Submission
2016 National Research Infrastructure Roadmap
Capability Issues Paper

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(N.B. IMOS comments are provided as dot points under the Questions. On some questions we have made no comment.)

Questions

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

- Given that the process is now well advanced, it is perhaps best to comment on relative emphasis across the capability areas.
- We note that two changes have been made to the capability areas between the start of the process and release of the Issues Paper.
- 'National Interest and National Security' has been narrowed to just 'National Security'. It is not clear why this occurred and in our view it weakens the representation of capability required for Australia in the coming decade. National science and research priorities in Energy Security, Resource Security, and Food Security are not well represented in the Issues Paper. We think this is a significant shortcoming.
- From an IMOS perspective, it seems that our existing national research infrastructure has been pigeonholed into 'Environment and Natural Resource Management', whereas it is already delivering much more broadly and has significant potential to increase socio-economic impact, not just environmental. The National Marine Science Plan identifies seven grand challenges associated with driving the development of Australia's blue economy – marine sovereignty and security, energy security, food security, biodiversity conservation, sustainable urban coastal development, climate change adaptation, and resource allocation. IMOS is now a critical research infrastructure dependency for five of these seven national challenges (marine sovereignty and security, food security, biodiversity conservation, sustainable urban coastal development, and climate change adaptation), and highly relevant to the other two (energy security and resource allocation).
- The capability area of 'Data for research and discoverability' has been added in addition to 'Underpinning research infrastructure', which we understood to include what is currently described as 'eResearch'. It is not clear why this occurred, and we do not actually see 'data' as a separate capability area to the others. It is our understanding that the eResearch Review conducted by Rhys Francis concluded that data and compute should be considered as an integrated package. We agree. Furthermore, data for research and discoverability is core business for any national research infrastructure in the year 2016, and we do not support a paradigm that continues to see investment in research data as an 'added extra'. For the last

decade, IMOS has been clearly focused on establishing a marine research data infrastructure through the Australian Ocean Data Network (AODN).

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

- Yes, they are appropriate.

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

- Yes, where the benefits clearly exceed the costs, including opportunity costs.

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

- Where the scale of facility required is well beyond our national capacity to build, operate and maintain it, and/or where it is in Australia's strategic interest to partner rather than go it alone.

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

- Yes, to the extent required to build, operate and maintain the research infrastructure. We do not think that the research infrastructure budget should be shackled with the cost of training researchers. This should be done through research training budgets. If research infrastructure investments are well targeted to support future research needs, this will happen organically.

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

- With respect to technical and research staff required to build, operate and maintain the research infrastructure, the biggest issue has been uncertainty of funding with flow on impacts to job security and career development. The decadal commitment to NCRIS is a wonderful opportunity to address this fundamental problem.

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

- Research institutions should take full responsibility for developing researchers and technical specialists capable of utilising contemporary research infrastructure, and funding for research institutions should incentivise this outcome.

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

- IMOS is an open access system which is entirely appropriate for the research we support. Publicly funded data should be publicly available. We acknowledge that in other domains this may not be so clear cut.

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

- It does depend on the nature of the infrastructure.

- Where it is an asset to be managed (such as a research vessel), a whole of lifecycle approach would be appropriate.
- In other cases (such as for a sustained ocean observing system), the infrastructure may be dynamic and need to evolve over time in response to new scientific understanding and technological innovation. Here the 'defunding and decommissioning' issues are essentially ongoing. A structured approach is required to moving away from very mature components (which may include transitioning them to an operational context), and closing down pilot activities which have not delivered at the level required for ongoing support. Under this approach, IMOS would expect to be completely renewed over a ten-year cycle in response to new scientific knowledge and technological innovation.

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

- In our view, Government investment in national research infrastructure should be targeted into areas where there is market failure i.e. where there is a clear national need, but no institution, company or jurisdiction (or group thereof) has the mandate, capability and resources required to do the job. Experience suggests that significant co-investment can be leveraged from well targeted Government investments into areas of genuine market failure. For every NCRIS dollar invested through IMOS, $1.40 has been co-invested by partners. Annual funding of NCRIS in recent years has heavily constrained our ability to grow more co-invested partnerships (e.g. with State Governments and the private sector). The decadal commitment to NCRIS is a wonderful opportunity to address this fundamental problem.

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

- Where the benefits outweigh the costs of doing so.

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

- As conceived, NCRIS benchmarks very well against all comparable programs we are aware of in other nations. Where the principles of NCRIS have been fully embraced and effectively implemented, world class research infrastructure has been established. In the case of IMOS we are able to provide hard evidence that the international community believes we have 'got it right' in Australia. Based on our involvement with reviewing research infrastructures in other countries (e.g. Canada, the USA, New Zealand, Singapore), one area for improvement of NCRIS would be to include international peer review.

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?

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

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?

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

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?

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?

- As noted under Question 1, national science and research priorities in Energy Security, Resource Security, and Food Security are not well represented in the Issues Paper. As a result, too much ground is left to be covered under Environment and Natural Resource Management. This section is very expansive and it is difficult to see how the Issues Paper will inform 'key priority areas for investment' in the upcoming Roadmap Exposure Draft.
- In general, this section is also somewhat unbalanced, with overemphasis of some issues and under emphasis of others. More specific comments are provided below.
- 6.1.1 – We agree that Integration continues to be an emerging direction. It does need to go beyond the bio-physical and encompass the socio-economic (link to Cultures and Communities). As written this section focuses largely on data but makes little mention of the smart sensors, and autonomous systems and platforms that are driving the step change in availability of environmental data. It can't be assumed that this will just come from 'climate and weather models' and 'operational data'. Our thinking about national research infrastructure needs to be end-to-end, from acquisition to impact.
- 6.1.1 – The Issues Paper talks about sustainable management of 'our continent's 7.741 million km^2', and will be better balanced by also noting our 10.2 million km^2 of ocean territory, including Antarctic Territory. (A reference from the Geoscience Australia website can be found here.)
- 6.1.2 – The second emerging direction is perhaps focused too narrowly on Climate and Water. Arguably Climate and Weather Extremes would be a more appropriate focus for the coming decade. The Issues Paper (both under Environment and Natural Resources, and National Security) has a heavy emphasis on Water relative to other issues. Whilst Water is clearly important, the Issues Paper does not really articulate the national research infrastructure capability gap that needs to be addressed. Australian Government and State and Territory Governments have invested very heavily in water observations, catchment modelling and water information over the last decade (including through the Bureau of Meteorology and CSIRO) and it will be important to articulate future research infrastructure needs in the context of current national knowledge and capability across jurisdictions. The Issues Paper is also quite focused on the 'demand' side of the water equation i.e. use of available water. More consideration could be given to the 'supply' side of the water equation. From this perspective,

the role of the ocean in the hydrological cycle is critical, and the utility of ocean observing for terrestrial agriculture and environmental management can be clearly articulated across seasonal, decadal and multi-decadal timescales.

- 6.2 – This section starts with a statement that 'some clear gaps have emerged', but it is not clear how those gaps are identified. The decadal National Marine Science Plan (which is mentioned in 6.3) articulates gaps not mentioned here, and we consider these to have a high priority for inclusion. It is important to note that, unlike other 'decadal plans' developed through purely academic processes, the National Marine Science Plan sets out priorities agreed by 25 organisations spanning academia, research, federal and state governments, and marine industry. It provides an exemplar for the type of research-government-industry collaboration that the Issues Paper is seeking to incentivise.
- 6.2.1 - The importance of land-air fluxes is noted, but no mention is made of ocean-atmosphere fluxes (which IMOS is currently investing in). Given that numerical weather prediction (NWP) globally is moving towards coupled ocean-atmosphere models, this is considered to be particularly important.
- 6.2.1 – Reference to the Australian Community Climate and Earth-System Simulator (ACCESS) is very important. It is perhaps misplaced under 'Atmospheric observations' as ACCESS includes ocean and land surface modelling as well. It would be better placed in the opening paragraph as Earth system modelling is a key integrator of environmental observations, and major uncertainties in the models should help to inform future research infrastructure investments.
- 6.2.2 – Clear statements of the need to sustain our ocean observing capability and its continuing high priority are strongly supported, and very welcome. It says that 'integration needs to be enhanced' and 'enhanced data management and integration to ensure Australian participation in international science projects' is required. It is not entirely clear to us what is meant by these statements. If they mean that we should continue to focus on enhancing integration across disciplines, across scales and between observing and modelling, we would agree.
- 6.2.2 – Aquaculture is the only marine industry mentioned in this section. The decadal National Marine Science Plan is focused on driving the development of Australia's blue economy and provides a comprehensive assessment of future needs across all sectors, including aquaculture. Reference to broader opportunities presented by the blue economy would be welcome (see Question 27). These include offshore oil and gas, marine tourism and recreation, fisheries, ports and shipping, coastal engineering, ocean renewables, and marine bio-products.
- 6.2.2/3 – Coastal zones are mentioned under Terrestrial Systems, but not under Marine Environment. The Marine Environment sections reads as if it is very offshore, whereas a lot of focus within IMOS is already being placed on integration across scales (open ocean to coast) and opportunities to extend into coastal and estuarine systems. Extending IMOS into coastal and estuarine systems is one of eight high level recommendations in the National Marine Science Plan.
- 6.3 – Under Desirable New Capabilities, the focus is solely on 'water related challenges'. As noted above, climate and weather extremes, energy security, resource security and food security are also high priorities.
- 6.3 – Priority areas yet to be addressed are all around satellite remote sensing. We agree that positioning Australia to fully exploit new international satellite missions covering the southern

hemisphere is a high priority. However it should be acknowledged that across IMOS, TERN, AuScope and NCI there is already significant activity in this area which needs to be sustained and enhanced. It is not accurate to say that it is 'yet to be addressed'. The role of research infrastructure investment also needs to be carefully considered relative to the role of operational government agencies at both Federal and State & Territory levels.

- 6.3.1 – This section makes very general statements about sensing and environmental data that are hard to disagree with. The need for a National Baselines and Long Term Monitoring Program is one of eight high level recommendations in the National Marine Science Plan. However the section is actually titled 'Nationally integrated automated database', singular. We do not believe that a single national database for environmental data would work. IMOS has, since inception, been a 'data-centric' NCRIS capability. We have always seen datasets and time series as the research infrastructure being created and developed. As a result, IMOS has been given responsibility for implementing the Australian Ocean Data Network (AODN) with a vision of being the interoperable online network of marine and climate data resources for Australia. This includes connections to all of the relevant international marine observing/data programs. Consistent with this vision, IMOS/AODN is providing the marine component of the National Environmental Information Infrastructure (NEII). NEII is being developed by the Bureau of Meteorology as a standards-based national framework to enable interoperability of expert systems in various domains, with IMOS/AODN responsible for the marine 'domain'. In our view, this is a far more realistic approach than a 'Nationally integrated automated database'. We also note that there is no mention of quality assurance and quality control (QA/QC) in this section. In some areas it may be that the volumes of data now available make QA/QC less of an issue, but this is not true in all areas of environmental data e.g. in maintaining a climate record, QA/QC is vitally important.
- 6.3.2 – We strongly support the need for national model systems, including for coasts and oceans. As noted above, the need for coastal and ocean modelling and observing capability goes beyond Environment and National Resource Management and into Advanced Physics, Chemistry, Mathematics and Materials, National Security, and Underpinning Research Infrastructure. We also support comments about full utilisation of the research vessel fleet. The modelling and vessel priorities are two of eight high level recommendations in the National Marine Science Plan.
- 6.3.3 – We support the need for much greater use of 'omics in Environment and Natural Resource Management. The recently established 'marine microbes' project involving Bioplatforms Australia and IMOS is a pilot scale activity which is indicative of an exciting new national capability area under development. We also support the idea of experimental facilities being networked to become ecosystem observatories. Facilitating coordinated national studies on marine ecosystem processes and resilience is one of eight high level recommendations in the National Marine Science Plan.
- P26 – AODN is the Australian Ocean Data Network.
- P26 - IMOS is the Integrated Marine Observing System.
- P26 – The Marine National Facility (CSIRO) encompasses RV *Investigator*. The 'icebreaker', RSV *Aurora Australis*, is separately managed by the Australian Antarctic Division as a research and supply vessel.

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

- Comments under 6.3 about exploiting new international satellite missions covering the southern hemisphere are relevant here. We also propose that Australia becomes an active participant in international programs gearing up to measure the deep ocean (below two kilometres depth) and the sea ice zone. Targeted investment in the required capabilities will leverage substantial international co-investment and grow Australia's reputation as a world leader in marine, climate and Antarctic sciences. It will support the development of a national, decadal forecasting capability.

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?

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?

- The Grace Follow-On mission (7.1.1) is highly relevant for the study of sea level rise, and marine sensing is mentioned 7.3.1. We would like to see IMOS listed as one of the Existing Infrastructures on P31, which helps to explain that it is not just relevant to Environment and Natural Resources. Advanced physics, chemistry and mathematics are required to drive ocean/climate modelling, forecasting and analysis, and advanced materials are required for use in the marine environment e.g. to address significant issues such as biofouling .

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

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?

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?

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

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?

National Security

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

- As noted under Question 1, the fact that National Security now has such a narrow focus means that some important national science and research priorities are not well represented in the Issues Paper. The Issues Paper only considers Biosecurity and Cyber Security, with Water Security an additional emerging issue (noting that it is already heavily emphasised under Environment and Natural Resources).
- National science and research priorities in Energy Security, Resource Security, and Food Security are not well represented, and we think this is a significant shortcoming.
- Within the context of Australia's National Innovation and Science Agenda for the next decade, the National Marine Science Plan lays out key drivers of future growth in the blue economy related to Energy, Resources and Food i.e.
    - ocean renewable energy,
    - assessment of offshore geological basins (for oil and gas potential and/or CO2 storage),
    - marine biotechnology (for biofuels, bioremediation and bio-products),
    - green engineering (for ecological restoration and damage prevention),
    - doubling of aquaculture value (mentioned under 6.2.2), and
    - increasing market value of wild fisheries through sustainable harvest practices
- These important issues are not covered under Environment and Natural Resource Management. Articulation of these Emerging Directions would reinforce Current and Emerging Capability Needs i.e. sustaining and expanding the integrated marine observing system including coastal and estuarine systems, national coastal and ocean modelling system, research vessel utilisation, national marine baselines and long-term monitoring, and coordinated national studies on marine ecosystem processes and resilience.
- 9.1 – Marine biosecurity is a significant issue for Australia as an island nation. Aquaculture and fisheries biosecurity are noted in this section, but marine biosecurity issues are much broader than this. They include marine pests and invasive species which have both environmental impact and economic impact on marine industries such as ports and shipping. Use of new genomic technologies in early warning systems for marine pests and invasive species is an emerging capability need.

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

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

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?

- As noted under Question 1, it is not clear why eResearch capability has been split across the Underpinning Research Infrastructure Capability Area and a seventh Capability Area called Data for Research and Discoverability. We agree with the recommendation of the eResearch Review conducted by Rhys Francis that data and compute should be considered as an integrated package.
- We see some risk in again separating 'Data for Research and Discoverability'. This supports a paradigm that continues to see investment in research data as an added extra, that it is someone else's problem. We see data for research and discoverability as core business for any contemporary national research infrastructure. For the last decade, IMOS has been clearly focused on establishing a marine research data infrastructure through the Australian Ocean Data Network (AODN). It is true that there are many legacy research datasets across the Australian research landscape that would benefit from being made discoverable. However we feel strongly that there is 'no excuse for creating tomorrow's legacy today'. All newly created research data should be discoverable and accessible, and investment in legacy datasets should be targeted towards areas where the socio-economic benefits generated by open access will be greatest. This approach ensures that Australian Government funded research infrastructures create data once that can be used many times. It avoids the problem of Australian Government effectively paying for the same data multiple times.
- Inclusion of neutron and x-ray scattering, geospatial systems and digitisation as Underpinning Research Infrastructure seems somewhat idiosyncratic i.e. why these things, and not others? Perhaps they would be better included as part of the portfolio of capabilities required by the other Capability Areas where relevant.

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

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

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?

- See Question 30.

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

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?

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.