WHITE PAPER

Recommendations towards cooperation between Australian and European research infrastructures

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EXECUTIVE SUMMARY

International cooperation in science and technology is an important part of addressing major global issues like climate change, infectious disease, food security and natural disasters. Research infrastructures (RIs) are organizations that enable scientists to use specific facilities, resources and services in order to accelerate scientific achievements, break boundaries and promote sustainable research. Fostering RI partnerships across borders has the potential to improve the efficiency and quality of research to tackle the many challenges faced by society today.

RI-VIS is a Horizon 2020-funded project to increase the visibility and raise awareness of European RIs to new communities in Europe and beyond. This report, as part of RI-VIS, focuses on ways to increase collaboration between Australian and European RIs. It collates the insights of experts from Australian RIs, European RIs and policymakers into sections that cover examples of successful collaboration, lessons learned and possible challenges/bottlenecks.

The following key recommendations from experts to facilitate Australian-European RI partnerships are categorized into actionable items for RI representatives, policy makers and funders:

Key recommendations for RI representatives

RATIONALE/GLOBAL CHALLENGES:
- RI partnerships should start with common interest and perception of mutual benefit on both sides.

FUNDING:
- RIs should budget for international collaboration.

ACCESS:
- Take advantage of technology that enables virtual meetings and collaborative documents.

CO-CREATION BASED ON NEEDS:
- Overseas events should be customized to the host country's needs.

OUTREACH:

- Connecting on a personal level with others from abroad can lead to successful joint projects down the line.

BEST PRACTICE:

- Value RI staff members and give them a rewarding career pathway.

Key recommendations for policy makers & funders

BEST PRACTICE:

- RIs need the bare minimum amount of national contributions to sustain operations in order to take the next step of international collaboration.

OUTREACH:

- Policy makers and funders should recognize that RIs may take several years to produce significant scientific results.

SUSTAINABILITY:

- Multi-year funding schemes give Australian RIs the security to plan ahead and develop fruitful international partnerships.

FUNDING:

- Europe should find ways to open up funding access to Australian organizations by including RIs in the work programmes.

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Background

In 2015, the United Nations General Assembly outlined a set of 17 Sustainable Development Goals to achieve a better and more sustainable future for all (Sustainable Development Goals, 2015). They aim to address major societal challenges faced by humankind related to disease, climate change, food security, environmental degradation and poverty. Scientific research is an essential part of tackling these issues. The process of gathering information and expanding our knowledge of the world has the power to improve overall health, safety and standard of living.

Research infrastructures (RIs) are crucial to the advancement of science in many fields. The availability of well-maintained RIs facilitates cutting-edge research and training of highly skilled specialists. They include major scientific equipment and infrastructures, cyber- or e-infrastructures, scientific collections, archives and structured information and entities of a unique nature that are used for research (European Strategy Forum on Research Infrastructures, 2018).

A key motivation of RIs is the sharing of knowledge and resources across institutions, countries and continents. Large-scale research facilities are generally expensive and challenging to build and maintain by one single nation on its own. Other RIs require data collection from different parts of the world. Thus, a more effective and productive way to conduct research is to pool together resources and share costs.

RI-VIS is a Horizon 2020-funded project to increase the visibility and raise awareness of European RIs to new communities in Europe and beyond (RI-VIS, 2020). Part of RI-VIS involves identifying routes to maximize the exchange of information and bases for new partnerships, in particular with RIs or communities outside of Europe. Mutually beneficial RI partnerships across borders can harness collective knowledge, assist in meeting global challenges and enhance global science capacity.

This report assembles the insights of several experts from both Europe and Australia who have previous experience with such collaboration. Interviews were conducted from August to October 2020 with seven representatives from RIs in Europe and Australia (see Appendix A). They highlighted examples of Australian-European RI collaboration, best practices for successful collaboration, challenges/bottlenecks and recommendations to policy makers and funders. The preceding sections will outline the definition of an RI, the importance of RIs to society and the benefits of international research collaboration.

What is a research infrastructure?

The term “research infrastructure” comes with a certain degree of flexibility, since it lacks an established formal definition in scientific and policy literature. The European Commission defines research infrastructures (RIs) as “facilities that provide resources and services for research communities to conduct research and foster innovation” (European Research Infrastructures, 2020). The RI-VIS Communication Toolkit for European Research Infrastructures states that an RI is “an organization that enables the research community to use specific facilities, resources, and services in order to accelerate scientific achievements and promote sustainable research” (Abecasis & Pintar, 2020).

As part of the Australian Government’s National Innovation and Science Agenda (NISA), an Expert Working Group led by Australia’s Chief Scientist, Alan Finkel, developed the 2016 National Research Infrastructure Roadmap (Expert Working Group, 2016). The document interprets RIs as “the nationally significant assets, facilities and services to support leading-edge research and innovation… accessible to publicly and privately funded users across Australia, and internationally.”

Despite it being used in different contexts both internationally and even within Europe, the term maintains some common threads across definitions (International Research Infrastructure Landscape 2019: A European Perspective, 2019; Florio, Forte, Pancotti, Sirtori, & Vignetti, 2016):

- RIs are motivated first and foremost by **scientific goals**. The main purpose of RIs is to acquire new knowledge in a scientific field, allow research and innovation to break barriers and push the frontiers of science. They may be purely **curiosity-driven** without any direct, obvious practical application, or they could have a more application driven, practical **benefit to humanity.**
- All RIs at their heart contain **valuable and unique assets**, whether they be major facilities, instrumentation, knowledge-based collections or collaborative networks.
- RIs often require **substantial capital investment** that typically goes beyond the capacity of an individual faculty, institution or funding programme.
- Access to RIs expands **beyond an institutional level** to a national or international reach. The uniqueness and steep cost of the assets means that the RI's capabilities will be in demand by external researchers in the field.

RIs are often placed into three broad categories: single-sited, distributed or virtual. Single-sited RIs are centralized facilities at a single physical location. These include large telescopes, particle accelerators, synchrotrons, nuclear reactor sources or extreme laser sources. Distributed RIs usually have a central hub and interlinked nodes scattered in different regions. They consist of a network of distributed instruments or collections that, taken as a whole, constitute a large-scale facility. An interferometrically linked array of radio telescopes and large genome sequencing projects are two types of distributed RI. Lastly, virtual RIs are internet-based systems for scientific research, such as an archive of historical texts or virtual research environments (virtual labs) for data processing and analysis. RIs often offer a mixed category that combines physical and virtual aspects.

High-profile examples of RIs include CERN's Large Hadron Collider, the world's largest and most powerful particle accelerator; INSTRUCT, a collection of distributed facilities that promote structural biology research; the Australian Synchrotron, the largest particle accelerator in the Southern Hemisphere; and the National Imaging Facility, a grid of imaging facilities spread across Australia. Further examples from Europe and Australia are provided in Table 1.

Societal impact of research infrastructures

The development, operation and maintenance of RIs require large investments from countries, sometimes encompassing tens or hundreds of millions of Euro per year. Decisions about investment in RIs at a national level often include an assessment of any direct societal benefits in addition to their future scientific impact (Horlings, Gurney, Somers, & van den Besselaar, 2013). However, such benefits tend to be difficult to predict, particularly for curiosity-driven projects.

For example, the overarching goal of CERN's Large Hadron Collider (LHC) was to better understand the fundamental structure of matter. The total cost of the accelerator, detectors and computing was 4.332 billion Swiss francs, making it the most complex and most expensive scientific research facility ever constructed. Beyond its obvious contributions to physics, CERN has been responsible for innovations that have improved medical and biomedical technology, space missions, art restoration and energy efficiency (Our Contribution to Society, 2020). The building of LHC has resulted in highly advanced

superconducting magnets, exceedingly accurate measurement equipment and breakthroughs in data communication and storage. CERN also sparked the invention of the World Wide Web in 1989 (The birth of the Web, 2020) and the capacitative touch screen in 1972 (Stumpe & Sutton, 2010).

Other RIs have a more direct impact with their observations. For instance, the European Plate Observing System (EPOS) and the European Multidisciplinary Seafloor and water-column Observatory (EMSO) are both distributed RIs that inform society about environmental hazards and allow for more advanced preparation. Similarly, the AuScope Infrastructure Program (AuScope) allows for better coastal management informed by improved sea level estimates, reduced resource exploration cost through more efficient acquisition of Earth structure data and disaster planning and management for extreme weather events with enhanced meteorological analysis.

The Australian Government recently published a report on the scope, scale and reach of its National Collaborative Research Infrastructure Strategy (NCRIS) projects (NCRIS, 2019). NCRIS is a national network of 24 active RI projects that have been awarded government grants for operating and capital expenses, supplemented by co-investment from other parties. According to the 2016 National Research Infrastructure Roadmap, funding decisions consider the RI's ability to "maximise the capability of the research and innovation system to improve productivity, foster economic development and serve the national interest" (Expert Working Group, 2016).

The census report covered the academic and commercial impact of NCRIS projects in 2017-18. The network of RIs enabled a total of 8,371 publications in fields like engineering, chemistry, physics, biology and medicine. Over 70 percent of projects provided critical or operational/functionality to enable federal government policies and program delivery. For instance, Bioplatforms Australia – a distributed RI that manages research facilities for genomics and other life sciences – worked with the federal government on risk assessment mechanisms for the importation of plants, the environmental impact of breeding threatened species and genomic developments for use in pathology.

RIs in Australia also provide services to key sectors of industry. The census revealed that 62 percent of NCRIS facilities are utilized by companies in the agriculture, forestry and fishing industries and 57 percent are used by the mining industry. In terms of commercialization outputs, NCRIS projects had 72 patents granted and 1,112 pieces of copyrighted material produced in 2017-18 alone. They initiated 240 clinical trials during this time period and from 2015 to 2018, the network introduced 15 products to market.

The European Strategy Forum on Research Infrastructures (ESFRI), which plays a key role in policy making on RIs in Europe, also places high priority on socioeconomic impact when it comes to supporting projects. Socioeconomic impact is an element of the ESFRI Roadmap assessment procedures and is central in the networking activities of ESFRI RIs. It is used to evaluate the effective use of public resources, to inform future decision and policy making and to secure funding for the continuous operation of RIs. For instance, assessment of health and food RIs takes into account drug discovery and production, new diagnostics and therapies, new models of human rare diseases and the emergence of new biomedical applications.

Aside from such spillover technologies, RIs impact the economy and society in several other ways. RIs serve as key learning environments and hubs where knowledge is exchanged (Horlings, Gurney, Somers, & van den Besselaar, 2013). Researchers, students, industry and government all interact throughout the RI's development, construction and use. In addition, many RIs participate in public outreach to stimulate

interest in students and other members of the community. The aim is to inspire curiosity and encourage a new generation of scientists to enter the field.

Taking all of the above points into consideration, the general consensus tends to be that RIs provide a positive return on investment and a substantial net benefit to society, economic development and scientific progress (European Strategy Forum on Research Infrastructures, 2018).

Scientific collaboration across borders

The collaborative nature of scientific research is inherent to its success. By sharing skills and data, researchers improve the efficiency and quality of their work while supporting the process of scientific production, knowledge creation and breakthroughs. The whole of a scientific collaboration is undoubtedly greater than the sum of its parts. But what are the benefits of collaborating with researchers based in other countries?

Different motivations exist, depending on the scientific field and country at hand. However, one thing is clear: The number of scientists participating in international collaborations is growing. An analysis of scientific publications and co-authorships found that international scientific collaboration is increasing in volume in all research fields over time (Coccia & Wang, 2016). Research is more global, cross-national and cross-cultural than ever before.

A metaphor used to describe the importance of international collaborations is a frog deep inside a well, who has an excellent view of a small patch of sky (National Research Council, 2008). If most of the research in a field is done predominantly stuck in one well, such as North America or Europe, it can prove detrimental to scientific discovery. Getting out of the well can provide new research topics and collaborators, which help question underlying assumptions and spark fresh insights.

Scientific cooperation beyond borders can take many different forms, in particular for RIs. In 2019, the National Research Infrastructure Census surveyed NCRIS projects regarding their activities with entities outside of Australia (NCRIS, 2019). The 21 RIs included in the study reported having 41 active memoranda of understanding (MOUs) with international entities in 2017-18. Outside of MOUs, the group also declared 57 informal and 43 formal collaborative arrangements with RI providers. Other activities included invitations to speak at international conferences, representation on working groups or key committees and collaborative arrangements with research organizations.

In addition, international collaborations have the power to mobilize a global network to consider and refine important ideas that affect humanity as a whole. Global issues include environmental protection, energy security, natural disaster mitigation, preventing/curing infectious diseases and food security. RIs bring experts together to form a network where they can openly share knowledge and technology. In the area of food security, for example, researchers from academia and industry across the globe often have similar goals, such an increase in crop productivity and resilience, and RIs are pivotal in this respect (Pieruschka & Schurr, 2019).

According to the National Research Infrastructure Census, 86 percent of NCRIS RIs were a member of, partnered with or were a participant in global RI in 2017-18 (NCRIS, 2019). More than 60 percent plan to join some or more global RI networks in the future. The RIs find that participation in global or international RI enables them to adopt best practice as well as international standards.

Beyond the scientific benefits, international collaboration in large science projects can also save money and support foreign policy (U.S. Congress, Office of Technology Assessment, 1995). The cost of "big science" has gone up, which makes it more difficult for a single nation to undertake such projects alone. Of course, reducing net costs for individual countries also motivates the creation of RIs. Collaboration makes it possible to share both the financial and technical risks of ambitious projects.

Lastly, research can also be a form of diplomacy, leading to alliances and memoranda that support foreign policy objectives. Joint scientific research can strengthen bonds with other countries and establish levels of trust.

Australian-European research infrastructure collaboration

Australia is already an important economic and trading partner for the European Union (EU), and the two regions have a long history of productive research collaboration. Australia collaborates more with the EU than any other single country in the world, averaging over 13,000 co-publications per year over the period 2011-15 (Researching innovative opportunities with Australia, 2020). Australia ranks as the EU's fifth highest international collaborator over the same time period.

The EU signed a treaty-level science and technology agreement with Australia in 1994, which represented the first time it had done so with an industrialized country (European Commission, 2018). The agreement established the Australia-EU Joint Science and Technology Cooperation Committee (JSTCC), which meets every two years to set bilateral research collaboration priorities and monitor cooperation activities. Most recently, the JSTCC gathered in Canberra for their 15th meeting in July 2019, which included a discussion of ongoing and future cooperation in RI, possibilities to host major international conferences on RI and using global RIs as a forum to foster international cooperation.

Australia and the EU also share a common approach to investing in and prioritizing RIs. Bringing together RIs from both regions with the common goal of scientific advancement and innovation has the potential to breathe fresh life into research topics, bring new perspectives and spur on novel developments. In fact, because RIs are already focal points of collaboration within themselves, the mutual advantages of Australian-European RI partnership are expected to be even greater.

Broadly, RI partnerships at a global or intercontinental scale are worth developing for the following reasons:

- To harness collective global knowledge and experience
- To support leveraging of new international funding for RIs
- To promote access to and exchanges between RIs
- To facilitate the mobility of researchers
- To assist in meeting global challenges
- To compensate each other's shortcomings with regard to available infrastructures

Australian-European RI collaboration can take many forms, and the examples that follow represent only a small sampling of partnerships. However, our objective is to learn from these real-world cases for the benefit of future collaborations and to better recognize opportunities for the two regions to work together.

Examples

NIF & Euro-BioImaging

Founded in 2007, the Australian National Imaging Facility (NIF) provides state-of-the-art imaging facilities and services of animals, plants, and materials for the research community. The NCRIS-funded distributed RI has ten nodes based at universities and medical research institutes across the country, with each node offering its own specialized instrumentation and experts. Research performed at NIF includes visualizing human brain structure with magnetic resonance imaging (MRI), scanning native animal species to better understand their anatomy and even computed tomography (CT) imaging of an Egyptian mummy.

NIF signed an MoU with Euro-BioImaging, a European RI that offers much of the same services, in 2014. Euro-BioImaging gives life scientists access to biological and biomedical imaging infrastructure through 21 nodes spread across eight countries. The RI was granted the legal status of an ERIC (European Research Infrastructure Consortium) in 2019.

The Australian-European RI collaboration kicked off with a signing ceremony and two-day symposium in Brussels to celebrate the MoU. Other RIs, including Therapeutic Innovation Australia and the European Clinical Research Infrastructure Network (ECRIN), joined the festivities as well.

“It was about sharing the experience and challenges of a research infrastructure around things like staff recognition, promotion prospects and what’s the career pathway for an infrastructure scientist,” said Graham Galloway, NIF’s Chief Executive Officer. “The other theme of the event was around building better data practices.”

At the symposium and during the period of time that followed, NIF and Euro-BioImaging discussed the development of systems that promote best practice data curation and the promotion of fair data in imaging research. As a result of this initial connection, Euro-BioImaging invited NIF to become a partner on a Horizon 2020 project that aimed to create an international network of imaging infrastructures and communities.

The project culminated in the creation of Global BioImaging in 2015, which brings together imaging facility operators and technical staff, scientists, managers and science policy officers from around the globe. The network organizes an annual international workshop called Exchange of Experience to discuss common goals, trends and challenges in running open access imaging facilities. In September 2020, Global BioImaging held its fifth Exchange of Experience workshop virtually with a record turnout of 158 participants across 16 time zones.

“By demonstrating that we are partnering with researchers through Euro-BioImaging and Global BioImaging, we are able to say to the Australian government that we are developing international best practices,” said Galloway. “We’re not doing it alone – we’re doing it with the rest of the world.”

APPF & EPPN

Australia has long emphasized innovation in agriculture, with farmers historically achieving strong productivity growth driven by improvements in technology and structural change. As one example, the

country pioneered significant aspects of plant phenomics research, which uses automated image analysis to characterize the complex traits of living plants.

The Australian Plant Phenomics Facility (APPF) is an NCRIS-funded distributed RI that aims to accelerate the development of new and improved crops, healthier food and more sustainable agriculture practice. Established in 2007, APPF operated across three nodes at the University of Adelaide, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Canberra and the Australian National University. Each node has unique, specialized facilities that interlink to offer open access to plant phenomics technologies and expertise.

“Australia was probably one of the earliest adopters in the area of plant phenotyping, and to some degree, we were ahead of the game at that point,” said Bettina Berger, Scientific Director of the APPF node at the University of Adelaide. “Since then, others have caught up. Europe is the next area to really invest quite heavily into plant phenotyping.”

The RI has closely interacted with three European centres: Forschungszentrum Jülich and the Leibniz Institute of Plant Genetics and Crop Plant Research in Germany, as well as the French National Institute for Agricultural Research. Cooperative efforts arose either through personal connections among researchers or because they used similar pieces of equipment.

Since then, APPF has been a partner in two EU-funded RI projects that link multiple facilities together into a single transnational network in order to integrate plant phenotyping efforts. The European Plant Phenotyping Network (EPPN) ran from 2012-15 with a total of 14 participants, including APPF, enabling 66 experiments and various joint research activities. The follow-up project to EPPN is the Horizon 2020-funded EPPN2020, which runs from 2017-21 with 21 partners across 12 countries.

The benefits of such a network go beyond simply increasing facility access for researchers. Because plant phenotyping is still a fairly young discipline – only about a decade or so old – such partnerships are needed to quickly overcome challenges being faced by the field as a whole. While the initial limiting factor for performing efficient research was having the right cameras and sensors to acquire data, now the bottleneck has shifted towards questions around data storage and analysis.

“How do we share, annotate and analyze the data? How do we best extract knowledge out of it? This is nothing that a single institution can solve. It really requires a community effort and also community funding,” said Berger. “Having those links is absolutely critical because there’s no point in any individual country or institution working in isolation if what they’re developing will then be adopted by the rest of the community across the world.”

APPF was also a founding member of the International Plant Phenotyping Network (IPPN), an association representing the major plant phenotyping centres around the world. IPPN enables cooperation by fostering communication among members through workshops and symposia. The inaugural International Plant Phenotyping Symposium – the first-ever international meeting that brought together plant biologists under a phenomics banner – was held at the Canberra node of APPF in 2009.

PHRN

The Population Health Research Network (PHRN) aims to link existing health and services data from around Australia for the purpose of action-oriented research. National data collections include hospital admissions, emergency department attendance, births, deaths, cancer registries, doctor's visits and various other information. Research projects based on PHRN's data may aim for a better understanding of disease, the development of new treatments or improvements in services.

The RI has a programme office in Perth, along with a network of project participants and data linkage units located in each Australian state/territory. Merran Smith, Chief Executive of the PHRN, also serves as the current director of the International Population Data Linkage Network (IPDLN), which connects over 1,000 members that specialize in data linkage. The IPDLN Executive Committee, chaired by Smith, includes two members from the UK and one from Germany.

"There is a strong international collaboration existing now around big data that's been going on for about ten years," said Smith. "Through the IPDLN, we have connections to many European groups, including colleagues in the Netherlands and France."

The network organizes a biennial conference to create more opportunities for interdisciplinary collaboration, cross-jurisdictional studies, and robust, accessible international data. The 2008 inaugural meeting of the IPDLN was held in London and included over 30 participants from the UK, Australia, New Zealand and Canada. The event was hosted by the Research and Development Directorate of the UK's National Health Service.

The IPDLN now includes over 1,000 members with 234 from Australia and 92 from Europe. The 2020 conference was supposed to be held in Adelaide but transformed into a virtual event due to the COVID-19 pandemic. The agenda included researchers from Australia and the UK sharing their work on population health data and the response to COVID-19 in their respective countries.

Cooperative efforts across borders most often focus on methodologies to link data on a large scale, ways to ensure data privacy and improving the infrastructure itself. Researchers at the University of Swansea in Wales created a platform that secures information very well, and it has now been adopted at two Australian universities. Such an example highlights how the expertise from Europe is being exported and shared with Australia in a collaborative way.

Insights flow the other way as well, with active information exchange from Australia to the UK happening related to methodology. For instance, some elements of the linkage system developed by the PHRN have been incorporated into UK platforms.

"People are generally relatively altruistic. Researchers around the world have a passion for the research they do and are keen to progress, particularly in the health and human services area," Smith said. "To the extent that those infrastructures become better through international collaboration, then we see that as a win-win for everybody."

DARIAH beyond Europe

While the majority of RIs remain STEM-focused, others fall into a category that the European Strategy Forum on Research Infrastructures (ESFRI) calls "Social and Cultural Innovation" (European Strategy

Forum on Research Infrastructures, 2018). In fact, ESFRI notes that RIs in this domain are among the first known infrastructures, with libraries, museums, and archives as the most obvious examples.

The Digital Research Infrastructure for the Arts and Humanities (DARIAH) is a European RI aimed at enhancing and supporting digitally enabled research and teaching across the arts and humanities. Established as an ERIC in 2014, DARIAH includes 19 countries as members and has several cooperating partners – basically, participating institutions in countries who aren't yet members – in eight non-member countries.

In 2017, the RI began a Horizon 2020-funded project called DARIAH ERIC Sustainability Refined (DESIR) that explored ways to strengthen its position as a long-term leader and partner within the arts and humanities communities (DESIR, 2017). One goal of DESIR involved the dissemination of DARIAH's tools and services to researchers outside of Europe.

"We had been doing so much work on bringing the countries within Europe together, and we wanted to explore how we could work with similar initiatives overseas," said Sally Chambers, the National Coordinator of DARIAH for Belgium. "So we had this series of workshops in the U.S. and Australia, and we chose those countries because they are doing a lot of work already in the digital arts and humanities."

The 3rd DARIAH Beyond Europe workshop took place in Canberra at the end of March 2019 (DARIAH Beyond Europe, 2019). The three-day conference highlighted how ongoing work in DARIAH could intersect with initiatives in the Australian academic community. The first day involved a series of "big idea" panels, where speakers explored new horizons for humanities, arts and culture within the context of policy, research and infrastructure. The second and third days were billed as an Australia-DARIAH knowledge exchange, looking at areas to build fruitful, long-term collaborations.

A report written by Chambers and her colleagues in 2019 provided an overview of the three workshops and highlighted key outcomes (Chambers, Daems, & Raciti, 2019). Overall, the DARIAH Beyond Europe initiative "not only increased DARIAH's visibility internationally, but has led DARIAH to reflect on its long-term approach to its international activities much more deeply." The Australian workshop specifically sparked a number of ideas for further follow-up, including concrete areas of shared interest between Australian and European colleagues.

Since the workshop, the European and Australian researchers have kept the discussions going by developing collaborative research proposals and scientific advisory boards. In addition, they have continued to connect by attending the same events.

"The humanities have such a small voice in the research community in general, so the more people that we collaborate with, the stronger that voice becomes," said Chambers. "Also, because of sustainability issues, if we can collaborate on activities rather than reinventing the wheel, that is also very helpful."

Bioplatforms Australia & EMBL-EBI

Bioplatforms Australia supports researchers in the life sciences with 15 node facilities across the country that cover genomics, proteomics, metabolomics and bioinformatics. Notable research projects include the first-ever sequencing of the Australian koala genome, wine yeast systems biology, wheat pathogenomics, and the world's largest coral genome sequencing project on the Great Barrier Reef.

Established in 2007, the NCRIS-funded RI has strong ties to Europe through multiple organization-level collaborations. It has a long-standing relationship with the European Molecular Biology Laboratory (EMBL), Europe's flagship laboratory for basic research in molecular biology. EMBL operates from six laboratory sites throughout Europe, providing both physical and digital experimental services for researchers. Australia became the first associate member of EMBL in early 2008.

"We cooperate both at a scientific level through our partner laboratory network that is reasonably analogous to how EMBL operates in Europe, and also at an organizational level with EMBL itself," said Andrew Gilbert, Chief Executive of Bioplatforms Australia. "We try to find points of difference and harmony where we can share value on both sides."

The EMBL partnership has been extended to an extensive and meaningful collaboration with the European Bioinformatics Institute (EBI), a part of EMBL that provides freely available data and bioinformatics services to the scientific community. A high-profile example of their collaboration is the sequencing and analysis of the koala genome, which made the cover of *Nature Genetics* in 2018 (Rebecca N. Johnson, 2018). While Bioplatforms Australia provided most of the infrastructure for the project, EBI contributed by performing annotation of the genome.

The EBI relationship subsequently led Bioplatforms Australia to sign an MOU with ELIXIR, a European distributed RI for biological data, in April 2020 (ELIXIR, 2020). EBI is an ELIXIR node, an RI that manages bioinformatics resources across 22 member states and one observer. Gilbert and his colleagues noticed that ELIXIR was trying to address many of the same challenges faced by Bioplatforms Australia, and the RIs could both benefit from open knowledge exchange.

"We have a lot to learn, but we have something to contribute back to ELIXIR as a first-class scientific contributor too," he said. "We've been so appreciative of them contributing to our program in terms of standard protocols, collaborative framework, and other things that would have taken us years to catch up. In time, our relationship will lead to actual scientific collaboration."

The COVID-19 pandemic has slowed down international collaborations for Bioplatforms Australia at the moment, as the RI is trying to suss out its own operations first during these trying times. But Gilbert and his team hope to restart projects involving their European colleagues very soon.

Recommendations and best practices

The successful Australian-European partnerships outlined above have several similarities that point to recommendations for future RI collaboration.

RATIONALE/GLOBAL CHALLENGES
Gilbert notes that any RI partnership should start with personal interest on both sides, since without that driving motivation, it's very difficult to transact on either a strategic or structural level. Signing the MOU is only the first step to broker the future activity, and parties must keep up the energy around the activity in the months or years that follow. Projects should benefit both communities locally, with each side aiming to contribute something, whether that be finances, data or know-how.

“There are collaborations that, on paper, sound really easy. But without a science driver or clear need as to why you’re collaborating, people kind of lose that enthusiasm and energy, and it’s really hard to get things off the ground,” said Sarah Nisbet, Platforms and Engagement Manager at Bioplatforms Australia.

FUNDING

While funding isn’t an issue for NCRIS projects, Gilbert strongly recommends that RIs budget for international collaboration. Without having dedicated funds, it can easily become an afterthought. RIs need to be proactive rather than reactive, and international partnerships should be a focus from the outset.

ACCESS

When organizing an overseas workshop such as DARIAH Beyond Europe, Chambers suggests using technology that enables virtual collaboration. For a whole year before the meeting, the team at DARIAH had monthly Zoom calls with its partners in Australia and used Google Documents to work on key aspects of the workshop together. Today, such technology has become much more commonplace due to the COVID-19 pandemic. The widespread familiarity with organising and attending virtual meetings, workshops, and conferences could largely benefit future overseas collaboration.

CO-CREATION BASED ON NEEDS

She also emphasizes the importance of tailoring an event to the host country. For instance, the Australian Government had recently given a larger proportion of funding to STEM-focused RIs, and DARIAH’s partners wanted to make the workshop more strategic. The whole first day became dedicated to policy, research and infrastructure for this reason.

“We decided to move the workshop to Canberra because that’s where the Australian Government is,” said Chambers. “We wanted to raise the profile of the importance of research infrastructures for the arts and humanities as well.”

OUTREACH

Many experts emphasized the importance of personal relationships in terms of sparking scientific or organizational collaboration between Australia and Europe. People getting to know one another through conferences, workshops, committees, and exchanges can lead to successful joint projects down the line.

“Collaborations happen in an organic way, and underpinning that are good relationships and good communication,” said Smith, who cites in-person meetings as more conducive to relationship creation than virtual meetings. But she does note that virtual meetings, with their much lower cost and time commitment, allow a much greater number of people to attend.

BEST PRACTICE

Galloway believes that the best thing RIs can do to facilitate partnerships across borders is knowing how much their staff is worth and nurturing their careers. Sometimes RIs and their experts fail to receive adequate recognition for their work. Often times, they aren’t getting first author on papers or high-profile mentions in the press.

“The number one recommendation to increase collaboration is to ensure that we employ the best expertise that we can, value that expertise, and give them a career pathway. Because collaboration is only ever going to be driven by people, not equipment,” Galloway said. “If you’ve got a unique piece of

equipment, researchers will come use it, but collaboration is around interactions of people and sharing expertise as well as opportunities."

CHALLENGES AND BOTTLENECKS

In terms of factors that hinder Australian-European RI collaboration, several experts mentioned the difficulty in getting funding out of Europe and into Australia. While Australian RIs may be accepted as members or official partners of European RIs, they are expected to fund any work themselves. Berger brings up the example of EPPN and EPPN2020, noting that APPF was an official partner in both European RIs but could not receive any funding.

"A lot of European projects are like that: as someone from the outside, you can't necessarily tap into that funding. While we have a seat at the table, everything we do or contribute has to be on top of what we already do," said Berger. "There are often good intentions, but unless there is funding and time allocation that goes with it, the collaboration can sometimes stop there."

Stewart Newman, Chief Executive Officer of Therapeutic Innovation Australia, believes that the lack of access to European funding is a major roadblock to intercontinental collaboration. He suggests Europe could take the path of the United States, which opened up National Institutes of Health (NIH) funding for foreign organizations years earlier. Enabling countries like Australia to have access to EU funding could offer a unique opportunity to become more competitive with the US in terms of research output and innovation.

"I think it's all about the money. European money needs to leave Europe and enable Australian researchers to go over there or do work here that has applicability," said Newman. "It used to be hell trying to get money out of the US, but now it's very possible. Ten years ago, when somebody was writing an NIH grant here, you'd think, 'Why?' But now, it's quite common."

Lastly, most experts mentioned the time difference between the two regions as a challenge. For instance, Sydney can be ahead of London by up to 11 hours, depending on the time of year. While setting up one-on-one virtual meetings isn't an issue, Australian experts cited larger online gatherings, workshops and conferences as being harder to manage.

"It sounds ridiculous that you get stuck by such a physical problem, but it really is the time zone being difficult," said Nisbet. "ELIXIR working groups have meetings, and we want to attend the meetings so that we can benefit and contribute, but it's just really hard when they're in the middle of the night."

While it makes sense for a European RI to set a meeting time that prioritizes its member countries, some collaborators in Australia may feel left out of the discussion or regarded as an afterthought. Nisbet recommends speaking up and making European partners aware if meetings are set at times that are less than ideal for those in Australia. She's had previous success with such open communication, and in her experience, European partners will happily accommodate.

Despite the significant effort and cost of long-distance travel, Australian experts seemed to have no qualms about taking trips to Europe to attend events. They realize the importance of reaching out to the rest of the world when living in such a physically isolated country.

"Australia is far away from everywhere, but as an Australian researcher, you learn fairly quickly that if you want to be connected to the research community, you have to travel and put up with being jet-

lagged at every single conference that you go to," said Berger. "Thankfully, a lot of the Australian research funding has fairly generous travel budgets because it is essential to stay connected."

Smith remarked that travel and time differences are just part of the way Australians do business, while Europeans may find them more of a barrier. Exchanges do occur, where a European delegation will fly over to Australia, but from speaking to the experts, it certainly seems less common than Australians going to Europe.

ADVICE FOR POLICY MAKERS AND FUNDERS

The expert interviews revealed recommendations for policy makers and funders coming from the government side, both in Australia and Europe, that would increase RI partnerships between the two regions.

BEST PRACTICE

Newman described that the difficulty in Australia is that there's a fairly limited pool for funding to either maintain or upgrade infrastructure, whether it's a benchtop device or large instrument like a synchrotron. Without this bare minimum amount of funding, international collaboration could appear to RIs as a further stretching of resources that just isn't possible.

One issue that his RI ran into was the difficulty in hiring an operator or technician who specializes in keeping equipment running. NCRIS-funded projects certainly have the means to hire such experts, but the majority of Australian RIs are not NCRIS capabilities. There is ample project funding for pure research, which gives institutions the ability to hire postdocs and research assistants, but that money doesn't go to long-term RI maintenance.

"The challenge has been to argue with universities and governments and other public funded research organizations to say that we need this ongoing operational funding to keep this knowledge from walking out the door when the grant finishes," said Newman.

Policy makers should consider that RI-specific expertise is necessary to keep equipment and other resources optimized for the benefit of the research scientists who use them – and funding schemes should reflect this point. Many RIs must reach the point of being operationally stable and secure within themselves in order to take the next step of international collaboration.

OUTREACH

Galloway believes that policy makers should understand that RIs can take many years to have a commercial, societal or even scientific impact. It could even take a decade or more to see significant results, but that's just the nature of the beast. He suggests that RIs should remain committed to various marketing and communications efforts in order to raise the RI's profile in the eyes of both the government and the public.

"Sharing the success stories that we can identify is important so that we can make these cases to governments on both sides of the world," said Galloway. "But policy makers need to realize that you're not going to see impact within the three- to four-year political cycle. This is long-term research."

SUSTAINABILITY

Newman also brings up the fact that NCRIS funding used to be a year-to-year proposition, and this 12-month cycle made it very hard to manage budgets and infrastructure. In 2018, Therapeutic Innovation

Australia received 10 additional years of funding through NCRIS, a scheme that allowed for more breathing room and the ability to consider long-term international partnerships.

“The first thing we did with our funding security was to reorganize ourselves to make sure we made sense internally,” he said. “We have to take care of our own community first before we look outside, but now that things are sorted for us, I think we’re in a position to increase collaborations with Europe and others.”

FUNDING

European programmes that are open to the world or emphasize non-EU partners have worked well to foster collaboration between the two continents. Horizon 2020 is the biggest EU Research and Innovation program to date, with nearly 80 billion Euro worth of funding available over seven years (2014 to 2020). It is “Open to the World,” meaning that participants from anywhere can apply for most of the calls. In addition, several topics strongly encourage or require cooperation with non-EU partners. The successor to Horizon 2020, Horizon Europe, will allocate an even more ambitious 100 billion Euro and cover the period of 2021 to 2027.

However, Australian participants in Horizon 2020 are only eligible for funding when their participation is deemed essential for the project (European Commission, 2017). For example, they must have outstanding competence or expertise, access to particular geographical environments or access to RI/data. In the majority of cases, because they reside in an industrialized country, Australian participants must themselves determine the sources of funding for the Australian part of the project. Based on recently proposed regulation from the European Council, Horizon Europe will likely have the same funding scheme with regards to eligible countries (European Council, 2020).

Newman recommends that either Europe open up its funding to Australian organizations, or the Australian Government could adopt a funding match for those who have won a Horizon 2020-like grant from Europe. Another option is for European partners to make funding for the Australian partner part of their proposal, which is how DARIAH Beyond Europe happened.

“I think DARIAH Beyond Europe went really well. We had good collaborations, and we’ve made a lot of personal contacts,” said Chambers. “Yet it’s about keeping up the momentum when the project is finished, and I think the biggest thing is that we need funding opportunities from both sides to continue to collaborate.”

FUTURE OPPORTUNITIES AND AREAS FOR GROWTH

Overall, experts believed that Australian-European RI collaboration would only increase in the future and highlighted several potential avenues for cooperation.

Regardless of the country or region of origin, RIs within the same field often face the same scientific challenges. All experts mentioned that a key motivation for collaboration is the need to solve mutual problems in a better and more efficient way. In some cases, a European RI had already established methodology or platforms that an Australian RI could adopt, or vice versa. In other instances, both RIs were starting from square one, and cooperation helped to accelerate the process of learning something new.

Berger described a situation where APPF and Wageningen University & Research in the Netherlands had both purchased a new kind of field phenotyping vehicle, a complex piece of equipment that drives over

plots to capture plant data with various sensors. Because they received the first two systems made by the company, the groups agreed to work together to figure out the best ways to use it.

“A lot of the success in collaboration is learning from each other: optimizing workflows and efficiencies, sharing ways to capture and analyze data, etc. There are plenty of the same issues that many are grappling with,” said Berger. “Having that open conversation and making sure that people are able to contribute or become partners in projects is really critical.”

Also, it is important to note that Australia and Europe have different strengths, scientifically and organizationally. RIs in each region could leverage the other’s strengths by reaching out and establishing a partnership for joint research projects.

Gilbert cited Australia’s biodiversity as a contributor to the country’s collaborative science efforts, as in the koala genome study or experiments involving the Great Barrier Reef. The unique flora and fauna offers something distinct from what is available in Europe. Chambers recalled being impressed with Australia’s linguistics research, given that there are 200 to 300 indigenous languages spoken there. Newman also lists marine biology, astronomy, clinical trials, and genetic/population studies as strong areas.

The European Green Deal, an action plan to make the EU’s economy sustainable, could also provide incentive for collaboration with Australia. The EU aims to become climate neutral by 2050, and it plans to work with international partners to improve global environmental standards.

Organizationally, Australian and European RIs have accelerated at different paces and within different areas, opening up opportunities for RIs to lift one another up. Galloway offered an example of Euro-BioImaging needing guidance to grow their biomedical and human imaging components. They brought him on to chair a working group and help review initial calls for nodes to join Euro-BioImaging, which has mostly focused on microscopy up to this point.

“At that stage, we had more experience in human imaging at a collaborative level. Of course, there’s a huge amount of human imaging in Europe, but the idea of a national or pan-national collaboration was in very early stages,” said Galloway. “So from that, there was a natural interest in us coming together to share those opportunities.”

Lastly, several of the experts mentioned training exchange as an excellent avenue for intercontinental RI partnership. Bioplatforms Australia signed an MOU with EBI focused on training in bioinformatics and the digital workforce more than a decade ago. Australian practitioners go to Europe to get trained in best practices while finding ways to apply them back home, and a European delegation heads to Australia as well.

“That transfer of knowledge by training is low-hanging fruit for global collaboration, particularly over research infrastructures that by their definition are capital-intensive, and there are very few people who can operate them,” he said.

Conclusion

Australian-European RI collaboration has the potential to advance scientific progress in several areas, including genomics, agriculture, arts and humanities, and medicine. Challenges and bottlenecks do exist

– for instance, large time differences and the lack of European funding available to Australia – but the case studies outlined in this report demonstrate that these can be successfully overcome.

Key recommendations from experts to facilitate Australian-European RI partnerships can be categorized into actionable items for RI representatives, policy makers, and funders.

Key recommendations for RI representatives:

RATIONALE/GLOBAL CHALLENGES:
- RI partnerships should start with common interest and perception of mutual benefit on both sides.

FUNDING:
- RIs should budget for international collaboration.

ACCESS:
- Take advantage of technology that enables virtual meetings and collaborative documents.

CO-CREATION BASED ON NEEDS:
- Overseas events should be customized to the host country's needs.

OUTREACH:
- Connecting on a personal level with others from abroad can lead to successful joint projects down the line.

BEST PRACTICE:
- Value RI staff members and give them a rewarding career pathway.

Key recommendations for policy makers & funders:

BEST PRACTICE:
- RIs need the bare minimum amount of national contributions to sustain operations in order to take the next step of international collaboration.

OUTREACH:
- Policy makers and funders should recognize that RIs may take several years to produce significant scientific results.

SUSTAINABILITY:
- Multi-year funding schemes give Australian RIs the security to plan ahead and develop fruitful international partnerships.

FUNDING:
- Europe should find ways to open up funding access to Australian organizations by including RIs in the work programmes.

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Table 1: Examples of Research Infrastructures in Europe and Australia

Energy	• European Carbon Dioxide Capture and Storage Laboratory Infrastructure (ECCSEL) • Brazilian Centre for Research in Energy and Materials (CNPEM) Australian Nuclear Science and Technology Organization (ANSTO)
Environment	• European Multidisciplinary Seafloor and water column Observatory (EMSO) • Integrated Marine Observing System (IMOS)
Biomedical Sciences	• European Clinical Research Infrastructure Network (ECRIN) • Therapeutic Innovation Australia (TIA)
Physics & Engineering	• European X-Ray Free-Electron Laser Facility (European XFEL) • Australian Synchroton
Social Sciences & Culture	• Survey of Health, Ageing and Retirement in Europe (SHARE) • Australian Data Archive (ADA)
Big Data & Computing	• European High-Performance Computing Joint Undertaking (EuroHPC JU) • Australian Research Data Commons (ARDC)

Many more examples of research infrastructures can be found in the RISCAPE International Research Infrastructure Landscape 2019, which can be found online at https://riscape.eu/riscape-report/.

APPENDIX A: List of experts interviewed

Dr. Bettina Berger, Scientific Director of The Plant Accelerator

Berger joined The Plant Accelerator when it opened in 2010 as Senior Scientist and became Scientific Director in 2015. The Plant Accelerator is one of the nodes of the Australian Plant Phenomics Facility (APPF) funded under the National Collaborative Infrastructure Strategy (NCRIS) and provides critical infrastructure and services to the plant science community in Australia and abroad. In her roles, she has set up novel screening techniques to study plant growth and performance using automated, non-destructive imaging. Users of The Plant Accelerator include Australian researchers, as well as overseas customers from Europe, North America, and Saudi Arabia. Berger has a degree in biotechnology and a PhD in molecular biology of plants.

Sally Chambers, Digital Humanities Research Coordinator at Ghent University

Chambers is the Digital Humanities Research Coordinator at Ghent University, where she coordinates the day-to-day activities of the Ghent Centre for Digital Humanities and Belgian participation in DARIAH, the Digital Research Infrastructure for the Arts and Humanities. From 2011-2015, Chambers was Secretary-General for DARIAH-EU, based in the Göttingen Centre for Digital Humanities, Germany. Before joining DARIAH-EU, she worked for The European Library, focusing on interoperability, metadata and technical project coordination. She initially started working in libraries in the mid-1990s, where she coordinated a digital enquiry service for UK public libraries and the development of an online library for distance learning students at the University of London. Chambers has a first degree in Literature with Psychology and postgraduate qualifications in Cultural Studies and Information Services Management.

Dr. Graham Galloway, Chief Executive Officer of the National Imaging Facility (NIF)

Professor Galloway is the Chief Executive Officer of the National Imaging Facility (NIF). He has been instrumental in establishing Imaging collaborative research infrastructure in Australia. In 2006, he led the collaborative team that developed the Investment plan for Imaging, within NCRIS (National Collaborative Research Infrastructure Strategy). This plan was accepted by Department of Industry, Innovation and Science, with $7M Commonwealth funding, plus $10M state and institutional funding, and Galloway was nominated by the Imaging Community as the Inaugural Chief Executive Officer of the National Imaging Facility. In this role, he provides leadership to the NIF as it develops a strategic vision for imaging in Australia. Under his leadership, NIF has expanded through the Education Investment Fund and further capital investment through NCRIS. With state and institutional funding, this is a $130M project. He is passionate about providing open access to the imaging resources and enabling effective use of those resources.

Andrew Gilbert, Chief Executive of Bioplatforms Australia

Gilbert has been Bioplatforms Australia's general manager since its inception in 2007. He is a graduate of the Australian Institute of Company Directors. He oversees the investment of $300 million in Commonwealth Government research infrastructure funding in the discovery sciences of genomics, proteomics and metabolomics. He has an extensive network of contacts from Commonwealth and State Governments, along with prominent universities, medical research institutes, agricultural research institutes and commercial entities. The Bioplatforms Australia network now supports 4500 users per annum across the spectrum of pure research to commercial production. In addition to managing the

national infrastructure network, Gilbert has also catalysed the formation of a series of strategic national scientific collaborations. Each of these projects is by design multi-disciplinary, multi-institutional and contain both discovery implications and pathways to end use.

Dr. Stewart Newman, Chief Executive Officer of Therapeutic Innovation Australia (TIA)

Newman is the Chief Executive Officer of Therapeutic Innovation Australia (TIA), which supports translational research infrastructure to develop new therapeutics for human health. Since completing a PhD in Antarctic Biology from the University of Tasmania, he has built up considerable experience of science policy, pharmaceutical R&D, grant funding, IP management, business development and commercialization. Newman previously worked with TIA as Queensland Development Manager, where he assisted the development of TIA's Queensland Node, and assisted in establishing the iQDOCs resource and the ATRAX database.

Sarah Nisbet, Platforms and Engagement Manager at Bioplatforms Australia

Nisbet is responsible for overseeing Bioplatforms Australia's investment in its Genomics, Proteomics, Metabolomics, and Bioinformatics platforms. She is also responsible for enhancing and extending cooperation and collaboration across Bioplatforms networks and capabilities. Nisbet works closely with the CEO to execute the organization's vision and strategy to deliver research infrastructure to the life sciences in Australia. Nisbet was previously COO at eResearch South Australia, a state based eResearch infrastructure provider, delivering HPC, Cloud and Storage solutions to researchers in SA. She began her career delivering communications solutions in the health care sector where she mastered the art of working across institutions, departments, and organizational silos. Nisbet has a Bachelor of Media from the University of Adelaide and an Industry Certificate (Festival & Event Design & Management).

Dr. Merran Smith, Chief Executive Officer of the Population Health Research Network (PHRN)

Smith commenced as the inaugural Chief Executive of Australia's Population Health Research Network (PHRN) in 2009. The PHRN is a national research infrastructure capability focused on the provision of high quality linked data in privacy preserving ways. It receives core funding from the Australian Government's National Collaborative Research Infrastructure Strategy (NCRIS). Prior to joining the PHRN, Smith was a Director in the Western Australian Department of Health. She was in charge of the Department's Health Information Centre for more than 10 years and was responsible for establishing data linkage as a core Department of Health service during this period. She also participated in a number of significant nationally funded population health research projects. Smith has served as Chair or Member of a number of Australia's peak national health information committees.

APPENDIX B: Further reading

ESFRI Roadmap 2018: Strategy Report on Research Infrastructures
http://roadmap2018.esfri.eu/media/1066/esfri-roadmap-2018.pdf

RISCAPE International Research Infrastructure Landscape 2019
https://riscape.eu/wp-content/uploads/2019/12/Riscape_report_digi_19122019.pdf

Australia's 2016 National Research Infrastructure Roadmap
https://www.education.gov.au/2016-national-research-infrastructure-roadmap

Australia's National Research Infrastructure Census (NRI Census)
https://www.education.gov.au/national-research-infrastructure-census-nri-census