

Research Infrastructure Decadal Plan

2022 - 2032



Science. Ingenuity. Sustainability.

———— ANSTO ————

Research Infrastructure

Decadal Plan

———— 2022 - 2032 ————

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Foreword

The ANSTO research infrastructure portfolio comprises capital investment in the region of AU \$1 billion, more than 350 employees and contractors, and an extensive array of operating systems and procedures that supported more than 8,000 users over the 2019-2021 period. As we enter the second decade of the 21st century and global and domestic challenges are clearly identified, it is essential that the excellence of ANSTO's capabilities is sustained and benefit to the nation remains front of mind.

In the context of nuclear science and technology, there is now a range of nationally significant programs that will be developed over the course of the next ten years. These include the establishment of a national radioactive waste management facility by the Australian Radioactive Waste Authority (ARWA) and the design, build and operation of a new nuclear medicine manufacturing facility at Lucas Heights. The biggest "game changer", however, will be the establishment of a nuclear-powered submarine fleet for the Royal Australian Navy along with all associated technologies and capabilities.

Maximising utilisation, continuous improvement and predictable operation of infrastructure, together with developing expert staff who are focused on research support, is critical to strengthening the science and technology standing of the nation. With a long and successful track record, ANSTO has the demonstrated capability to inform and support long-range planning for future landmark and national capabilities.

To this end, this document is ANSTO's first Research Infrastructure Decadal Plan.

This Decadal Plan was developed in consultation with our staff, users, partners and clients. It considers the environment within which ANSTO, as a Publicly Funded Research Agency (PFRA), operates and was informed by current and emerging science, research, policy, innovation challenges, as well as technology drivers. It is aligned and coincides with the Commonwealth Government's 2021 National Research Infrastructure Roadmap process.

The value of long-term strategic planning of research infrastructure of any scale has been demonstrated for many years. The benefits include planned strategic investment into facilities that enable research across priority areas, predictable funding to sustain operations, and investment in workforce to drive utilisation, impact and benefits.

Much of ANSTO's multi-disciplinary research infrastructure has evolved over many decades in line with changing research drivers and needs inside and outside ANSTO. The Decadal Plan looks towards future development and invites us to keep scanning the horizon for opportunities beyond the next decade. Growing, developing, and improving our research infrastructure happens deliberately and with intent. The Decadal Plan recognises this and seeks to understand the drivers that will spur our growth. It expresses those drivers through priority areas where we need to focus our efforts over the next ten years and allows us to plan our development to achieve sustainable funding.

Our people are core to our infrastructure. The Decadal Plan brings ANSTO's people into focus to support them in growing together across our buildings and campuses, recognises the unique contribution they make, and nurtures their growth and development.

ANSTO's research infrastructure is embedded in Australia's scientific infrastructure framework, including strategic planning of national capabilities and connects us to the world with high visibility. The Decadal Plan sets us on a path to increase this visibility and provides a roadmap for our future growth and development, enabling the ANSTO Vision to be achieved by positioning ANSTO as key to Australia's research and innovation ecosystem.



Dr Miles Apperley

Head of Research Infrastructure
January 2022



Executive summary

Managing and operating research infrastructure has been a core part of ANSTO's purpose for decades. The Research Infrastructure Decadal Plan provides the organisation with a ten-year outlook for the portfolio. It has been informed by ANSTO's mission, research and business needs, as well as those of the Australian research community, industry and government. It will guide process improvements, prioritising of resources and investment choices for the coming years.

ANSTO's core purpose is stipulated by the *ANSTO Act* and the Minister's Statement of Expectations. The ANSTO Strategy has formulated these into three strategic imperatives around research and research infrastructure, commercial products and services, and the organisation's role as a trusted advisor to Government. The services and expertise held within the research infrastructure portfolio underpin all of ANSTO's strategic imperatives.

ANSTO's research portfolio centres around three core themes: health, environment, and the nuclear fuel cycle, as well as a strategic program to deliver research and engineering solutions for the management of nuclear waste forms (ANSTO Synroc® technologies). The work undertaken in each of these areas challenges ANSTO's research infrastructure to constantly improve performance and evolve capabilities.

The diversity of ANSTO's portfolio of research infrastructure is unmatched in Australia and offers unique capabilities and opportunities to the nation's industries. Industry may access ANSTO's research infrastructure directly via commercial service channels or through the merit-based general user access programs, in collaboration with academia.

The concept of Institutional, National and Landmark infrastructure is described in [Section 2.2.8](#), and the figure to the right shows how these categories apply to ANSTO's facilities.

ANSTO currently has eight research infrastructure Platforms:

Landmark

Australian Synchrotron

Australian Centre for Neutron Scattering

National

Centre for Accelerator Science

National Deuteration Facility

Nuclear Stewardship

Institutional

Biosciences

Isotope Tracing in Natural Systems

Nuclear Materials Development and Characterisation

The Platforms and their specific capability offerings are described highlighting the differences in user numbers, user base and throughput between Institutional, National, and Landmark infrastructure Platforms. The case studies provided in this Plan showcase some of the impacts of each Platform.

Collectively, ANSTO's research infrastructure:

enables extended longitudinal studies over multiple decades

provides capabilities that target specific scientific challenges

represents capabilities that are applied across many fields of research

is generally openly accessible

is Australia's leading capability provider in terms of sensitivity and accuracy for some techniques

may be the only provider of a particular capability in Australia

maintains sovereign capabilities for nuclear security science and translational nuclear research

undertakes activities for the national benefit and addresses sovereign needs (e.g. nuclear technologies and engineering, isotope development, nuclear waste forms, radioactive waste management)

is best placed to operate some capabilities highly relevant to industry, and

is connected to global networks.

The User Experience concept arises from the nexus of four characteristics of research infrastructure: instruments and facilities, people, research, and business plans and systems. Within ANSTO, the users of facilities are scientists within the Research Themes but can also be instrument or beamline scientists within the Platforms. Requests for support from ANSTO engineering and operational staff across Nuclear Operations and Commercial Products and Services also count as users. External to ANSTO, universities, businesses, and Government, are the major beneficiaries of the services and capabilities of the Platforms. Users can be individuals or organisations.

The diversity of the user population, and the variety of services they require, means the experience of a user utilising ANSTO facilities needs to be equally diverse.

Given the scale and scope of ANSTO's facilities, strategic planning is required to ensure they are sustainable, remain cutting edge, and enable world-class research outcomes with impact and benefit. This planning needs to be informed by scientific and research drivers, as well as the advances in techniques and technology that are revealed by both internal and external users of ANSTO facilities through stakeholder consultation.

Two anonymous surveys were used to capture a range of views about the Research Infrastructure portfolio and to inform the development of this Plan.

The first survey was distributed internally at ANSTO, and included all staff in Platforms and Themes, as well as operational support functions. It was also sent to key representatives of relevant ANSTO Businesses and Nuclear Operations.

The second survey was sent to external users and stakeholders. While the topics addressed were similar in both surveys, the individual questions were not identical. The external survey was informed by the results of the internal survey, particularly the large number of written comments that staff submitted. The external survey attracted over 800 responses, primarily from Australian Synchrotron (AS) and Australian Centre for Neutron Scattering (ACNS) users, with around 75% of the responses from universities.

Analysis of the surveys elucidated comments and responses in connection with the following themes: networks and collaborations; people, staff, and skills; research and science drivers; technology drivers and opportunities for renewal and investment; user experience and outreach; communicating impact and relevance; industry and commercial engagement; and policy drivers.

The findings of the internal and external consultations were combined with the views and opinions of Platform and Research Theme staff to formulate a working list of common priorities. These were distilled into a final list during a workshop involving experienced Platform staff members and the Nuclear Science and Technology (NST) Leadership. The workshop and subsequent meetings of the Working Group developed a range of detailed initiatives for each priority, which together form the heart of the Decadal Plan. These initiatives will inform the development of the research infrastructure portfolio over the next ten years.

As a result of the consultation and workshop process, six Priority Areas were identified:

PRIORITY 1	World-class infrastructure delivering excellent outcomes Maintain, expand, and improve current capabilities to ensure ANSTO continues to provide excellent outcomes with high impact 
PRIORITY 2	Operational effectiveness Improve and optimise the way ANSTO operates and manages its research infrastructure 
PRIORITY 3	Next-generation research infrastructure Plan for critical research infrastructure and emerging technology areas at the national scale to deliver sovereign capability and ANSTO's core mission into the future 
PRIORITY 4	Skilled, productive and engaged people Support and enable a highly-skilled workforce, working together as one community towards common objectives 
PRIORITY 5	ANSTO user experience Deliver improvements to the ANSTO User Experience and ensure excellent outcomes with high impact 
PRIORITY 6	Partnerships that leverage ANSTO's expertise and infrastructure Identify, select, and foster research infrastructure partnerships that deliver on ANSTO's vision 

For each Priority Area, a set of Objectives was identified, as well as Key Initiatives. The initiatives describe activities to address specific or collective feedback or opportunities identified through the consultation process. Some of the Initiatives cut across the Platforms, while others may be relevant to, and implemented within selected Platforms. There are a small number of Key Initiatives that address well-understood future needs within the National or Landmark Platforms.

With the development of this strategic outlook, there is now a responsibility and accountability to implement the Decadal Plan and ensure its impact is aligned with ANSTO's vision and purpose over the next ten years. To support effective prioritisation and implementation, the Key Initiatives within each Objective have been grouped under three time horizons: 1-2 years, 5 years and 10 years.

The Decadal Plan will be a living document. A framework incorporating planning, action and review stages has been developed to support implementation and to identify where primary responsibility for delivery rests. An annual review and integration into business planning at the NST level will be a key success factor for effective implementation. An in-depth review at the five and ten year periods will allow recalibration with contemporary science, research, policy, and innovation challenges, as well as technical drivers. These reviews are timed to coincide with strategic research infrastructure planning that is performed by Government at the national level through the National Research Infrastructure Roadmap process. Key communication activities associated with these milestones will support ongoing awareness of the Decadal Plan and achievements across ANSTO.

Introduction

2.1 The need for a Decadal Plan

ANSTO is the custodian of Australia's nuclear science, technology, and engineering capabilities and expertise, including significant research infrastructure assets and a highly-skilled and dedicated workforce. The organisation has a mandate to provide expert and technical advice to Government on all matters relating to nuclear science, technology, and engineering. ANSTO also must ensure the research infrastructure enables national prosperity and growth by supporting excellent science and innovation outcomes with impact that benefits Australia.

Compared to other national research infrastructure, ANSTO's portfolio is diverse not only in relation to the fields of research in which it is applied but also in the manner in which it operates, the breadth of its user base, and its role in supporting ANSTO operations and business.

Managing and operating research infrastructure is central to ANSTO's purpose. The ANSTO Research Infrastructure Decadal Plan provides the organisation with a ten-year outlook for the portfolio that has been informed by ANSTO's mission research and business needs, as well as those of the Australian research community, industry, and Government.

The Decadal Plan:

- identifies Priority Areas and sets Objectives for the next decade
- outlines Key Initiatives to achieve these Objectives and Priorities, and
- includes a framework for its implementation and review to ensure it remains a contemporary strategic planning resource over the next ten years.

The Decadal Plan was informed by ANSTO staff, external users from universities, industry, and Government agencies. It supports the development of world-class landmark, national and institutional capabilities to meet evolving and emerging needs, and to enable world-class translational research and innovation that creates economic impacts and benefits.

Looking ahead and understanding priorities enables planning of investment, strengthening of partnerships, and ensuring ANSTO's research infrastructure remains focused on delivering an excellent User Experience. With a clear understanding of priorities, ANSTO will be prepared to leverage the most relevant opportunities as they arise. In relation to workforce development, the Decadal Plan will inform initiatives to refresh and broaden ANSTO's workforce as necessary to meet the challenges of the future and to maintain a reputation as a provider of world-class research infrastructure and services.

A guiding principle for the Decadal Plan is to further strengthen our agility and responsiveness to future changes in the global research landscape. The Decadal Plan, with its six priority areas, underpinning objectives and key initiatives, was developed to deliver this outcome.

2.2 Strategic context

In developing the Decadal Plan, a range of internal and external factors such as ANSTO's legislative mandate, current corporate strategy, and priorities and initiatives of Government were taken into consideration.

2.2.1 ANSTO Vision

Nuclear science and technology for the benefit of all Australians.

ANSTO's Vision, Strategy and activities are defined in the Corporate Plan. The ANSTO Strategy, developed in late 2020, dictates how ANSTO will achieve its purpose (Figure 2.1), meets its obligations under the *ANSTO Act* and addresses the Minister's expectations.

The first Strategic Imperative emphasises the importance of ANSTO's research infrastructure within the organisation's Vision – *To conduct research and enable external use of our research capability and infrastructure for the national benefit.*

The objective, to *operate world-class research infrastructure and leverage capabilities to support discovery and translational research that delivers real-life benefits and impact*, further frames a high-level goal of ANSTO's Research Infrastructure portfolio. The skills of staff and capabilities within the portfolio also underpin the second and third Strategic Imperatives for ANSTO to deliver commercial products and services and provide trusted advice to Government. The Research Infrastructure portfolio's staff are key providers of training for the next-generation of Australia's nuclear science and technology workforce.

OUR STRATEGIC IMPERATIVES

These focus our activities, ensuring they are aligned with our purpose, the priorities of Government, and the expectations of our Minister

1. Research and infrastructure

To conduct research and enable external use of our research capability and infrastructure for the national benefit

Deliver and translate research that has specific and industry impact, with a focus on health, the environment and the nuclear fuel cycle

Form strategic partnerships and collaborations to leverage more effective research outcomes for Australia and the world

Operate world-class research infrastructure, and leverage capabilities to support translational research that delivers real-life benefits and impact

2. Commercial products and services

To provide nuclear medicines and commercial services for the benefit of Australia and the world

Ensure the reliable and sustainable supply of nuclear medicines, products and services

Develop and produce new radioisotopes through working collaboratively with partners using our nuclear-related expertise

Use knowledge incubation, research translation, collaboration and connectivity within the Innovation Precinct to produce real-world benefits

3. Expert and trusted advisor

To be an expert and trusted advisor to Government, industry, international partners and the Australian public

Deliver expert advice to Local, State and Federal Governments and related stakeholders in support of organisational and national interests

Participate in global and regional nuclear discussions to ensure that Australia remains a leader in the applications of nuclear science and technology

Grow a more informed generation of Australians who understand the benefits of nuclear science and technology

OUR ENABLING OBJECTIVES

These are vital in delivering our Strategic Imperatives

To mobilise and develop the nuclear science and technology workforce of the future

Train and develop the next generation of specialised nuclear professionals

Provide an inclusive environment that empowers our people and supports a culture of collaboration and engagement

To ensure the ongoing financial and operational sustainability of ANSTO

Ensure a highly reliable, safe and secure environment

Ensure ANSTO operates sustainably

Figure 2.1:

ANSTO Strategy (2020).

2.2.2 ANSTO Act and Minister's Statement of Expectations

ANSTO's purpose is derived from Section 5 of the *Australian Nuclear Science and Technology Organisation Act 1987* (Cth) (the *ANSTO Act*), which highlights the core functions it undertakes for the benefit of Australia:

- conduct research and development in relation to nuclear science, engineering, and technology
- produce and use radioisotopes, isotopic techniques and nuclear radiation for medicine, science, industry, commerce and agriculture
- encourage and facilitate the application and use of the results from research and development
- manage radioactive materials and waste arising from various prescribed activities
- provide goods and services related to core activities
- provide advice to Government and liaise with other countries on behalf of Australia in nuclear-related matters
- make available to other persons whether or not on a commercial basis, the knowledge, expertise, equipment, facilities, resources and property of the organisation for the purposes of scientific research, innovation and training
- publish scientific and technical reports, periodicals and papers, and provide public information and advice, and
- facilitate education and training in nuclear science and technology, including through granting scientific research studentships and fellowships, in cooperation with universities, professional bodies and other education and research institutions.

ANSTO is an agency within the Federal Government's Industry, Science, Energy and Resources portfolio. On a regular basis, the Minister issues a Statement of Expectations outlining the Government's expectations of ANSTO, including the important contributions ANSTO can make to national priorities and to support the health of Australians through nuclear medicine production. The most recent Statement of Expectations (at time of writing) was received 13 February 2020, from the then Minister for Industry, Science and Technology, the Hon Karen Andrews MP.

The Statement of Expectations is largely aligned with ANSTO's functions under the Act but also includes specific areas that Government wishes the organisation to engage in, such as: resolving national challenges; working collaboratively to advance Australian industry; managing research infrastructure and national facilities; embracing the digital economy; and achieving STEM equity.

2.2.3 ANSTO research

ANSTO's research and research infrastructure delivers national benefit through research and development activities that have public benefit, maintain sovereign capability and deliver ANSTO business outcomes. ANSTO's research and business needs have driven its research infrastructure capability development in the past and will continue to be an important driver in the future.



Human Health investigates biological processes that lead to the development of treatments for disease, strategies to reduce the risk of disease, and the development of more effective treatments. Key areas of focus include:

- advancing the understanding of the effect of radiation on biological systems in a variety of contexts, including in space, in order to improve the prevention, diagnosis, treatment, and monitoring of disease
- identifying, quantifying, and monitoring the mechanisms which cause, or influence the development and progression of disease, and translating this research into precision diagnostics and evidence-based treatments ('translational research'), and
- improving nuclear technology-based therapy outcomes, especially for hard-to-treat cancers, through theranostics and the use of proton therapy, heavy ion therapy, and microbeam/mini-beam radiotherapy.



Environment undertakes interdisciplinary environmental research using nuclear and isotopic techniques to fill data and knowledge gaps, to inform sustainable management strategies, and to increase Australia's capacity to respond to modern environmental challenges. Key areas of focus include:

- improving and contributing to the sustainable management of water resources in Australia
- identifying, quantifying, and monitoring the scale and speed of human impacts on the natural environment and climate change, and
- advancing knowledge of the pathways and impacts of contaminants upon animals, plants, and the broader environment.

ANSTO's research portfolio has three core themes: Health, Environment, and the Nuclear Fuel Cycle, as well as a strategic program to deliver research and engineering solutions for the management of nuclear waste forms (ANSTO Synroc® Technologies). The work undertaken in each of these themes challenges research infrastructure to constantly improve performance and evolve capabilities to meet research demand.



Nuclear fuel cycle research ranges from the mining of uranium to the disposal of radioactive waste. ANSTO has unique capabilities and expertise in radioactive waste management, theoretical predictions of fuel properties, and modelling of the impacts of radiation on materials. Key areas of focus include:

- developing improved fuels for advanced reactor designs
- investigating materials for use in nuclear applications and the effects of irradiation, corrosion and high temperature on their structural properties
- advancing understanding of the management of spent fuel and associated waste forms, including ANSTO Synroc® technology, and
- providing support for the lifetime management of the OPAL reactor.



ANSTO Synroc® Technologies undertakes world class research and development to create innovative waste form and engineering waste treatment solutions. Key focus areas include:

- demonstrating ANSTO Synroc® Technologies for ANSTO site waste, as part of global best practice in direct disposal and termination of nuclear waste
- extracting commercial value and delivering impact from the program's intellectual capital, and
- developing a highly-skilled and motivated team for the delivery of specialised nuclear projects.

The research portfolio also includes projects within the Platforms that are focused on capability development relevant to the Platform, for example, the establishment of in-air radiobiological beamlines or novel methods to produce radioisotopes for environmental and nuclear medicine research. In some instances, this also extends to strategic projects within the Platforms

focused on particular research areas, such as X-ray imaging and therapy; food materials science; cultural heritage; functional materials for energy systems and devices; and magnetic and superconducting materials.



2.2.4 ANSTO operations and business

ANSTO's businesses provide a range of commercial products and services, including nuclear medicines, irradiation of silicon, radiation training and calibration services, detection technologies, minerals research and development, and waste management. ANSTO manufactures nuclear medicines that are essential for the diagnosis of a wide range of cancers, in addition to heart, brain, bone, lung, and endocrine diseases. Therapeutic nuclear medicine products give vital options to Australian clinicians in their approach to the treatment of many cancers.

The reliable and predictable operation of the OPAL multi-purpose reactor is essential for the supply of ANSTO's nuclear medicine products and delivery of other commercial services.

The reactor also supports research through the supply of neutrons to the instruments at the Australian Centre for Neutron Scattering. Research infrastructure unique to ANSTO is used to support the surveillance testing of reactor materials, a function that is essential to the continued safe operation of OPAL. The capabilities are also crucial for trouble shooting and developing solutions to operational and production issues and ongoing process improvement. Research infrastructure capabilities associated with environmental assessment and monitoring demonstrate ANSTO's compliance with conditions for the operation and management of legacy sites, as set by the Australian Radiation Protection and Nuclear Safety Agency and other regulatory agencies.



2.2.5 Australian research sector and AINSE

ANSTO has strong ties with the Australian research sector, in particular with academia through the Australian Institute of Nuclear Science and Engineering (AINSE). For over 60 years, AINSE has played a role in promoting research partnerships between ANSTO and universities and industry members across Australia and New Zealand.

AINSE aims to foster scientific advancement and effective collaboration between AINSE member universities and ANSTO. It offers a range of programs and services to its members, including conference support, symposiums, scholarships for honours and postgraduate students and early career researchers, and intensive undergraduate education schools.

ANSTO staff work closely with AINSE scholars, providing professional training, in addition to access to research infrastructure and capabilities.

Beyond the relationship with AINSE, ANSTO undertakes Strategic Partnership Agreements with universities where there is alignment with ANSTO's mission-based research themes. Jointly funded staff appointments between ANSTO and Australian universities have also strengthened relationships, creating opportunities for more targeted research and industry usage.

2.2.6 Australian industry

The diversity of ANSTO's portfolio of research infrastructure is unmatched in Australia and offers unique capabilities and opportunities to the nation's industries. Industry usage of ANSTO's research infrastructure covers multiple Technology Readiness Levels (TRLs), including new materials research and development, product development, testing and verification of manufactured products, and troubleshooting investigations of processing issues.

In addition to the broad range of industry-relevant applications of the existing Platforms, most infrastructure upgrade projects consider and include additional industry benefits. Examples are the new beamlines being constructed by the Australian Synchrotron Project BRIGHT program, a new

additive manufacturing capability for *in-situ* neutron scattering measurements at the Australian Centre for Neutron Scattering, and the external beam irradiation capability being commissioned at the Centre for Accelerator Science.

Direct industry access to research infrastructure Platforms takes place through commercial service channels that run in parallel to the merit-based general user access programs. The industry footprint extends beyond these direct client-based interactions. Many academic users have industry connections of their own and carry out research for these companies. Using ANSTO's research infrastructure benefits their partnerships and significantly increases industry utilisation of ANSTO research infrastructure.



2.2.7 Government priorities, policies, and initiatives

The Commonwealth Government has an extensive range of policies and associated initiatives that have relevance not only to ANSTO but also to academia and industry – the two largest groups that make up external users of ANSTO capability. Current Government priorities in these areas were considered in consultation with internal and external stakeholders.

Australia needs science and research to increase productivity, achieve sustainable economic growth, create jobs, and improve national well-being. Australian science also contributes to the global stock of knowledge across a broad range of areas. The national capacity to support research is finite. With diverse investments in research across multiple agencies and many processes, Australia ensures that capacity to pursue research of particular importance to the nation is achieved.

The current Science and Research Priorities as defined by Government are designed to increase investment in areas of immediate and critical importance to Australia and its place in the world. These Priorities are: *Food; Soil and Water; Transport; Cybersecurity; Energy; Resources; Advanced Manufacturing; Environmental Change and Health.*

In addition to these identified science-related priorities, Government also has policies and initiatives with the potential to influence how science and research investment in Australia is prioritised. These include: Modern Manufacturing Initiative including sovereign manufacturing capabilities; climate change; energy production and emissions reduction; medical technologies and pharmaceutical production; space industry; food and agribusiness; and radioactive waste management.

2.2.8 Strategic planning of national research infrastructure

The value of long-term strategic planning of research infrastructure of any scale by Government has been demonstrated for many years. The benefits include planned strategic investment into facilities that enable research into priority areas, as well as predictable funding to sustain operations and investment in workforce to drive utilisation, impact, and benefits.

Since 2006, the Federal Government has used research infrastructure roadmaps to identify and prioritise investments in national facilities for Australia. Prior to that, and originating in the 1990s, the Major National Research Facility program provided a level of national planning. National research infrastructure comprises the nationally significant assets, facilities, and services to support leading-edge research and innovation. It is accessible to publicly and privately funded users across Australia, and internationally.¹

As strategic planning in national research infrastructure has matured over successive roadmaps, the national research infrastructure system has been more fully characterised and can be considered to comprise research infrastructure that is:

1. Institutional – a foundation layer that is focused within organisations and operates as platforms at a smaller scale. Often, they can be the precursor to the formation of national networks. An example within ANSTO would be the Biosciences Platform.

2. National – optimises the use of scarce resources to create scale and can either be highly networked facilities geographically distributed or located at a single site. They are characterised by serving cross disciplinary user communities, supported by the

best highly-skilled technical workforce and represent national best practice. Examples from ANSTO include the National Deuterium Facility and the Centre for Accelerator Science.

3. Landmark – of a scale that the national interest is best served by a single-sited, multi-decadal facility, which operates for the benefit of the entire Australian research community. Examples include the Australian Centre for Neutron Scattering associated with OPAL and the Australian Synchrotron.

4. Global – is multinational, collaborative and of a scale where the cost of establishment is beyond the resources or expertise of a single nation. Access to international facilities is vitally important in the Australian context, as it fosters collaboration and provides access to infrastructure that might not otherwise be available. An example where Australia is leading such a facility is the Square Kilometre Array (SKA), and instances where Australia participates as an affiliate, include CERN and ITER.

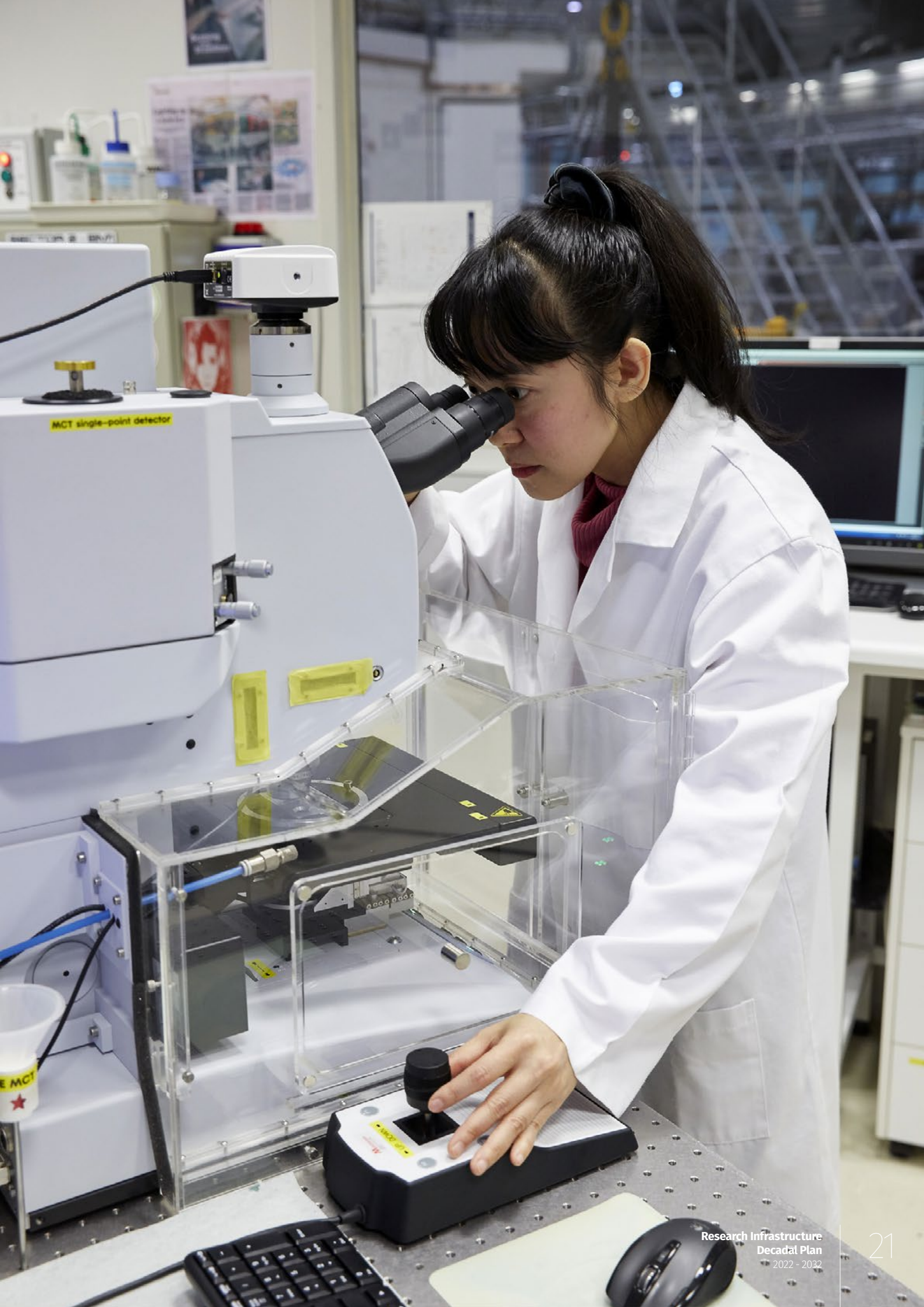
As custodian of a large portfolio of research infrastructure for Australia, ANSTO has facilities and relationships spanning all four categories and is consistently included in the National Research Infrastructure Roadmap. Given the scale and scope of facilities and the need to ensure they are sustainable, remain cutting-edge and enable world-class research outcomes, impact and benefit, strategic planning is required. This planning needs to be informed by scientific and research drivers, as well as the advances in techniques and technology that are revealed by both internal and external users of ANSTO facilities through stakeholder consultation.



Figure 2.2:

Categories of research infrastructure as defined in the 2016 National Research Infrastructure Roadmap.

1. 2016 National Research Infrastructure Roadmap



ANSTO's research infrastructure portfolio

3.1 Overview

The existing operating model of the Nuclear Science and Technology (NST) group at ANSTO is based on:

- a well networked and connected organisation which allows communication, ideas and projects to enhance research, innovation and development across functional groups
- a well-managed portfolio of Research Themes and strategic programs, and
- research infrastructure Platforms that conduct and enable research.

NST operations are supported by enabling functions which ensure integration of safety, quality, research services, user office, industry and stakeholder engagement across research themes and research infrastructure.

The purpose of a Platform is to enable and conduct research and can be described as:

An open-access research facility combining instrumentation, technology, highly-skilled staff with business systems that enables and conducts research through a user-focused experience.

An important consideration within the NST operating model is to have expedient connections between the Platforms, to ensure the strength of the combined research from the Platforms supports the strategic intent of the entire NST group. The Research Infrastructure portfolio comprises eight Platforms.

Landmark

Australian Synchrotron

Australian Centre for Neutron Scattering

National

Centre for Accelerator Science

National Deuteration Facility

Nuclear Stewardship

Institutional

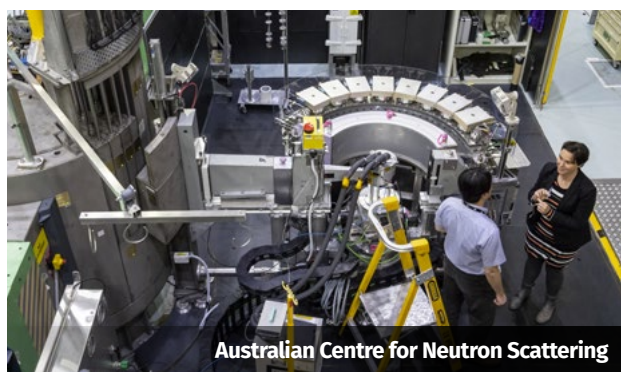
Biosciences

Isotope Tracing in Natural Systems

Nuclear Materials Development and Characterisation



Australian Synchrotron



Australian Centre for Neutron Scattering



Centre for Accelerator Science



National Deuterium Facility



Nuclear Stewardship



Biosciences



Isotope Tracing in Natural Systems



Nuclear Materials Development and Characterisation

This large portfolio places Australia at the forefront of translational research and innovation for the benefit of public health, industry, and the environment, and is used by universities, researchers, and industry from around Australia and internationally.

ANSTO's landmark facilities (Australian Synchrotron and Australian Centre for Neutron Scattering) are predominantly focused on external merit users. Among the national facilities, the Centre for

Accelerator Science and the National Deuterium Facility share the same external user focus. While not offering merit access to the same extent as the other national facilities, Nuclear Stewardship comprises a range of sovereign capabilities that services the mandated needs of various Government and ANSTO users. On this basis, it is considered national research infrastructure.

3.2 Characteristics of research infrastructure

Research infrastructure Platforms are ecosystems comprising four major elements or characteristics (Figure 3.1). The four elements work together to provide a research-enabling capability. Fundamentally, Research Infrastructure achieves excellent outcomes when each element is the very best it can be - thus enabling an outstanding user-focused experience.

Instruments and facilities: This is the most obvious characteristic of a Platform. Instrumentation and equipment, machinery, buildings and laboratories, workshops, and IT and data systems make up the hardware of a facility. Having the very best or state-of-the-art instrumentation is important. Advances in science and discovery are undeniably linked to the most advanced high-performance instruments, with well-maintained capabilities that remain operational and upgraded throughout service life.

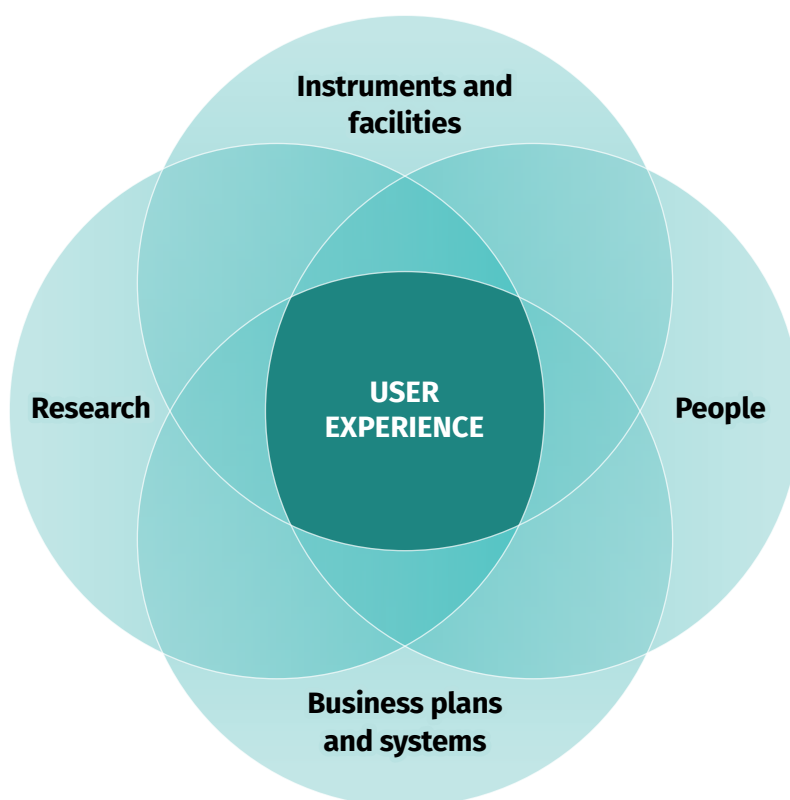
People: Any world-class equipment is only as good as the staff who deliver safe and secure operations and management, plus those who deliver scientific and technical support to users. Platform, instrument, and beamline scientists engage in scientific and research activity and/or further develop capabilities aimed

at pushing the boundaries of science. This hands-on experience is applied to user experiments ensuring the very latest know-how is available. Without dedicated infrastructure staff, instruments would remain idle or, at the very best, facilities would suffer from not being fully utilised.

Research: High-performing research infrastructure has programs of research embedded within the Platforms. Projects include developing capabilities or methods to facilitate new types of experiments and enable scientific discovery. Other research is conducted by scientists to extend the applications of a technique. These research activities ensure that the very best capabilities and knowledge can be applied to user projects.

Business plans and systems: Underpinning the other three characteristics are effective and efficient processes, governance structures, planning and reporting frameworks that allow all the elements to work together effectively. These include access policies, proposals, and associated review processes relevant to the type of user.

Figure 3.1:
Characteristics of a research
infrastructure Platform.



3.3 Access models

There are four main routes by which users gain access to ANSTO research infrastructure:

- merit-based access
- internal access (ANSTO researchers)
- user-pays access, and
- discretionary or rapid access.

All access proceeds via proposals submitted through the ANSTO Research Portal (ARP) or the Synchrotron Portal online. For merit access, there are two or three (Australian Synchrotron) calls for proposals per year.

Most external users, including nearly all academic users, gain access through a merit scheme. Merit-based access is free-of-charge. Some costs, such as travel and accommodation, may be covered by ANSTO. In return, the user commits to publish their results in the open scientific literature. Merit applications to the portals are peer reviewed by external expert referees and ranked in priority order by proposal review committees. The committees recommend time allocations.

There is an internal mechanism for ANSTO staff to gain access to the infrastructure Platforms. It is similar to the merit access route with the exception that proposals are prioritised and approved within ANSTO.

The user pays commercial access route is described more fully in [Section 3.5.3](#). The user pays an agreed access fee, typically calculated on a full cost recovery basis. In return the user obtains various benefits, including rapid turnaround access and confidentiality. While designed with industry users in mind, the user-pays mechanism can also be used by other research institutions to preserve intellectual property (IP) by avoiding the requirement to publish. Users can contribute partial cost on a collaborative basis for non-proprietary work with an agreement to publish. This often occurs through the discretionary access mechanism described below.

Rapid or Director's Discretion access is an exceptional mechanism designed to allow access on very short notice or outside of formal proposal rounds for time-critical projects, as capacity allows and at the decision of the Platform Leader. For example, rapid access for high impact research can be granted when the urgency is due to either a very competitive research environment or national benefit. COVID-related research is a recent example of rapid access status.

Each Platform reserves time in each proposal cycle for potential use by the commercial and rapid access mechanisms. In addition, a percentage of time is set aside for use by the Platform staff, primarily for maintenance activities, and development and commissioning of new capabilities.



**Merit-based
ACCESS**



**User-pays
ACCESS**



**Internal
ACCESS**



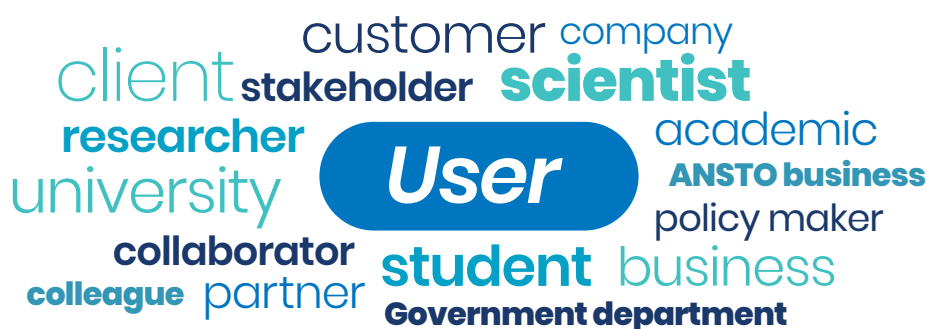
**Discretionary or rapid
ACCESS**

3.4 User experience

The purpose of the research infrastructure portfolio is to enable and conduct research in a user-focused, open-access manner.

The concept of a *user* of research infrastructure in this context is very diverse and can be described by a wide range of nomenclature. Within ANSTO, the main users of facilities are scientists within the Research Themes, who identify strongly as researchers but can also be instrument or beamline scientists

within the Platforms. Within the broad classification, requests for support from engineering and operational staff across Nuclear Operations and Commercial Business and Services are also classified as users. External to ANSTO, universities, businesses, and Government, benefit from the services and capabilities that Platforms offer. Users can be individuals or organisations.



The diversity of the user population, and the variety of the capabilities and services they require, means the experience of a user accessing ANSTO facilities needs to be equally diverse. High levels of satisfaction amongst a diverse user community require accounting for an individual experience or, at the least, a similar user experience across the same type of user, e.g. university researchers through merit-based access. A standardised, “cookie-cutter” approach to the experience of a user will not deliver excellence to all users. Nor will a fully customised approach for each individual user be effective.

To support excellence in the User Experience, ANSTO has a seven-stage workflow which reflects how all users will transit (Figure 3.2). The ANSTO User Experience is a concept. While integrated, each stage is designed to be a separate focus area adapted for broad user types. It is the role of research infrastructure Platforms to support users throughout each stage of the User Experience, thereby ensuring excellence in research outcomes and impact.

Regardless of a user’s background or affiliation, each moves through the User Experience stages to a lesser or greater extent during their interaction with ANSTO. Some users will come to ANSTO with well-informed ideas and understanding of the capabilities they require. These users can transit rapidly through the early stages and reach the Experiment and Discovery stages more quickly. Others, who do not have an understanding of ANSTO capabilities, may require considerable support to identify capabilities that are relevant for their research question before data can be converted into knowledge once the experimental work is completed.

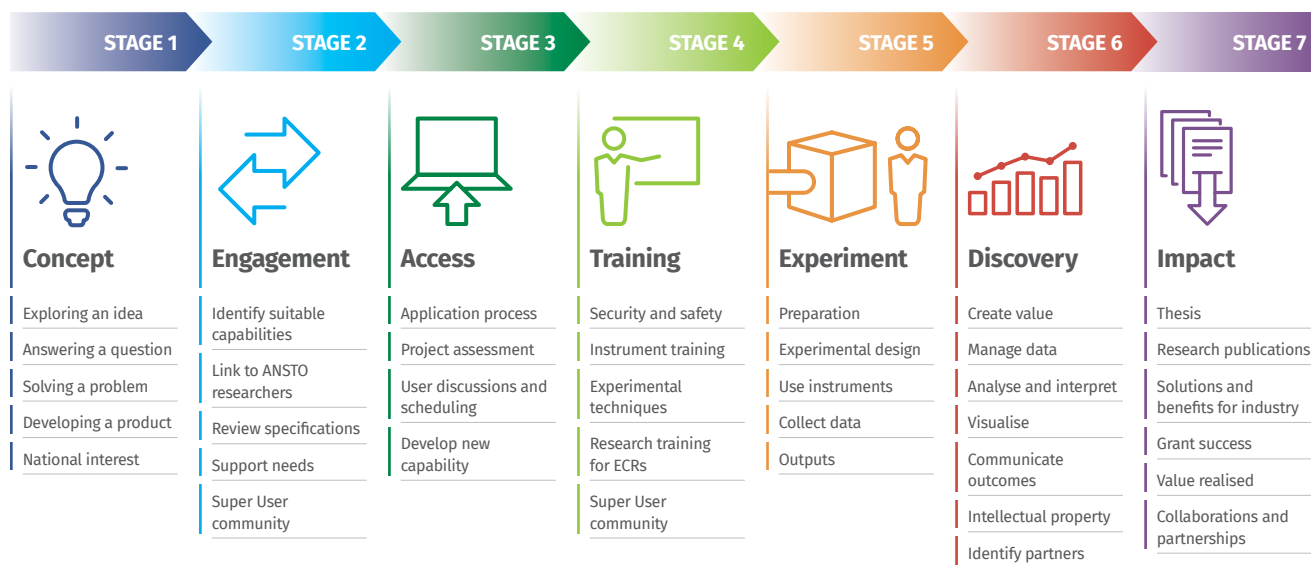


Figure 3.2:
The ANSTO User Experience.

Although illustrated as a linear concept, the experience of a user may not follow the usual sequence. It is possible that some users will oscillate between stages for various projects, particularly, as one project finishes and another commences. Similarly, each stage is illustrated as the same size; but, in reality, the stages can be of different duration. Some projects can vary from a few weeks to many years in order for research outcomes to make an impact or generate value.

The User Experience is therefore a useful concept to ensure an individual experience as much as possible. It also provides the operators of facilities with a framework on which to base improvement processes and concentrate resources as required. With respect to the Decadal Plan, the User Experience is at the centre of diverse initiatives to improve operations and management, decisions related to investment in new instrumentation and choices of staff training in order to better support users.

3.5 Industry

ANSTO's portfolio of research infrastructure offers unique capabilities and opportunities to the nation's industries. Industry usage of ANSTO's research infrastructure covers multiple Technology Readiness Levels, including new materials research and development, product development, testing and verification of manufactured products, and troubleshooting investigations of processing issues. Two representative industry studies are illustrated in Figures 3.3 and 3.4.

3.5.1 Industry access mechanisms

University access predominantly occurs via the merit access pathway, in which experimental proposals are subject to a scientific peer review process. This access mode often supports higher degree student projects, whereby research results are ultimately published in the open literature. This is currently a major access route for indirect industry use of ANSTO research infrastructure.

The exact degree of industry usage or access through this mechanism can be difficult to quantify as the company in question may not always be referenced on an application. However, recent neutron beam data analysis indicates that on average 40% of merit users have some degree of industry collaboration on their approved proposals.

There are advantages and disadvantages for ANSTO in using this mechanism. On the one hand, university collaboration addresses any expertise barrier within a company, thereby significantly increasing industry engagement. On the other hand, depending on the exact nature of each project, the company in question may not even be aware that they are benefitting from access to ANSTO infrastructure. This is a lost opportunity for ANSTO to increase its industry stakeholder base and a missed opportunity for a company to gain knowledge and expertise.

ANSTO Research Themes regularly offer characterisation studies or other Platform Services as part of a commercial research offering to universities, industry or Government entities. Commercial research contracts are prioritised within Platforms and a closer connection between ANSTO and the recipient is more likely to capture reputational value for ANSTO.

Access to ANSTO research infrastructure by external entities proceeds via two main models. Most external users, including nearly all academic users, gain access via the merit scheme described in [Section 3.3](#). Alternatively, there is a commercial paid access route, which offers various benefits as detailed below. See [Sections 3.5.1](#) and [3.5.3](#) for more details on access mechanisms.

Direct industry usage takes place when a company purchases services or products directly from a Platform, either purchasing time allocations on particular instruments or beamlines, or on a per-sample or per-product basis. Paid industry use constitutes only a small fraction of the total external uptake of ANSTO infrastructure but is an important source of revenue. On average this is less than 5% across all capabilities; although some instruments experience higher industry use, such as the neutron residual stress instrument Kowari. The instrument was specifically designed with industrial applications in mind.

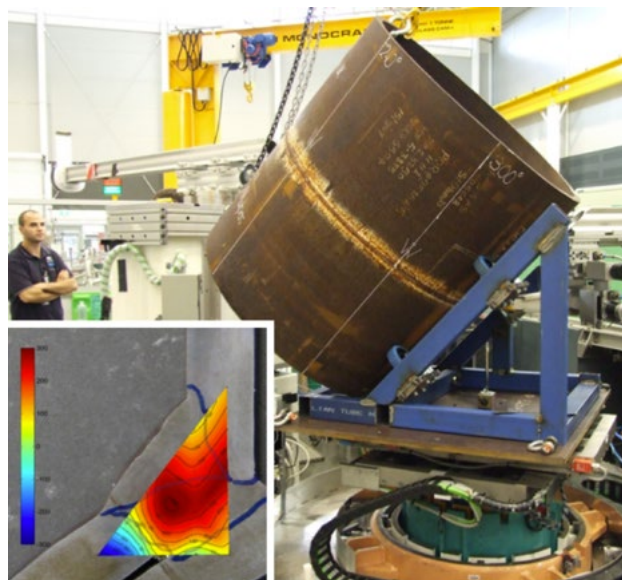


Figure 3.3:

Residual stress measurements on a sample gas pipeline weld using the Kowari instrument at ACNS. Weld rupture due to unrelieved stress has been implicated in catastrophic pipeline failures.

3.5.2 International experience

The low level of direct industry use is in line with international experience, especially for large-scale infrastructure, such as synchrotron light sources and neutron scattering centres.

In the 1990s, two synchrotrons were designed, and one funded, based on a service-to-industry business plan. The Nano-Hana project in Japan did not proceed to construction. In Germany, the ANKA synchrotron, although constructed with industry in mind, did not attract sufficient clients to support its continued operation and is now funded as a more traditional light source serving both academic and industry users.

The fact that these two projects, located in heavily industrialised nations, were not able to generate sufficient industry use to operate sustainably, illustrates the difficulty of generating sustainable industry revenue in Australia. While industry demand for ANSTO's research infrastructure portfolio does not cover operational costs, industry engagement still brings significant national benefit. For this reason, nearly all large-scale user facilities, including ANSTO, devote resources to engaging with industry.



Figure 3.4:
3D synchrotron X-ray Computed Tomography: non-destructive imaging of complex additive manufactured components.



3.5.3 Commercial access to ANSTO infrastructure

The key features of the commercial access route to NST research infrastructure are:

IP certainty: the commercial client owns all IP generated. Any analyses or data made or produced by ANSTO in the provision of the service, with the exception that any IP related to a technical development of the infrastructure itself which may be generated during the experiment, is retained by ANSTO.

Confidentiality: commercial projects are not peer-reviewed but are assessed for safety and technical feasibility only. In some cases, non-disclosure agreements are put in place. In very competitive environments, a company may not even wish to disclose that it is utilising advanced techniques such as synchrotron or neutron capabilities.

Timely access: commercial projects are given fast-track approval and access, compared with the typical 6-8 months wait time via the merit access scheme. A proportion of time on each beamline/instrument is reserved in each schedule cycle for industry projects.

Access to world-class capabilities, which ANSTO operates within ISO quality systems, ensuring the delivery of reliable data to customers.

Certainty of access: in particular, for some synchrotron and neutron beamlines and instruments which are 2-3 times oversubscribed in the merit access system.

Access to support from world class instrument scientists in designing and performing measurements. ANSTO Platform staff are subject matter experts, and, in many cases, have experience working with industrial clients on a commercial basis.

3.5.4 Industry and stakeholder engagement

The NST group has a dedicated team who have developed and are implementing a sector-based industry engagement model that aligns with the unique capabilities of NST Platforms and Research Themes. The primary objective is to broaden the revenue base and deliver a range of benefits to ANSTO, particularly through higher value projects and deeper engagement with industry. It is anticipated that, over time, these projects will grow to involve multiple Platforms and Themes, with support and coordination from the Industry and Engagement team. The sector-based approach aims to deliver more sustainable long-term engagement with industry, in association with some sector entities, such as defence industry associations, the Australian Space Agency, and Industry Growth Centres.

Industries who are new to the advanced capabilities offered by ANSTO research infrastructure face a number of entry barriers. In the case of Small or Medium size Enterprises (SMEs), it is likely that the businesses have little or no appreciation of both the capabilities and potential benefits offered by ANSTO's research infrastructure Platforms and capabilities.

The NST Industry and Stakeholder Engagement team attempts to reduce these barriers where possible. Engagement with expert scientists can be beneficial in overcoming the inexperience barrier. The two main routes are: university collaborations, in which a company links with university researchers who already possess a high degree of expertise; and engagement via either the Industry and Stakeholder Engagement team or individual NST Platform scientists.

Not all companies have the capacity to build in-house expertise in advanced analytical methods offered by ANSTO Platforms. Pharmaceutical companies who use macro-molecular crystallography at the Australian Synchrotron for rational drug design, based on atomic structures of target proteins and other macro-molecules, are the exception. This is now a well-established drug development pathway. Most large pharmaceutical companies employ skilled crystallographers and many will have laboratory scale X-ray crystallography instruments in-house.

The perceived high cost of commercial access can be a significant barrier unless the company in question has a detailed understanding of the value to be gained from using ANSTO Platforms. This is especially true for the Australian Centre for Neutron Scattering, where 24-hour operation and scheduling constraints mean that the minimum purchase is one day of time, costing approximately \$10,000.

A potential mechanism to lessen the cost barrier is offering initial discounted access for pilot or proof-of-principle studies. This approach would demonstrate the feasibility and value of using infrastructure to the company in question. Should the measurement deliver the predicted value, companies are then required to pay for continued access.

3.5.5 ANSTO Innovation Precinct

The ANSTO Innovation Precinct was established to be a nexus where industry connects with science, enabling start-ups and industries to partner with ANSTO. Two major components of the Precinct, the Graduate Institute and the *nandin* Innovation Centre, have extensive links to ANSTO's research infrastructure.

ANSTO's Graduate Institute expands human capital by increasing the number of graduate students and post-doctoral fellows that are embedded within ANSTO during the formative years of their careers. Proximity to ANSTO research infrastructure is a key aspect of the value proposition presented to Australian Universities to encourage engagement with the Graduate Institute. The Institute was conceived to connect Australia's academic, applied research and industry sectors in the ANSTO Innovation Precinct

Voucher schemes can also introduce new industries to advanced research infrastructure. These schemes are typically broader than a low initial rate proof-of-principle scheme. The New South Wales industry synchrotron access program, which ran from 2013-2017 with funding from the NSW Office of Science and Research, is an example. It provided 27 NSW-based companies with access to the Australian Synchrotron, as well as analysis and reporting of results. Health sector industries demonstrated the strongest uptake of this scheme, comprising just over 40% of beamtime awarded, followed by manufacturing (17%), food (14%), and energy and resources (12%).

with a strong emphasis on industry translation. To that end, the Graduate Institute FutureNow scholarship program offers support to graduate students, who are working with industry partners under the guidance of NST scientists, researchers, and engineers, to deliver research impacts with relevance for industry.

Proximity to NST infrastructure and researchers has been a significant feature of the *nandin* Innovation Centre and has led to over 30 start-ups and SMEs located in *nandin*. These businesses are developing new solutions in fields such as health and respiratory medicine, safety systems and emergency services, air quality infrastructure design and fabrication, cybersecurity, defence and aerospace, and automated asset tracking and management.

3.6 Platform snapshots

To develop an understanding of the Platforms that are part of the research infrastructure portfolio and to plan for the next ten years, it is necessary to outline the present state of each facility. While categorising the Platforms as Landmark, National and Institutional infrastructure provides a convenient means to classify ANSTO's capabilities in the national research infrastructure context, it does not reflect the diversity of the facilities. The depth and richness of ANSTO's portfolio lies not only in the fields of research in which it is applied but in the manner in which it operates, the breadth of the user base, and its role in supporting ANSTO operations and business.

A range of input and output measures are required to capture the extent of operations and the potential scale of research with regard to impact and benefit. Some of these measures are directly comparable (e.g. utilisation) while others are more difficult to compare (e.g. the raw number of outputs). Measures of quality and value are much more significant and meaningful than quantity.

The following sections provide a snapshot of each Platform through a brief description of capabilities and a summary of high-level performance metrics. These snapshots are designed to give the reader an appreciation of the diversity of Platforms and help frame the findings of the consultation surveys in [Section 4](#) as well as the priorities for the next decade in [Section 5](#).



3.6.1

Platform snapshot

Australian Synchrotron

LOCATION



ANSTO Victoria
Clayton Campus





SIGNIFICANT NATIONAL/INTERNATIONAL PARTNERS OR NETWORKS

New Zealand Synchrotron Group
(NZSG)

Australian Institute of Nuclear Science and Engineering
(AINSE)

Asia-Oceania Forum for Synchrotron Radiation Research
(AOFSTR)

BRIGHT Funders 31 Universities, PFRAs and MRIs

ARC Centre of Excellence in
Functional Low Energy Electronics Technologies
(FLEET)

AIR Hub Aerostructures Innovation Research Hub

Medicines Manufacturing Innovation Centre
(MMIC)

STAFF MEMBERS

194

The Australian Synchrotron has **10 beamlines** which can operate in parallel providing key synchrotron capability across multiple techniques, with a further eight beamlines currently under construction as part of the BRIGHT Beamline Program.



SUPPORTING

AUSTRALIA'S NATIONAL SCIENCE AND RESEARCH PRIORITIES



Advanced manufacturing



Cyber security



Energy



Environmental change



Food



Health



Resources



Soil and water



Transport



Platform snapshot

Australian Synchrotron

The Australian Synchrotron (AS) is a 3 GeV, 216 m circumference, electron synchrotron light source facility that provides world-class synchrotron tools and expertise that enable researchers and clients to deliver scientific advances and industrial innovations with medical, social and economic benefits.

The AS operates multiple beamlines and associated ancillary laboratories to support a large user program.

The AS capabilities provide an array of non-destructive, high-resolution, in-situ, real-time imaging and analysis techniques. These generate elemental, structural and chemical information from diverse sample types ranging from living cells to advanced materials, industrial components and mineral processes. AS beamlines support a broad range of high-quality research, with applications in sectors from medicine and nanotechnology to manufacturing and mineral exploration.

Six departments which collectively provide the expertise and tools required to enable high impact research:

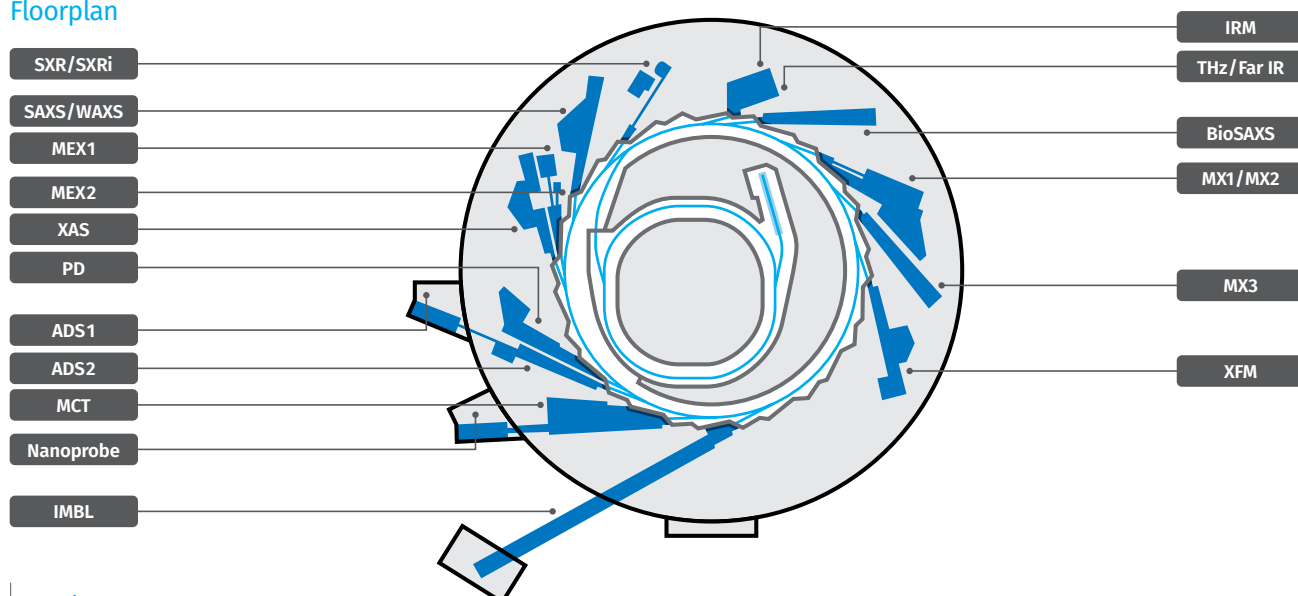
- Science
- Accelerator Science and Operations
- Operations
- Engineering
- Controls and Computing
- Project Management Office

Australian Synchrotron beamlines - operating and under construction

TECHNIQUE	BEAMLINE			
Diffraction	MX1 Macromolecular Crystallography	MX2 Microfocus Crystallography	PD Powder Diffraction	
Imaging / Microscopy	IMBL Imaging and Medical	SXRi Soft X-ray Imaging	IRM Infra-Red Microscopy	XFM Fluorescence Microprobe
Spectroscopy	XAS X-ray Absorption Spectroscopy	SXR Soft X-ray Spectroscopy	THz / Far IR Spectroscopy	
Scattering	SAXS / WAXS Small and Wide Angle Scattering			
BRIGHT Beamlines	MEX 1 & 2 Medium-Energy XAS ADS 1 & 2 Advanced Diffraction and Scattering	MCT Micro-Computed Tomography MX3 High-Performance Macromolecular Crystallography	BioSAXS Biological X-ray Small Angle Scattering	Nanoprobe High-Resolution Microscopy

■ Branchlines – not operated in parallel
■ Under construction or commissioning

Australian Synchrotron Floorplan

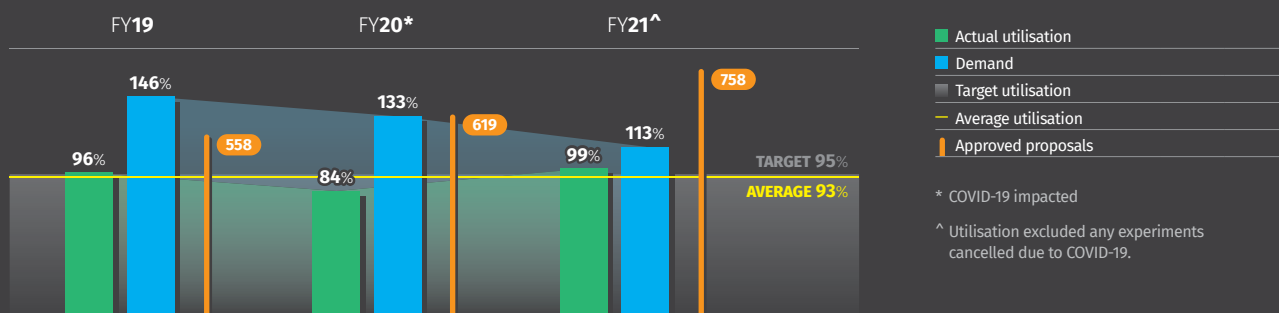


Australian Synchrotron

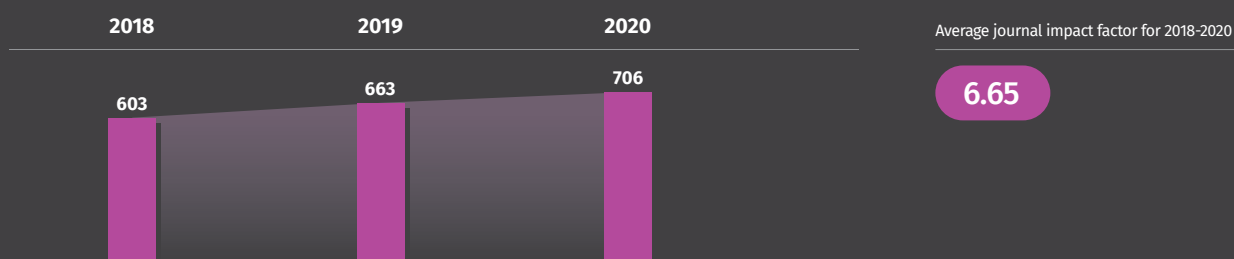
Key metrics

AS utilisation performance is measured by the number of hours delivered out of the scheduled number of hours available (beamline availability). The AS is routinely over-subscribed, with demand an average of 130% for the three financial years from FY19-FY21. Demand is calculated from approved projects for access compared to those submitted.

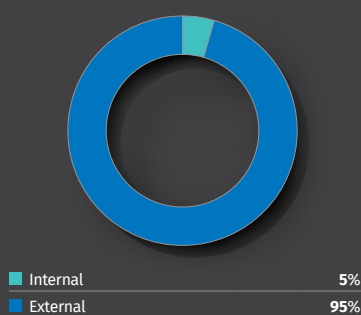
AS utilisation and demand



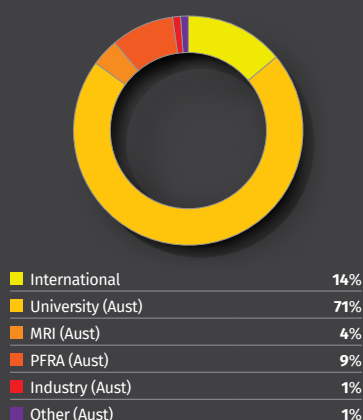
AS refereed publications



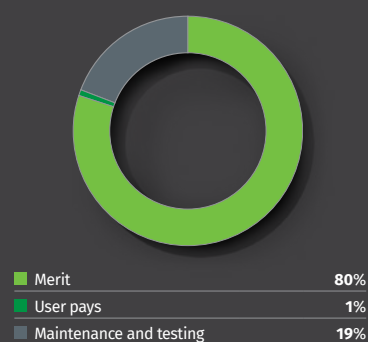
Internal and external users



Users by sector



User access mode



AS user profile. Numbers are averaged for three financial years (FY19-FY21) from a total of 3,914 unique users (based on user visits to AS). PFRA category includes ANSTO users.

AS user access mode distribution averaged for three financial years (2019 to 2021) for approved proposals.

Platform snapshot

Australian Synchrotron

CASE STUDY

Taking the fight to malaria

Problem

- Malaria is a major international blood borne disease spread by mosquitoes.
- In 2019 there were approximately 230 million cases of malaria infection, and around 409,000 deaths.
- We lack a complete understanding of the disease and early diagnosis techniques.

Solution

Two teams have separately tackled these problems using the SAXS/WAXS and MX crystallography beamlines:

- Researchers from the Walter and Eliza Hall Institute (WEHI) and Bio21, University of Melbourne have used synchrotron based structural biology techniques (MX and SAXS/WAXS beamlines) to reveal the biological mechanism for how the malaria parasite invades young blood cells, with findings published in *Science* and *Nature*.
- Early detection is essential for effective treatment but presents challenges in developing countries. A Monash-ANSTO team used the IRM to quantify the biomolecular signatures associated with malaria-infected blood cells with the aim of developing an easily deployable diagnostic.

Impact

The WEHI-ANSTO team were able to use atomic-level MX crystallography data to demonstrate that PvRBP2b monoclonal antibodies inhibit the binding of a malaria parasite protein to a blood cell receptor. The team is using the results to help in the development of a new and effective anti-malaria vaccine.

The Monash team used the IRM results to develop a small, portable infrared spectrometer that can be used in any setting to rapidly detect early-stage malarial infections with a single drop of blood.

The team is using the results to help in the development of a new and effective anti-malaria vaccine



Health

COLLABORATORS



CASE STUDY

Can sodium power the 21st century?

Problem

- Energy storage technologies, including advanced batteries, are essential for the adoption of large scale intermittent renewable power generation.
- Lithium-ion batteries face increasing raw material costs, leading to a search for lower cost more sustainable materials such as sodium, which is 1,000 times more abundant than lithium.
- Currently, sodium-ion batteries suffer from lower energy density, and poor cycling stability.

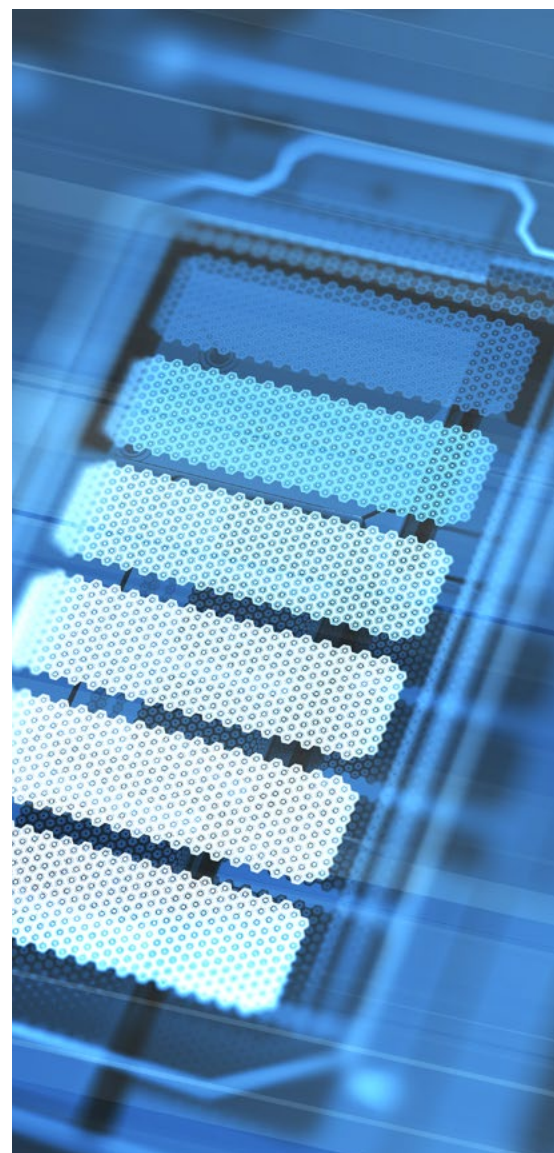
Solution

A collaboration led by the University of Wollongong has investigated a new sodium-ion battery cathode material, carbon coated $\text{Na}_{3.32}\text{Fe}_{2.34}(\text{P}_2\text{O}_7)_2$, using the Australian Synchrotron. This material displayed good energy density and cycle stability. The transport of sodium ions during operation causes the cathode material to expand or contract, limiting its lifetime. Synchrotron diffraction data taken during operation of the battery measured relatively small changes in the lattice parameters, which results in 90% charge retention over more than 1,000 charge-discharge cycles.

Impact

The discovery of this new cathode material is an important step in the development of high-performance low-cost sodium-ion batteries. This work illustrates a key capability of synchrotron X-rays (and neutron scattering techniques) which is especially useful in investigating batteries: the ability to acquire data while a device is operating, so called in-operando measurements.

The discovery of this new cathode material is an important step in the development of high-performance low-cost sodium-ion batteries



Energy

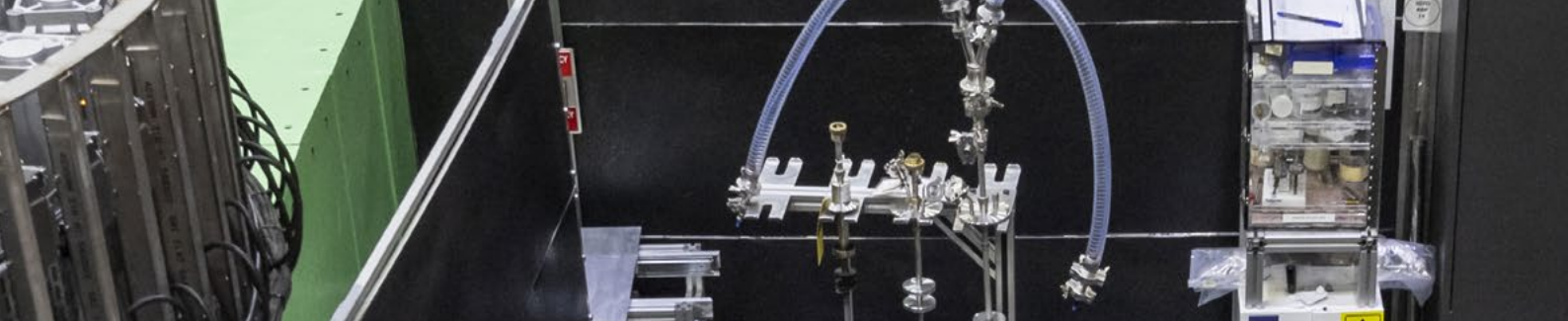


Advanced
manufacturing

COLLABORATORS



UNIVERSITY
OF WOLLONGONG
AUSTRALIA



3.6.2

Platform snapshot

Australian Centre for Neutron Scattering

LOCATION



ANSTO New South Wales
Lucas Heights Campus





SIGNIFICANT NATIONAL/INTERNATIONAL PARTNERS OR NETWORKS

Australian Neutron Beam Users Group
(ANBUG)

Australian Institute of Nuclear Science and Engineering
(AINSE)

Asia-Oceania Neutron Scattering Association
(AONSA)

International Atomic Energy Agency
(IAEA)

National Synchrotron Radiation Research Center
(NSRRC) Taiwan

Paul Scherrer Institute
(PSI) Switzerland

Japan Proton Accelerator Research Complex
(J-PARC) Japan

Helmholtz-Zentrum Berlin
(HZB) Germany

ARC Centre of Excellence in
Functional Low Energy Electronics Technologies
(FLEET)

STAFF MEMBERS

72



The ACNS operates a suite of
15 neutron beam instruments
with expert instrument scientists across
5 capability focused teams.



SUPPORTING

AUSTRALIA'S NATIONAL SCIENCE AND RESEARCH PRIORITIES



**Advanced
manufacturing**



Cyber security



Energy



Environmental change



Food



Health



Resources



Soil and water



Transport



Platform snapshot

Australian Centre for Neutron Scattering

The Australian Centre for Neutron Scattering (ACNS) provides neutrons from Australia's multi-purpose reactor, OPAL, to solve complex research and industrial problems for external and internal users.

ACNS is currently the leading neutron-scattering centre in the Southern Hemisphere, and amongst the top five reactor-based neutron scattering centres in the world. The ACNS is one of three research infrastructure facilities at ANSTO supported by the National Collaborative Research Infrastructure Strategy (NCRIS) program.

ACNS contributes to Australia's innovation ecosystem through the provision of world-leading neutron scattering techniques that enable the structure, dynamics and properties of a range of materials to be characterised.

Fields of research include medicine, minerals, transportation, engineering, food processing, energy, chemistry, physics, electronics, and cultural heritage.

The neutron is a unique and irreplaceable probe with advantages including deep penetration into materials and scattering behaviour characteristic of the nucleus of constituent atoms.

Five specialised and cross-cutting teams support ACNS instrument scientists and users to enable research:

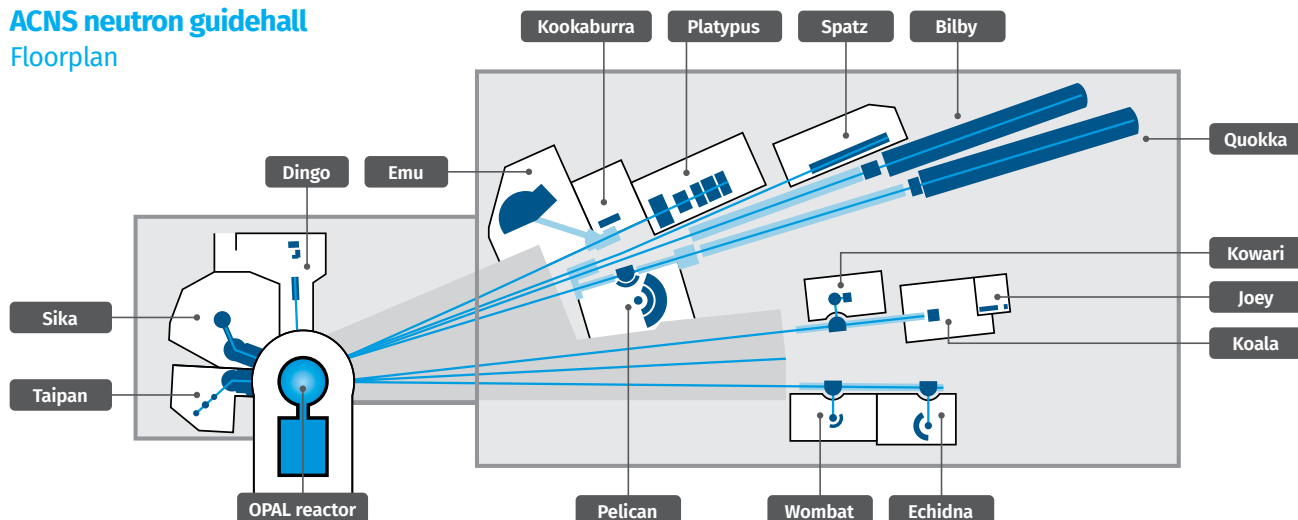
- Computing and electronics
- Sample environments
- Electrical and control systems engineering
- Scientific operations
- Laboratories and compliance

ACNS neutron instruments and selected other major instruments

TECHNIQUE	INSTRUMENTS				
Diffraction	Echidna High resolution	Koala Single crystal	Wombat High intensity		
Inelastic Scattering	Emu High resolution	Pelican Time-of-flight	Sika Cold triple axis	Taipan Thermal triple axis	Joey Laue camera
Reflectometry	Platypus	Spatz	X-ray reflectometer	Polarised helium-3	
Small Angle Scattering	Bilby Time-of-flight	Kookaburra Ultra SANS	Quokka Pinhole SANS	X-ray (SAXS)	
Strain and Imaging	Dingo Radiography	Kowari Strain scanner			

■ Neutron instrument
■ Other major instrument

ACNS neutron guidehall Floorplan

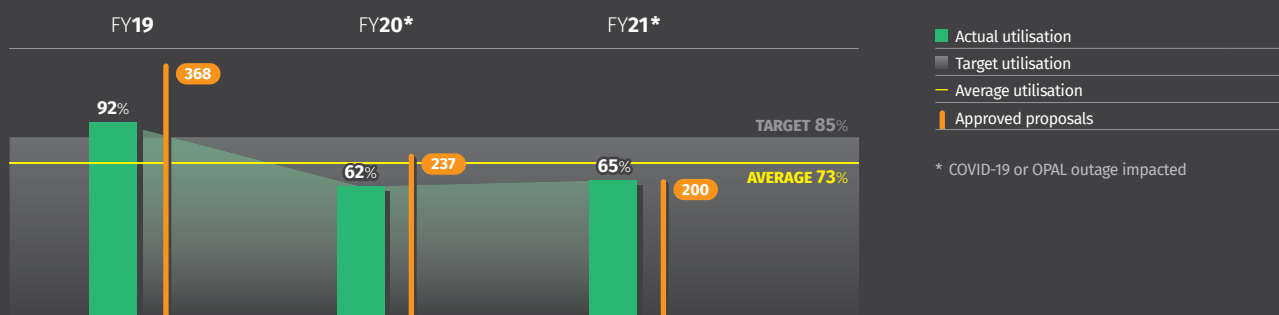


Australian Centre for Neutron Scattering

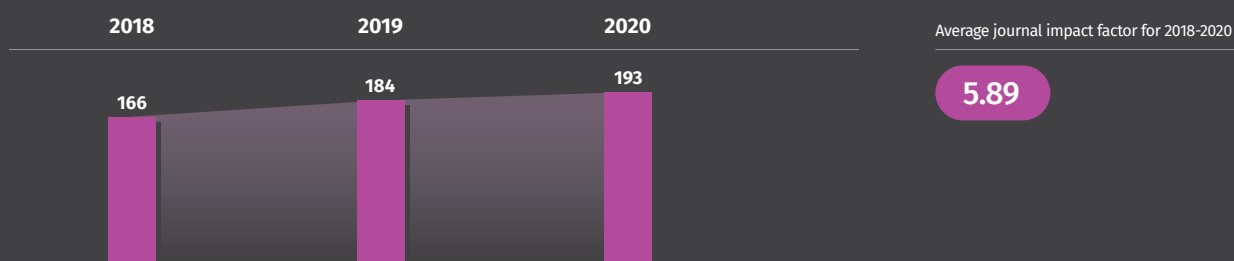
Key metrics

ACNS utilisation is measured by the number of actual operating days out of the scheduled operating time. Demand is calculated using requested and available days per proposal round. All ACNS neutron beam instruments are routinely over-subscribed. Average merit access demand from FY19 to FY21 ranges from 170 to 360% for 13 neutron beam instruments across this period (excluding Spatz and Joey).

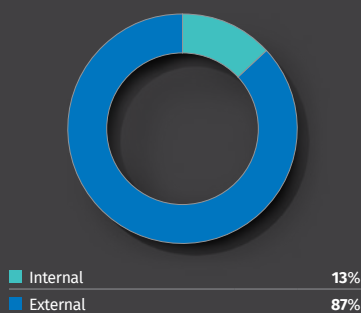
ACNS utilisation



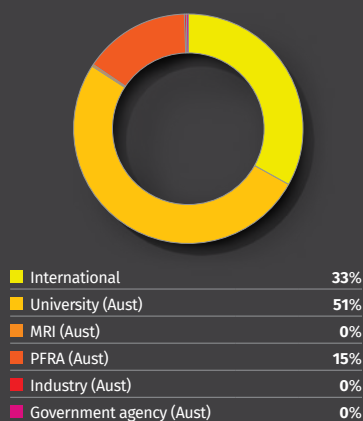
ACNS refereed publications



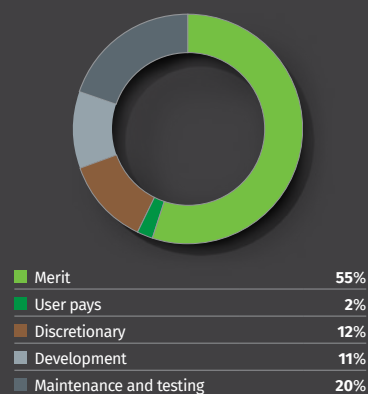
Internal and external users



Users by sector



User access mode



ACNS User Profile. Numbers are averaged for three financial years (FY19-FY21) from a total of 1,353 unique users (based on usage and user visits to ACNS). PFRA category includes ANSTO users.

ACNS user access mode distribution averaged for three financial years FY19- FY21) for neutron beam instrument days utilised across the suite of instruments available. Planned maintenance and testing has also been included.

Australian Centre for Neutron Scattering

CASE STUDY

A new class of hydrogen conductors

Problem

- Materials that can conduct ionised hydrogen atoms (protons) are vital for the transition to a hydrogen-based economy, as they are needed for fuel cells, electrolyzers, catalyzers etc.
- However, only a limited number of these proton-conducting structures are known.
- The detailed mechanism of proton conduction needs to be determined to allow tuning of a material for better conduction, or discovery of new materials in the same family.

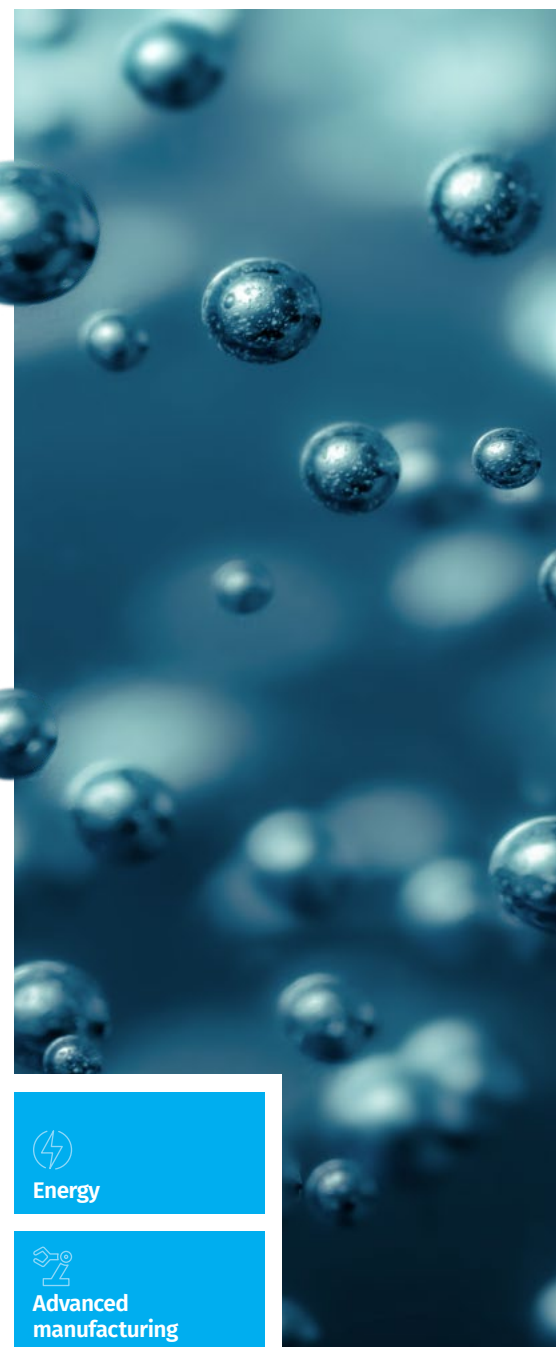
Solution

A team from the Tokyo Institute of Technology and ANSTO have identified a new hydrogen conducting material, $\text{Ba}_5\text{Er}_2\text{Al}_2\text{ZrO}_{13}$, a member of a new family of proton conductors. The Echidna neutron powder diffractometer at ACNS was used to determine its atomic structure, in particular the positions of the oxygen atoms which is crucial for understanding the conduction mechanism. The determination of oxygen positions in the presence of heavier elements is a particular strength of neutron scattering, as the heavy atoms dominate X-ray diffraction signals.

Impact

A new class of proton conductors has been found and the conduction mechanism elucidated. This means that a new range of materials has become available for potential application in large-scale industrial applications, including in fuel-cells, industrial-scale catalysis, and hydrogen pumping.

A new range of materials has become available for potential application in fuel-cells



Energy



Advanced
manufacturing

COLLABORATORS



東京工業大学
Tokyo Institute of Technology



Antimicrobial peptides could be used to address multi-drug resistance and develop more effective antibiotics

CASE STUDY

Tackling antimicrobial resistance using peptides from Australian tree frogs

Problem

- Antibiotic resistance is becoming an increasing health concern with what were once treatable infections becoming untreatable with traditional antibiotics currently available.
- New antimicrobials are required to combat the rise of "superbugs".
- More than half a million people globally per year are estimated to die because of antimicrobial resistance.

Solution

Antimicrobial peptides which are short strings of amino acids that can attack the membrane of a bacterial cell, are an alternative that is being explored. A synthetic analogue of a peptide in the skin secretions of the Australian green-eyed tree frog (maculatin 1.1), part of the frog's natural immune response, is one promising candidate. A research team from Bio21 Institute, University of Melbourne and ANSTO utilised the Platypus neutron reflectometer at ACNS and maculatin 1.1 deuterated by the National Deuteration Facility to investigate how maculatin 1.1 assembles in model cell membranes to drive its bactericidal action.

Impact

This work helps us understand how antimicrobial peptides that occur in nature target bacterial membranes and kill bacterial cells. This increases our understanding of how antimicrobial peptides select bacterial versus non-bacterial cells and the potential damage that could be caused to human cells if antimicrobial peptides are used as therapeutics. The peptide attacks specific lipid components of the bacterial membrane making it less possible for the bacteria to build resistance to the antimicrobial peptide. All this information together informs us on how antimicrobial peptides could be used to address multi-drug resistance and develop more effective antibiotics.

COLLABORATORS



Health

3.6.3

Platform snapshot

Centre for Accelerator Science

LOCATION



ANSTO New South Wales
Lucas Heights Campus





SIGNIFICANT NATIONAL/INTERNATIONAL PARTNERS OR NETWORKS

International Atomic Energy Agency
(IAEA)

Australian Collaboration for Accelerator Science
(ACAS)

National Space Qualification Network
Australian Space Agency Space Infrastructure
Funded Partnership

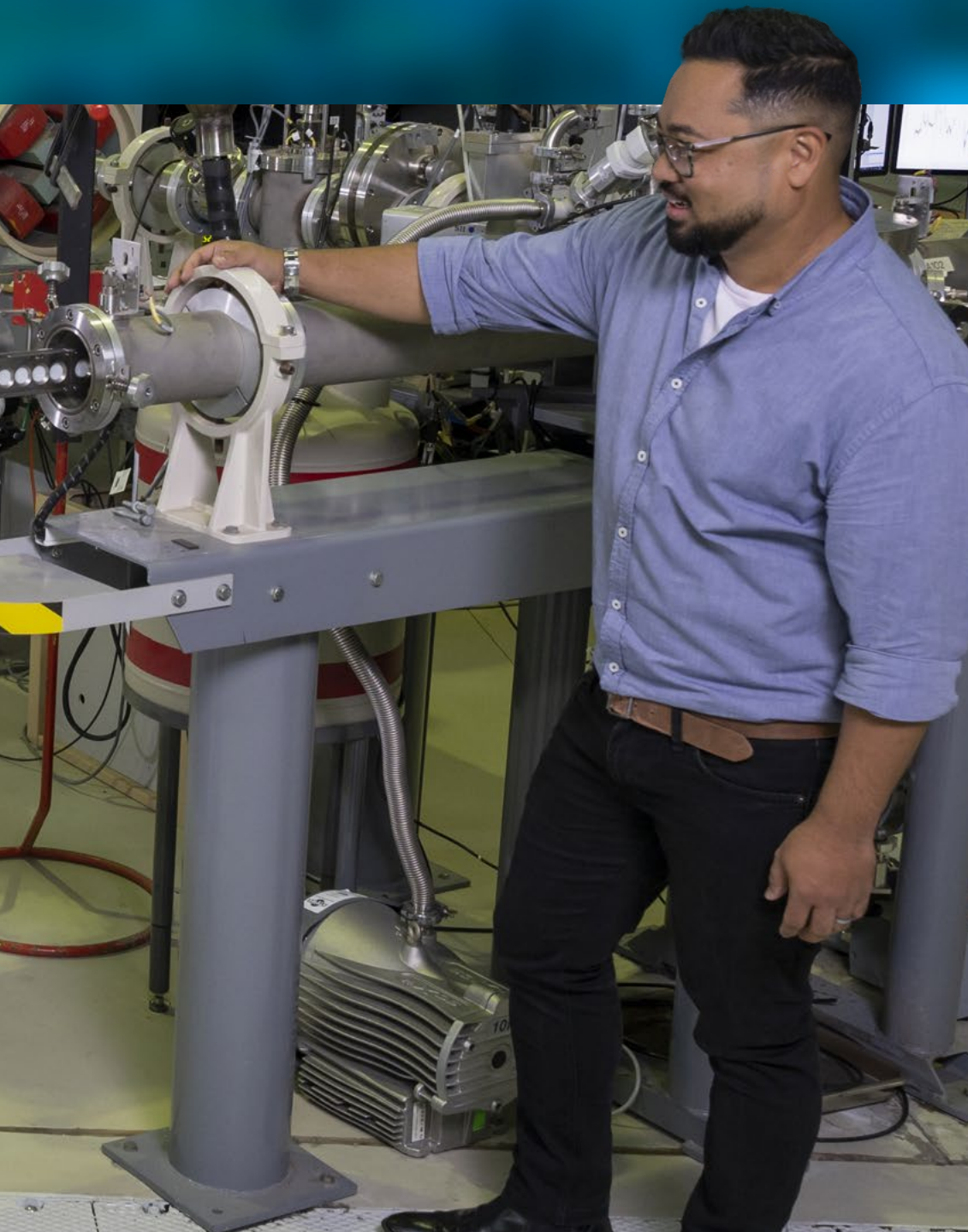
ARC Centre of Excellence in
Dark Matter Particle Physics

STAFF MEMBERS

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The CAS is a multi-disciplinary team of scientists and engineers supporting academic and industry users across Australia and the world.



SUPPORTING

AUSTRALIA'S NATIONAL SCIENCE AND RESEARCH PRIORITIES



Advanced
manufacturing



Cyber security



Energy



Environmental change



Food



Health



Resources



Soil and water



Transport

Platform snapshot

Centre for Accelerator Science

The Centre for Accelerator Science (CAS) is ANSTO's Platform for ion beam accelerator instrumentation and applications.

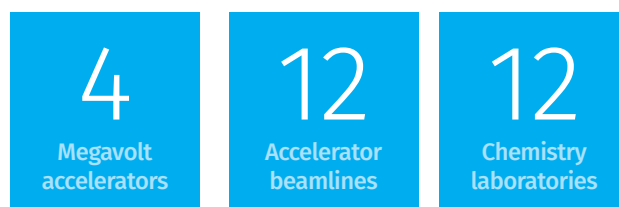
The CAS supports research and industry user communities to explore the past, understand the present, and design for the future with a suite of accelerator science capabilities that can help answer complex questions. The CAS is one of three research infrastructure facilities at ANSTO supported by NCRIS.

Capabilities at the CAS include a range of radioisotope dating techniques, trace element and actinide identification, surface engineering and characterisation, and radiation exposure and damage, all at ultra-high sensitivity. The facility informs policy, provides critical services in nuclear forensics and air pollution monitoring, and enables discovery and innovation in areas such as environment, climate and health sciences, space technologies, advanced materials for biotech, energy, nuclear and quantum, and cultural heritage.

Capabilities

CAS capabilities deliver:

- ultra-sensitive analysis via accelerator mass spectrometry (AMS) and ion beam analysis (IBA) techniques, and
- precision irradiation via a suite of ion beam implantation and irradiation modalities covering material doping and defect engineering, nanostructure fabrication, bulk or surface material modification, or radiation testing.



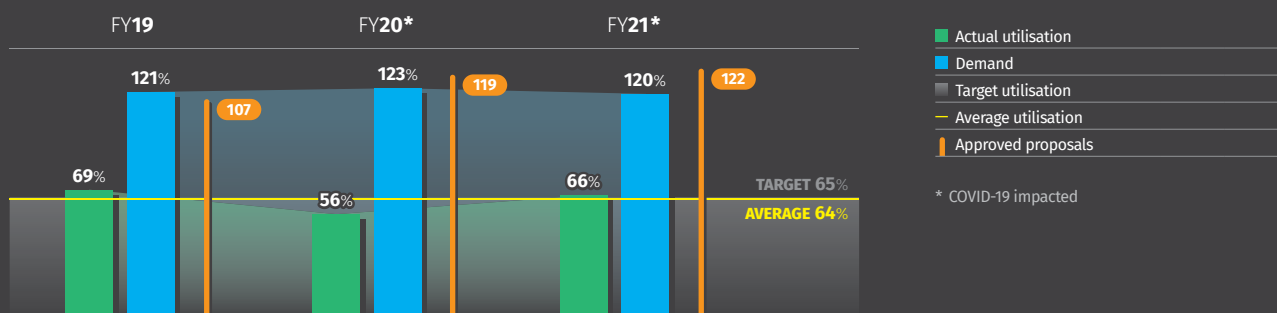
The CAS operates four megavolt accelerators delivering to 12 beamlines, 12 chemistry laboratories and multiple workshops for accelerator systems maintenance and development.

CAS accelerators

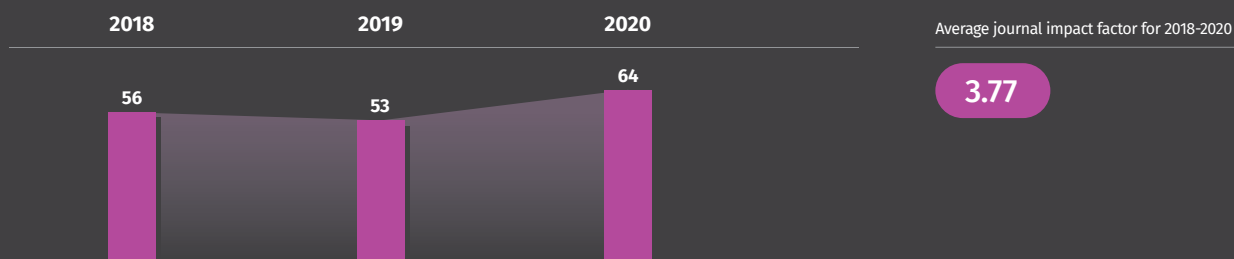
CAPABILITY	ACCELERATOR AND TECHNIQUES			
	VEGA (1 MV)	STAR (2 MV)	SIRIUS (6 MV)	ANTARES (10 MV)
Radioisotope dating	AMS ¹⁴ C		AMS ³⁶ Cl ²⁶ Al ¹⁰ Be	AMS μg- ¹⁴ C
Actinide counting	AMS ²³³ U- ²³⁶ U ²³⁸ U ²³⁹ Pu- ²⁴² Pu ²⁴⁴ Pu ¹²⁹ I ²¹⁰ Pb			
Trace element analysis and surface characterisation		Bulk sample IBA	Microprobe IBA	
Irradiation		Long-exposure protons, alphas	Microprobe implantation and irradiation, protons and heavy ions	Fast neutrons, microprobe protons and heavy ions, in vacuum or air

The CAS utilisation is measured by the number of days operating for the user program against the number of days available. The number of days available for the user program is the number of accelerator days (250 business days per year per accelerator) minus the number of days used for planned and unplanned maintenance and system upgrades. Demand represents the total number of proposals submitted compared to those approved.

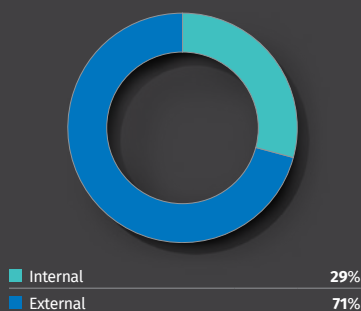
CAS utilisation and demand



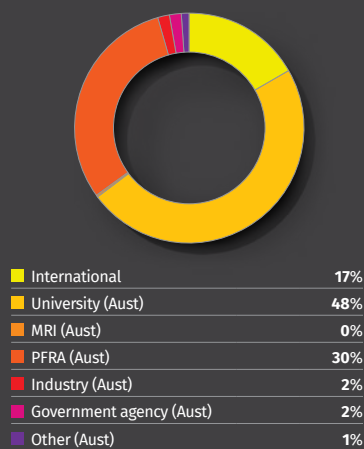
CAS refereed publications



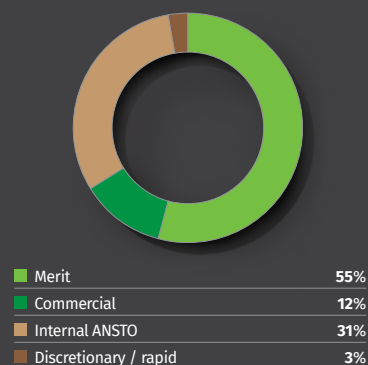
Internal and external users



Users by sector



User access mode



CAS user profile. Numbers are averaged for three financial years FY19-FY21) from a total of 830 unique users from approved proposals. PFRA category includes ANSTO users.

CAS user access mode distribution averaged for three financial years (FY19-FY21) for approved proposals.

Centre for Accelerator Science

CASE STUDY

Exploring the past with radiocarbon dating

Problem

- Radiocarbon dating is a powerful tool for researchers exploring the past.
- For the high impact-research areas highlighted here, only minute amounts of carbon can be extracted from the bulk samples.

Solution

The CAS supports ultra-sensitive analyses to enable reliable radiocarbon dating from just a few micrograms of sample. CAS is the only facility in Australia to overcome challenges in delivering this level of sensitivity.

Impact

Informing the date of oldest known Aboriginal rock art

A collaboration led by the University of Melbourne in cooperation with Traditional Owners in the Kimberley used microscopic amounts of charcoal in fossilised mud wasp nests to determine dates for the oldest Aboriginal rock art. Radiocarbon dating demonstrated that the painting was between 17,500 and 17,100 years old.

World Heritage Listing for Gunditjmara Aboriginal community site

In research that was led by Monash University in partnership with the Gunditjmara Aboriginal community, radiocarbon dating placed the age of the aquaculture system in the Budj Bim cultural landscape at 6,600 years old – amongst the oldest known fish traps in the world. This data helped secure its place on UNESCO World Heritage Listing in 2019.

Revealing significance of human fossil methane contribution

A team from the University of Rochester, CSIRO and ANSTO, funded by the US National Science Foundation, found that methane emissions from human fossil sources has been underestimated by 25-40%. A history of the amount of methane in the atmosphere was reconstructed from 1750 to 2013 using air and ice cores from Antarctica and Greenland.

Radiocarbon dating placed the age of the aquaculture system in the Budj Bim cultural landscape at 6,600 years old



Environmental change

COLLABORATORS



CASE STUDY

Advancing quantum technology

Problem

- Precise measurement of magnetic fields can enable diagnosis and treatment neurodegenerative disorders.
- Engineering and fabricating biocompatible devices and sensors requires high levels of control at the nanoscale.

Solution

A team of researchers from the Istituto Nazionale di Ricerca Metrologica, Torino, the University of Torino, Italy, and CAS has developed a biocompatible sensor that can measure magnetic fields with an unprecedented sensitivity at the nanoscale.

Precision ion beam irradiation for materials modification was undertaken at CAS to fabricate nitrogen-vacancy centres in synthetic diamond of 15 nm thickness at 10 nm depth.

Impact

This innovative method has been used to produce sensors with excellent magnetic sensitivity at an ultra-small scale and with full biocompatibility. As such, this method shows unprecedented potential for nanoscale magnetic sensing in biological systems at the cellular level.

This innovative method has been used to produce sensors with excellent magnetic sensitivity at an ultra-small scale



Advanced
manufacturing

COLLABORATORS



UNIVERSITA
DEGLI STUDI
DI TORINO

3.6.4

Platform snapshot

National Deuteration Facility

LOCATION



ANSTO New South Wales
Lucas Heights Campus





SIGNIFICANT NATIONAL/INTERNATIONAL PARTNERS OR NETWORKS

Deuteration Network
(DEUNET) International

Japan Proton Accelerator Research Complex
(J-PARC) Japan

Institut Laue-Langevin
(ILL) France

STAFF MEMBERS

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The NDF has a multidisciplinary team with expertise in the production, purification and analysis of deuterated and multiple-labelled molecules.



SUPPORTING

AUSTRALIA'S NATIONAL SCIENCE AND RESEARCH PRIORITIES



Advanced
manufacturing



Cyber security



Energy



Environmental change



Food



Health



Resources



Soil and water



Transport



National Deuteration Facility

The National Deuteration Facility (NDF) provides isotopic labelling of molecules with the stable, non-radioactive isotope deuterium (^2H) using chemical or biological (*in vivo*) processes.

The NDF is one of the few open access facilities in the world offering chemical deuteration for Australian and international researchers, and is the only such facility to offer both chemical and biological deuteration in the Southern Hemisphere.

Deuteration of molecules is useful in studies investigating the relationship between molecular structure and function and where it leads to improved material properties in their end-use application.

Capabilities

The NDF has a multidisciplinary team with expertise in the production, purification and analysis of deuterated and multiple-labelled molecules and can provide advice regarding research involving or experimental application of deuterated molecules. The NDF team includes:

- biological deuteration specialists
- chemical deuteration specialists
- structural biologists
- microbiologists, and
- synthetic chemists and biochemists.

NDF provides access to a range of capabilities:

- deuteration of natural and synthetic lipids
- multiple labelling of proteins for NMR spectroscopy (combinations of isotopes ^2H , ^{13}C , ^{15}N)
- deuterium labelling of proteins (to tailored deuteration levels)
- protein expression and purification
- deuteration of detergents, surfactants and other organic molecules, and
- deuterium analysis.

Deuteration can enhance contrast and reduce background from incoherent absorption, when conducting structural studies using neutron scattering or using spectroscopic techniques such as nuclear magnetic resonance (NMR) and infrared or mass spectrometry.

Through its user program, the NDF produces molecules for use in experiments in the fields of pharmaceutical science, structural biology, nanotechnology, energy and polymer science, amongst others. Deuteration also enables more fundamental science investigating mechanisms across biology, chemistry, physics, and materials science. The NDF is one of three research infrastructure facilities at ANSTO supported by the NCRIS funding scheme.

With a catalogue of the extensive range of molecules and materials available that is regularly updated, NDF can provide more than 200 molecules for researchers and industry.

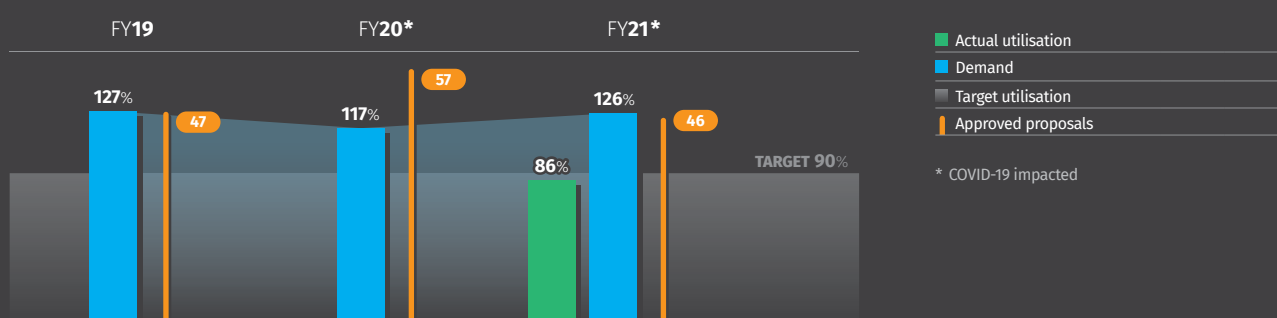
ANSTO's National Deuteration Facility is the only facility to offer both chemical and biological deuteration in the Southern Hemisphere.

National Deuteration Facility

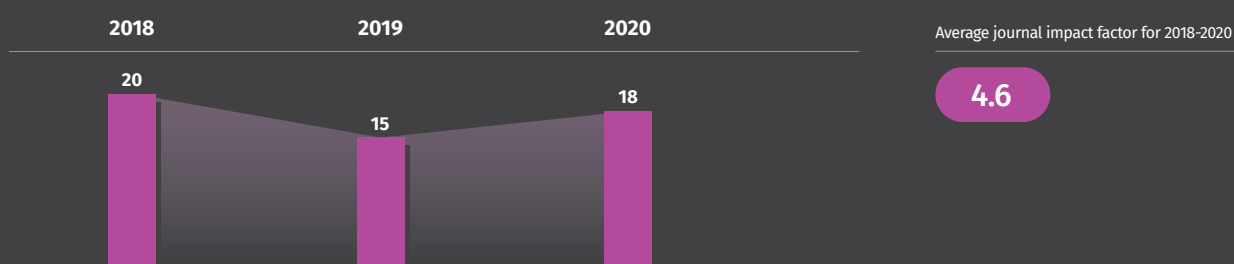
Key metrics

NDF utilisation performance is measured by the percentage of the NDF production capacity utilised by the approved user demand. The NDF is consistently over-subscribed. Demand is calculated from approved proposals for access compared to those submitted.

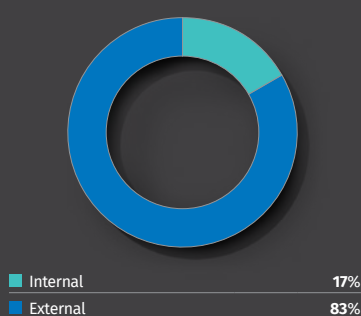
NDF utilisation and demand



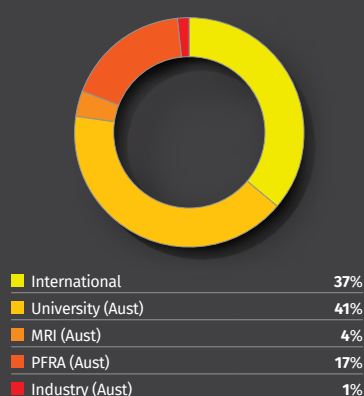
NDF refereed publications



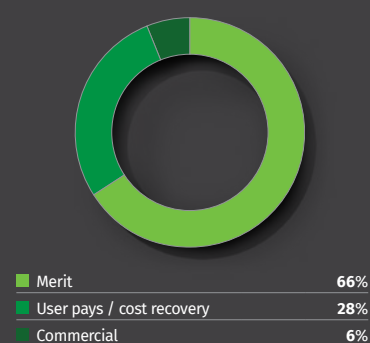
Internal and external users



Users by sector



User access mode



NDF user profile. Internal and external unique users averaged for three financial years (FY19-FY21) from a total of 391 users who accessed NDF (completed and ongoing proposals). PFRA category includes ANSTO users.

NDF user access mode distribution averaged for three financial years (FY19- FY21) for approved proposals. Commercial indicates full cost access and user pays/cost recovery indicates partial cost contribution from users for collaborative and non-proprietary work. Both access types can be approved through Director's discretion.

National Deuteration Facility

CASE STUDY

Improving and stabilising materials using deuteration

Problem

Degradation and instability of materials is the enemy of nearly everything in life, from biology to chemistry and including industrial products. Although essential for life, oxygen is the cause of oxidative damage to our cells and the oxidation of materials such as healthcare products, lubricants, electronics and food. Enzymes act similarly in the body by breaking molecular bonds of foreign materials such as drugs. Chemists endeavour to design better performing molecules, additives and preservatives to slow down these effects while retaining the original functionality and quality of the product.

Solution

The deuteration of molecules can reinforce weak bonds in molecules of a material without changing its chemical nature, making the material more resistant to damage by oxygen or enzyme action. This can result in materials with enhanced performance and improved physical properties through the deuterium kinetic isotope effect, with this aspect of deuteration having applicability across multiple research and industry sectors.

Impact

The NDF enables innovation across diverse sectors and in collaboration with ANSTO's research programs with sectors including medical imaging, personal care products, manufacturing, advanced materials, and mRNA technology. For example:

- deuteration of the ANSTO developed radiotracer [^{18}F]PBR111 has been demonstrated to improve image quality through slowing the breakdown of the molecule *in vitro* and *in vivo*
- deuteration of mineral oil for a Japanese chemical manufacturer allowed R&D in the formulation of new polymeric products and higher thermo-oxidative resistant oil for potentially better performing lubricants and oil-based products, and
- deuteration of the sunscreen ingredient avobenzone, enabled evaluation and understanding of the degradation mechanism of this compound which is the cause of poor performance of sunscreen products.

COLLABORATORS



UNSW
SYDNEY



Dermatest

The NDF enables innovation across diverse sectors, including medical imaging, manufacturing, advanced materials, and mRNA technology



Deuteration is essential for neutron studies to be able to differentiate between cell membrane components and highlight those of interest

CASE STUDY

Understanding cellular functions and mechanisms of disease and infection

Problem

Understanding the complex structure of the cell membrane and its components that regulate cellular functions is critically important to elucidating mechanisms of infection and the causes of disease. It is, however, difficult to discern between cell membrane components at the nanoscale using X-ray or neutron techniques alone.

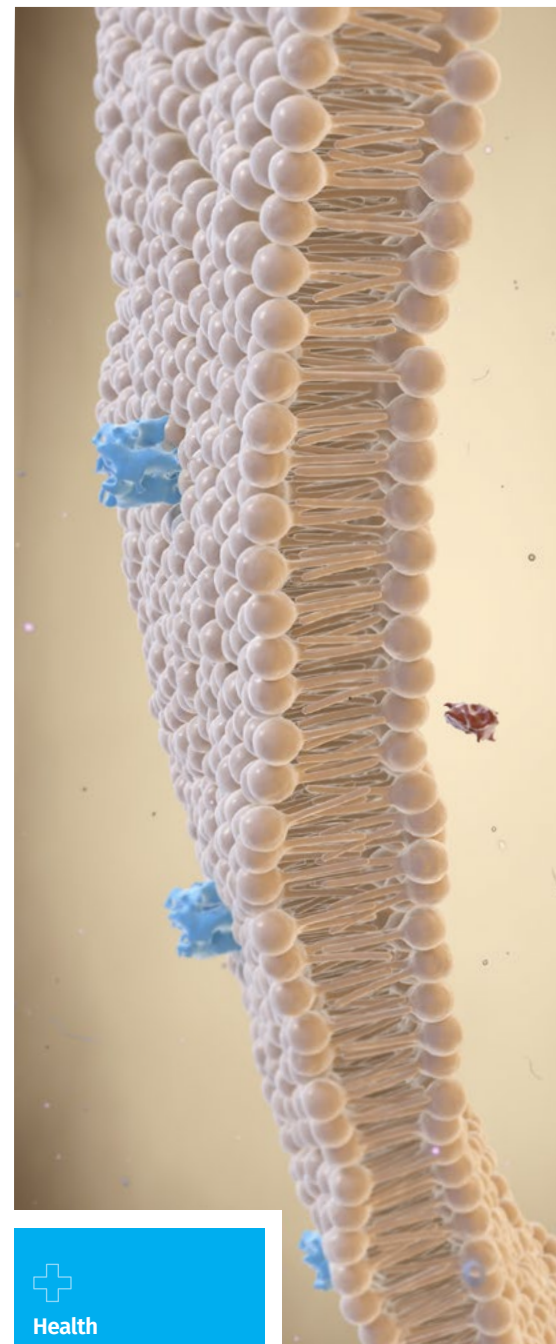
Solution

Deuteration is essential for neutron studies to be able to differentiate between cell membrane components and highlight those of interest. The NDF has developed unique capabilities to provide specifically deuterated cell membrane components including lipids, sterols, and proteins, and is the world leader for provision of these components to the research and industry communities.

Impact

The NDF was part of novel international research studies which:

- investigated the fundamental understanding of how the SARS-CoV-2 (COVID-19) spike protein interacts with cell membranes to enable viral infection and the role of calcium and cholesterol in the infection stage. The research provided valuable insights for the development of future vaccines or more effective therapeutics
- provided novel insight into the removal and deposition of lipids into artery walls and factors of importance for the build-up and reversibility of atherosclerotic plaque, and
- developed a novel method for the fast screening of membrane protein structures which mediate multiple cellular processes, including transport mechanisms of various molecules into and out of the cell. The NDF is the only place in the world that can produce the deuterated molecules (detergents) necessary to enable solution phase small-angle neutron scattering (SANS) structure studies of membrane proteins, which has led to a partnership with the Institut Laue-Langevin (ILL), France.



COLLABORATORS



3.6.5

Platform snapshot

Nuclear Stewardship

LOCATION



ANSTO New South Wales
Lucas Heights Campus



SIGNIFICANT NATIONAL/INTERNATIONAL PARTNERS OR NETWORKS

International Atomic Energy Agency
(IAEA)

Department of Defence

Australian Federal Police
(AFP)

STAFF MEMBERS

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Nuclear Stewardship team capabilities are underpinned by labour-intensive analytical measurement processes.



SUPPORTING

AUSTRALIA'S NATIONAL SCIENCE AND RESEARCH PRIORITIES



Advanced
manufacturing



Cyber security



Energy



Environmental change



Food



Health



Resources



Soil and water



Transport



Platform snapshot

Nuclear Stewardship

The Nuclear Stewardship Platform is a cohesive set of nuclear science and technology capabilities and functions that are either mandated by Government, by regulators, or otherwise considered essential to ongoing ANSTO operations.

The Platform comprises four groups: Radionuclide Metrology, Nuclear Forensics, Radioanalytical Chemistry, and Environmental Monitoring.

A mandated function of Radionuclide Metrology is maintenance of the national standard of measurement for radioactivity (the national Becquerel standard). This supports Australia's nuclear medicine industry and patients.

Government has recognised that ANSTO's Nuclear Forensics capability is essential to fulfilling its policy objectives in relation to counter terrorism, nuclear security and non-proliferation, including regional considerations in South East Asia. The Environmental Monitoring and Radioanalytical Chemistry capabilities are essential capabilities that support ANSTO's research, business, and nuclear operations by providing expert advice, analysis, and data interpretation services on radioactive stack discharges and environmental monitoring.

Capabilities

Radionuclide Metrology services/capabilities:

- primary standards – 4pi Beta-Gamma coincidence counting, liquid scintillation counting
- secondary standards – Ionisation chamber measurements, precision gamma spectrometry, and
- source preparation.

Environmental Monitoring services/capabilities:

- radiological characterisation of stormwater, groundwater, air, soil, and biota for the environmental survey of the Lucas Heights campus and buffer zone
- stack monitoring and plume dispersion modelling to monitor and characterise airborne releases from ANSTO licenced facilities
- operation of the Lucas Heights weather station to provide real-time weather data, and
- open loop wind tunnel for instrument calibration and dispersion and re-suspension research.

Nuclear Forensics services/capabilities:

- high precision alpha and gamma spectrometry
- electron microscopy – SEM, TEM; X-ray fluorescence spectrometry and X-ray diffraction, and
- mass spectrometry – Inductively coupled plasma (ICP-MS); Isotope Dilution (IDMS).

Radioanalytical Chemistry services/capabilities:

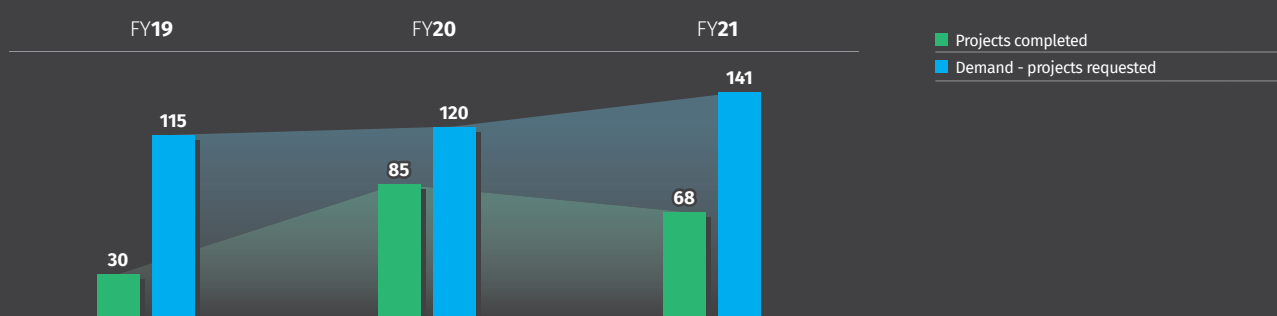
- gamma spectrometry (natural and anthropogenic)
- radioanalytical chemistry/alpha spectrometry/liquid scintillation analysis (U, Th, Pu or Am isotopes by alpha spectrometry; Sr-90 by liquid scintillation analysis)
- radioanalytical chemistry/liquid scintillation analysis (tritium), and
- radioanalytical chemical method development (alpha and/or beta emitters).

Nuclear Stewardship

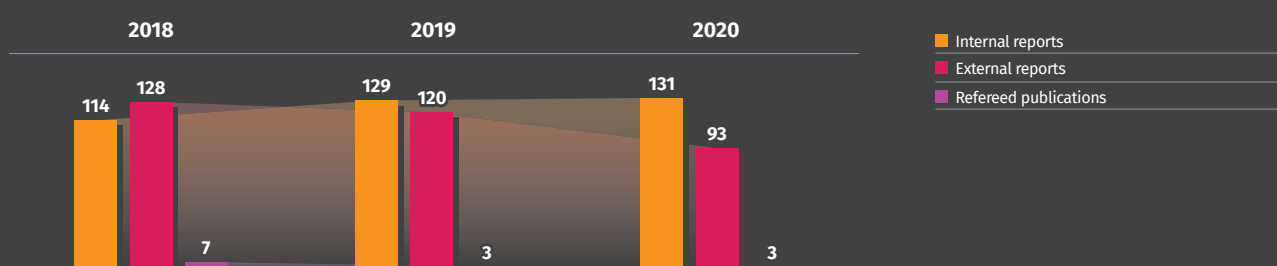
Key metrics

Utilisation of the Nuclear Stewardship capabilities is estimated at 90%. Demand is described as the number of projects requested per year, demonstrating the high demand for Nuclear Stewardship capabilities compared to supply capacity (completed projects).

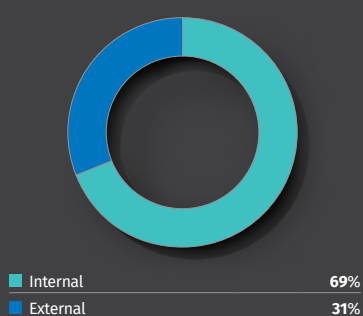
Nuclear Stewardship utilisation and demand



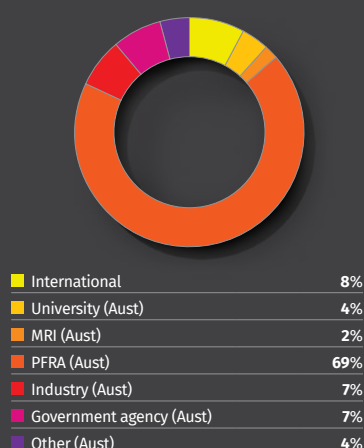
Nuclear Stewardship publications and reports



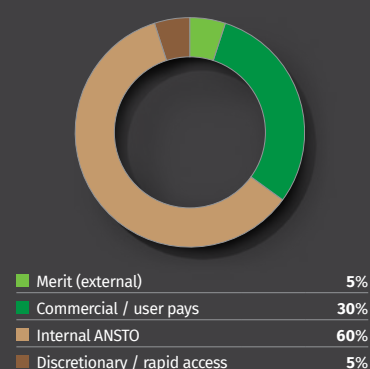
Internal and external users



Users by sector



User access mode



Nuclear Stewardship user profile. Numbers are averaged for three financial years (FY19-FY21) for 640 total users from completed and ongoing projects. PFRA category includes ANSTO users.

Nuclear Stewardship user access mode distribution on average per year for commenced and completed projects.

Platform snapshot

Nuclear Stewardship

CASE STUDY

International measurement traceability for nuclear medicine

Problem

- Radioisotope production relies on measurement traceability to the Australian standard to ensure TGA licencing, regulatory compliance, quality assurance and trade.
- In nuclear medicine, measurement traceability contributes to improved patient outcomes through the accurate and reliable administration of radiopharmaceuticals.
- Accurate metrology is also needed to allow Single-Photon Emission Computed Tomography (SPECT) and Positron Emission Tomography (PET) images to be directly compared to Computed Tomography (CT) and magnetic resonance imaging.

Solution

ANSTO, as the designated Australian institution with the authority to maintain primary and secondary radiation activity standards, provides calibrations services to nuclear medicine practices and industry. To this end, it has developed primary standards for the most widely-used radioisotopes: Technetium-99m (the major radionuclide used for SPECT, comprising 82% of all nuclear medicine procedures); Fluorine-18, (the major PET isotope, used in 10% of procedures); Germanium-68/Gallium-68 (PET); and Copper-64 (PET theranostic).

Impact

ANSTO's radionuclide metrology services have led to improved accuracy and precision in the administration of radiopharmaceuticals, assisted with meeting regulatory compliance obligations and improved patient outcomes. Approximately 100 certificates of traceability and 100 client reports were issued as part of calibration services for imaging radionuclides during 2020.

ANSTO's radionuclide metrology services have led to improved accuracy and precision in the administration of radiopharmaceuticals



Health

CASE STUDY

Minimising hazardous dust generated from mine tailings

Problem

- Mine tailings storage facilities are a potential source of harmful airborne respirable dust particles through the resuspension of dust from their dried surfaces.
- The characteristics of a dried tailings surface will influence the potential for dust generation.
- ANSTO was approached by a client to determine the effect of seven different tailings treatments.

Solution

A series of experiments were run on samples of dried mine tailings surfaces under a range of expected wind speeds, using NST's open-loop wind tunnel. Dust concentrations, including the respirable PM_{10} and $PM_{2.5}$ fractions, were measured with the aim of identifying differences in dust resuspension characteristics between the seven tailings treatments. A light scattering laser photometer was used to measure the respirable particulate concentrations ($PM_{2.5}$ and PM_{10}) downwind of the tailings surface.

Impact

The study demonstrated the importance of maintaining intact crusts on dried tailings surfaces to reduce the potential for dust resuspension. It identified the tailings treatments that were less susceptible to dust resuspension under wind conditions that are typically experienced at the mine site. The project will assist in minimising the human health and environmental impacts from tailings storage facilities.

The project will assist in minimising the human health and environmental impacts from tailings storage facilities



Health



Resources



Soil and water

3.6.6

Platform snapshot

Biosciences

LOCATION



ANSTO New South Wales
Lucas Heights Campus



SIGNIFICANT NATIONAL/INTERNATIONAL PARTNERS OR NETWORKS

National and international biotechnology and pharmaceutical companies

National Imaging Facility (NIF)

Forum for Nuclear Cooperation in Asia (FNCA)

STAFF MEMBERS

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The Biosciences Platform is composed of three groups: Radiochemistry Group, Irradiations Group and Biology and Preclinical Imaging.



SUPPORTING

AUSTRALIA'S NATIONAL SCIENCE AND RESEARCH PRIORITIES



Advanced manufacturing



Cyber security



Energy



Environmental change



Food



Health



Resources



Soil and water



Transport

Platform snapshot

Biosciences

The Biosciences Platform represents a national capability to develop and produce radioisotopes and radiopharmaceuticals, and to evaluate radiopharmaceuticals.

This includes investigating mechanisms of action *in-vitro* and *in-vivo* using preclinical small animal disease models and related technologies. Biosciences is dedicated to supporting a broad research community with a focus on pre-clinical and clinical medical research. The Platform is a repository of core radiochemistry knowledge and expertise that is used in the training of future workforce personnel. ANSTO Business draws on it to assist with product development and troubleshooting. The Platform also partners with innovative biotechnology, pharmaceutical and medical device companies to improve national health outcomes.

Capabilities

Biosciences offers users unique access to an integrated capability portfolio, including radiochemistry, gamma, and neutron irradiations, in vitro and in vivo biology, and preclinical imaging. Until 1 July 2021, the Biosciences Platform operated the National Research Cyclotron Facility at the ANSTO Camperdown campus.

Radiochemistry Group:

- radioisotope research, development, production and characterisation
- radiotracer research, development, production and characterisation
- radiochemistry automation, and
- radioanalytical measurement.

Irradiations Group:

- gamma irradiation – The Gamma Technology Research Irradiator (GATRI) 60Co irradiator
- neutron irradiation – OPAL reactor, and
- elemental analysis.

Biosciences provides research collaborators and industry partners with access to standard and novel radioisotopes and radiotracers for preclinical, clinical and other uses. Biology and preclinical imaging capabilities enable biological research in radiopharmaceutical translation, radiation biology and radiotracers studies.

The neutron activation analysis technique in the OPAL reactor provides elemental characterisation of samples. The high-dose gamma irradiation and dosimetry capability is used for commercial and research applications in key areas of food biosecurity, Australian healthcare manufacturing, advanced materials, space science and national security.

Biology and Preclinical Imaging:

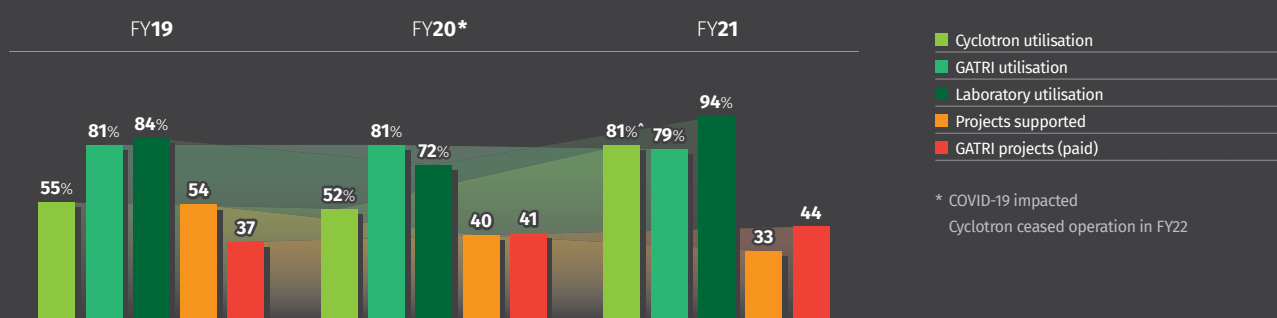
- functional imaging (PET/CT, SPECT/CT, PET/SPECT/CT)
- structural imaging (micro-CT)
- imaging quantification
- radiotracer characterisation and evaluation
- radiotracer studies, and
- radiation biology.

Biosciences

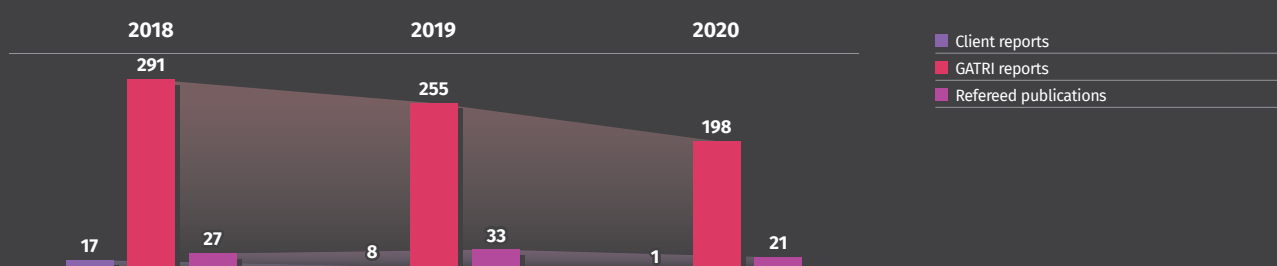
Key metrics

Biosciences utilisation is measured as a percentage of availability and matches demand. GATRI and the cyclotron are presented separately.

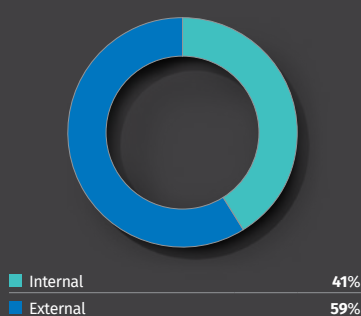
Biosciences utilisation and demand



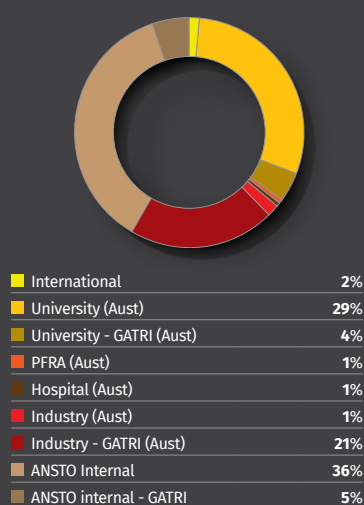
Biosciences publications and reports



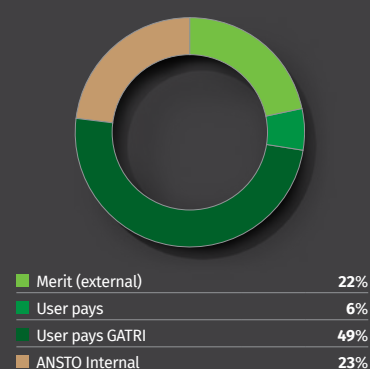
Internal and external users



Users by sector



User access mode



Biosciences user profile. Numbers are averaged for three financial years (FY19-FY21) from a total of 580 unique users from approved proposals. PFRA category includes ANSTO users.

Biosciences user access mode distribution averaged for three financial years (FY19-FY21) for proposals supported.

Platform snapshot

Biosciences

CASE STUDY

Development of new vaccines

Problem

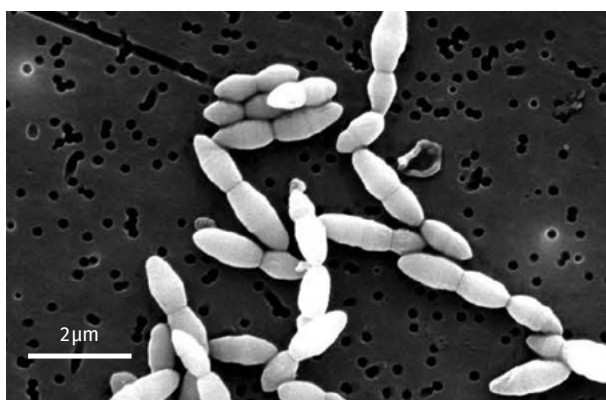
- *Streptococcus pneumoniae* is the world's most prevalent bacterial pathogen. Not only does this bacterium cause infection in the blood and middle ear, it also causes pneumonia and meningitis.
- Each year it is responsible for 1-2 million deaths worldwide, killing more children than AIDS, malaria, and tuberculosis combined.
- Current vaccines have major shortcomings in terms of cost and restricted serotype coverage. They protect against just 13 of the 97 known serotypes of *S. pneumoniae*.

Solution

GPN Vaccines Pty Ltd was established in 2017 to develop and commercialise a new broad-spectrum vaccine against *S. pneumoniae*. When cultured and then inactivated using ANSTO's high-dose gamma irradiation facility, a whole cell pneumococcal vaccine is produced that induces broad-spectrum immunity against all pneumococci, regardless of strain serotype.

Impact

The use of gamma irradiation to create novel universal vaccines shows promise as a breakthrough in the development of a serotype-independent pneumococcal vaccine. The project has resulted in four journal publications and two PhD theses to date.



Electron micrograph of *S. pneumoniae* after irradiation.

COLLABORATORS



Streptococcus pneumoniae
is the world's most prevalent
bacterial pathogen



CASE STUDY

Clinical translation of potential cancer treatments

Problem

- Treatment of metastatic or recurrent urogenital and pancreatic cancers remains a challenge and new treatments are required.
- Glypican-1 (GPC-1) is a protein that becomes elevated in cases of prostate, pancreatic and bladder cancer.
- MIL-38 (Miltuximab) is an antibody directed against GPC-1 but the ability to radiolabel it effectively and safely for clinical use had not previously been demonstrated.

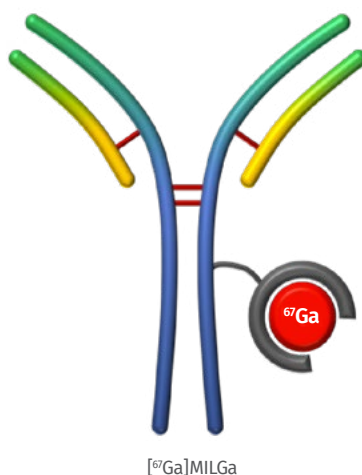
Solution

The study demonstrated that MIL-38 could be successfully radiolabelled with gallium-67 while retaining the form and function of the antibody to target the GPC-1 protein. The product was designated [^{67}Ga]MILGa, the first molecular imaging agent targeting GPC-1. To translate [^{67}Ga]MILGa from the laboratory into the clinic, the study team developed radiochemistry methods, robust radiolabelling conditions, purification, formulation and quality control criteria, and tests to meet stringent quality standards.

Impact

The [^{67}Ga]MILGa agent produced by ANSTO enabled the successful completion of a first-in-human clinical trial. The clinical trial met all primary trial endpoints with no adverse events found in any of the patients. This outcome led to a successful Cooperative Research Centres Projects grant application with ANSTO as a major partner. The grant will provide \$3 million to continue the development of radiotheranostics targeting GPC-1.

The success of the project has demonstrated ANSTO's clinical translation capability. The capability will attract companies in the pharmaceutical and medical devices sector seeking to advance the technology readiness level of potential cancer treatments.



The success of the project has demonstrated ANSTO's clinical translation capability





3.6.7

Platform snapshot

Isotope Tracing in Natural Systems

LOCATION



ANSTO New South Wales
Lucas Heights Campus



SIGNIFICANT NATIONAL/INTERNATIONAL PARTNERS OR NETWORKS

Commonwealth Scientific and Industrial Research Organisation (CSIRO)

Bureau of Meteorology (BOM)

International Atomic Energy Agency (IAEA)

World Meteorological Organisation (WMO)

Australian industry

STAFF MEMBERS

16



ITNS staff operate and develop unique nuclear instrumentation.



SUPPORTING

AUSTRALIA'S NATIONAL SCIENCE AND RESEARCH PRIORITIES



Advanced manufacturing



Cyber security



Energy



Environmental change



Food



Health



Resources



Soil and water



Transport

Platform snapshot

Isotope Tracing in Natural Systems

Isotope Tracing in Natural Systems (ITNS) provides a range of radioanalytical, isotopic and elemental analytical techniques, measurements, and expertise: low level radiometric analysis, stable isotope analysis, and geochemistry and elemental analysis. ITNS is the only provider of low-level atmospheric radon detectors, tritium analysis, Itrax core scanning and lead-²¹⁰Pb dating capabilities in Australia. The suite of complementary analyses available at ANSTO and the Platform's ability to develop techniques for unique problems are a distinct competitive advantage.

ITNS provides analytical support and expertise to ANSTO operational and business units, external commercial clients and industry, enabling them to meet their commercial and regulatory requirements. The broad range of isotopic and elemental analyses, with field measurements, support research outcomes that quantify and/or provide a temporal view of environmental processes (including climate, atmospheric, water resources and soil erosion). Training is provided to post-graduate students and early career researchers in isotopic analysis techniques and methods that are integral components of environmental studies.

Capabilities

ITNS staff operate and develop unique nuclear instrumentation, including world-leading atmospheric radon detectors, detection systems of alpha, beta and gamma emitting radionuclides, stable isotope mass spectrometers and X-ray fluorescence instruments. The Itrax sediment analysis laboratory is an Australia Research Council (ARC)-Linkage, Infrastructure, Equipment and Facilities (LIEF)-funded facility.

ITNS Low Level Radioisotope Analysis (LLRA) facility:

- very low activity, close to background measurement of alpha, beta and gamma emitting radionuclides including uranium, thorium and polonium in environmental samples
- tritium dating of water, and
- ²¹⁰Pb and ¹³⁷Cs dating of sediments.

Stable Isotope Analysis (SIA) facility:

- isotopic ratio analysis of carbon, nitrogen, hydrogen and oxygen on a range of sample types
- expert advice and input to experimental design and in interpretation of results, and
- isotope ratio mass spectrometers (IRMS).

Geochemistry and Elemental Analysis (GEA) facility:

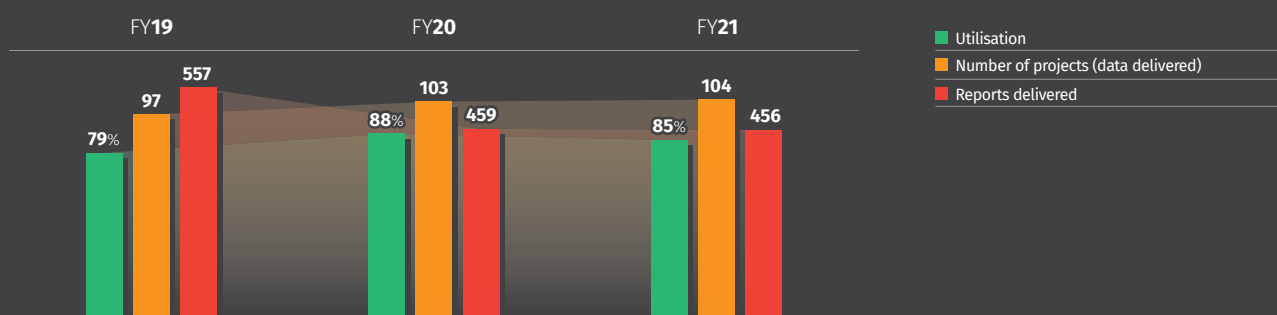
- triple quadrupole inductively coupled plasma – mass spectrometer (TQ-ICP-MS) for rare earth elements, trace metals, and their isotopes
- simultaneous inductively coupled plasma – atomic emission spectrometer (ICPAES) for major and trace metals
- laser ablation unit coupled to the ICPs for high resolution elemental measurements
- anion chromatographs (IC), and
- Itrax X-ray Fluorescence (XRF) core scanner.

Isotope Tracing in Natural Systems

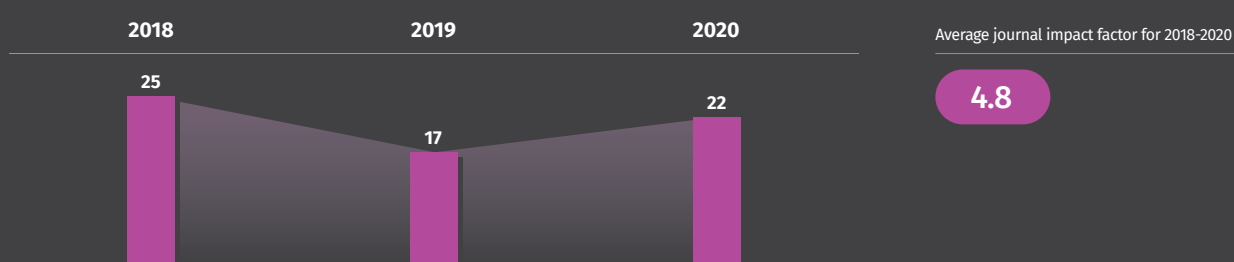
Key metrics

ITNS utilisation is based on average monthly instrument usage over each year. Demand is based on sample analyses delivered compared to analyses requested. For ITNS, this demand ranges from approximately 110% to 600% across the three financial years FY19-FY21, a reflection of available capacity.

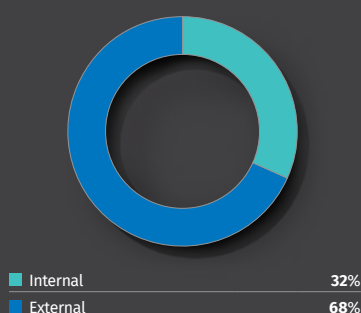
ITNS utilisation and demand



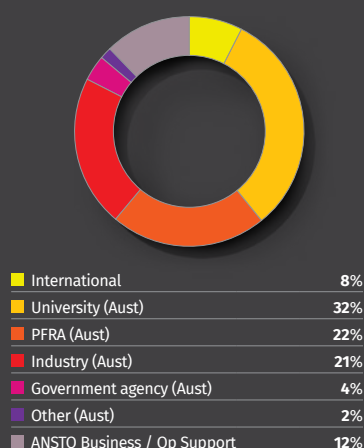
ITNS refereed publications



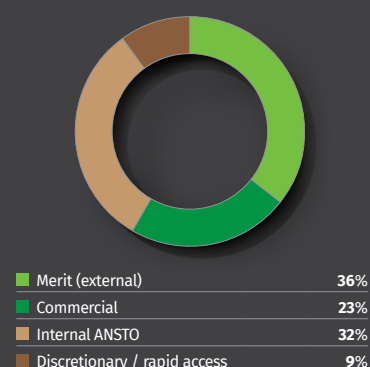
Internal and external users



Users by sector



User access mode



ITNS user profile. Numbers are averaged for three financial years (FY19-FY21) from a total of 369 unique users from submitted portal requests. PFRA category includes ANSTO users.

ITNS user access mode distribution averaged for three financial years (FY19-FY21) from portal requests for which reports were completed in a year. Discretionary/rapid access includes partial access payment, commonly under collaborative research arrangements. Commercial includes full cost access from all user types including industry and universities.

Platform snapshot

Isotope Tracing in Natural Systems

CASE STUDY

IAEA Global Network of Isotopes in Precipitation (GNIP)

Problem

Tritium and stable water isotopes are important tools for assessment of the age and origin of groundwater and water resources in the present and past. They are also used in paleoclimate, climate modelling and isotope ecology studies nationally and globally. However, to enable these applications, longitudinal data and spatial models of tritium and stable isotopes in rainfall are required across Australia and globally. The short-term funding model of universities does not allow these long-term datasets to be maintained.

Solution

ANSTO operates a national network, as part of the IAEA Global Network of Isotopes in Precipitation (GNIP), to provide rainfall isotopic time series data and to enable monitoring of nuclear activities in our region. Other participants include Agency/World Meteorological Organisations, Australian Bureau of Meteorology, CSIRO, and the Environment Theme. The sampling network is managed jointly by ITNS and the Environment Theme. ITNS provide stable isotope analysis (oxygen-18) and have developed Australia's only low-level tritium capability, which has achieved detection limits amongst the lowest in the world.

Impact

Australian data from 1963 onward is available for download from GNIP or by request to ANSTO. Data was used in ~35 ANSTO co-authored publications in the past decade and in ~25 commercial and contract research reports. More than 2,000 Australian and global publications reference the Australian network and GNIP.

Tritium and stable water isotopes are important tools for assessment of the age and origin of groundwater



COLLABORATORS



Australian Government
Bureau of Meteorology

Allowing the mining industry to understand and manage their impact on the environment

CASE STUDY

Managing impact on the environment

Problem

Community concerns and regulatory requirements to minimise the impacts of coal mining, coal seam gas (CSG) extraction, and hydraulic fracturing have led these industries to seek ANSTO expertise in the measurement of low-level radionuclides and environmental tracers present as contaminants in water and air.

Solution

ITNS provides measurements of low-level radionuclides, stable isotopes and trace elements to the mining industry to allow them to understand and manage their impact on the environment. ITNS:

- provides low-level tritium analysis of water from mining operations and groundwater
- performs low-level analysis of radium, uranium, and thorium in water at coal seam gas (CSG) sites
- has deployed radon detectors to measure radon in air from CSG sites, and
- provides measurement of stable water isotopes at coal mining sites.

Partners and collaborators include the Gas Industry Social and Environment Research Alliance (GISERA – CSIRO and Australia Pacific LNG), and NSW Sydney Basin coalfields operators. The project has generated commercial revenue of over \$200K per year to ITNS over the past five years and hundreds of confidential analytical reports to clients.

Impact

Improved scientific basis for CSG and coal mining water and emissions management in Australia, particularly in the Sydney (NSW), Surat (Qld) and Beetaloo Basins (NT).

COLLABORATORS



Resources



Soil and water



Environmental change



3.6.8

Platform snapshot

Nuclear Materials Development and Characterisation

LOCATION



ANSTO New South Wales
Lucas Heights Campus



STAFF MEMBERS

22



NMDC staff support ANSTO's core functions of nuclear materials processing and characterisation and the development of advanced materials.



SUPPORTING

AUSTRALIA'S NATIONAL SCIENCE AND RESEARCH PRIORITIES



Advanced manufacturing



Cyber security



Energy



Environmental change



Food



Health



Resources



Soil and water



Transport

Platform snapshot

Nuclear Materials Development and Characterisation

The Nuclear Materials Development and Characterisation (NMDC) Platform supports ANSTO's core functions and maintains a sovereign capability in nuclear materials processing and characterisation for Australia.

NMDC enables the synthesis, processing, engineering, and characterisation of the structure-property relationships of nuclear relevant materials. Both radioactive and nonradioactive work can be conducted within its large suite of material processing and characterisation infrastructure. Engineering of materials up to the pilot plant scale is a unique feature, which involves expert skills, specialised instrumentation, and facilities to ensure safety.

The Platform is predominantly directed to fulfilling ANSTO thematic research and waste form development projects, business, and operational needs. It provides a small number of services directly to commercial clients, other national laboratories and international agencies.

Capabilities

NMDC has a broad set of capabilities focused upon synthesis, processing, characterisation, modelling, and theoretical aspects that underpin research and the development of advanced materials. The Platform is the only licenced and permitted infrastructure in Australia with expertise to handle a wide range of complex radioisotopic, physical and chemical forms of materials. Specific capabilities include:

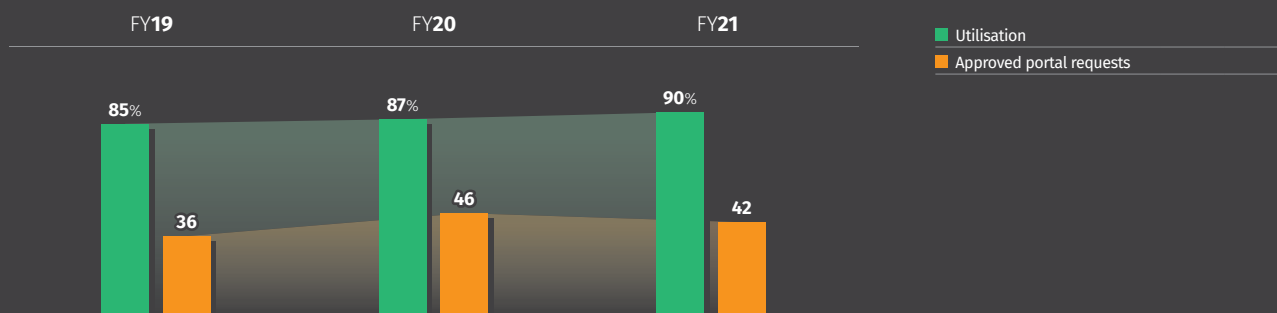
- Actinide Suite – actinide materials handling facility
- Materials Fabrication Bay (MFB) for active materials handling and characterisation including X-ray diffraction and scanning electron microscopy (SEM) with microanalysis capability
- non-active sample X-ray diffraction
- post-irradiation examination infrastructure including hot cells and materials testing
- non-active materials and chemical processing and characterisation
- non-active materials testing including tensile, creep, fatigue and hardness
- Electron Microscopy Facility – TEM and FIB-SEM, and
- metallography and sample preparation capability.

Nuclear Materials Development and Characterisation

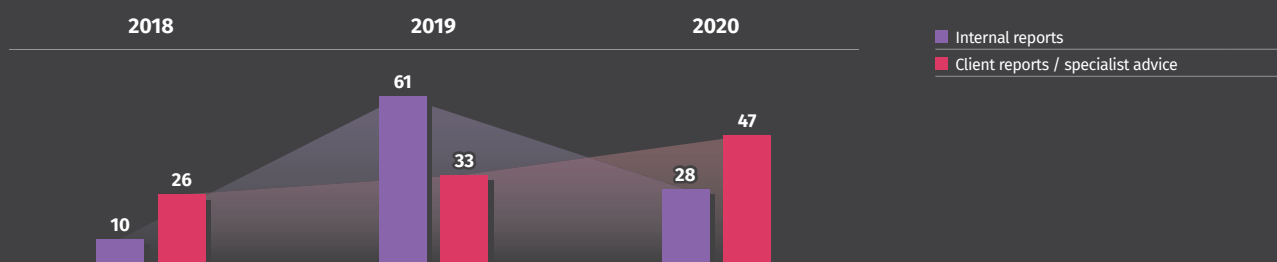
Key metrics

NMDC utilisation is estimated by laboratory capacity utilised for approved portal applications/proposals from the laboratory capacity available.

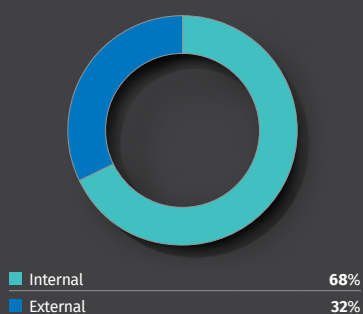
NMDC utilisation and demand



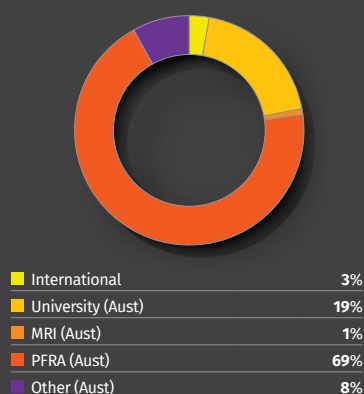
NMDC reports



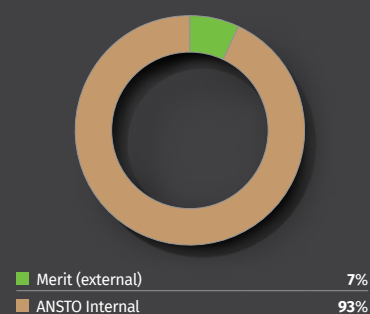
Internal and external users



Users by sector



User access mode



NMDC user profile. Numbers are averaged for two financial years (FY20 and FY21) from a total of 222 unique users from approved portal requests.

NMDC user access modes distribution averaged for two financial years (FY20 and FY21) for approved proposals.

Nuclear Materials Development and Characterisation

Provides ongoing safety and integrity assurance for OPAL

CASE STUDY

The OPAL materials surveillance program

Problem

- The OPAL multi-purpose reactor is the most important national nuclear facility operated by ANSTO.
- OPAL's structure is subject to neutron irradiation and its material properties change over time.
- Along with the routine maintenance there is a specific requirement to assess the effect of neutron irradiation on the materials that make up the core components of the reactor.

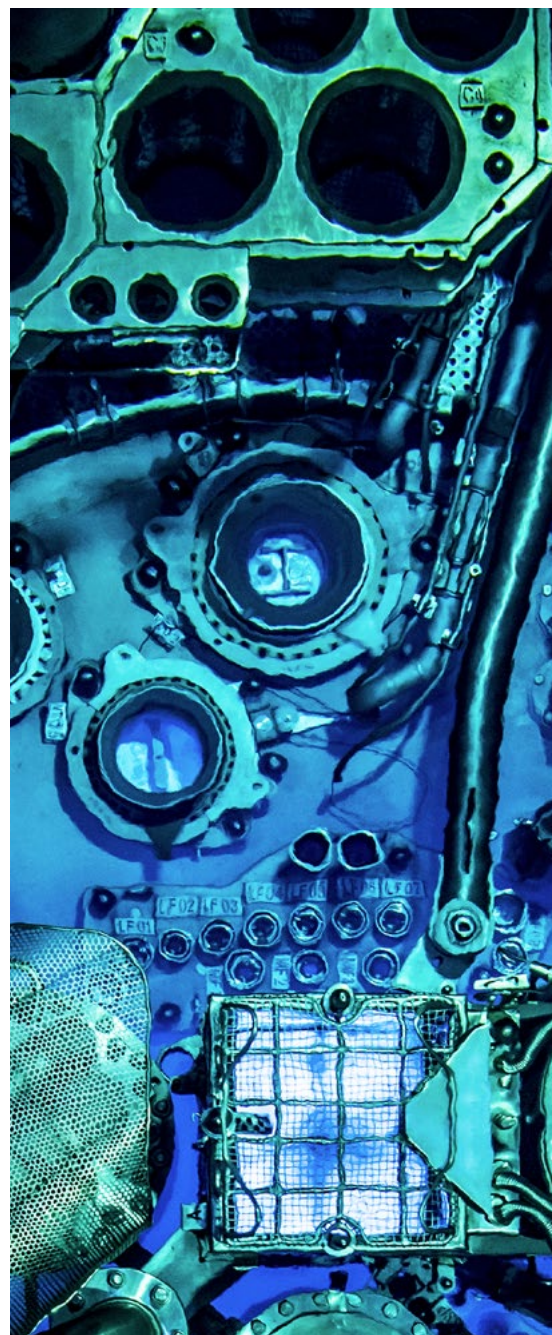
Solution

The OPAL Materials Surveillance Program, conducted within NMDC, has the important goal of providing support-based research, root cause and structural integrity analysis for the stewardship of the OPAL reactor. To achieve this objective, NMDC:

- provides and maintains the hot cell facility and skills for Post Irradiation Examination (PIE) in special radioactively shielded hot cells
- periodically removes samples from the reactor and tests them to assure structural integrity, and
- uses international best practice methods for the analysis modelling and fracture mechanics of nuclear components to predict the remaining life of reactor components.

Impact

The OPAL Materials Surveillance Program provides ongoing safety and integrity assurance for OPAL, to forecast, maintain, and assure the safe operation of the OPAL reactor core components for its 40-year design life and potentially beyond. The program has enabled the life extension of the cold neutron source moderator, performed fatigue analysis and damage estimation of the Control Rod Guide Box pins, and has led to the development of irradiation damage acceptance criteria for the cold neutron source vacuum containment.



The ability to diagnose complex material failure problems 'in-house'

CASE STUDY

Materials in extreme conditions

Problem

ANSTO operates complex plant and equipment, much of it working in extreme conditions of radiation, corrosive environments and high temperature and pressure. The need to provide a prompt diagnosis of the cause(s) of materials failure of components working in such environments is a significant challenge.

Solution

The NMDC team operates a suite of materials characterisation tools, including high-end electron microscopy, chemical analysis and processing, and structural materials testing, in both inactive and radioactive laboratories. Many of these facilities and capabilities, and their ability to handle radioactive material, are unique in Australia. Projects include:

- characterisation of corrosion of Waste Operations drum driers
- identification of blockage in ANSTO Nuclear Medicine (ANM) process tubing
- remaining life assessment of metallic liquid waste storage tanks
- identification of debris recovered from the reactor pool of OPAL, and
- assessment of failure mechanisms of Hot Cell manipulators.

Impact

The ability to diagnose complex material failure problems "in-house" enables a rapid and focused analysis of materials failure and root cause in support of ANSTO's critical infrastructure, including the nuclear medicine production facilities.



Summary of the consultation surveys

More than 260 staff completed the internal survey with 67% respondents from Platforms, 21% from Themes, and 12% from other areas. The survey featured ample opportunity to provide written comments. Staff made good use of this feature by submitting more than 6,000 responses.

The external survey attracted over 800 responses, primarily from AS and ACNS users, with around 75% from universities (see Figure 4.1). To avoid the large number of AS and ACNS responses skewing interpretation of the data, many responses from the external user community survey are broken down into "ACNS and AS" and "Other Platforms" groups. The external respondents were almost evenly split between those who have worked with ANSTO for less than or more than five years.

The survey also attracted feedback, ranging from positive to negative but constructive. Positive comments included:

"The big-ticket facilities managed by ANSTO provide me with a fantastic opportunity to leverage my research."

"I am very much looking forward to using the new beamlines at the Synchrotron."

"Facilities and personnel at the ACNS are exceptional!"

"ANSTO have been of tremendous help to our museum through their in-kind support in scanning fossils which has greatly increased our ability to bring new discoveries and science to the public."

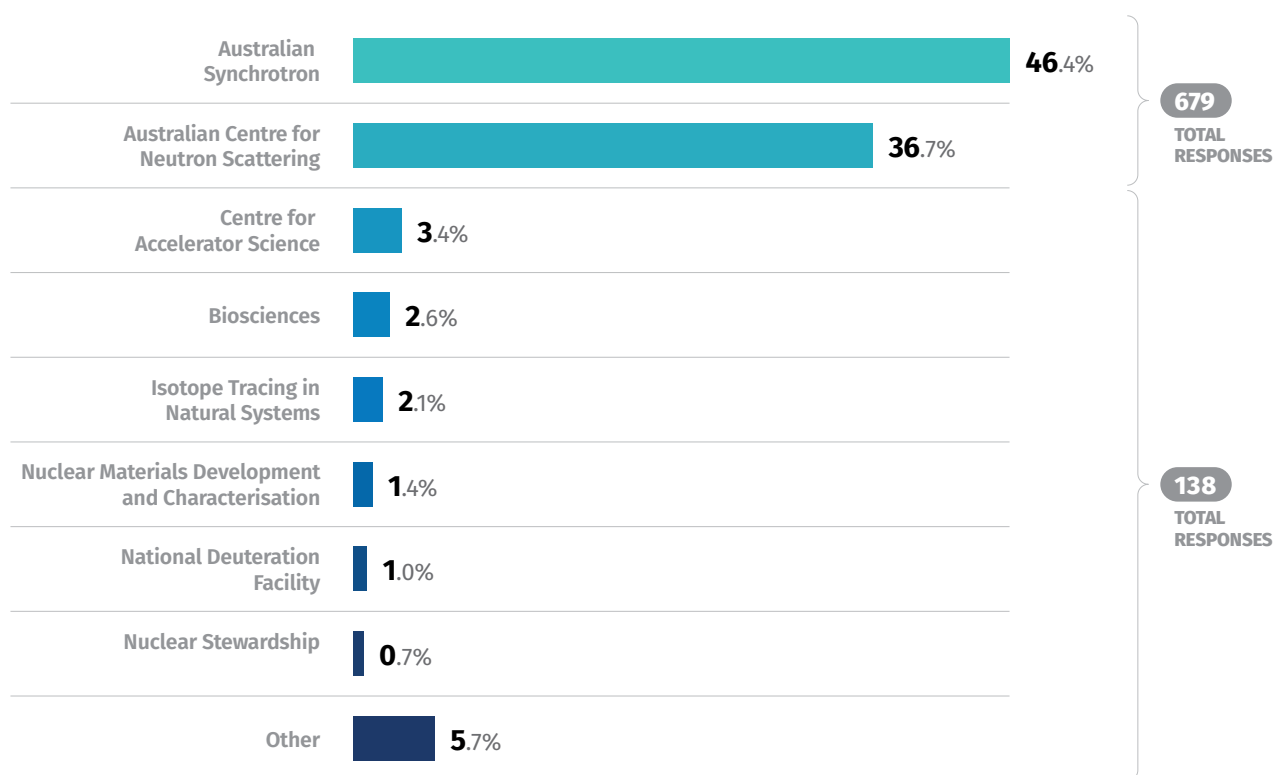
Some respondents felt that the survey, as such, limited thinking and missed a connection to the community. There were also some comments about barriers encountered by our external users. Concerns expressed included the need for more funding for ANSTO infrastructure, issues with the proposal review system, and barriers imposed by ANSTO processes and procedures. Some examples include:

"Both the User Office experience and the ANSTO webpages have deteriorated significantly in the last 5 years."

"It seems that ECRs barely have a chance to get proposals accepted, especially on very busy beamlines when they are [Principal Investigator] on the proposal."

"There is a need for much greater agility in handling small amounts of nuclear and/or radioactive material. It is paradoxical that [a] university can handle these materials better and faster than ANSTO."

ANSTO responses



Institutions surveyed

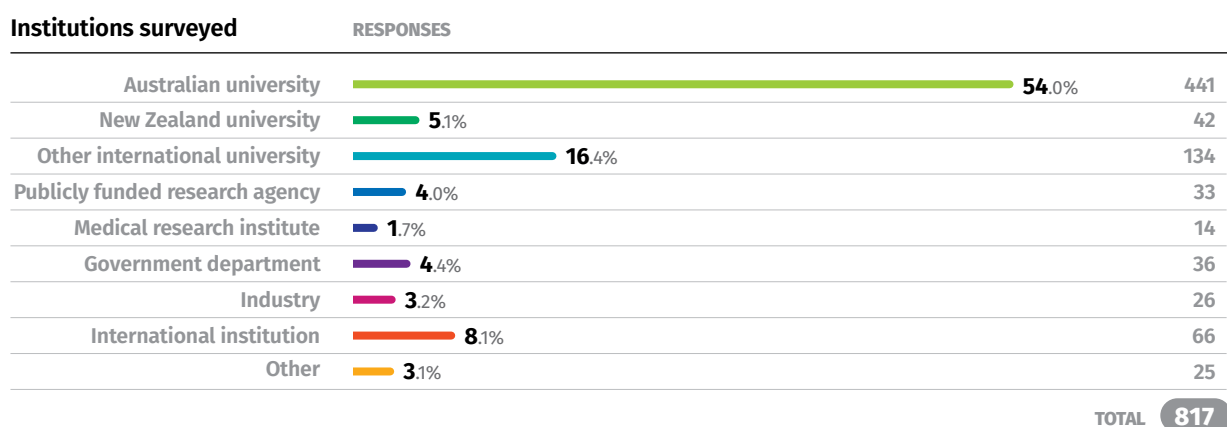


Figure 4.1:

Breakdown of external survey responses by research infrastructure most used (top) and by institution type (bottom).

Respondents also made a range of suggestions about how to improve or develop ANSTO research infrastructure and the user experience, for example:

"[...] more resources need to be invested in sample environments, because this is where high end research is often done."

"Short, focused webinars throughout the year would help us understand what we can do at ANSTO and how to access facilities."

"Victorian users should also be provided with free accommodation" and "Funding for staying at the guesthouse for those of us who live in Sydney, but more than an hour away would help."

"The NDF is unique in the world and this should be recognised with increased support so they can help maintain their place as a world leader in deuteration."

"Proper remote access to experiment[s] is a must especially with the current global pandemic. Other international facilities (synchrotrons) currently offer full remote beamline access."

"National core research infrastructure facilities could be partnered with better as they often have analogous capabilities and could act as conduits for research activity at the synchrotron."

"ANSTO research infrastructure is one of the most important instruments to fundamental and applied innovation in our country. Its possibilities should be advertised much more broadly and aggressively to R&D departments in many industries."

"In addition to supporting academic research projects and students in health care areas, ANSTO should invest part of its resources in partnering and collaborating with eligible partners in healthcare. It should integrate and build on its strengths in radiopharmaceutical development programs and engage with the community on major projects that deliver good value, recognition and acceptance globally."

Networks and collaborations

The internal survey revealed ANSTO staff valued building networks and relationships highly, both nationally and internationally. National networks were not specifically covered in the survey; however, there was a broad appreciation of the opportunities presented by collaboration with other organisations, as evidenced by the responses to questions on partnership opportunities for ANSTO. National partnerships suggestions included:

- universities for research collaboration, students and joint grant opportunities (the most common response group)
- complementary skills or infrastructure, e.g. CSIRO/DATA61 and NCI for software and HPC

“Partnership with CSIRO scientific software experts to collaborate on data processing”

“The ACNS should partner with the National Computing Infrastructure, including the Pawsey Centre, and aim to be an early adopter of quantum computing”

“CSIRO is investing heavily in scientific computing capabilities and is ahead of the curve in this area”, and

- industry for linkage grants and specific sectors such as pharmaceuticals

International networks were a focus area for ANSTO staff. Knowledge of ANSTO’s engagement with international organisations and networks seems quite uneven. Whereas many respondents were aware of links to the IAEA and synchrotron/neutron networks, only 16% of Platform respondents and almost half the Theme/Business unit respondents were aware of any international linkages.

Despite the variable knowledge of ANSTO’s international linkages, there was a reasonably consistent appreciation of how such links create value. Common themes were: an exchange of experience, technology, software and personnel (including early career researchers and students); benchmarking against the world’s best; organising and participating in conferences and schools; and enhancing ANSTO’s international reputation.

There was no clear theme among the answers relating to the international networks or entities that ANSTO should join. The question was answered by less than 20% of Platform respondents, and one third of those who answered made no suggestions.

Figure 4.2 shows the responses on how to best to deepen ANSTO’s international connections. One third of respondents selected “other”, with a consistent theme of better enabling personal engagement internationally by conference attendance, support for membership and office holders in international organisations, or staff exchanges such as sabbaticals.

ANSTO staff, who are involved in international networks, were asked to rate the effectiveness of ANSTO’s international engagement (see Figure 4.3). The question was answered by 105 out of 261 respondents, who rated effectiveness from zero (not at all effective) to 100 (extremely effective). The external survey did not address the area of international engagement as directly as the internal survey. However, two questions did give some insight into the external view of ANSTO collaboration: “Which research areas would you like to partner with ANSTO?” (Figure 4.4), and “Which of the following are significant barriers to your engagement with ANSTO research infrastructure?” (Figure 4.5).

How to best deepen international connections

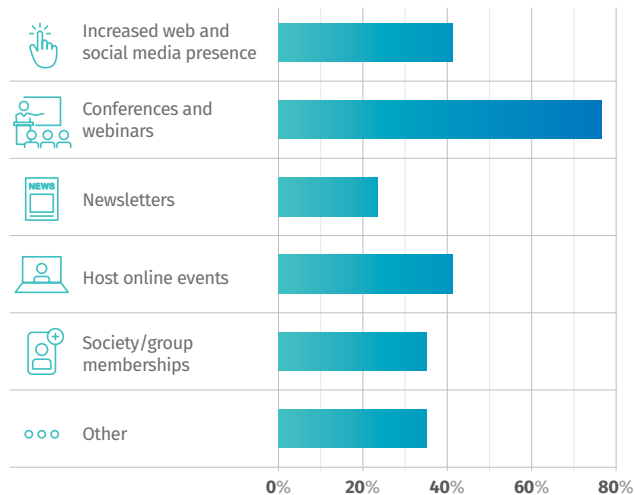


Figure 4.2:
How to best deepen ANSTO's international connections (respondents were asked to check all options that applied to them).

Effectiveness of international engagement

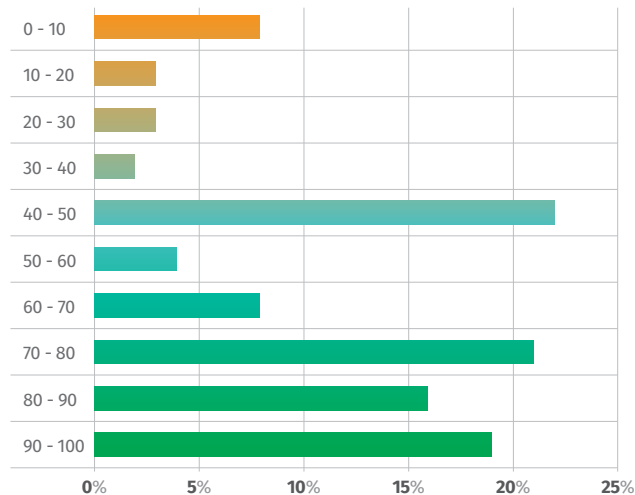


Figure 4.3:
How effective are ANSTO's international networks. Rated from 0, not at all effective, to 100, extremely effective.

Potential partnerships

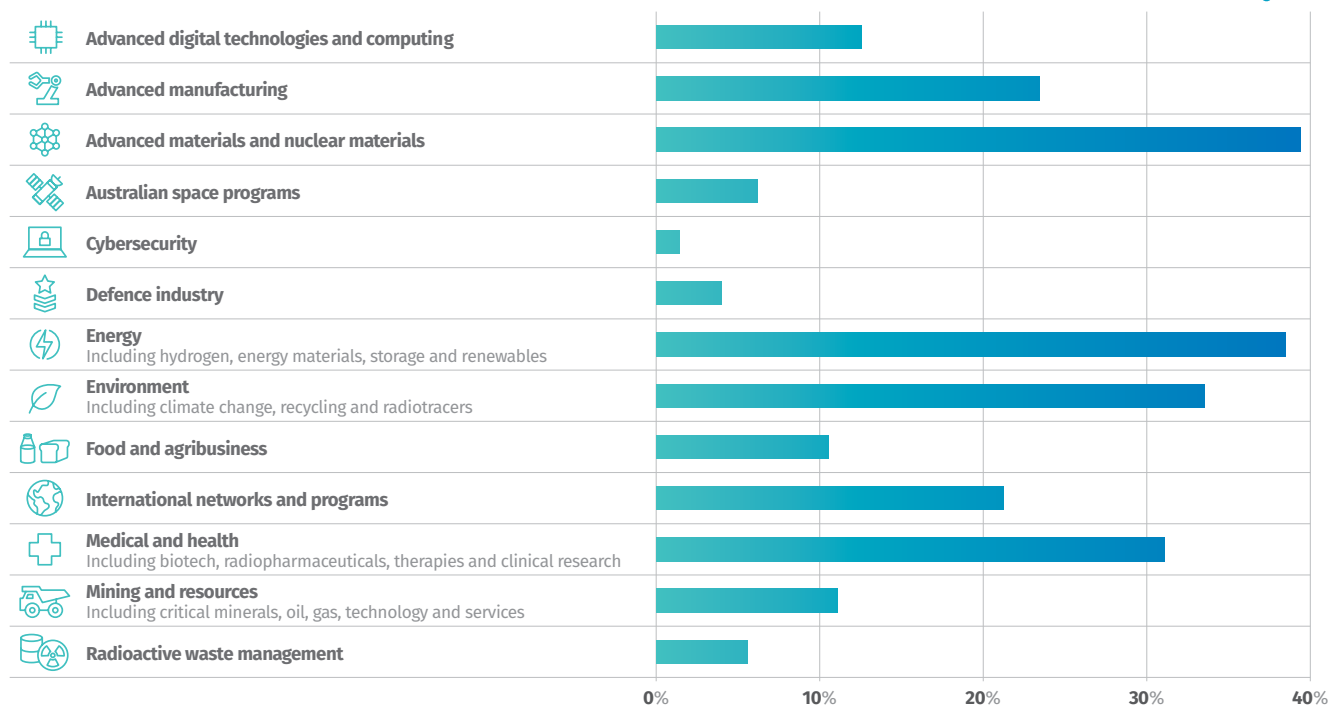


Figure 4.4:
External responses to the question in which areas they would like to partner with ANSTO.

Responses to the first question “Which research areas would you like to partner with ANSTO?” were reasonably consistent between large user facilities and smaller Platforms, with many key Australian priorities featuring prominently. This feedback was also broadly consistent with the closely related question “What priority areas should ANSTO be involved in” (see also [Section 4.3](#)).

ANSTO’s international engagement and networks were not explicitly addressed in the external survey, except that “International networks and programs” was one choice in the set of three questions addressing research priority areas. In each case, roughly 25% of respondents chose international networks as a priority area for national benefit, or as an area where they would like to partner with ANSTO.

The second question on barriers gives some insight into externally perceived difficulties in collaborating with ANSTO (Figure 4.5). Putting aside the user convenience items, notable features are a high level of satisfaction with the user office, some dissatisfaction with the proposal submission system (the portals) and the security clearance processes, and a very significant call for improvements to remote access infrastructure.

Barriers to engagement

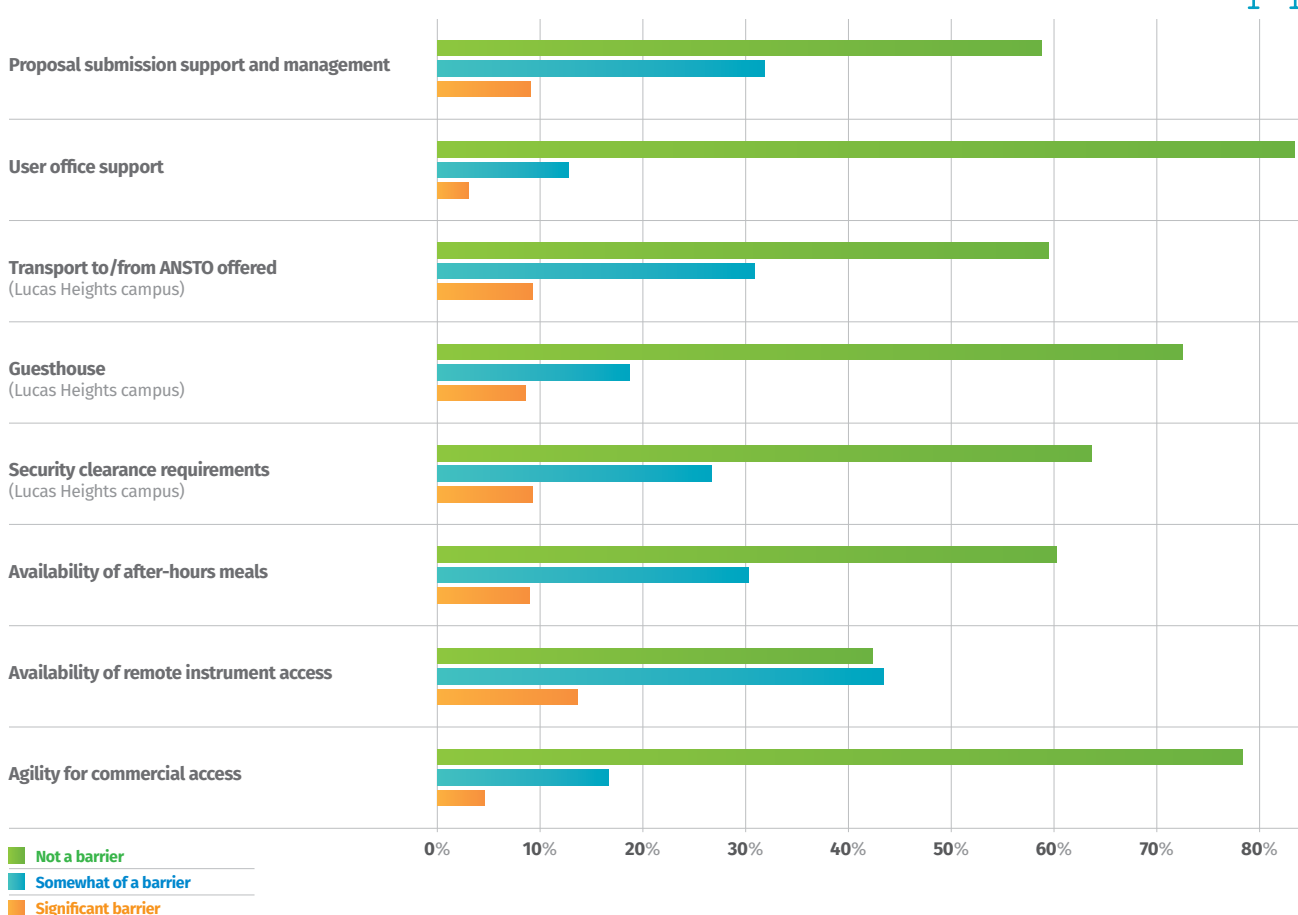


Figure 4.5:
Barriers to engaging with ANSTO.

4.2 People, staff, and skills

Staff expressed a need to develop a diverse and inclusive STEM workforce. Equally, pathways to support and engage students and early career researchers, locally or in partnership with organisations abroad, were seen as important. The mental health and wellbeing of staff was also flagged, as was a desire for a workplace where trust is placed in the ability and expertise of staff.

ANSTO staff considered it important to develop skills and networks. This was in part expressed through a desire for improved internal collaboration and communication. Some staff also articulated that they need greater awareness of capabilities available across Platforms or ANSTO.

There was a recognition that developing skills should not only occur on-campus. Support to attend conferences and workshops was emphasised accordingly. Similarly, staff commented that there is benefit in formal affiliations with universities and that building skills should also include support for international connections and short-term postings.

ANSTO staff identified a range of specific areas in which they wished to develop or acquire skills (see also Figure 4.6):

- handling and managing radioactive and nuclear materials
- radiochemistry and synthetic chemistry
- advanced digital skills in data processing, scientific computing, modelling, simulation, and automation
- artificial intelligence and machine learning
- biotechnology and bioengineering
- X-ray and neutron optics, instrumentation, and detectors
- accelerator physics and technologies
- controls and electronics engineering and technical support, and
- electron microscopies and associated technical support

Respondents to the external survey commended ANSTO on its people, their skills, expertise, and engagement and noted that ANSTO staff are the organisation's greatest asset. Continuous development and training of people was strongly supported. Users of the AS and the ACNS emphasised corresponding technical skills, while other respondents highlighted radiochemistry and synthetic chemistry skills. Across all Platforms, there was a recognition that ANSTO staff need skills relating to instrument detectors, possibly because detectors are typically visible to users and closely connected to their experience.



4.3 Research and science drivers

Internally, a broad range of science fields resonated with staff, including environment and climate change, health and food, and medical and pharmaceuticals featuring prominently, along with energy and space. In this part of the survey, some staff

also expressed the desire to form national and international partnerships and networks across a range of fields, including those mentioned in [Section 4.1](#).

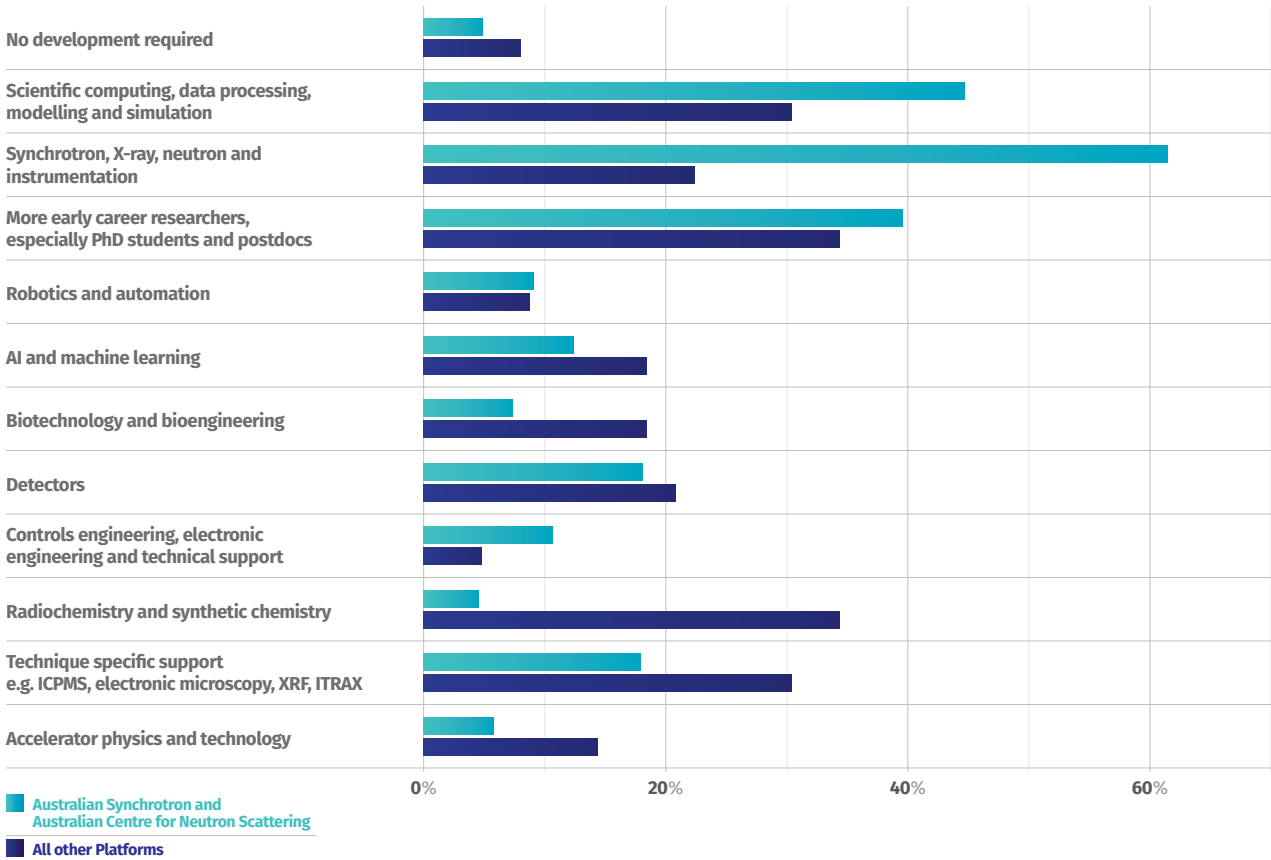


Figure 4.6: Breakdown of areas where external survey respondents see opportunities to develop NST Platform staff skills.

The external survey responses reflected these trends (see top four nominated areas in Figure 4.7). There were some differences between respondents who used the ACNS or AS and respondents connected to the “other Platforms”. Most prominently, health and environment rated higher as priorities for the “other Platforms”, compared to energy and advanced materials for ACNS and the AS. These differences are likely to reflect the makeup of ANSTO’s user communities. For example, research into high-performance batteries is one of the present drivers for user uptake of synchrotron and neutron techniques.

External respondents also generally expressed a desire to partner with ANSTO in those four areas, although the trends were less prominent for this question. Interestingly, users thought that ANSTO should have some involvement with cybersecurity but they did not see themselves working with ANSTO in this field (compare to Figure 4.4).

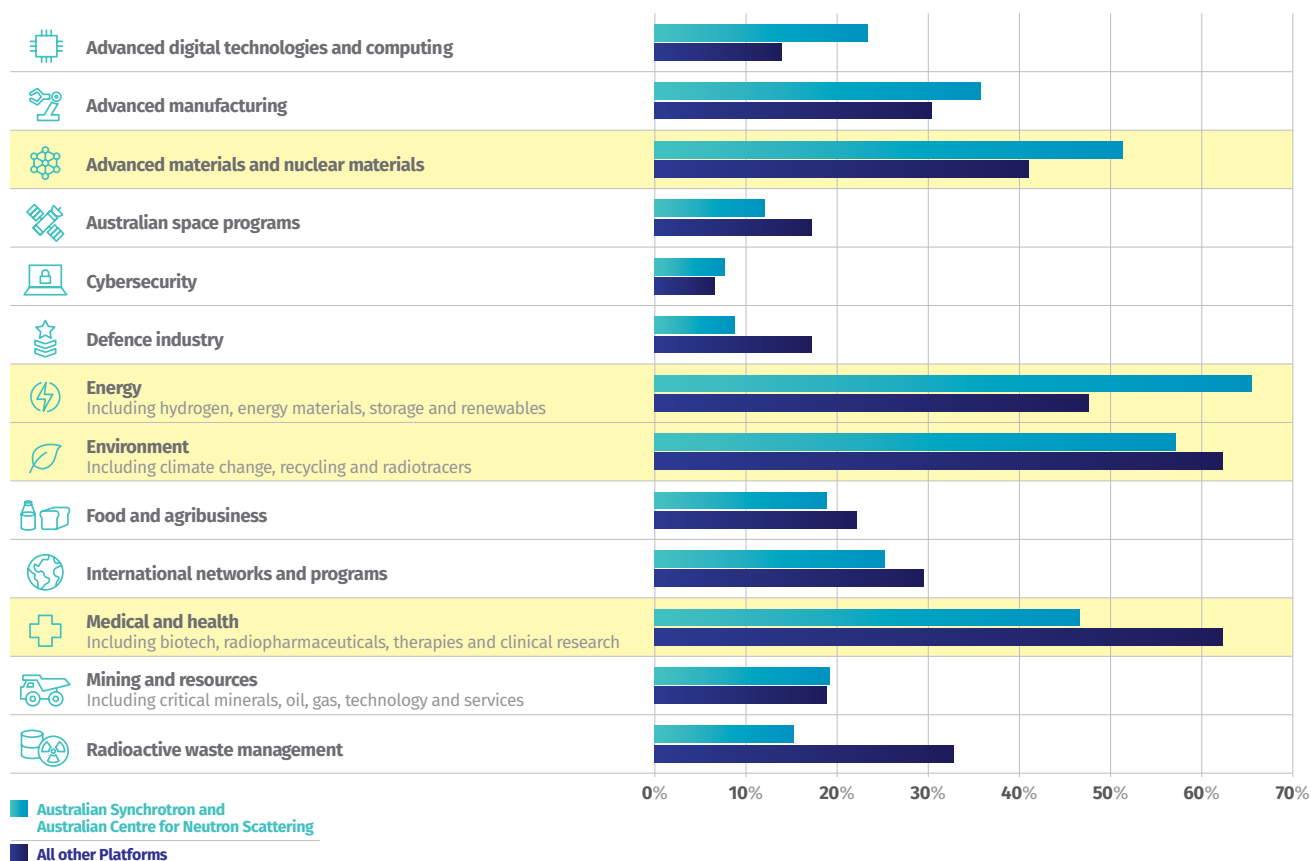


Figure 4.7:
Breakdown of priority areas which external responses would like ANSTO to be involved in (top 4 areas highlighted).

4.4 Technology drivers and opportunities for renewal and investment

The need for continual upgrades to ANSTO's infrastructure was a common theme, as was the need to better inform stakeholders of plans and capabilities.

The internal survey contained two linked questions relating to emerging infrastructure opportunities. Responses were grouped into themes and are presented in the following Table 4.1 with a colour coded number of responses in each group. In addition to specific new infrastructure, popular choices included robotics and automation of instruments, High Performance Computing (HPC), Artificial Intelligence (AI), data analysis and software development and detectors.

Table 4.1:

(a) Emerging technologies and (b) investment options, summarised from free-text fields in the internal survey. The numbers indicate how often the corresponding area was mentioned by staff. The highlighted light blue items with a blue tick were included in the external survey.

(a) What are the emerging technologies and techniques relevant to your field of research?

GROUPING	COUNT
High performance computing and software development	8
Novel accelerators / next gen light source	9
Artificial intelligence and machine learning	8
New synchrotron techniques and beamlines	7
Electron microscopy	8
Mass spectroscopy (ICPMS etc)	5
Materials treatment / processing / fabrication	9
Nuclear medicine	11
Radiation therapy	6
Data processing	11
Data acquisition	7
E-science / information systems	5
Detectors	13
Medical imaging	10
Robotics and automation	17
Irradiations / hot cells	3
Ion accelerator techniques and instrumentation	6
Neutron optics / instrumentation	6
Chemistry / biology facilities	11
Environment	5
Materials characterisation	8
Society impacts	6
Space applications	4
Other research areas / measurement	7
Other	1

 Included in external survey

The internal responses were used to refine a set of options for the external survey, indicated by the blue highlighted groups. The internal survey also recorded ANSTO staff opinions on the drivers for changes in demand. Responses were grouped into themes and are summarised in Table 4.2. The table is dominated by drivers for increased demand, which was answered by 40% of Platform respondents.

(b) Considering emerging technologies, what opportunities are there for ANSTO to develop new techniques or capabilities to serve internal and external users?

GROUPING	COUNT
High performance computing and software development	8
Novel accelerators / next gen light source	1
Artificial intelligence and machine learning	2
New synchrotron techniques and beamlines	3
Electron microscopy	3
Mass spectroscopy (ICPMS etc)	6
Materials treatment / processing / fabrication	2
Nuclear medicine	6
Radiation therapy	3
Data processing	5
Data acquisition	1
E-science / information systems	0
Detectors	9
Medical imaging	2
Robotics and automation	9
Irradiations / hot cells	2
Ion accelerator techniques and instrumentation	7
Neutron optics / instrumentation	11
Chemistry / biology facilities	7
Environment	2
Materials characterisation	5
Society impacts	1
Space applications	2
Other research areas / measurement	4
External collaboration / partnership	9
Staff development	9
Concentrate on current facilities first, resourcing	10
General / multiple categories	9
Big facilities	7
User related	6
Not clear or unhelpful	11

Table 4.2:

Drivers for change in demand, summarised from free-text fields in the internal survey. The numbers indicate how often the corresponding area was mentioned by staff.

What are the drivers for the increase / decrease in demand or capacity?

GROUPING	COUNT
Domestic demand	13
International demand	13
ANSTO drivers / internal demand	20
ANSTO unique capabilities and skills	25
User driven – requirements / needs	16
Industry needs / commercial opportunities	21
National capability gap	9
International trends	4
ANSTO capability gap or improvement opportunity	19
New science / techniques	20
New ANSTO capability is driving increased demand	10
Computing / software drivers and gaps	9
Decreased demand drivers and organisational barriers	14
Underutilised capability	3
User / stakeholder engagement	16
More staff / capacity needed to meet demand	22
National interest and priorities	17
Not sure what is meant; unsure of relevance to demand / capacity	29
COVID-19	2

The external survey respondents were also presented with a list of technologies and technique investment options informed by the response to the internal survey (Figure 4.8). Given the dominance of responses from users of the large user Platforms (83% from ACNS and AS), the data were broken into the two groups shown in Figure 4.8. The differences in the data were primarily what would be expected (e.g. new synchrotron and neutron techniques were more popular with AS and ACNS users).

However, it was interesting to note that:

- HPC, AI, machine learning scored highly in both groups
- a desire for isotope and radiochemistry capabilities was the highest priority for “other Platform” users. Coupled with “Novel accelerators/next-generation light source” unexpectedly being a more popular choice for users of the “other Platforms”; this may point to a desire for novel accelerator produced isotopes, and
- while lab scale instrumentation (the advanced characterisation and lab scale imaging groups) was more popular with the “other Platform” group as expected, the AS and ACNS combined group are very keen on new electron microscopy capabilities (4th highest choice, compared to 10th choice for the other Platforms).

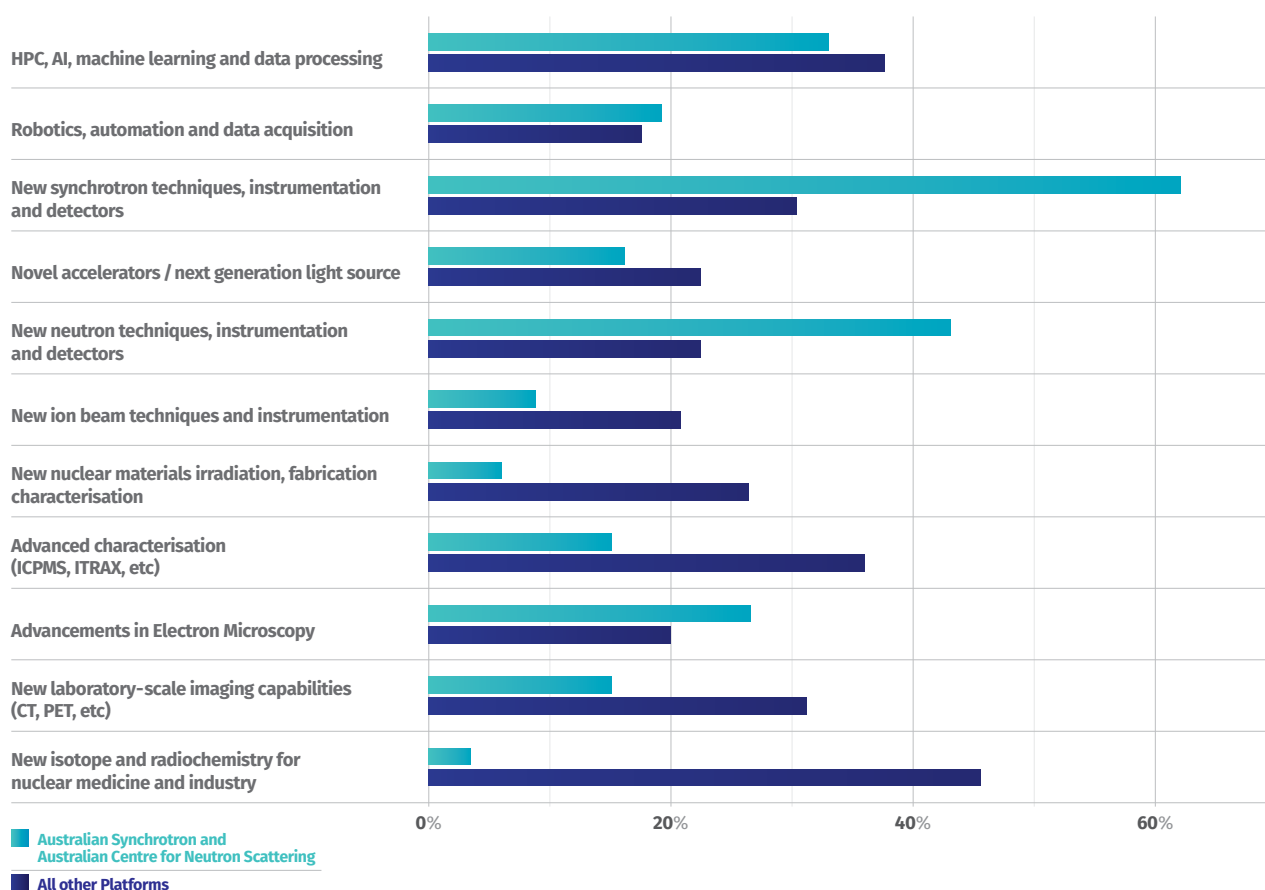


Figure 4.8:
How external respondents prioritise emerging technologies and techniques (respondents could choose multiple options).

The user requirements for computing infrastructure were further interrogated by the question, “Which elements of digital/data/ computing infrastructure should be improved?” Again, the results were separated into two user-based groups in Figure 4.9.

There was a notable contrast between the two groups of respondents. While both groups recognised the importance of HPC activities, the users of the “other Platforms” were relatively satisfied with the level of computing and data analysis support they receive. On the other hand, AS and ACNS users were looking for more support for remote access, data analysis (both assistance and analysis software), data management and visualisation tools etc.

In addition to the specific computing infrastructure question, users were asked which additional tools and resources would improve their user experience after their visit (see [Section 4.5](#) for further details). Remote data access, online analysis tools and downloadable analysis software were all rated as “would significantly improve my user experience” by well over 50% of respondents.

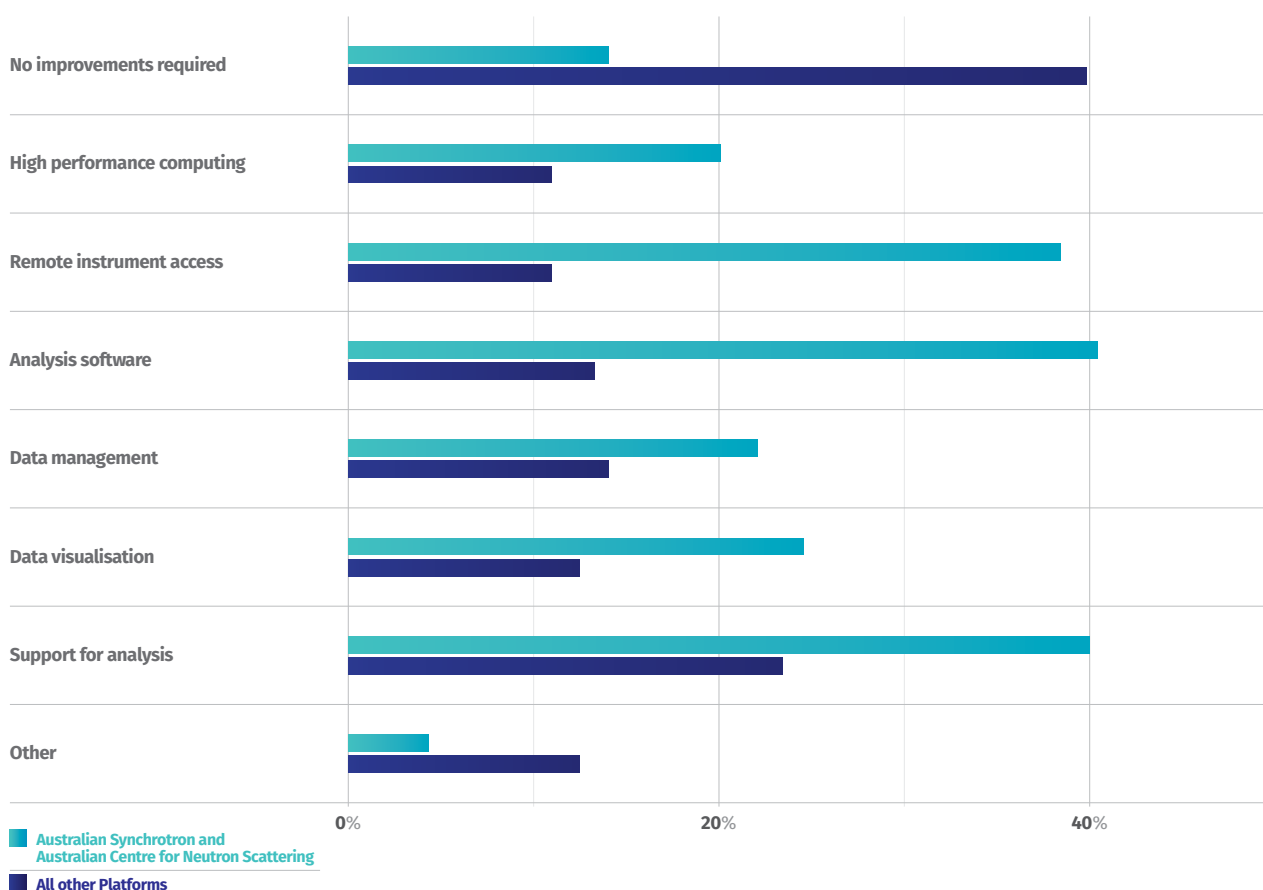


Figure 4.9: Which elements of ANSTO’s digital, data and computing infrastructure should be improved (respondents could choose multiple options).

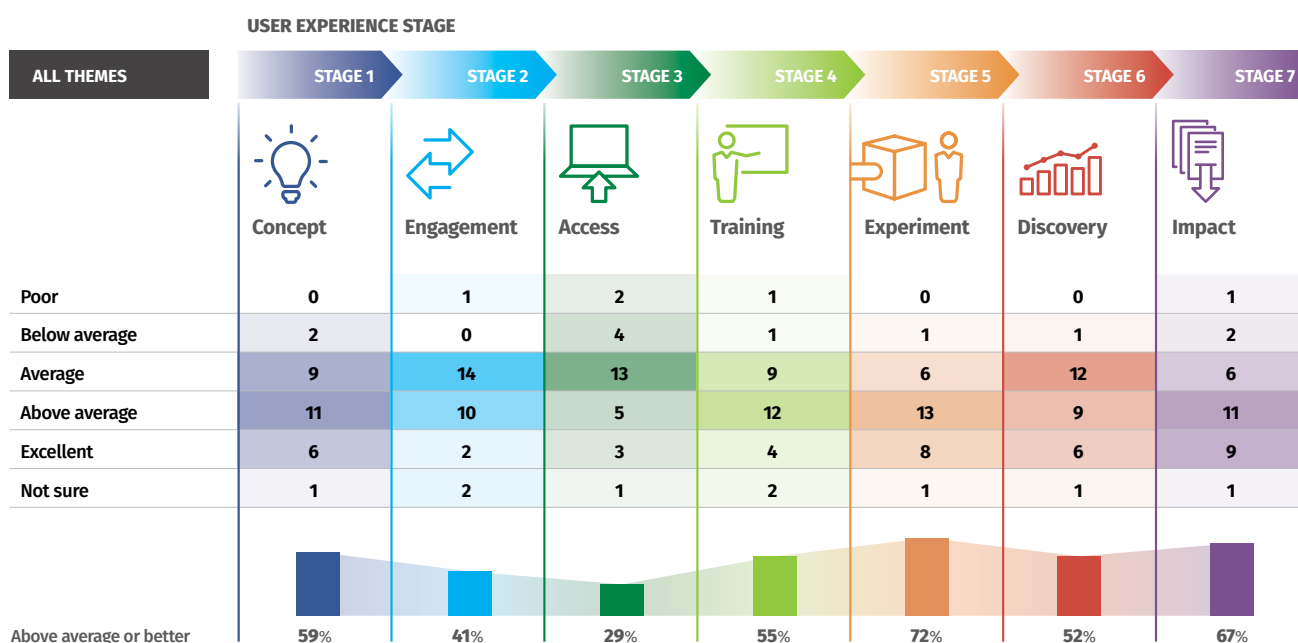
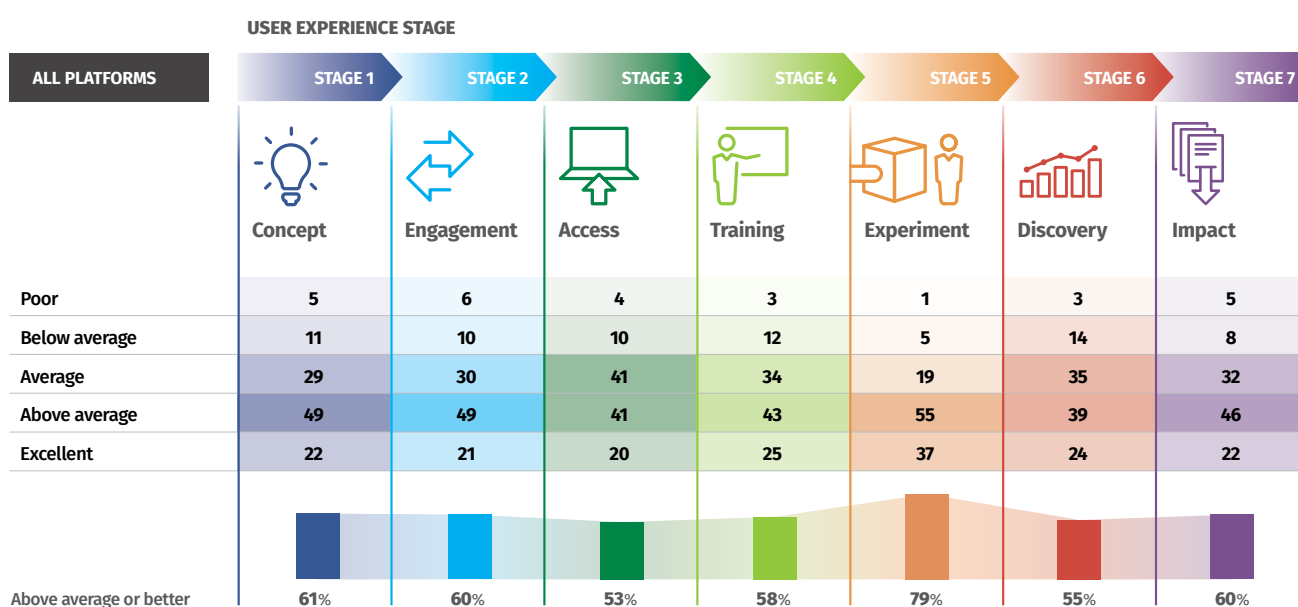
User experience and outreach

The user experience was a central part of the surveys. Among ANSTO staff, there was general consensus that ANSTO's research infrastructure delivers a user experience that is above average or better with the concept, experiment, and impact stages ranking highest (Table 4.3). Staff in the Platforms ranked our pre-access

Engagement phase of the user experience significantly higher than staff in the Themes, reflecting a perhaps natural difference in perspective between the capability and service provider and the customer.

Table 4.3:

Heatmaps indicating how ANSTO staff across Platforms and Themes ranked the seven stages of the User Experience on a 1–5 scale (1=Poor). The numbers in the maps represent how often a ranking was chosen. The percentage values show the fraction of rankings "Above average" + "Excellent".



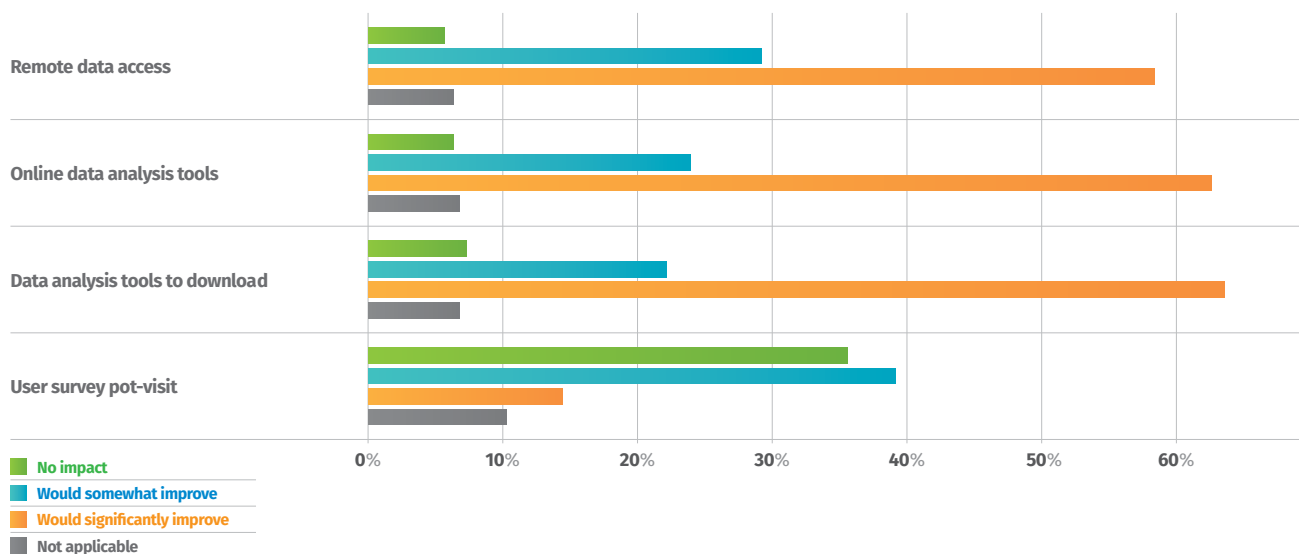


Figure 4.10:
Survey responses to the importance of selected post-experiment tools.

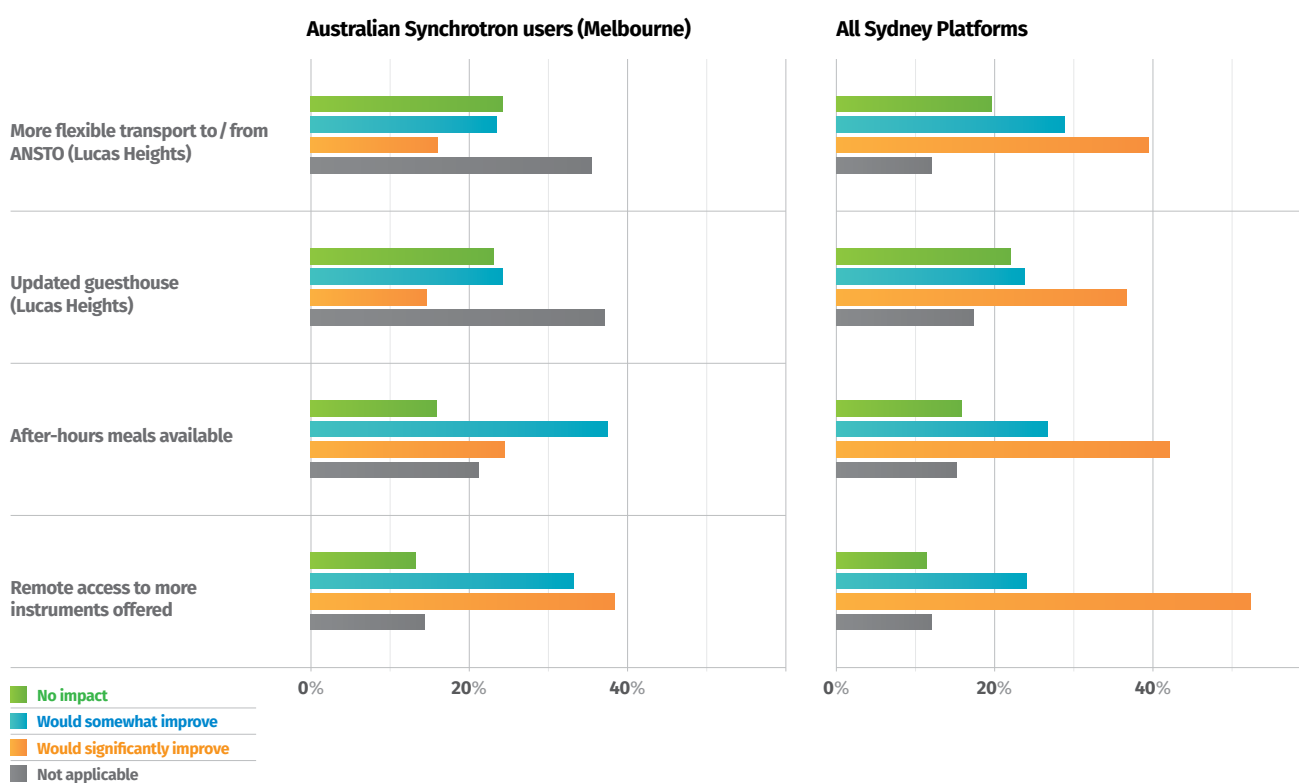


Figure 4.11:
Additional user convenience responses. The division is based on the respondents' answers to which Platform they have used the most. Hence AS users may have an opinion on Lucas Heights infrastructure.

External survey respondents felt that at the early stages of the user experience, in-person engagement with (new) users could be improved, as could our websites and user portal (Figure 4.10), and on-site amenities (Figure 4.11). Even though not rated as a significant barrier by most, improvements to the guest house and easier transportation at Lucas Heights featured strongly, as did access to after-hour meals at Lucas Heights and Clayton. At the tail-end of the user experience, remote access to data and data analysis tools were highlighted as areas for improvement.

A clear focal point for many staff and users across all campuses was remote access to instrumentation. Anecdotal evidence indicates that this was accelerated by the COVID-19 pandemic and the way international facilities have responded to remote access and sample mail-in challenges. Users also noted that the proposal review system could be strengthened by providing them with more feedback, including proposal scores and comments. This was also coupled with a perception that early career researchers face significant hurdles and there could be opportunity to enhance their proposal success chances.

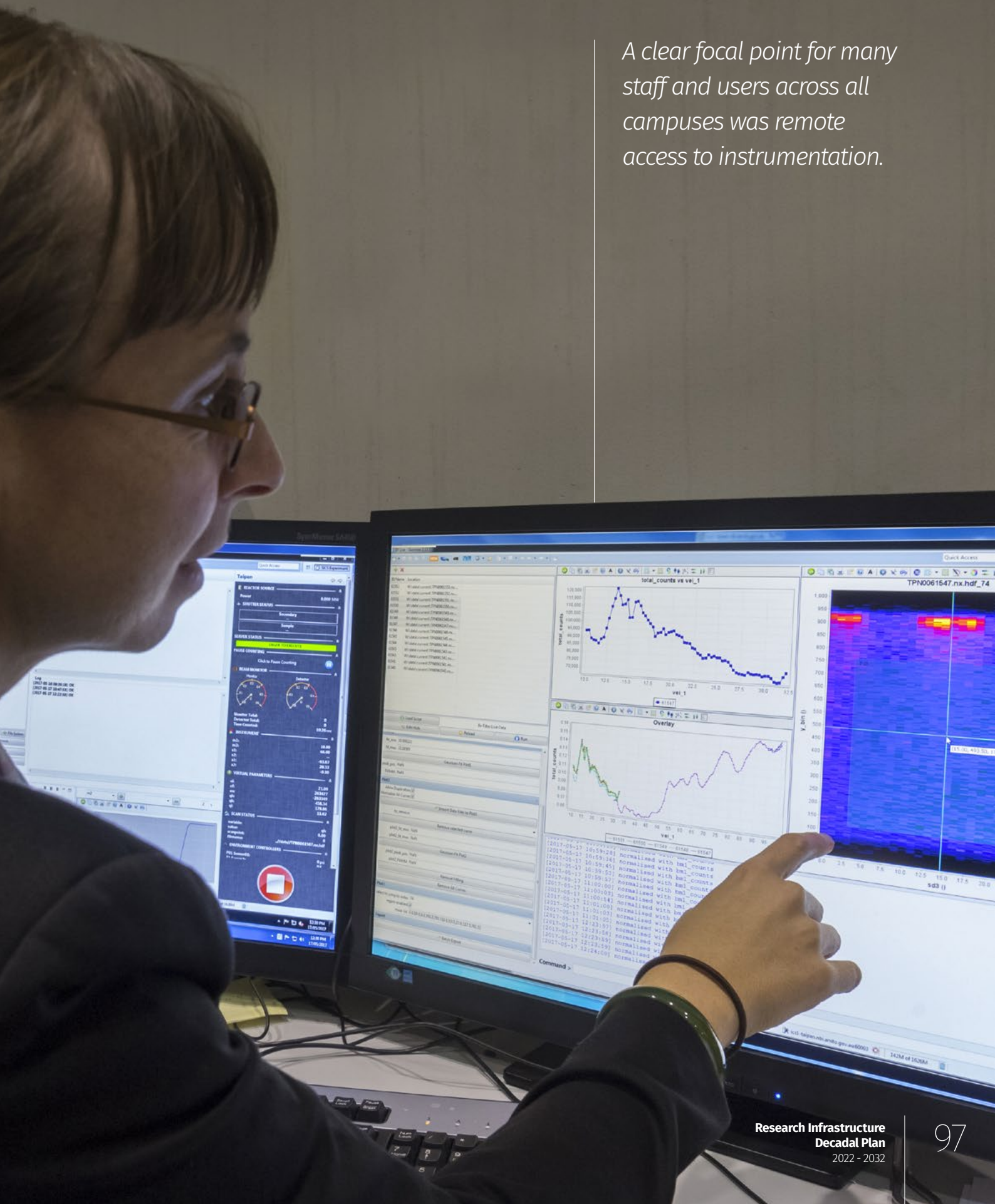
Interestingly, social media did not rate highly as a method to improve the user experience with only about one third of external survey responses inclined towards social media. Instead, respondents considered our websites (80%), online access to manuals (80%) and find-an-expert tools (60%) to be more important.

This was consistent with comments that there is scope to improve information and training for users both on-the-day and post-experiment. Internally, webinars and conferences were ranked as the most useful tools to engage with the user community, reflecting a desire by staff to engage with the user community directly and in person.

“Shared researchers – postdoctoral level researchers in strategic areas would help to bring techniques of analysis and Platform use to external stakeholder groups where these become part of their routine approaches to research.”

“Additional instrument time (neutron supply) is key to growing the local community. In particular, encouraging first-time users, ECRS and female applicants by having a specialised access program for 'start-up' beamtime.”

A clear focal point for many staff and users across all campuses was remote access to instrumentation.



4.6 Research translation and communicating impact and relevance

Questions about the impact of the work across Research Infrastructure were directed internally. The data indicated that journal articles and industry engagement were a key measure of impact across many, but not all, Platforms and Themes. Depending on the focus of a Platform, the relevance shifted to other forms of impact, such as generating revenue or delivering policy and advice. The examples in Table 4.4 illustrate some of these differences.

ANSTO Staff made a variety of comments that relate to impact and how ANSTO's work connects to the outside world. Here are a few selected comments on working with industry and engaging with intellectual property. These comments reflect known tensions between research and industry engagement, as well as views expressed in other parts of the survey about managing priorities given resource constraints.

"Our main impact is on merit-based research applications, which are largely foundation research activities. We have some degree of industry engagement (although this is a rather nebulous term) in that we do run a reasonable effort to do commercial work and schedule time for commercial partners. The basic foundation research can lead to IP, although more often for our researchers, than for the facility. I would also suggest that impact could be measured through reputation amongst our research community."

"I think industry engagement, IP, and revenue are all relevant to [the Nuclear Materials Development and Characterisation Platform]. However, we are not a private enterprise and I think we need to be careful as to where we direct our goals. We are ultimately best at nuclear science and engineering and this should be our focus for improving these areas. We should balance our accounts and help industry when required but this should not be our focus."

"When I think about IP, I am thinking of the additional value, and the edge our amassed environmental isotope data (some unpublished) gives us when engaging with stakeholders. Finding the balance between making it freely available, and getting the best outcomes for ANSTO is hard. Also, we have no database infrastructure for managing this."

Table 4.4:

Comparison of impact measures across the research infrastructure Platforms.

Australian Centre for Neutron Scattering						Australian Synchrotron					
Impact measure	Not relevant	2	3	4	Very relevant	Not relevant	2	3	4	Very relevant	
 Publications	0	0	1	2	23	1	2	1	10	22	
 Industry engagement	1	0	6	14	5	3	9	10	8	6	
 IP generation	1	9	11	4	1	6	12	15	2	0	
 Revenue generation	2	8	10	4	2	11	7	13	3	2	
 Policy and advice	3	10	8	3	2	9	13	7	4	3	
 Health	3	8	11	2	2	5	4	7	9	11	
 Jobs	3	9	9	3	2	5	7	16	5	3	
 Environment	1	7	11	5	2	2	4	13	9	8	

Centre for Accelerator Science						Isotope Tracing in Natural Systems					
Impact measure	Not relevant	2	3	4	Very relevant	Not relevant	2	3	4	Very relevant	
 Publications	0	0	2	5	5	0	2	1	1	2	
 Industry engagement	0	1	4	5	2	1	0	1	2	2	
 IP generation	2	2	5	3	0	3	1	1	0	1	
 Revenue generation	0	0	3	8	1	0	2	0	0	4	
 Policy and advice	2	3	3	4	0	3	2	0	1	0	
 Health	2	4	4	1	1	4	1	0	0	1	
 Jobs	3	4	1	1	2	2	1	0	2	1	
 Environment	0	1	1	6	4	1	0	0	2	3	

Nuclear Materials Development and Characterisation						Nuclear Stewardship					
Impact measure	Not relevant	2	3	4	Very relevant	Not relevant	2	3	4	Very relevant	
 Publications	0	2	2	0	2	1	3	3	3	3	
 Industry engagement	0	1	3	2	0	0	1	4	4	4	
 IP generation	0	2	2	1	1	6	0	3	1	0	
 Revenue generation	1	1	2	1	1	1	0	6	1	3	
 Policy and advice	1	2	3	0	0	0	1	2	4	6	
 Health	1	4	0	0	1	1	2	3	2	3	
 Jobs	1	2	2	0	1	3	3	2	2	0	
 Environment	1	2	1	1	1	3	1	2	3	2	

Biosciences						National Deuterium Facility					
Impact measure	Not relevant	2	3	4	Very relevant	Not relevant	2	3	4	Very relevant	
 Publications	0	5	5	1	4	0	0	0	3	5	
 Industry engagement	0	0	5	3	7	0	0	3	3	2	
 IP generation	1	5	7	1	1	1	5	1	1	0	
 Revenue generation	0	0	4	4	5	0	2	3	2	1	
 Policy and advice	2	7	3	1	1	4	2	1	0	1	
 Health	0	2	2	2	9	1	2	2	2	1	
 Jobs	1	2	6	5	0	2	3	2	0	1	
 Environment	1	9	3	0	2	1	5	1	0	1	

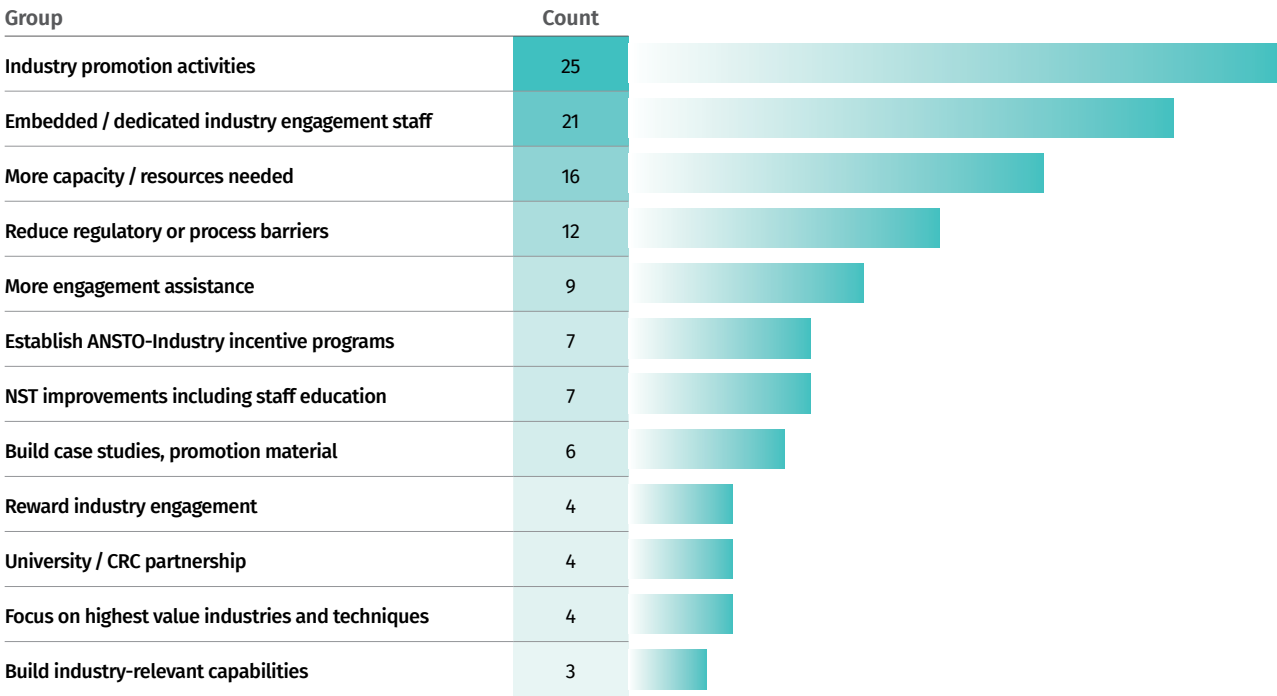
4.7

Industry and commercial engagement

Data from the internal survey question “What would be the most useful thing to increase industry engagement with the Platform?” was grouped into themes (see Table 4.5), with improved resourcing, assistance, and training seen as needed most.

Active industry promotion, coupled with creating collateral material, were also important to staff, as were incentive and reward mechanisms for working on industry engagement.

Table 4.5:
ANSTO drivers promoting increased industry engagement.



Commercial users were included in the external survey. Responses to questions of research priorities for national benefit, and which priority areas were attractive for partnership with ANSTO, give some indication of the industry sectors perceived as important by

external users. The data presented in [Section 4.3](#) showed strong support for ANSTO involvement in the advanced manufacture, advanced materials, energy (hydrogen, storage, renewables, energy materials) and food and agribusiness sectors.

Policy drivers and international perspectives

The responses from the internal survey as to what global challenges may drive demand for ANSTO infrastructure are summarised in Figure 4.12. Platform staff saw infrastructure as contributing to most of the listed issues, whereas the Themes and Business area responses were more nuanced. Perhaps unsurprisingly, no one expected ANSTO infrastructure to influence global conflict.

The internal survey respondents were also asked to consider current Commonwealth Government policy areas and list opportunities or impact on their Platform or research. These responses were used to develop a list of priority areas for ANSTO for the external survey (shown in [Section 4.3](#) and Figure 4.7). The top five priority areas from the external survey in order are: environment, medical and health, energy, advanced materials, and advanced manufacturing. This aligns roughly with the internal survey responses, although it was interesting to note that food/agribusiness ranked lower with our external users.

Respondents from outside ANSTO also provided infrastructure-related input more broadly in the open comment section. Some respondents expressed the view that careful consideration should be given to ANSTO's sustainability position and its choices with regard to taking on major initiatives. Engaging with the community around significant infrastructure developments was similarly flagged. ANSTO should also maintain its own identity and purpose in the landscape of national laboratories, as well as partner with other national infrastructure. Support of national security was identified, as was policy settings around long-term prospects for people working in science. Working to benefit society and build a knowledge economy was also highlighted.

Collaboration and cooperation with the international community was seen as important and ANSTO's (unique) position in the international landscape was recognised. Respondents pointed out opportunities to improve our capabilities in the global context, including remote instrument access and cryo-electron microscopies.

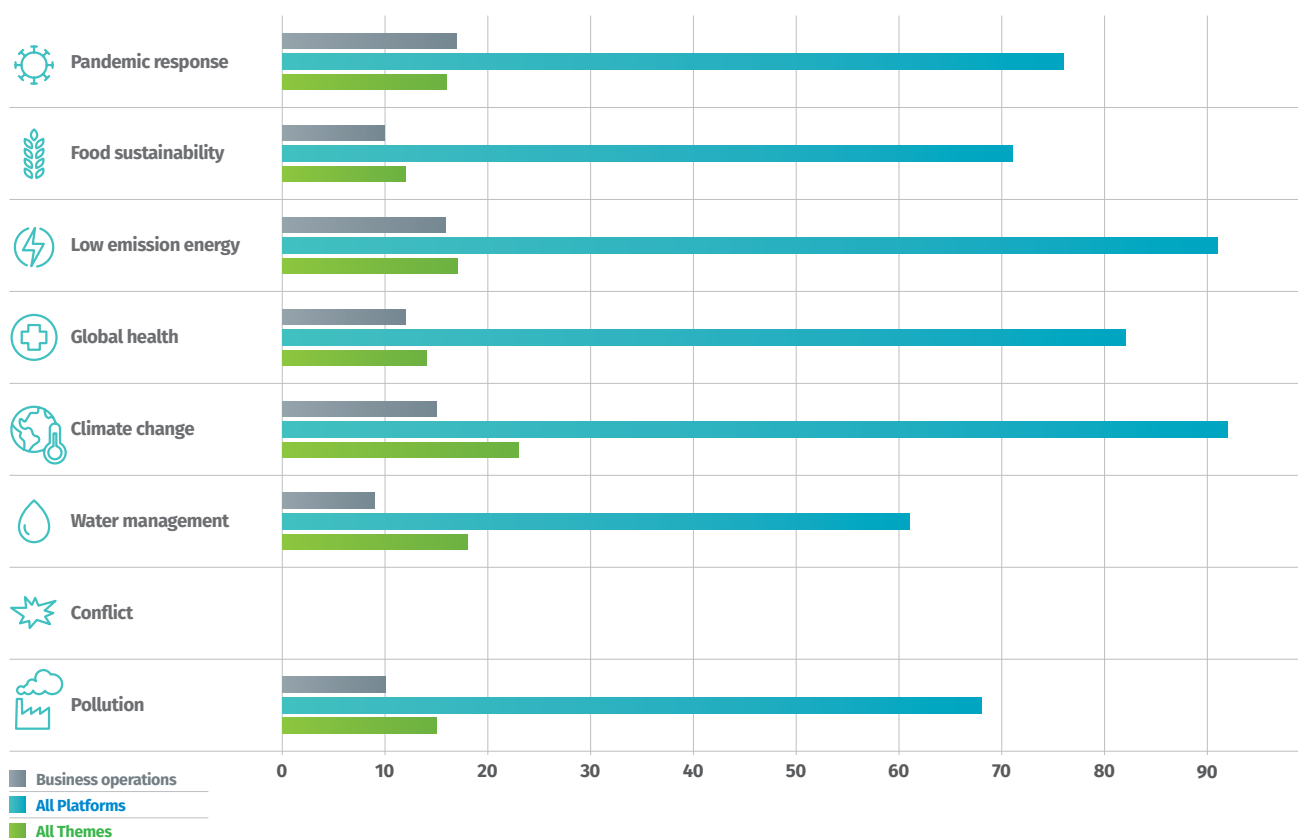


Figure 4.12:
Demand drivers for research infrastructure (respondents could choose multiple options).

5 Priority areas for the research infrastructure portfolio

5.1 Introduction

Compared to other national research infrastructure, ANSTO's portfolio of research infrastructure is diverse not only in the fields of research where it is applied but in the manner in which it operates, the breadth of the user base and its role in supporting ANSTO operations and business. Some characteristics of ANSTO's research infrastructure presented in [Section 3](#) include:

- it spans Institutional, National and Landmark categories
- it enables extended longitudinal studies over multiple decades
- some capabilities that target particular scientific challenges while others are applied across many fields of research
- it is generally openly accessible
- in some techniques, a leading national capability in terms of sensitivity and accuracy
- ANSTO may be the only provider of a capability in Australia
- sovereign capabilities for nuclear security science and translational nuclear research
- it undertakes activities for the national benefit and addressing sovereign needs (e.g. nuclear technologies and engineering, isotope development, nuclear waste forms, radioactive waste management)
- capabilities that are highly relevant to industry but best operated by ANSTO, and
- it is connected to global networks.

In considering the next ten years, therefore, it is expected that the areas of greatest focus for the Platforms would be equally as diverse, whether they be ageing buildings, the state of instrumentation, changes in workforce or evolving science drivers of users. Through a workshop and consultation process, Priorities with Objectives and Key Initiatives for each were developed (further detail [Appendix A](#)).

5.2 Priority areas

As a result of the consultation and workshop process six Priority Areas were identified.

PRIORITY 1 World-class infrastructure delivering excellent outcomes



PRIORITY 2 Operational effectiveness



PRIORITY 3 Next-generation research infrastructure



PRIORITY 4 Skilled, productive and engaged people



PRIORITY 5 ANSTO user experience



PRIORITY 6 Partnerships that leverage ANSTO's expertise and infrastructure



For each Priority Area, a set of Objectives were identified, as well as Key Initiatives. The initiatives describe activities that were developed to address specific or collective feedback or opportunities identified through the consultation process. Some of the Initiatives cut across the research infrastructure Platforms while others may be relevant to, and implemented within, selected Platforms. There are a small number of Key Initiatives that address well understood future needs within the National or Landmark Platforms.

In general, the Key Initiatives stop short of outlining specific solutions for individual Platforms. This level of detailed implementation planning will reside, in most cases, in the respective business plans. It should be noted that not all specific deliverables or solutions underpinning the Key Initiatives were resourced or funded at the time the Decadal Plan was prepared. Securing resources and funding will be a critical element of implementation planning.

In developing the Key Initiatives, reoccurring assumptions and overarching perspectives that will impact the delivery of specific tasks were identified. These span all initiatives and are foundational to planning and decision making. They include:

- ensuring this plan and its key activities are aligned to NST and ANSTO strategy
- the need for sustainability
- prioritising the highest levels of safety and regulatory compliance
- maintaining integrated business planning processes to inform investment decisions,
- including specific tasks and actions in the business plans for relevant operating units across NST
- establishing change management and communication plans to guide and support our people in key projects and improvements, and
- building investment cases as required to identify and secure new infrastructure.

Perspectives on implementing the Decadal Plan are further outlined in [Section 6](#).

5.3

Time horizon for achievement of Key Initiatives

To support effective prioritisation and implementation, the Key Initiatives within each Objective have been grouped into three time horizons.





This is about maintaining, expanding, and improving the capabilities that ANSTO currently has so it can be the very best it can be, and ensures ANSTO continues to provide excellent outcomes with high impact.

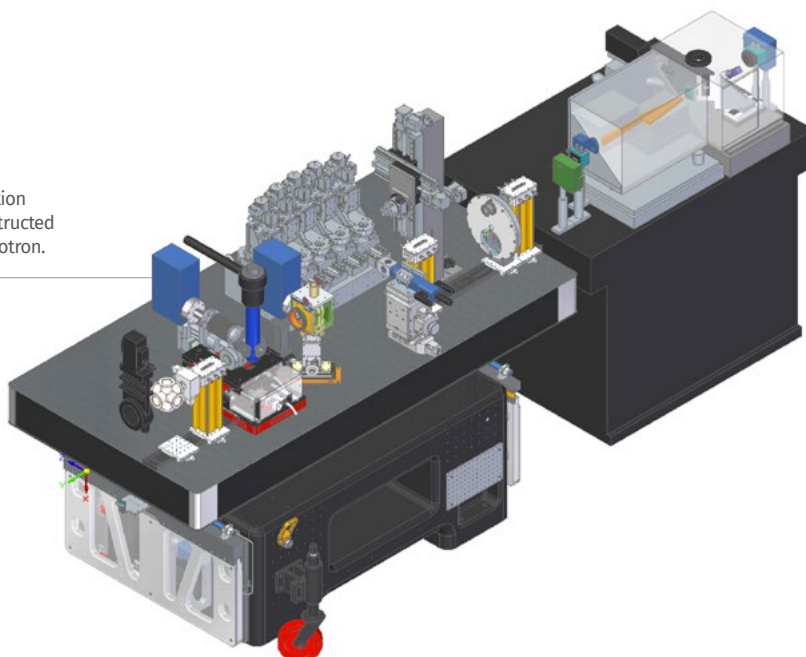
Objective	Key Initiatives to achieve	Time
1.1 Upgrade and modernise our tools and equipment and develop capabilities to continue supporting ANSTO and national priorities	1.1.1 Identify, drive, and deliver capability development requirements in consultation and partnership with key internal and external stakeholders	1-2 YEARS
	1.1.2 Plan for suitable and modernised instrumentation to meet regulatory, safety standards and future-proofing operations, and then use to inform Asset Management plans	
	1.1.3 Identify and decommission legacy and redundant tools, equipment and capabilities	
	1.1.4 Invest in automation, remote handling and enable remote access	3-5 YEARS
	1.1.5 Enable real-time reporting of data (e.g. environmental monitoring)	
	1.1.6 Upgrade and expand our nuclear capabilities (e.g. nuclear materials handling, fabrication and characterisation capabilities; isotopic measurements for environmental research; nuclear medicine)	
	1.1.7 Ensure co-ordination of plans between business units for establishment of specialised and shared capabilities	6-10 YEARS
	1.1.8 Drive delivery of Asset Management strategies through securing predictable (and ideally additional) funding	
	1.1.9 Leverage partnerships and activities (external and internal)	
1.2 Optimise our buildings and laboratories (to enable new work and support collaboration and efficiencies)	1.2.1 Active engagement in ANSTO 2035 Master plan	1-2 YEARS
	1.2.2 Identify opportunities for repurposing spaces and laboratories	
	1.2.3 Identify and deliver opportunities to consolidate similar analytical capabilities	
	1.2.4 Identify and deliver co-location opportunities to support collaboration and ideas sharing	
	1.2.5 Design laboratories to improve efficiencies of identified workflows	3-5 YEARS
	1.2.6 Plan for buildings and laboratories that meet regulatory and safety standards and future proof operations, then use to inform site infrastructure renewal	
	1.2.7 Coordinate plans between business units for access to specialised capability (e.g. PC2 labs and hot cells)	
	1.2.8 Upgrade conference and training facilities	
1.3 Drive fit for purpose digital research infrastructure	1.3.1 Develop a digital research infrastructure strategy by reinvigorating the eResearch Game Plan for NST	1-2 YEARS
	1.3.2 Strengthen partnership and planning with ANSTO IT	
	1.3.3 Identify and enable remote access opportunities (internal and external users)	
	1.3.4 Secure digital infrastructure upgrades and ongoing renewal	3-5 YEARS
	1.3.5 Include digital infrastructure requirements for all new equipment plans	
	1.3.6 Enable accessibility to historical and ongoing data collections guided by the FAIR principle (Findable, Accessible, Interoperable, Reusable)	
	1.3.7 Provide improved data analysis solutions	6-10 YEARS
	1.3.8 Negotiate IT network security protocols, process and policies that meet our needs and support our work	
	1.3.9 Maintain and improve our linkages to (inter)national groups and facilities	



This is about improving the way we operate and manage research infrastructure. Activities are to be well planned, appropriately resourced and sustainable.

Objective	Key Initiatives to achieve	Time
2.1 Maximise productivity by streamlining and standardising processes and workflows	2.1.1 Audit shared processes across NST to identify and prioritise and align improvements	1-2 YEARS
	2.1.2 Investigate centralised process and task delivery opportunities	
	2.1.3 Support take-up and use of our customer relationship management tool (CRM) across NST	
	2.1.4 Establish continuous improvement plans across NST and implement agreed process improvements	3-5 YEARS
	2.1.5 Establish NST cross Platform/Theme process to develop, secure and deliver commercial projects	
	2.1.6 Establish communities of practice to share skills, transfer knowledge and share lessons learnt across NST and ANSTO	
2.2 Improve metrics and quality systems to better support best practice	2.2.1 Review our infrastructure measures to maximise the value return (consistency, reporting, interpretation, etc)	1-2 YEARS
	2.2.2 Increase understanding (at all levels) of our metrics and how to best use them to inform decision making, and better communicate our performance internally and externally	
	2.2.3 Benchmark facilities to drive best practice in management and operations	3-5 YEARS
	2.2.4 Explore the value and suitability of additional Industry specific quality systems for Research Infrastructure	
2.3 Deliver system integrations	2.3.1 Develop and implement our research information management systems and portal improvements (CRISP project)	1-2 YEARS
	2.3.2 Ensure integration of Project BRIGHT	3-5 YEARS
	2.3.3 Rollout lessons learnt from broader systems integrations across Research Infrastructure	

3D representation of the Medium Energy X-ray Absorption Spectroscopy Beamline (MEX-1) endstation, to be constructed as part of Project BRIGHT at ANSTO's Australian Synchrotron.





This is about critical national scale research infrastructure for the future as well as those emerging areas we need to adopt to deliver on sovereign and ANSTO's core missions into the future.

Objective	Key Initiatives to achieve	Time
3.1 Build strategic research infrastructure for Australia	3.1.1 Develop Stawell Underground Physics Lab (SUPL) and associated program of capability development	1-2 YEARS
	3.1.2 Scope the research infrastructure needs for next-generation nuclear medicine and develop plans for implementation	
	3.1.3 Establish clinical research therapy centre around the Breast CT capability at the Imaging and Medical Beamline (Synchrotron)	
	3.1.4 Establish an accelerator-based precision irradiation facility as the replacement for GATRI	
	3.1.5 Scope, design, and secure funding for additional neutron instruments in the existing neutron guide hall at ACNS	3-5 YEARS
	3.1.6 Develop next-generation, ultra low-level radioanalytical capability	
	3.1.7 Develop high-activity chemical characterisation capabilities	
	3.1.8 Scope, design and secure funding for second neutron guide hall and new instruments at ACNS	
	3.1.9 Establish new Nuclear Security Science facility	6-10 YEARS
	3.1.10 Scope, design, and secure funding for Project BRIGHT 2	
	3.1.11 Scope and design a next-generation Synchrotron	
	3.1.12 Establish and operate the research end station of the National Particle Treatment and Research Centre (Westmead)	
3.2 Adopt next-generation of modelling systems, data analytics and AI	3.2.1 Identify opportunities for ANSTO to develop advanced data analytics programs (AI, machine learning, data automation, etc) that support the ANSTO mission and users	1-2 YEARS
	3.2.2 Expand modelling and simulation capabilities across ANSTO mission-based Research Themes	3-5 YEARS
3.3 Horizon-scan for new opportunities and directions	3.3.1 Develop a roadmap to guide next-generation accelerator systems and science	1-2 YEARS
	3.3.2 Identify nuclear research infrastructure capabilities and skills to support ANSTO's sovereign mandate	
	3.3.3 Identify opportunities for NST that lie in disruptive digital technologies (e.g. quantum computing)	
	3.3.4 Support Australia's involvement in next-generation nuclear systems (e.g. fusion, Generation IV nuclear power, small modular reactors, etc)	3-5 YEARS
	3.3.5 Pursue international and local collaborations and partnerships to support next-generation aspirations	6-10 YEARS
	3.3.6 Work with Australian industry and businesses to develop new supply chains for research infrastructure not only to remove single points of failure but add value to the economy	

Skilled, productive and engaged people



This is about working together as one community and towards common objectives as a connected and cohesive organisation.

Objective	Key Initiatives to achieve	Time
4.1 Attract and retain a diverse and talented workforce	4.1.1 Implement a NST wide succession plan (in line with organisation framework) and deliver solutions for each Platform to ensure business continuity	1-2 YEARS
	4.1.2 Ensure infrastructure workforce plans are integrated into the overall NST plan to meet current and future needs (particularly around next-generation capabilities)	3-5 YEARS
	4.1.3 Maintain and evolve training pathways to support early career researchers who will become the next generation workforce skilled at applying nuclear and accelerator techniques	
4.2 Support our people to grow and develop	4.2.1 Foster the ANSTO Diversity and Inclusion plan within the Research Infrastructure portfolio	1-2 YEARS
	4.2.2 Advocate for an expanded remuneration approach with improved benchmarking to market	
	4.2.3 Advocate for an ANSTO-wide reward system that better recognises expertise, contribution, and collaboration in line with ANSTO's values	3-5 YEARS
	4.2.4 Establish a Research Infrastructure fellowship scheme for NST staff and visiting experts to undertake focused research or capability development activities that benefit ANSTO	
4.3 Improve our communication, connection and collaboration across NST and beyond	4.3.1 Ensure our key targets and metrics support connection, collaboration, and desirable behaviours in line with ANSTO values	1-2 YEARS
	4.3.2 Establish and support discipline-specific communities of practice across ANSTO to share knowledge, foster collaboration and build capability	3-5 YEARS
	4.3.3 Establish joint research and capability development projects across NST that foster integration across the campuses and develop a sense of togetherness	
	4.3.4 Maintain and build our networks nationally and internationally	6-10 YEARS
	4.3.5 Participate in global communities of practice of benefit to ANSTO	
	4.3.6 Further capitalise on collaborations and integrated capabilities that help our people generate benefits and value to ANSTO	



Each person who interacts with research infrastructure needs an individual experience. This is about how the core elements of the ANSTO User Experience can be used to deliver improvements to their experience ensuring excellent outcomes and high impact.

Objective	Key Initiatives to achieve	Time
5.1 Enhance the overall internal and external user experience	5.1.1 Improve and streamline the Portal processes	1-2 YEARS
	5.1.2 Improve communication with AINSE over RSS, ECR and PGRA grant rounds and approval processes	
	5.1.3 Establish contemporary and compelling collateral that communicates the possibilities and impact of our capabilities	
	5.1.4 Establish and maintain ongoing user experience feedback, benchmarking, and improvement mechanism(s)	3-5 YEARS
	5.1.5 Continue to embed the User Experience framework across Research Infrastructure to evolve our approach to delivering improvements	
5.2 Enhance the merit user experience	5.2.1 Foster a productive and rewarding User Experience for students and ECRs with Research Infrastructure (and ANSTO)	1-2 YEARS
	5.2.2 Improve approaches to communicate to all applicants to facilities (pre- and post-access) in a transparent manner	3-5 YEARS
	5.2.3 Improve remote access and post-access support	
	5.2.4 Improve the onsite wellbeing services and support for users accessing our facilities	6-10 YEARS
5.3 Be agile and responsive to ANSTO researchers and business needs	5.3.1 Improve the project proposal processes for our internal Research Themes to ensure agile access	1-2 YEARS
	5.3.2 Improve consultation mechanism(s) between Research Themes and Research Infrastructure planning	6-10 YEARS
	5.3.3 Better convey the value proposition of Research Infrastructure to the rest of ANSTO	
5.4 Enhance and extend the commercial and industry user experience	5.4.1 Secure more opportunities by streamlining the commercial project processes (quotation, fees, legal, contracts, etc)	1-2 YEARS
	5.4.2 Develop targeted communication and case studies to demonstrate solutions to industry problems and potential impact (broaden industry user base)	3-5 YEARS
	5.4.3 Improve our ability to identify opportunities and engage with clients	
	5.4.4 Capitalise new opportunities for ANSTO to supply holistic solutions to industry	
	5.4.5 Adopt quality management and relevant standards to support industry engagement and commercial services	

PRIORITY

6

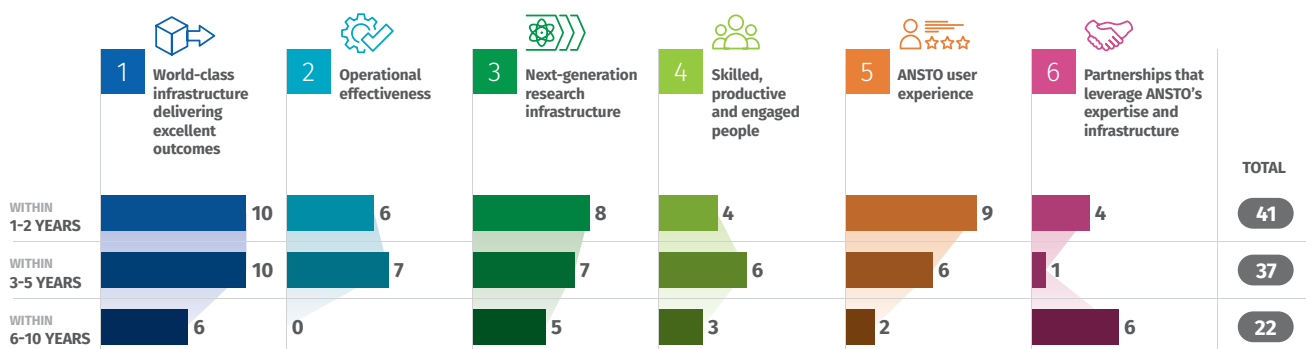
Partnerships that leverage ANSTO's expertise and infrastructure



Partnerships are central to the way that ANSTO can sustainably achieve its objectives in the future. This is about how research infrastructure identifies, selects and fosters partnerships that are high value to deliver on ANSTO's vision.

Objective	Key Initiatives to achieve	Time
6.1 Identify high value partnerships	6.1.1 Review, re-prioritise and maintain existing domestic and international partnerships	1-2 YEARS
	6.1.2 Establish evaluation criteria to assess potential new partnerships	
	6.1.3 Establish partnerships to build expertise and expand research infrastructure capabilities and capacity in and beyond ANSTO	3-5 YEARS
	6.1.4 Leverage ANSTO's sovereign capabilities and unique nuclear techniques and expertise to strengthen partnerships and explore new more strategically-aligned partnerships	6-10 YEARS
	6.1.5 Identify and secure strategic opportunities to partner with researchers and industry to translate science for impact and benefit	
	6.1.6 Identify value adding multi-party relationships and opportunities (new and restructure existing)	
6.2 Foster and maintain high value partnerships	6.2.1 Evolve existing partnerships to further build expertise and expand capabilities and capacity in and beyond ANSTO	1-2 YEARS
	6.2.2 Establish cohesive communications and engagement plan for our strategic partnerships	
	6.2.3 Identify and secure partners for co-investment and for complementary techniques to ANSTO	6-10 YEARS
	6.2.4 Better support and leverage embedded research partners at ANSTO	
	6.2.5 Support our people to develop and foster collaborative external partnerships	

Time horizon for achievement of Key Initiatives



6 Implementing the Plan and reviewing impact

Developing a Decadal Plan was in and of itself an important process. It provided staff from within research infrastructure platforms an opportunity to consult with internal and external stakeholders, and have a say in the longer-term outlook for the portfolio. Likewise, ANSTO and external researchers were able to engage and provide perspectives that shaped and calibrated the importance of the core Priorities. The formulation of Priorities, supporting Objectives and Key Initiatives was informed by current and emerging science, research, policy and innovation challenges, as well as technical drivers. These outcomes were of real significance and warrant inclusion in thinking for the future.

With the development of this strategic outlook, there is now a responsibility and accountability to implement the Decadal Plan and ensure it has an impact through embodying it in ANSTO's vision and purpose over the next ten years.

All staff have a stake in the implementation of the Decadal Plan. Maintaining awareness of the purpose of the Decadal Plan amongst the Executive, Senior Leadership of the platforms and research staff, as well as connection to the Plan's high level Priorities, Objectives and Key Initiatives is, therefore, critical to its utility.

Implementation of the Decadal Plan comes with responsibilities at all levels of the organisation, ranging from governance through to specific Platform initiatives. It draws upon established ANSTO processes to execute these initiatives. A Plan-Act-Review framework (Table 6.1) has been developed to support implementation and identify where primary responsibility effectively rests. The framework includes existing ANSTO planning and business processes which will be utilised to implement the Decadal Plan Priorities, and identifies where responsibility lies for each.

Table 6.1:

The Plan-Act-Review framework to support implementation of the Decadal Plan within ANSTO's standard planning approach.

Plan	Act	Review	Responsibility
ANSTO vision and purpose ANSTO Strategy - Strategic imperatives - Enabling objectives - Key activities	Governance	Corporate Plan Annual Report Performance measures	ANSTO Board ANSTO Executive
NST strategic plan - Research infrastructure - Key performance areas - Integrated business - Planning	Strategic alignment Resourcing	NST plan on a page Performance measures	NST Executive and Senior Leadership
Platform and research Business planning - Business plans - Asset management - Individual objectives	Implement - Cross-cutting - Platform specific - Communities of practice	Annual business plan - Objectives - Performance measures - APEA	NST Leadership and Staff

The Decadal Plan will be a living document, and the Plan-Act-Review framework will be applied throughout its lifetime. An annual review and integration into business planning at the NST level will be a key success factor for effective implementation. In-depth review at the five and ten year periods will allow recalibration against contemporary science, research, policy, and innovation challenges, as well as technical drivers.

These are timed to coincide with strategic research infrastructure planning performed by Government at the national level through the National Research Infrastructure Roadmap process. Key communication activities associated with these Milestones will support ongoing awareness of the plan and achievements across ANSTO (Table 6.2).

Table 6.2:

The schedule of milestones to be used for review and monitoring of Decadal Plan implementation from 2022 through to 2032.

Year	Activity	Communication
2022	Publication Develop score card and impact measures	Print and digital RIDP Intranet Board and Executive presentation
Annual	Integration into business planning ▪ Cross-cutting initiatives ▪ Platform specific	RIDP Intranet Annual Report Board reports NST reporting
2026	Health-check ▪ Progress against score card ▪ Impact assessment ▪ Revise priorities, objectives, key initiatives National Research Infrastructure Roadmap*	RIDP Intranet Board and Executive presentation
2031	Decadal Plan review and impact assessment Renewal of the Decadal Plan National Research Infrastructure Roadmap*	RIDP Intranet Board and Executive presentation

*Assumes Government will continue the cycle of strategic infrastructure planning using the roadmap approach.

Appendix A:

Decadal Plan development process and priority area inputs

To determine if common priorities could be identified and form the basis of the Decadal Plan, the findings of the internal and external consultations (Section 4) were combined with the views and opinions of Platform and Research Theme staff. This combination of information was distilled into potential

priority areas relevant to each Platform or Research Theme and presented by the respective Leaders at a facilitated workshop that included all the NST Leadership and key subject matter experts. The potential priority areas for each Platform and Research Theme are outlined here.

Platform priority area inputs

Australian Synchrotron

- Our people; headcount cap increase; expert training and skills development; promotions and job progression opportunities
- User research; maintain world-class infrastructure to deliver impact and public benefit; strong user community support and influence; communications and outreach (public and Government support)
- User experience; streamline user management; upgrade user platforms; provide remote access capabilities across the beamlines; improve high-throughput sample capabilities; upgrade data management and data analysis platforms
- Industry usage; establish standard programs and return-client base; build expert reputation; develop/shared input into research and development industry priority areas
- Science and business case for upgrade/new Australian 4th Generation Synchrotron Light Source

Australian Centre for Neutron Scattering

- Workforce skills, development and succession planning
- Early Career Researchers – supporting next-generation of scientists
- Growth and continual renewal of research infrastructure including capabilities, buildings, laboratories, workshops
- Support and development of sovereign suppliers
- Growth and support of “Value” partnerships
- Digital Research Infrastructure supporting Platforms and users
- Increasing Lucas Heights user experience – creature comforts

Centre for Accelerator Science

- Invest in capability: automation; laboratory consolidation; remote access and precision irradiation
- Commitment to particle/radiation therapy and space sector community needs, skills, and technology development
- Focus on diverse workforce, new users and partnerships
- Invest in roadmap planning, tools for process management and administrative support
- Increase prominence of communities of practice across NST

National Deuteration Facility

- Separation of hydrothermal processes (Parr reactors) into dedicated lab
- Advance the yeast platforms through partnership and MTAs with expert labs, e.g. Synthetic Biology Platforms (local and International)
- mRNA and lipid nanoparticle (LNP) efforts: research and development of new deuterated components of LNPs
- Enhance purification (HPLC) and tracking systems to work towards GMP/GLP principles
- Specific and site selective deuteration of drugs and clinical agents and their metabolomic studies for enhanced drug efficacy and stability
- Establish formal internal research with ANSTO Research Themes
- Establish PC2 lab and cleanroom facility, shared resource with ACNS and Biosciences

The workshop process established a working list of priority areas and the NST Leadership then collectively began to consider the range of detailed initiatives and actions that would potentially be needed over the next ten years by the Platforms. A considerable

number of tasks were identified, which a smaller working group analysed and distilled into Objectives for each Priority and associated high level Key Initiatives.

Nuclear Stewardship

- Nuclear Security Science Capability
- Internal strategy
- NST to be a strong contributor into the LH campus renewal plan
- Engagement that focuses on delivery of benefit
- Investment in compliance functions
- External/outreach strategy
- Universities and industry
- Recognition of, and time to deliver on, affiliations and networks
- End-to-end project tracking integrated into ARP

Biosciences

- Centralised modern facilities for safe and effective research and manufacture in nuclear based health applications
- High-energy accelerators for radioisotope provision and security
- State-of-the-art pre-clinical and clinical imaging capabilities

Isotope Tracing in Natural Systems

- Connect ITNS with ANSTO researchers and universities to bring ECRs focused on method development not just applied research, and grants to support
- Change ARC policy or influence Government to better fund sovereign capabilities at ANSTO
- Work with Platforms and Research Themes, Minerals and Waste Ops to reduce fragmentation
- Consider pathways to resource high-revenue earning capabilities externally to free up development capacity

Nuclear Materials Development and Characterisation

- Secure IT and sustainable data systems
- Expand characterisation capability
- Investment in reliable fit-for-purpose infrastructure
- Consolidate and refurbish existing laboratory spaces
- Workforce skilling and succession planning
- Streamline regulatory and safety processes to meet the needs of research activities

Research Theme priority area inputs

Human Health Theme



Biology and Physics

- Facility and capability upgrades (PC2 laboratories, animal house (vivarium), multiplex tissue imaging, confocal microscope, radio-flow cytometry)
- Radioactive compound screening (surface plasmon resonance, isothermal titration calorimetry)
- Neutron capture drug development beamline at ACNS (for NCEPT and NCT)
- Access to a high-energy ion beam facility

Chemistry

- Fully functional synthetic chemistry laboratory for small scale reaction optimisation and multi-step synthesis of new cancer theranostic vectors, and neutron capture agents
- HPLC-MS for reaction monitoring, automated MP chromatography, 2nd NMR spectrometer

Radiochemistry

- State-of-the-art radiochemistry hot cells, fume hoods and glove boxes for safe radiotracer production (F-18, radioiodine and radiometals)
- Production or acquisition, purification and dispensing of theranostic radioisotopes: Tb-161, F-18, Sc-47, I-131/124, Hg-203

Scientific computing

- Upgraded local scientific computing cluster (CPU, GPU, queue management)
- Increased node capacity, data transfer and storage

Environment Theme



- Automated sample preparation for increased sample throughflow for stable isotopes and AMS
- Focus on new isotopes: MC-ICP-MS, 18O in solids, CSIA, DOC
- Direct mercury analyser
- Replace automated gamma counter
- Cross Platform-Theme Project management system including a dedicated business development/admin person – capture the entire cycle – fosters interaction between clients and researchers

Nuclear Fuel Cycle Theme



- Access to world-class infrastructure for active materials processing and characterisation. Retire/maintain/upgrade/develop new, with focus on:
 - PIE; MFB; Actinide Lab; electron, ion, neutron, synchrotron probes
- Standardisation of procedures and measurements for active/inactive work
- Streamline active work approval process:
 - Generic SWMES for research work with low quantities/activities
- Access to world-class mechanical testing infrastructure, with focus on:
 - Creep; creep-fatigue; corrosive molten salt environment; in-beam/in-situ testing
- Support for advanced computational methods in materials physics:
 - Hardware and software; IT support; access to supercomputer capability

ANSTO Synroc® Technologies



Strategic plans

- Development of capabilities that create impact and benefit and support national priorities
- Develop and qualify engineering solutions for full life cycle treatment of ANSTO's legacy wastes
- Leverage engineering solutions for other waste producers (international)

Technology drivers

- Nuclear waste chemical characterisation
- Process technologies (HIP & EBW)
- Process automation (with active materials)
- Advanced materials and process development

Disruptive drivers

- Waste arising from new nuclear fuels (Gen IV)
- New waste re-use or disposal pathways
- New manufacturing technologies and applications

Appendix B:

List of acronyms

ACNS	Australian Centre for Neutron Scattering
AI	Artificial Intelligence
AINSE	Australian Institute of Nuclear Science and Engineering
ALMERA	Analytical Laboratories for the Measurement of Environmental Radioactivity
AMS	Accelerator Mass Spectrometry
ANKA	Angströmquelle Karlsruhe
APEA	Annual Performance and Effectiveness Appraisal
ARC	Australian Research Council
ARP	ANSTO Research Portal
AS	Australian Synchrotron
CAS	Centre for Accelerator Science
CERN	Conseil Européen pour la Recherche Nucléaire
CRC	Cooperative Research Centre
CRM	Customer Relation Management
CSIA	Compound Specific Isotope Analysis
CT	Computed Tomography
DOC	Dissolved Organic Carbon
EBW	Electron Beam Welding
ECR	Early Career Researcher
FAIR	Findable, Accessible, Interoperable, Reusable
FIB	Focused Ion Beam
GATRI	Gamma Technology Research Irradiator
GLP	Good Laboratory Practice
GMP	Good Manufacturing Practice
GNIP	Global Network of Isotopes in Precipitation
GPU	Graphics Processing Unit
HIP	Hot Isostatic Pressing
HPC	High Performance Computing
HPLC	High-Performance Liquid Chromatography
HPLC-MS	High-Performance Liquid Chromatography - Mass Spectrometry
IAEA	International Atomic Energy Agency
IBA	Ion Beam Analysis
IDMS	Isotope Dilution Mass Spectrometry
IP	Intellectual Property
ISO	International Organisation for Standardisation
ITNS	Isotope Tracing in Natural Systems
LH	Lucas Heights
LIEF	Linkage Infrastructure, Equipment and Facilities

LNP	Liquid Nanoparticle
MC-ICP-MS	Multicollector-Inductively Coupled Plasma - Mass Spectrometry
MFB	Materials Fabrication Bay
MRI	Medical Research Institute
mRNA	messenger Ribonucleic Acid
MTA	Material Transfer Agreement
NCEPT	Neutron Capture Enhanced Particle Therapy
NCI	National Computational Infrastructure
NCRIS	National Collaborative Research Infrastructure Strategy
NCT	Neutron Capture Therapy
NDF	National Deuteration Facility
NMDC	Nuclear Materials Development and Characterisation
NMR	Nuclear Magnetic Resonance
NS	Nuclear Stewardship
NST	Nuclear Science and Technology
NUS	National University of Singapore
OPAL reactor	Open Pool Australian Light-water reactor
PC2	Physical Containment Level 2
PET	Positron Emission Tomography
PFRA	Publicly Funded Research Agency
PGRA	Postgraduate Research Award
PI	Principal Investigator
PIE	Post-Radiation Examination
PM	Particulate Matter
RIDP	Research Infrastructure Decadal Plan
RSS	Residential Student Scholarship
RT-qPCR	quantitative Reverse Transcription Polymerase Chain Reaction
SANS	Small-angle Neutron Scattering
SEM	Scanning Electron Microscopy
SKA	Square Kilometre Array
SMEs	Small or Medium Size Enterprises
SPECT	Single Photon Emission Computed Tomography
STEM	Science, Technology, Engineering, and Mathematics
SUPL	Stawell Underground Physics Lab
SWMES	Safe Work Method and Environment Statement
TEM	Transmission Electron Microscopy
TRL	Technology Readiness Level
UNESCO	United Nations Educational, Scientific and Cultural Organisation



Australian Government



LOCATIONS

Lucas Hieghts
NEW SOUTH WALES

Clayton
VICTORIA



www.ansto.gov.au