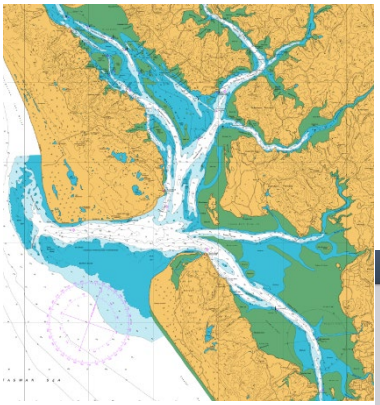
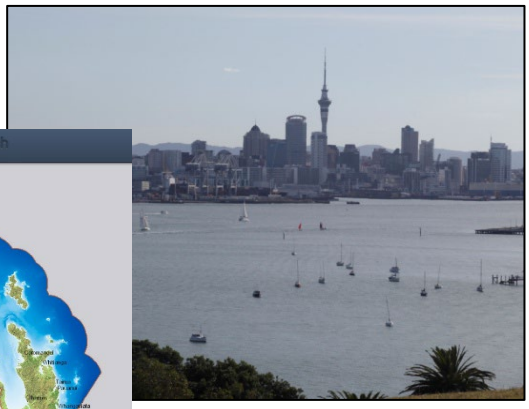
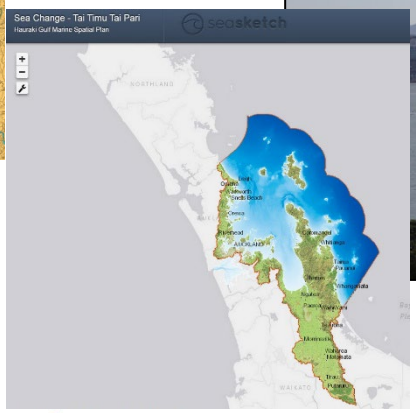
The LINZ Hydrographic Group
Strategic Options Study

21st March 2016







ConsultingWhere

Maximising the value of location information

Version History

Version	Date	Description	Authors
0.4	21/03/2016	Quality Assurance review comments incorporated and executive summary added	AMC / LJR

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Executive Summary

Objectives

The study reports on how to achieve two key objectives:

i) Maximising the use of bathymetric (and related) data that LINZ collects for hydrographic purposes in domains other than charting such as coastal zone management, marine science, mineral exploitation and offshore construction;

ii) Optimising the potential use of the skills LINZ possesses with respect to marine data management to meet the requirements of the entire marine community within the Exclusive Economic Zone of New Zealand.

Achieving these objectives might be described as the creation and curation of a National Marine Spatial Data Infrastructure (MSDI) for New Zealand.

Section 2 is devoted to defining concepts, such MSDI and clarifying terminology.

Context

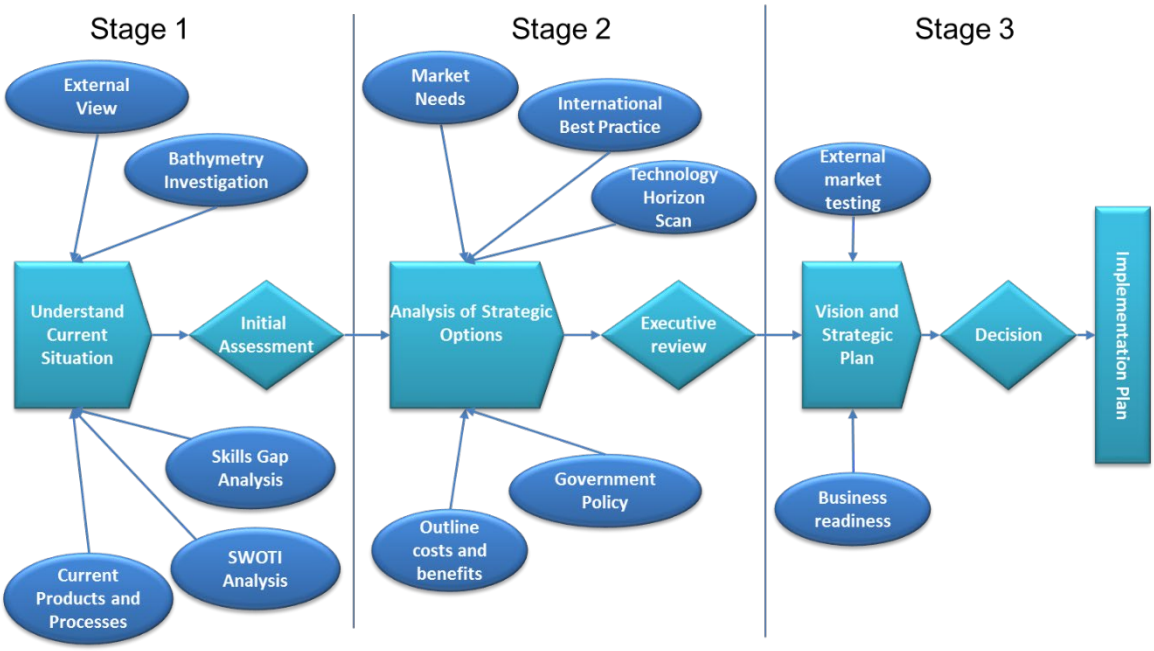
The world of mapping and charting is changing very rapidly. Commercial organisations, with global coverage and huge volumes of users, such as Google, are turning their attention to the marine environment. The traditional divide between land and sea in terms of data capture and processing technology is also beginning to disappear. Light Detection and Ranging (LiDAR) technology which has the potential to provide "fit for purpose" shallow sea elevation data, is already a viable choice when conditions are favourable and has near-term potential to become a cost-effective general purpose tool for bathymetry. Furthermore, Earth observation (EO) data from satellites, is an area of rapid technological change with the cost of developing and launching EO satellites decreasing rapidly.

Such change needs to be set against a backdrop of increasing volumes of work to keep pace with demands for improved navigation products and services and the problems of staff recruitment and retention in a specialised and globally competitive jobs market. Balancing this "business as usual" and the potential benefits to the economy of developing an MSDI must be central consideration in any future strategy.

In short, there is a pressing need to rapidly plot a strategic long-term direction that takes into account all these influences, chooses a preferred direction from a range of strategic options, tests it with customers, and then executes the actions required to achieve it.

Methodology

In respect to the overall project, as illustrated below, the main focus of this report and considers the longer-term options, looking at the external influences of changing market needs, international best practice and technology advances plus internal factors of workflows, Government and LINZ policy. It also includes on outline strategy to inform Stage 3.



Four strategic options were considered:

1. Status quo – maintain focus only on hydrographic charting mission (including SW Pacific / Antarctica NZ)

2. Supporting coordination by others of better bathymetric data sharing

3. Adopting a coordination role for a national Marine SDI similar in concept to what LINZ provides for imagery

4. Proactive leadership in the development of a full MSDI for New Zealand

Section 3 detail the activities undertaken to flesh out and compare and assess these options.

Market Needs

This was established by stakeholder engagement. A total of nearly 50 formal interviews were conducted across Stages 1 and 2 of the study. Interviewees were supplied in advance with a brief describing the study. In order to obtain some of the information gathered it was necessary to provide interviewees with assurance concerning anonymity of their input, which is respected in all the deliverables.

An enhanced role for LINZ in management of marine spatial data was generally supported. A number of concerns were raised as to how this might work in practice and funding was recognised as the most important impediment. The idea of a coalition of willing agencies making a coordinated approach to Treasury was generally agreed as perhaps the only feasible approach to securing financial support for creating a National

MSDI. **Section 4** details the evidence collected from both public and private sector stakeholders and opinion formers.

International Best Practice

A wide range of organisations in various geographies with comparable levels of development were visited to provide best practice. These included the United States, Australia and the European Union, with particular emphasis on the United Kingdom, Ireland and Denmark. The overall conclusion was that New Zealand can readily "piggy back" upon many different International initiatives covering almost all of the areas of opportunity that an MSDI provides. Detailed feedback and advice on areas for collaboration is given in **Section 5** of the report.

Technology Horizon Scan

We are living in a period of enormous technological change that is arguably changing the lives of all peoples in the developed and developing world more fundamentally than any other change since the industrial revolution. Discerning from the range of technologies those that will have the most impact on MSDI was challenging. We chose to focus on:

- Big data,
- Internet of Things
- Crowd sourcing,
- Optical and acoustic sensors,
- Autonomous vehicles,
- Software advances
- Visualisation.

Their likely impacts over a 5-10 year are considered in **Section 6.**

Government Strategy

Our analysis suggests that LINZ would be well placed from a policy perspective to take on an enhanced role in developing a MSDI. The current policy settings in respect to SDI and cadastre appear to be adaptable to suit National needs without major changes to primary legislation. Furthermore, there is plenty of "best practice" policy guidance from Europe and the United States that can be leveraged. See **Section 7** for details.

Benefit-Cost Analysis

It is not the purpose of this stage of the study to produce a full benefit-cost analysis. However, the Bathymetric Investigation, work being currently undertaken on the risk assessment for better charting in New Zealand waters and local evidence of potential savings give a positive indications that a strong business case could be assembled. Overseas exemplar projects have also been identified to enable a full benefit-cost assessment to be validated using benefits transfer and scaling from these sources. Details can be found in **Section 8**.

Conclusions and Recommendations

The report does not support the status quo (option 1) on the grounds that it will not support optimum realisation of the potential opportunities from MSDI. Leading MSDI development (option 4) it is concluded is also not a viable option for LINZ – at least in the short to medium-term. LINZ visibility in the wider marine sector is not high, therefore attempting to step into an overarching active leadership role is over ambitious and unlikely to be accepted by other stakeholders.

We therefore recommend that option 2 with components of option 3 as the preferred strategy. This will entail coordination beyond bathymetry with focused leadership in areas of LINZ core competences. It is recommended that a new separate dedicated team is established within LINZ to provide clear focus for MSDI development.

With regard to the secondary objective of optimising the effectiveness of the Hydrographic Authority we endorse the business improvement plan. The risks regarding its delivery are lack of resources dedicated to its achievement. It will be too easy for "business as usual" demands to result in it being given lower priority.

Detailed justification of our conclusions and recommendations can be found in **Section 9** of the report.

Draft Strategy

In order to provide some clarity on the practical implications of the recommendations the report also provides a draft strategy with six goals and associated actions.

Goal 1: Complete Elevation coverage

This to be achieved by:

- Working through the open data team to encourage other agencies to minimise restrictions on bathymetric data availability
- Providing open access to all existing LINZ bathymetric data through LDS
- Defining of the land – sea datum variation for the coastal zone around NZ
- Developing a long-term plan to provide bathymetric data at appropriate scales for all waters where New Zealand has jurisdiction.

Goal 2: Define MSDI Framework

This to be achieved by:

- Working with other agencies within the public sector to determine market needs
- Establishing the economic impact of an MSDI and its intercept with the political agenda
- This will build on the economic assessment work already undertaken under the New Zealand Bathymetric Investigation
- Define and prioritise fundamental spatial data themes for the marine environment leveraging International best practice
- This will build on the work undertaken already within the Geospatial Office in the terrestrial domain
- Adopt or adapt existing data management standards already established in marine communities of practice
- Use international terminology and vocabularies.
- This goal not be restricted to consideration of the IHO S100 series standards

Goal 3: Create National MSDI Geoportal

This to be achieved by:

Collaborating with the other public agencies and businesses to determine market needs and priorities

- International best practice in creating the right conditions for collaboration will be important in informing this work
- Revisit the NIWA proposal from 2014 to make less technically focused

Creating a federated network of data management systems that are interoperable and exposed to non-specialist users through a single portal

- A number of existing portals are candidates to be upgraded to perform this function
- Data should be accessible through the web services within practical limits (requesting large volumes should be supported offline)

Goal 4: Marine Cadastre

This to be achieved by:

- Socialising the marine cadastre concept.
- Establish the policy and business case for creating and managing a marine cadastre:
  - Reducing effort in data discovery and maintenance, aiding better planning and decision making;
  - The US Marine Cadastre initiative is indicative of the wide range of applications it might support.
- Work with other agencies to identify sources and collate marine cadastre information
  - The information would not be stored in one central repository but harvested from existing sources but exposed through LDS;
  - LDS would support storage of smaller organisations' data.
  - Maintenance mechanisms between systems to ensure consistency and currency.

Goal 5: Internal Strategy

This to be achieved by:

- Delivering business improvement projects and implementing their recommendations
  - Expedite work on the release of current bathymetric data holdings.
- Improvement to data accessibility through LDS
  - Thematic aggregation / attribution intelligibility.
- Work more closely with other parts of LINZ
  - Leverage GIS knowledge as part of the data management review;
  - Short-term Secondments
- Review of software tools and technology
  - CARIS appropriate tool for routine chart and digital production;
  - Look to introduce other tools where appropriate.
- Dedicating more resources to Digital Management (data plus software) within the hydrographic group.

Goal 6: Leverage Innovation

To be achieved by:

- Defining a series of technology frontiers to be tracked and investigated;
- Examining the potential role of social changes such as crowd sourcing in the delivery.
- Opportunistic Data Acquisition
  - Tracking planned cruises and actively seeking to use them as opportunities for increasing the coverage of ocean floor mapping;
  - Using an existing Data Acquisition Planning System, such as POGO which has been operating for over 10 years, see the figure and text below.
- Research sharing
  - Seeking to present results of research work, such as the recent work on bathymetric LiDAR in Waikato, to the wider marine community as part of raising LINZ external profile.

Implementation Costs

One of the main purposes of Stage 3 is to provide the detail that would enable costs to be evaluated in detail. However, as a rough order of magnitude estimate LINZ should budget as follows:

- Dedicated MSDI team
  - Current estimate: $500k per annum (3 FTEs);
  - Support from SDI team on standards and LDS on technical implementation.
- Maximise reuse of existing systems and resources to keep capital investment to a minimum
  - Geoportal: upgrade existing GNS system (capital circa $200k);
  - Marine Cadastre addition to LDS (implementation circa $250k);
- Hydrographic Authority changes largely achieved from internal efficiencies
  - Outsourcing;
  - Notice to Mariners (NtM) simplification;

Software process improvements.

Next Steps

LINZ need to decide what priority (and resources) they are willing to assign to advancing a National MSDI.

If it does decide to push ahead and agrees with the direction laid out in this report, then the following immediate actions follow:

- Identify / recruit resource to lead on MSDI
- Establish working group of key stakeholders to refine big vision and define early wins
- Commission Stage 3 of the study to “flesh out” the strategy.

1 Introduction

1.1 Background

1.1.1 Economic Importance of the Marine Economy

New Zealand has the 4th largest Exclusive Economic Zone (EEZ) in the world with an area of ocean 20 times the size of the land mass[1].

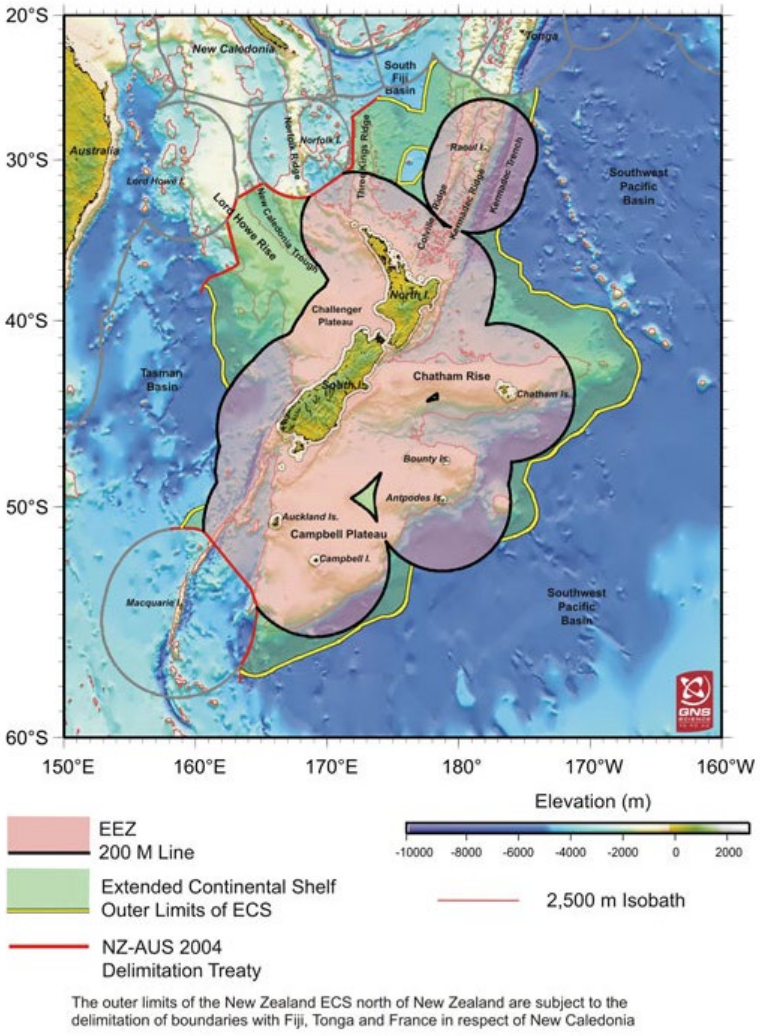


Figure 1: Map of the Exclusive Economic Zone

The marine environment is an important asset to New Zealand and already provides extensive benefits to the country. In 2002, the last time its contribution was assessed, the marine economy contributed$3.3 billion[2] (3% of total GDP) to the total economy

[1] Environmental Protection Authority (EPA) website. http://www.epa.govt.nz/eez/Pages/default.aspx

[2] Unless indicated explicitly to the contrary all financial values are expressed in New Zealand Dollars.

($115 billion). Shipping (27%), fisheries and aquaculture (26%), and offshore minerals (23%) being the largest contributors from the marine economy[3].

The importance of the marine economy is further underscored by the fact that 99.7% (60 billion tonnes per annum) of New Zealand's imported and exported cargo/goods are transported by sea – an export value of $5 billion per month and $50 billion for the year in March 2014[4].

Presently 90% of fish caught in New Zealand waters are exported, and the value of fishing quota is estimated to be worth $1.2 to $1.5 billion per annum. Lastly, in 2014 oil was New Zealand's fourth largest export revenue with an estimated value of $2.2 billion per annum which generates around $400 million per annum in royalties and $300 million in taxes for the government.[5]

1.1.2 Marine Data Scarcity to Abundance

The geospatial information that is currently available about the world's seas is currently woefully inadequate for the growing demands of the marine economy. Robert Ward, President of the Directing Committee of the International Hydrographic Organisation (IHO), recently observed that:

"There are higher resolution maps for the Moon and Mars than for many parts of our seas and coastal waters[6]."

The EEZ of New Zealand is no better served in this respect than most countries.

However, technological advances such as crowdsourcing, satellite derived bathymetry and autonomous survey vehicles, in addition to a burgeoning number of data acquisition missions for other purposes such as marine science and mineral exploration, offer impressive and increasingly affordable opportunities to change this picture.

In a few short years, through essentially the same evolution, the geospatial data landscape has changed from a scarcity of data to one of perhaps even over-abundance. There a signs of the same pattern emerging in the marine environment. The statistics quoted in a recent presentation[7] of 125,300 square kilometres of bathymetry captured, processed and published as a bi-product of three biogeographic research cruises is an indication of the opportunity.

[3] LINZ Publication: New Zealand Bathymetric Investigation (2015) http://www.linz.govt.nz/about-linz/what-were-doing/projects/new-zealand-bathymetry-investigation

[4] Op cit

[5] LINZ publication: New Zealand Bathymetric Investigation (2015) http://www.linz.govt.nz/about-linz/what-were-doing/projects/new-zealand-bathymetry-investigation

[6] Hydro International, Volume 19 Number 6, September 2015

[7] Opportunistic Multibeam Surveying, Hoy, Robinson and Huvenne, US HYDRO 2015 Conference

1.2 Objectives

Land Information New Zealand (LINZ) is the national hydrographic authority for the country and also has responsibilities, under international treaties, in the South West Pacific and Ross Sea area of Antarctica. As such, it is charged with overall responsibility for hydrographic matters particularly as they relate to the provision of nautical and hydrographic charting services under the obligations in the Safety of Life at Sea (SOLAS) convention to which New Zealand is a signatory.

The requirements of mariners for navigation, both currently and in the foreseeable future, are evolving but there are well established mechanisms through the International Hydrographic Organisation (IHO) for setting standards and reviewing methodologies. The challenge for the Hydrographic Group now and in the future is therefore less to do with navigation of vessels covered SOLAS and more to do with the wider issue of marine requirements for location information. In particular, how the group contributes to achieving the LINZ long-term strategic goal of increasing the value created through the use of location information tenfold over the next 10 years[8].

The study was commissioned by Jan Pierce, Deputy Chief Executive, Land Information, to report on two key objectives:

i) Maximising the use of bathymetric (and related) data that LINZ collects for hydrographic purposes in domains other than charting such as coastal zone management, marine science, mineral exploitation and offshore construction;

ii) Optimising the potential use of the skills LINZ possesses with respect to marine data management to meet the requirements of the entire marine community within the Exclusive Economic Zone of New Zealand.

Achieving these objectives might be described as the creation and curation[9] of a National Marine Spatial Data Infrastructure (MSDI) for New Zealand.

[8] LINZ Statement of Intent 2014-8

http://www.linz.govt.nz/about-linz/publications/statement-intent/statement-intent-2014-2018

[9] Data curation definition: the active and ongoing management of data through its life cycle of interest and usefulness to scholarship, science, and education. Data curation activities enable data discovery and retrieval, maintain its quality, add value, and provide for reuse over time, and this new field includes authentication, archiving, management, preservation, retrieval, and representation. http://www.clir.org/initiatives-partnerships/data-curation

1.3 Scope

The scope of the study is primarily to consider the marine environment, however we have interpreted this to cover the coastal zone, since the past division of land and sea largely predicated on technological grounds is now increasingly irrelevant and unhelpful.

The focus is on geospatial data but again, as location is often an attribute of other application data, it considers such information where it is relevant to the primary goal of exploiting location information to grow the economy of New Zealand.

The stakeholders consulted in the study have included most parts of the public sector and a representative sample of private sector business. As a result of time constraints rather than by design, direct consultation with members of the public has been limited, although vendors of consumer equipment and software aimed at the recreational market have been included.

1.4 Context

Consideration of the potential and appetite within Government for the wider role set out in the objectives implies also needs to take into account that the world of mapping and charting is changing very rapidly. Commercial organisations, with global coverage and huge volumes of users, such as Google which are influential players in the consumer mapping market, are turning their attention to the marine environment though their Google Ocean programme[10] and their plans for the earth observation satellite market through their purchase of Skybox Imaging, now renamed Terrabella[11].

Furthermore, the traditional divide between land and sea in terms of data capture and processing technology is beginning to disappear. Light Detection and Ranging (LiDAR) technology which has the potential to provide "fit for purpose" shallow sea elevation data, is already a viable choice when conditions are favourable and has real near-term potential to become a cost-effective general purpose tool for bathymetry. Earth observation data from satellites, already a valuable reconnaissance tool for bathymetric survey, is also an area of technological change. The cost of developing and launching satellites is rapidly decreasing to the extent that there are now 35 agencies with active earth observation programmes[12]. More details of significant technology trends is provided in section 6 of this report.

Other public sector bodies are also becoming important players in marine data capture and management, of particular interest in New Zealand, is the LiDAR capture

[10] Oceans in Google Earth http://www.google.co.uk/earth/explore/showcase/ocean.html

[11] Terra Bella website https://terrabella.google.com/

[12] CEOS Satellite Database: http://database.eohandbook.com

programmes of the larger regional governments and the Hauraki Gulf Marine Spatial Planning system[13].

As a result, should LINZ decide to become more widely engaged in the marine space, the hydrographic group will need to adapt rapidly. It is already recognised that its relationship with other key public sector bodies in the marine sector such as Maritime NZ and National Institute of Water and Atmospheric Research (NIWA) needs to be reviewed but the required strategic changes may be substantially greater.

However, such change needs to be set against a backdrop of increasing volumes of work to keep pace with demands for improved navigation products and services and the problems of staff recruitment and retention in a specialised and globally competitive jobs market. Balancing this "business as usual" and the potential benefits to the economy of developing an MSDI must be central consideration in any future strategy.

In short, there is a pressing need to rapidly plot a strategic long-term direction that takes into account all these influences, chooses a preferred direction from a range of strategic options, tests it with customers, and then executes the actions required to achieve it.

1.5 Key Assumptions

It is assumed that there are no constraints on the ability of LINZ, should they wish to pursue leadership in the marine information space, to take on this role on behalf of the New Zealand Government.

In practice, there are inevitably limitations ranging from finance to human capacity. However, a zero-constraint approach enables the study to "think the unthinkable" which is in our view essential to informing development of a strategic, long-term vision.

1.6 Acknowledgements

This study would not have been possible without the collaboration of a large number of people who gave their time willingly and supplied many valuable insights into the management of marine information.

The authors would particularly like to thank the hydrographic group for their input, many of the ideas included in the report originated from their knowledge of the existing systems and contacts in the maritime community.

1.7 Structure

The report is structured as follows:

Executive Summary

[13] Hauraki Gulf: Marine Spatial Planning: http://www.aucklandcouncil.govt.nz/en/planspoliciesprojects/plansstrategies/seachange/Pages/home.aspx

Introduction

Concepts: establishing a common vocabulary

Approach:

Current State Summary: recap of results of Stage 1

Stage 2 Findings

Market Needs: summary feedback from engagement with stakeholders

International Best Practice: observations from visits / discussions

Technology horizon scan: relevant hardware, systems and software trends

Government Policy review: NZ and International policies in respect to marine spatial data

Benefit-cost Analysis: NZ and International evidence

Conclusions and Recommendations

Outline Strategy

Next Steps

2 Concepts

It is important at the start of such a study to ensure that readers have a common base of concepts and terminology to avoid the author and readers using the same terms but understanding them differently. Particularly in a relatively small community where different terms are also used interchangeably leading to further sources of confusion. In this section we first describe the principal terms used in this study to define the current scope of work undertaken by LINZ in the marine domain and then define what we mean by Marine Spatial Data Infrastructure (MSDI), which represents the scope of the future opportunity.

2.1 Hydrography

Hydrography is the branch of applied sciences which deals with the measurement and description of the physical features of oceans, seas, coastal areas, lakes and rivers, as well as with the prediction of their change over time, for the *primary purpose of safety of navigation* and in support of all other marine activities, including economic development, security and defence, scientific research, and environmental protection.

Source: International Hydrographic Organisation[14].

2.2 Bathymetry

Bathymetry - the term "bathymetry" originally referred to the ocean's depth relative to sea level, although it has come to mean “submarine topography,” or the depths and shapes of underwater terrain. In the same way that topographic maps represent the three-dimensional features (or relief) of overland terrain, bathymetric maps illustrate the land that lies underwater. Variations in sea-floor relief may be depicted by colour and contour lines called depth contours or isobaths. Bathymetry is the foundation of the science of hydrography, which measures the physical features of a water body. Hydrography includes not only bathymetry, but also the shape and features of the shoreline; the characteristics of tides, currents, and waves; and the physical and chemical properties of the water itself.

Source: National Oceanographic and Atmospheric Authority (NOAA[15]).

2.3 Spatial Data Infrastructures

2.3.1. Defining MSDI

A Marine Spatial Data Infrastructure (MSDI) is a specialised form of Spatial Data Infrastructure, crafted to address the needs those working in the maritime and marine environment.

[14] IHO Home page: https://www.iho.int/srv1/index.php?lang=en

[15] NOAA Office of Coastal Survey: http://www.nauticalcharts.noaa.gov/

2.3.2. What is a Spatial Data Infrastructure?

So it is wise to set out initially what we consider an SDI to encompass.

To start with a definition (with the key terms italicised):

A Spatial Data Infrastructure facilitates the *sharing of data*, by *avoiding duplication* associated with the *generation and maintenance of location information* and supporting *integration* with other datasets.

This leads to *development of innovative business applications*, *greater efficiency* in both public and private sector organisations and provides better information to support *decision making*.

The word *infrastructure* indicates that such systems are part of the *basic physical and organisational structures and facilities* needed for the *operation of a society or enterprise*.

Source: Williamson (2003)

2.3.3. What is a Spatial Data Infrastructure?

Over a period of time the scope of what we understand to be necessary for an SDI has expanded, particularly to extend beyond the technical data issues to include human resources (people and skills) components and critically consideration of financial arrangements.

Figure 2: Components of an SDI below illustrates this wider scope.

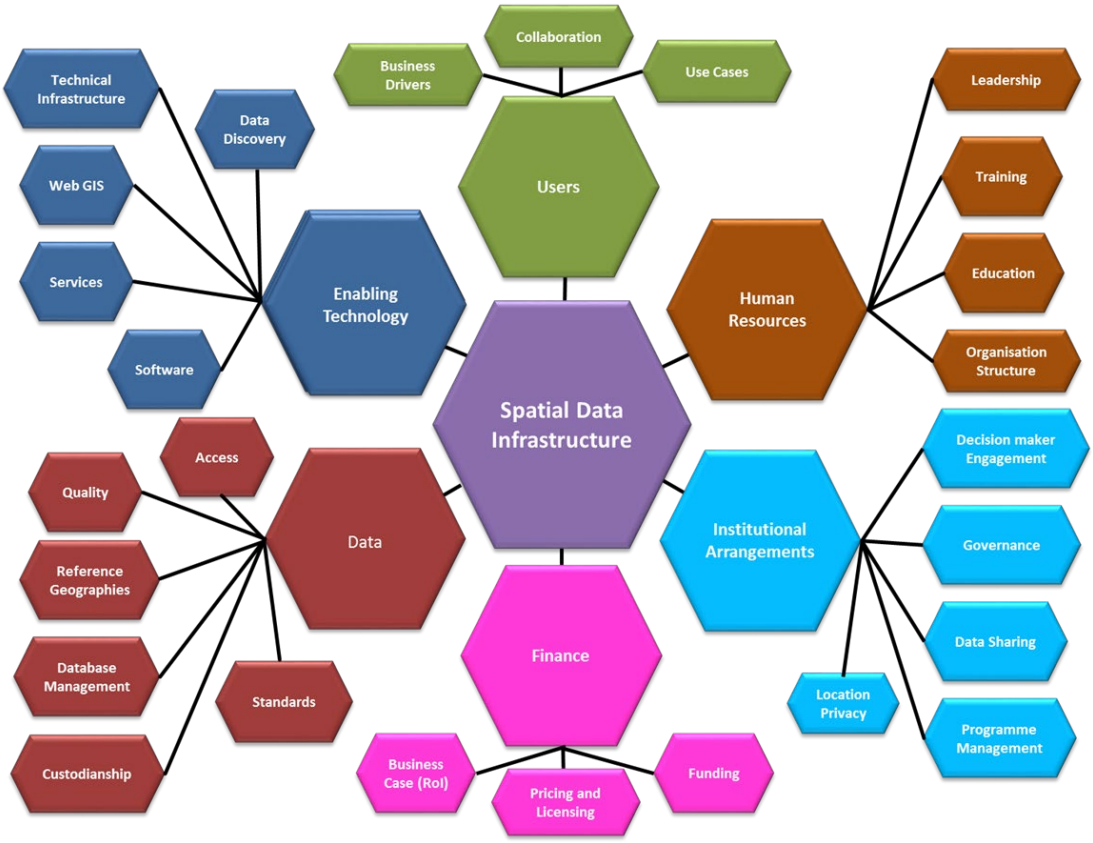


Figure 2: Components of an SDI

Glossary of Terms

A useful glossary of other terms used in the Marine spatial data field is published on the LINZ website at: http://www.linz.govt.nz/about-linz/what-were-doing/projects/new-zealand-bathymetry-investigation/bathymetry-glossary

3 Approach

3.1 Summary

Building on the experience of previous similar exercises, both within LINZ and other countries, the review involved a number of inter-related activities to analyse alternative strategies and then advise LINZ management.

The fundamentals of the approach adopted are “stepwise refinement” and learning from best practice, aimed at adding value at each stage of a three stage review.

Stage1: An assessment of the current situation was provided with recommendations on short-term actions. This report only refers to this work where relevant.

Stage 2: Is the main focus of this report and considers the longer-term options in more depth, looking at the external influences of changing market needs, international best practice and technology advances plus internal factors of workflows, Government and LINZ policy. It also includes on outline strategy to inform Stage 3.

Stage 3: The final stage will be to work up the chosen option into a robust, implementable plan for transformation of the hydrographic group to deliver the chosen strategic vision.

The figure below represents the overall approach diagrammatically.

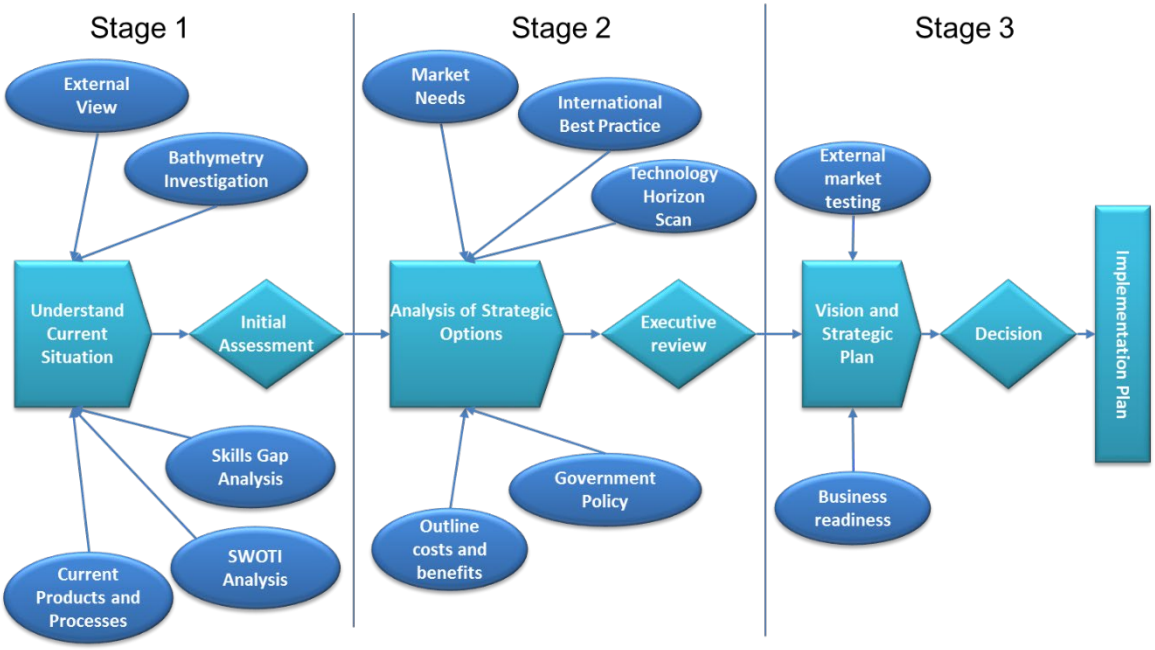


Figure 3: Stages in the Hydrographic Authority Review

3.2 Current Stage Detail: Analysis of Strategic Options

Having compiled and validated the "as is" picture of the group and the wider context in Stage 1, the focus in stage 2 was to draw up a series of "to be" strategic options for the future of the group.

The following sections provide more detail of the tasks and outputs from Stage 2.

3.2.1. Options Summary

The options evaluated in Stage 2 were:

1. Status quo – maintain focus only on hydrographic charting mission (including SW Pacific / Antarctica NZ)
2. Supporting coordination by others of better bathymetric data sharing
3. Adopting a coordination role for a national Marine SDI similar in concept to what LINZ provides for imagery
4. Proactive leadership in the development of a full MSDI for New Zealand

In the paragraphs that follow, we detail the activities undertaken to flesh out and compare and assess these options.

3.2.2. Task 2.1 Kick-off

Under this task, the following activities were completed:

i) Review the stage 1 report, taking on board any subsequent developments within the group and views not previously expressed regarding its conclusions and recommendations;

ii) Presentation to the entire hydrographic group, this included a summary of the stage 1 report giving an indication of the direction of travel, show them that their participation in the previous stage was taken into account. The presentation also briefed them on the work programme for stage 2;

iii) Discussions with the sponsor and hydrographic group managers of the short-term recommendations from stage 1 and how they were being prioritised and progressed;

iv) Agreeing the strategic options to be evaluated.

v) Project Planning - agreeing deliverables, work plan and support arrangements for interviews, workshops and other activities within stage 2.

3.2.3. Task 2.2 Market Needs

Using the stage 1 review as a basis, the consultant re-engaged with the key stakeholders, focusing this time on their views on the strategic options.

In particular, we sought to establish the key priorities in respect to growing the use of marine and maritime geospatial information to the benefit of the economy and how LINZ might best facilitate achieving that objective.

3.2.4. Task 2.3 International Best Practice

Under this task the consultants arranged meetings (in some case virtual) with a wide range of organisations facing similar challenges to those faced by the Hydrographic Authority.

The meetings undertaken included:

- Australian Hydrographic Service
- National Oceanic and Atmospheric Administration (NOAA)
- Port of London Authority
- Danish Hydrographic Office
- Channel Coastal Observatory, Southampton
- British Oceanographic Data Centre, Liverpool
- Infomar, Ireland

In addition, a continuation of the dialogue with CARIS was undertaken through a visit to their headquarters in Fredericton, New Brunswick. This is the subject of a separate report supplied to LINZ in October 2015, it is not reproduced here due to the commercial sensitivity of the material discussed.

3.2.5. Task 2.4: Technology Horizon Scan

Currently, there are more technologies that will potentially impact upon geospatial organisations, than at any stage within living memory.

This task looked at relevant technological innovations and considers how they will “play out” in relation to each strategic option.

3.2.6. Task 2.5: Government policy

There are many elements of Government policy that need to be factored into the choice of strategic options. Relevant current initiatives include climate change, environmental protection, aquaculture, fisheries, transparency (open data), public sector efficiency, stimulating economic growth and emergency management.

Under this task the consultants attempted to draw these together to consider if a new mandate for the group is required to underpin a new role.

3.2.7. Task 2.6: Outline Cost / Benefit Analysis

There are different costs and benefits attached to the strategic options. The costs include purchase or upgrade of technology and tools but also include training and recruitment to meet the needs identified in the skills gap analysis undertaken in Stage 1. The benefits considered include direct cost savings in time or staff numbers but also indirect benefits to other organisations and the New Zealand economy as a whole.

The intention is not to provide a full business case but to provide indications of the "delta" between costs and benefits. The principles of the "better business cases" methodology from Treasury are adopted in this respect.

3.2.8. Outputs

The principal output from Stage 2 is this written report.

The report presents a critical assessment of the strategic options. It then provides a recommendation of the preferred option with back-up information on budgetary costs and benefits.

4 Market Needs

This was established by stakeholder engagement. A total of nearly 50 formal interviews were conducted across Stages 1 and 2 of the study. Interviewees were supplied in advance with a brief describing the study. In order to obtain some of the information gathered it was necessary to provide interviewees with assurance concerning anonymity of their input, which is respected in all the deliverables.

The Stage 2 external brief sent to interviewees is included as Annex A.

4.1 Public Sector

4.1.1. Introduction

The following paragraphs provide a summary of the feedback from the public sector organisations interviewed over Stage 1 and Stage 2. Fuller descriptions are available in presentation slides and associated notes.

4.1.2. National Institute for Water and Atmospheric Research (NIWA)

NIWA have a defined role as a national authority for storage of marine scientific data. They are one of a number of Crown Research Institutes within the public sector. They receive part of their funding (about 30%) from Government but the remainder has to be realised from commercial activities. Commercial confidentiality prevents them from releasing much of the data they hold and in cases where data has been collected using public funds the funding does not include curation (management and dissemination) and so is not available, at least not without charge.

The relationship has been adversely affected recently by not having won tenders let by LINZ for hydrographic surveys. The research vessel Tangaroa is funded by Government for only 65 days currently but to recover its costs requires to be working for 165 days per annum. These contracts which NIWA argue are in the interests of New Zealand as a whole to be awarded to them would help fund the vessel. A further issue is that NIWA were formerly paid to store LINZ data but this contract was terminated and this work taken in-house.

NIWA feel they have no visibility of (or influence in) future survey plans by LINZ – they feel this is important as the access to the raw data from LINZ surveys could be of considerable value to the national science programme. There is also a risk of duplication of effort as NIWA may commission surveys in areas that LINZ intends to survey.

The relationship is now being “re-baselined” through senior management engagement which seems to be positively received on both sides. This is important since NIWA are already central to many marine initiatives and development of a Marine Spatial Data Infrastructure cannot, in our opinion, be advanced without their full and active participation.

4.1.3. GNS Science

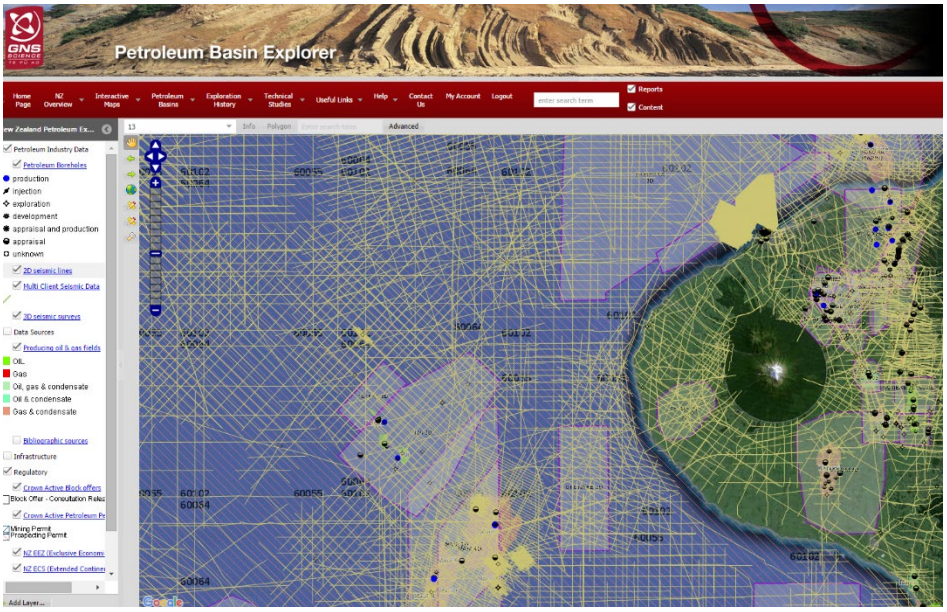
GNS Science is a Crown Research Institute (CRI). Its website[16] describes the organisation as New Zealand's leading provider of earth, geoscience and isotope research and consultancy services.. It is funded as follows:

- Public good research contracts (40-45%)
- Consultancy and services (20-30%)
- NZ Earthquake Commission (15-20%)
- Advice to Government agencies (5-10%)
- Grants for capability development (5-10%)

Of particular interest in the context of this study is their data holdings and sharing policies. GNS was commissioned by New Zealand Petroleum and Minerals (NZ P&M) within the Ministry of Business, Innovation and Employment (MBIE) to develop the Petroleum Basin Explorer (PBE)[17]. The PBE is a geoportal providing access, via a mapping interface, to GNS, NIWA, NZ P&M owned data.

PBE only has viewer capabilities i.e. there is no download facility. GNS do not regard the portal as core business.

An illustrative screen shot is shown in the figure below.



[16] GNS Science website home page: http://www.gns.cri.nz/

[17] Petroleum Basin Explorer: http://data.gns.cri.nz/pbe/ - registration required

Figure 4: Screenshot of the GNS Petroleum Basin Explorer

GNS Science relationship with LINZ is well established but better developed in the geodetic area than in marine science. They appreciate the LINZ open data policy but would like greater visibility of the bathymetric data that LINZ holds which might be of value for marine geoscience.

Raw data is of most interest since data processed for hydrographic charting has "shoal bias" so not ideal for their scientific needs and would want to re-process for "mid water" information. Better access to bathymetric information for water depths below 200m depth that is currently very sparse would be of particular value.

GNS collect substantial quantities of multi-beam data that might be useful to LINZ; they undertake around 10 surveys per annum. There is a shared interest in better data for Antarctica.

4.1.4. NZ Petroleum & Minerals (NZ P&M)

NZ P&M is part of the Ministry of Business Innovation and Employment (MBIE). It is a relatively new entity, established in 2010. It grants permits and collects royalties, under the Crown Minerals Act, for:

- Seismic surveys
- Exploration licences
- Boreholes

Permits are granted on the basis that data captured is submitted to the Crown:

- Data is held confidential for 5 years or until the end of permit term, then is released in raw (as submitted) form
- They have a close relationship with NIWA and GNS but are frustrated by the lack of open access (charges restrict data sharing).

Their overall objective is to provide as much information to prospective exploration companies as possible. This encourages such companies to come to New Zealand rather than explore elsewhere. To support this they have a data investment fund (NZ$8m over the next 4 years).

Technologically, they operate a geological online database (GOLD). However, the technology platform is old (based on Landmark software) and they are looking to replace it. GOLD contains metadata for all data stored (including that commercially restricted). They use LINZ cadastral parcel and topographic data for context onshore, NIWA is the main source of

bathymetry. They supply bathymetric data as “data packs” on 2 Gb hard drives because of the large volumes.

Currently, management level Interaction with LINZ is through the inter-departmental Natural Resources Information Directives group but this is not ideal, they would value more focused bi-lateral contact.

Their vision in relation to marine spatial data is to have one national geophysical data centre, accessed through a single portal and including all relevant Government and CRI data. They believe that a federated structure of storage/ownership will produce optimum interoperability between databases and ultimately this will grow into a full MSDI.

They believe LINZ also has a key role in helping agencies raise their geospatial capabilities.

4.1.5. Maritime NZ

Maritime NZ (MNZ) is the national maritime regulatory, compliance and response agency.

More regular senior management engagement between the organisations has recently been re-established, this is very welcome. Now it needs some “early wins” to convince both sides of the value of closer co-operation.

Operational level engagement between the Rescue Coordination Centre[18] (RCC NZ) and hydrographic authority works well. LINZ coordinates NAVAREA XIV warnings, long range radio navigational warnings that are broadcast to ships in New Zealand waters which would appear to lie more naturally with Maritime NZ.

There is a lack of formalised relationship between the organisations with no Service Level Agreement (SLA) or underpinning Government policies as a basis for collaboration. However, a draft SLA was prepared a couple of years ago and could be used as a starting point for discussion. Furthermore, process maps have been drafted within Maritime NZ that could be usefully reviewed to rationalise engagement.

In July 2015, Maritime New Zealand announced a review of coastal navigation safety[19], to consider how coastal navigation safety risks are identified and managed within New Zealand’s territorial waters. The review commenced on 1 July. MNZ has conducted its research and consultation phases, and expects to report its findings by the end of 2015. LINZ active involvement in workshops around the country has helped raise its profile.

MSDI is recognised as a clear opportunity for both organisations but definition and implications not well understood within Maritime NZ. There is an opportunity for some “early wins” as MNZ has very little capability in respect to GIS which could aid its intelligence and planning work, particularly in relation to tracing the origins of oil spills.

[18] RCC NZ Role: http://www.maritimenz.govt.nz/About-us/RCCNZ-profile.asp

[19] Coastal Navigation Review http://www.maritimenz.govt.nz/Consultation/Coastal-navigation/

Further, MNZ also recognise that they are not doing enough to advance Government policy in relation to open data. There may be an opportunity for LINZ to assist here by offering to provide a mechanism for dissemination through the LINZ Data Service as the organisation has no central spatial database.

4.1.6. Ministry for the Environment (MfE)

MfE is very supportive of what LINZ is looking to achieve but, as in most cases, would require further information regarding issues of governance, resources and costs of setting up and maintaining an MSDI. They also have questions regarding the level of buy in, and commitment from, other agencies and CRIs.

In terms of strategic direction, their preferred option would be either option 3 (coordinate) or option 4 (leadership). Having LINZ take a leadership role would make it really clear to all agencies and sectors who is driving it. However, there would need to be clear buy-in from all the main stakeholder agencies (Department of Conservation (DoC), Ministry of Primary Industries (MPI), Maritime NZ, Environmental Protection Agency (EPA) and MfE) and CRIs (principally GNS and NIWA).

MfE indicated they would be happy to be involved in some shape or form but this buy-in needs to be there so you can be sure that all the relevant data will made accessible through the MSDI. They believe it would be really helpful to have a single point of truth when it comes to data in the marine domain, which the MSDI could be.

4.1.7. NZ Defence Force

NZ DF is supportive of LINZ - they want them to succeed and if asked are willing to lend political help when necessary. Geospatial has been elevated in importance within the force and moved to be the responsibility of the Assistant Chief of Strategic Commitments. The hydrographic domain is a priority for defence, they have assets to map topographic features using remote sensing but the hydro domain is “invasive” so more difficult for them which means they need the certainty they can rely on LINZ. The South West Pacific is particularly important, knowing where landing craft can safely go ashore is critical.

Coordination of hydrographic survey programmes is vital to their interests. NZ DF feel it is too heavily skewed to shipping at the expense of defence requirements. There are obviously restrictions in sharing some of the data they collect.

Their strategic needs are for LINZ to take over the remaining third of charts that were not transferred when responsibility for charting was transferred from the Navy. Prioritisation of charting work they feel is not transparent, they want more awareness of plans for future surveys.

NZ DF believe they are central to the development of the SDI in New Zealand both onshore and offshore and are concerned there is a lack of appreciation of the importance of NZ DF

role in geospatial in LINZ. They observe that the Geospatial Strategy[20] is now nearly 10 years old and believe it needs reinvigoration. A further observation concerned the relationship between LINZ and emergency services which is not as close as it should be. Stronger LINZ leadership in the area of national standards development would also be appreciated.

4.1.8. National Maritime Coordination Centre (NMCC)

The NMCC is part of NZ customs and collects information and manages "tasking" for all forms of military and civilian maritime surveillance to meet civilian needs.

NMCC has a coordinating role for marine spatial data in the procurement of systems for Automatic Identification System (AIS), the automatic tracking system used on ships and by vessel traffic services (VTS) for identifying and locating vessels by electronically exchanging data with other nearby ships, base stations, and satellites. Maritime NZ, MPI and NZ DF are the largest users of the system, which is supplied by Orbicomm[21].

Currently their major challenge is bringing AIS data together with other sources to provide a Common Operational Picture (COP) when assessing the need to despatch assets to incidents such as when illegal fishing is reported.

The COP is used daily and currently requires between one and two FTE staff to maintain. Their work is largely transforming data from many different sources so that it can be represented consistently. A marine geoportal would be a valuable tool, reducing and eventually eliminating this need.

4.1.9. Ministry of Foreign Affairs and Trade (MFAT)

MFAT is the sponsor of a programme of hydrographic work currently being undertaken by LINZ in the South West Pacific. They are happy with relationship at present and feel it has vastly improved in the past two years, largely built on personal relationships between individuals in both organisations, clear timetable commitments, constant communication and well defined deliverables.

Longer-term they are concerned about the lack of a clear policy mandate at LINZ for the South West Pacific work. They have no specific interest in better data management.

4.1.10. Department of Conservation (DoC)

DoC is one of the main partners in the Hauraki Gulf Marine spatial planning system, along with Auckland Council. In our view, this system[22] represents the closest approach to a currently operational Marine SDI in New Zealand.

[20] Geospatial Strategy: http://www.linz.govt.nz/about-linz/our-location-strategy/geospatial-strategy-and-work-programme/new-zealand-geospatial

[21] Orbicomm Maritime: http://www.orbcomm.com/en/industries/maritime

[22] Hauraki Gulf public browser: http://www.seachange.seasketch.org.

They are also leading similar initiatives in Otago Marine Protected Area and locally focused work such as Waimea inlet. They have a proposed programme to extend the Hauraki Gulf system to national coverage over a 10 year period. DoC have also developed their own geoportal[23], estuarine waters (including bathymetry) is a major focus of this work.

DoC are concerned that a National Marine SDI will be difficult to control and will not necessarily provide what they need as an organisation. They cite the failed NAPALIS[24] initiative between LINZ and DoC was a case in point, taking the view that generally agencies "don't necessarily play nicely together".

Their main policy concern is whilst MFAT license research vessels to sail in NZ EEZ, they do not have the interest or capability to fulfil the role of data curator. In consequence, potentially very useful data is not available to agencies in New Zealand for operational and research purposes.

DoC also have considerable interest in what data LINZ may able to offer, including:

- More complete bathymetric data
- Tidal currents
    - Used for modelling estuarine habitats
    - Setting conservation priorities
    - Ecological integrity
- Restriction boundaries
- Sea level data

Currently DoC let contracts to commercial organisations to assemble data from available sources. This is costly and would be unnecessary with better coordination in Government.

4.1.11. Regional Government

Regional government organisations are responsible for planning not only onshore but offshore within the 12 nautical mile limit. Interviews were undertaken with the following during the study:

- Auckland
- Waikato
- Bay of Plenty

Auckland

Auckland Council is the lead partner in the Hauraki Gulf Marine Spatial Planning project, working closely with DoC to develop the GIS based on Esri's ArcGIS Online and Seasketch

[23] DoC Geoportal http://geoportal.doc.govt.nz/geoportal/catalog/search/search.page

[24] NAPALIS: http://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=11174568

platform[25]. The key applications for the system are pollution monitoring, licensing of dredging, biodiversity studies and tsunami planning. It contains over 200 datasets and took about five man year's effort to compile. The aim is to create a set of planning zones, based on the Resource Management Act (RMA) principles that extend out to the edge of the 12 nautical mile limit of their jurisdiction.

The steering group is made up of stakeholders from the marine science community. LINZ is not a partner organisation in the project.

Waikato

The perspective provided was that of the harbourmaster community. Recreational boating is their main responsibility as there are no commercial ports in the region. There is an increasing demand for bathymetry covering rivers and estuaries.

Their main policy concern is restrictions on sharing data imposed by LINZ; this may be more related to accessibility than openness itself.

Port Surveys are undertaken regularly by their main vessel but this only has single beam sonar capability. Although this data may not be suitable for charting is useful for other purposes e.g. scientific and environmental studies. They would, with appropriate agreements, share this data. They believe this is generally true for port authorities and would like to encourage LINZ to engage in new dialogue with the harbourmasters community on:

- Data sharing: harbourmasters can provide a lot of more widely useful bathymetric and other navigational data
- Storage: much is currently thrown away as they do not have necessary storage facilities
- Dissemination: would like to investigate this being achieved through LDS.

Bay of Plenty

Within the Regional Council they have formed a single group called CLAW (Coastal Land Air Water) for coordinated consenting. The maritime team is responsible for enforcing local marine byelaws, particularly, fishing consents and recreational boating.

Tauranga harbour is major coastal responsibility, the Regional Council is a shareholder in the operating harbour company.

[25] Seasketch is developed by the University of Santa Barbara, the home page for the Hauraki Gulf system is: http://www.seasketch.org/case-studies/2014/05/28/doc.html

They have a strong interest in vessel multi-tasking to enable them to acquire additional data but also to share the capabilities of the vessels they contract-in to undertake their surveys. They are very committed to data sharing and believe the current inter-governmental processes for sharing are poorly coordinated. Even within the Council sharing could be improved – other departments in the Council often do not know what is available within their own organisation.

4.1.12. Environmental Protection Agency (EPA)

The EPA has only recently been formed to take responsibility for regulation of activities outside the 12 nautical mile limit but within the EEZ, covering:

- Resource management: administering applications for projects of national significance
- Emissions trading, control of hazardous substances and regulating import of new organisms.

They have a limited geospatial capability at the moment but are working on a roadmap using external advisors (e-Spatial). Their main issues are finding data sources and issues of access - the EEZ is so large and little data is available for much of it.

Their chief executive has declared a desire for EPA to become a repository for marine data, so there is strategic interest in data management. However, EPA is likely to be a consumer of data rather than a major supplier – it has so far only granted four consents.

In terms of the strategic options, EPA would want to use existing facilities and their natural alignment would be with NIWA or LINZ. As their interests require collation of a large, diverse body of data they would prefer a more holistic approach to marine data management.

4.1.13. Ministry of Primary Industries (MPI)

There are a number of different aspects of marine spatial data management that are of interest to MPI. A primary area of interest is the relationship between fish stocks and bathymetry where they are already partnering with NIWA and GNS.

A comprehensive central repository or portal for marine spatial information would be very valuable to this work. One of the significant challenges will be how to enforce restrictions on access necessary because of commercial considerations – MPI has data provided by fishing boats as a condition of their licence that cannot be shared.

In respect to the strategic options, MPI are most likely to support of option 3 for the following reasons:

i) For any development in this area to occur there needs to be at least one person who has it as their major role.

ii) There also needs to be a known individual that people can rely on to act as a conduit for new and existing information and a chief communicator of current and upcoming projects in the maritime space.

iii) This person should also share information freely with the person responsible for image capture as there are definitely opportunities for both land and maritime data development and sharing.

Furthermore, they can't see option 3 being successful without option 2 (bathymetry) being in place.

MPI caution that it needs to be established - if there are sufficient efficiencies and economies of scale in the maritime space - are organisations, companies, councils paying for data capture companies to go out and capture maritime information to a similar extent as onshore?

4.1.14. Antarctica NZ

NZ is signatory to the Antarctic treaty but also has a predating territorial claim to Ross Dependency; this claim is underpinned in part by mapping, so an on-going commitment is important.

Most of Antarctic operations are on land, however, Antarctica NZ contributed $2m to a recent NIWA scientific cruise.

There is considerable marine survey activity by other nations in the Ross Sea:

- Korean modern icebreaker (Araon) has multi-beam sonar
- Chinese vessel (Snowdragon) has sonar (type unknown)

Both Korean and Chinese cruises have considerable data assets, in some cases time series data covering acidification, currents, sea ice and bathymetry have been captured through multiple visits over as much as ten years. These vessels operate outside MFAT control and are not subject requirements to share their data.

Antarctica NZ has increasing safety and rescue concerns as tourism and construction activity grow - charts are old and particularly unsatisfactory for shallow water in areas where structures are being built.

Currently the relationship with LINZ is strong and works at multiple levels, However, the need for data to support operational needs (search and rescue) and management (construction and tourism) is increasing and opportunities are being missed for LINZ to be involved in ensuring data assets from foreign vessel activity is accessible.

4.1.15. Māori

Engagement has proved difficult, at the time of the study there was no Business with Māori lead in LINZ to help broker a dialogue and the advice received was that either the study must engage fully or not at all.

The situation was complicated by a previous discussion as part of the NZ risk assessment with the LINZ Hydrographic Authority that for whatever reason was not pursued.

For these reasons, and given time constraints, we have spoken to Māori representatives within this stage, but we would strongly recommend are actively pursued at the start of Stage 3.

We would observe that interests of iwi as observed in the NIWA SDI proposal are likely to be focused in aquaculture, fisheries and environmental protection.

4.2 Private Sector

4.2.1. International Supplier of Marine Technology

This organisation did not wish to be identified. However, it is one of the leading international suppliers of marine engineering equipment for both commercial (non-SOLAS) vessels and recreational craft. . They are very careful to put a prominent disclaimer on all their products that they are not designed for navigation. Their estimates are that that they have possibly the largest share of the recreational market worldwide but are currently focusing on growing their share of the commercial market. They believe that at least 50% of recreational craft do not have any digital technology.

Their GIS team spends considerable amounts of time transforming charts acquired from various sources to their own internal format. Charts are bundled with the products and currently add substantially to the cost, typically this can be NZ$ 100 – NZ$200 per unit. However, the information content of their systems has more long-term value than the display component, so data is recognised as an important differentiating factor in purchasing decisions.

In terms of development of a Marine SDI for New Zealand, they would be very interested in being able to access authoritative data from a single source. Option 3, where the scope is wider than just bathymetry, they view as being optimal. With respect to data it would only be useful if it conformed to globally recognised standards to ease its integration into their systems. They would like to be able to move software resources from ingesting data to being able to adding greater value to customers through providing data analysis.

4.2.2. Fisheries Company

The company is a global seafood enterprise based in New Zealand with a worldwide fishing, processing and marketing network. The company undertake substantial charting work in both the Pacific and Indian Oceans in support of their operations. Wherever their fishing vessels go they need high quality bathymetry and other data related to sea bottom and water column conditions.

Although the much of the information they capture is hugely important to their commercial position and could not be shared, some of their information, for instance mid water data, could be put into the public domain providing proper access restrictions were put in place. The “quid pro quo” would be for the Government to “free-up” more of its bathymetric and other marine data.

They believe there is a lot of duplicated surveying in the world’s oceans and would be willing to play their part, for sound economic reasons, in improving data sharing. As such they would welcome an enhanced role for LINZ.

4.2.3. Marine Data Consultancy

This organisation describes themselves as a science-based organisation, providing high quality environmental data and analytical / numerical services to the maritime and offshore industries.

They are very positive about the benefits of a national MSDI, their "added value" is in scientific analysis but too often they spend most of their effort in sourcing and collating data.

Anecdotally, they suggest that public bodies hold vast amounts of marine spatial information that is, at best stored on hard disks, and at worst disposed of, when projects are completed. This is not because of wanton destructive behaviour but because the data is collected to underpin a report or decision and the organisations do not have the resources to curate such information.

4.2.4. Chatham Rock Phosphates

Chatham Rock Phosphate[26] were happy to be identified in connection with the study. The company aims to be the premier supplier of direct application phosphate to the New Zealand and global agricultural sector. One of their primary objectives is to achieve consent of the Chatham Rise phosphate mining project and develop the asset, although their recent application for consent was rejected[27].

They are passionate supporters of enhanced marine data sharing. A large proportion of the effort involved in mounting their consent application was expended on acquiring, collating and presenting data and its analysis. Although they believe that the decision to reject the application was not primarily caused by lack of data, better accessibility would have considerably reduced their costs – between NZ$ 10 million and NZ$ 12 million was spent on surveys.

Along with many other useful insights, the interviewee provided the following advice:

- The concept of an MSDI is not new and has been advanced on a number of occasions but each time fails to garner enough political support to be funded;
- Oceans 20/20 provided a good framework for prioritisation of projects but was too process-driven and suffered from a lack of vision;
- A distributed architecture was more likely to succeed than a centralised model;
- It would need to be seen as a long-term project, requiring significant sustained financial support;

[26] Chatham Rock Phosphate Home Page http://www.rockphosphate.co.nz/

[27] EPA rejects consent CRP application. http://www.epa.govt.nz/news/epa-media-releases/Pages/EPA-refuses-marine-consent-application-by-CRP.aspx

- There are a number of good International examples of how such an infrastructure should be built. The Australian Integrated Marine Observing System (IMOS) initiative[28] was cited as a good example;
- A powerful policy would be needed to oversee the project.

In terms of the strategic options a combination of options 2, 3, 4 and involving not only LINZ but key roles for NIWA and GNS would be most likely to succeed.

4.2.5. Oil and Gas Exploration Company

This exploration company has interests in three offshore producing fields in the Taranaki basin. Both its exploration and drilling operations require detailed bathymetry. In addition, its public outreach and consultation work requires "as much data as we can find", including:

- Hazards, pipelines
- Consents, cultural areas
- Environmentally sensitive areas

Google maps is current default data source but they would prefer to use authoritative data whenever possible. Access needs to be easy as they cannot afford to slow exploration because of the need to negotiate complex data licences leads to legal loops and consequent delays.

They have ArcGIS and well developed processes for assembling databases. They currently use LINZ for coordinate datum conversions, are aware of LDS but use the Koordinates website. The mechanisms for accessing GNS and NIWA data are particularly "clunky".

It is unlikely they would be able to share their extensive bathymetric data as it is too closely coupled to the seismic survey data and could not be easily separated out.

It is unlikely that they would be heavy users of a MSDI – the pressures on exploration mean that cost is less of a factor than commercial advantage. This view was backed up by an interview with PEPANZ[29] the trade association, which promotes the interests of petroleum producers and explorers in New Zealand.

4.3 Other Interviews

4.3.1. Coastal Society

The primary role of the New Zealand Coastal Society is to promote and advance knowledge and understanding of the coastal zone. It provides a forum for those with an interest in the coastal zone to communicate amongst themselves and to the public.

[28] Integrated Marine Observing System (IMOS): http://imos.org.au/

[29] Petroleum Exploration and Production Association of New Zealand (PEPANZ) website: http://www.pepanz.com/about/

Their main interest in respect to marine spatial data are the issues that the lead from the undefined vertical separation of onshore and offshore datums. They are also well aware of the substantial volume of marine spatial and other scientific data that "languishes in desks in many of the members' offices" and would be supportive of any measures to promote making such information available and discoverable.

They did not feel able to advance an opinion on the strategic options without formally consulting their members but were helpful in publishing a short note about the study in their weekly newsletter.

4.3.2. International Hydrographic Office (IHO)

As part of the study, we were fortunate enough to be able to interview Robert Ward, IHO Director, who was in Wellington in advance of a meeting in Rarotonga in the Cook Islands. He was effusive in his praise of LINZ is one of the "shining examples" of hydrographic organisations that understand the importance of geodata. In contrast to other authorities that are driven by commercial imperatives to the detriment of the public good.

Robert sees SDI an opportunity to "join" land and sea domains and share experience. One of his main priorities is to establish ground rules around the reuse of crowd sourced data. This would include engaging professional mariners as well as "boaties" in contributing to bathymetric databases.

4.4 Summary

4.4.1. Overview

There was general acceptance that marine data sharing in general and spatial data in particular is currently poor. The current situation is summed up by the figure below:

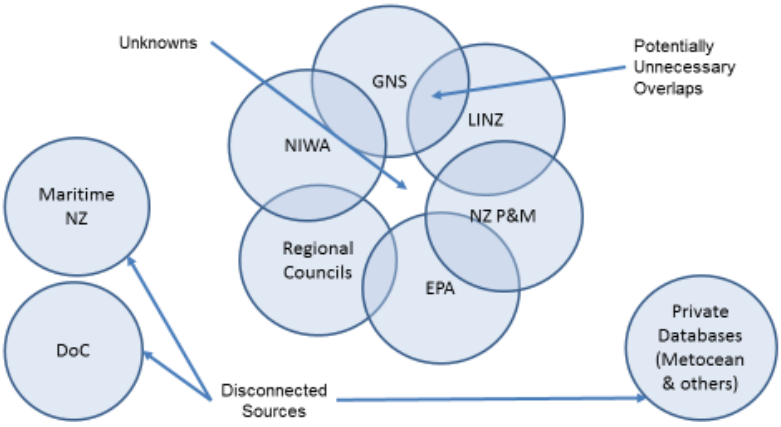


Figure 5: Current State of Marine Spatial Data Sharing

There are both “unknown unknowns” in terms of missing parts of the overall picture of data holdings and overlaps resulting in unnecessarily duplicated storage. There are also many completely disconnected “private” databases.

4.4.2. Stakeholder relationships

LINZ relationships with key NZ stakeholders we assess as being mostly good to strong

- There are “issues” with some Government partners, particularly NIWA, that need to be resolved.
- Commercial engagement is not as well developed, outside of the navigation sector.

LINZ is not currently viewed as a leader in MSDI - if the organisation wants to take a lead in this space then it needs greater credibility and wider visibility.

4.4.3. Strategic Options

Each of the stakeholders interviewed were asked to indicate their preferred option(s).

An enhanced role for LINZ in management of marine spatial data was generally supported. A number of concerns were raised as to how this might work in practice and funding was

recognised as the most important impediment. The idea of a coalition of willing agencies making a coordinated approach to Treasury was generally agreed as perhaps the only feasible approach.

The figures 6 and 7 overleaf summarise separately the responses from public and private sector stakeholders respectively.

The colour indicates positivity to an enhanced LINZ role. Blue indicates a largely negative reaction, yellow mild support and orange positive support.

From analysis of these response we surmise that there is a general desire to see more done in the field of MSDI building and an enhanced role for LINZ would be welcomed. Key issues regarding governance, resources and funding are seen as the major barriers to progress.

To provide a reminder the strategic options considered were:

Option 1: Status quo – maintain focus only on hydrographic charting mission (including SW Pacific / Antarctica NZ)

Option 2: Supporting coordination by others (NIWA/GNS) of better bathymetric data sharing

Option 3: Adopt a coordination role for a national MSDI, similar in concept to what LINZ provides for imagery.

Option 4: Proactive leadership in the development of a full MSDI for New Zealand

Stakeholder	Option 1	Option 2	Option 3	Option 4	Comments
NIWA					NIWA have large bathymetry holdings, their CRI cost recovery needs makes sharing problematic
GNS					Have operational Portal but running it not core business
DoC					Agencies don't play nicely together, NAPALIS has left a scar
Regional Government (Auckland)					Keen to see Government sort marine spatial data standards, but don't see core role for LINZ in Marine Spatial Planning
MBIE					Concerned about "control" – they have a knowledge management project and may do their own thing
MfE					Interested particularly in forward cruise planning but would also value better data sharing
MFAT					Can see value of LINZ coordinating the storage of all marine boundaries
EPA					More likely to be users than contributors. E-Spatial doing spatial strategy for them currently
MPI					Already partnering with NIWA, focus on updating operational systems not data sharing
NMCC					Want improved interoperability to reduce their effort to produce COPs
NZ DF					Supportive of LINZ – partly as if LINZ does more, NZDF does less
Maritime NZ					Would support better coordination, are likely to supportive of an enhanced LINZ role

Figure 6: Public Stakeholders: Strategic Option Preferences

Stakeholder	Option 1	Option 2	Option 3	Option 4	Comments
Supplier of Marine Tech					Better data sharing would aid sales, they currently crowd source bathymetry and sell it
Fisheries Company					Potentially willing to share bathymetric data with NZ entities but have concerns on wider sharing
Marine Data Consultancy					Their value add is in analysis but waste a lot of time currently collating data
Chatham Rock Phosphates					Keen supporters of better marine spatial data sharing.
Oil and Gas Exploration					No real interest, see seismic as commercially sensitive, so would not share. Feel companies will pay for what they need to do when they need to do it.

Figure 7: Private Sector Stakeholders: Strategic Option Preferences

5 International Best Practice

This section presents a summary of the engagements with a number of organisations that either perform a similar function to the LINZ hydrographic group or offer examples of best practice in marine data management.

5.1 United States

5.1.1. National Oceanographic and Administrative Authority (NOAA)

Discussion focused on the work of the Office of Coastal Survey (OCS), with roughly equivalent responsibilities to the NZ Hydrographic Authority.

Key Facts

- Responsible for 3.4m nautical square miles of sea (500km^2 are actively charted);
- Produce over 1000 charts (both ENCs and Raster[30] in almost all cases);
- Do not produce any hardcopy charts, this is completely outsourced to a number of business partners;
- They have a national responsibility for providing emergency response on expediting the re-opening of ports after storms or other natural disasters[31];
- Produce hydro-dynamic models for US continental shelf e.g. currents through water column, salinity (affects vessel drafts);
- Represent US on International forums and standards bodies in hydrographic domain.

Legislative Framework

A number of mandates underpin their activities. These include the Hydrographic Act (1947) but most significant recent legislation is the Ocean and Coastal Mapping Integration Act (2009), see section 7.4.1 for details. The ocean science panel of experts helped push this through Congress. It gives a coordinating role for the Federal Government but also places a responsibility on local government to collaborate.

Budget

Survey and Charting	US$ 51m
Research and Development	US$ 7m (part of this is grant to Universities[32], see below)
Contracts	US$ 25m (+ 50% of capture from own ships, so covered under survey and charting)
Total	US$ 83m (2014/5)

[30] *Terminology: NOAA refer to paper charts in their digital representation as "Raster".*

[31] Recent work after major storms closed the port of Norfolk, Virginia were estimated to have avoided lost revenues of US$ 14m per day.

[32] University of New Hampshire and University of Mississippi

Arctic Transportation

This has created a huge new requirement for accurate charting. The possibility of opening up the north east/west passage means that potentially 242k nautical square miles of shipping lanes have to be surveyed. Given this represents an additional 50% area to be charted this is a major challenge, particularly because of the limited season of operation and the shallow depths (more obstacles = more risk to survey vessels).

Rapid Response Team

Their "day job" is chart verification and surveying ports. The six teams are stationed around the country so they can be deployed more easily if a disaster occurs. However, being "on the ground" they also perform an important job in customer affairs (stakeholder engagement). Engagement managers in these teams spend a lot of time speaking to local customers and partners. They are heavy users of CARIS.

Research and Development (Development Lab)

The development lab has four divisions:

- Hydro systems - covers new technology evaluation, transitioning from evaluation to production, software development
- Marine modelling – hydrodynamic model development and deployment
- Geospatial Applications and development – meet GIS needs of other divisions, database management
- IT – hardware and increasingly high demand to address cyber-security concerns.

The Hydro systems R&D is largely undertaken through grants to the University of New Hampshire (although some of their staff are working on-site at NOAA). It focuses currently on the following:

- Technology: Sonar, AUVs
- Vertical Separation: using GPS buoys for away from shore, this is part of the VDatum project[33],
- Coastal Ocean Modelling – storm surge and inundation studies under a wider initiative called Coastal Resilience.
- Backscatter processing
- Water column analysis – methane content is interesting to oil and gas community

A desk study on extending their UNCLOS claim, based on studies of extended continental shelf is also in progress.

Training

[33] VDatum website: http://vdatum.noaa.gov/

NOAA annually offer a basic training course for one month at the Joint Hydrographic Centre in University of New Hampshire. A week of this is CARIS HIPS/SIPS basics. NOAA would welcome LINZ delegates.

Outsourcing

Survey Data Acquisition

About 50% of NOAA's requirement are outsourced. They have established a framework contract. The contract runs for 5 years and NOAA try to arrange it so each company gets one contract per annum. The framework suppliers are a mix of SMEs and larger organisations.

Cartography

NOAA only use IIC Technologies[34] currently. Although IIC have an Indian parent company, there is subsidiary operating in the US with US management and local staff. A scale of fees has been established whereby price is determined by the complexity of the source material supplied.

Main facts

- About 70% of the raster chart production is done by contractors on-site.
- About 90% of ENC production is done off-site (in India)
- NOAA do not outsource chart maintenance.

NOAA believe that IIC do the majority of the charting work for the majority of Hydrographic Authorities who outsource nautical cartography. If this is true then we would suggest that this is not a health market position. In a market with limited competition there is little incentive for innovation and prices will tend to rise unnecessarily.

Furthermore, LINZ, as smaller country may find it difficult to get the best deal on quality, innovation and price from IIC if it has a dominant supplier position. We recommend that alternative outsourcing options should be investigated. One option may be to investigate capabilities in the Philippines and Vietnam, as both have a reputation for good quality, cost-effective geospatial digitising.

Open Data Dissemination

NOAA have done a lot of work on making dissemination of national ENC data "GIS friendly", this includes:

- Providing as RESTful services - they recognise the using OGC web services can be difficult to implement and inefficient for some users.

[34] http://www.iictechnologies.com/geosurveys-hydrographic-surveys.html

- Have worked out a series of thematic aggregations of S57 object types to suit different user communities
- Interpretation of ZOC descriptions into terms that are more intelligible to end-users and non-specialist developers is provided.
- Developing portrayal rules / symbology to allow ENC data to look "less ugly" is underway.

NOAA are willing to share their experience in this area.

Crowd Sourcing

NOAA have developed a relationship with an organisation that runs the website Active Captain[35]

- The site was originally created to provide information on maritime facilities such as small marinas in which NOAA has no interest.
- NOAA has reached an agreement for them to share the Active Captain database to better inform chart updates and to provide a channel for crowd sourcing of reports of errors on charts.
- How to integrate this and other such data sources into their chart production processes is under active discussion.

CARIS and Esri Functionality Enhancements

NOAA use both Esri and CARIS. CARIS is the main tool used by the disaster response group. Esri was selected in their main procurement several years ago. NOAA had chosen Esri over CARIS in this case, in part, as they felt that they could more easily influence their development agenda.

NOAA have recently returned from a visit to CARIS HQ. In NOAA's view CARIS is very efficient for making ENCs but they are frustrated that enhancements they have suggesting over a number of years still seem to be some way from appearing in the product.

NOAA observed that both Esri and CARIS do not seem do not seem to be sufficiently responsive to the specific needs of the hydrographic community. Furthermore, the existing user groups do not seem to be effective in eliciting action in this respect.

The conclusion of this discussion was that a "coalition of the willing" amongst the more advanced Hydrographic Authorities to lobby both suppliers in a coordinated manner might be more effective in driving the agenda of CARIS.

Charting Backlog

NOAA have source materials acquired over ten years that has not yet been published. They calculate the average time it is currently taking from validated source arriving at NOAA and reaching the chart is 53 months.

[35] Active Captain website: www.activecaptain.com

Seasketch

NOAA are using the same software as in the Hauraki Gulf project, called Seasketch. They are using it as a platform for collaboration between agencies in planning future survey work and getting maximum input into decision making. The tool is very visual and easy to use – one of its advantages is that it encourages involvement of Native American tribes in the process. The tool is being initially applied to their Topo-Bathy LiDAR project, a collaboration between NOAA and USGS[36].

5.1.2. Marine SDI Initiatives

Integrated Coastal and Ocean Mapping (IOCM)

Marine spatial planning is the current main driver application for MSDI.

NOAA works with other stakeholders in the US marine / maritime community in this domain, encompassing three main areas:

i) Data acquisition;
ii) End to end data management;
iii) Maximising use and re-use – use more of other people's data.

The project is funded as part of the implementation of the Integrated Coastal and Ocean Mapping (IOCM) Act, this act is covered in more detail when Government policy is discussed in section 7.4.1.

Marine Fundamental Data Schemas

Marine Fundamental Data Schemas have been developed as part of a worldwide initiative in the ecological community called CMECS[37]. CMECS is a classification system for ecological information, with a controlled vocabulary, what might in the geospatial and IT world be described as a data dictionary. It is endorsed by the Federal Geospatial Data Committee (FGDC).

Marine Cadastre (Boundaries)

The term marine cadastre is used in the US for the spatial definition of boundaries of features offshore. NOAA worked with the Bureau of Ocean Energy Management (BOEM) to catalogue these features based on a standard data schema. There is a working group within IHO chaired by Geoscience Australia looking to take these and their own ideas into the Maritime Limits and Boundaries standard (S121)[38].

[36] See http://coast.noaa.gov/digitalcoast/tools/inventory

[37] CMECS website: http://www.cmecscatalog.org/

[38] For further information see article in Hydro-International: http://www.hydro-international.com/news/id7112-Australia_and_Canada_Cooperate_on_IHOstandard_Development.html

Standards

It is accepted that within IHO resources and the ISO process are constraints on progress with the S100 series – most of the work is being done by volunteers, within both public and private organisations, as an addition to the day job. However, IHO standards do have the endorsement of IMO, so maybe more widely adopted in the long run than industry-specific standards, such as SSDM developed by the oil and gas industry.

In recent times, the Koreans in particular, have become very engaged in the hydrographic standards process and have provided funding, for instance, for the IHO repository[39].

5.2 Australia

5.2.1. Australian Hydrographic Service (AHS)

The AHS are very keen to collaborate more closely with the hydrographic group, there are obvious benefits from sharing experience and resources across the huge expanse of ocean that represents their combined EEZ.

Of particular relevance are the following:

- Their tools for Notice to Mariners (NtM) process automation could at first sight be implemented in LINZ with limited effort
  - These are written in .net language, so not tied to a particular package
  - The process has been well documented
- National ENCs
  - AHS dissemination system could readily support NZ ENCs
- Best of breed approach to using software
  - AHS make heavy use of Esri's ArcGIS platform for various functions
- Process reversal - ENC then paper chart
  - This took 18 months to achieve and was met with strong resistance from longer-serving nautical cartographers but has now been fully implemented with considerable benefits
- Paper chart sale study
  - Demand for Australian paper charts is likely to decline by two thirds to three quarters of current levels by 2018.

[39] This now holds the official data dictionary of real world features, http://registry.iho.int/GIhelp.html

5.2.2. Commonwealth Scientific and Industrial Research Organisation (CSIRO)

The CSIRO is Australia's national science agency. The contact here, Tara Martin, has responsibility for data sharing across the conservation activities of the organisation and a strong interest in metadata and international collaboration on ontologies - the formal naming and definition of the types, properties, and interrelationships of the entities that exist for a particular domain of discourse.

The major contribution to the study came from her directed us to the Marine Science Data System[40] which appears to be the "font of all knowledge" in the marine information field. It would certainly be unwise not to understand what this system provides before embarking on any data modelling or more general work on an MSDI.

In addition, CSIRO is currently embarking on a data interlinkage project and is looking for early adopters. LINZ might do well to investigate this opportunity should it be decided to adopt the strategy recommendation in this report.

5.2.3. Integrated Marine Observing System (IMOS)

IMOS is routinely operating a wide range of observing equipment throughout Australia's coastal and open oceans, making all of its data accessible to the marine and climate science community, other stakeholders and users, and international collaborators.

As an illustration of the status and level of investment made by Australian Government in this field, under the National Collaborative Research Infrastructure Strategy (NCRIS), it has received AU$130M of public funding over nine years (2006-15), with co-investment from industry of AU$ 170m over the same period[41].

IMOS represents a "fully formed" marine data infrastructure and will be a useful template for any New Zealand initiative.

5.3 European Commission

5.3.1. EModNet

The European Marine Observation and Data Network (EMODnet)[42], is a network of marine organisations and an exemplar of sustained collaboration in the creation of a marine data "observatory" or portal. Its key characteristics are:

- It provides a single entry point for accessing and retrieving marine data derived from surveys, observations or samples;
- Access is free of restrictions on use;
- Quality assured data comes from databases maintained by 100 organisations;

[40] Marine Geoscience Data System: http://www.marine-geo.org/index.php

[41] IMOS About Us: http://imos.org.au/about.html

[42] EMODnet home page: http://www.emodnet.eu/

- Coverage is across all EU countries;
- Full implementation is planned by 2020.

As a coordinating mechanism it has a lot of attractive features that could be adopted for MSDI development in New Zealand.

5.3.2. INSPIRE

The European Union initiative to create a Spatial Data Infrastructure for the member states has been adapted in Germany to underpin the development of an MSDI. The figure below presented at the Lisbon INSPIRE conference[43] shows the thematic structure they have adopted with red indicating marine lead and green marine involvement.

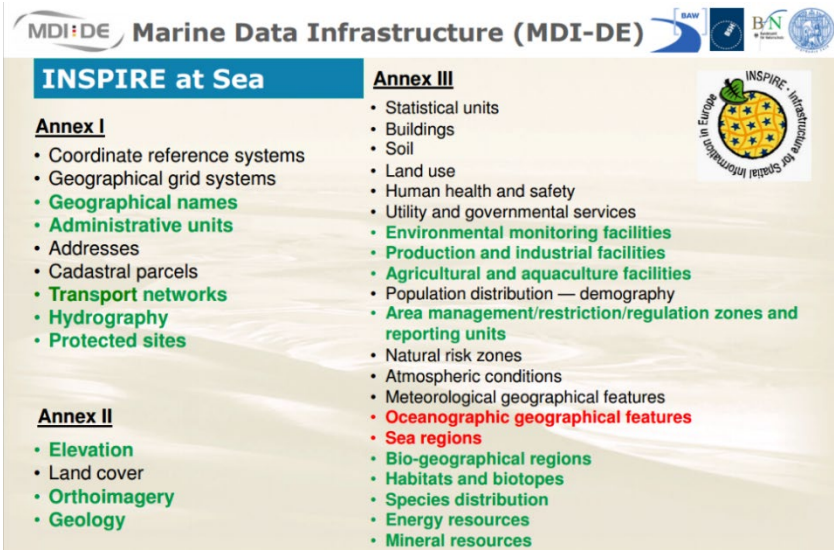


Figure 8: German Marine Spatial Data Infrastructure - Thematic Breakdown

5.4 Irish Republic

5.4.1. InfoMAR

Ireland is somewhat unique amongst developed countries in that despite have a long coastline and an extensive EEZ, it does not have a dedicated hydrographic service. InfoMAR was consequently born out of a collaboration between the Irish Marine Institute that has a wide ranging strategic remit across marine affairs and the Geological Survey of Ireland (GSI)

[43] Presentation by Johannes Melles on MDI-DE at INSPIRE Lisbon 2015
http://geospatialworldforum.org/speaker/SpeakersImages/Johannes%20Melles.pdf

with a more technical focus. Both had a strong interest in seabed mapping to underpin their scientific work.

The primary objective of InfoMAR is to completely map Ireland's offshore waters and to create a range of integrated mapping products of the physical, chemical and biological features of the seabed. A large part of this task is data acquisition, data management and interpretation (e.g. the production of a range of information products such as bathymetric/water depth maps) and data exchange (providing improved dissemination of information to policy makers, shared cost approaches, and reduction of duplication of effort).

The project was helped in getting off the ground initially by having sponsorship from within the European Commission in the form of the Directorate-General of Marine Affairs and Fisheries(DG Mare) being headed by a politician from Galway where the Marine Institute is based.

Some of the key outcomes of the conversations with senior staff at the project office were:

- The political support at a European level was vital to getting initial funding;
- The collaborative working of the MI and GSI has been vital, the joint management has given confidence to Government decision makers that the approach is "joined up";
- Linked to this is strong governance which ensures buy-in from the widest range of users, including the private sector;
- On-going funding was critically underpinned by having a good benefits realisation approach and a strongly favourable report[44] indicating value in many sectors;
- A strong communication strategy has kept the project in the public's consciousness. The project was an early exponent of YouTube videos[45] to illustrate their work.
- The communications strategy has also focused on the value of InfoMAR in terms of creating new jobs.
- A "value add" project creating an API to increase accessibility for app developers which helps to get the data available to consumers. This includes work on 3D visualisation.

5.5 Denmark

5.5.1. Greenland West Coast Charting Project

This engagement focused on the work undertaken over the last five years by GST, the Danish national mapping agency, to chart the west coastal region of Greenland. This exercise was unique in being a "green field" chart production and survey project of a large region, only 16 charts covering a small percentage of the area were available at the start of the project, the rest had to be produced from scratch.

[44] InfoMAR external evaluation http://www.infomar.ie/documents/2013_PwC_Infomar_Evaluation_Final.pdf

[45] InfoMAR on You Tube http://www.infomar.ie/YouTube/index.php

The use of ArcGIS for Maritime on this project was a major departure from the traditional use of CARIS products within the main GST workflows for maintaining charts in the waters around Denmark. It is believed to be the first HOs (Hydrographic Office) to roll out a full production in the ArcGIS enterprise setup.
Key insights relevant to the study were:

- The S57 standard was restrictive outside of soundings ad contours, the cultural data that was collected as part of the survey work could not be fitted into its data model.
- The Esri workflow manager was very useful for NtM processing.
- The team of 15 FTEs included nine staff with either cartographic or GIS skills who were expected with training to be inter-changeable.
- The ArcGIS platform had to be heavily customised, the team had four FTEs involved in software development and customisation.
- Creating, collecting, organizing and maintaining data requires good GIS knowledge and preferably a considerably hand-on experience with Esri tools, tips & tricks.
- The “data first” approach i.e. ENC then paper was proven to be the most efficient process.
- Steep learning curve for cartographers when adapting to s57 and ENCs – in terms of both geometry and attribution capture.

A full presentation of the work is available as part of the package of additional materials supplied to LINZ as part of the study completion.

5.6 United Kingdom

5.6.1. Port of London Authority (PLA)

The Port of London Authority operations cover 95 miles of the River Thames. The PLA is responsible for keeping commercial and leisure users safe, protection and enhancement of the environment, and promotion of the use of the river for trade and travel.

From a marine spatial data viewpoint the PLA's main purpose is to produce more detailed charts than are available from United Kingdom Hydrographic Office (UKHO) for the area under their jurisdiction. A substantial quantity of their work is contract hydrographic survey work particularly for major schemes such as the Thames Tideway Tunnel[46].

In respect to software for their operations they are amongst the few major hydrographic operations that have chosen to standardise their editing around a conventional GIS package, Cadcorp[47]. Its capabilities to work across multiple projections and merge marine and

[46] Thames Tideway Tunnel website: http://www.tideway.london/

[47] Cadcorp website: http://www.cadcorp.com/

topographic data from CAD, GIS and raster models is critical. PLA do also use CARIS and a number other packages, including FME, for specialist tasks.

The PLA collaborated in a major European Commission project under the Community Research and Development Information Service (CORDIS) initiative. This project named EFFORTS (Effective Operation in Ports) included development of a new port electronic navigational chart (ENC) standard, along with an electronic chart display and information system (ECDIS) viewer, to meet the emerging needs. The standard is compatible with both inland and maritime ENCs and included additional features and objects compared to conventional alternatives[48].

Key practical advice from the visit can be summarised as:

- The skills required by PLA for the future are NOT embodied in the description nautical cartographer, the more important skills are an understanding of the marine environment and the ability to manipulate and manage geospatial data;
- The IHO emphasis on “big ships” is misplaced as most incidents tend to involve small vessels, which in turn leads to the need to focus on shallow waters.
- In Europe a significant impact is being made by an organisation called TeamSurv[49]. Under a strapline of "Community sourcing and sharing of navigational data" they are a group of volunteers working in the marine sphere who might be regarded as the equivalent of OpenStreetMap.
- Aerial Lidar is becoming the tool of choice for inter-tidal surveys.
- Photogrammetry is making a return to prominence in marine data processing.

5.6.2. British Oceanographic Data Centre (BODC)

BODC is the national centre for oceanographic data for UK and surrounding waters. The best practice advice provided for New Zealand was as follows:

- It is as important to build a social network as part of the initiative (and at same time as) the data network;
- For a small country like NZ their advice is to maximise the extent to which you “ride on the back of” international initiatives on standards and portal building;
- BODC is a large centre with a team of 12-14 FTEs – NZ might ultimately need a team of half that size;
- Not possible to curate everything – BODC's priorities are based on stakeholder demand;
- Stewardship of datasets is determined by the user community itself;

[48] EFFORTS Report http://cordis.europa.eu/result/rcn/47142_en.html

[49] Team Surv home page: http://www.teamsurv.eu/

- Interaction with the hydrographic community (through UKHO) is limited as they do not share their data free of charge;
- International Oceanographic Data and Information Exchange (IODE)[50] is the "pinnacle" international body for collaboration in this area.

5.6.3. UK Channel Coastal Observatory (CCO)

The CCO[51] is one of a National Network of Regional Coastal Monitoring Programmes around the coast of England. The Programmes collect and distribute the necessary data to underpin evidence-based decisions regarding strategic and local level Flood and Coastal Erosion Risk Management (FCERM). Funding for the Programmes is secured in five-year cycles from the UK Government Department of Environment Food and Rural Affairs (Defra). Their work is undertaken on behalf of maritime local authorities.

Their main task is marine data curation from acquisition to dissemination. All their holdings are freely and publicly accessible under the UK Government's Open data licensing policy. Although much of this engagement focused on benefit-cost analysis, see section 7.3, their experience is relevant to other parts of the study:

- The CCO has a staff of 14 FTEs, three are GIS technicians the remainder are mostly involved in data capture and analysis;
- They have used International standards for acquisition and management of their information where possible;
- Their website was developed and is maintained externally.

[50] The IODE was set up by the Intergovernmental Oceanographic Commission (IOC) which is part of UNESCO. Its purpose is to enhance marine research, exploitation and development, by facilitating the exchange of oceanographic data and information between participating Member States, and by meeting the needs of users for data and information products.

[51] CCO website home page http://www.channelcoast.org/

6 Technology Horizon Scan

6.1 Introduction

We are living in a period of enormous technological change that is arguably changing the lives of all peoples in the developed and developing world more fundamentally than any other change since the industrial revolution. It has led to what is now popularly referred to as the dawning of the Information Age, a period in human history characterised by the shift from traditional industry, to an economy based on information computerisation[52].

In this context it is perhaps important to remember that the iPhone, the first of a new generation of Smartphones, was only launched in the US in 2007, less than a decade ago and yet it has changed the geospatial industry fundamentally by putting location and the apps that exploit it into the hands of citizens.

In this section we attempt to extract from the current set of technological advances those likely to have the most profound effect on national scale marine spatial data infrastructure development in the next 5-10 years.

6.2 Big Data

The opportunity exists to use Big Data to make infrastructure more resilient and responsive to our changing environment and needs of society. Big Data can help us identify gaps in service provision and target infrastructure investments to those people and areas that need it most and where the benefits are greatest[53]. The marine spatial community is currently lagging considerably behind work in other sectors such as banking and retail in this respect.

However, recent interactions between LINZ and the UK Satellite Catapult initiative have demonstrated some of the potential use cases for Big Data spatial analysis in the marine environment. Of particular interest is the analysis of vessel movements derived from AIS to aid in the identification and reaction to Illegal, Unreported and Unregulated (IUU) fishing a particular problem within the further reaches of the EEZ. Their work, called Eyes on the Seas aims to deliver a secure and trusted analytical capability applicable not only to IUU but also remote monitoring of activity in marine reserves and at-sea supply chains[54]. We believe the potential exists for use of such Big Data analytics technology in MPI, NMCC and EPA.

The Institute of Marine Engineering, Science and Technology (IMarEST) has recently conducted a roundtable to look at the potential of big data in the marine sector[55]. Understanding the state of the environment and impacts of climate change, making oil and

[52] Wikipedia definition

[53] Association for Geographic Information (AGI) Foresight Report 2015

http://www.agi.org.uk/news/foresight-report

[54] Illegal, Unreported and Unregulated (IUU) Fishing https://sa.catapult.org.uk/-/catapult-partners-with-polynesian-leaders-group-on-anti-iuu-operations

[55] Big data in the marine sector http://www.imarest.org/policy-news/newsroom-press/item/1834-big-data-in-the-marine-sector-avoiding-ozone-hole-2-0-and-other-challenges

other hazardous materials spill support decisions, improving fuel efficiency and voyage optimisation were identified as amongst the most important applications. The key challenges included those associated with data ownership and sharing, standardisation to avoid disparate types and quality of data, financing the collection of environmental data and the successful marrying of Big Data with the human element in decision-making. These are all issues within the purview of MSDIs and where marine geospatial professionals have much to contribute.

6.3 Internet of Things

The Internet of Things (IoT) concept is simple The concept is simple, everyday objects linked to a network allowing the ability to read, write and execute data and thereby taking the internet into a plethora of new applications[56]. Now everything is potentially a data source or data gatherer, from the traditional science based weather stations (now on-line) to the household toaster. In many cases they will be geospatially enabled.

Not only will this bring a huge increase in data sources (10.3 billion devices in 2014 to 29.5 billion in 2020)[57] but it will also increase the amount of "data noise" which will need to be sifted to find real nuggets of actionable knowledge.

However, the potential is huge. In the marine world, recent successful trials of an app called REX (route exchange) is indicative of future developments in this area. REX is installed on vessels using the shipping lanes around Oslo and brings together data from the IoT onboard sensors and navigation systems into an ENC. It enables seafarers to show their intentions to other sea-space users and onshore vessel traffic services in real time to prevent collisions. It is proving far more reliable than verbal communication via VHF[58].

6.4 Crowd Sourcing

Crowd sourcing of data in the marine environment is not new. Arguably the routine compilation of charts from multiple sources is one of the better established and successful examples of crowd sourcing in the scientific community.

Over the next few years, a number of additional crowd sources and companies are likely to have substantial impact. Passive crowd sourcing of data from recreational and other non-official vessels will lead to the production of bathymetric databases. Vendors of fish finders and navigation systems into the non-SOLAS market are already beginning to be marketed on a world-wide basis. The Insight Genesis[59] system is an example of this type of development,

[56] A Future View of Geospatial: Towards the Geography of Everything: Andrew Hudson-Smith Page 135 of AGI foresight report http://www.agi.org.uk/news/foresight-report

[57] Forbes Article 2015: http://www.forbes.com/sites/gilpress/2015/07/30/9-new-predictionsand-market-assessments-for-the-internet-ofthings-iot/

[58] Oslo IoT trial http://osdelivers.blackducksoftware.com/2015/02/11/industrial-internet-of-things-in-the-maritime-industry/

[59] Insight Genesis: http://www.gofreemarine.com/insight-genesis

boat owners can choose whether or not to contribute the data from their sonars to the database and in return are provided with access to free bathymetric charts and other data such as weather, bottom hardness and vegetation maps, as illustrated in the figure below.

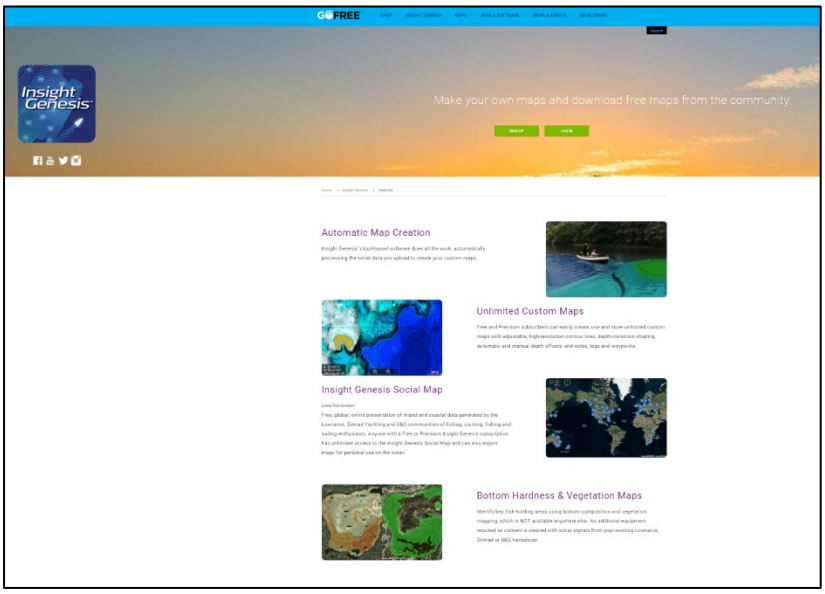


Figure 9: Insight Genesis Website

In the UK, a significant impact is being made by an organisation called TeamSurv[60]. Under a strapline of Community sourcing and sharing of navigational data they are a group of volunteers working in the marine sphere who might be regarded as the equivalent of OpenStreetMap.

The focus of geospatial research effort in respect to crowd sourcing is moving to development of the "trust model" for integrating crowd sourced data that encompasses both professional and public sources into authoritative databases[61].

6.5 Multi-Sensor Developments

The rapid development in the capabilities of growing range of sensors will lead to a greater number of surveys where a range of device types are deployed.

6.5.1. Optical Sensors

- Laser scanners
- LiDAR
- Cameras

[60] Team Surv home page: http://www.teamsurv.eu/

[61] Crowdsourcing Spatial Phenomena Using Trust-Based Heteroskedastic Gaussian Processes Matteo Venanzi et al http://eprints.soton.ac.uk/354861/9/trustgp.pdf

Although LiDAR systems are still expensive, their capabilities are rapidly increasing making them more cost-effective.

6.5.2. Acoustic Sensors

- Multibeam sonar
- Sidescan sonar
- Synthetic aperture sonar
- Imaging sonar
- Sub-bottom profilers

The key point from this discussion was that this wide range of devices are suited to different types of surveys in different conditions. The combination of different sensors means that wider coverage in the coastal zone is now possible by deploying a wider range of sensors in a single mission.

6.6 Autonomous Vehicles

The term covers a variety of types of vehicles in the marine environment. A useful classification is:

Autonomous underwater vehicle (**AUV**) - a robot which travels underwater without requiring input from an operator.

Unmanned Surface (or Survey) Vehicle (USV) - a robot travelling on the water surface.

Unmanned Aerial Vehicle (UAV) - an aircraft with no pilot on board. **UAVs** can be remote controlled aircraft (e.g. flown by a pilot at a ground control station) or can fly autonomously based on pre-programmed flight plans or more complex dynamic automation systems.

These technological developments are likely to be powerful game changers for the medium-term future. The principal benefits are lower operating costs, rapid deployment/recovery and the ability to work closer to the intended target.

Some of the key current challenges are:

- Payload – often limiting the size of sensors, batteries etc;
- Data Storage and Processing – currently it is stored internally and processed post mission;
- As power sources improve, operating times will extend, exacerbating the data processing bottleneck;
- The need for automation and near real-time processing.

One response to these challenges is to move storage and processing on-board the vehicle or mother vessel. This is the approach adopted in the CARIS Onboard system[62].

[62] CARIS Onboard http://www.caris.com/onboard/

6.7 Software

The future of software in geospatial will be less about functionality for data capture and editing and more about increasingly sophisticated modelling and analysis of big data.

The web-based "platform" and Data/Software/System "as a service" offerings will continue to become more prevalent, although cyber-security will need to rapidly evolve if it is not to slow down business confidence in cloud computing solutions for mission critical applications, particularly where it contains personal information.

The growth in the volumes and resolution of satellite-derived imagery will drive the development of more and more capable pattern recognition algorithms which will be used to successfully automate complex feature extraction. The impact of these development in bathymetric and other sub-surface charting applications will radically reduce survey costs.

The impact of open source software will be increasingly felt in the marine community. Although, it is our considered opinion that it will still be specialist vendors that most cost-effectively harness these tools rather than end-users.

6.8 Visualisation

Our final major trend is perhaps likely to be the most significant in terms of the everyday work of marine spatial data practitioners. As the default modes of acquisition become 3D or 4D (including time), the need to represent these data in a two dimensional form of a map or chart, will reduce. Maps and charts will still have their place for abstraction and analysis but routine presentation of spatial data will be 3D and dynamic.

The visualisation of the coastline at Folkestone, in southern England, presented at the Shallow Survey 2015 conference is indicative of the future norm[63]. As the presentation titled "understanding the littoral environment"[64] makes clear this technology is not yet mature but demonstrated the feasibility of littoral zone 3D model creation using existing data sources and software. Offshore and onshore data sources were merged to create a single surface model, based on alignment of vertical datums using the Vertical Offshore Reference Frame (VORF)[65].

Over the next few years the development of this type of software and the data to fuel it will open up use cases from situational awareness onboard ships, to communications and marine science.

It is also expected that this will become the default editing environment for nautical cartography.

[63] City Engine Folkestone visualisation http://arcg.is/1isZokr

[64] Understanding the Littoral Environment http://www.shallowsurvey2015.org/presentations/SS2015_Session07_Talk2_Helyx.pdf

[65] VORF Project (University College London) https://www.ucl.ac.uk/vorf

7 Government Policy: Marine Spatial Data

In this section of the report, we review the policy and legislative environment into which a future strategy will need to fit. It includes consideration of previous, current and future policy settings first within New Zealand and then looks to international best practice that might be adapted to underpin any required legislative and regulatory change.

7.1 Previous Initiatives

MSDI is not a new concept in New Zealand. Before the turn of the millennium papers had been published by key luminaries of the industry such as Bill Robertson and Chris Hoogsteden[66] and Don Grant[67], setting out the requirements.

More recently, starting in 2005, Oceans Survey 20/20, a comprehensive programme of ocean and coastal survey activity which LINZ coordinated has had a limited impact in the MSDI sphere. Oceans 20/20 did produce tangible outputs such as the NIWA coastal and marine geoportal[68] but later became a vehicle for the rather different purpose of part-funding the Research Vessel Tangaroa[69].

The most recent attempt was a proposal for research funding submitted to MBIE for research funding in 2014. It was led by NIWA and entitled Integrated Coastal and Oceanic Management (ICOM)[70]. With a focus on environmental research, this proposed the development of an SDI to mobilise existing and future disparate estuarine, coastal and oceanic data sources including the development of new tools for data integration, analyses, access and visualisation, The level of funding requested was $2.5m over 4 years.

This proposal was rejected. We would suggest that although strong in scientific terms, the proposal was very technically focused and lacked a quantified cost-benefit analysis

7.2 Current Policy Settings

In this section we outline the evidence found during the study of the currently defined roles and responsibilities in relation to the marine environment.

[66] Robertson, B., Benwell G., Hoogsteden, C. The Marine Resource: Administration Infrastructure Requirements. UN-FIG Conference on Land Tenure and Cadastral Infrastructures for Sustainable Development, Melbourne, Australia 1999

[67] Grant, D. Principles for a Seabed Cadastre. New Zealand Institute of Surveyors Conference and AGM, FIG Commission VIII Conference. Bay of Islands, New Zealand 1999

[68] NIWA Coastal and Marine Data Portal http://www.os2020.org.nz/#os-20-20

[69] Tangaroa is a research vessel operated by the New Zealand National Institute of Water and Atmospheric Research.

[70] Private communication from Jochen Schmidt, Head of Spatial Data Management at NIWA.

7.2.1. Marine Spatial Data Infrastructure and NZ GO

There appears to be no reason why facilitating the creation of a MSDI is not covered by defined role of NZ Geospatial Office[71].

The NZ Geospatial Strategy defines geospatial information "as information relating to the location and names of features beneath, on, or above the surface of the earth". The strategy prominently features a case study on fisheries and references Oceans 20/20.

The stewardship of the elevation fundamental data theme has already been allocated to LINZ and includes the bathymetric data.

7.2.2. Marine Cadastre

In section 5.1, the United States experience in marine cadastre was highlighted. The recognition of the increasing importance of boundaries, rights and jurisdiction in the marine space, has stimulated significant investment there.

Again, it would appear that the concepts that underpin the NZ land registration system are a very close parallel to those now required in the coastal zone and further offshore.

7.2.3. Crown Research Institutes (CRIs)

As observed earlier in section 4, both NIWA and GNS are CRIs and under current arrangements must act as commercial entities as public funding only covers a relatively small part of their activities. They are not covered by the open data accord.

As a result, CRIs are not currently willing or able to share much of the data that they hold. This will affect their ability to act as an "honest broker" in moves towards creating a national MSDI and suggests that a central government agency may be in a better position to coordinate.

7.2.4. MFAT

As observed in section 4.2 by several public sector bodies, MFAT has responsibility for granting licences to foreign research vessels to operate in New Zealand's EEZ. However, it does not ensure data generated is delivered on completion of the cruise. As part of this study we approached MFAT regarding this matter but there appeared to be little appetite for resolving it.

This represents a missed opportunity for New Zealand and is a policy / process gap that needs addressing. LINZ could step into this role with limited effort and would be a positive "early win" in terms of growing credibility in the marine data space.

[71] NZ Geospatial Office role and Governance
http://www.linz.govt.nz/about-linz/our-location-strategy/geospatial-strategy-for-spatial-data-infrastructure

7.3 Current Initiatives

This section lists the known major initiatives within NZ Government which relate in whole or part to marine spatial data infrastructure.

7.3.1. NZ P&M Group (MBIE)

The NZ P&M group is in the process of preparation of a Knowledge Management Plan. There are many potential parallels with the LINZ study and there may be the potential for the proposal to be tested with a wider governance group at general manager level that could include LINZ.

In the context of better marine data sharing, NZ P&M would prioritise the following:

- data content standards and interoperability
- thematic division of marine data in a similar way to terrestrial SDI
- establishing the value of a shared repository for nationally significant marine datasets
- optimising data discovery
- reducing overlapping data storage and associated costs
- morphology not stopping at the land/sea divide
- Big Data analytics
- collaboration on planning future survey cruises
- consideration of joint action between agencies to get larger information-centric programme through Treasury.

7.3.2. Marine Spatial Planning (Regional Government / DoC)

The rolling out of the Hauraki Gulf system to all areas of the country over the next 10 years is currently being considered at a management level within DoC. Continued support for the Hauraki Gulf project beyond the end of funding at the end of 2015 seems assured.

7.3.3. NIWA

There is a possibility that the research proposal for creating an MSDI referenced in section 7.1 could be resurrected.

7.4 International Experience

7.4.1. US Oceans and Coastal Data Integration

The most significant recent legislation is the Ocean and Coastal Mapping Integration Act (2009). The national ocean science panel of experts helped push this through Congress. It gives a coordinating role for the Federal Government but also places a responsibility on local government to collaborate. The main clauses of the Act and funding levels are summarised in Annex B.

7.4.2. INSPIRE

Section 5.1 explains how the INSPIRE directive which underpins development of SDI in the European Union has been adapted in Germany to cover marine data. This would provide a model for the development of standards policy if required.

7.4.3. European Commission: Incorporating Private Data

According to the recent study commissioned by the European Commission Maritime Affairs Directorate[72], more marine data is collected by the private sector than by the public sector.

In the European Union, private companies are already obliged to collect data as part of the impact assessment to obtain a licence for certain offshore activity. In many cases, they are obliged to hand the data collected over to the licensing authority.

However, the European Commission is aware that imposing reporting obligations on private companies under normal circumstances creates an administrative burden that is to be avoided. It is therefore advocating the replacement of a hotchpotch of different obligations with a single reporting mechanism with common INSPIRE-based (SDI) standards could reduce the existing burden.

A study has been launched to help assess costs and benefits. Progress on this initiative should be tracked since it will be useful in informing the approach adopted in New Zealand to incorporating private data into a future MSDI.

7.4.4. InfoMAR

As part of the InfoMAR initiative in Ireland, the team produced a map of legislation and regulation relating to various onshore and offshore in order to provide a basis for rationalising responsibilities for marine spatial data. This is illustrated in the figure below taken from the InfoMAR Proposal Strategy[73].

[72] European Commission Green Paper – Marine Knowledge 2020 from seabed mapping to ocean forecasting. http://ec.europa.eu/maritimeaffairs/documentation/publications/documents/marine-knowledge-2020-green-paper_en.pdf

[73] InfoMAR Proposed Strategy, Figure 3.2: http://www.infomar.ie/documents/INFOMAR_Proposal_Strategy.pdf

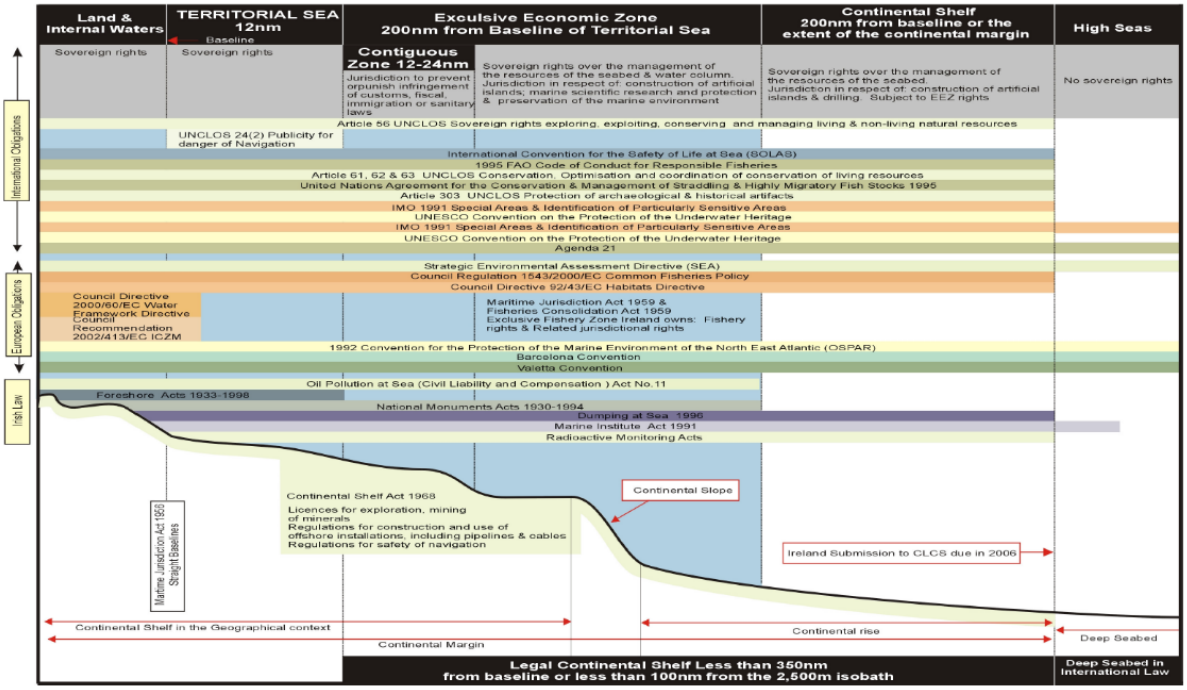


Figure 10: InfoMAR Irish Government Legislation and Policy Map (2007)

This is a useful template for potential policy work in support of the strategy.

7.5 Implications for the Strategy

The foregoing analysis suggests that LINZ would be well placed from a policy perspective to take on an enhanced role in developing a MSDI. The current policy settings in respect to SDI and cadastre appear to be adaptable and there is plenty of “best practice” policy guidance from Europe and the United States that can be leveraged.

8 Benefit-Cost Analysis

8.1 Introduction

It is not the purpose of this stage of the study to produce a full benefit-cost analysis. However, there has been considerable work already undertaken within LINZ as part of the bathymetric investigation which should be recognised, this forms section 8.2. Furthermore, there is a body of international best practice in the specific area of marine spatial data sharing that offers an excellent starting point for developing a full business case, this forms section 8.3. Finally, there were some powerful local benefit examples that were uncovered during the study that are summarised in section 8.4.

8.2 Bathymetry Investigation

The New Zealand bathymetry investigation report[74] published in October 2015, provides an excellent overview of the work undertaken globally to assess the economic value of a MSDI and although the primary focus is on bathymetry, in this respect the report covers a much wider range of marine and maritime spatial data.

Some of its principle relevant conclusions are:

- At least $20 million per annum is spent on collecting bathymetric data through hydrographic and bathymetric surveys.
- There are noticeable gaps in the coverage of bathymetric data (even in priority areas), up to 70% of New Zealand's waters are unmapped to a high resolution.
- There is little coordination of effort in New Zealand to streamline the acquisition and dissemination of bathymetric data.
- There are a range of sectors in the New Zealand economy where marine spatial data is vital to decision making for example:
    - shipping
    - fishing and aquaculture
    - offshore minerals
    - Government and defence.
- Review of international literature shows:
    - return on investment for having hydrographic services is between 1: 3 and 1:9, and
    - return on investment for having good bathymetric data provision between 1:2 and 1:6.

[74] New Zealand Bathymetric Investigation Report, Ed Griffin (author) http://www.linz.govt.nz/about-linz/what-were-doing/projects/new-zealand-bathymetry-investigation

8.3 Specific International Evidence

8.3.1. EMODnet Impact Assessment

There is a clear cost to the fragmentation and inaccessibility of marine data. The impact assessment of EMODnet[75] estimated that existing users would save €300 million (NZ$480million) a year if the data were properly integrated and managed.

The impact assessment also suggested the value of improved competition could be of the order of €200 million (NZ$320 million) per year.

8.3.2. Value of Information: Channel Coastal Observatory (CCO)

The UK Channel Coastal Observatory (CCO) is required by their parent Government department to prepare an economic justification each year for their investment in marine data collection, management and dissemination.

The method used is simple but is accepted as the "best possible" approach in an area where many of the benefits, such as improved flood defence are complex and as they involve many factors, it is difficult to arrive at a sensible rationale for apportionment of the value of information.

The cost of each dataset has been calculated from contract values for collection and processing, for instance the average cost of Lidar acquisition in 2014 was estimated at £350 (NZ$770) per km^2. We understand that an allowance is then made for the contribution to the costs of management and dissemination.

The economic value is then simply calculated based on multiplying the acquisition value per km^2 by the download volumes. The figure overleaf shows the results of this calculation for the last few years. The vertical scale, the financial value, is omitted on grounds that the information is sensitive.

However, the method is potentially useful. For further guidance on the economic theory behind the value of information assessments we would recommend reading Molly Macauley's seminal paper on the subject, "The Value of Information: A Background Paper on Measuring the Contribution of Space-Derived Earth Science Data to National Resource Management"[76].

1. [75] European Marine Observation and Data Network Impact Assessment, 8.9.2010, SEC(2010) 998

http://ec.europa.eu/smart-regulation/impact/ia_carried_out/docs/ia_2010/sec_2010_0998_en.pdf

[76] The Value of Information: A Background Paper on Measuring the Contribution of Space-Derived Earth Science Data to National Resource Management Molly K. Macauley

http://www.rff.org/files/sharepoint/WorkImages/Download/RFF-DP-05-26.pdf

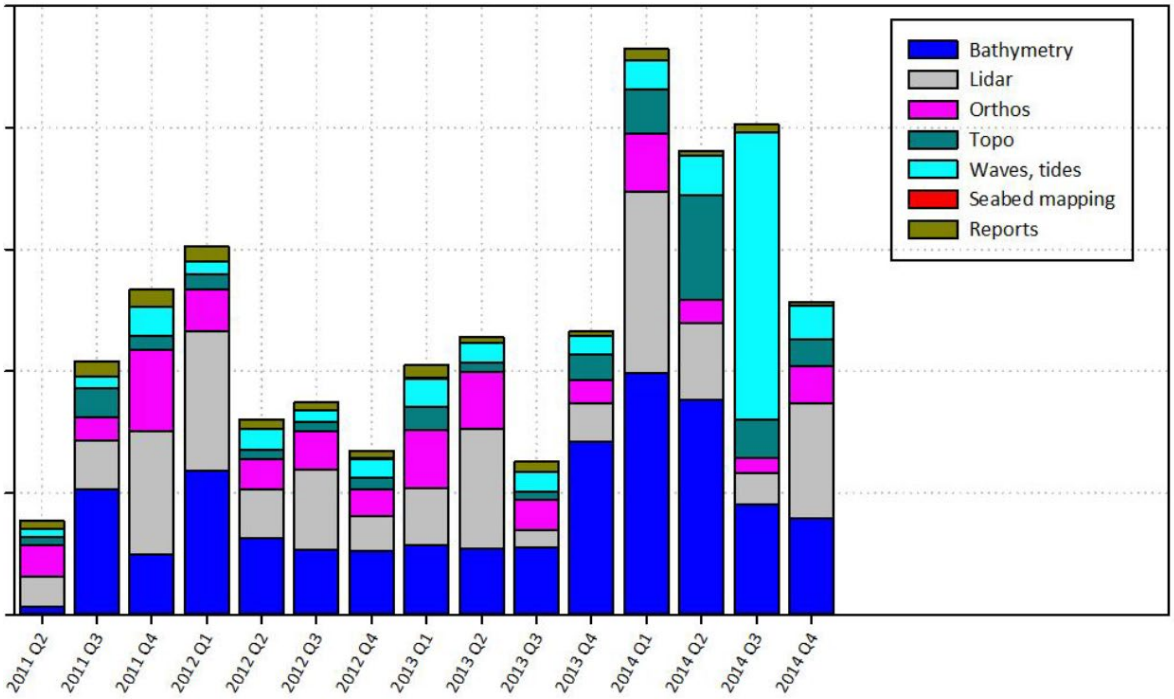


Figure 11: Value of Information based on download volumes

8.3.3. InfoMAR (Ireland)

The InfoMAR project undertook a comprehensive benefit-cost analysis in order to justify further investment by the European Union in their marine spatial data programme. The figure below shows the results of an analysis undertaken by PwC. The fishing sector, aquaculture and aggregates industries are shown as the major beneficiaries.

There are many similarities between the Irish and New Zealand economies and similar results would be expected if the same methodology were applied.

Forecast INFOMAR Impact (2013)	Low Scenario	Medium Scenario
Commercial		
Fishing Sector	€47.7m	€95.4m
Aquaculture	€28.9m	€57.8m
Biodiversity	€5.6m	€11.1m
Renewable Energy	€20.0m	€40.0m
Energy Exploration	€24.7m	€49.3m
Aggregates Industry	€42.7m	€85.5m
Knowledge Economy		
Research	€5.1m	€10.2m
Legislative		
Non-Compliance Fines	€3.7m	€7.5m

Figure 12: InfoMAR Economic Benefit Assessment

8.4 Specific Local Examples

A few specific examples of potential benefits of Marine SDI captured but not validated as part of this stage were:

- Easier Data Discovery
  - There is near universal acceptance from stakeholders that considerable time is wasted finding marine spatial data;
  - By taking a benefits transfer approach based on the experience in other countries, a rough order of magnitude estimate of the national value is NZ $250k per annum.
- Reduced effort of Assembling Data
  - 1-2 FTEs in Customs supporting their Common Operational Picture (COP) at a value of circa NZ$100 p.a.;
  - Hauraki Gulf Spatial Data Planning tool: required an estimated 2 FTEs for 3 years to assemble the data – at an estimated cost in excess of NZ$300k.
- Reduced survey costs
  - For the Chatham Phosphate application, it was estimated that NZ$3-$4m could have been saved in acquisition costs had data been available.
- Improved intelligence-led operations
  - The NZ Defence Force (NZ DF) see particularly value in better data access.
- Commercial Fisheries - new fishing grounds
  - An NZ$6m p.a. new business opportunity resulted from de-restriction of fishing based on marine spatial data analysis.
- More sales of systems for recreational boats
  - Only 50% currently have systems and more accessible bathymetric and other marine spatial data will stimulate sales according to one of the major vendors.
- Reduced consultancy contract costs
  - Move emphasis from data collation to analysis, will also add greater value to scientific studies.
- Survey cost sharing
  - More sensors on cruises will reduce the numbers of surveys required;
  - Opportunistic multi-beam surveys will increase the coverage of bathymetric data within NZ waters.

9 Conclusions and Recommendations

9.1 Strategic Options Appraisal

The primary objective of Stage 2 was to evaluate the strategic options for the Hydrographic Authority.

9.1.1. Recap of Options

Option 1: Status quo – maintain focus only on hydrographic charting mission (including SW Pacific / Antarctica NZ)

Option 2: Supporting coordination by others (NIWA/GNS) of better bathymetric data sharing

Option 3: Adopt a coordination role for a national MSDI, similar in concept to what LINZ provides for imagery.

Option 4: Proactive leadership in the development of a full MSDI for New Zealand

9.1.2. Evaluation

The summary of the feedback from stakeholders was that they recognise the emerging importance of a MSDI in growing the blue economy and would value LINZ playing a greater role in this space.

However, LINZ is not recognised currently as central to developing the necessary infrastructure in the way that its centrality in the terrestrial SDI field is accepted. There are others who have already made progress in marine data sharing and have developed nascent MSDIs, albeit for quite specific and often limited purposes.

The Status Quo (Option1) is not a viable option for LINZ. The “Power of Where” objective of growing use of geospatial data by 10 times in 10 years will not be achievable, however it is measured, without a substantial input from the marine space.

If however LINZ do not, for whatever reason, feel that they have the appetite for moving beyond the status quo, then others, most notably NIWA and GNS will step into the void. This may have a negative impact since although they have the will and arguably the capability to create a MSDI, their status as Crown Research Institutes and consequent need to charge may “act as a brake” to data sharing.

Option 1 is not recommended.

Leading MSDI development (option 4) is also not a viable option for LINZ – at least in the short to medium-term. LINZ visibility in the wider marine sector is not high, therefore attempting to step into an overarching active leadership role is over ambitious and unlikely to be accepted by other stakeholders. Furthermore, LINZ has

some unwanted "history" in its perceived role in the failure of the Oceans 20/20 initiative. Although this is somewhat unfair in our view, it points to the need for the organisation to establish its credentials and deliver some tangible benefits for the community before attempting to offer itself in such a role.

Therefore, Option 4 is not recommended.

Bathymetry coordination (option 2) – focuses only on one data theme, what is described in fundamental data theme terms as elevation. The objective of combining elevation data seamlessly from "mountain top to deep sea trench" is important particularly in relation to the coastal zone.

However, if it were to be the sole focus of a future strategy it would have limited impact on the overall goal of making a major contribution to the growth of the New Zealand economy.

MSDI coordination (option 3) – as worded this option is perhaps overly ambitious given LINZ's current weak position in the marine community but there is much scope to go beyond bathymetry, particularly working with other public and private sector organisations.

Within the organisation LINZ has the experience and capabilities to contribute much to the next stage of development of a MSDI. It has considerable credibility with the IHO who have a legally underpinned international role in marine spatial data management. The NZ Geospatial Office's mandate in respect to coordination of SDI in New Zealand appears to have no limitations with regard to scope in marine matters. Furthermore, the authority of the Registrars General of cadastral survey and land registration would also appear to extend to the marine domain.

Without "treading unduly on the toes" of other public service bodies that have already established track records, it is possible for LINZ to step into the void of responsibility if it focuses on areas of core competence.

9.1.3. Recommendation

ConsultingWhere therefore recommend that option 2 with components of option 3 as the preferred strategy. This will entail coordination beyond bathymetry with focused leadership in areas of LINZ core competences.

The outline strategy presented in section 10 below, fleshes out this option by providing a strategic vision and a framework of six key goals and associated actions.

9.2 Hydrographic Group

A secondary objective of Stage 2 was to report on the Hydrographic Group, providing recommendations on short-medium term actions to help align their activities to fit with the preferred strategic direction.

9.2.1. Business Improvement Plan 2015/6

We endorse the programme for 2015-6, with the following comments:

Hydrographic Strategic review – this report completes stage 2, executive review and stage 3 needs completing in early 2016.

Chart Programme Prioritisation – the successful outsourcing trial is encouraging and as outsourcing offers real potential savings it should be accelerated.

Digital Driving Paper – this "process reversal" has been successfully implemented in Australia and has the potential to have major impact on efficiency.

Notices to Mariners (NtM) Policy Review – implementation is likely to require significant resource and can only be changed in stages. The move to digital driving paper (see above) will facilitate process change. The review requires substantial personal input from the hydrographer himself as it is complex and has dependencies beyond LINZ.

Hydro Risk Assessment – a major "ground breaking" research contribution. It should be used to increase LINZ credibility within the marine community as its results have wider applicability than just chart production.

National ENC Series – this should leverage work done by Australian Hydrographic Service which already has processes to publish charts of NZ waters.

NtM Website Update }
HPD Upgrade }
Data Management Review }
A restructure of the group to provide more resource for data management is needed to ensure successful and timely implementation of these three projects

Release of LINZ Bathymetry Archive – this project has the largest potential of all the business improvements to lift the profile of LINZ in the marine community. The speed of implementation of this project is too slow because of the limited resource being applied to it.

Summary

We endorse the business improvement plan. The risks regarding its delivery are lack of resources dedicated to its achievement. It will be too easy for "business as usual" demands to result in it being given lower priority.

9.2.2. LDS Thematic Re-Structuring

This is not included in the Business Improvement Plan but represents an important "quick win" in terms of stakeholder perception. Currently, LDS hydro data complies with the "letter but not the spirit" of open data.

The format is pretty unfriendly to all but S57 experts:

- The ENC 6 letter acronym cannot be simply decoded;

– Each object class is a separate file (218 per chart).

Creating thematic structuring, portrayal rules and attribute translation would result in a much higher usage of this very rich data resource.

9.2.3. Software Tools

The consultants were requested to advise “inter alia” on the leading available software tools. Our conclusions are as follows:

CARIS

- The products are a good tool set for ENC production and paper chart production.
- Hydrographic Authorities would be well advised to seek to collaborate in order to have more influence over their software development roadmap.
- A separate internal report has been prepared which provides a detailed assessment.

Other GIS tools

- Are widely used by other Hydrographic Authorities for a variety of tasks and should have a place in the forward strategy for the group.
- Understanding their capabilities will help plan future direction of software and data management

MSDI

- Esri is leader in this field through its ocean science group and partners such as Seascape used in the Hauraki Gulf. It is already heavily deployed in NZ and internationally for SDI.
- An evaluation of the tools, which LINZ has already deployed extensively, is recommended.

10 Draft Strategy

10.1 Context Statement

The marine economy represents a significant proportion of national GDP and encompasses many areas which represent the best opportunities for substantial growth, such as mineral exploration, fishing, wind energy for example.

The current landscape in relation to marine spatial data sharing in New Zealand is fragmented with consequent missed opportunities for greater efficiency in the public sector and accelerated growth in the private sector.

The pace of technological and social change in this field is dramatic and offers significant opportunities for innovation.

10.2 Vision

To maximise the value of location information in the marine environment, including coastal areas and the oceans, through embedding a "capture once reuse many times" culture and practice across Government and private sectors[77].

This will be achieved, in collaboration with other major players in Government and business, by LINZ facilitating the creation of a Marine Spatial Data Infrastructure for New Zealand covering the waters of New Zealand, South West Pacific and Ross Sea.

10.3 Goals

Goal 1: Under its mandate as steward for national elevation data, LINZ will complete the mapping of "mountain top to deep sea trench"

Goal 2: LINZ will create an MSDI framework by defining, prioritising and assigning "stewardship" for fundamental data themes for marine environment under its national SDI mandate

Goal 3: Working with other agencies, LINZ will create and populate a single national portal for open access to all existing marine spatial data.

Goal 4: LINZ will lead the creation of a system for collating, managing and disseminating information from a "marine cadastre" to support administration of marine spaces.

Goal 5: LINZ will optimise the internal efficiency of navigation chart production and other tasks of the hydrographic authority.

[77] This Vision Statement is in part borrowed from that in the EC Green Paper Marine Knowledge 2020 – "To ensure that the expansion of the blue economy happens, that it is sustainable and that Europe's seas will achieve good environmental status, we need to know what the state of the sea is now, in the past and how it might change in the future".

Goal 6: LINZ will track and bring to production new developments in geospatial technology relevant to the marine environment.

10.4 Action Plan

For each goal, the priority actions to achieve the goal are set out in the sections that follow, in some cases suggested starting points are also included.

10.4.1. Goal 1: Complete Elevation coverage

This to be achieved by:

Working through the open data team to encourage other agencies to minimise restrictions on bathymetric data availability

Providing open access to all existing LINZ bathymetric data through LDS

Defining of the land – sea datum variation for the coastal zone around NZ

Developing a long-term plan to provide bathymetric data at appropriate scales for all waters where New Zealand has jurisdiction.

10.4.2. Goal 2: Define MSDI Framework

This to be achieved by:

Working with other agencies within the public sector to determine market needs

Establishing the economic impact of an MSDI and its intercept with the political agenda

This will build on the economic assessment work already undertaken under the New Zealand Bathymetric Investigation

Define and prioritise fundamental spatial data themes for the marine environment leveraging International best practice

This will build on the work undertaken already within the Geospatial Office in the terrestrial domain

Adopt or adapt existing data management standards already established in marine communities of practice

Use international terminology and vocabularies.

This goal not be restricted to consideration of the IHO S100 series standards

The figure overleaf, provides a starting point for marine theme definitions and establishing priorities.

Theme Name	Possible Steward	Data Sharing Priority	Comments
Geodetic Framework	LINZ	*	
Elevation	LINZ	*	Includes bathymetry
Marine Cadastre	LINZ	1	All marine boundaries
Water Column	NIWA	2	Salinity, nutrients
Geographical Names	LINZ	*	Shared through LDS
Marine Transport	Maritime NZ?	1	Commercially sensitive
Undersea Geology	GNS	1	Already well shared
Protected Sites	Environmental Protection Agency	1	Marine reserves
Habitat	Department of Conservation	2	Includes marine species
Sea use	MPI	1	Fisheries, aquaculture
Coastal Infrastructure	Regional Government	2	Pipelines etc.
Marine Resource consents	Regional Government	1	Already well shared

Figure 13: Suggested MSDI Fundamental Theme List

Note: * means that responsibilities under the SDI have already been assigned.

10.4.3. Goal 3: Create National MSDI Geoportal

This to be achieved by:

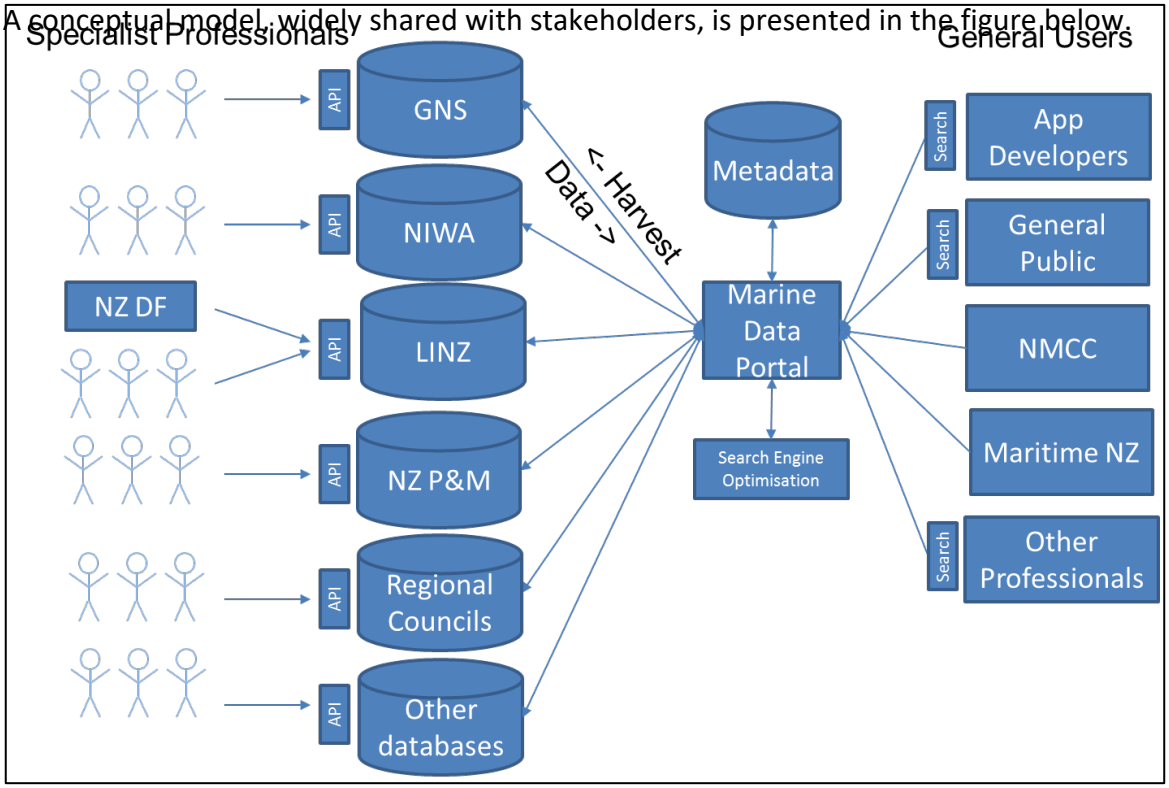
Collaborating with the other public agencies and businesses to determine market needs and priorities

- International best practice in creating the right conditions for collaboration will be important in informing this work[78]
- Revisit the NIWA proposal from 2014 to make less technically focused

Creating a federated network of data management systems that are interoperable and exposed to non-specialist users through a single portal

- A number of existing portals are candidates to be upgraded to perform this function
- Data should be accessible through the web services within practical limits (requesting large volumes should be supported offline)

A conceptual model, widely shared with stakeholders, is presented in the figure below.



[78] InfoMAR and EMODNet in particular in Europe, Coastal and Ocean Data Integration Act in US

Figure 14: MSDI Portal Conceptual Model

It is envisaged in this model that specialist professionals would still access the information that they need through the specialist organisation that most closely provides their needs normally through specific APIs.

However the information in their databases represented by the drum shapes will be more easily accessed by general (non-specialist) users through a marine data portal providing access to marine data.

The portal would not store data itself but only the metadata (data about the data) such as the polygon representing its coverage and basic characteristics such as date of acquisition, restrictions on use etc.

In response to a request from a general user the Marine Data portal would "harvest" the most current data from the appropriate databases and supply it through a standard transfer mechanism.

10.4.4. Goal 4: Marine Cadastre[79]

To be achieved by:

- Socialising the marine cadastre concept.
- Establish the policy and business case for creating and managing a marine cadastre:
  - Reducing effort in data discovery and maintenance, aiding better planning and decision making;
  - The US Marine Cadastre initiative[80] is indicative of the wide range of applications it might support.
- Work with other agencies to identify sources and collate marine cadastre information
  - The information would not be stored in one central repository but harvested from existing sources but exposed through LDS;
  - LDS would support storage of smaller organisations' data.
  - Maintenance mechanisms between systems to ensure consistency and currency.

[79] See Canadian reference Paper for potential definition of scope

DEFINING THE MARINE BOUNDARY COMPONENT OF CANADA'S GEOSPATIAL DATA INFRASTRUCTURE (CGDI) http://www2.unb.ca/gge/Research/GEG/OceanGov/documents/GeoTools.doc

[80] US Operational Marine Cadastre: http://coast.noaa.gov/data/docs/marinecadastre/facts.pdf

The suggested priority datasets for a marine cadastre are:

- Limits of private and public ownership (e.g. high water mark);
- Limits of private rights below high water (e.g. aquaculture sites, oil and gas license boundaries);
- Local government and other limits of jurisdiction and administration (including iwi)
- National and international boundaries, including national coastal baselines;
- Government departmental limits;
- Environmental protection areas (e.g., wetlands, marine protected areas, coastal zone management)
- Fishing zones for quota management
- Military limits (e.g., disposal and weapons firing ranges);
- Pipeline and cable rights-of-way.

10.4.5. Goal 5: Internal Strategy

Achieved by:

- Delivering business improvement projects and implementing their recommendations
  - Expedite work on the release of current bathymetric data holdings.
- Improvement to data accessibility through LDS
  - Thematic aggregation / attribution intelligibility.
- Work more closely with other parts of LINZ
  - Leverage GIS knowledge as part of the data management review;
  - Short-term Secondments.
- Review of software tools and technology
  - CARIS appropriate tool for routine chart and digital production;
  - Look to introduce other tools where appropriate.
- Dedicating more resources to Digital Management (data plus software) within the group.

10.4.6. Goal 6: Leverage Innovation

To be achieved by:

- Defining a series of technology frontiers to be tracked and investigated;
- Examining the potential role of social changes such as crowd sourcing in the delivery.
- Opportunistic Data Acquisition
  - Tracking planned cruises and actively seeking to use them as opportunities for increasing the coverage of ocean floor mapping;
  - Using an existing Data Acquisition Planning System, such as POGO[81] which has been operating for over 10 years, see the figure and text below.
- Research sharing
  - Seeking to present results of research work, such as the recent work on bathymetric LiDAR in Waikato, to the wider marine community as part of raising LINZ external profile.

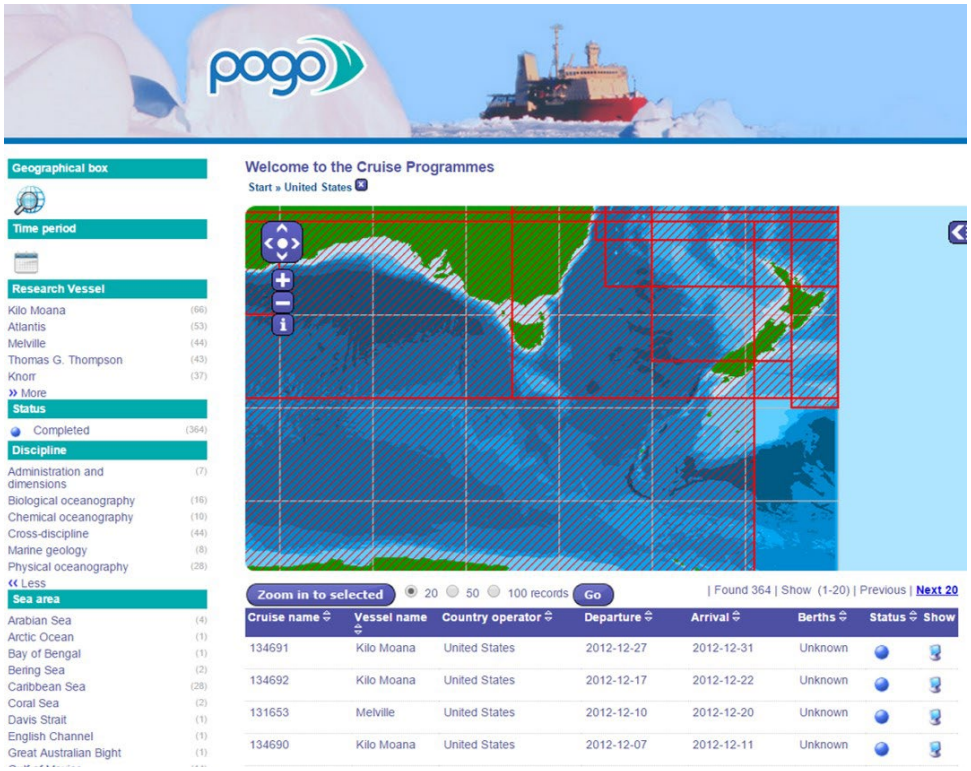


Figure 15: Screen shot of POGO Cruise Planning Tool

[81] Partnership for Observation of the Global Oceans (POGO): http://www.ocean-partners.org/

The Partnership for Observation of the Global Oceans (POGO) has served as a forum for leaders of major oceanographic institutions around the world to promote global oceanography, particularly the implementation of international and integrated global ocean observing systems.

The POGO directory[82] is a searchable database of the cruise programmes of global ocean-going research vessels. The numbers in brackets behind the items in the left menu column indicate the number of related programme records.

A user can select relevant programme records and narrow down its selection by clicking on these items in the left menu column. The individual records give further details on the planned cruise and related contacts. Clicking on the vessel name gives a detailed factsheet of the RV characteristics. Clicking on the organisation names gives the full addresses. The button on the right side of the map gives the user a menu to select map layers.

[82] POGO cruise directory home page: http://www.pogo-oceancruises.org/v_pogo_v1/browse_step.asp

10.5 Resources

This section provides a high-level assessment of the resource implications of the proposed strategy:

- Complete elevation coverage (Goal 1) is (in part) already an established priority within Location Information with joint responsibility between the topographic and hydrographic teams.
- The outcome of the risk assessment will be used to prioritise work in coastal areas within current levels of staffing.
- Leverage existing and research cruise bathymetry to minimise new survey required in deeper water by working more closely with NIWA/GNS.
- To deliver Goals 2-4 will require a new team within Land Information separate from the Hydrographic Authority. It would be led by a business manager, with a full time stakeholder engagement leader and technical support resource.
- Goal 5 can be achieved by the Hydrographic Authority with moderate extra resourcing, internal efficiencies and some re-organisation
- Goal 6 would be the responsibility of the Hydrographic Authority to define targets and the Location Information project group to deliver.

10.6 Strategy Implementation Costs

One of the main purposes of Stage 3 is to provide the detail that would enable costs to be evaluated in detail. However, as a rough order of magnitude estimate LINZ should budget as follows:

- Dedicated MSDI team
  - Current estimate: $500k per annum (3 FTEs);
  - Support from SDI team on standards and LDS on technical implementation.
- Maximise reuse of existing systems and resources to keep capital investment to a minimum
  - Geoportal: upgrade existing GNS system (capital circa $200k);
  - Marine Cadastre addition to LDS (implementation circa $250k);
- Hydrographic Authority changes largely achieved from internal efficiencies
  - Outsourcing;
  - Notice to Mariners (NtM) simplification;
  - Software process improvements.

11 Next Steps

11.1 Executive Leadership Team Consideration

LINZ need to decide what priority (and resources) they are willing to assign to advancing a National MSDI.

If it does decide to push ahead and agrees with the direction laid out in this report, then the following immediate actions follow:

- Identify / recruit resource to lead on MSDI
- Establish working group of key stakeholders to refine big vision and define early wins:
  - MBIE
  - NIWA
  - GNS
  - Regional Councils
  - Maritime NZ
  - DoC
- Build a Programme Business Case backed by a coalition of willing information-centric organisations.

11.2 Strategy Stage 3

Should the Executive Leadership Team (ELT) be minded to proceed with the recommended strategy then the tasks in stage 3 should be undertaken.

This final stage will be to work up the chosen option into a robust, implementable plan for transformation of the hydrographic group to deliver the chosen strategic vision.

It will include the following activities:

- Assessing Business Readiness
- Market Testing
- Business Case Development

Main Document Ends

Annex A: Stage 2 Brief

LINZ Hydrographic Group
Creating a Strategic Vision
Stage 2 Briefing Note

Context

Land Information New Zealand (LINZ) is the national hydrographic authority for New Zealand and also has responsibilities under international treaties in the South West Pacific and Ross Sea area of Antarctica. As such, it is charged with overall responsibility for hydrographic matters particular as they relate to the provision of nautical and hydrographic charting services under the obligations in the Safety of Life at Sea (SOLAS) convention to which New Zealand is a signatory.

The requirements of mariners for navigation, both currently and in the foreseeable future, are evolving but there are well established mechanisms through the International Hydrographic Organisation (IHO) for setting standards and reviewing methodologies.

The challenge for the hydrographic group now and in the future is to do with both hydrography and the wider issue of marine use of location information. In particular, how the group contributes to achieving LINZ's long-term strategic goal of increasing the value created through the use of location information tenfold over the next 10 years[1].

This document

This document is a briefing note for Stage 2 of continuing the work being undertaken by ConsultingWhere in reviewing the strategic direction for the LINZ Hydrographic Group.

The focus of Stage 1 was to gathered information about the current state of maritime location information in New Zealand and the organisations, both private and public, involved in its management.

The focus of Stage 2 will be assessing strategic options by which LINZ can facilitate optimising its contribution to the growth of the economy and well-being of its people. In defining a sustainable strategic long-term direction it is necessary to consider a range of options and tests them with key stakeholders. In the next few paragraphs the broad options we are considering are outlined, this will give context to the discussions we hope to conduct with the community during the next few weeks.

Responding to Rapid Change

Commercial organisations, with global coverage and huge volumes of users, such as Google which are influential players in the consumer mapping market, are turning their attention to the marine environment though their Google Ocean programme[83]

[1] LINZ Statement of Intent 2014-8 http://www.linz.govt.nz/about-linz/publications/statement-intent/statement-intent-2014-2018

83 Google Oceans program: https://www.google.co.uk/earth/explore/showcase/ocean.html#

and their plans for the earth observation satellite market through their purchase of Skybox[84].

Furthermore, the traditional divide between land and sea in terms of data capture and processing technology is beginning to disappear. Light Detection and Ranging (LiDAR) technology which has the potential to provide "fit for purpose" shallow sea elevation data, is already a viable choice for favourable conditions and has real near-term potential to become a cost-effective general purpose tool for bathymetry. Earth observation data from satellites, already a valuable reconnaissance tool for bathymetric survey, is also an area of technological change. The cost of developing and launching satellites is plummeting to the extent that there are now 54 countries with active earth observation programmes.

Other public sector bodies are also becoming important players in marine data capture and management, of particular interest in New Zealand, is the LiDAR capture programmes of the larger regional governments and the Hauraki Gulf Marine Spatial Planning system.

Approach

Building on the experience of previous similar exercises, both within LINZ and other countries, the review will involve a number of inter-related activities to analyse alternative strategies and then advise LINZ management.

The fundamentals of the approach are "stepwise refinement" and learning from best practice, aimed at adding value at each stage of a three stage review.

Stage1: This has been completed. An assessment of the current situation has been provided with recommendations, where appropriate, on short-term actions.

Stage 2: In the second stage, the review will consider the longer-term options in more depth, looking at the external influences of changing market needs, international best practice and technology advances plus internal factors of workflows, Government and LINZ policy.

The main deliverable from this work will be assessment of series of strategic options with associated outline benefit-cost analysis. Broadly the options being consider are as follows:

1. Status quo – maintain focus only on hydrographic charting mission (including SW Pacific / Antarctica NZ)
2. Supporting coordination by other public sector stakeholders of better bathymetric data sharing

[84] Google + Skybox: http://www.skyboximaging.com/blog/skybox-imaging-google

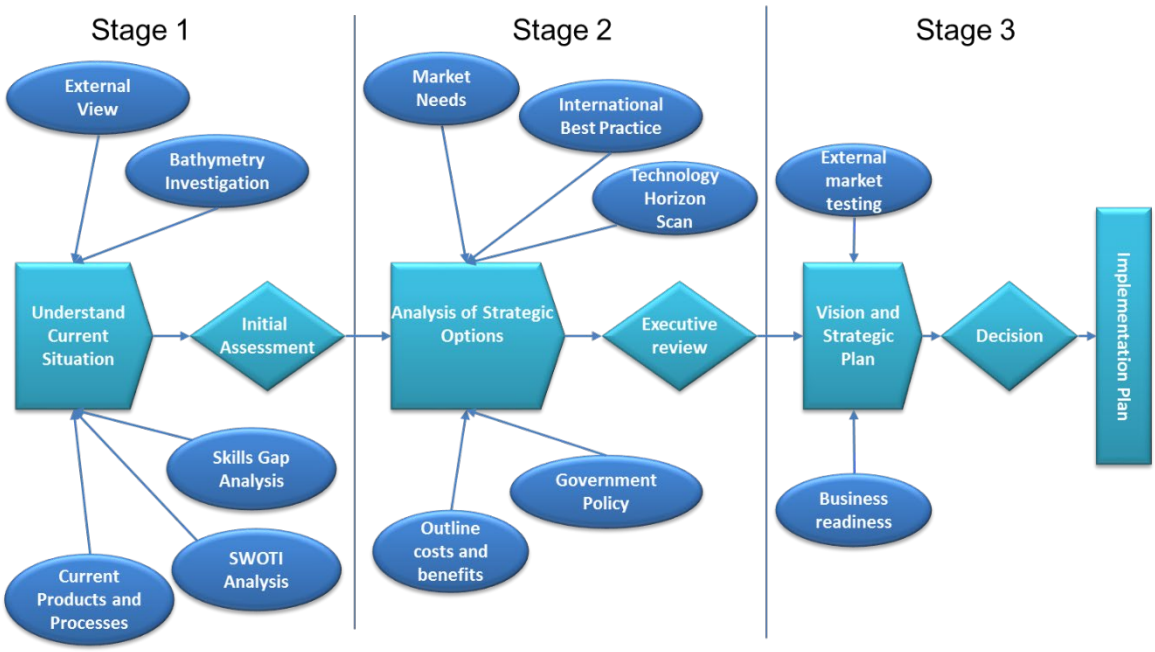
3. Seek to provide a coordination role for a national Maritime SDI, similar in concept to what LINZ provides for imagery

4. Proactive leadership in the development of a comprehensive MSDI for New Zealand

These options are clearly points on a continuum of approaches that LINZ could choose to adopt. The choices within these broad options will be articulated in the report.

Stage 3: The final stage will be to work up the chosen option into a robust, implementable plan for transformation of the hydrographic group to deliver the chosen strategic vision.

The figure below represents the overall approach diagrammatically.



Lead Consultant

This exercise is being led by ConsultingWhere's Principal Consultant Andrew Coote. Andrew has been working in the geospatial industry for nearly thirty years both in the private and public sectors. He is eminently suited to this role as he has wide international experience of surveying and cartographic systems from both design and implementation perspectives. He is a chartered surveyor and whilst not a hydrographic expert, he does have an understanding of the field and practical experience from his early professional career in the Seychelles.

In addition, he brings considerable GIS and organisational management experience. He worked for the Ordnance Survey for nearly nine years much of this time responsible for developing new software-driven approaches to both small and large scale mapping systems. More recently, he led a team of over 100 professional services staff at ESRI (UK) who implemented many of the largest and most complex GIS projects in the UK. As an independent consultant since leaving ESRI (UK) in 2008, he has advised many public sector organisations and "blue chip" commercial companies on business strategy in the field of location-based services.

He has particular knowledge of the New Zealand situation by virtue of his position as external advisor to the LINZ Geospatial Office and lead consultant on the recent topographic mapping strategy project.

Annex B: United States Ocean and Coastal Mapping Integration Act (2009)

Introduction

The US has taken a legislative approach to creating a Marine SDI, with particular focus on integrating coastal and oceanographic work within Government.

The objectives, as outlined in the Act are a useful starting point for any policy work in NZ.

Objectives

i) Identify all Federal and federally funded programs conducting shoreline delineation and ocean or coastal mapping, noting geographic coverage, frequency, spatial coverage, resolution, and subject matter focus of the data and location of data archives;

ii) facilitate cost-effective, cooperative mapping efforts that incorporate policies for contracting with non-governmental entities among all Federal agencies conducting ocean and coastal mapping, by increasing data sharing, developing appropriate data acquisition and metadata standards, and facilitating the interoperability of in situ data collection systems, data processing, archiving, and distribution of data products;

iii) facilitate the adaptation of existing technologies as well as foster expertise in new ocean and coastal mapping technologies, including through research, development, and training conducted among Federal agencies and in cooperation with non-governmental entities;

iv) develop standards and protocols for testing innovative experimental mapping technologies and transferring new technologies between the Federal Government, coastal state, and non-governmental entities;

v) provide for the archiving, management, and distribution of data sets through a national registry as well as provide mapping products and services to the general public in service of statutory requirements;

vi) develop data standards and protocols consistent with standards developed by the Federal Geographic Data Committee for use by Federal, coastal state, and other entities in mapping and otherwise documenting locations of federally permitted activities, living and non-living coastal and marine resources, marine ecosystems, sensitive habitats, submerged cultural resources, undersea cables, offshore aquaculture projects, offshore energy projects, and any areas designated for purposes of environmental protection or conservation and management of living and non-living coastal and marine resources;

vii) identify the procedures to be used for coordinating the collection and integration of Federal ocean and coastal mapping data with coastal state and local government programs;

viii) facilitate, to the extent practicable, the collection of real-time tide data and the development of hydrodynamic models for coastal areas to allow for the application of V-datum tools that will facilitate the seamless integration of onshore and offshore maps and charts.

Funding

(1) $20,000,000 for fiscal year 2008;

(2) $26,000,000 for fiscal year 2009;

(3) $32,000,000 for fiscal year 2010;

(4) $38,000,000 for fiscal year 2011; and

(5) $45,000,000 for each of fiscal years 2012 through 2015.

End of Annexes