Submission
2016 National Research Infrastructure Roadmap
Capability Issues Paper

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Executive Summary

The Marine National Facility (MNF) provides an exemplar landmark research infrastructure operation with RV *Investigator*, Australia's only blue water research vessel operating across our vast marine estate. Under direction of an independent Steering Committee, the Marine National Facility is owned and operated by CSIRO on behalf of the nation, leveraging specialist support from CSIRO to provide a science ready turn-key capability for Australian marine researchers and their international collaborators.

Applying enduring principles set out in the *Guidelines for the Operation of National Research Facilities Report of 1984*[1], research vessel time is awarded through a competitive, peer reviewed and merit-based applications process to meet national and international research challenges. This model of operation is comparable to international best practice examples of publicly funded research fleets.

[1] Australian Science and technology Council 1984, accessed 8 September 2016, http://www.industry.gov.au/innovation/reportsandstudies/ASTEC/Guidelines-for-the-Operation-of-National-Research-Facilities.PDF

Aside from physical capability, the MNF houses a unique and growing record of publicly available marine data collected since its inception over 32 years ago.

The MNF is currently funded to operate the RV *Investigator* 180 days at sea per year to deliver merit granted voyages in accordance with the fundamental principle behind the establishment of the Facility. Demonstrating Australia's research demand for the RV *Investigator's* capabilities, for the 2017-18 scheduling year the MNF received 25 applications for a total of 752 days at sea, with ~90% of these assessed as supportable by an independent Science Advisory Committee should sufficient sea time be available.

MNF supports the submission from the National Marine Science Committee (NMSC) which details the necessary infrastructure required to produce the robust scientific evidence required for sustainable growth in marine industries including fisheries, aquaculture, shipping, petroleum, mining and ecotourism.

Question 1: Are there other capability areas that should be considered?

The capability areas are appropriate to the research enabled through the MNF, and consistent with the grand challenges listed in the National Marine Science Plan 2015-2025 to unlock the full benefits of our blue economy and keep our marine science at the leading edge and internationally competitive. This is specifically covered in the Environment and Natural Resource Management capability area. Marine science and the need for marine research vessels, however, is broader than this area and relevant to the other capability areas in National Security, Underpinning Research Infrastructure, and Data for Research and Discoverability, as well as the National Science and Research Priorities in food security, energy security and resources security.

Question 2: Are these governance characteristics appropriate and are there other factors that should be considered for optimal governance for national research infrastructure (NRI).

The governance characteristics are appropriate, but might explicitly reference the assessment of science excellence in addition to the focus on benefits and outcomes.

National research infrastructure should also be established and governed to enable science ready facilities by leveraging specialist support to maximise the performance of researchers who access the infrastructure on an irregular basis. This is relevant, for example, with the research vessel where users may only have voyages every two or three years, so their effective use is critically dependent on access to not only the ship, but experienced crew and technical support to ensure safe, effective and efficient operations.

Question 3: Should national research infrastructure investment assist with access to international facilities?

Where appropriate, this should occur. Australia's location makes it problematic to share access to blue-water research vessels, although the opportunity exists for international collaborators to participate in MNF voyages, and similarly Australian researchers to participate on voyages on ships from other countries. We should also actively contemplate the sharing of equipment on a global basis to enhance performance of Australian infrastructure e.g. ROVs.

Question 4: What are the conditions or scenarios where access to international facilities should be prioritised over developing national facilities?

No comment.

Question 5: Should research workforce skills be considered a research infrastructure issue?

Certainly, ensuring the RV *Investigator* is science-ready requires an effort from a specialist team of technical staff who prepare and maintain a large pool of science equipment deployed permanently or as-required on the vessel. These staff also provide specialist at-sea support during delivery of voyages. Without the support of this technical capability, the challenge of preparing and delivering the science platform would be subject to significant inefficiencies and, with no access to technical staff at sea, greater risk of failure of the Facility to achieve science objectives.

Question 6: How can national research infrastructure assist in training and skills development?

Marine science training and skills development requires significant hands-on experience. As such, research infrastructure, such as the proposed National Research Vessel Alliance, is required to be available not only for research activities but also for training of future marine scientists.

MNF Case Study – Training and Skills Development

Promoting the next generation of users is identified by the Marine National Facility (MNF) to be essential to its ongoing sustainability. Over the next three years (2017-19) the Collaborative Australian Postgraduate Sea Training Alliance Network (CAPSTAN) program will train 90 post-graduate students in all aspects of sea-going research on board Australia's only dedicated blue-water research vessel, *Investigator*. The experience gained by participants will equip them with unique, specific and practical sea-going research skills as well as recognized marine industry safety training, preparing them for future maritime related careers in academia, government and industry. Participants will be required to complete a nationally standardised course attributable to their field of study. Completion of the training program will provide students with a significant competitive advantage internationally given the small number of programs worldwide that offer student training opportunities in the discipline of blue-water marine research. Importantly, CAPSTAN shall facilitate networking for early-career researchers promoting the research and career development opportunities required to build a successful research career.

In development between Macquarie University and the Marine National Facility, the program will be governed by a network of leading industry and university partners from within marine science and geoscience and is a truly national education initiative designed to develop a national approach to teaching and learning in the marine sciences, whilst also providing a platform for institutional, industrial and generational knowledge transfer and collaboration on-board the RV *Investigator*.

Question 7: What responsibility should research institutions have in supporting the development of infrastructure ready researchers and technical specialists?

Research institutions can provide the capability home over timescales required to build and maintain specialist skills to support the irregular access to technical specialists through national research infrastructure.

Question 8: What principles should be applied for access to national research infrastructure, and are there situations when these should not apply?

In May 2014 the Australian Government reaffirmed a commitment to the MNF, allocating AU$65.7million over the next four years to operate RV *Investigator*. This funding allows approximately 180 research days at sea per year to be competitively funded on merit as Granted Voyages (GV) which is the fundamental principle underpinning the establishment of the Marine National Facility.

Given RV *Investigator*'s capacity to provide up to 300 days per year at sea, the MNF can provide additional days through other arrangements to maximise research in the national interest. Currently, the MNF funding for 180 GV days creates significant opportunities to utilise up to 120 additional days at sea as User Funded Voyages (UFV) within each annual research schedule.

Assessment of Applications for Access – Granted Voyages (GV)

Proposals for GV are only accepted through the MNF applications process following a call for applications. Applications are called two years in advance of an annual research schedule and are typically open for a two to three month period. GV applications are nationally and internationally peer reviewed, then assessed by an independent committee against three equally weighted Core Criteria:

Criterion 1: scientific and/or technical excellence;

Criterion 2: potential to contribute to Australia's national benefit; and

Criterion 3: the ability of investigators (demonstrated, or potential relative to opportunity) to successfully undertake the project.

Assessment of Proposals – User-Funded Voyages (UFV)

UFV proposals are open year round and are assessed by the MNF against the potential to contribute to Australia's national benefit. In addition, a risk assessment is conducted on each proposal with a particular focus on:

- scientific and/or technical excellence (Criterion 1);

- the ability of investigators (demonstrated, or potential relative to opportunity) to successfully undertake the project (Criterion 3);
- legal risks including any proposed departures from the standard MNF Voyage Agreement;
- commercial risks;
- reputational risk to the MNF/CSIRO;
- any proposed departures from RV *Investigator's* policies;
- fit with MNF schedule; and
- operational constraints.

Question 9: What should the criteria and funding arrangements for defunding or decommissioning look like?

A whole of life cycle approach is required to design, build, operate, maintain, decommission and, refresh national marine research infrastructure. This is particularly relevant for marine research vessels, where their life cycle is expected to be 25-30 years.

Question 10: What financing models should the Government consider to support investment in National research infrastructure?

No comment.

Question 11: When should capabilities be expected to address standard and accreditation requirements?

Data standards. The Marine National Facility has a policy of making all data acquired publically available. It is appropriate that all published data meets applicable QA and QC standards.

Industry Standards. Operation of a blue water research vessel requires meeting the obligation of all relevant national and international marine standards and accreditation.

Question 12: Are there international or global models that represent best practice for national research infrastructure that could be considered?

No comment.

Question 13: In considering whole of life investment including decommissioning or defunding for national research infrastructure are there examples domestic or international that should be examined?

There are many examples of managing whole of life investment in marine research vessels, both domestically and overseas. All research vessel owner-operators have demonstrated experience in this area, none more so than the MNF and the Australian Antarctic Program.

Question 14: Are there alternative financing options, including international models that the Government could consider to support investment in national research infrastructure?

No comment.

Health and Medical Sciences

Question 15: Are the identified emerging directions and research infrastructure capabilities for Health and Medical Sciences right? Are there any missing or additional needed?

No comment.

Question 16: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

No comment.

Question 17: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Health and Medical Sciences capability area?

No comment.

Environment and Natural Resource Management

Question 18: Are the identified emerging directions and research infrastructure capabilities for Environment and Natural Resource Management right? Are there any missing or additional needed?

The National Marine Science Plan (NMSP) identifies the following seven grand marine challenges: marine sovereignty, security and safety; energy security; food security; biodiversity conservation and ecosystem health; urban coastal environments; climate variability and change; and resource allocation. Only some of these are included in the Issues Paper, although it would be valuable to include all of them in the 2016 Roadmap.

In terms of the National Research Vessel Alliance there is reference made to the MNF, icebreaker and marine vessels to support ongoing research in the coastal zone.

A national alliance of a coordinated fleet of large-scale, offshore research vessels that cover Australia's marine estate, from the coast to the blue water, and the tropics to Antarctica, will increase the opportunities for scientific collaboration and discovery and enable the necessary data and information to be collected to derive the benefits from the nation's blue economy, while ensuring Australia's marine science infrastructure and capabilities remain world leading, innovative and cutting-edge. The development of a coordinated national fleet of research vessels will be a strategic long-term investment for Australia and is critical to the future of marine science and the sustainable development of our seas and oceans.

MNF Case Study - Weather Prediction

The first-ever shipborne observations of the vertical distribution of cloud properties and surface shortwave radiation over the Southern Ocean were made using the Marine National Facility RV *Investigator* on two voyages delivered in 2015/16. Using RV *Investigator's* suite of state-of-the-art meteorological instruments and laboratories has allowed scientists to conduct an assessment of the Australian Community Climate and Earth System Simulator (ACCESS) performance for the first time over the Southern Ocean, providing a clear path towards improvements in the model. The ACCESS Coupled earth system models seamlessly link together models of the oceans, atmosphere, sea-ice, land surface, global carbon cycle and chemistry, and aerosols, to simulate changes in the Earth's

climate systems with ever-increasing precision. These models enable scientists not only to project major changes in the Earth's climate in the longer term, but to make short and medium-range weather forecasts and seasonal predictions for particular regions. This forecasting capability is critical to Australia's capacity to anticipate and address extreme weather events such as tropical cyclones, bushfires and flooding.

ACCESS provided Australia's major input to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). This included simulations of the climate of the 20th century, and projections for the 21st century for a range of future greenhouse gas and aerosol concentration scenarios. ACCESS simulations rank in the upper level of international climate model simulations and are particularly skilful over Australia, based on simulations of historical climate. However, specific issues related to the representation of atmospheric processes in ACCESS, in particular existing radiation and warm sea surface temperature biases, have been identified over the Southern Ocean due to a lack of observations. The observations collected with RV *Investigator* provide the research community with the unique opportunity to improve the representation of atmospheric processes in ACCESS only available as a result of the capability provided by a blue-water research vessel. These improvements will increase the reliability of ACCESS to accurately model Earth's climate systems.

MNF Case Study - Fisheries Sustainability

The State of World Fisheries and Aquaculture 2016 report, the flagship publication of the Food and Agriculture Organization of the United Nations, reports Australia's success in ending overfishing in all fisheries managed solely by the Government of the Commonwealth of Australia in 2014. This significant and rare achievement has its roots in the research conducted by a range of research, industry and government stakeholders aimed at advancing Australia's understanding of its vast marine estate including essential research that could only be undertaken using the Marine National Facility.

MNF users have, for a number of years, been actively involved in leading the development of acoustic remote sensing methods to assist in determining the population size, species discrimination and spatial gradients, applied to the dominant acoustic fish species and their dynamics on the coasts of Australia. In parallel, MNF voyages aimed at establishing the environmental context have conducted physical, chemical and geological oceanography to elucidate their habitat.

The outcomes from this research, not possible without a blue water research vessel and its suite of sophisticated scientific equipment, has assisted government and industry to build an accurate picture of the population, habitat and eco-system status of key commercial fish species, and informed strategies and policy aimed at developing sustainable fishery management of high value species, as well as implementation of appropriately situated Marine Protected Areas.

Techniques and methodologies developed on board MNF vessels have also contributed to technology transfer to commercial vessels which have been fitted with echo sounding equipment to assist in ongoing population surveys and improved fishing efficiency. The ability to demonstrate sustainable fisheries provides a valuable marketing advantage to Australian fisheries.

Question 19: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

No comment.

Question 20: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Environment and Natural Resource Management capability area?

No comment.

Advanced Physics, Chemistry, Mathematics and Materials

Question 21: Are the identified emerging directions and research infrastructure capabilities for Advanced Physics, Chemistry, Mathematics and Materials right? Are there any missing or additional needed?

No comment.

Question 22: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

No comment.

Question 23: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Advanced Physics, Chemistry, Mathematics and Materials capability area?

No comment.

Understanding Cultures and Communities

Question 24: Are the identified emerging directions and research infrastructure capabilities for Understanding Cultures and Communities right? Are there any missing or additional needed?

No comment

Question 25: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

No comment

Question 26: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Understanding Cultures and Communities capability area?

No comment.

National Security

Question 27: Are the identified emerging directions and research infrastructure capabilities for National Security right? Are there any missing or additional needed?

Marine sovereignty, marine (bio)security and marine safety are important components of national security, yet are missing from the Issues Paper. Our marine estate is a vital contributor to Australia's sovereignty, national security and safety. Governments and marine industries all require accurate and up-to-date information about sea state, atmospheric conditions and geohazards, to support their operations to utilise the blue economy. In addition, as highlighted in the National Marine Science Plan, national security should also encompass food security, energy security and resources security.

A national marine research vessel fleet will enable the collection of critical data and information on marine environmental baselines and impacts, ocean conditions, petroleum and mineral resources, climate change, fish stocks, ecosystem effects of fishing and biosecurity threats; all of which will contribute to unlocking the wealth and opportunities from our blue economy. A coordinated national research fleet will provide the ability to support national marine science and industry

initiatives, including the collection of scientific data of national significance on the state of the environment, whilst maintaining our status as a world class, leading marine research nation.

Knowledge about Australia's marine estate is not only critical to Australia but also for global understanding. The United Nations' Law of the Sea arrangements require us to satisfactorily manage our marine jurisdiction, and that management requires scientific understanding. Australia requires its marine science community to explore, understand and monitor our marine estate at a high spatial resolution to conduct research that underpins effective management and development of marine resources. Only 28% of Australia's marine estate has been mapped with any detail. A systematic program needs to be undertaken from suitably equipped research vessels to continue to build foundation knowledge of our marine environments that may contain significant untapped resources and ecosystems of national ecological significance. Coordination of coastal-shelf and blue water research vessel surveys is a necessary and cost effective step toward efficiently mapping Australia's marine estate, as well as consideration of new capability to be deployed from these vessels.

Question 28: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

No comment

Question 29: Is there anything else that needs to be included or considered in the 2016 Roadmap for the National Security capability area?

No comment

Underpinning Research Infrastructure

Question 30: Are the identified emerging directions and research infrastructure capabilities for Underpinning Research Infrastructure right? Are there any missing or additional needed?

The identified emerging directions and research infrastructure capabilities align with the marine science research infrastructure requirements detailed in the NMSP.

Research vessels are also considered as key underpinning infrastructure required to explore and discover Australia's vast marine estate. Undersea exploration, particularly in the deep oceans, is conducted using cutting edge technologies deployed from research vessels such as the use of autonomous underwater vehicles (AUVs) and remotely operated vehicles (ROVs) that enable accurate mapping and analysis of the sea-floor. Maintaining technological currency and maximising the area covered by these explorations is important as it provides the geological context for our biological understanding and documents geological events that have occurred throughout history and shaped our marine estate.

Question 31: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

No comment.

Question 32: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Underpinning Research Infrastructure capability area?

No comment.

Data for Research and Discoverability

Question 33 Are the identified emerging directions and research infrastructure capabilities for Data for Research and Discoverability right? Are there any missing or additional needed?

No comment.

Question 34: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

No comment.

Question 35: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Data for Research and Discoverability capability area?

No comment.

Other comments

If you believe that there are issues not addressed in this Issues Paper or the associated questions, please provide your comments under this heading noting the overall 20 page limit of submissions.

See below.

Marine National Facility

Funded by the Australian Government since 1984 and operated by CSIRO under direction of an independent Steering Committee, the Marine National Facility (MNF) provides a keystone element of the nation's research infrastructure by providing the only blue water research capability available to Australian marine researchers and their international collaborators for work in Australia's vast marine estate. Access is provided through an independent and peer reviewed applications process focused on scientific and/or technical excellence, the potential to contribute to Australia's national benefit and the ability of the research team. This ensures research undertaken through the MNF is specifically selected for excellence and contribution to Australia's national benefit, and provides key information to government, industry and other stakeholders to support evidence-based decision-making focused on research challenges in fisheries management, geological resources, regional and global climate, coastal and offshore developments and marine operations.

In 2014, delivery of the new purpose-built 94 metres multi-purpose RV *Investigator* provided a step-change in Australian marine and atmospheric research capability acting as a catalyst for international collaboration. The RV *Investigator* can undertake voyages from the tropics to the Antarctic ice edge, carry up to 40 scientists and support staff on voyages up to 60 days in duration and spend 300 days per year at sea. The RV *Investigator* also hosts an extensive suite of state-of-the-art scientific research equipment and is one of a handful of research vessels globally designed for very quiet operation with the ability to undertake research to the deepest parts of our oceans. Demonstrating Australia's research demand for the RV *Investigator's* capabilities, for the 2017-18 scheduling year the MNF received 25 applications for 752 days at sea, with ~90% of these assessed as supportable by an independent Science Advisory Committee should sufficient sea time be available.

The MNF is currently funded to operate the RV *Investigator* 180 days at sea per year to deliver merit granted voyages in accordance with the fundamental principle behind the establishment of the Facility. While limiting operations to 180 days compared to full utilisation at 300 days reduces operating costs in some areas, inefficiencies reduce these cost savings. For example, crew and maintenance costs do not reduce pro-rata with operating days as corrosion and machinery require ongoing attention to maintain a science ready platform and rotating machinery has a reduced service life if not operated continuously. While not at sea, additional costs arise with port charges while an accelerated rate of hull fouling increases fuel consumption on subsequent voyages until the next scheduled dry-docking. As the fixed costs of ownership such as insurance, marine survey and baseline crewing remain static, the incremental increase of $8 million per annum in the operating budget required to move from 180 to 300 days per year, compared to the present budget of $26 million, is an incremental increase which nearly doubles the return on investment delivered to the science community. The cost per day for the additional time would be $67,000, compared to $144,000 for the 180 days, bringing the cost per day for the whole 300 days to $113,000 per day.

Case study – the use of new technologies and leverage on investment

An investment in Australia's offshore research vessels will provide substantial economic returns with each voyage leveraging significant funding from other sources, most notably the in-kind salaries of the teams of scientists on board. It will also secure and advance the use of technology to collect critical data, complementing vessel based research.

Technology is increasingly expanding the reach of marine research with tools that collect data virtually autonomously. For example, as part of IMOS, marine animals, deep sea floats and gliders have been used to autonomously collect time-series oceanographic data to complement and expand more traditional means such as the use of research vessels (albeit these are required as the necessary platforms to access the deep ocean and coastal-shelf waters to deliver and service the new technologies).

An example of the interplay between existing research vessel activities and new technology is demonstrated by a research voyage along 170°W in April/May 2016 on the RV *Investigator*. This voyage represented Australia's regional contribution to the international GO-SHIP program to monitor decadal ocean change, with a consortium of countries undertaking repeated occupation of hydrographic stations from the poles to the equator. Vessel-based hydrography remains the only method for obtaining high-quality, high spatial and vertical resolution measurements over the full water column which is essential for documenting ocean changes, especially for the deep ocean below 2000 metres where 52% of the global ocean volume is not sampled by profiling floats.

The RV *Investigator's* 170°W voyage also gathered high precision baseline data to calibrate the international Argo array, XBT program, and other autonomous observations made by ocean gliders, moorings and satellites which provide more detailed understanding of dynamic ocean processes occurring between research vessel visits. These autonomous observations are part of highly co-operative international efforts to meet global research challenges. For example, Australia is a member of the international Argo program and the second largest contributor globally after the USA. Argo Australia is operated by CSIRO, with financial and operational support from the Bureau of Meteorology, IMOS, the Antarctic Climate and Ecosystem Cooperative Research Centre, Royal Australian Navy and the Department of Environment and Energy.

Australia's participation in the international research community is very important as a key beneficiary of the value derived from data streams critical to weather prediction globally and in our region. Geographically located in a vast ocean area, it would be difficult or impossible for other countries to replace Australia's research efforts, presenting the risk of losing our leadership and opportunity to influence international initiatives.

It is also important to note that the operational costs of research voyages, such as those undertaken as part of these initiatives, typically leverage significant funding from a range of sources. This was demonstrated in the 170°W voyage on RV *Investigator* whereby the MNF ship time cost of $4.5 million leveraged an additional $3.9 million in co-contributions and in-kind support provided by the science team and its partners to bring the total value of the voyage to $8.4 million; excluding the supplementary and piggy-back projects that were able to be undertaken alongside this primary voyage.

	Line Item	Cost ('000)
MNF Investment	MNF Ship Time	$4,489
	TOTAL	**$4,489**
Science Team Investment	Pre Voyage Planning Costs	$205
	Voyage Costs	$1,768
	Argo Floats	$1,675
	Post Voyage Costs	$274
	TOTAL	**$3,922**
	TOTAL Investment	**$8,411**