PATHWAYS TO THE FUTURE

A strategy to lift the positive impact of science on Aotearoa New Zealand's economy, environment, society and cultures

Authored by the New Zealand Crown Research Institutes | 1 September 2021

Science New Zealand
agresearch ātaa mātai, mātai whetū
GNS SCIENCE TE PŪ AO
E/S/R Science for Communities
Manaaki Whenua Landcare Research
NIWA Taihoro Nukurangi
Plant & Food Research Rangahau Ahumāra Kai
SCION FORESTS • PRODUCTS • INNOVATION

CONTEXT STATEMENT

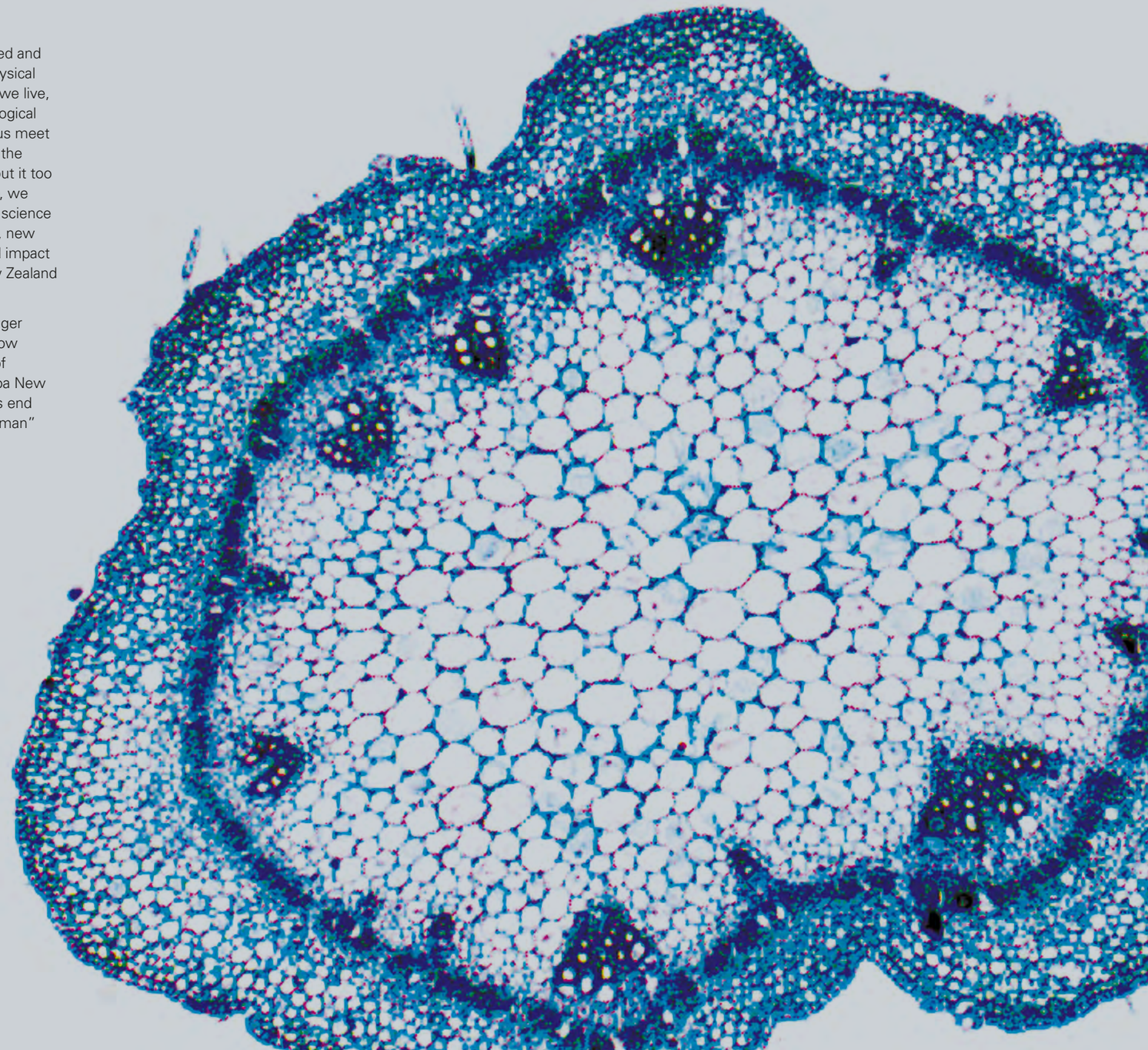
Science has never been more valued by the public and decision makers – for the way it has guided global approaches to managing the COVID-19 pandemic and the development of vaccines, the challenges of climate change, advancing technology and creating economic opportunities. A robust and productive science system will be essential for creating a better future for Aotearoa New Zealand, economically, environmentally, culturally and socially.

This paper takes a functional approach outlining the mechanisms by which the various layers in the Aotearoa New Zealand Science System can be maximised to create impact that enhances the wellbeing of the country. It contains high-level principles that should be considered when thinking about the future of science in this country. It is agnostic as to the structure of the system, although it has been developed in the context of the current one. The paper creates a framework to think about how science can have an impact and, from that, institutional arrangements, science priorities and funding can be considered.

Aotearoa New Zealand's science system is composed of a broad range of organisations ranging from universities through to corporate R&D departments and deep tech start-up companies working on research, development and innovation. The Crown Research Institutes (CRIs) are positioned right in the middle of this system. Their 3800 staff deliver $800M of crucial science across this spectrum annually.

Today, we face unprecedented and rapid global change in our physical environment and in the way we live, given transformative technological advances. Science will help us meet these challenges and realise the opportunities they present, but it too must continually adapt. Here, we suggest changes to the way science is resourced and undertaken, new knowledge is generated, and impact is delivered to Aotearoa New Zealand and the world.

This report is intended to trigger informed discussion about how we might energise the role of science in advancing Aotearoa New Zealand's welfare, and to this end includes a number of "strawman" recommendations.



SUMMARY

Aotearoa New Zealand's science system is made up of three interacting layers:

1. RESEARCH

Science is undertaken to produce new knowledge

2. DEVELOPMENT

Scientific knowledge is used to create new products/services, new businesses, improved processes and/or improved policies and regulations

3. INNOVATION

The outputs of development are applied and scaled to lift productivity, increase income, enhance the environment and produce positive social outcomes

Much has been done over the last 30 years to optimise the performance of the system. This has resulted in a system with a productive and collaborative Research layer. Despite below average investment levels, the system's research organisations produce above average outputs with a high level of cross organisational collaboration. To make the most of this capability Aotearoa New Zealand needs to increase the conversion of those research outputs into impact.

The opportunity is to:

- Continue to implement the Government's policy to lift investment into research, development and innovation – this will lift the level of knowledge creation
- Lift the effectiveness of this investment through improved focus and prioritisation – this will ensure that knowledge is created in areas of the greatest national need
- Increase collaboration and connections between the 3 layers of the system – this will increase the conversion of knowledge into economic, environmental, social and cultural impact.

We can capture these opportunities by:

1. Appointing an RD&I Council to agree a small number of high-level priorities for Aotearoa New Zealand
2. Establishing each priority area as a Mission with a clearly identified impact target and a defined timeframe for its achievement
    a. Each mission would be led by a small team of leaders from Government, Industry, Māori and Research
    b. The team would develop a strategy and lead its implementation
3. Empowering each of the 4 stakeholder groups so that they can enact the strategy
    a. Government should engage with Māori to understand the changes they require the crown to make so that Māori are empowered to take a full partnership role in both the establishment of priorities and the development of Mission Strategies
    b. Increase the availability of repayable grants to allow small and emerging sectors to participate at scale
    c. Increase the proportion of institutional funding provided to research organisations so that they have the ability to act on the strategy
4. Ensuring that decisions about the design of the RD&I system are focused on increasing the flow of knowledge through the layers of the system rather than tweaking the performance within a layer of the system
    a. Regularly review the scope of Public Research Institutes (PRIs) to ensure that they are aligned to key end users
    b. Review and where possible improve the existing collaboration mechanisms in order to both save cost and increase the focus on the new Mission approach
    c. Broaden the discussion on connectivity of research organisations to include Government, Industry, Māori and Research and ensure that it covers all 3 layers of the RD&I system.

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ABOUT THE CRIs

This is us

The seven Crown Research Institutes (CRIs) were established in 1992 as Aotearoa New Zealand's primary public research institutes. They are Crown-owned companies that have been commissioned by the Government to deliver research and innovation to ensure the future success of Aotearoa New Zealand's key sectors. Each CRI is aligned with natural resource groups or productive sectors of the economy, including the people and communities that depend on them.

Each CRI works continually with key stakeholders to shape its science plans. This model also enabled CRIs to invest in the science capability they needed to deliver their plans. Over the 9 years to 2020, CRIs generated net profit of $192M, of which $8.9M was returned to the Crown as dividends and the rest reinvested in science capability – people, equipment and facilities. Now, 3800 CRI staff deliver $800M of critical science annually to industry, government and Māori for the benefit of all New Zealanders.

CRIs have become independent and trusted advisors providing objective information to government, from justice to hazards to natural resource management, and they hold the core capability that government relies on. CRI science matches or exceeds the science excellence of the OECD, and indeed the New Zealand universities, in terms of outputs and citation impact. Over the years, CRIs have made significant contributions to Aotearoa New Zealand, ranging from the creation of gold kiwifruit and new forest products, maximising pastoral production, improved biosecurity and pest management, world-leading forensic techniques for the police, future climate projections enabling adaptation to sea-level rise, floods and droughts and real-time monitoring of earthquakes, to detailed maps of the country's soils, minerals, faults and seabed.

Individually and collectively, CRIs have links with numerous Māori entities – whānau, hapā, iwi, and Māori businesses, land-owning incorporations, etc. – to ensure meaningful engagement between Māori and CRIs. These include long-established extensive networks and engagement with Māori communities on local Māori needs. Our collective purpose is to improve sector productivity, address national issues, enhance people's wellbeing and ensure the future sustainability of Aotearoa New Zealand's natural capital assets. Issues of this scale and importance require interdisciplinary approaches to address complex risks. Each CRIs' capabilities are unique and essential in contributing to addressing different aspects of these challenges. In addition, the CRIs play a key role in enriching a highly dynamic Research, Development and innovation (RD&I) system and are well-networked with other essential research and education providers that collectively are creating better futures for all New Zealanders.

Our reason for being

The core mission of CRIs is to protect and advance Aotearoa New Zealand's current and future prosperity and wellbeing.

For Aotearoa New Zealand to become a more productive, sustainable and inclusive economy and realise the Government's vision, we need RD&I to address economic, environmental, social and cultural ambitions; realise opportunities that arise from improvements in the sustainable production of goods and services; safeguard our natural capital assets, including biodiversity and our soils; and increase the effectiveness of public services.

Our focus is Research, Development and Innovation that is useful, usable and used.

This is our vision

For Aotearoa New Zealand to be a place where science-based insight and innovation is valued for its contribution to people's lives and inspires them and their communities to achieve their aspirations.

BACKGROUND

An overview of the RD&I system and its performance

New Zealand's RD&I system is complex and multi-dimensional. At a high level it can be represented by three interacting layers:

1.

Research

Science is undertaken to produce new knowledge

2.

Development

Scientific knowledge is used to create new products/ services, new businesses, improved processes and/or improved policies and regulations

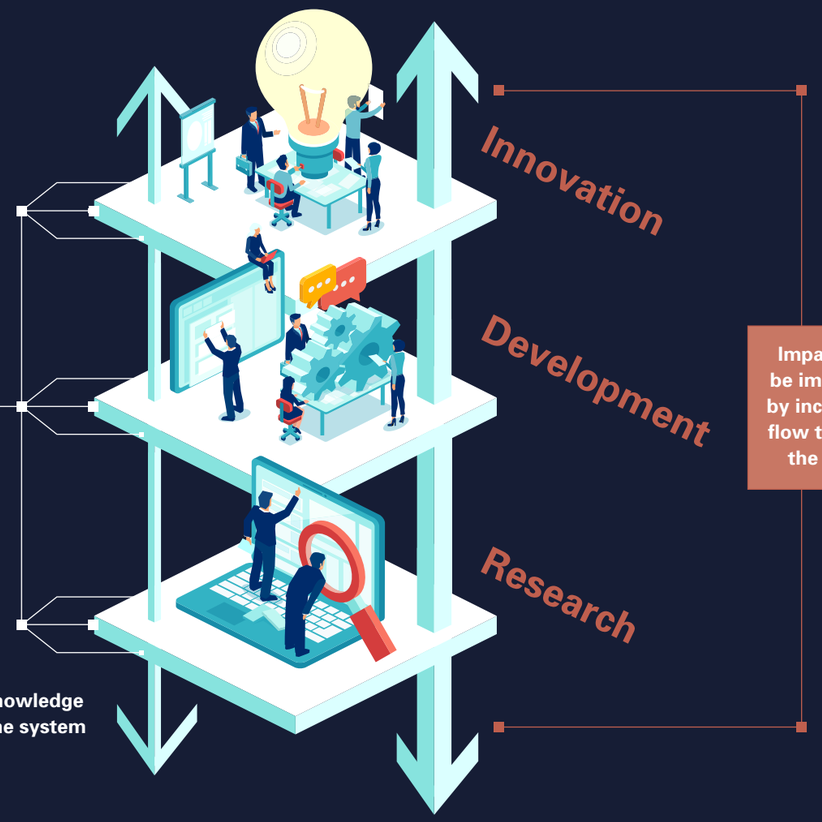
3.

Innovation

The outputs of development are applied and scaled to lift the efficiency of productivity, increase income, enhance the environment and produce positive social outcomes.

For the system to function well, each individual layer needs to work effectively (i.e., we need strong horizontal connections between the organisations in each layer) and strong flows are needed between the layers (i.e., we need strong vertical connections between the organisations which operate in different layers).

Layers of the RD&I System



Much has been written on the pros and cons of Aotearoa New Zealand's RD&I system. The following is a very high-level summary of the conclusions:

1. While Aotearoa New Zealand invests less than some developed economies in research, our system is very productive, resulting in good levels of knowledge generation relative to the OECD

2. Aotearoa New Zealand invests less in development than its peers. Patenting levels are relatively low. While Aotearoa New Zealand is dominated by SMEs, relatively few are deep tech companies

3. Our start-up ecosystem is viewed as embryonic or emerging – the Development layer is under developed

4. Long-run productivity growth in the Aotearoa New Zealand economy has been flat. Export growth has been as much from volume as value. Aotearoa New Zealand continues to struggle to adopt and scale new technologies in order to produce economic, environmental, cultural and social outcomes

5. While the ***Research*** layer of the system is generating above OCED average levels of knowledge, conversion of that knowledge into developments and ultimately economic, environmental, social and cultural outcomes is below average. This suggests either a bottleneck at the ***Development*** layer of the system (poor conversion of knowledge to new products, processes, businesses or improved policies and regulations) or poor flow between the layers

6. Work by the Productivity Commission concluded that Aotearoa New Zealand lacks a coherent innovation policy[1]

7. The implications are clear; rather than focusing on improving the ***Research*** layer of the system we should be working to lift the flow through the system. Our efforts should be on vertical alignment between the layers rather than alignment within a layer of the RD&I system.

[1]New Zealand firms: Reaching for the frontier, New Zealand Productivity Commission, April 2021

INCREASING THE FLOW THROUGH THE SYSTEM

There are three key channels by which science flows through the system to create impact:

1.

Broadcast

New science knowledge is shared broadly through publication, presentation or teaching. This is the primary channel used by universities. It's also an important channel for the CRIs

2.

Knowledge exchange

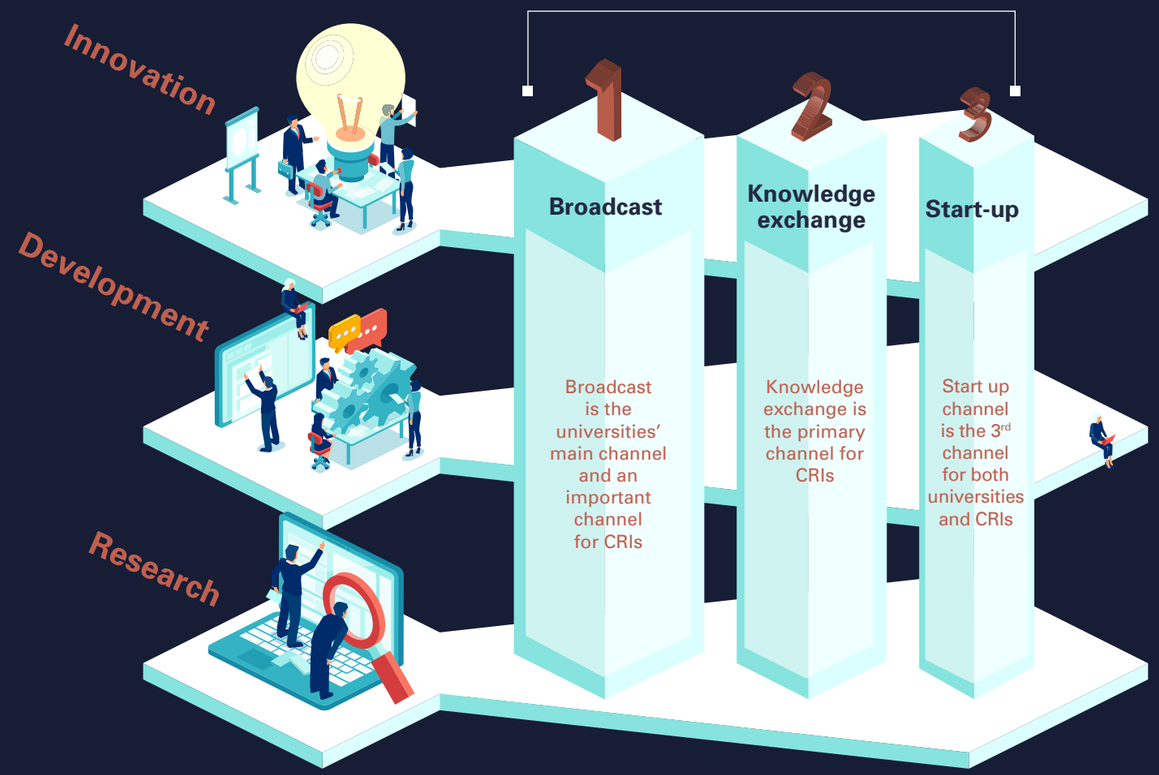
Knowledge Exchange, where science is shared with industry (who use it to grow or improve their business, and to create new products or processes) or government (who use it to develop policy or regulation). This is the primary channel used by CRIs who work within long term collaborations with end users. Three out of every four dollars invested externally by companies are invested with CRIs

3.

Start-up

There is no existing end user, so new science knowledge is used as the basis for creating a new company or even a whole new sector. This is a secondary or tertiary channel for both universities and CRIs

Channels which flow through the system



Each of these channels delivers a different mix of impacts. *Broadcast* lifts science literacy and human resource capacity in the system and advances global knowledge. *Knowledge Exchange* lifts the productivity of existing organisations and sectors. Start-ups create new jobs and even new sectors.

Many of the arrangements of the Aotearoa New Zealand RD&I system incentivise the use of the first two channels. The Performance-Based Research Fund's (PBRF's) focus on publication, and MBIE's Endeavour Fund's focus on science excellence pushes research organisations to use the *Broadcast* channel. The MPI's Sustainable Food and Fibre Futures (SFFF) programme and Callaghan Innovation's co-funding requirements push researcher organisations to partner with large existing players with deep pockets and hence to use the *Knowledge Exchange* channel.

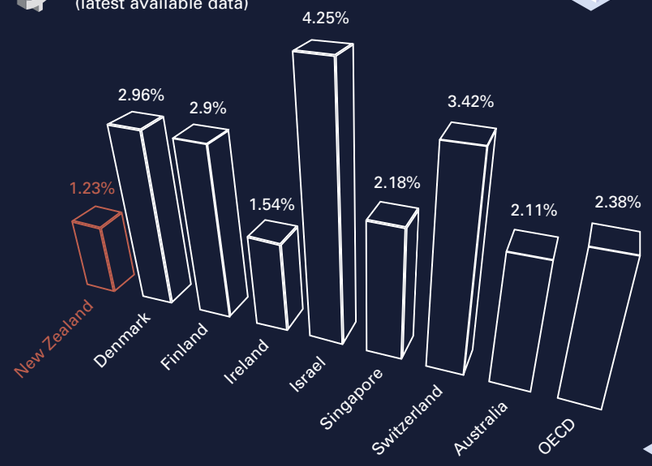
While Callaghan Innovation and programmes such as the Commercialisation Partner Network provide support for the *Start-up* channel, the level of support provided and incentives to use the channel are small when compared with the other channels and hence only a relatively small portion of Aotearoa New Zealand's new knowledge flows out to become start-ups or to create new sectors.

Performance data on the Aotearoa New Zealand RD&I system suggests that the *Broadcast* channel is working well. New Zealand's researchers have an above average publication rate and these papers show a high level of national and international cross-organisation collaboration. The CRIs perform above the NZ average on cross-organisation collaboration.

Efficient Research

Our science system is relatively small...

Proportion of GDP spent on R&D (latest available data)



...but highly productive

Publications per $M higher education and government research expenditure

NZ **13** | OECD **5**

Publications per researcher per year

NZ **0.7** | OECD **0.3**

Publications in top 1% most-cited worldwide

NZ **2.0%** | OECD **1.3%**

Connected to Users

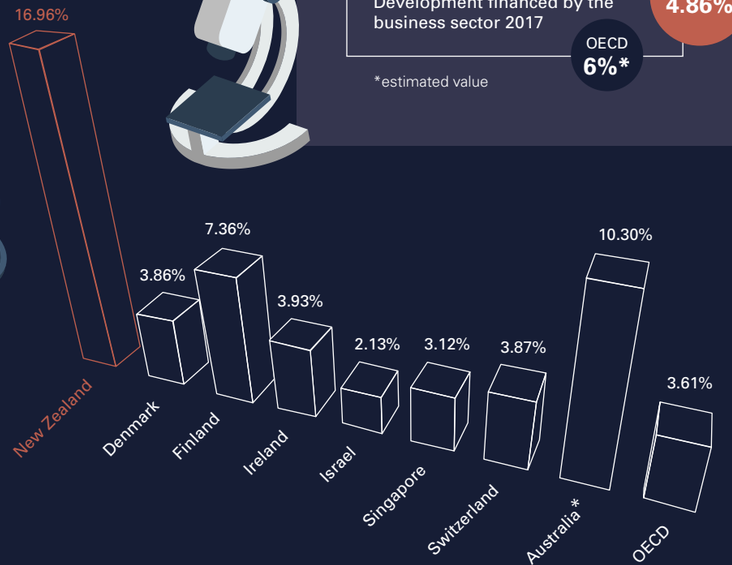
Percentage of public research institute funding from business

Proportion of GDP funding on R&D from business (latest available data from 2017, *data from 2016)

Percentage of Higher Education Expenditure in Research and Development financed by the business sector 2017

NZ **4.86%** | OECD **6%***

*estimated value



The *Knowledge Exchange* is primarily used by mission-led research organisations such as CRIs and Independent Research Organisations. The performance of the Knowledge Exchange channel is less clear. A number of measures suggest that this channel is working well. Aotearoa New Zealand leads the OECD in the percentage of Public Research Institute funding coming from businesses – which suggests strong links between businesses and the CRIs . This is further supported by customer satisfaction survey data, which shows that end users of CRI research are generally very positive about the delivery from the CRIs. But the use of the science services offered by CRIs is generally contracted by a small number of relatively large and well-established customers, including government departments. Hence there is an opportunity to build on this strong foundation to broaden and deepen the *Knowledge Exchange* channel.

Aotearoa New Zealand's start-up ecosystem has been categorised as "emerging" by external reviewers. Furthermore, there are structural issues which make it difficult for new or emerging sectors to engage with the *Research* layer at scale. This third channel is underdeveloped and can be scaled up significantly.

Conclusions:

[C1] The ***Broadcast*** channel is operating well – this level of performance needs to be enhanced and maintained but there's limited opportunity to increase the impact of the RD&I system by making further improvements to this channel

[C2] The ***Knowledge Exchange*** channel works well for large existing organisations and sectors. There is an opportunity to build on this success and use this channel to reach small or emerging sectors or other infrequent users. Deepening and broadening this channel should be a priority and a major focus of our national effort

[C3] The ***Start-up*** channel is emerging and underdeveloped. There is an opportunity to build upon the work that has been done. A small increase in the amount of knowledge flowing through this channel would contribute to a significant percentage increase in impact from this channel

[2] Research, Science and Innovation System Performance Report 2018 (mbie.govt.nz)
[3] Global Startup Ecosystem Report 2017, Startup Genome, www.startupgenome.com

CHANGES IN THE FUNDING OF THE RD&I SYSTEM

In recent years, MBIE's research funding has been moved towards the basic science end of the spectrum in an effort to prioritise transformational research. Development funding from organisations like MPI has been increasingly put into the hands of industry (with a requirement for co-investment) or into departmental operational activities, both of which increase the effectiveness of implementation. This has created a funding gap in the large, mission-led areas of RD&I that fall between early-stage transformation science and applied science. The gap is felt most acutely by new or emerging sectors (including government agencies) that lack the funds to co-invest in Development and lack the capacity to interpret, adapt and absorb *Broadcast* science directly.

These moves have tended to deepen the bias towards *Broadcast* as the predominant channel, as this channel is usually used for basic science. They focus *Knowledge Exchange* on existing large incumbents, as they are more likely to invest the co-funding. This concentrates the benefits of RD&I in a narrow set of legacy stakeholders and does little to increase the resilience of our economy in the face of shocks such as pandemics, environmental crises or politically driven manipulation of global markets.

Public-good research, to sustain our natural capital and protect us from natural hazards, is especially vulnerable because of market failure. Businesses tend to invest in direct benefits and governments either lack capacity or invest in supporting innovation for economic growth. Yet natural capital is the foundation for economic and social wellbeing.

A further challenge in the current model is achieving partnership with Māori. The system's focus on the *Broadcast* channel disadvantages Māori, both in the process of engagement in research design and the pathway for disseminating new knowledge. Māori often lack the capacity to engage with the plethora of science projects in genuine partnership. They also struggle to win funding for mātauranga-based research programmes that do not fit the western science model.

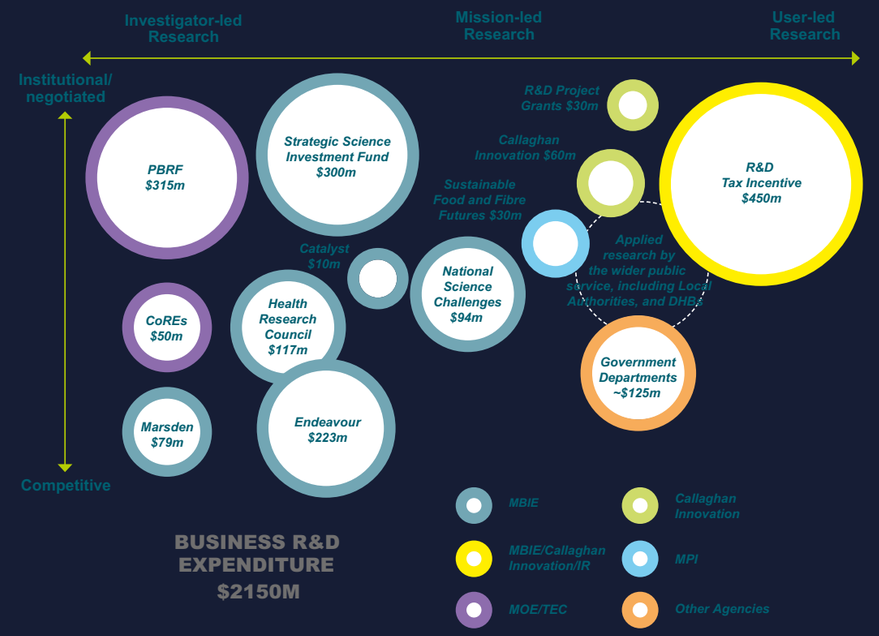
Our level of RD&I funding is low compared with other small developed economies. Successive Governments have made commitments to raise the percentage of GDP invested in RD&I and BERD. If these targets are to be achieved, both Government and business will need to increase their investment research in the next 5 years.

Conclusions:

[C4] Changes in Research and Development increased the bias towards the *Broadcast* channel and large existing players in the *Knowledge Exchange* channel

PRIORITISATION WITHIN THE SYSTEM

The Aotearoa New Zealand RD&I system is also characterised by a plethora of separate funding mechanisms each with its own focus and rules and intended to address particular emerging needs or threats. Each system works independently of the others, resulting in an absence of national-level mechanisms to prioritise areas of national importance. Each of the funding mechanisms tends to operate within a layer of the system. Few of the mechanisms create pathways through the layers from knowledge creation to knowledge use and impact.



Source: MBIE NZ's Research, Science & Innovation Strategy: Draft for Consultation September 2019

Various initiatives, for example the National Science Challenges and Centres of Research Excellence, were established in part to address the issue of a lack of national-level prioritisation by providing some connectivity and coordination around key themes that are important to all New Zealanders. They have achieved some success and have led some changes in the way the system operates, for example a number of the challenges introduced co-leadership with Māori but this success comes at a high administrative cost (upwards of 30% of the funding spent on administration and marketing).

There is an opportunity, when the challenges come to an end in 2024, to learn from their strengths and weaknesses and develop a new approach with even greater impact. Such an approach would:

1. Focus on increasing the flow of knowledge through the system rather than coordinating work within layers of the system
2. Involve all key stakeholders (Industry, Māori, Government and Research) in co-leadership from the start
3. Be focused on creating impact on key priorities rather than attempting to coordinate broad domains of work
4. Utilise existing governance structures and marketing rather than introducing additional layers of management, marketing and Governance.

Conclusions:

[C5] There is an opportunity to change Aotearoa New Zealand's funding mechanisms so that they better support national priorities and flow through the layers of the system

[C6] There is an opportunity in 2024, when the National Science Challenges come to an end, to learn from their strengths and weaknesses to develop a new approach with even greater impact

IMPLICATIONS FOR THE RD&I SYSTEM

Much has been done in the last 30 years to optimise the performance of the system. This has resulted in a system with a productive and collaborative Research layer. Despite below average investment levels, the system's research organisations produce above average outputs with a high level of cross organisational collaboration. To make the most of this capability Aotearoa New Zealand needs to turn its focus to the conversion of those research outputs into impact. We need to hold the gains we have made around collaboration and efficiency within the Research layer and at the same time increase the flow of knowledge between all 3 layers.

To increase the flow between layers we need to ensure that all three channels (*Broadcast, Knowledge Exchange, and Start-ups*) are operating well and that the flow of knowledge up and down these channels is balanced and optimised. Aotearoa New Zealand needs to maintain the flow through the *Broadcast* channel and work to ensure that the linkages between research organisations continue to grow, for example further work can be done to ensure that the universities and research institutes work together to build the key talent that the country will need in the future.

The *Knowledge Exchange* channel is already operating well for large established sectors and companies. This strength needs to be leveraged and the channel expanded so that smaller or poorly funded (or structured) sectors can also tap into knowledge from the RD&I system. This should be the country's key focus.

Finally, the *Start-up* channel is emerging as a means of creating impact in areas where Aotearoa Aotearoa New Zealand does not have an existing sector. It is currently the smallest of the three channels but with some promising signs of growth. In the long term this channel could be of strategic importance for the country. While not as important as the *Knowledge Exchange* channel, the country needs to continue to invest in expanding our capabilities in this area.

Increasing the flow through the layers of the RD&I system by optimising the 3 knowledge channels will significantly increase the impact from the country's investment, but optimisation of the system will only take the country so far. Ultimately to increase impact, funding of RD&I will also need to increase. As this is already the stated policy of Government, we will not comment further on the quantum in this report, however it is clear that changing the way that the investment is applied will be critical to achieving the changes needed in the system

Finally, as long as Aotearoa New Zealand invests less than its peers it will be vital that the investment is prioritised on the most critical issues for the nation and that the country's capabilities are aligned behind these priorities. Historically, the country has used mechanisms such as the National Science Challenges to prioritise and coordinate. These measures have been partially successful but there is now an opportunity to move from focusing on collaboration within layers of the system to a focus on prioritisation and alignment across the layers.

IMPLICATIONS FOR THE PUBLIC RESEARCH INSTITUTES

The current CRIs bring real strengths, and any change to the system needs to ensure these strengths are retained and built upon. The functional strengths are:

- Each CRI is focused on a defined set of end users creating a basis for strong and enduring partnerships which support a strong flow of knowledge between layers of the RD&I system.
- The CRI's statements of core purpose create a strong public good framework ensuring that the CRIs focus on impact for Aotearoa New Zealand
- The CRIs are at a scale where they can act as a central point for connections to government, industry and other science in Aotearoa New Zealand and internationally.

But this paper also acknowledges there are weaknesses that a system redesign should aim to correct. Namely:

- Partnerships with Māori are not structurally mandated
- Science to support emerging sectors and Iwi Māori land owners is not well served by current arrangements
- Continuity of multidisciplinary research is difficult to maintain as leaders work to navigate a multitude of funding mechanisms.

While this paper aims to remain agnostic to the structure of the system, we expect that any future system will retain some form of Public Research Institute (PRI) or Institutes. When considering how PRIs should fit into the system the following should be considered.

1. The CRIs actively use the *Broadcast* channel producing proportionally a similar or higher level of outputs to the universities. As this channel is working well, in the future the PRI(s) should maintain the level of flow and performance and seek to enhance their connections with the universities

2. CRIs are the primary users of the *Knowledge Exchange* channel, enjoying high levels of investment from Industry. A number of the CRIs are critical providers to Government departments and local government. This channel is working well for large existing incumbents who have both the cash to fund the work, an appetite to invest in the work, and the ability to work within Government programmes which require co-funding. They consistently express high levels of satisfaction in their relationships with the CRIs. There is an opportunity to broaden and deepen this channel by finding new ways to engage with small or poorly funded/organised sectors

3. The CRIs are involved in the creation of *Start-ups* but this is a relatively small part of the CRIs overall activity. There is an opportunity for this channel to be a much more significant part of the PRI(s) activities

4. Because the CRIs span a broad cross-section of Aotearoa New Zealand's economy and natural environment and they span the 3 layers of the RD&I system, they are ideally positioned to show leadership in the identification and alignment of resources behind national-level priorities

5. CRIs have developed many relationships with Māori entities and built their own internal Māori research and engagement capability. However, much is still to be achieved in terms of representative levels of Māori research capability and support for mātauranga-based and Māori-led research

6. CRIs are charged with maintaining national science capability and resources. These are far from static as national priorities shift to address changing risks and opportunities, for example with climate change. Lead-times for developing areas of new capability and resource may be a decade, while skills are recruited and developed and infrastructure is created or renewed. Strategic investment in RD&I is essential for PRI(s) to maintain and grow these critical skills in addition to research discipline expertise. Such skills are a defining characteristic of the CRIs that we must not lose.

THE TIME FOR IMPACT IS NOW

Science has never been valued as much by the public and decision makers. Citizens around the world turned to science for help to guide and provide national responses to the COVID-19 pandemic. Aotearoa New Zealand's RD&I system provided world-class support to the country at a time of significant need.

As we transition to the new normal, many are again looking to science to help create a better future for Aotearoa New Zealand, economically, environmentally, socially and culturally. The work of the Climate Change Commission and many others has reminded Aotearoa New Zealand of the power of science to address the hardest problems, and often with great urgency. As a nation, we are rediscovering the vital importance of having a highly effective RD&I system.

The work on efficiency and coordination within the Research layer has produced a system which is productive and collaborative. Aotearoa New Zealand now needs to build on this to lift the foundation impact of the RD&I system on the country's economy, environment, society and cultures. In summary:

1. Aotearoa New Zealand has a relatively productive and collaborative RD&I system

2. There are challenges with converting knowledge creation from Research into successful Development and Innovation

3. The *Broadcast* channel is working well, but the *Knowledge Exchange* and *Start-up* channels require expansion to create a more balanced RD&I system that drives stronger Development and Innovation performance

4. Arrangements within the system currently favour the *Broadcast* channel. Changes to these arrangements offer a mechanism for increasing the flow through the other channels

5. Aotearoa New Zealand's funding with RD&I is low compared to other small developed economies. The funding mechanisms are poorly co-ordinated and fragmented around national priorities, compromising the capacity to realise opportunities for improvement

6. Public-good research, to sustain our natural capital and protect us from natural hazards, is especially vulnerable because of market failure.

7. Mātauranga-based and Māori-led research continue to be disadvantaged in the current system, both by low capacity and difficulty in securing research investment.

"The time is right to review and redesign the science system to increase its impact on Aotearoa New Zealand's economic, environmental, social and cultural wellbeing"

OPPORTUNITIES IN FRONT OF US

So far this paper has reviewed the status of Aotearoa New Zealand's RD&I system and identified a series of opportunities to increase the flow of knowledge through the 3 layers of the system while increasing the focus and alignment around the country's priorities. This section of the paper provides recommendations on how Aotearoa New Zealand can capture these opportunities within the next decade. They are offered as a "Strawman" to support an informed discussion between Government, Māori, Industry and Research.

AGREEING ON NATIONAL SCIENCE PRIORITIES

Aotearoa New Zealand is a small economy with limited resources to invest in RD&I. There is an opportunity to more effectively align these resources around important priorities. The process for setting national science priorities needs to be agile, dynamic, respected and mandated. As discussed above, Aotearoa New Zealand does not currently have such a process.

In order to develop a process that achieves these goals it is recommended that:

[R1] An RD&I Council establishes a small number of high-level priorities (or Missions) for Aotearoa New Zealand that science can contribute to

[R2] Each Mission has a clearly identified impact target and a defined timeframe for its achievement, e.g., reduce methane emissions by x% within X years

RD&I Council

It is recommended that the Government sets up a Council comprising key stakeholders from Industry, Government, Māori and Research. This body would develop the criteria for establishing a small set of national priorities and use the agreed criteria to make a selection. The Council would not be an allocator of funding, but rather it would be a coalition of the willing. Its aim is to bring together the key stakeholders so that they develop and share a common agenda. The priorty areas would not cover all of the work done within the RD&I system, but rather a subset of the work that is currently a priority and needs focus and alignment to be best achieved.

The prioritisation process will be dynamic and agile. Because the Council is not allocating funding they will not need to be tied to slow moving budgeting and contracting processes. Rather they will be able to continually review the set of national priorities, adjusting them if required to changes in the environment.

To galvanise actions behind the priorities, the Council would establish a team to lead the development of a strategy for each priority area or mission. This team would be comprised of Industry, Government, Māori and Research stakeholders in a structure that we have called `the quadruple helix' (after the Dutch triple helix approach). More detail on the functioning of these strategy teams is provided below.

Priority areas framed as Missions

It is recommended that each of the priority areas is framed as a time-bound national Mission. Like the US moon mission of the 1960s, the framing of each Mission should consist of:

1. A clear measurable impact target, e.g., get a man to the moon and back safely
2. A timeframe within which the target needs to be achieved, e.g., by the end of the decade

This is in contrast to the approach taken in the past with mechanisms such as National Science Challenges. Historically, these mechanisms have been framed around coordinating areas of research rather than delivering on impact targets. The emphasis has been getting as many people as possible involved, which further drove an expansion of scope and focus. The Missions, in contrast, need to be highly impact focused with a narrow scope and an acceptance that not everybody needs to be involved to achieve the mission.

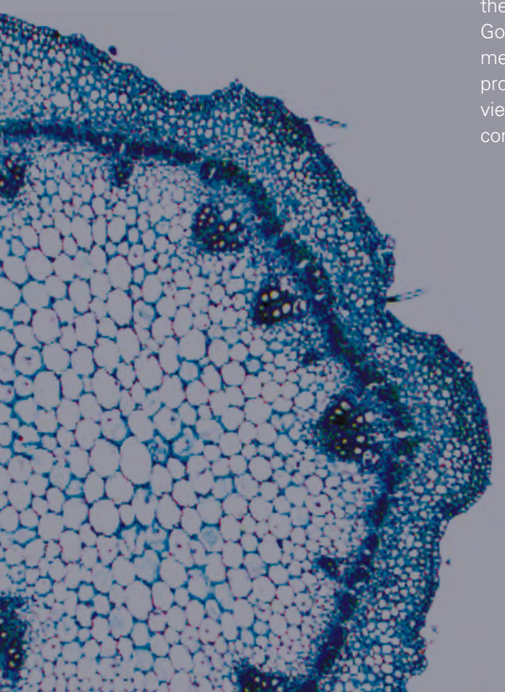
DEVELOPING NATIONAL STRATEGIES FOR EACH MISSION

For each Mission, we recommend that:

It is recommended that:

[R3] For each Mission a National Science Strategy is developed by a four-way coalition of Industry, Government, Māori and Research

[R4] Missions replace existing mechanisms to drive vertical as well as horizontal alignment of effort to achieve national priorities



Mission strategy team

We propose that the Strategy Team for each Mission is limited to 4–8 people. Team members should each be leaders of key stakeholder organisations needed to implement a plan that will deliver the strategy. They should be capable of committing their organisation to the plan agreed by the Team.

They will also represent other key stakeholders, in their domain, in the delivery of the Mission. Government members of teams need to be sufficiently senior to ensure that they can obtain support from other Government departments. Team members from particular research providers need to represent the views of the wider research community and secure their support.

This approach is a significant departure from the current approach taken to enabling innovation from RD&I interventions. Currently, representatives in each of the four strands of the quadruple helix develop their own National Strategy for a priority area (in many cases there are in fact multiple organisations, each with their own strategies within each strand). Individuals or organisations often seek to consult during their strategy development, but consultation is very different from genuine co-development. The net result is a confusing set of strategies competing for attention, legitimacy and resources. Culturally, New Zealanders will act in the national interest when they feel invested and engaged (we saw this with the `Team of 5 million' response to COVID-19); they will kick back if they feel that decisions are unreasonably imposed by an external party. Genuine co-development provides the mechanism to ensure investment and engagement from key stakeholders.

WHAT WOULD A MISSION LOOK LIKE?

A MISSION WILL NEED TO BE:

A priority

The Mission structure should be reserved for a small number of clearly recognisable national priorities. The key stakeholders needed to form the Mission Strategy Team should be willing to volunteer their time, despite the many other calls on them, because of the importance of the task. The priorities should have widespread public support and interest

Measurable and time bound

They should be framed like the US moon mission of the 1960s with a clear unambiguous and measurable impact target e.g., "a man to the moon and back" with a medium term time target, e.g., "by the end of this decade". The target should not be a general theme, e.g., "Better science together for a better start to life" nor should the target be hard to measure or explain, e.g., "Reverse the decline of Aotearoa New Zealand's biological heritage"

Of significant scale

The Mission should address priorities which impact on all 4 strands of the quadruple helix (Government, Industry, Māori and Research). It should involve the effort of multiple organisations

Existing Mechanism

A number of mechanisms have been used in the past, such as the National Science Challenges, to coordinate the science layer of the RD&I system. They were focused on ensuring that science organisations worked effectively with other science organisations. As already discussed, while this is a worthy pursuit, it is not addressing the primary opportunity of improving Aotearoa New Zealand's RD&I system, i.e., the flow of knowledge through the layers of the system. Instead it focuses on improving coordination across one layer of the system.

It is recommended that Missions replace the existing approaches as a very different mechanism to prioritise and drive vertical as well as horizontal alignment of effort to achieve national priorities.

EMPOWERING AND ENABLING INDUSTRY, MĀORI AND RESEARCH TO ACT

Getting alignment across the Government, Industry, Māori, and Research on Strategic Missions is essential, but not sufficient. For strategy to create positive change, it needs to be implemented. Implementation will occur when the key organisations required to do the heavy lifting are empowered and enabled to act.

To achieve this it is recommended that:

[R5] Domain leaders who are able to represent the key stakeholders in their domain are appointed to the Strategy Teams

[R6] Each of the key organisations needed to support Mission strategies is empowered and enabled to act rather than contracted into acting via funding mechanisms

Empowering Industry, Māori, and Research to act in support of the Mission strategies will require changes in how we think about leadership and in the way that some parts of the RD&I system are funded. In our current paradigm one party creates strategy and seeks to gain the support of the other parties through funding. In this new proposed model, strategy is co-developed by the key parties who will implement the strategy. The parties come as willing participants, prepared to commit the resources they control in order to achieve the strategy.

In order for Industry, Māori and Research to fully participate some changes are needed.

The Chicken and Egg problem for Industry

Aotearoa New Zealand has a small number of large and sophisticated companies and sectors who have invested in RD&I and have become world leaders in their fields. The scale and productivity they have achieved creates a virtuous cycle where they generate enough cash from their operations to invest in further RD&I and retain their leadership position. In contrast, the country has a number of small or emerging companies or sectors with the potential to be world leading if they could access relevant RD&I. Currently, in order to access knowledge relevant to their context they need levels of resources that only world leaders operating at scale can afford. Hence there is a "Chicken and Egg" problem – to be world leading they need to invest substantially in RD&I, but in order to invest substantially in RD&I they need to be world leading.

The Government has established grant mechanisms to help emerging companies improve their competitiveness, but these grants often require significant co-investment. Again, this favours the existing, large, successful players. One potential solution is to offer repayable grants more extensively. Under this approach, an emerging company or sector could secure funding to acquire the technology it needed to become globally competitive in the form of a grant, which converts to a loan when milestones are met.

It is recommended that:

[R7] Repayable grant mechanisms are expanded to support emerging sectors and companies in priority areas

Such a mechanism would enable and empower emerging companies and sectors to contribute to, participate in and benefit from successfully delivered Missions.

Changes to funding for Public Research Institutes

For Public Research Institutes to be genuinely at the table with Government, Industry and Māori, They need to be able make and deliver on commitments. Under the current funding system the CRIs have limited ability to make such commitments. The majority of CRI funding comes from a mix of contestable MBIE funding and commercial contracts. These tend to be piecemeal and sporadic, rather than strategic and consistent. There is only limited institutional funding and hence only limited empowerment.

It is recommended that:

[R8] MBIE increases the ratio of institutional funding to the PRIs to empower them and enable them to deliver on the commitments they make as part of the Mission Strategy Teams

Changes to Māori funding

Over the last few years there has been growing recognition of both the Treaty obligation to have Māori as co-designers of science strategy and also the real benefits it brings through access to mātauranga Māori. The increasing requests for Māori to support this type of work are placing heavy demands on the resources of individuals and organisations.

It is recommended that:

[R9] Government engage with Māori to understand the changes they require the Crown to make so that Māori are empowered to take a full partnership role in both the establishment of priorities and the development of Mission strategies

SIMPLIFYING STRUCTURES AND GOVERNANCE

The implementation of a new approach will often require new structures to be put in place and at the same time it may allow the removal of old structures which are no longer needed. Structure should follow strategy, so the starting place for any discussion of structures is the needs of the strategy. The key features of the strategy described in this document with implications for structure are:

1. The need for Aotearoa New Zealand to focus on the flow of knowledge from Research through to end users
2. The need for an agile and dynamic process to agree national priorities
3. The need to align, empower and enable all the players in the system.

This section of the report discusses the implications of each of these aspects on structure.

Focusing on flow of knowledge

A primary focus of this strategy is increasing the flow of knowledge from *Research*, though *Development* and *Innovation* into the hands of end users. To support this focus, PRI organisations should be structured around the end users they serve. Fortunately, this was the approach taken when the CRIs were implemented. The scope of each CRI was aligned to a set of end users. The CRI review in 2010 reinforced this design feature through the introduction of Statements of Core Purpose. In summary:

END USER	CRI
Forestry and Timber products	SCION
Agriculture	agresearch
Horticulture and plant-based foods and beverages	Plant & Food Research
Health	ESR
Justice	ESR
Oceans, fresh water, and climate	NIWA
Environment and conservation	Manaaki Whenua Landcare Research
Natural hazards and energy	GNS Science

Since the CRIs were established, much has changed in the economy and society. There are a number of new and emerging end users to be supported. Most of these new end users are easily aligned to specific CRIs.

NEW OR EMERGING END USER	CRI
Bio-materials and the circular economy	SCION
AgriTech	agresearch
HortTech	Plant & Food Research
Geothermal and hydrogen-based energy	GNS Science
Space, big data analytics and AI	NIWA
Plant-based foods	Plant & Food Research
Community and hapū-based environmental action	Manaaki Whenua Landcare Research
Digital forensics and genomics	ESR

There are some new or emerging end users who are not well aligned to the CRIs

- Fintech
- Digitech (gaming, graphics and media)
- The social sector

In conclusion, the fundamental design of the CRI component of the RD&I system remains sound, with each CRI orientated to a set of end users and a structure that is well-aligned with strategy.

It is recommended that:

[R10] The RD&I Council review the alignment of PRIs with end users to ensure that major end user groups have a simple and clear alignment to a single PRI – this may involve the creation of a new PRI if there is a significant gap

Prioritisation of effort and alignment of stakeholders behind priorities

In order to create a dynamic and agile approach to identifying National Priorities it is recommended that a RD&I Council (see recommendation R1 above) be established. Once agreed the Council will establish Priority Area Strategy Teams to co-develop a strategy for the area and ensure that all the key stakeholders have committed to that strategy. As they will not be allocating funding, these teams will be coalitions of the willing, rather than legal entities.

With this approach in place, the need for a number of the existing mechanisms will diminish.

It is recommended that:

[R11] Existing collaboration mechanisms are reviewed and where possible removed in order to both save cost and increase the focus on the new Mission approach

COLLABORATION

Collaboration within the Research layer is already a strength of the Aotearoa New Zealand RD&I system. CRIs collaborate extensively with each other, and all New Zealand's universities, through jointly authored papers, collaborative bids, student supervision and mentoring, and via joint graduate schools, joint research institutes, Centres of Research Excellence, and specialised programmes. In fact, CRIs typically co-supervise upwards of 500 Masters and PhD students each year to support the development of the next generation of the nation's science capability. CRIs also commission about $20M of research from the universities each year. This level of collaboration must be maintained.

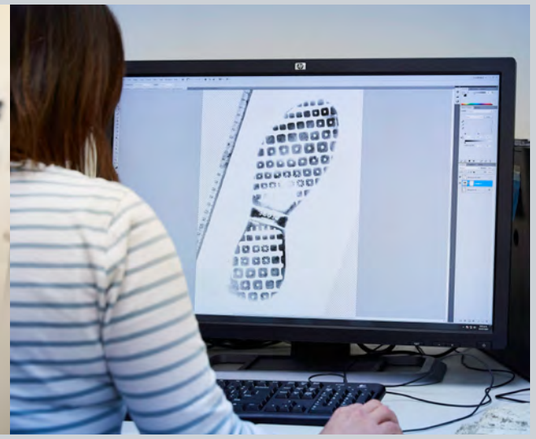
To lift impact we need to increase the breadth of collaboration between the layers of the RD&I system. Ensuring meaningful engagement between Māori and CRIs is a priority, underpinned by the Crown-Māori relationship. Individually and collectively, CRIs have links with numerous Māori entities – whānau, hapū, iwi, and Māori businesses, land-owning incorporations, etc. These include long-established extensive networks and engagement with Māori communities on local Māori needs. CRIs value the contribution mātauranga Māori makes to knowledge generation and its application in Aotearoa New Zealand. We need to build on this foundation to ensure that Māori are genuine partners, jointly setting the priorities and co-developing and co-delivering the Missions.

The same is true for Industry and Government end users. We need to expand our thinking beyond collaboration between Research organisations to include all four parts of the quadruple helix. This could be aided by increased co-location but again we need to think beyond co-location of Research organisations.

Silicon Valley is successful not because all the research organisations are on the same campus (because they are not), but because of the number of research, development and innovation organisations within a part of a city. Co-location of research organisations within a building or campus maybe helpful, but not critical. Co-location with end users would bring bigger gains to the RD&I system.

It is recommended that:

[R12] Discussion on co-location of research organisations be broadened to include all 4 strands of the quadruple helix and all 3 layers of the RD&I system



ROADMAP FOR CHANGE

This roadmap is designed to achieve, within a decade, a set of ambitious targets for a more impactful RD&I system:

- **Agreed National Priorities framed as time-bound missions**
- **Clear Strategies to achieve these priorities**
- **Aligned and committed stakeholders from Government, Industry, Māori and Research working together effectively to deliver these strategies**
- **Improved flow of knowledge from knowledge creators through to users through all 3 key channels**
- **Lifts in productivity, patenting at globally competitive levels, and a thriving set of deep technology start-up companies**
- **Achievement of key economic, environmental, social and cultural goals.**

SUMMARY OF RECOMMENDATIONS FOR DISCUSSION

In order to reach these targets the following changes need to be made:

[R1]
An RD&I Council establishes a small number of high-level priorities (or Missions) for Aotearoa New Zealand that science can contribute to

[R2]
Each Mission has a clearly identified impact target and a defined timeframe for its achievement, e.g., reduce methane emissions by X% within X years

[R3]
For each Mission a National Science Strategy is developed by a four-way coalition of Industry, Government, Māori and Research.

[R4]
Missions replace existing mechanisms to drive vertical as well as horizontal alignment of effort to achieve national priorities

[R5]
Domain leaders who are able to represent the key stakeholders in their domain are appointed to the Strategy Teams

[R6]
Each of the key organisations needed to support Mission strategies is empowered and enabled to act rather than contracted into acting via funding mechanisms

[R7]
Repayable grant mechanisms are expanded to support emerging sectors and companies in priority areas

[R8]
MBIE increases the level of institutional funding to the PRIs to empower them and enable them to deliver on the commitments they make as part of the Mission Strategy Teams

[R9]
Government engage with Māori to understand the changes they require the Crown to make so that Māori are empowered to take a full partnership role in both the establishment of priorities and the development of Mission strategies

[R10]
The RD&I Council review the alignment of PRIs with end users to ensure that major end user groups have a simple and clear alignment to a single PRI – this may involve the creation of a new PRI if there is a significant gap

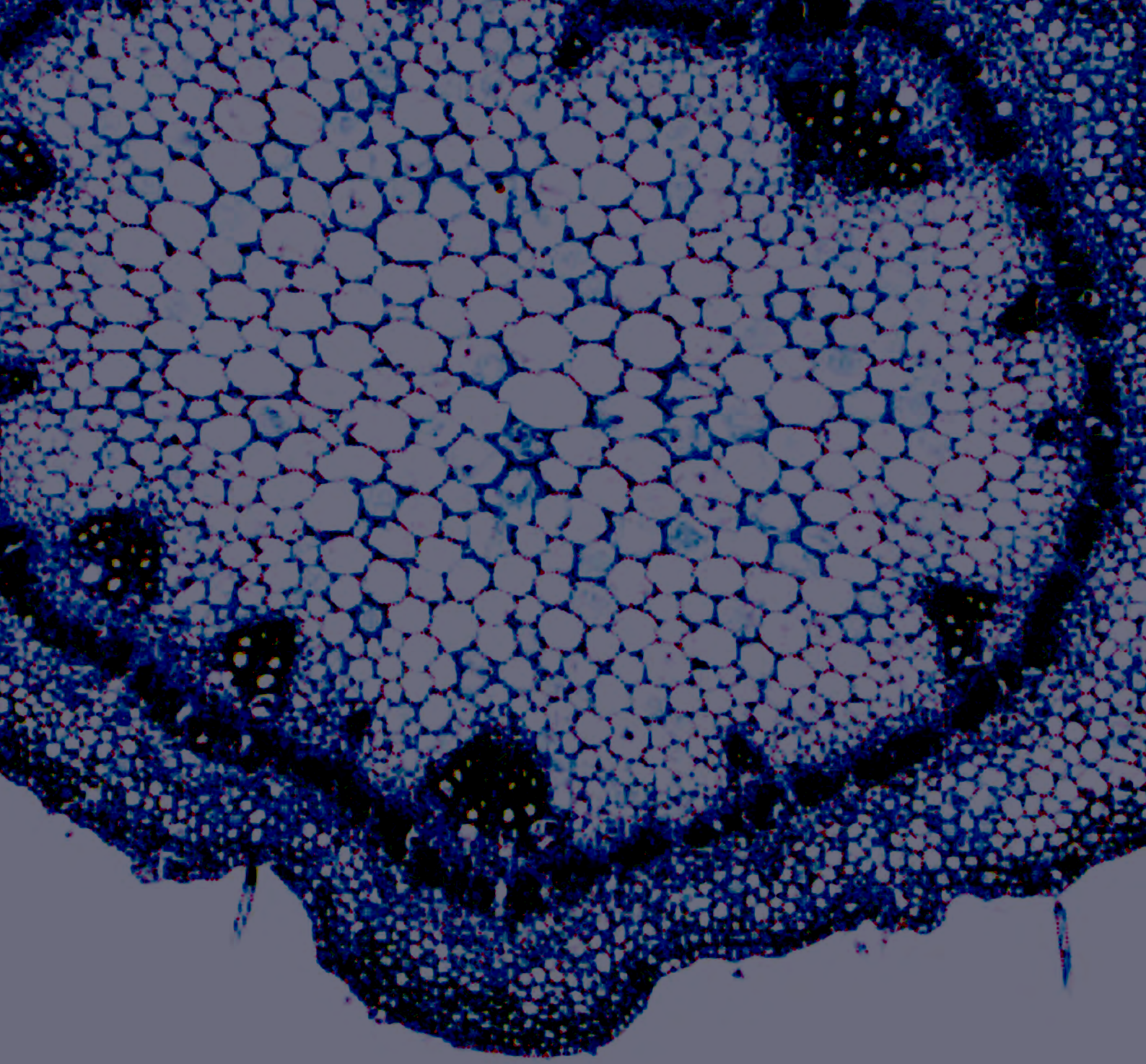
[R11]
Existing collaboration mechanisms are reviewed and where possible removed in order to both save cost and increase the focus on the new Mission approach

[R12]
Discussion on co-location of research organisations be broadened to include all 4 strands of the quadruple helix and all 3 layers of the RD&I system

ROADMAP FOR CHANGE

To support the adoption of these changes we have created a suggested roadmap of actions to illustrate a potential sequencing of actions and a possible timeline for the changes

	CHANGE	ACTION	WHEN	LED BY
1.	The Government work with leaders from Māori, Industry and Resarch to establish an RD&I Council that develops a small number of high-level priorities (or Missions) for Aotearoa New Zealand	The Government consults with Māori, Industry and Research about this roadmap and the establishment of a RD&I Council	February 2022	The Minister of Science
		An RD&I Council is established comprising Government, Industry, Māori, and Research	March 2022	The Minister of Science
		The Council agrees an initial set of priorities with the Minister	June 2022	The Chair of the RD&I Council
2.	Each Mission has a clearly identified impact target and a defined timeframe for its achievement, e.g., reduce methane emissions by x% within X years	The Council appoints a leader and team for each of the Missions	September 2022	The Chair of the RD&I Council
		The Council agrees the Mission definitions with the Mission leaders	October 2022	The Chair of the RD&I Council
3.	For each Mission a National Science Strategy is developed by a four-way coalition of Industry, Government, Research and Māori	The Mission teams co-design a Mission strategy	February 2023	Mission leaders
		The Mission teams develop a science and technology roadmap for the Mission	September 2023	Science leader on each mission
4.	Missions replace existing mechanisms to drive vertical as well as horizontal alignment of effort to achieve national priorities	The RD&I Council reviews the existing coordination mechanisms and recommends changes to the Minister	February 2023	The Chair of the RD&I Council
		Financial implications of changes are incorporated into the 2024 budget process	September 2023	MBIE
5.	Domain leaders who are able to represent the key stakeholders in their domain are appointed to the Strategy Teams	See 2 above		
6.	Each of the key organisations needed to support Mission strategies is empowered and enabled to act rather than contracted into acting via funding mechanisms	See below		
7.	Repayable grant mechanisms are expanded to support emerging sectors and companies in priority areas	The Council identifies the key repayable granting mechanisms needed	March 2023	The Chair of the RD&I Council
		The Government representative(s) on the Council works across Government departments to design the required mechanisms	June 2023	The Government representative(s) on the Council
		Financial implications of changes are incorporated into the 2024 budget process	September 2023	Government departments
8.	MBIE increases the level of institutional funding to the PRIs to empower them and enable them to deliver on the commitments they make as part of the Mission Strategy Teams	The Council identifies the key institutional funding mechanisms needed	March 2023	The Chair of the RD&I Council
		The Government representative(s) on the Council works with MBIE to design the required mechanisms	June 2023	The Government representative(s) on the Council
		The Financial implications of the changes are incorporated into the 2024 budget process	September 2023	MBIE
9.	Government engage with Māori to understand the changes they require the Crown to make so that Māori are empowered to take a full partnership role in both the establishment of priorities and the development of Mission strategies	The Council works with Māori to identify the support needed to allow them to fully engage with the missions	March 2023	The Māori representative(s) on the Council
		The Government representative(s) on the Council works across Government departments to design required support mechanisms	June 2023	The Government representative(s) on the Council
		The Financial implications of the changes are incorporated into the 2024 budget process	September 2023	Government departments
10.	The RD&I Council review the alignment of PRIs with end users to ensure that major end user groups have a simple and clear alignment to a single PRI – this may involve the creation of a new PRI if there is a significant gap	The Council reviews the alignment of PRIs after the current change process is completed	Timing of the change process is unclear at this time	The Chair of the RD&I Council
11.	That existing collaboration mechanisms are reviewed and where possible removed in order to both save cost and increase the focus on the new Mission approach	The Council and MBIE review existing collaboration mechanisms	June 2023	The Chair of the RD&I Council
		MBIE discontinue those mechanisms which are no longer needed and incorporate the financial implications of these changes into the 2024 budget process	September 2023	
12.	Discussion on co-location of research organisations be broadened to include all 4 strands of the quadruple helix and all 3 layers of the RD&I system	The terms of the current MBIE RSI and capital project are broadened	Immediately	MBIE



Science New Zealand

agresearch
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