Please note: the substantive content of the 2026 NRI Roadmap Survey begins at Question 20 (with prior questions dealing with administrative and other information).

As such all submissions that are published include the responses submitted from Question 20 onwards only.

Q20.

Part 2: Research themes

2.1 NRI comprises the assets, facilities and associated expertise to support leading-edge research and innovation in Australia and is accessible to publicly and privately funded users across Australia and internationally. We are seeking your input on possible directions for future national-level investment - i.e., where the requirements are of such scale and importance that national-level collaboration and coordination are essential.

The 2021 Roadmap used a challenge framework to support NRI planning and investment. With this in mind, consider likely future research trends in the next 5 - 10 years, and with respect to one or more of the 8 challenge areas identified in the 2021 Roadmap as listed below:

- describe emerging research directions and the associated critical research infrastructure requirements that are either not currently available at all, or not at sufficient scale and
- describe current national infrastructure requirements that you anticipate will no longer fit the definition of NRI in 5-10 years.

Do not limit your commentary to NCRIS funded capabilities.

Q21.

Resources Technology and Critical Minerals Processing

Q22.

Food and Beverage

Q23.
Medical Products

Q24.
Defence

Q25.
Recycling and Clean Energy

Q26.
Space

Q27.
Environment and Climate

The CSIRO Marine National Facility (MNF), including the Research Vessel (RV) Investigator, provides Australia's only dedicated blue-water research vessel, delivering multipurpose and critical blue-water research infrastructure which supports our ability to gather data to ensure policies are grounded in scientific evidence. Critical Research Infrastructure Requirements: 1. Environmental Baselines to Inform State of the Environment: • Closing gaps in observing systems, a critical issue for observation data. Caused by limited fixed infrastructure and research vessel capability/availability. • Funding of Industry-leading blue-water research vessels for full-year operations to close the gap. Only 35% of Australia's marine estate are surveyed, with a goal of 100% by 2030 set. 2. Atmospheric and Oceanographic Data from the Southern Ocean: Sustained research efforts, including the RV Investigator, unmanned vehicles, deep-water moorings, and sensor networks, are essential for monitoring this major carbon sink, which absorbs ~40% of global ocean uptake. Understanding its function is critical for climate change mitigation and ocean process research. • Improved ability to monitor long-term impacts of anthropogenic changes in our oceans. 3. Cutting-Edge Research Systems: • Combining research vessel infrastructure with autonomous systems to enhance data collection efficiency and reduce carbon footprints. • Autonomous operations between mainland and Antarctica, supporting traditional research vessel data delivery. • Interoperable systems capable of transfer between vessels, reducing costs and increasing usage. • Precision Extraction Methods/techniques to minimise environmental impact, e.g. remotely operated vehicles and eDNA collection. • Innovation platforms for early testing and adoption of new technologies, with potential for commercialisation. 4. Greening Research Infrastructure to Transition to Net Zero: • Establishing baseline data for key infrastructure. • Utilising autonomous systems and increased underway observations to reduce the data collection carbon footprint. • Exploring short- to medium-term gains in carbon emissions through operational efficiencies. • Long-term transition to new fuel technologies for research vessels, requiring significant funding. • Developing smarter, greener infrastructure to conduct science alongside existing technology. • Creating a roadmap to achieve realisation of greener research vessels, first in coastal research vessels as a technology precursor to larger research vessels. 5. Integration of National Research Assets: • Linking and coordinating various research facilities, datasets, expertise, and funding sources. 6. Data dissemination: • Networked Data Sets to support national and global decision-making and policy development. • Ensuring publicly available data sets are findable, accessible, interoperable, and reusable (FAIR). All current national infrastructure requirements will continue to fit the definition of NRI

Q28.

Frontier Technologies and Modern Manufacturing

Q29.

2.2 The 2024 statement of National Science and Research Priorities (NSRPs) includes outcomes linked to each priority to assist in identifying critical research needed in the next 5 to 10 years.
Consider the priority statements and, with respect to one or more of the 5 priority areas as listed below:

- describe emerging research directions and the associated critical research infrastructure requirements that are either not currently available at all, or
- not at sufficient scale and describe current national infrastructure requirements that you anticipate will no longer fit the definition of NRI in 5-10 years.

Do not limit your commentary to NCRIS funded capabilities, and where relevant, refer to the underpinning outcomes and research identified in the NSRPs document.

Q30.

Transitioning to a net zero future

Emerging research directions in climate modelling, biodiversity, and ecosystem management are crucial to underpin policy initiatives. Climate mitigation technologies are essential for assisting Australia's transition to net-zero, and the Marine National Facility (MNF) plays a significant role in supporting this transition. By building the necessary research capabilities and infrastructure today, we can accelerate the deployment of both offshore renewables and carbon capture and storage (CCS) technologies to support the transition to net-zero, both efficiently and environmentally responsibly. Key Infrastructure Requirements: 1. Dedicated Blue-Water Research Vessels: o Fully funded, industry-leading blue-water research vessels are essential tools as the world transitions to net-zero emissions. These vessels support emerging research in offshore geoscience datasets and national assessments for potential offshore geological storage and offshore renewables. o Offshore renewable energy, such as wind and tidal power, requires specialised, comprehensive geoscience data delivered by assets like RV Investigator. This data is crucial for identifying suitable sites, optimising resource potential, minimising environmental impacts, and ensuring cost-effective deployment. 2. Offshore Geological CCS: o Specialised infrastructure, such as RV Investigator, are enablers of offshore geological CCS with the provision of foundational geoscience datasets. These provide critical information regarding characteristics of potential storage sites. o The delivery of datasets and national assessments is crucial for informed decision-making, policy development, and regulatory frameworks to guide offshore energy projects and CCS initiatives as outlined in the $3.4b "Resourcing Australia's Prosperity" initiative. 3. Net-Zero Transition Efforts: o As part of the net-zero transition, infrastructure to help reduce emissions, ensure energy security, and support sustainable development. o Dedicated research undertaken on RV Investigator aims to enhance our understanding of new approaches to sequester carbon in the ocean for long periods. By investing in these critical research infrastructure requirements, it ensures that Australia is well-equipped to meet the challenges of climate change and transition to a sustainable, net-zero future. All current national infrastructure requirements will continue to fit the definition of NRI in 5-10 years.

Q31.

Supporting healthy and thriving communities

Working with Traditional Owners (TO) on access to Sea Country is pivotal for upholding Indigenous rights, preserving cultural practices, demonstrating cultural respect, relationship building, effective collaboration, inclusive approaches to process development, and ensuring sustainable marine management. Emerging research directions include the exploration of submerged landscapes to provide historical context and maintain the connection to Sea Country for TO. RV Investigator offers unique opportunities for engagement with TO and the identification of submerged Indigenous landscapes. Key priorities not at sufficient scale include: 1. Engagement with Traditional Owners: RV Investigator provide opportunities to engage with TO of Sea Country in the discovery of submerged Indigenous landscapes. Exploring submerged Indigenous landscapes is a key aspect of ensuring an enduring connection to the past. Research activities require a mix of advanced archaeological, geological, and remote sensing techniques, supported by critical research infrastructure provided by the MNF. Key areas requiring further capability include: 2. Remote Sensing & Geophysical Survey: o Multibeam Sonar: for the mapping of underwater terrain in high resolution to identify potential human-made structures. o Side-Scan Sonar: to Produce detailed images of the seabed to detect anomalies like ancient settlements or artifacts. o Sub-Bottom Profiling: to penetrate layers of sediment to locate buried structures. 3. Marine Archaeology: o Underwater Excavation: Using remotely operated vehicles (ROVs) to carefully excavate sites. o Photogrammetry & 3D Mapping: Capturing images of underwater artifacts and landscapes to create digital reconstructions. o Dredging & Core Sampling: Extracting sediment layers to analyse environmental changes and human activity. 4. Paleoenvironmental & Geological Analysis: o Sediment Analysis: Examining cores for pollen, charcoal, and organic material to reconstruct past environments. 5. Indigenous Knowledge & Collaboration: o Oral Histories & Traditions: Indigenous knowledge provides insights into places that were once above water. o Community-Led Research: Partnering with Indigenous groups ensures respectful exploration and interpretation of findings. 6. ROVs & AUVs (Remotely Operated & Autonomous Underwater Vehicles): o ROVs: Used for precise exploration in deeper waters. o AUVs: Autonomous drones that scan large underwater areas with sonar and cameras. There are no current national infrastructure requirements that we anticipate will no longer fit the definition of NRI in 5-10 years.

Q32.

Elevating Aboriginal and Torres Strait Islanders knowledge systems

Q33.

Protecting and restoring Australia’s environment

Emerging research directions in protecting and restoring Australia's environment focus on marine estate protection of Australian Marine Parks and biodiversity and ecosystem studies. Marine protected areas help protect key habitats and representative samples of marine life and supports biodiversity and ecosystem health, ensuring the sustainable management of marine resources for future generations. Biodiversity and Ecosystem studies are increasingly integrating environmental DNA (eDNA) techniques with physical sampling and imaging methods to create a comprehensive picture of ocean biodiversity. Key areas and infrastructure requirements include: 1. Transitional studies to inform technology application: Large area eDNA studies coupled with existing techniques are essential for ensuring new technologies can be applied with confidence to detect and monitor species presence and distribution in marine environments. 2. Physical Sampling and Imaging: Combining eDNA with physical sampling and imaging methods provides a more complete understanding of marine biodiversity and ensures transition to the new technology is a robust process. 3. Support for eDNA Activities: Establishing extensive reference DNA libraries is crucial for identifying species from eDNA samples. These libraries enhance the accuracy and reliability of biodiversity monitoring assessments. 4. Machine Learning Applications: Creating reference imaging datasets supports the development of machine learning applications for visual imagery. These applications can automate the identification and monitoring of marine species and habitats. 5. Leveraging eDNA and Imaging: Utilising eDNA and imaging methods for biosecurity purposes helps in early detection of invasive species and monitoring of biosecurity threats. This proactive approach is vital for protecting marine ecosystems. By addressing these critical research infrastructure requirements, we can enhance our ability to protect and restore Australia's marine environment.

Q34.

Building a secure and resilient nation

Building a Secure and Resilient Nation: Emerging research directions aimed at building a secure and resilient nation focus on establishing baseline data to support the definition of Australia's Exclusive Economic Zone (EEZ). This is crucial for national security, resource management, and environmental protection. Key areas and infrastructure requirements include: 1. Baseline Data Collection: o Comprehensive Surveys: Conducting extensive marine surveys to gather baseline data on the physical, biological, and geological characteristics of Australia's EEZ. This data is essential for informed decision-making and policy development in areas such as sustainable fisheries and resource management, energy and resource management and environmental protection and conservation. o Advanced Technologies: Utilising advanced technologies such as multibeam sonar, satellite remote sensing and autonomous vehicles, coupled with calibration via in situ sampling, to collect high-resolution data at scale across vast ocean areas. 2. Data Integration and Management: o Centralised Networked Data Sets: Fully networked, centralised data sets to support national and global decision-making and policy development. o FAIR Principles: Ensuring publicly available data sets are findable, accessible, interoperable, and reusable (FAIR). These repositories should be accessible to researchers, policymakers, and other stakeholders. o Interoperable Systems: Developing interoperable systems that allow seamless integration and sharing of data across different platforms and institutions. 3. Collaborative Research Efforts: o National and International Partnerships: Fostering collaborations between national and international research institutions to enhance data collection and analysis capabilities. These partnerships can leverage shared resources and expertise. o Indigenous Knowledge Integration: Incorporating Indigenous knowledge and perspectives into research efforts to ensure a holistic understanding of the marine environment. 4. Policy and Regulatory Support: o Informed Policy Development: Using the baseline data to inform policy development and regulatory frameworks that govern the use and protection of Australia's EEZ. This includes resource management, environmental conservation, and national security measures. o Adaptive Management Strategies: Implementing adaptive management strategies that can respond to new data and changing conditions in the marine environment. By addressing these critical research infrastructure requirements, Australia can build a secure and resilient nation. This approach ensures the sustainable management of marine resources, enhances national security, and protects the marine environment for future generations.

Q35.

2.3 The case for a new NRI capability, or enhancements to existing capabilities, typically emerges through advocacy from research communities clustering around rigorously identified needs and goals. Such a concept could respond to a requirement for novel or expanded capacity within a domain, or across domains, and must be such that it could only be made available with national-level investment.

If you have identified such a requirement, briefly describe the need, the proposed infrastructure capability, the medium-term goals, impacted research communities, and the timeframe over which you advocate its establishment. Your response can include links to relevant existing reports.

In situ ocean observing is limited by the ability to make comprehensive observations due to remoteness, and the sheer scale of the ocean environment. A significant information gap in the deep ocean and under ice exists, along with the need for improved seabed mapping globally. Many of these challenges will be tackled by the rapid expansion and uptake of unmanned semi-autonomous and autonomous systems, supported by dedicated manned research infrastructure such as RV Investigator and a coastal vessel fleet. Proposed Infrastructure Capability To address the significant challenges posed by the ocean environment and enhance regional and global-scale research, the following infrastructure capabilities are proposed, currently all of which require secure funding and/or a commitment to develop to scale: 1. Development of Autonomous Platforms: Investment in more affordable, modular, capable, and easier-to-maintain autonomous systems. These platforms should be able to operate in various ocean conditions and provide comprehensive data on parameters such as salinity, temperature, nitrate, pressure, oxygen, and biomass. Creative new types of platforms and compact, low-power sensors to expand autonomous observations and augment existing marine research delivery options. 2. Connectivity: Continued expansion of mobile network capabilities and satellite connectivity to ensure reliable communication with Marine Autonomous Vehicles (MAVs), enabling real-time data transmission and remote control. 3. Integration of AI and Machine Learning: Development of the application of AI and machine learning for navigation, collision avoidance, and route optimization. These technologies will help adapt to changing conditions and optimize their operations for maximum efficiency. 4. Support for Research Vessels: Develop pathways for testing and trialling new technologies on existing platforms such as RV Investigator to support the transition to more autonomous operations and extending the reach the autonomous systems can have. Medium-Term Goals To achieve the proposed infrastructure capabilities, the following medium-term goals are proposed: 1. Regulatory Framework: • Overcome regulatory constraints to ensure the safe deployment of MAVs. This includes developing standards and guidelines for the design, operation, and maintenance of autonomous platforms, as well as addressing legal and liability issues. 2. Adoption of Autonomous Vessels: • Increase the use of semi-autonomous and fully autonomous vessels for research projects with funding support for existing dedicated resources within an integrated coastal and blue water research vessel fleet. This will enhance the scope and efficiency of marine research, allowing scientists to collect more data over larger areas and longer periods. • Further development of Remotely operated Unmanned Underwater Vehicles (UUVs, Unmanned Surface Vehicles (USVs), Autonomous Surface Vehicles (ASVs) and Autonomous Underwater Vehicles (AUVs) supported by manned, dedicated platforms such as RV Investigator, will allow more temporal and spatial coverage of measurements through extension of range and near real time control. 3. Hybrid Vessels: • Develop vessels that combine traditional crewed operations with autonomous capabilities to deliver flexible and efficient approach to research, allowing for incorporation of fully autonomous operations. 4. Data Portals: • Link the observing network to data portals that can be accessed by multiple users. This will ensure that the data collected by autonomous platforms is widely available and useful for various research communities, facilitating collaboration and knowledge sharing. Impacted Research Communities The proposed infrastructure capabilities and medium-term goals will impact a wide range of research communities, including: 1. Marine Scientists: Enhanced capabilities for collecting comprehensive oceanographic data will support marine scientists in studying ocean processes, ecosystems, and climate change. 2. Environmental Researchers: Improved data on ocean conditions will aid environmental researchers in understanding and mitigating the impacts of human activities on marine environments. 3. Climate Scientists: Access to more comprehensive and accurate ocean data will help climate scientists model and predict climate change and its effects on global weather patterns. 4. Maritime Security Experts: Autonomous surveillance and patrolling capabilities will support maritime security experts in monitoring and protecting ocean areas from illegal activities. 5. Technology Developers: The development and deployment of advanced autonomous platforms and sensors will provide opportunities for technology developers to innovate and create new solutions for oceanographic research. Timeframe for Establishment The proposed infrastructure capabilities and medium-term goals are to be achieved within the following timeframe: 1. By 2030: Achieve widespread adoption of semi-autonomous vessels, with the necessary infrastructure and regulations in place to support their operation. This will involve significant investment in research and development, as well as collaboration between industry, government, and academia. 2. By 2040: Integrate fully autonomous vessels significantly into the maritime industry, enhancing the efficiency and scope of marine research. This will require continued investment in technology development, as well as efforts to address regulatory and operational challenges. 3. By 2050: Achieve full-scale deployment of MAVs, alongside green research vessels to contribute to net-zero emissions and creating a digitally connected maritime network. Marine science operations require a mix of autonomy and "green" manned research vessels, as there are activities on research vessels that will likely never be replaced. This process will involve the widespread adoption of advanced technologies, and the development of new business models and operational practices.

Q36.

Part 3: Industry perspectives

This section is seeking input specifically from industry-based respondents. Other respondents can skip this section.

Recommendation 6 of the 2021 Roadmap related to improvements in industry engagement with NRI. To complement work on this topic that has occurred since then, we are seeking additional advice on NRI requirements as perceived by current or potential industry-based users.

Q37.

3.1 Have you (or your organisation) interreacted with or used Australia's NRI?

- ○ Yes
- ◉ No

Q38.

3.2 If so, please briefly outline the NRI capabilities you (or your organisation) have interacted with or used. Do not limit your response to NCRIS capabilities.

This question was not displayed to the respondent.

Q39.

3.3 Please indicate your (one or more) primary reasons for interacting with NRI:

This question was not displayed to the respondent.

Q40.

3.4 If you answered no, please indicate your (one or more) primary reasons:

- ☐ I did not know about it
- ☐ Other facilities suit my needs better
- ☐ I would like to, but cannot get access due to geographical location
- ☐ I would like to, but believed that access was only available to academic researchers
- ☐ I am not aware of any capability that meets my needs
- ☐ Other (please specify) [ ]

Q41.

Part 4: Other comments

4.1 Please elaborate on any of your above responses or add any other comments relevant to the development of the 2026 Roadmap. Your response can include reference or links to existing reports that you recommend be considered during the 2026 Roadmap development process.

Q49.

4.2 Optional Document Attachment.

Note: Our strong preference is that answers are provided against the relevant questions in the survey. However, this file upload option is available for submissions in file format, where needed. Please ensure the document includes your name or organisation.