
ACCELERATING RESEARCH AND INNOVATION THROUGH DATA



Australian Research Data Commons



The ARDC
is enabled
by NCRIS

ACCELERATING RESEARCH AND INNOVATION THROUGH DATA

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We acknowledge and celebrate the First Australians on whose traditional lands we live and work, and we pay our respects to Elders past, present and emerging.

Aboriginal and Torres Strait Islander people should be aware that this booklet may contain images and names of deceased persons.

Thank you to ARDC staff and ARDC-supported project and program team members for their contributions to this publication.

Approved by:
Rosie Hicks, CEO, ARDC

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A MESSAGE FROM OUR CEO

In early 2022 we welcomed the release of the Australian Government's 2021 National Research Infrastructure Roadmap, which committed \$900 million over the period 2023–2028 for the tools, technology and skills to keep Australian research internationally competitive.

The roadmap reinforces the critical nature of data — for decision making, for commercialisation and for fundamental research. It supports our focus on ensuring Australian researchers are internationally competitive through having access to high-quality data assets, platforms, infrastructure, policies, people and training.

In the government's upcoming planning process for capital investment to realise the roadmap, we will ensure Australian researchers continue to benefit from world-leading digital research infrastructure and expertise.

Digital Research Infrastructure That Endures

We are now in the third year of the COVID-19 global pandemic. As you will read in the impact case studies in this booklet, digital research infrastructure provided by the ARDC and our fellow NCRIS facilities has helped researchers respond quickly to the pandemic, and continues to support them with vital platforms and computational capacity.

The ARDC's digital research infrastructure is delivering maximum impact for Australia thanks to our long-term investment and our trusted collaboration with the research community.

The **ARDC Nectar Research Cloud** is celebrating its 10th birthday this year. Its very first users, Professor James McCaw and his team, have provided weekly epidemic assessments and forecasts to the Australian Government for use in managing the response to COVID-19 since the outbreak of the pandemic.

Surveillance and sequencing of SARS-CoV-2 variants is facilitated by the open, international Galaxy platform, which has been supported by the ARDC Nectar Research Cloud since 2012. The platform makes it possible for the global research community to share data and perform fast and reproducible analyses.

These are just 2 recent examples of the impact of vital digital research infrastructure that has been developed over the past decade and continually enhanced thanks to the long-term investment and vision of the ARDC and our partners. Both rely on the open-source flexibility of the ARDC Nectar Research Cloud and our ongoing investment in world-class research infrastructure. ►





A Thematic Approach to Tackling Australia's Biggest Challenges

The ARDC is transforming the approach to creating digital research resources. We have embarked on the development of a suite of **Thematic Research Data Commons (Thematic RDCs)** that scale up digital research infrastructure to meet Australia's future research needs.

Under the new ARDC Thematic RDCs, we will develop national-scale data assets, digital tools and platforms within thematic areas to address Australia's science and research priorities. Through coordinating research activities across research domains, industries and government within a strategic priority area, we will provide the foundational digital infrastructure to facilitate industry partnerships and research translation.

We are investing \$15.8 million in 2 initial pilot Thematic RDCs, which will be established in the 2022–23 financial year. In May, we launched the engagement process to help define the first Thematic RDC, the 'People Research Data Commons', which will develop enduring national-scale data assets, digital tools and platforms that align with Australia's science and research priority of health. The second Thematic RDC will open for consultation later this year, with a focus on the environment and agriculture.

Co-designed with the research community, our Thematic RDCs will realise our goal of supporting the maximum number of researchers in strategic priority areas of research through a new approach to participation and organisation.

As a hub of expertise, the ARDC is positioned to drive best practice in creating, analysing and retaining high-quality data assets, and sharing this expertise across domains. Our established digital research services — which include Research Data Australia, Research Vocabularies Australia and the Nectar Research Cloud — are the foundational capabilities for Thematic RDCs, alongside existing research platforms and data assets, and new components.

Also this year, we started work on **Food Security Data Challenges**, which will create digital research infrastructure that promotes food security in Australia. This is our second Translational Research Data Challenge. The first, **Bushfire Data Challenges**, now has 13 projects underway, developing innovative digital infrastructure solutions to share data to improve Australia's bushfire resilience, response and recovery. It has over \$6 million in co-investment, highlighting the commitment of our partners.



We are excited to be on the verge of launching our first 2 ARDC Thematic Research Data Commons. These new Thematic Research Data Commons will develop enduring national-scale data assets, digital tools and platforms within a thematic area to address Australia's science and research priorities.

Rosie Hicks
Chief Executive Officer
Australian Research Data Commons

Creating National Data Assets

To accelerate leading-edge research, under our **National Data Assets** program we are creating 26 national-scale data assets through strategic partnerships with research communities and institutions.

Also this year, our **Institutional Underpinnings** program will present a framework for managing research data at Australian universities. This will be the culmination of 18 months' work by over 90 experts from 25 of Australia's universities to develop a shared approach to managing research data.

Our **Health Studies National Data Asset (HeSANDA)** program has completed a design phase and is now building national research infrastructure that will enable researchers to securely access and share data from health studies, with an initial focus on clinical trials. This is a partnership between 9 nodes, which cover 72 health research organisations, health service operators and clinical trial networks from across Australia. The program aims to stimulate data-driven research ideas, increase the impact of health research and, ultimately, improve the health and wellbeing of Australians.

New National Agendas

In the past year, we have launched 2 ambitious agendas for national research infrastructure — specifically, digital research skills and research software. These agendas will develop and support the often-hidden skills and resources that Australian researchers need if they are to use and manipulate data to its full potential.

Our **National Digital Research Skills Agenda** empowers key stakeholder groups with the resources, tools, and pathways to ensure Australia will lead in this critical space.

Our vision for the **National Agenda for Research Software** is for research software to be recognised as a first-class output of research, alongside publications and research data.

Both agendas aim to ensure that Australian researchers have the digital research skills that are essential in modern research, and that those skills and research outputs are recognised in their own right, are maintained, and continue to be enhanced.

Our Strength is our Community

We could not achieve our ambitious goals without our community, who are integral to our success. This past year, due to the pandemic, we have endured everchanging restrictions, and our team and community have shown tremendous resilience, adapting to remote working, home-schooling children and managing the stress of uncertainty.

Yet, we have still managed to provide vital research infrastructure and support research impact on our continuing journey to accelerate the translation of research into real benefits for Australia. Together with our board, our members, our partners and the research community, we're proud to be creating data assets, digital platforms, and cultural change that position Australia's researchers for maximum impact and success.

Rosie Hicks
Chief Executive Officer
Australian Research Data Commons



■ ARDC HOSTS

WHO WE ARE

At the ARDC, we drive development of national digital research infrastructure that provides Australian researchers with competitive advantage through data.

The ARDC is Australia's peak body for research data. We facilitate access to research data sets and tools from academia, industry and government for all Australian researchers.

The ARDC's national digital research infrastructure is accessible to all Australian researchers. For example, the ARDC Nectar Research Cloud is used by over 50,000 researchers every year.

We have over 80 staff based at host institutions around Australia, and 20 member institutions and growing.

The ARDC is enabled by the Australian Government's National Collaborative Research Infrastructure Strategy (NCRIS).

OUR MEMBERS



**Australian
National
University**

— HOST —



— HOST —



Curtin University

— HOST —



**Federation
University**



**Flinders
UNIVERSITY**



**Griffith
UNIVERSITY**
Queensland, Australia



**MACQUARIE
University**
SYDNEY · AUSTRALIA



**MONASH
University**

— HOST —



**THE UNIVERSITY
of ADELAIDE**



— HOST —

— HOST —



**THE UNIVERSITY
OF QUEENSLAND**
AUSTRALIA

— HOST —



**THE UNIVERSITY OF
SYDNEY**



**THE UNIVERSITY OF
WESTERN
AUSTRALIA**



**UNSW
SYDNEY**

— HOST —



**UNIVERSITY of
TASMANIA**



UTS

— HOST —



**UNIVERSITY
OF WOLLONGONG
AUSTRALIA**

OUR STRATEGY



Purpose

To provide Australian researchers with competitive advantage through data.



PEOPLE & POLICY

Connecting the ARDC

Connecting the ARDC to researchers, research institutions, industry and government to enhance knowledge exchange and drive an effective national data skills ecosystem.

Communications

Communicate our aims, impact and activities.

Engagements

Manage the ARDC's interactions with stakeholders.

Skills and Workforce Development

Ensure the research sector has the skills to create, find and use research platforms, compute and storage resources, and national data assets.

Data Policies

Work with government agencies, peak bodies and institutions on a coherent policy environment supportive of using data in research.



PLATFORMS & SOFTWARE

Accelerating Research Insights and Supporting Collaboration

Supporting an increase in high-quality / high-impact research through eResearch platforms and better research software practices.

Platforms for Analysis and Curation

Enable transformative research using advanced software and platforms.

Research Software

Advocate for software as a first-class output of research.

AUSTRALIA'S RESEARCH



Mission

To accelerate research and innovation by driving excellence in the creation, analysis and retention of high-quality data assets.



DATA & SERVICES

Maximising the Value of Australia's Data Assets

Providing competitive advantage to Australian researchers by improving the discoverability, accessibility and usability of Australia's research data assets.

Data Assets

Develop national scale data assets to support leading-edge research through a portfolio of co-investment programs.

Information Infrastructure

Accelerate research and improve research integrity by providing services for the discovery, linkage and interoperability of data and other inputs/outputs of research.

Data Capability

Provide targeted specialist data expertise to assist in solving complex data issues.



STORAGE & COMPUTE

Providing Foundation Infrastructure

Supporting Australia's data and research advantage through the provision of reliable and sustainable underpinning infrastructures.

Research Computing Cloud

Enable the sustainable development and support of research data analysis and platform activities through the delivery of cost-effective, distributed and flexible national compute resources.

Data Retention

Ensure Australia's nationally significant research data assets are sustainably managed for maximum impact.

DATA COMMONS



Jenny Fewster, Program Manager for the Humanities, Arts and Social Sciences Research Data Commons at the ARDC speaking at the Social Sciences Research Infrastructure Roundtable in April 2022.

(L to R) Juanita Pettit (Indigenous and Social Information Branch, Australian Bureau of Statistics), Professor Mark Western FASSA (Institute for Social Science Research, The University of Queensland), Jenny Fewster (ARDC), Professor Robert Ackland (Virtual Observatory for the Study of Online Networks, Australian National University).

WHAT WE DO

We run programs and facilitate partnerships that ensure Australian researchers are internationally competitive through having access to high-quality data assets, platforms, infrastructure, policies, people and training to transform our lives.

Our activities provide innovative and high-impact digital infrastructure solutions to real-world problems, with an increasing focus on translational research. We operate at the intersection of research and broader society to provide tangible and enduring economic, environmental and social benefits to Australia.

We know it takes the collective efforts of research, government and industry to solve society's greatest challenges. Our national and international collaborations and partnerships ensure valuable data and software assets are developed, made available and sustained for everyone.

We're delivering world-class digital research infrastructure to support research impact. ►

OUR PROGRAMS

Thematic Research Data Commons

The Thematic Research Data Commons program will commence in 2022 with an investment of \$15.8 million in the 2022–23 financial year. The program is supporting 2 pilot Thematic Research Data Commons (Thematic RDCs) — one for health and one for environment and agriculture.

A Thematic RDC is a vehicle for the ARDC and our national partners to collaboratively develop and deliver sustainable digital research infrastructure on a national scale. It will enable us to best meet the needs of our diverse national research communities in a strategic and comprehensive way. Thematic RDCs will integrate the ARDC's underpinning compute, storage infrastructure and services, with analysis platforms and tools that are supported by expertise, standards and best practices. These coordinated, structured, and complementary data assets, tools, and skills will create a national 'knowledge infrastructure' that enables Australian researchers to transform our lives.

Translational Research Data Challenges

The ARDC's Translational Research Data Challenges program is a national-scale initiative providing innovative and high-impact digital infrastructure solutions to real-world problems. In partnership with governments, research institutions and industry, the ARDC co-designs projects that focus on addressing the data challenges that currently impede research into these problems. The projects establish data infrastructure, such as platforms for visualising or analysing data, data assets, data catalogues and the enabling data-sharing frameworks and policies.

There are currently 2 data challenges:

- **Bushfire Data Challenges:** The ARDC is investing \$4.77 million in 13 projects that address data challenges in bushfire research.
- **Food Security Data Challenges:** The ARDC will invest \$4.5 million in projects that develop solutions to current data challenges in food security research, with the aim of improving Australia's production, consumption and distribution of safe and high-quality food.



The ARDC Institutional Underpinnings project has brought the opportunity for a national discussion that has provided new insights from an extraordinary range of practitioners in research, research support, libraries and scholarly publishing, and is making significant breakthroughs that will lift practice across the nation.

Roxanne Missingham OAM
University Librarian and Chief Scholarly
Information Officer, Australian National University

Institutional Underpinnings is an ARDC-led project in the National Data Assets program.

Humanities, Arts and Social Sciences (HASS) Research Data Commons and Indigenous Research Capability

This program is a two-year, \$8.9 million investment by the Australian Government to build national digital research infrastructure for HASS and Indigenous research, creating tools and platforms to extend researchers' capacity. The investment represents the initial stage of a proposed long-term program to address the challenges and opportunities presented by a diverse grouping of research fields.

National Data Assets

The National Data Assets initiative is a multi-year, \$20 million+ investment by ARDC that will provide Australian researchers with access to a portfolio of national-scale data assets that support leading-edge research. The initiative involves strategic co-investment project partnerships with over 200 organisations across the Australian research sector to create enduring and to create enduring national data assets that are findable, accessible, interoperable and reusable (FAIR). It leverages existing research and administrative investment to ensure ongoing sustainability and stewardship of these assets.

Platforms

The ARDC is co-investing in the development of 26 research platforms (also called virtual research environments, science gateways or virtual laboratories) that enable researchers to collect or generate data, analyse those data, and produce outputs that can be made FAIR. The platforms program is increasing the number of researchers and the diversity of disciplines with access to relevant research platforms.

Research Software

Our National Agenda for Research Software aims to see research software recognised as a first-class output of research, alongside publications and research data. We are making this vision a reality by leading concerted, coordinated action with the Australian research community to see, shape and sustain research software, and drive the uptake of the FAIR Principles for Research Software.

Digital Research Skills

Our National Digital Research Skills Agenda brings together research institutions, peak bodies and other stakeholders in a coordinated approach to develop training infrastructure, encourage shareable training materials, and support key communities. The ARDC has developed, with our partners, the tools and resources that identify and develop skills, roles, job profiles and learning pathways needed for an effective digital research sector. Increasingly, these capabilities and skills frameworks will ensure Australian researchers have access to the experts and expertise needed to effectively make use of national digital research infrastructure.

Data Retention

The Data Retention program partners with the research sector to increase the impact of investment in data storage infrastructure for important data collections. Our partnerships leverage contemporary research data management practices to enrich data collections with controlled and consistent structural metadata. Having a coherent, national view of these important data collections is driving the uptake of FAIR data principles, particularly the findability, accessibility and reusability of data collections.

INPUT INTO AUSTRALIAN GOVERNMENT CALLS FOR CONSULTATION

The ARDC provides specialist input into consultations regarding the treatment and use of data. In the past year, we have provided input into the following consultations:

- **Regional Data Hub**
(Department of Infrastructure, Transport, Regional Development and Communication (DITRDC))
- **Copyright Amendment**
(Access Reform) Bill 2021 (DITRDC)
- **Administration of the Research and Development Tax Incentive**
(Australian National Audit Office (ANAO))
- **Operation of Grant Hubs**
(ANAO)
- **Australian Data Strategy**
(Department of Prime Minister and Cabinet)
- **Decadal Plan on Australian Space Science**
(Australian Academy of Science)
- **Medical Research Future Fund Strategy and Priorities**
(Department of Health)
- **National Digital Health Strategy**
(Department of Health)
- **National Healthcare Interoperability Plan**
(Department of Health)
- **Vision for the Australian Cancer Plan**
(Department of Health)
- **Privacy Act Review**
(Attorney General's Department)
- **National Biosecurity Strategy**
(Department of Agriculture, Water and the Environment)
- **Excellence in Research Australia 2023**
(Australian Research Council)

CO-INVESTMENT PROJECTS

We collaborate and partner with organisations and institutions on projects that enable Australian researchers to access nationally significant, data-intensive, digital research infrastructure, platforms, skills and collections of high-quality data.

MEDICAL PRODUCTS (HEALTH)

Air Health Data

Australian Cancer Data Network

Australian Companion Animal Registry of Cancers

Australian Electrophysiology Data Analytics Platform

Australian Imaging Service

Australian Urban Health Indicators

BioCommons Bring Your Own Data Expansion Project

Biomedical Discovery Asset

Child Health and Development Atlas

Health Studies National Data Asset (HeSANDA) (ARDC-led)

Hospital EMR Data as a National Data Asset for Research

Human Genomes Platform

Integrated Microscopy and Proteomics

Linked Data Asset for Australian Health Research

National Poisons Information Centre Dataset

National Transfusion Dataset

Veterinary and Animal Research Data Commons

DIGITAL RESEARCH

Australian Characterisation Commons at Scale

Australian Learned Academies
Data Interworking Network (ARDC-led)

Data Retention Program (ARDC-led)

Environments to Accelerate Machine
Learning Based Discovery

Institutional Underpinnings (ARDC-led)

Scalable Governance, Control and
Management of FAIR Sensitive Research Data

Secure Cloud Computing for Sensitive Data (ERICA)



This collaboration with CHeBA and Swansea University enables data sharing and secure data analysis to occur at an international scale.

Professor Paul Bonnington
Director of the Monash eResearch Centre
Monash University

Secure Platform for Sharing Dementia Data Takes Ageing Research Global

The launch of Dementias Platform Australia (DPAU) gives Australian researchers access to data from dementia studies carried out in Australia and overseas, enabling new insights into ageing, age-related diseases, and risk of Alzheimer's disease and other dementias.

The platform was developed by a new international collaboration of UNSW Sydney's Centre for Healthy Brain Ageing (CHeBA) and Dementias Platform UK.

Underpinning DPAU is the Secure eResearch Platform (SeRP), which supports the secure sharing of sensitive health data. It provides a secure, online data analysis environment, making it easy for researchers to comply with ethical and regulatory requirements for using sensitive data. SeRP is deployed at Monash University through the ARDC-supported research platform project: Scalable Governance, Control and Management of FAIR Sensitive Research Data.

Professor Paul Bonnington, Director of the Monash eResearch Centre said, "We have collaborated with Swansea University to adapt their gold-standard eResearch platform, UKSeRP, for implementation within the Australian context.



This is an exciting tool because, for the first time, researchers can view changes in Australian cultural data over time, using deep maps that combine multiple layers of data to visualise new patterns and relationships in complex spatio-temporal and cultural materials.

Emeritus Professor Hugh Craig
Project Leader, TLCMap platform
The University of Newcastle

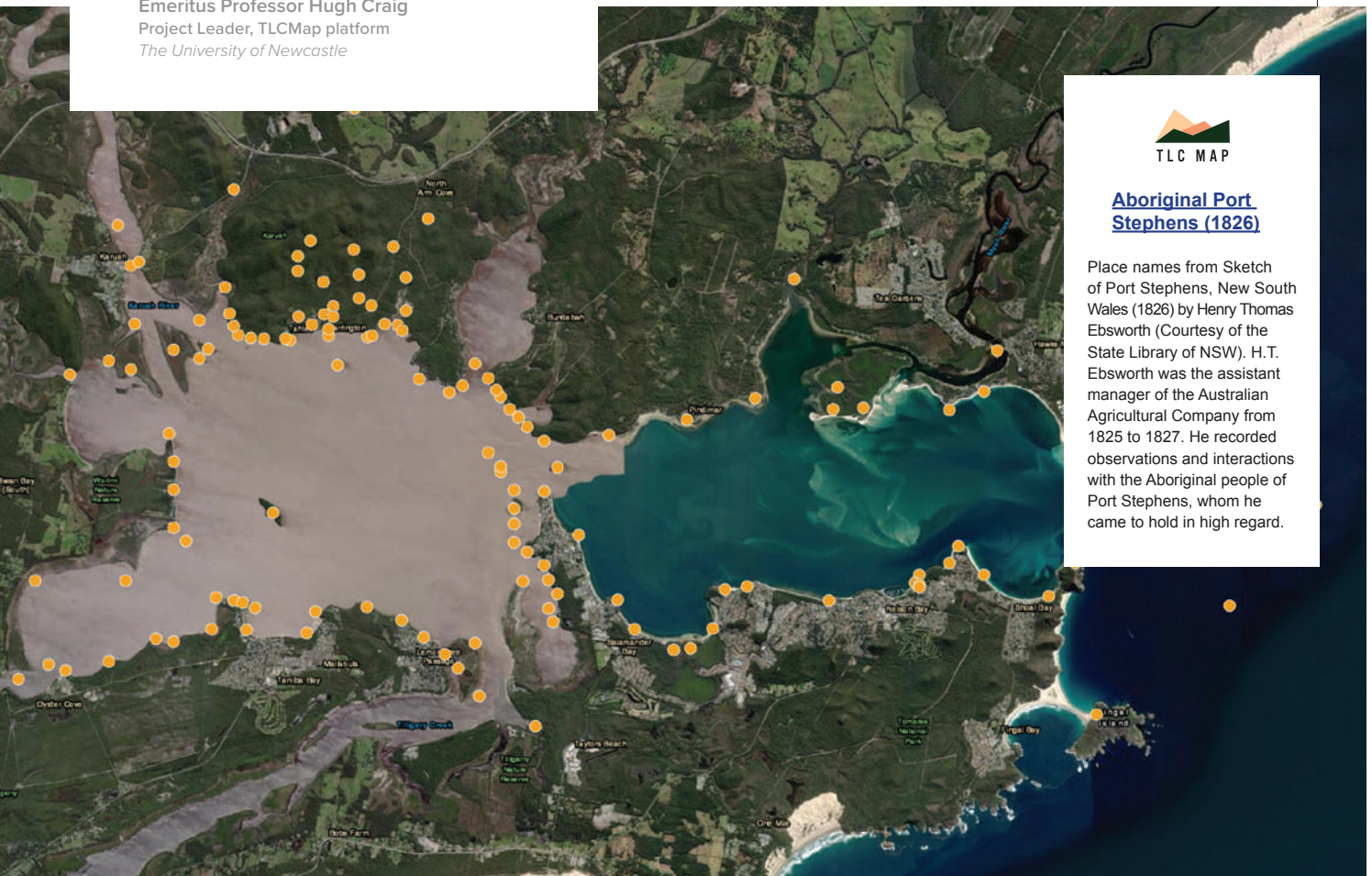
Culture-Mapping Tool Wins National Award

A digital platform that revolutionises how researchers analyse Australia's history and culture over time has won gold for education services at the 2021 Good Design Awards.

The Time Layered Cultural Map of Australia (TLCMap) is a suite of digital tools that gives humanities and social science (HASS) researchers a unique means of visualising and interrogating historical and cultural data, given a set of spatial and temporal coordinates.

The University of Newcastle led the development of TLCMap, which was designed by The Growth Drivers and Studio Zed, and supported by an Australian Research Council LIEF grant and a \$100,000 co-investment from the ARDC.

Project leader Emeritus Professor Hugh Craig said the TLCMap platform democratises access to historical and cultural datasets.



Place names from Sketch of Port Stephens, New South Wales (1826)
by Henry Thomas Ebsworth (Courtesy of the State Library of NSW), TLCMap.

ENVIRONMENT AND CLIMATE CHANGE

2030 Geophysics Collections

Air-Health Scientific Workflow System

AU Pest Genomes

AusTraits

Australia's Scalable Drone Cloud

Australian Transport Research Cloud

Biosecurity Commons Australia

Bushfire Data Challenges
(ARDC-led, 13 co-investment projects)

Catching Oz Waves

EcoAssets

EcoCommons Australia

Fish and Shark Data

FishID

Geodynamic Adjoint Optimization Platform

Global Multi-Resolution Topography for Australian
Coastal and Ocean Models (GMRT-AusSeabed)

Microbial Ocean Atlas

Mobility Australia Dataset

Open Ecoacoustics

Sensitive Species Data Pathways

FRONTIER TECHNOLOGIES AND MODERN MANUFACTURING

Australasian Computational and Simulation Commons

FOOD AND BEVERAGE

AgReFed: A platform for the
transformation of agricultural research

Food Security Data Challenges (ARDC-led)

OzBarley Data Asset

HUMANITIES, ARTS AND SOCIAL SCIENCES

Australian and New Zealand
Leaders, Elections and Democracy Data Asset

Australian Digital Observatory

Australian Housing Data Analytics Platform

Australian Text Analytics Platform

Coordinated Access for Data, Researchers
and Environments (CADRE)

FAIMS 3.0 Electronic Field Notebooks

Framework for Sensitive Data in HASS

Improving Indigenous Research Capabilities: An Aboriginal
and Torres Strait Islander Research Data Commons

Integrated Research Infrastructure for Social Sciences

Language Data Commons of Australia

Leveraging Data to Support Young People's
Education and Wellbeing Data Asset

National Free Access Colonial Findings,
Recommendations & Responses Data Asset

Time-Layered Cultural Map of Australia 2.0

Trove Researcher Platform for Advanced Research

OUR SERVICES

As a national research infrastructure, the ARDC is creating research environments that accelerate the translation of research into real benefits for society. We achieve this by:

- developing data skills and national data standards for research
- providing software, platforms, storage and services to meet research needs
- driving the creation, analysis and retention of high-quality data assets in Australia.

Our services are developed for researchers and delivered through infrastructure providers.

The ARDC Nectar Research Cloud

The ARDC Nectar Research Cloud (Nectar) is a freely available national research cloud for eligible Australian researchers and research institutions. Nectar has enabled over 21,000 researchers to work on 5,000+ groundbreaking research projects since 2012. Nectar provides Australia's research community with fast, interactive, self-service access to large-scale computing infrastructure, software and data, and is a powerful platform for collaboration. Its versatile cloud infrastructure can be used in many different ways to support research, such as a virtual desktop for a single researcher, or a powerful computational server that can be shared by researchers in Australia and internationally.

Services Powered By Nectar

Virtual Desktop Service

This service allows researchers to quickly and easily create a virtual desktop — a personal computer in the cloud. It is for researchers who need another computer to carry out compute processes for research, which they can leave running for uninterrupted processing for up to 14 days (with the ability to extend).

Digital Services

Over 200 digital services are hosted on Nectar, including national infrastructure facilities, databases, data repositories, large-scale research platforms and virtual research environments. The services cover most fields of research, from earth sciences to education, and while most are designed for use by researchers, some are also aimed at policymakers, private industry, citizen scientists, students and decision-makers.



IMAGE — DAVIDE DE MARTIN & EDWARD W. OLSZEWSKI / EUROPEAN SPACE AGENCY & NASA

“

I research the evolution of stars, so I can run 20 or 30 star models all at once on Nectar, which means I have the power of many laptops or PCs. Parallel work makes a big difference in terms of efficiency, and it's very user friendly. I can access it all from my laptop, anywhere.

Dr Simon Campbell
ARC Future Fellow
Monash University

ARDC Research Data Australia

ARDC Research Data Australia is an online portal for finding research data and associated projects, researchers, and data services. You can find, access, and reuse data for research from over 100 Australian research organisations, government agencies, and cultural institutions. Research Data Australia covers a broad spectrum of research fields from science, technology, engineering and mathematics through to social sciences, arts and humanities.

Services Powered By Research Data Australia

Research Grants and Projects

Search for Australian research grants and projects via this discovery service, which includes grant information from Australia's principal research funders as well as project descriptions from various institutions and agencies. These descriptions include grant identifiers and connections to related datasets and publications.

A weather station capturing climate data.

“

The fact that Research Data Australia was the first of its kind in Australia means that it provides a standard for data so we can follow its lead. I work across CLEX's 5 university partners, so following a national standard for metadata provided by Research Data Australia is invaluable, along with data standards and guidance provided by the ARDC.

Dr Paola Petrelli
CMS Data Manager for CLEX
The ARC Centre of Excellence for Climate Extremes



IMAGE — IOAN PANAIT / ADOBE STOCK

Persistent Identifiers

The ARDC creates and manages persistent identifiers that support researchers with citation and attribution of resources, including research data, samples, files, documents or other research outputs. Our identifier services provide globally unique persistent identifiers at no cost for Australian research organisations and institutions, enabling them to support their researchers in the citation and discovery of data and related materials.

We provide 4 types of persistent identifier services:

Digital Object Identifier (DOI)

A DOI is used internationally by researchers to identify research data and related materials such as software. A DOI provides a persistent link to the location of these research materials on the internet. This supports research citation and tracking of citation metrics.

Handle

A handle is used for creating references to datasets, collections, papers and other research objects that can be maintained, even if the location changes.

International Geo Sample Number (IGSN)

An IGSN provides an unambiguous globally unique persistent identifier for physical samples. The service facilitates the location, identification, and citation of physical samples used in research.

Research Activity Identifier (RAiD)

A RAiD is an identifier for research projects and activities. It is persistent and connects existing persistent IDs for researchers, institutions, outputs and tools together to create a timeline of research activity. RAiD makes the tracking of research projects clear and easy.

Each of these identifiers can be linked to a researcher's ORCID record.

ARDC Research Vocabularies Australia

ARDC Research Vocabularies Australia helps create, maintain, find, access, and reuse vocabularies for research. It caters for researchers and those who support, describe and discover research, including vocabulary managers, ontologists, data managers and librarians.

Research Platforms

The ARDC has supported many research platforms that help researchers to integrate and analyse data and streamline their research. Platforms are also called virtual research environments or virtual laboratories and examples include the FAIMS 3.0 Electronic Field Notebooks, Characterisation Virtual Laboratory and EcoCommons.

Communities of Practice


The ARDC provides a platform for information exchange, best practice, problem solving and peer support through a wide range of communities of practice.

Engagement, Expertise and Support

The ARDC Engagements team assists the Australian research community with data and digital research challenges. We provide information and expertise on the FAIR principles, and on managing sensitive data and its governance; we assist with data description and preparation for publishing and sharing; and we identify appropriate national infrastructure that is available for use, and that helps researchers conduct data-intensive research more efficiently and effectively. We also provide a range of data maturity self-evaluation workshops such as the Research Infrastructure Self Evaluation (RISE) workshops and run the ARDC Leadership Series of events to engage with key decision-makers on topics such as sensitive data, digital research skills, and industry-researcher collaboration.

OUR IMPACT - 5 CASE STUDIES

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A LANGUAGE DATA COMMONS FOR AUSTRALIA



Banduk Marika and Ernie Dingo. Photo from the TV series Talking Language with Ernie Dingo. Made by CAAMA Productions for Imparja Television, distributed by Ronin Films.

Language data is an important source of information for revitalising Indigenous language in Australia. New digital research infrastructure backed by the ARDC is being developed to support it.

2022 marks the beginning of the International Decade of Indigenous Languages, declared by the United Nations General Assembly to draw attention to the critical status of many Indigenous languages across the world and encourage action for their preservation, revitalisation and promotion.

The international attention on Indigenous languages comes at a critical time for Australia, with the state of most of the 250 Aboriginal and Torres Strait Islander languages, plus around 800 dialects, in steep decline, triggered by the systematic separation of people from their language through colonisation.¹

The National Indigenous Language surveys record the decline, said Ms Christie Wishart, a researcher at Central Queensland University. Ms Wishart is Ngugi from Quandamooka Country (Grandmother) and Nalbo from Jinibara Country (Grandfather).

“Since 2005, despite government funding and increased language programs, we continue to lose languages. We have lost 8 strong languages between 2005 and 2019,” she said.

“I hear the devastation when I’m talking to people who say, ‘I don’t know who my mob is, I don’t know where I come from, I don’t know my language.’

“It is devastating to think that we’re losing something that could genuinely close the gap in a really big way.”

Language and Wellbeing are Linked

Ms Wishart is researching the connection between First Nations language and wellbeing as part of a higher degree by research.

“There are known links between the loss of First Nations language and the resulting disadvantage and reduced wellbeing within First Nations communities,” she said. “Language is integral to our identity and a strong identity has positive effects on health and wellbeing.”

The benefits of language are already well known by First Nations communities, but Indigenous-led research by Ms Wishart will contribute to understanding the impact of language on wellbeing at a broader level.



There are known links between the loss of First Nations language and the resulting disadvantage and reduced wellbeing within First Nations communities ... Language is integral to our identity and a strong identity has positive effects on health and wellbeing.

Christie Wishart
Researcher
Central Queensland University

Revitalising and Reawakening Language

On a positive note, the reclamation and revitalisation of First Nations language is growing across Australia, and this is strengthening identity, culture, health and wellbeing in Indigenous communities. Its importance has been recognised in the recent National Agreement on Closing the Gap, with Target 16 stating that by 2031 there is a sustained increase in the number and strength of Aboriginal and Torres Strait Islander languages being spoken.

According to the National Indigenous Languages Report (2020), “Many Aboriginal and Torres Strait Islander people are actively seeking ways to reconnect with traditional languages. This is painstaking work, but in parts of the country some languages are being reawakened, demonstrating what is possible with community will and ongoing investment.”

¹ Sivak et al. (2019) doi.org/10.3390/ijerph16203918



IMAGE — AIATSIS GOVAU

Warlpiri translator Theresa Napurrurla Ross with granddaughter Bethalia Kelly. We know that educational outcomes improve when children are taught in their first language, especially in the early years.

Language Data, a Crucial Piece of the Revitalisation Puzzle

Language data is an important source of information for Indigenous language revitalisation, and new digital research infrastructure supported by the ARDC is being developed to support it.

Language data includes audio and video recordings of people speaking, and written text, from entire newspapers to tweets. It's used for linguistic research into pronunciation, syntax, semantics, how language is used, how language and language use change over time, and how language varies across social groups.

Large collections of language data have been amassed in Australia by several institutions — AIATSIS (Indigenous Australian languages) and PARADISEC (South West Pacific languages and Indigenous Australian languages) are some of the bigger ones.

But much of Australia's language data is scattered, hard to find, and in danger of being lost.

Now, with co-investment from the ARDC, the Language Data Commons of Australia is being developed by 17 partner institutions as a sustainable long-term resource for language data collections of national significance. Capitalising on existing infrastructure, it will secure vulnerable and dispersed collections, and link with improved analysis environments for new research outcomes.

The Language Data Commons will work like an online portal, with a search function that directs users to the institutions that hold the relevant data. For collections that are at risk of being lost, it will provide a pathway to repositories that will ingest and curate them for the long term. As well as the data collections, it will provide access to tools to analyse the data.

While the Commons is for all languages used in Australia and our region, Australian First Nations languages are at its core.

The Commons project will also aim to strengthen First Nations languages through community outreach and education, and Indigenous-led research on First Nations languages.

To date, little research has focused on language reclamation and the effects on the mental health and wellbeing of First Nations Peoples.

Ms Wishart said, "There is only one study I have identified that is Indigenous-led and uses Indigenous methodologies [and] its main focus is on language reclamation and the impacts on wellbeing of First Nations Peoples." ►

Language Data for Non-linguists

An important part of the project is working with First Nations communities to ensure responsible sharing of data and tangible benefits for language speakers, alongside researchers.

Two industry fellows at the University of Queensland will be a direct link between the project and Aboriginal and Torres Strait Islander communities.

Robert McLellan is a Gooreng Gooreng man and Industry Fellow at the University of Queensland working on the Language Data Commons.

In his role he will be “upholding Indigenous interests in the process and seeing that Aboriginal voices are heard and that we are actively engaging with people in the community.

“In the bigger picture, we’re working towards this digital catalogue that will make these language resources more accessible to everyone. But there’s a large piece of that puzzle that needs to be culturally informed, culturally appropriate, and we need to see that Indigenous peoples are benefitting from this initiative too,” added Mr McLellan.

*Members of the Language Data Commons team from the School of Languages and Cultures at the University of Queensland. The team includes over 20 members from across the project partners.
(L to R) Simon Musgrave, Alvin Sebastian, Marco Fahmi, Ben Foley, Peter Sefton, Martin Schweinberger.*



IMAGE — MARC GRIMWADE / ARDC

Language Data Is Dispersed and "Hidden in a Vault"

On his journey to strengthen his Gooreng Gooreng language, Mr McLellan described his frustration with trying to find and access language data:

"You find your language and it's hidden in a vault, and the vault might be a 'sketch grammar' or other linguistic papers. And if you don't know linguistics, it's so frustrating to know you can hold your language in your hand, but you can't understand it. You don't know what all of this jargon is about," said Mr McLellan.

This frustrating experience is echoed in communities M McLellan has spoken with who are seeking language data.

The Language Data Commons will be a valuable source of information for those seeking to revitalise language. It will not only be a registry, but will also provide tools to analyse the data for research, and facilitate training on how to use and understand linguistics data.

"Till now, finding language data has really relied on talking to people. And if you weren't connected with academics, well then you would never know," said Mr McLellan.

"With the Language Data Commons, if you apply the right search, you'll be able to access that material, but you'll also be able to access anthropological materials and other papers that contain less linguistic terminology that can help you get a better understanding about your language.

"With the Language Data Commons, the only barrier that exists is Internet access, which is just one barrier as opposed to the plethora that existed before."

With the UN spotlight on the importance of Indigenous languages over the coming decade, the Language Data Commons has the potential to strengthen language revitalisation efforts in Australia, and contribute to closing the gap, one dataset at a time. ■



With the Language Data Commons, if you apply the right search, you'll be able to access that material, but you'll also be able to access anthropological materials and other papers that contain less linguistic terminology that can help you get a better understanding about your language.

Robert McLellan
Industry Fellow, School of Languages and Cultures
Faculty of Humanities and Social Sciences
The University of Queensland


PARTNERS

The project is led by **The University of Queensland** in partnership with: **AARNet**, **ARC Centre of Excellence for the Dynamics of Language (CoEDL)**, **First Languages Australia**, **Monash University**, **Australian National University**, **The University of Melbourne**, **The University of Sydney**.

The project is consulting with the following stakeholders: **Australian Academy of Humanities (AAH)**, **Australian Institute for Aboriginal and Torres Strait Islander Studies (AIATSIS)**, **Common Language Resources and Technology Infrastructure (CLARIN)**, **Digital Observatory at Queensland University of Technology**, **Indigenous Data Network (IDN)**, **Language Technology Group Pty Ltd**, **Macquarie University**, **PARADISEC**, **The University of Western Australia**

ARDC SUPPORT

The Language Data Commons received co-investment from the ARDC through these programs: **Humanities, Arts and Social Sciences (HASS) Research Data Commons** and **Indigenous Capability Program**, **National Data Assets and Research Platforms**. Datasets of national significance managed by project partners **PARADISEC** and **CoEDL** are being supported by the ARDC Data Retention Project. The Language Data Commons is using these ARDC services: **ARDC Nectar Research Cloud**, **ARDC Research Data Australia**, and **Persistent Identifiers**.

A large blue and red cargo ship is sailing on the ocean under a sunset sky. The ship is moving towards the right, leaving a white wake behind it. The sky is filled with orange and yellow clouds, and the water is a deep blue. In the background, there are faint silhouettes of mountains or hills.

SHARED VOCABULARIES CREATE OCEANS OF OPPORTUNITIES



Research vocabularies are helping researchers aggregate data from a wide range of sources and disciplines to find evidence-based solutions to big societal challenges such as climate change.

In 2021, an analysis of sea temperature data collected from the Southern Ocean over 25 years revealed disturbing evidence that the potential for Antarctic ice-sheet melting has been hugely underestimated in past studies. The resulting sea level rise could have dramatic impacts around the world.²

The unique time series of data was collected on board the French Antarctic resupply vessel *L'Astrolabe*, from 1992 to 2017, between Hobart and Antarctica.

It's not unusual for scientific institutions to use volunteer merchant vessels to routinely gather observations. Known as 'ships of opportunity', they are a cost-effective way of collecting multidisciplinary oceanographic data for measuring the speed of change in the marine environment.

Taking the Ocean's Temperature

CSIRO data analyst and scientific programmer Ms Rebecca Cowley manages the Integrated Marine Observing System (IMOS) Ships of Opportunity program and is responsible for quality control and for sharing the data with other institutions.

CSIRO is part of the consortium that operates IMOS, which is enabled by the National Collaborative Research Infrastructure Strategy (NCRIS).

To record the ocean temperature, IMOS uses expendable temperature probes, which are deployed overboard at regular intervals. Attached to a long copper wire, the probe can sink to about 900 metres, and sends temperature data up the wire at various depth intervals, to an on-board system.

Within minutes, Ms Cowley can review the data from her office in Hobart and share it with the Global Telecommunication System (GTS), a global network for the transmission of meteorological data.

Within hours, the data is available to weather bureaus around the world, for use in climate modelling and forecasting, and is automatically added to Australia's marine and climate science portal, the open access Australian Ocean Data Network (AODN). All this, with minimal human intervention.

Using a Common Language Speeds Up Data Sharing

A crucial part of what makes this machine-to-machine data sharing possible, streamlined and fast is the agreed research terminology, defined in 'research vocabularies', which institutions share and adhere to for describing collections of data — both the metadata and the data itself.

A vocabulary can be used to annotate data unambiguously; for example, the data must be attributed to the correct ship, so the name of the ship or its unique 'call sign' must already be registered in the AODN Platform Vocabulary or the data transfer will fail.

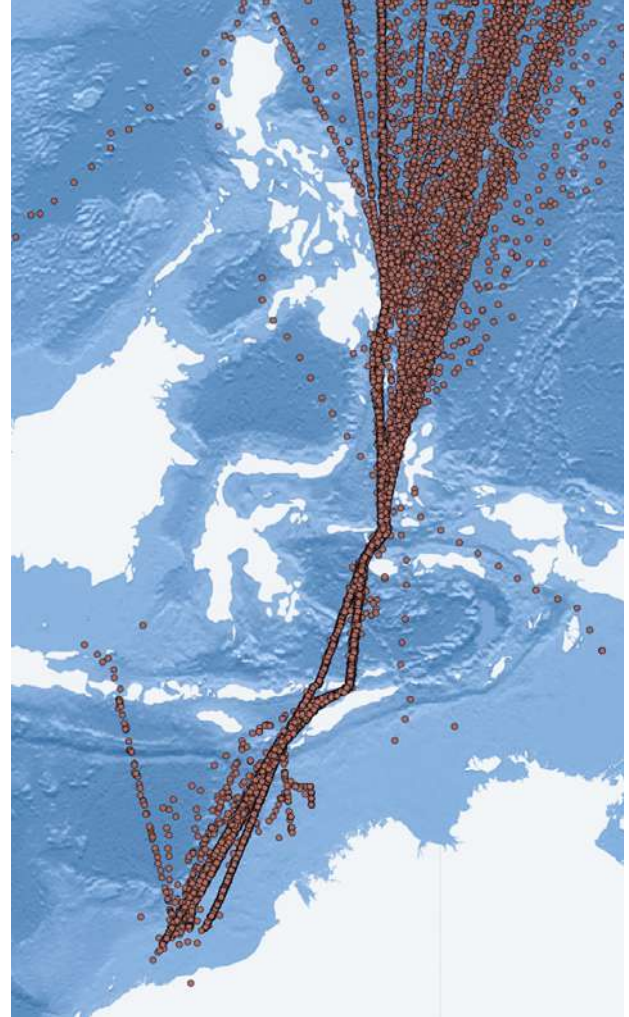
Vocabularies Support Data Discovery and Aggregation

A research vocabulary can be as simple as a glossary or a list of codes that anyone in the research community can add to. Others, such as units of measure, taxa and rock types, are tightly controlled. The minimum requirements for a useful vocabulary are a unique label and a description or definition for each term in the list, though increasingly they also contain synonyms, intra-vocabulary relationships and cross-vocabulary mappings.

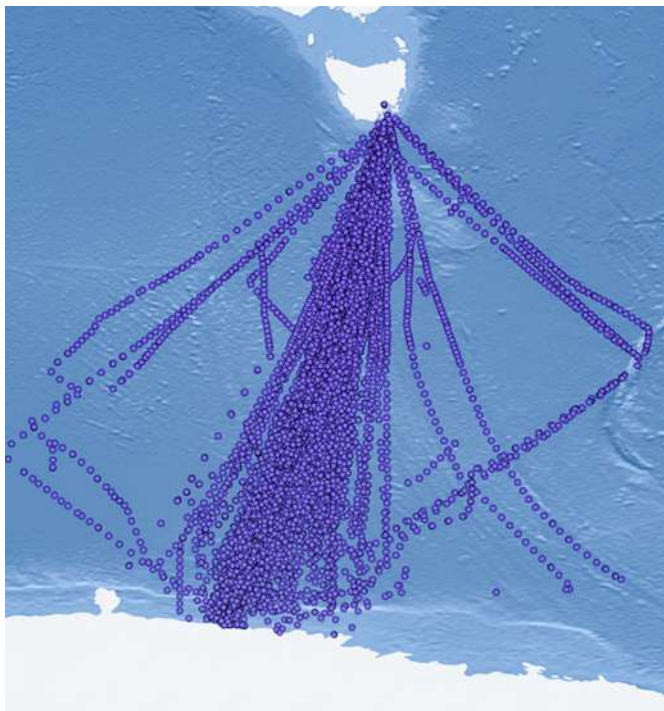
From plant taxonomy to disease classification, science depends on precise language and referencing. Finding evidence-based solutions to the grand societal challenges of this century requires that scientists use shared scientific concepts to pool their work. This enables them to aggregate vast amounts of data from multiple sources, often from multiple disciplines and domains, and from countries where differing languages are spoken. Clearly, unless a data collection is tagged using globally agreed terms, it cannot be part of the global web of information systems necessary for tackling challenges such as climate change ►

² Auger, M. et al. (2021), 'Southern Ocean in-situ temperature trends over 25 years emerge from interannual variability', *Nature Communications*, doi.org/10.1038/s41467-020-20781-1

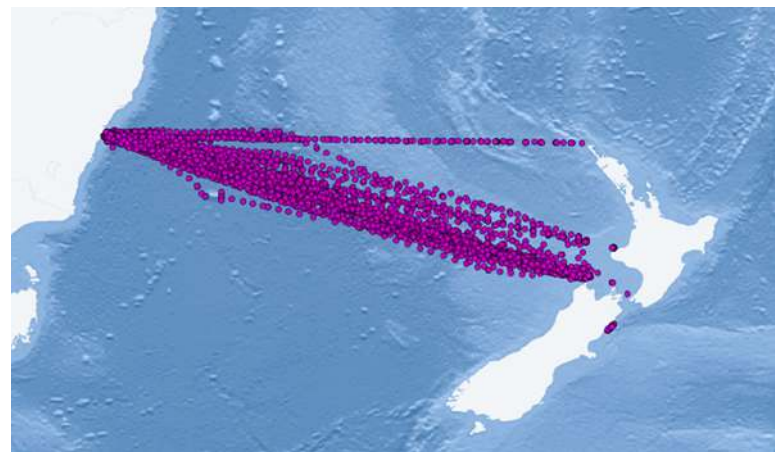
A crucial part of what makes this machine-to-machine data sharing possible, streamlined and fast is the agreed research terminology, defined in ‘research vocabularies’, which institutions share and adhere to for describing collections of data — both the metadata and the data itself.



XBT line : IX22-PX11
XBT line description : Port-Hedland-Japan
Vessel Name: Northwest Sandpiper
Callsign : VNVG



XBT line : IX28
XBT line description : Dumont-d-Urville-Hobart
Vessel Name: l'Astrolabe
Callsign : FASB



XBT line : PX32/PX34
XBT line description : Sydney-Wellington
Vessel Name: Hansa Offenburg
Callsign : D5TL2

These maps were sourced from the AODN portal supported by Australia's Integrated Marine Observing System (IMOS). IMOS is enabled by the National Collaborative Research Infrastructure Strategy (NCRIS). It is operated by a consortium of institutions as an unincorporated joint venture, with the University of Tasmania as Lead Agent.



- Launched in **2015**
- **484** research vocabularies
- **87** registered publishers, including IMOS, TERN, Geoscience Australia and the Australian Bureau of Statistics
- More than **100** people from research institutions are registered vocabulary contributors
- **11,088** filtered page views per year on average

The ARDC provides an open, web-based service for publishing and accessing vocabularies. ARDC Research Vocabularies Australia is designed for people who support, describe and discover research — such as vocabulary managers, ontologists, data managers and librarians — and for researchers. It helps them create, maintain, find, access and reuse research vocabularies.

Vocabularies are Best When They are FAIR

Like research data, research vocabularies are best when they are FAIR — findable, accessible, interoperable and reusable.

The ARDC provides an open, web-based service for publishing and accessing vocabularies. ARDC Research Vocabularies Australia is designed for people who support, describe and discover research — such as vocabulary managers, ontologists, data managers and librarians — and for researchers. It helps them create, maintain, find, access and reuse research vocabularies.

Several institutions host their vocabularies directly on ARDC infrastructure. Others are linked to on their home websites.

As of this year, 484 research vocabularies are openly shared on Research Vocabularies Australia by 87 registered publishers, including IMOS, TERN, Geoscience Australia and the Australian Bureau of Statistics. More than 100 people from research institutions are registered vocabulary contributors.

Some of the most heavily accessed vocabularies are a 'fields of research' vocabulary, a public policy taxonomy, an astronomy thesaurus, and an index of psychological terms.

158 of these vocabularies come with a readymade tool, or 'widget', which users can 'plug in' to their own data capture tools, allowing them to draw directly from ARDC-hosted vocabularies to classify their data.

An independent evaluation by CSIRO of Research Vocabularies Australia in 2019 found that it "is meeting a clear need, and provides a suite of capabilities that are valued by the community."

A vocabulary is not only useful for humans, but also for machines. ARDC-hosted vocabularies follow contemporary best practice whereby each term is allocated a unique web identifier.

The information is structured using the Simple Knowledge Organization System (SKOS), the W3C recommendation for representing vocabularies in a format understandable by computers. This supports interoperability and reuse of the vocabulary term, and discovery and integration of data.

Governance and Reuse of Vocabularies at IMOS

Dr Natalia Atkins is the metadata manager for all IMOS vocabularies used in managing the Australian Ocean Data Network. She creates all the metadata records for IMOS content, using vocabulary terms such as the vessel name and the name of the organisation that collected the data.

“We created our vocabularies to make the IMOS data collections more discoverable. We have separate vocabularies which are used for different workflows. The main use of our vocabularies is for driving the faceted searching on the AODN portal,” said Dr Atkins.

The vocabularies are also used in the data ingestion process [to AODN] to ensure that it is catalogued in a systematic way. “Water temperature is a good example,” said Dr Atkins. “Some people call it ‘temperature of the water body’, others call it ‘sea temperature’; then there’s ‘sea surface temperature’ or ‘SST’. If you don’t mark things up in a systematic way, you can never be sure it’s the same [thing].

“We also try to have good governance and part of that is not reusing terms already used in other vocabularies.”

For example, if a term already exists in a vocabulary of the British Oceanographic Data Centre — whose vocabulary service is the point of truth for many international oceanography initiatives — Dr Atkins will link to it from the IMOS vocabulary. Not only does this avoid duplication, it ensures the definition is always up to date, and the provenance of the definition is visible for all to assess.

Promoting FAIR Research Vocabularies and Fostering Collaboration

Through the power of the semantic web, vocabularies are evolving beyond the simple concept of a dictionary or thesaurus and are beginning to be shared across disciplines and domains.

It’s important that the research community signs up to use vocabularies in their metadata and data. The ARDC plays a leading role in promoting FAIR research vocabularies in Australia and internationally, not just through our Research Vocabularies Australia service but also through our support for the Australian Vocabulary Special Interest Group and through facilitating several working groups.

As the faraway, menacing drip of melting ice grows ever more insistent, dissolving the barriers that prevent researchers from sharing data quickly and easily has never been more necessary. ■



We created our vocabularies to make the IMOS data collections more discoverable. We have separate vocabularies which are used for different workflows. The main use of our vocabularies is for driving the faceted searching on the AODN portal.

Dr Natalia Atkins
Metadata Manager, *Integrated Marine Observing System (IMOS)*



AUSTRALIA'S NATIONAL RESEARCH CLOUD CELEBRATES 10 YEARS



Prof James McCaw leads a team of researchers who conduct infectious disease modelling and epidemiological analysis on the ARDC Nectar Research Cloud.

Since 2012, the ARDC Nectar Research Cloud has been providing Australia's research community with fast, self-service access to large-scale computing infrastructure, supporting over 21,000 users and 5,000 projects across all fields of research.

IMAGE — ED SLOANE / ARDC

January 2022 marked the 10-year anniversary of the ARDC Nectar Research Cloud, the world's first national federated cloud dedicated to research.

Over its decade of operation, it has supported more than 5,000 projects across all fields of research — projects that have contributed to positive outcomes for society, human health and the environment, both in Australia and internationally.

“It’s an exciting milestone for a vital, unique Australian research infrastructure,” said Carmel Walsh, Director of eResearch Infrastructure and Services at the ARDC.

Nectar provides Australia’s research community with fast, interactive, self-service access to large-scale computing infrastructure, software and data, and is a powerful platform for collaboration. Specifically designed for research computing, it has defined and established research computing standards that enable collaboration on a global scale.

Nectar is supported by the Australian Government through the National Collaborative Research Infrastructure Strategy (NCRIS). Nectar nodes are hosted in Australia and New Zealand by: The University of Melbourne, Monash University, the Tasmanian Partnership for Advanced Computing, QCIF, Intersect, Swinburne University and the University of Auckland.

Dr Stephen Giugni OAM, Director of Research Computing Services at The University of Melbourne said, “The University of Melbourne shares Nectar’s excitement at reaching this milestone. As the foundation node, we take pride that many of our staff who were involved with establishing Nectar are all still involved in creating the future of this resource for the Australian research community.” ►



As the foundation node, we take pride that many of our staff who were involved with establishing Nectar are all still involved in creating the future of this resource for the Australian research community.

Dr Stephen Giugni OAM

Director, Research Computing Services
The University of Melbourne



The ARDC Nectar Research Cloud is hosted by a network of federated nodes at partner institutions in Australia and New Zealand and is accessible to all Australian researchers.



QCIF
Brisbane



The University of Melbourne
Melbourne



Swinburne University of Technology
Melbourne



Monash University
Melbourne



Intersect
Sydney



The University of Auckland
Auckland



TPAC
Hobart

SINCE ITS LAUNCH 10 YEARS AGO, NECTAR HAS SUPPORTED:

- **21,401** users
- **5,009** research projects
- **414** Australian Research Council (ARC) grants
- **186** National Health and Medical Research Council grants
- **35** Australian universities
- **18** ARC centres of excellence
- **9** ARC industrial transformation hubs and training centres
- **20** cooperative research centres and projects
- **15** NCRIS capabilities
- **28** research platforms / virtual laboratories
- **2,875** research papers
- **1.2** million virtual-machine instances
- **2.3** billion virtual-processor hours.

An International Success Story

Nectar is seen internationally as an exemplar of national digital research infrastructure and a trailblazer in using open-source cloud computing for research. Nectar pioneered the use of OpenStack open-source cloud software technology, which is now used by many large-scale federated research clouds, including the European EGI Federated Cloud.

In 2021, the *Financial Times* suggested that the campaign to create a national research cloud for the United States might draw inspiration from Nectar. Since then, US academics have sought our advice on creating a national research cloud.

Also in 2021, the ARDC joined the technical working group for the Global Open Science Cloud Initiative, and Nectar staff were interviewed by the UK Centre for Data Ethics and Innovation to help develop a business case for a national research cloud in the UK.

Essential Infrastructure for Australian Research

Nectar is a vital resource used by thousands of Australian researchers to store and analyse data and run computations and software across all fields of research. More than 200 research services are hosted on Nectar — national infrastructure facilities, databases, data repositories, large-scale research platforms and virtual research environments — and are used by more than 50,000 researchers worldwide.

The way in which Nectar has supported Australia's response to the COVID-19 pandemic demonstrates its important role in Australia's research ecosystem. Professor of Mathematical Biology James McCaw from the University of Melbourne holds an honorary appointment at the Doherty Institute and is an invited expert on the Australian Health Protection Principal Committee, the government's peak decision-making committee for public health emergency management and disease control. His team has contributed to the Australian Government's response to the pandemic by modelling potential scenarios using Nectar and other computational resources.

Interestingly, Prof McCaw and his team were the first research group to use Nectar when it launched in 2012. They have continued to use it ever since to study influenza, malaria and now COVID-19, modelling how viruses and other pathogens infect the host and spread through the population.

"If this resource [Nectar] was not there, it would be a nightmare," said Prof McCaw. "A lot of my team's work is absolutely contingent on this resource or equivalent resources continuing to exist. That it has been so stable and reliable over the last decade has been very important.

"[Nectar] has been essential to support and grow the computational capability of my research team, which has continued to grow since 2012."



IMAGE — ED SLOANE / ARDC

Members of the Infectious Disease Modelling team at the University of Melbourne.

(L to R) Punya Alahakoon (PhD student), Ke Li (PhD student), Dr Rob Moss, Prof James McCaw, Dr Freya Shearer, Dr David Price, Yang Yue (PhD student)

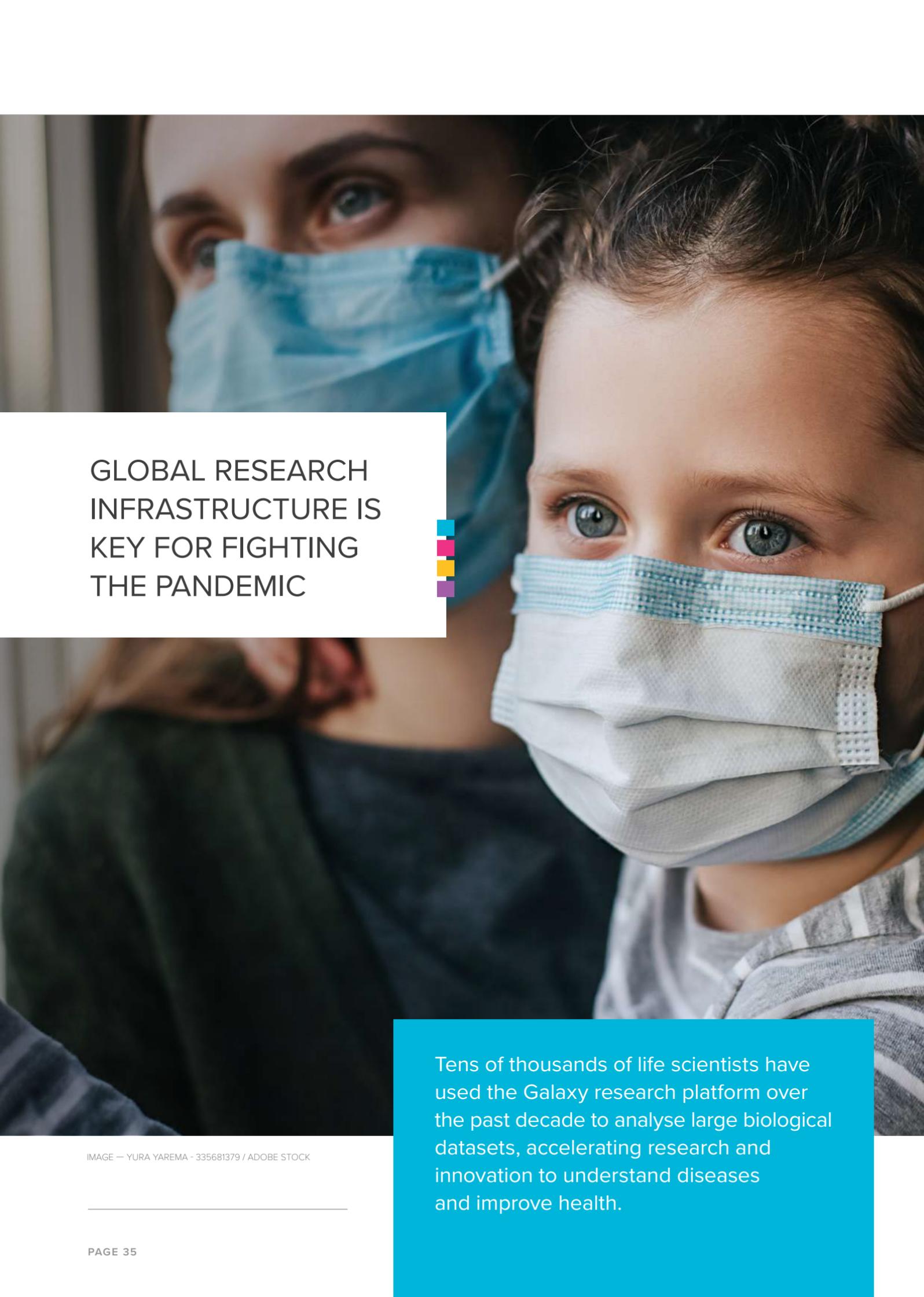
What's Next for Nectar?

Today, Nectar hosts most of the research platforms supported by the ARDC Platforms program. The range of research areas and technologies supported by these research platforms includes artificial intelligence, machine learning, sensitive data, drone technology, ecology, advanced imaging, and genomics. To support these platforms, the ARDC has invested in leading-edge infrastructure for Nectar, with large-memory machines, graphics processing units, and new and separate regions of Nectar for hosting sensitive-data platforms.

Having doubled the research computing capacity of Nectar in 2021, we are launching a suite of new services in 2022. These new national services are designed to accelerate research computing over the next decade. Already this year, we have launched our Virtual Desktop Service, which allows hundreds of new users to more easily access cloud compute resources.

We are also moving to usage-based allocation quotas to support bursty usage and new functionality and services, as well as more efficient use of cloud resources. A national GPU and Large Memory Machine Service will be launched later this year so that researchers can run more complex and larger scale applications, including artificial intelligence and machine learning workloads, in the national research cloud.

The use of new and innovative technologies at a national scale remains a cornerstone of Nectar. Through our innovation program, we are exploring the benefits of data processing units for improved cybersecurity, and we are leading the Australian Research Container Orchestration Services (ARCOS) project, which is developing best practices and standards for using containers for research software. Containers make it easier to share research workflows and software, and deploy them across different compute platforms, and support the reproducibility of research results. ■



GLOBAL RESEARCH
INFRASTRUCTURE IS
KEY FOR FIGHTING
THE PANDEMIC

Tens of thousands of life scientists have used the Galaxy research platform over the past decade to analyse large biological datasets, accelerating research and innovation to understand diseases and improve health.

IMAGE — YURA YAREMA - 335681379 / ADOBE STOCK

Our genome, or genetic code, defines how we respond to certain diseases, how we age, and how we respond to medications.

The original Human Genome Project took 13 years of work by researchers around the globe and cost close to US\$3 billion. For the first time, we could read the complete genetic blueprint for human life. This global effort to sequence the human genome pushed the boundaries of technology and thinking and spawned a new industry of high-throughput genome sequencing with new data analytics methods to match. A new era in medicine began, and great advances were made in the types of technology used to sequence DNA.

Today, a human genome can be analysed in hours thanks to third-generation DNA sequencers matched to the latest data processing algorithms. This, combined with improvements in computer techniques and processing power to map a genome, means the cost of genetic analysis has plummeted. Researchers have seized the opportunity to study valuable genomic data to inform research that helps us understand life on Earth.

However, while the amount of genomic information has exploded, capacity to analyse the data has not kept pace; neither have the skills of researchers to use complex, statistical and mathematical analysis tools.

Research platforms are important for overcoming analysis bottlenecks for researchers. Using the global Galaxy Project, researchers can analyse large biological datasets without needing advanced analytical and software engineering skills.

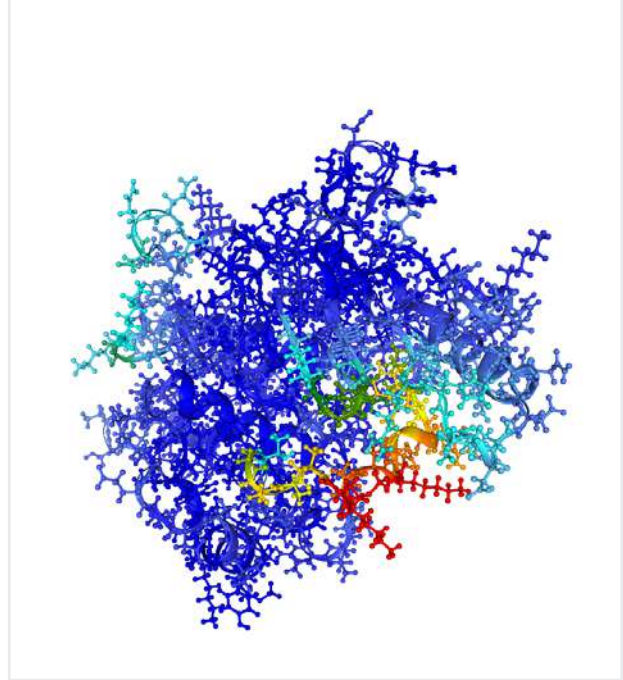


IMAGE — DR GARETH PRICE / GALAXY AUSTRALIA

The structure of the mitogen-activated protein kinase kinase kinase 10 (MAP3K10, X.laevis) kinase domain, visualised on AlphaFold 2.0 running on Galaxy Australia. AlphaFold is an AI system developed by DeepMind and EMBL's European Bioinformatics Institute; it predicts a protein's 3D structure from its amino acid sequence.

Accelerating Genomic Research with the Galaxy Research Platform

Research platforms are important for overcoming analysis bottlenecks for researchers. Using the global Galaxy Project, researchers can analyse large biological datasets without needing advanced analytical and software engineering skills, and without having to manage access to compute and storage. An international open-source platform, Galaxy is supported in Australia, Europe, the US and many other countries for the benefit of researchers worldwide.

Galaxy has helped tens of thousands of life scientists analyse large biological datasets found in genomics, proteomics, metabolomics, phenomics, transcriptomics, epigenomics and imaging. As a result, research and innovation are accelerating, from understanding diseases suffered by millions of people each year to mapping the genomes of threatened species to aid conservation.

Researchers can test, evaluate and review their peers' work within the Galaxy platform, placing the next cure for chronic disease potentially within reach of anyone with the dedication and skills to look for it. Thanks to built-in workflows and comparative genomes, researchers using Galaxy are ready to start analysing their data weeks earlier than they otherwise would be.

Dr Gareth Price is General Manager of Galaxy Australia and Head of Computational Biology at QCIF. He shares just how easy Galaxy is for a non-technical researcher to use: "In Galaxy, each analytical tool has dropdown menus, free-text fields, and check buttons. All that is seamlessly turned into command line executable code in the background, so the user doesn't need to know any software programming to be able to analyse a genome." ►



In Galaxy, each analytical tool has dropdown menus, free-text fields, and check buttons. All that is seamlessly turned into command line executable code in the background, so the user doesn't need to know any software programming to be able to analyse a genome.

Dr Gareth Price

General Manager, *Galaxy Australia*, Head of Computational Biology, *QCIF*

Thanks to the ARDC and our Nectar node partners increasing the compute and storage capacity for Galaxy, the genome of the Golden Wattle was assembled in less than 24 hours, which is an unprecedented speed for a genome of its size.



IMAGE — LEV - 25714043 / ADOBE STOCK

Investing in Research Platforms for Long-term Impact

Galaxy Australia is the local branch of the global Galaxy Project. The ARDC's investment in the platform — through the ARDC Nectar Research Cloud and the ARDC Platforms program — has seen Galaxy Australia become an essential service for training and analysis in data-intensive research in the life sciences. Our investment ensures that Galaxy Australia maintains the tools, workflows and reference datasets essential for the Australian research community to remain competitive and innovative in the global research system.

Since 2012, Galaxy Australia has been hosted in the ARDC Nectar Research Cloud. The service has seen rapid uptake by researchers and now has over 17,400 users, with 5,000 new users joining in the past 2 years alone and 1.5 million jobs submitted in the past year.

Over the past 2 years, the ARDC and our Nectar node partners increased the compute and storage capacity for the platform, including adding large-memory servers. These servers are game-changers in terms of efficiency, giving Galaxy users instant access to powerful tools such as machine learning, cheminformatic analysis and long-read sequencing. As an example, the genome of Australia's national floral emblem, the Golden Wattle (*Acacia pycnantha*), was assembled in less than 24 hours, which is an unprecedented speed for a genome of its size.

To further broaden Galaxy Australia's capabilities, we have co-invested in the BioCommons BYOD [Bring Your Own Data] Expansion Project. Already underway, the project will increase the number of research communities that can use the BioCommons platform and the types of analyses it can perform.



The enhanced Galaxy Australia platform will position Australia at the forefront of bioinformatics infrastructure and substantially improve Australian researchers' access to bioinformatics.

Professor Andrew Lonie,
Director, Australian BioCommons

The ARDC co-investment of \$2.21 million bolsters the contributions of the Australian BioCommons, The University of Melbourne, Bioplatforms Australia, AARNet, the Australian Access Federation, the National Computational Infrastructure (NCI), the Pawsey Supercomputing Centre, QCIF, Melbourne Bioinformatics, The University of Queensland and the Sydney Informatics Hub.

According to Professor Andrew Lonie, Director of the Australian BioCommons, digital technologies are proving transformational for researchers in the life sciences.

"The enhanced Galaxy Australia platform will position Australia at the forefront of bioinformatics infrastructure and substantially improve Australian researchers' access to bioinformatics," said Prof Lonie.

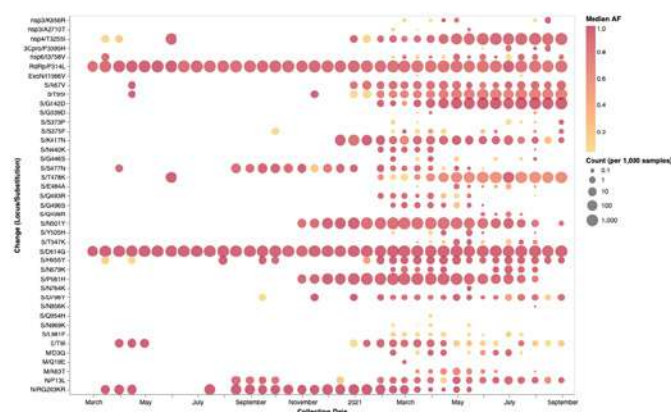


Galaxy Australia is an **Australian BioCommons** service, jointly supported by the Australian Government's **National Collaborative Research Infrastructure Strategy (NCRIS)** through the **ARDC** and **Bioplatforms Australia**; the **Queensland Government's Research Infrastructure Co-investment Fund**; and **The University of Melbourne**.

Managed by **QCIF, Melbourne Bioinformatics** and **AARNet**, Galaxy Australia is underpinned by computational resources provided by **AARNet, the ARDC, The University of Melbourne, The University of Queensland, QCIF, National Computational Infrastructure**, and the **Pawsey Supercomputing Centre**.



Right: Intra-host allelic variation seen at Omicron amino acid mutation sites in a subset of SARS-CoV-2 raw sequencing data since March 2020 analyzed using a standardized variant calling pipeline. Source: Martin et al. (2022) doi.org/10.1101/2022.01.14.476382



Global Collaboration on Emerging Diseases

The COVID-19 pandemic is the first health crisis in history where researchers have been able to access vast amounts of genomic data. Open data, combined with open analytics and computational infrastructure, has played an essential role in accelerating research to understand and respond to the pandemic.

The development of fast and effective pandemic countermeasures relies on the global research community's ability to share data and perform fast and reproducible analyses.

In 2020, the global Galaxy platform responded to the urgent need for insight into the SARS-CoV-2 virus, building a truly global, democratised, reproducible and transparent approach to systematically analysing the virus.

Galaxy Australia provided vital research infrastructure for researchers scrambling to understand the new virus sweeping the world. Alongside the computational power provided by the ARDC Nectar Research Cloud, Galaxy Australia also became part of the COVID-19 Acceleration Program of NCI and the Pawsey Supercomputing Centre, giving researchers working on the virus access to high performance computers.

The resources provided by Galaxy made it possible for researchers anywhere in the world to perform their own analyses with the freely available data, analysis pipelines and public computational infrastructure.

A year and a half into the pandemic, when WHO declared the Omicron lineage a variant of concern in November 2021, it asked countries to “enhance surveillance and sequencing efforts to better understand circulating SARS-CoV-2 variants”.

At this point, the Galaxy Project had for several months already been operating a free, global, public genome surveillance program based on raw sequencing data deposited in the public databases. Among the countries that had been contributing were South Africa, where the Omicron variant was discovered.

Within 3 days, the Galaxy Project announced that the first view of the mutational pattern of the Omicron lineage was available on the platform. Derived transparently and fully reproducibly from raw sequencing reads, it was immediately available to the global research community via Galaxy.

Ready for the Next Health Crisis

The world continues to grapple with the evolving COVID-19 pandemic. Thanks to the ARDC's ongoing investment in Galaxy, Australian researchers are improving our global understanding of the virus, along with persistent genetic diseases such as breast cancer, Crohn's disease and cystic fibrosis. When the next health crisis inevitably occurs, this enduring digital research infrastructure will ensure that Australian researchers are ready to rapidly respond. ■



IMAGE — NATASHA SIMONS / ARDC

A FRAMEWORK FOR AUSTRALIA'S DIGITAL RESEARCH SKILLS

The ARDC Digital Research Skills Summit in 2019.

To ensure Australia's researchers have the digital skills to tackle our biggest challenges, the ARDC is leading the development of a national agenda for digital research skills.

To tackle Australia’s biggest challenges, such as climate change, infectious diseases and radicalisation, today’s researchers must have the digital skills to collect, manage, analyse and manipulate data.

Yet the training community for digital research skills is often disconnected, time poor, siloed within research institutions, and unable to find best practice training materials.

Skills and workforce development around digital research skills have consistently been recognised as a key challenge for Australian research institutions and research organisations. The Australian Government’s 2021 National Research Infrastructure Roadmap highlighted digital skills and workforce development as areas of rich opportunity for researchers:

“An important driver for maintaining quality research output is Australia’s ability to generate and analyse data as well as improving the digital skills of researchers.” *[Recommendation 7, Draft 2021 NRI Roadmap Final (DESE), page 9]*

“Rapid advances in computing techniques and analysis, and management of large and complex datasets have resulted in researchers no longer having sufficient expertise in computational, data management and analysis techniques”. *[Draft 2021 NRI Roadmap Final (DESE) page 57]*

To ensure Australia’s researchers remain globally competitive, the ARDC is leading the development of a national digital research skills agenda, in collaboration with training organisations, universities, research institutions, national research infrastructure facilities, government and peak bodies.

Our coordinated approach to national digital research capabilities, skills and workforce development has been recognised internationally, including a notable mention in the Elsevier report *Research Futures 2.0* (2022).

Also, Mark Leggott, Director of International Relations at Digital Research Alliance of Canada, said, “The Digital Research Alliance of Canada is crafting a national strategy for the provision of digital research infrastructure services across data management, research software and advanced research computing. The ARDC’s skills agenda is the only one I have discovered that includes all three, and is a coherent and robust national approach that accommodates the interests of all stakeholders.”

The ARDC Digital Research Skills Agenda: A National Approach

Our approach addresses 5 key areas. Fundamental to all is the Digital Research Capabilities and Skills Framework.



01 - Digital Research Capabilities and Skills Framework

Working out what skills and capabilities researchers need is the first step. We consulted widely with the training community to understand how we can make the biggest impact for Australian researchers. Based on the outcomes of the consultation, we established a Capabilities and Skills Landscape, and began to develop the Digital Research Capabilities and Skills Framework.

We designed the framework to help the research sector understand the skills that researchers and research institutions need to work with research data, build capability, and improve training in digital research skills. It identifies the essential knowledge, skills, abilities and experience levels needed to work effectively in digital research, and the organisations currently best placed to develop and deliver skills training.

The framework also outlines roles, job profiles and learning pathways. For individual learners, it provides a toolkit to address specific skill needs. For organisations, it helps them to assess and resolve skills gaps, and target the design and delivery of training programs and resources that will enhance skills and career opportunities in a cost-effective way. Organisations can also use it as a mechanism for workforce transformation and change management.

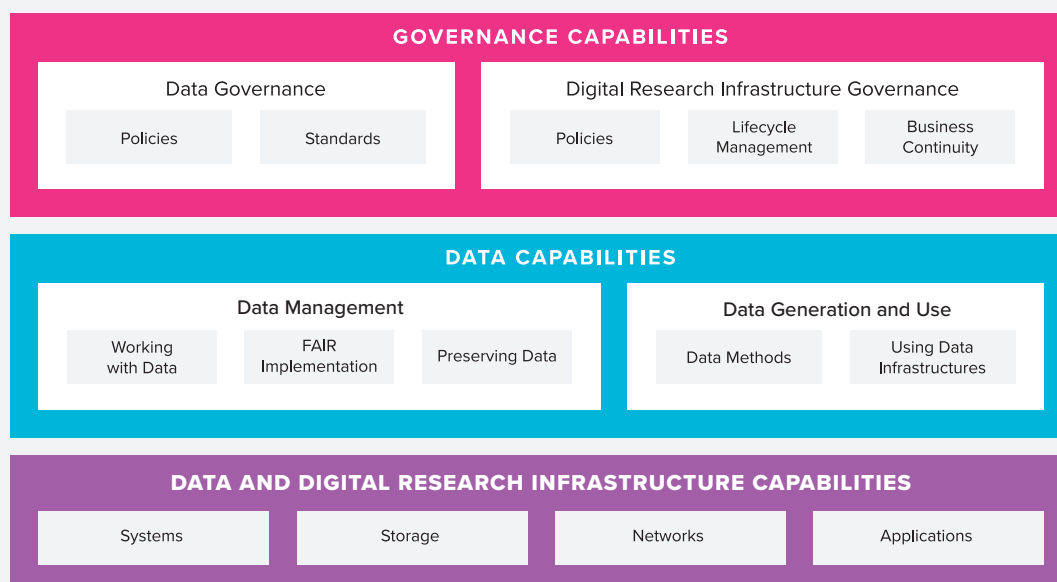
The Capabilities and Skills Framework will continue to evolve and grow. New skills will be added as emerging technologies, methods and tools come to the fore. We encourage all those involved in digital skills training and recruitment to help us expand and build upon the framework to ensure researchers and research support professionals have pathways to improve their digital skills.

The ARDC Digital Research Capabilities and Skills Framework

Working with our partners, we have progressed towards realising a national framework. The 6 components of the Framework are described below.

I. Capabilities and Skills Landscape

An evolving capabilities and skills Landscape (taxonomy) outlines skills in governance, data, software and infrastructure management capabilities.



II. A Glossary

A Glossary that contextually defines the terminology used in the Framework.

III. Data and Digital Research Roles

The definitions for generalised data and digital research roles, which are data owner, data governor, data steward, data user/generator, research software engineer, and data infrastructure manager.

IV. Skills/Role Profiles

A set of prototype skills/role profiles.

V. Learning Paths

A series of prototype learning paths (or pathways).

VI. The Skills/Data Roles Matrix

The skills/data roles matrix also shows the level of competency and the organisations that are well placed to support each role/skill combination.

JOB/ROLE	Researcher	Data Scientist	Research Software Engineer	Inst Senior Research Manager	Data Infrastructure Manager	Data Manager	Data Librarian	Data Archivist	Data Custodian
GOVERNANCE CAPABILITIES									
DATA GOVERNANCE									
Policies									
Standards									
GOVERNANCE CAPABILITIES									
INFRASTRUCTURE GOVERNANCE									
Policies									
Lifecycle Management									
Business continuity									
DATA CAPABILITIES									
DATA MANAGEMENT									
Working with Data									
Implementing FAIR Principles									
Preserving Data									
DATA CAPABILITIES									
DATA GENERATION AND USE									
Data Methods									
Data Infrastructures									
DIGITAL RESEARCH INFRASTRUCTURE MANAGEMENT									
Systems Development & Management									
Networking Development & Management									
Storage Development & Management									
Application Development & Management									

'WELL-POSITIONED' ENTITIES

	Universities	Universities/NCRIS/ARDC
	Universities/ARDC	ARDC

COMPETENCY

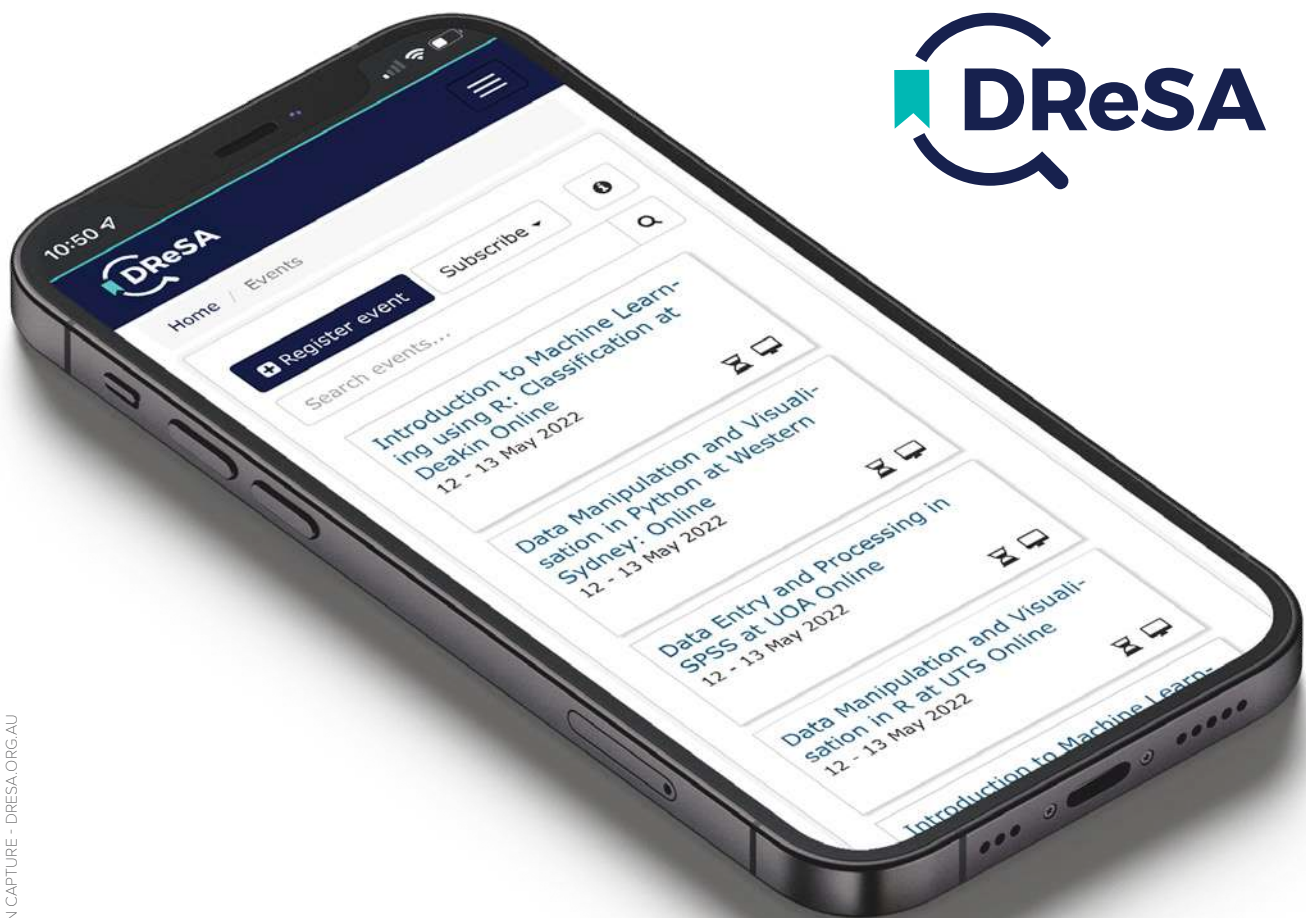
	Awareness	Practitioner
	Working	Expert

02 - Digital Research Training Infrastructure for Discovery

Sharing best-practice training materials among providers and making sure they are discoverable by the research community is essential. The ARDC partnered with Pawsey Supercomputing Centre and 10 other research skills training providers to develop Digital Research Skills Australasia (DReSA), which launched in October 2021. DReSA is a portal — a one-stop shop — where researchers can discover digital research training events, materials, providers and trainers in Australia, New Zealand, and the region. It is free and open to all.

Through DReSA, researchers and trainers can also find colleagues to collaborate with.

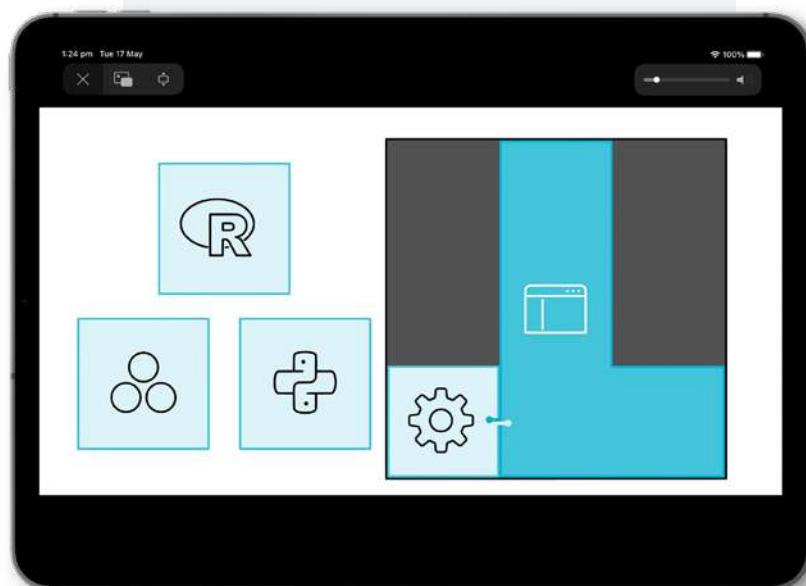
DReSA already lists over 70 current events and 100 unique training materials for digital research skills, and the collection continues to grow. To ensure DReSA comprehensively covers skills offerings across the sector, there is an open invitation for training providers and trainers in Australia and our region to contribute to DReSA.



SCREEN CAPTURE - DReSA.ORG.AU

Our training video -
**How Can Software
Containers Help Your
Research?** - has been
viewed over 1000
times and is used
across Australia in
training sessions.

Visit bit.ly/ARDCcontainers



03 - Skills Training Materials and Resources Development

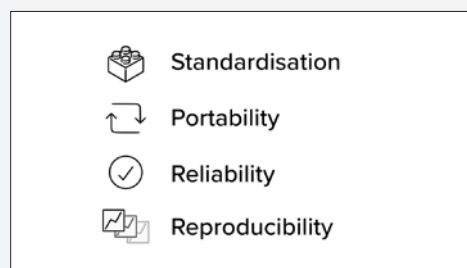
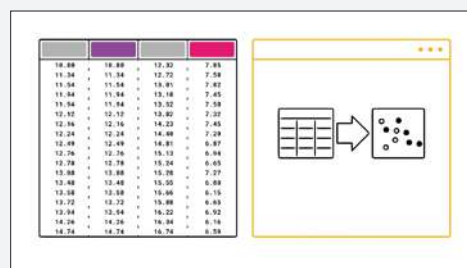
We are working with the digital research training community to coordinate a national approach to developing skills training materials.

To fill identified gaps, we are developing exemplar materials. As an example, our video *How can software containers help your research?* has been viewed over 1000 times and used across Australia in training sessions on digital research tools. It also features in training materials for Münster University in Germany and The Carpentries, an international organisation.

04 - Skills Training – ARDC Focus Areas

While the ARDC has neither the scope nor scale to meet all of the digital research infrastructure skills needs of Australia's researchers, we aim to be exemplars in ensuring our users and partners can fully exploit the digital infrastructure we provide and support. The ARDC Research Vocabularies Australia, Research Data Australia, the Nectar Research Cloud and our persistent identifier services are the backbone of FAIR research data management, data discoverability, and compute infrastructure across Australia, and are used by tens of thousands of researchers each year.

Ensuring researchers and infrastructure providers can effectively use these resources is critical for realising maximum national benefit. The ARDC is using the Capabilities and Skills Framework to identify areas of priority for training development to boost the ability of researchers and research support professionals to use our services to their full potential.





The Carpentries are a great organisation and we have found their teaching model to be really useful. With this new partnership we are getting the flexibility we need to share and expand this model across the country, for the benefit of all. Big thanks go to the ARDC for making this happen.

David Groenewegen
Director of Academic Services
Monash University Library



IMAGE — SVITLANA - 332263635 / ADOBE STOCK

05 - Community Leadership

The ARDC draws on local and international networks to facilitate targeted and accessible pathways for researchers and research support professionals to attain research data skills.

Since 2019, we have been bringing together skills trainers at our annual Digital Research Skills Summit. Each summit sees 100 to 150 attendees tackle national skills challenges and share best practices in training, skills priorities and training materials.

We are an active participant in Research Bazaar (ResBaz) events across Australia, which promote digital skills and capabilities emerging at the centre of modern research. These events are designed for higher degree and early career researchers, and replicated across the world. In 2022, each ResBaz in Australia will showcase the ARDC Nectar Research Cloud, alongside training on how to use ARDC-supported research platforms and data assets from other NCRIS facilities. The Digital Research Skills Agenda supports regional coordination of ResBaz in Oceania, bringing organising teams together to strengthen sustainable skills communities.

In October 2021, we launched a partnership with The Carpentries for Australian research institutions to access high quality instructor training.

The partnership gives research institutions of all sizes in Australia access to evidence-based pedagogical training at a competitive rate. The Carpentries is an international organisation that teaches foundational coding and data science skills to researchers worldwide. Today, 11 Australian research institutions are represented, including newcomers National Computational Infrastructure (NCI), the Burnet Institute, and the Australian Institute for Marine Science.

Instructors can be researchers, librarians, research support staff or research computing support staff.

David Groenewegen, Director of Academic Services at the Monash University Library, said, “The Carpentries are a great organisation and we have found their teaching model to be really useful. With this new partnership we are getting the flexibility we need to share and expand this model across the country, for the benefit of all. Big thanks go to the ARDC for making this happen.”

As technology continues to evolve and change the way we do research, the ARDC will continue to lead the skills community in Australia to ensure researchers are equipped with the skills they need to conduct world-leading research that addresses our biggest challenges. ■

ACKNOWLEDGEMENTS

We'd like to acknowledge all of our members, partners, collaborators and community for their contribution and support. The ARDC would not be possible without you.

Collaborations and Partnerships

Partnerships are essential for Australia to develop a national data and computational research infrastructure environment. A partnership approach is a core principle for the ARDC. Our national and international collaborations and partnerships ensure valuable data and software assets are developed, made available and sustained for everyone.

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RESEARCH ORGANISATIONS

[ARC centres of excellence](#)

[Cooperative research centres](#)

[Medical research institutes](#)

[Publicly funded research agencies](#)

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RESEARCH INFRASTRUCTURE PROVIDERS

Commercial digital infrastructure providers

Digital Data and eResearch Platform (DDeRP) members:
AARNet, Australian Access Federation, ARDC, National
Computational Facility, Pawsey Supercomputing Centre

Disciplinary archives and repositories

National research infrastructure (NCRIS) facilities

Other national and state infrastructure providers such
as the ARDC Nectar Research Cloud node community

GOVERNMENT (STATE AND COMMONWEALTH)

Data-rich departments

Galleries, libraries, archives and museums

Policy agencies

Science and research agencies

NATIONAL MEMBERSHIPS

Australian Data Science Network

Australian eResearch Organisation (AeRO)

Science and Technology Australia

INTERNATIONAL PARTNERSHIPS

American Geophysical Union

Committee on Data of the International
Science Council (CODATA)

DataCite

Earth Science Information Partners (ESIP)

FORCE11

Open Researcher and Contributor ID (ORCID)

OpenStack community

Organisation for Economic
Co-operation and Development (OECD)

Research Data Alliance

Research Software Alliance

INTERNATIONAL MEMBERSHIPS

DataCite (Member and Consortium Lead)

International Geo Sample Number (IGSN e.V., Member)

Open Infrastructure Foundation (Associate Member)

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