Te Ara Paerangi

FUTURE PATHWAYS GREEN PAPER 2021

Submission by

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with New Zealand-specific annotations by Anne French, Anne French Consulting Ltd

Introduction

This submission is based in part on my experience in the design and use of research ecosystems as used in the UK, EU, USA, Australia as well as in New Zealand. [I took part in two reviews of the then Industrial Research Limited, on my own on its 10th anniversary and subsequently with Dr Carnaby and Dr Austin as a part of the wholesale review prior to the formation of Callaghan Innovation. I was a personal friend of Paul Callaghan, with whom I discussed many of these issues.] During 2003-5, I was the Cambridge Executive Director of the Cambridge MIT Institute (CMI), an initiative of the then Chancellor of the Exchequer, later Prime Minister, Gordon Brown. CMI had as its mission statement to improve the UK economy in terms of competitiveness productivity, entrepreneurship. CMI was empowered to experiment with new systems of engaging researchers with the needs of wider UK economy, and the results of these experiments are of particular relevance, mutatis mutandis, to New Zealand.

The New Zealand Research Ecosystem, of which I have first-hand experience, is good in places, but not all places. The CoREs have been successful and grown strongly into their wider mission of undertaking and promulgating research and bringing new trained talent the workforce. By contrast the National Science Challenges bypassed many of the processes of quality control with public opinion settling the balance without prior information on which to consider issues in the round – a the rush to funding short-circuited strategic planning to a woeful degree.

I want to stress two key points among all the others in this submission.

The first is the importance of getting a **systematic dialogue** going between the members of the research community in New Zealand and the people who will subsequently take up the outcomes of the research and seek to exploit them for the total good of New Zealand, economically, healthwise and environmentally. At present we have a mismatch – researchers thrusting already prepared proposals in from of potential end-users asking for their support, and end-users finding it difficult to navigate arcane systems within universities and government laboratories to find the right people tuned to their needs. If the current review achieves only one thing, namely the practical elimination of this mismatch, the research ecosystem in New Zealand will be significantly improved.

The second point is where in New Zealand **patient capital** resides; where are the long-term investments today which belonged to the DSIR several decades ago. The earthquake base isolator technology was not an overnight wonder, but the result of a decade-long R&D project that delivered the final product. So too, the acoustic instrument for assaying live trees for their useful timber content was a second-generation device developed from an original that had been developed for

assaying tree logs after being felled. The current New Zealand system could not harbour those developments today.

Also, I will have nothing explicit on issues dealing with mātauranga Māori, as I have not had any direct experience of operating within a system which has specifically ethnicity outcomes as measures of research success. My emphasis here is on internationally leading research without ethnic overtones.

The structure of this submission is in four parts;

1. Systematic dialogue between researchers and end users
2. Patient Capital
3. A set of answers to the questions posed in the Green Paper, and
4. A set of general closing comments.

1 Systematic Dialogue

Imagine a call for research in some general area of importance to the future of the New Zealand economy. Over recent decades, the researchers would develop their consortium and their research aims, and, at the last days before the submission date, present a fully formed proposal to potential end-users to indicate their support, on a take-it-or-leave-it basis. Any subtleties from the end-users that in principle could greatly enhance the eventual impact on New Zealand's future do not get a look-in.

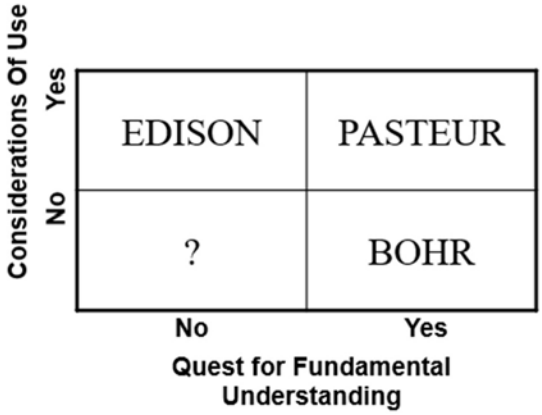
Now, imagine if the previous years had included biannual meetings of the researchers and their end-user communities working up a roadmap for the relevant sector in New Zealand, an indication as to where the sector wants to be in 5, 10, and 15 years' time. Such a roadmap would be based on what the sector was capable of delivering on what scale and by when, and buttressed by the R&D project outlines that would feed innovations into the sector. This roadmap would be a living document. In this scenario, a future call would immediately precipitate a meeting of key researchers and end-users to flesh out a joint proposal drawing heavily on the roadmap. The familiarity engendered by the sector meetings would greatly enhance the efficiency in which a seamless proposal could be prepared with fully signed up participants. That is the future vision for effective research in New Zealand. One great advantage in New Zealand is that joint academic/end-user support in many of the technical cases could eb supported within the remit of MBIE. It would be more difficult, but not impossible if other government departments held the research funds (as in healthcare or the environment).

I step back to point out how important this end-user/researcher interface is in the national ecosystem, by reference to a fundamental question, 'Why does a nation undertake research?' Thirty or more years ago, this question would have had a one-word answer: 'discovery'. Vannevar Bush, the Presidential Science Advisor to President Truman after WWII, wrote a report called *Science, the endless frontier* in which he envisaged a system in the USA where new ideas were invented in universities who 'threw them over the fence' to whomever might want them. Happenstance would play a dominating role, as the universities had no obligation to exploit their findings. A few enterprising faculty sometimes took initiatives, given that the best-quality research in electronics was actually being done in the industrial laboratories of the Bell Telephone, Company, IBM etc. Bush's report was influential in the establishment of the National Science Foundation, having made the argument for greater government support for science.

During the 1980s, the actual value-for-money of the level of internal R&D, and especially the level of R, came under sustained scrutiny. We have the case now that the industrial labs have shrunk in size and narrowed in focus to next-generation product development. Breakthrough and frontier research is now done at universities.

Apple is a great example of success in capturing the outcomes of publicly-funded research and exploiting them for private gain. The system justification of this situation is predicated on Apple doing most of its subsequent manufacture in the USA where the local taxes on the company and the federal taxes paid by corporations and individual taxpayers recirculates the initial investment many times over. When Apple and others offshore their manufacture to low labour-cost locations the system breaks down, as was noted frequently in the previous US administration.

The current thinking is exemplified with reference to Pasteur's Quadrant. There are now two reasons for undertaking research at a national level, (i) the quest for fundamental understanding (discovery) and (ii) the consideration of use. The following table has names that exemplify the types of research:



Niels Bohr researched the atom in great detail, but displayed no interest in applying his new-found knowledge to problems in materials science. Thomas Edison tried 800 different materials in search for a filament that would lighten the darkness better than a candle, without any interest in the other fundamental properties of the materials. Louis Pasteur was motivated to understand the microbes which he had discovered under a microscope so as to figure their role in causing sicknesses in Paris caused by impure milk, water, or beer.

The key issue for planners of a national innovation system is this: how to distribute scare funds between supporting work of present-day Bohrs, Edisons, and Pasteurs? At CMI, we asked a number of senior industrialists who split the funds between the Edisons and the Pasteurs, while Vice-Chancellors split the funds between the Bohrs and the Pasteurs. The CMI view was a split 10% to Bohr, 30% to Edison, and 60% to Pasteur. In this case, 70% are doing basic research and 90% are doing applicable research.

Finally, it would be salutary to undertake an exercise to see how much of New Zealand's publicly funded research fits into the fourth (?) quadrant.

How can the national research ecosystem enhance the interface between the research and the end-user? One of the most successful programmes in the US is the Small Business Innovation Research (SBIR). End-users put out a call for their next-generation product, and small companies (including university spin-outs) bid to undertake the R&D to deliver a prototype. The output of any project in

such a programme is a prototype in the hands of an already eager end-user, and not just a report collecting dust on a shelf or occupying a few MB in a repository.

The Cambridge-MIT Institute (2000-2006) pioneered a system of systematic dialogue at this interface. When the banking sector met with the academic IT specialists on the future of banking, banks put trust at the very top of their agenda – would the new IT systems be trustworthy? That put a whole new focus in front of the academics. When the supermarket chains met together to work out how their whole sector would benefit from academic research, the key issue was streamlining supply chains and making them more resilient to the very shocks they are being subject to as this paper is being written. When the pharmaceutical sector met with the academics, the degree to which new drugs could be devised more effectively using computer simulations than trial and error in vitro, and the extent to which artificial tissue and ligaments could be used to accelerate clinical trials was the emerging theme.

The most successful actual project of the CMI was the Silent Aircraft Initiative, where the tight links between Cambridge University and Rolls Royce on aeroengines were put together with the MIT-Boeing joint research on airframes. £3M over three years came up with the design to replace the Boeing 737 commuter jet, with 97% of the sound energy removed from the aircraft as it came into land. Senior executives from both Boeing and Rolls Royce attended review meetings, not just to hear of project progress, but to have corridor discussions with their counterparts on closer to the day issues. To these four core groups were added the National Air Traffic Controllers, to know what was coming, regional airports, passenger and freight airlines, and specialists in environmental law. A parallel study of the economic impact of noise showed that the revaluation of land around Heathrow Airport running only silent aircraft was much greater than the cost of development of the new aircraft, so local bodies would have an incentive to regulate for future silent aircraft. The outcomes from within this 'Knowledge Integration Community' were much greater than the mere engineering details of the new airframe and engine.

I would strongly urge a set of four-six pilot programmes to show what systematic dialogue could achieve in New Zealand, leaving the way open for an expansion of the programme if success warrants it. Without being prescriptive, one could ask about the future of high-performance radio links in New Zealand, involving several engineering schools and IT departments with Tate Electronics, Gallagher, and end-users in the agricultural, security, healthcare and other sectors producing a debated and agreed roadmap. The process begins with the end-users setting out their vision and seeking the support of the researchers to achieve that vision, i.e. a complete 180° shift from what happens now. A professional facilitator would be needed at the first three meetings to keep them on task. Similar meetings could be organised around, for instance, (i) the use of rare and high-value natural products, (ii) underpinning indigenous knowledge and practice with robust science and technology, (iii) the reduction and elimination of landslips, (iv) improved childcare from 0-10 years.

The Achilles heel of this proposal would be the unwillingness of end-users to get engaged. I have had direct experience of this, when on one occasion I met with the Employers and Manufacturers Association in Christchurch who wanted the then IRL broken up and the money given to the Association to invest in their members' pet projects which were nearly always very short-term and solvable by a consultant rather than a researcher. This would have been an entirely retrograde step.

Young people go into research after many years of study and their expertise is not turned off and on at a moment's notice: research careers do evolve, but not overnight. We don't expect accountants and anaesthetists to swap places in a day. The idea of jobbing researchers as opposed to jobbing

consultants is a nonsense: by their nature, researchers answer previously unanswered questions, and that takes time, while consultants look around for answers from elsewhere.

The MacDiarmid Institute (full disclosure: I was on the international advisory board from 2003-16) has developed an outreach activity to end-users, as well as to incoming scientists. Imagine if the next time there is a call for Centres of Research Excellence, or its near equivalent, the bids had been preceded by two years of systematic dialogue where the top priorities of the end users were put first. Note: this does not exclude the favourite projects of individual researchers, but they must have sold the ideas to the end-user community as being worth pursuing. One would expect a much higher-quality proposal with the linkages to eventual exploitation already worked out. I would offer, if asked, to write a think piece on the MacDiarmid Institute, which I consider is an international exemplar of carrying out materials physics and engineering research in a small country. It took some effort by the steering committee and the international panel to get the delivery work up and running, but most of us are pleased at the outcome of continued funding while still putting pressure on to improve.

2 Patient Capital

There are many hoops and hurdles to be got through and over between a eureka moment in the laboratory and a successful new commercial product on the market. The current New Zealand research ecosystem has a key missing element for many possible innovations. Where does the patient capital reside? Two examples, both particularly germane to New Zealand, are the earthquake base isolators for buildings and the acoustic assaying of live trees. In both cases the DSIR and IRL supported these projects for over a decade between the commissioning of initial research until a fully authentic solution was on the market. At any point in time the management of IRL could be subject to pressures that such long-term projects were terminated or finished with the departure of key individuals. I remember reviewing a project on high-temperature materials for the geothermal energy sector, playing into New Zealand's local geothermal resource. What happened to that, and was the New Zealand geothermal industry consulted about the impending closure?

Of all my international experience, the most crazy policy decision I have seen was made as the result of someone in Treasury in Wellington asking whether the CRIs were value for their research money compared with universities. Both tranches of money were put together and bid for competitively with science stretch as the key measure of quality. An Auckland academic could bid, at no risk, to develop third-generation chromophores for the Korean display industry, and hire a post-doc to do the work if he were successful. The leader of an IRL team on computer vision, with 60 years of research experience in his team which had already automated the first cut of a knife to the brisket in an abattoir, and had successfully removed the flesh from flax leaving just the fibre, bid to automate the opening of oysters using their computer vision system (this at a time when there was a labour shortage). In the funding round, the academic got the money and the IRL team were declined on the lack of science stretch over their previous projects! They were offered funding to transition out of R&D! [I told the leader to take the money and run to the private sector, and make sure they treble-charged the public sector if they were ever called in in a future emergency.] This is precisely the short-changing of patient capital that has held New Zealand back.

These examples can be multiplied in every funding round since.

Most recently, the National Science Challenges were a mistake. Public wishes were translated into programme titles and offered out to researchers in the absence of any form of roadmapping. The fact that only one of a dozen Challenges had any direct relation to New Zealand's economic

prosperity was a categorical error. Here again there was no sight of any patient commitment over decades if needed.

One thing this review must accomplish is the re-establishment of a place where highly specific New Zealand technologies can be incubated. The entry hurdle can be high, but some security is essential to get a radical technology through the valley of death. Harking back to my point on end-user inspiration of research, the outcome of a systematic dialogue may well be a wish-list of breakthrough technologies, highly specific to New Zealand conditions.

3 Answers (in regular type) to your 17 specific questions (in italics)

These answers are brief and to the point with some reference back to the prior sections.

1 What principles could be used to determine the scope and focus of national research priorities?

All research money commitments should be able to answer the question: 'how will New Zealand be a better place in 10-20 years if this research succeeds'? The improvement may refer to the economy, the environment, the nation's health, social cohesion, etc.

2 What principles should guide a national research priority-setting process? How can the process best give effect to Te Tiriti?

Benefit to New Zealand, excellence, and value-for-money against competing calls on the resources. No comment on Te Tiriti.

3 How should the strategy for each national research priority be set and how do we operationalise them?

A community of end-users, other impacted parties, and researchers should meet to produce an agreed roadmap, an evolving document as discussed above, against which detailed strategy can be benchmarked.

4 How would you like to be engaged?

I [MK] am willing to come and take part in the processes by which systematic dialogue leading to sector roadmaps can be established. I have other colleagues who could also help. I mentioned other examples of potential assistance in some answers below.

5 What are your thoughts on how to enable and protect mātauranga Māori in the research system?

I have no specific expertise or experience for answering this question.

6 What are your thoughts on regionally based Māori knowledge hubs?

I have no direct expertise or experience for answering this question. However, my comments above on working with end users to develop a research roadmap are relevant.

7 How should we decide what constitutes a core function and how do we fund them?

The existence of a national roadmap in a given sector which spells out what R&D is agreed to be needed should be a core function upstream of every major strategic funding bid.

8 Do you think a base grant funding model will improve stability and resilience for research organisations, and how should we go about designing and implementing such a funding model?

The Bohr quadrant of the earlier figure may as well be funded out of a base grant, but there will be a high barrier of risk/reward required to secure funding in this model. In addition, the idea of a 'well-found laboratory' as the source of bids to undertake competitive research could call on such funds, e.g. for materials diagnostics, software systems and other equipment that should not need to be itemised on more specific grants.

9 How do we design collaborative, adaptive and agile research institutions that will serve current and future needs?

In universities, a group of senior researchers, who swear to be impartial, should be supported by administrative support to ensure that the university is well linked into road-mapping exercises and prepares light-touch bid scenarios in advance of future calls, so that preparation of integrated bids can start quickly and effectively when the call is made. CRIs have a mandate to create national benefit, and consequently are better connected to their end users, having developed relationships with them over 30 years. But they too should be encouraged to update their roadmaps in preparation for future funding calls.

10 How can institutions be designed to better support capability, skills, and workforce development?

The is a whole book on this exercise for universities: *Universities as Engines of Economic Development: Making Knowledge Exchange Work*, Edward Crawley, John Hegarty, Kristina Edström and Juan Cristobal Garcia Sanchez, Springer © 2020. The book contains over 100 case studies of a total of 20 sets of practices, all tried and tested, and many of which I [MK] had a personal involvement in.

In respect of other research institutions, many of the lessons carry over.

11 How should we make decisions on large property and capital investments under a more coordinated approach?

Strategic infrastructure investment has suffered under the New Zealand competitive funding model. There are several UK success stories in this area, including the Joint Infrastructure Fund (1998) in which I [MK] led a successful bid for nearly £5M for half the cost of an Advanced Technology Institute at the University of Surrey. (There were subsequent rounds into which I did not bid.) I can offer a specific paper if asked. However, a national strategic exercise would reveal infrastructure gaps; and the funding decisions should be based on robust business cases.

The full-cost funding of research proposals has not resulted in the overhead component being ploughed back into research infrastructure. Instead, it has created a windfall that has supported universities' bottom lines. If a national research infrastructure fund is contemplated, New Zealand's idiosyncratic policy of full-cost funding should first be reviewed.

12 How do we design Tiriti-enabled institutions?

I have no direct expertise or experience for answering this question.

13 How do we better support knowledge exchange and impact generation? What should be the role of research institutions in transferring knowledge into operational environments and technologies?

See my answer to Question 10.

14 How should we include workforce considerations in the design of national research priorities?

This is a very tricky question. If a Royal Society of London can get 400 people to a climate science meeting but only 10% of that to a meeting on manufacturing technology, I suggest something is wrong! I [MK] would like to be engaged at some level if there is more work commissioned on this topic.

15 What impact would a base grant have on the research workforce?

Very modest, if my interpretation to the answer to Question 8 holds. The UK provides a negative example. The money for research students at the PhD level has been taken away from specific grants, and given as quotas to the Heads of Departments. Internal haggling now takes place, and there is no guarantee that one will get a PhD associated with a grant. Only post-docs are funded on grants now. I think this is retrograde in the UK, and such an approach would be even worse for New Zealand. But New Zealand's CRIs have had experience of using core funding to retain and develop key staff, and would argue that it is an essential component of maintaining an agile and responsive research system.

16 How do we design new funding mechanisms that strongly focus on workforce outcomes?

The 'Knowledge Integration Community' model that CMI pioneered (further details from me in the book cited above in Question 10) gave ample opportunity for end-users to see researchers and vice-versa, resulting in smooth transitions in many cases. What was asked during the bid was not just a research programme but a delivery programme as well.

In New Zealand, it is evident that we need new mechanisms to encourage the employment of researchers by industry. In some sectors, such as engineering, this already works well, but in many others it is hard for researchers to find work in industry and challenging for firms to afford them. Likewise, companies can become so focused on the near-term work they do for customers that they lose track of international technology and research directions and long-term trends. Two-way secondments and joint appointments would break down the barriers between research and industry, improve researchers' understanding of industrial needs, and feed usefully into the roadmapping and priority setting process.

17 How do we support sustainable, efficient and enabling investment in research infrastructure?

The CoRE model is of the highest rank internationally: sustained but regularly reviewed and refreshed. The NSC model has been wasteful and damaging. It is in the national interest for it not to be repeated.