the International Hydrographic Organization (IHO) Hydrographic Dictionary; please see here: <https://iho.int/en/hdwg>