

Science for Technological Innovation

Second Tranche Forward Strategy

(2019-2024)



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1. Overview of Progress

The Science for Technological Innovation (SfTI) Challenge's objective is to...

Enhance the capacity of New Zealand to use physical sciences and engineering for economic growth.

SfTI's capacity model is three-fold: technical, human and relational. We have a portfolio of processes to support all three capacity development needs in our community of 200+ researchers with exceptional progress made on all dimensions. SfTI:

- supports excellent 'stretchy' (5-10 year out) and 'sticky to NZ' science;
- insists researchers extend their leadership and commercialisation skills (Note: over 75% of SfTI researchers have engaged in these opportunities);
- exposes our community to relational development experiences with numerous stakeholder industry and Māori partners, the latter being a new rewarding engagement for most of our community.

And SfTI's strategy has evolved by... flipping how we develop large projects from being largely investigator-led, to a facilitated 'Mission-Lab' process with industry and Māori thought leaders. We see this innovative process as a key additionality of SfTI. Out of the Mission Labs emerge future high-level mission ideas which form the basis for subsequent calls for Expressions of Interest from researchers to bring capability to the table. Then, through a negotiated process, with industry and Māori still in the room, a multi-disciplinary proposal is formed. We have already seen this in action with the 2017 Lab generating missions including 'intelligent oceans', 'flexible robots' and 'digital marae' that have evolved into new Spearhead projects: 'Precision Farming Technology for Aquaculture', 'Adaptive Learning Robots to Complement the Human Workforce', and 'Ātea' (virtual marae).

We are particularly proud of... the progress SfTI has made towards our missions (in addition to the Mission Labs), including:

- our Kāhui Māori's development of a SfTI VM approach, its socialisation through our community, and integration into research where possible;
- lab-trials for needle-free diabetes treatment and relationships with entrepreneurial medics;
- 4D printing of biomaterials (3D materials that alter when exposed to heat, light or touch);
- advances in sensing of small signals of groundwater flow and completion of a lab model;
- a co-innovation project with Parininihi ki Waitotara Māori Trust using advanced textual learning techniques to decipher ambiguous stakeholder records, with potential application to Māori Land Court records;
- unique insights into best practice in relational capacity through Building NZ's Innovation Capacity (BNZIC) team, particularly regarding collaborative innovation with Māori;
- a ballot process for Seed project selection; this marks projects as having made SfTI's quality grade, but acknowledges a limited funding pool (we have been able to go back to some of those that missed out on the ballot as funding has freed up from other sources);
- progress of our intentionally risky Seed projects that are mentored, nurtured and monitored - against compulsory quantifiable critical steps and milestones - by our Theme leaders;
- more emerging researchers recruited through targeted Seed and open Spearhead processes;
- several SfTI Seed projects that have graduated towards commercialisation with support and encouragement (with 'finished' researchers remaining part of the SfTI community);
- a Capacity Development programme with pipeline commercialisation partners, KiwiNet and Return on Science (RoS), and customised approaches for our community learning;
- an international Science Quality Review (SQR) which reassured us SfTI is on the right track.

SfTI has not struck many difficulties except... an intent to introduce a 'fast fail' approach as part of successful research: that is, to stop or pivot projects when they hit a dead-end or are no longer aligned with SfTI's mission. This is probably better phrased as a 'slow let down' of such projects, as we push researchers and their organizations to consider early termination or change. The dearth of Māori researchers in physical sciences and engineering is a constant challenge. Some of our projects have experienced delayed starts due to difficulties recruiting suitable PhD students and/or post-doctoral researchers – an issue throughout the NZ innovation system. We are looking at ways to mitigate this in the second Tranche whereby once we have approved the project, searching can start, as opposed to the current system which waits until the contract has been signed and sealed.

The main strategic trade-offs have arisen because.... SfTI's themes have an incredibly broad scope. As we see ourselves as the 'tech for' Challenge and agnostic to which sector our work applies, we have had to make choices about our missions. We believe we have struck a good balance with our ~1:3 ratio of Spearhead (~\$1mpa) and Seed (~\$100kpa) projects. In some areas we are beginning to run up against the small scale of capability available in New Zealand, especially in artificial intelligence, virtual Reality, blockchain, space and robotics. SfTI cannot hire directly so we will discuss these capability needs with our research partners e.g. through new strategic appointments.

We have innovated a negotiated approach to building collaborative teams... through our negotiated, mission-led approach we believe we are in the 'sweet spot' of the original intentions for National Science Challenges. Contestability remains through calls to bring capability to the collaborative teams, as well as the Seed project process. Evidence that both are being appreciated by stakeholders is affirmed in the Colmar Brunton interview results. In fact, we now have industry contacting SfTI leaders to join our Spearhead Industry Advisory Groups, usually quite unheard of with busy industry people. The Seed project leaders, especially emerging leaders, are almost unanimous in appreciating the mentoring by Theme leaders. That a senior academic is regularly contacting and visiting them, we think, has resulted in quicker progress than might normally be the case. In addition to project level collaborations, we host an annual 'all of SfTI' researcher workshop, which is devoted to Capacity Development activities, and enables the whole community to mingle, and more importantly connect intellectually. We are already seeing research ideas spinning out between current projects as a result, and between projects in SfTI and other Challenges from wider conversations. To enhance these serendipitous connections, SfTI intends to introduce funding for internal and external cross-over collaborative projects in the second tranche.

This approach embraces early stakeholder co-design with industry/Māori partners, while ensuring bolder new science stretch... and we are reaping the benefits of bringing stakeholders into our Spearhead formation process earlier than is typical in NZ's science system. While researchers are always nervous of creating expectations through early engagement, which they may not be able to deliver on, this 'mid-stream' engagement means we don't view these contributors as merely end-users, but rather, as partners in our innovation process. (Traditional technology transfer from research to industry would be 'down-stream' engagement.) We are using our own and our partners' networks to gradually extend SfTI's reach to new industry and Māori leaders who would bring wisdom to SfTI. Our SfTI partner FoMA, Taumata project advisers and individual iwi/hapū/Trust and Māori businesses are so important to knowledge generation in our projects, that we are increasingly seeing them as co-researchers with the relationship being one of genuine sharing and co-generation of mātauranga. SfTI teams are investing the time and commitment in the kaupapa and tikanga of these relationships - still a new world for most physical scientists and engineers. We have several well respected Kaiārahi (navigators) who are crucial to championing SfTI in relevant Māori communities. We are working with young social tech entrepreneurs to ensure the youth world view is included in our new Missions.

We ensure science quality through... a two-level process. Firstly, we have been strict in instituting critical steps and fixed milestones, progress against which is regularly monitored and reported to the SfTI Board. Often there are understandable delays. If the milestones are missed and there are no

genuine mitigation options, we issue a change notice to the main contract holder. We then enter a negotiation, following due process (e.g. bringing in external reviewers) in good faith to instigate a pivot, or stop, of the research, and reallocate the funding to other, higher potential projects. Second, regularising a thorough international Science Quality Review, first held in October 2017, is the high-level approach. It provides an independent overview of the 'stretchy' value of our research against international benchmarks, and its alignment with SftI's 'sticky to NZ' mission. The research teams have been given the opportunity to articulate how they are responding to the recommendations. In a very few cases, major adjustments are needed, and we are working through a process with the Board and institutional hosts of the teams to resolve these appropriately.

Impact is multi-dimensional... as we are after technological and behavioural change in our research community and benefit for New Zealand. While many may think technological change is the hardest, in fact behavioural change takes longer and with more adjustment from the status quo for participants. We are experimenting not only in research but also with processes, with regular feedback from our BNZIC team. The SftI view is that we have been delegated the responsibility, with our partners, to try new things that will add value/additionality to the technological ecosystem. If we can lead the way in inspiring new collaborative behaviours in our innovation system, we will add immense value. Our BNZIC team is developing ways to measure this, but our stakeholders seem to appreciate that we are trying new ways of engagement for delivering value to the NZ economy.

We are the Challenge that changes behaviour... given we are shifting the traditional ways of doing our sort of research - away from being entirely competitive - towards a more facilitated, negotiated approach to accelerate towards our desired high-tech economy. Adopting new approaches is challenging to individuals, teams and institutions. However, we think we have the mandate to push boundaries to be internationally excellent - not just scientifically, but also in forming collaborative innovation teams. Like a venture capitalist, we are taking a portfolio approach, managing risks while expanding the horizons of NZ researchers, industry and Māori organisations, to reap the potential of New Zealand's physical and engineering sciences.

SftI at a Glance...

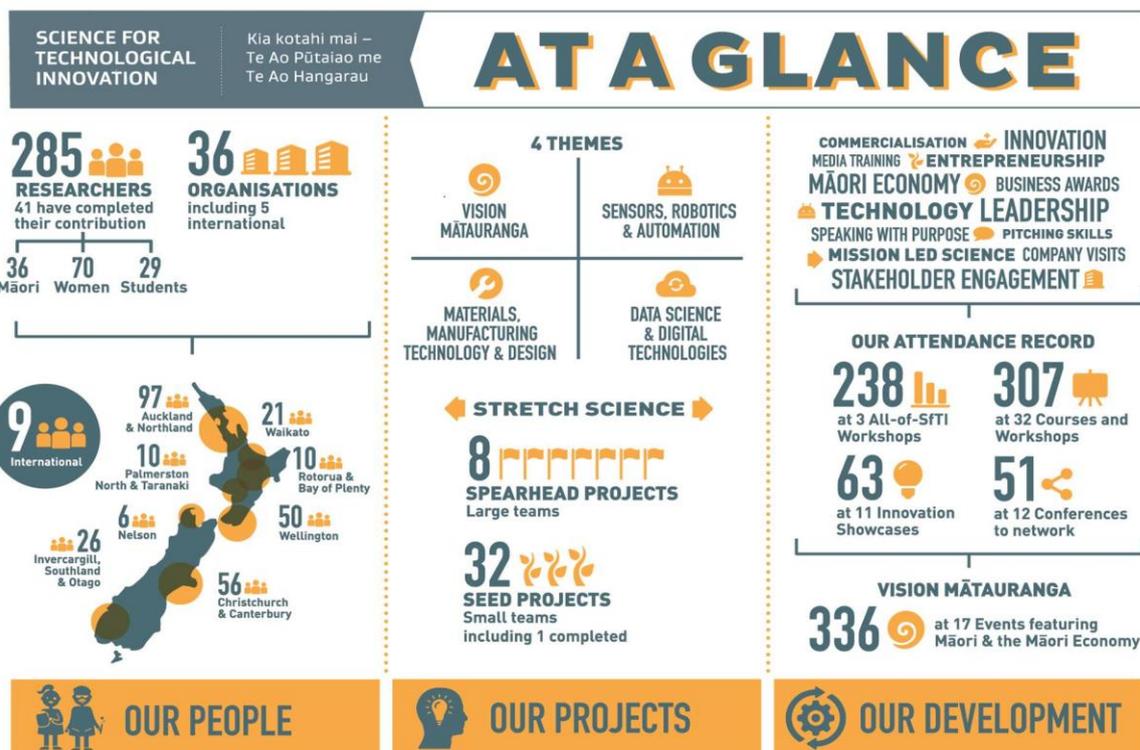


Figure 1.1: SftI at a Glance.

1.2 Financial Information

For the financial period ending 30 June 2019, the Science for Technological Innovation (SfTI) National Science Challenge has forecast \$232,000 remaining of the initial \$32.9 million in Tranche 1 funding.

The Challenge is considering a range of options to utilise this residual funding including:

- continued provision in FY2019 for the planning and proposal phases of the Personalised Value Chain (PVC) Spearhead project to promote an early start (prior to FY2020);
- further investment in the focused Mission Labs programme for developing our less well-defined and/or longer-term missions; and
- facilitated workshops for developing our 'first off the rank' mission teams ready for July 1 2019.
- NOTE: the amount includes contingency funding for FY2019.

All other Tranche 1 funding has been contracted and/or otherwise committed.

2.1. Long Term View

Our future vision is for a New Zealand that has a vibrant, prosperous technology-driven economy in which researchers are fully integrated and actively contributing to strategy, government policies, and daily activities, with new businesses who are offering high-value products and services that may not yet have been invented.

While our vision for New Zealand is a technology-driven economy, we also consider social, cultural and environmental impacts to be of high importance. Economic prosperity through an innovative economy will bring more wide-spread well-being as long as capability is built so all can be involved.

SfTI's focus is on capacity enhancement of the research community but this must be matched by capacity building in business and Māori organisations. New Zealand's poor record of business expenditure on R&D is well known; those companies that are our best R&D performers are also world-leading innovators. There is no doubt that we can do it, but more of our organisations need to step up. This is where SfTI will work with our host Callaghan Innovation (CI) to expand our mission led approach to 'Scale Up' – an imperative common to both SfTI and CI Future Strategies.

Unique insights into how NZ can achieve scale-up have emerged from our 'Building New Zealand's Innovation Capacity' (BNZIC) team. A survey of businesses found that those firms that collaborated with external partners experienced a larger positive impact on their product innovation, even with less internal technical human capital. We need to move our kiwi organisations' tendency to want to control everything, towards an appreciation that partnering can be so much more productive.

This is what SfTI is prototyping. Working within technology areas that are important for Aotearoa New Zealand's future economic growth, SfTI's process of co-innovating with Māori and industry leaders will create a research ecosystem that has a deep understanding of the benefit of co-innovation and early market validation. We are already seeing this in our joint work with strategic partners - CI, KiwiNet, RoS, and the NZ Product Accelerator - to feed the commercialization pipeline in a more seamless way. This approach will lead to breakthrough technologies that, together with CI's promotion of business innovation, drive economic prosperity.

SfTI has, and will continue to, cast the net wide in terms of developing science and technology for industry and community application. Our current missions are moving quickly towards commercial readiness, for example, through taking a systems technology approach to type 2 diabetes and a template for attacking costly chronic diseases, creating new ways to measure minute groundwater flow, building 4D printing of unique NZ biopolymers, developing advanced analytics to decode Māori stakeholder records, and investigating many proof-of-concept ideas from our small Seed projects. Exploration of potential new technologies for advancing priority areas will happen in the next five years, including low-carbon tech, space componentry and biosecurity, as outlined in this strategy.

It's not just the specific technologies that will provide the most impact – it's the change in behaviour in our innovation system. SfTI's twenty-year view is that it is the processes we have instigated around Mission Labs and forming co-innovation teams 'mid-stream' with Māori and industry in the room for the entire journey, that lays the fundamental platform for this long-term. Moving to a far more collaborative, 'NZ Inc' approach for a technology driven economy must provide benefits for all society.

2.2. Five Year Strategy

2.2.1 A Collaborative Challenge Responding to National-scale Issues and Opportunities

SfTI has developed a unique additionality model, which we believe can deliver our mission and New Zealand’s vision for the role of research in our prosperity. A key part of the model is our true ‘co-innovation’ process that is already manifesting in new teams and exciting (sometimes unexpected) collaboration, which would not have happened without our intervention. Our view is that, coupled with fresh optimism in how technology can contribute to our economy, the timing is perfect to scale up this model – moving it from our current proof of concept, to a widely accepted model in the next five years, then embedding it in the way New Zealand’s whole innovation system operates.

Our Additionality Model

SfTI’s additionality is what we do over and above what happens through regular research funding systems. If we don’t accomplish additionality, there would be no point in delegating the responsibility to us to manage our funding.



Figure 2.1: SfTI’s Additionality Model

We are achieving additionality through:

- **Building our community** – not just in scale but also enhancing their capacity in a range of ways, informed by our BNZIC results, particularly in how to form and lead large multi-disciplinary teams and how to engage in new ways with each other and with Māori and industry leaders;
- **Achieving our targets** – even though these targets, formed through our Mission Lab process, may be stretchy and ambitious. Instilling a more focused approach to meeting critical steps but, if not achieved, being open to a pivot or stop. SfTI takes a pragmatic approach to failure – that is, not always achieving risky science targets is part of our journey to success;
- **Sharing our stories** – not just about research achievements but also our learnings about, for example, how to productively engage ‘mid-stream’ with potential end-users in a way that enhances the likelihood of a smoother transition towards commercialisation or implementation, or how best to enhance VM capacity;
- **Scaling up** – by implementing our BNZIC team’s findings, sharing them more widely in our research and policy community, recruiting more researchers and industry/Māori into our Mission-Lab process, engaging industry at a larger scale with our CI host, and sometimes just pro-actively supporting the development of new opportunities. Our tech pipeline is feeding successful commercialisation with strategic partners KiwiNet and RoS for NZ’s benefit.

Any strategy must address the *resources* we have within our reach (sometimes held by others) in order to achieve the diversity of *goals* desired by our stakeholders, and the *environmental* context (including constraints) within which we operate. SfTI’s Future Strategy pays attention to these three fundamentals with the intent to scope how we scale up our additionality model to achieve our vision of **Success**.

Essence of our Future Strategy

Our Future Strategy rests on our additionality model platform and learning from our capacity enhancing experiments of the last ~3 years. Having now worked through the process of developing a programme of research, which has included testing new ways of operating, SfTI has identified general principles that will guide how we approach the next five years in a way that builds on what has been achieved to date. In essence, it flows from our resources, stakeholder goals and our environment. These aims will be expanded upon throughout the Future Strategy and are summarised below.

Resources: We will

- expand our science and technology reach whilst maintaining flexibility;
- evolve our new and current missions to expand the scope of teams;
- simplify our structure to enhance accessibility.

Stakeholder Goals: We will

- strengthen our stakeholder partnerships;
- further integrate VM into all that we do;
- keep enhancing our research community’s technical, human and relational capacity;
- work more closely and jointly with our host CI;

- explore international connections aligned with our missions.

Environment: We will

- embed the SfTI Cycle into the ecosystem commercialisation pipeline;
- take a collective innovation system approach to impact.

Resources: *Flexibility to expand science and technology foci*

Our consultation has revealed new technology areas for focus and more will continue to be identified through our co-innovation practices. At the beginning of the first Tranche, artificial intelligence, virtual reality, and ‘big data’ were not recognised as key technologies to develop within the Challenge. Similarly, New Zealand as a hub for space science would have been regarded as wishful thinking. Now these technologies have been highlighted as essential for our future, and the Government has related policies and platforms for which new long-term research is needed. Currently SfTI’s four Themes are well described and encompass the changing foci (more on Themes later). However, given the exponential changes we are seeing in global technology, we will ensure our structure maintains sufficient flexibility to pro-actively adjust as new exciting possibilities emerge.

Resources: *Expanding the scope of our teams*

We will continue to enhance our SfTI research community as we build new mission teams and evolve current teams. Our research community mapping will enable us to reach further into the larger research ecosystem to find necessary capability and identify capability gaps. We will engage our researchers in giving us advice, manage projects as an integrated portfolio of multiple programmes of related projects, bring projects together to create common activities, such as robotics in aquaculture, create a forum for researchers to contribute more to project ideation (since they will become familiar with the Mission Lab process), and promote researchers to contribute to media, government, and industry developments. We will also experiment with an entirely Rangatahi (emerging researcher) formed and led Spearhead project, mentored by SfTI Theme leaders.

Resources: *Simplify our structure*

Our matrix structure of Themes (that is, areas of capability) and Portfolios (areas of application) made perfect sense at the beginning of SfTI. However, as we created new missions we realised that the potential areas of application are vast, and dynamic; the old portfolios are no longer adequate to describe what we do, especially in a fast-changing technology environment. To make SfTI more easily accessible for those wishing to engage, we will remove the portfolio structure, and instead group large (Spearhead) and small (Seed) projects within enlarged Themes.

Stakeholder Goals: *Stronger stakeholder partnerships*

Our fledgling relationships with certain industry and Māori organisations are already bearing fruit. SfTI’s reputation for genuine engagement is growing such that more stakeholders are asking to be involved in our processes. In particular, our efforts in building common kaupapa and tikanga with Māori, which takes time and can’t be rushed, is exceptionally exciting. We are now moving into a phase where some of our stakeholders are becoming co-researchers rather than just ‘end-users,’

which we will expand in the second Tranche. Our links to other Challenges such as Sustainable Seas and Our Biological Heritage, are identifying new opportunities which we are exploring. Our Land and Water, for instance, is increasingly interested in digital agriculture given the relatively low uptake of technology in some areas of farming, creating points of potential synergy around new, NZ-specific technology with SfTI. Our BNZIC team is a unique undertaking, and one that provides excellent guidance on how stakeholder relationships can be strengthened based on many unique features of the New Zealand context. We will build our scope and range of partnerships, so the Challenge can achieve its overall goal of using science to enhance New Zealand's prosperity.

Stakeholder Goals: Further integrating Vision Mātauranga (VM) across the Challenge

SfTI's Vision Mātauranga (VM) goals are based on three *pou*, or pillars: *Pou Tahi*, to bring greater use of Māori knowledge in innovation into SfTI through Māori values and principles, Māori resources, and through innovation that advances Māori knowledge; *Pou Rua*, to have more Māori participating in technological research, through greater Māori leadership of and membership in projects, either as researchers or co-innovators; *Pou Toru*, to bring greater benefit to Māori by prioritising research for Māori, tailored for Māori and through processes that deliver for Māori in general, as well as for researchers. We will know whether our VM efforts are of high quality when the outcomes deliver value for Māori. To ensure this we will focus on projects (with >20% targeting of research resources) and people (targeting capacity development resources) that have high VM potential. Through the Kāhui Māori we will create a more metaphorical interpretation of the name for SfTI, develop a SfTI fit for purpose whakatauākī (purpose and proverb) and, where there is an appropriate Māori metaphorical story to tell, adopt Māori names for job titles, projects and renamed Themes.

Stakeholder Goals: Keep enhancing our community capacity

Our Capacity Development (CD) programme is perhaps one of the most popular aspects of our Challenge. While some researchers (internal stakeholders) were rather sceptical about it (either because they just wanted to do research, or didn't think they needed their capacity enhanced), the scope of enhancement approaches to both human and relational capacity has expanded, and the more recent targeted approach has proven very popular, especially with emerging researchers. A major focus for CD is VM training, which has already been well accessed and appreciated. We will continue delivering widespread foundational VM to our community, with introduction to VM and the Māori economy, marae and tikanga experience, and Te Tiriti o Waitangi workshops. As a new initiative, we will dedicate VM CD resources to developing our leading VM exemplars to greater heights of success with VM leadership training. We will continue to explore new ways of enhancing capacity aligned with achieving our mission.

Stakeholder Goals: Work more closely and jointly with our host Callaghan Innovation (CI)

While SfTI is focused on enhancing the capacity of New Zealand researchers to engage with industry and Māori to bring about economic growth (and well-being), CI is our natural home and partner as it is focused on enhancing the capacity of New Zealand's industry and Māori organizations to innovate through R&D. We work closely together at an informal level, our Programme Office is embedded in CI at Gracefield, and CI has proven to be a very supportive host. We have agreed with CI to step up this relationship through more jointly run initiatives envisaged in CI's strategy for scaling up connection between industry and researchers. CI has their industry networks and industry-facing

science and technology capacity, SfTI has our extensive science research networks – it just makes sense to work closely with CI to embrace the mutual benefit in our strategies and networks.

Stakeholder Goals: Explore international connections aligned with our missions

SfTI research teams have a myriad of international connections. In future we will institutionalise key relationships, not just on the researcher-researcher level, but also as mission team-mission team, and SfTI-international equivalent. International partnerships can enhance SfTI's work, bringing key international science capability and knowledge to New Zealand where we do not have the scale or ability to provide it, and where we can develop mutually beneficial collaborations. We have started to implement this strategy through MBIE's International Science Partnerships and through encouraging our current teams to identify potential international candidates. We will scan for such connections as we form our new mission teams and refresh our current teams.

Environment: Embed the SfTI Cycle in the ecosystem commercialisation pipeline

This Challenge is part of a pipeline in an ecosystem that stretches from idea generation and forming best teams, through research and development, to commercialisation and scaled markets. We have learned that an industry-led approach to defining technology needs is a crucial early step before forming best researcher-industry teams to define detailed research projects. However, we can't 'complete' the cycle without others, especially as more of our projects make progress towards commercialisation. We will work even more closely with our ecosystem pipeline partners, our host CI, university and CRI commercialisation offices, as well as the Product Accelerator, KiwiNet and RoS to progress our teams towards economic impact. We will explore, for example, whether an annual assessment by KiwiNet or RoS (or an equivalent market validation process) should be mandatory for all projects.

Environment: Take a collective innovation system approach to impact

Following on from our need to work with our pipeline, SfTI also recognises that we can't achieve impact alone. We will be increasing our outreach to businesses and industry organisations, as well as local and international researchers and research institutions; this will be an important foundation for a stronger and highly effective process as we seek to shepherd SfTI research achievements through to successful commercialisation and economic growth. Establishing a causal relationship between our projects and impact means we must keep in touch with our completed projects. We will maintain connection with our researchers - even when they have 'finished' a research contract they remain part of our community and we will continue to support them on the journey to impact.

Formulating the Strategy

The Future Strategy builds on the original Plan for SfTI and has been developed via a thorough process of internal and external consultation. Specific events such as the Mission Lab, held in March 2018 (the inaugural Industry Consultation prototype day was held in early 2017), and subsequent focused discussions with key industry and Māori leaders have been instrumental in both formulating best research directions and highlighting the effectiveness of such a collaborative process. The Mission Lab report (see supplementary material) formed the basis for discussions with our many and varied stakeholders.

Internally, a Management Strategy Day was facilitated by an external consultant in February 2018, and the SFTI Management Team have regularly discussed plans during fortnightly video conferences. The SFTI Annual Researcher Workshop was held in April 2018 and served as an opportunity for the SFTI Management Team to present achievements to date and take feedback from our community to inform Second Tranche directions.

All our larger projects have undertaken long term planning, and this has elicited good advice on how SFTI can best focus its resources heading into the second five-year term. Project plans have been documented and evaluated by the Theme Leaders and Directors to form strategy for refreshing our initial Spearhead projects ready for Tranche 2. Abbreviated versions are included in this plan.

Our experience since SFTI began, particularly in terms of developing new processes for project development and in creating additionality to the NZ Science ecosystem, underpins this document. Equally, the ongoing learnings from research by our spearhead BNZIC project provide fresh ideas and reassurance moving forward.

Our SFTI Directors have overseen the preparation of this Future Strategy, and made it available to the wider Management Team, Kāhui Māori Advisory Group, Independent Science Advisors, and Board for input. The plan has been reviewed by selected external stakeholders: Steve Wilson (Talbot Technologies, key advisor to SFTI), Melissa Clark-Reynolds (key advisor to SFTI), Margaret Hyland (MBIE chief scientist, former SFTI director), Shaun Hendy (Director, Te Pūnaha Matatini, member of our 2017 science quality review panel), Vic Crone (CEO, CI), Rosalie Nelson (General Manager – Strategy, Impacts and Insights, CI), Traci Houpapa (Chair, Federation of Māori Authorities), Desi Ramoo (Research, Technology & Innovation Practice Lead, MPI), Talia Green (Policy Analyst, MPI), Sir Neville Jordan (Chairman, Endeavour Capital), John Kennedy (GNS), Diana Siew (Consortium for Medical Device Technologies), and Catherine Beard (BusinessNZ).

Providing a Strategic, Integrated and Multidisciplinary Programme

SFTI's Theme structure creates an integrated and multidisciplinary Challenge. The projects are mapped across our four Themes, and Theme Leaders jointly supervise (according to overlap) each project. The current mapping of our projects against the four Themes is provided as a Venn diagram (figure 2.2). Our BNZIC project is all encompassing in that they are studying everything we do.

There is a general expectation that projects will utilise researchers from different disciplines, including social science, to ensure that holistic, applicable outputs result. We have commissioned mapping work to show what other research aligned with our Themes is taking place in New Zealand and by whom; this will help guide the search to locate capability that is a natural and enriching fit for SFTI moving into the second Tranche.

We expect the mapping diagram (Fig 2.2) showing SFTI's projects to become more densely populated over time, especially as there is potential for more overlap. A great example of how that may come about happened at our 2018 Annual Researcher Workshop. This year saw teams planning joint meetings to explore how they might benefit from working together, and to share learnings and resources. Specifically, the *Adaptable Robots* project is now working with *Precision Technology for Aquaculture* to consider underwater robotics, and with *Next Generation Additive Manufacturing* to

explore both robotic technology in additive manufacturing and robotic planting and harvesting of raw materials (such as trees) for extracting biopolymers.

Our integration strategy is to focus on Theme Leader management of projects. We will move our Portfolio Leaders into Theme co-Leader roles since they will effectively become programme managers (i.e. with multiple projects to supervise). This will also mean we can enhance the mentoring of projects to link Seed projects with related Spearhead projects (e.g. those related to Mātauranga Māori, those related to robotics, etc.) further enhancing the community feel of our portfolio of research.

Meeting our Challenge Objective Through Our Themes

As indicated earlier, SfTI thinks of economic growth broadly, as effectively about delivering well-being to New Zealand, and each of SfTI's four Themes has its own set of goals that are aligned to SfTI's overall vision and KPIs (see Impact section 2.2.3). We do not propose to add new Themes (although the overarching nature of BNZIC means it sometimes acts like a Theme) but rather to alter some names to better align them with areas of current and future capability.

The responsibilities of the Theme leaders include activities outside of SfTI's immediate scope, such as building NZ communities in the Theme areas, identifying NZ strengths (preferably unique) where we have or could have leverage, or identifying where NZ needs to develop a strength to be or stay competitive as an economy. Conversely, they might also identify where NZ needs to build ability for use of new technologies likely to be adopted in NZ.

1. Vision Mātauranga (VM) - Whakakitenga Mātauranga

VM guides researchers on how to integrate western science with Mātauranga Māori (Māori indigenous knowledge) to explore new opportunities to build a prosperous, technology-driven economy.

By 2025, Hanga rau ngātahi; hei oranga mō te mōtu – we will be creating tech for the benefit of all.

In addition to our challenge specific VM KPIs, SfTI will know our VM Theme is successful when:

- We receive global recognition for this approach to science;
- It is BAU for SfTI projects to use Māori informed knowledge and/or processes;
- Increased leadership and involvement of Māori in all Theme areas;
- Māori are using IP developed through SfTI projects, some of which may have been derived from Mātauranga Māori processes or materials;
- Māori see SfTI as the preferred vehicle for cutting-edge science and technology in its domain areas.

2. Sensors, Robotics and Automation (SRA) - Ngā Pūoko, karetao me te aunoatanga

This Theme develops sensors, robotics and automation for use in a wide range of products and applications. The focus is on cost reduction, improved productivity across all sectors from automation, improved safety in dangerous environments, technologies for precision monitoring and management across all sectors, and undertaking tasks which wouldn't be economically viable otherwise.

By 2025 we will have created a virtual networked New Zealand centre for SRA, providing capability to industry and government for sensing and automation technology including robotics, automation, and linked with our next Theme's focus on artificial intelligence and machine learning. New Zealand company engagement with such technology will have increased.

3. IT, Data Analytics and Modelling (ITDAM) - Hangarau Mōhiohio, te tātari raraunga me te whakatauirā

We propose to rename this Theme **Data Science and Digital Technologies (DSDT)** in order to encompass the recent emphasis on data science, including machine learning and artificial intelligence, as well as the breadth of the Theme. This Theme is aimed at developing innovative models, methods, tools and practices for new or enhanced business processes, hardware components, systems and software applications. We have established positive working relationships with others who have an interest in digital and data opportunities (e.g. the AI Forum, Precision Driven Health and the emerging Data Science Platform that MBIE describes in the Strategic Science Investment Fund Plan, for analysis and computation of big data) and this will ensure that we each support distinct, complementary research. Ultimately, we will enable industry to customise and turn these technologies into economically valuable products and services.

By 2025, New Zealand will be an internationally respected source of ubiquitous, trusted, burden-free digital technologies delivered through dynamic ecosystems of numerous small and larger ‘anchor’ enterprises.

4. Materials, Manufacturing and Design (MMAD) - Ngā matū, te whakanao me te hoahoa

We propose to rename this Theme **Materials, Manufacturing Technology and Design (MMTD)**. This change emphasizes a focus on new technologies for future manufacturing, not current manufacturing technologies, as well as materials and design innovation. The Theme aims to advance the reputation of New Zealand’s small, vibrant hi-technology processing and manufacturing sector so it is seen as a leader in smart, green manufacturing processes and materials. As a result, products, services and processes are developed that position New Zealand’s brand well in premium export markets. Design is a key factor, as are both materials and production processes.

By 2025 an agile, dynamic, mass-customisation ecosystem will have been created in addition to the traditional processing and manufacturing activities.

Meeting our Challenge Objectives Through Our New Missions

Our new project plans for Tranche 2 are already taking shape, based on the concepts developed by visionary NZ industry and Māori leaders in our March 2018 Mission Lab, which created seven new concepts for exploration summarized below (more detail is included in supplementary material). We expect that not all of the potential new missions will stand up to closer scientific and industry scrutiny in terms of their potential for enhancing NZ’s economy, hence our collaborative process.

During 2018/2019 we will be identifying where there is key ‘stretch and NZ-sticky’ research, and deciding the phasing of when, and if, we shall commence them as Spearhead projects. This will depend on how quickly we can define them technically and assemble the appropriate capability. Some we will be able to launch earlier than others.

Right now we are scoping these new concepts with industry leaders to focus on the new, stretchy goals, and soon will socialise them with researchers in a road-show around NZ. Then SFTI will put out a call for researchers to form teams around each concept. The teams will develop detailed research

proposals, which we will evaluate for 'stretch', 'stickiness' and project plans. As with all our research, each new mission will need to demonstrate how it will leverage NZ's unique strengths, capability or resources to take a measurable leadership position. SFTI then will assess the projects and for successful ones, prepare the contracts and establish research teams and industry and Māori stakeholders.

The concepts currently being developed (with indicative primary Themes) are:

MISSION 1: PLACE-BASED AWARENESS (Primary Theme: DSDT)

Very soon there will be a massive amount of data available, and it will potentially be available via Augmented Reality. We need to create a system that intuitively understands what information people need and then delivers it to them. How might it be possible to bring together AR, IoT and myriad other technologies to create contextual awareness about a place, what is happening there, how that place is performing, and how systems (human and technological) are working? For example, there are unsolved research problems related to scaling up such databases, and how to coordinate data drawn from multiple sources across broad regions or at single points in space, all while managing the rights and responsibilities of data providers and consumers.

MISSION 2: SPACE AND SPATIAL (Primary Theme: SRA)

New Zealand's fledgling satellite sector continues to grow, with a whole ecosystem developed to support and learn from the activities of Rocket Lab (and potentially other similar companies). As our space expertise grows, we could integrate the most accurate earth observation data with other pieces of science and cultural data to support activities on the ground. The commercialisation and democratization of space provides a wealth of opportunities in providing services, and NZ's remoteness is not a negative factor for space services. How can our nascent space technology industry be supported and capitalised on to advance potential benefits for New Zealand? For example, there is a novel research challenge in developing an integrated sensor suite to enable detailed monitoring of NZ's extended economic zone from space. Satellite/drone monitoring of health and terrain for forests, waterways and farms may provide novel technology innovation around real-time, machine learning and AI, and predictive models. New Zealand also has strong capability in vehicle positioning and a drone testing mission allowing beyond-line-of-sight testing, and stretchy sticky science is possible around both areas, especially given the coming disruption to business models in the transportation sector from electric and autonomous vehicles.

MISSION 3: A NEW VERSION OF SMARTHOUSES (Primary Theme: SRA)

Can existing smarthouse technology be taken up a significant step in technical capability and scale, and down a step in cost? Can houses be smart, active, and learn to be better? What are the new areas of science and technology that will lead to better understanding and augmentation of housing, rather than the existing technologies that are expensive and not widely deployed? While it received significant attention in our Mission Lab, we are still looking to find a compelling 'stretchy' and 'sticky to NZ' research mission around this area.

MISSION 4: VERACITY (Primary Theme: DSDT)

How do we manage distrust in the digital world? How do we remove source impurity and collusion opportunities? How do we verify veracity, especially with New Zealand's long-distance customers? Ultimately, this research will be about giving consumers confidence in our products and services, and in our country. What is the technology that sits behind proving we are delivering on our claims, or in other words, how can the truthfulness of data, place and people, be verified? For example there are novel research missions in creating zero-knowledge interactions (where the user does not have to give up information in order to verify their identity), in developing veracity technology that is resistant to the expected capabilities of future quantum computing devices, in creating blockchain technology that can effectively run on distributed embedded devices, and in creating a general purpose AI technology that can both use machine learning and reason about trust and bias.

MISSION 5: BIOSECURITY (Primary Theme: SRA or DSDT)

The focus is on being able to identify biohazardous incursions before they arrive in New Zealand in order to keep them out, and finding solutions to bio-problems we already have. How can science and technology assist New Zealand achieve much greater progress on biosecurity? For example, there may be novel technology to be created for smart traps (both for predators in NZ and for insects at ports), rapid pathogen analysis (for infections on ships prior to NZ port entry, and for E-Coli), for novel marine sensors such as eDNA technology, drones to find and kill pests, for novel crowd sourced analytics to model biosecurity risks to NZ, and perhaps for space-based biosecurity monitoring. We are developing a collaboration with Biological Heritage for this mission.

MISSION 6: SOFT ELECTRONICS (Primary Theme: MMTD)

Soft electronics have promise for new areas of science and technology, particularly in terms of power generation and stretch-ability, and its full potential is still being explored. How can this technology be advanced, and what might be some of the avenues to pursue? For example, there is potential to create new technologies that directly embed smart intelligence directly into soft materials to incorporate reasoning and decision making capability, radio frequency communication, or self-powering by collecting energy in the soft material. There is potential to create new kinds of soft robotic technologies based on novel NZ soft, stretchy materials.

MISSION 7: MĀORI DATA SOVEREIGNTY (Primary Theme: VM)

How can data be used in ways that are appropriate and beneficial for Māori, including how it gives effect to foundational Māori philosophies, and how we might ensure that the development of tech tools is guided by Māori values? While this concept is in an earlier stage of development, it is strongly supported by those working on Māori data sovereignty and the Iwi leaders group. Our plan is to be guided by Māori leadership to find the novel science missions, and form a project that is governed and led by Māori – aiming to create the new tech rather than implement existing tech. This is likely to include novel tech approaches to how data about, by or for Māori is collected and shared (data management and integration) as well as data access, security and control. Given that for Māori, data can be considered a taonga and hence subject to both individual and collective restrictions, new tech solutions will be required to advance this mission.

A RANGATAHI SPEARHEAD: INSPIRED, FORMED AND LED BY EMERGING TECH LEADERS AND RESEARCHERS

SfTI was challenged at our 2018 Mission lab to ensure the voice of young people (Rangatahi) comes through strongly into our missions to ensure relevance to coming generations. Three young(er) tech leaders at the Mission Lab have since taken on the mandate to coordinate that new generation tech voice. As a result, we expect to incorporate the Rangatahi voice into our existing and planned missions, and develop a Rangatahi inspired, led and sourced Spearhead project. Emerging technology and research leaders do not often have the opportunity to create large projects, so this is yet another of SfTI's experiments in innovating team formation processes; in this case ensuring that future leaders have a say in long-term research. The project will go through the usual SfTI EoI-for-capability process and be evaluated by our expert panel (with appropriate Rangatahi input). Our Theme Leaders will be always on hand to mentor, but we intend to give this group of exceptional thinkers a relatively free reign within SfTI's boundaries of accountability and transparency. Our long term goal is to provide a permanent pathway for Rangatahi to provide inspiring new leadership in NZ's technological innovation.

SEED PROJECTS: RISKIER, SMALLER, MENTORED PROJECTS

Our Seed projects (~\$100K pa) are smaller than our large Spearhead projects and are an essential component for bringing fresh new ideas to the SfTI portfolio and community. We know through the BNZIC research that mentoring, in particular, has proven worthwhile, as well as the fact that Seed researchers are eligible to access CD and attend our Annual Researcher Workshop, where they can mingle with the SfTI community.

Our processes for assessing and selecting the Seed projects, including a ballot process for those that meet our quality criteria under external expert review, will be continued as they are well accepted in the community (and we have been able to belatedly fund some of the high-quality projects that missed out on the ballot). In fact, our Science Quality Review panel was impressed with what some of these small projects were achieving.

The reason they were called Seed projects was the intent that they might grow into something larger, such as a Spearhead project. Feedback that the \$100k size is actually suiting many proof-of-concept type projects is heartening. These projects might then move (and in some cases already have moved) on to more commercially-oriented funding, with our support.

Our Seed projects each have an annual critical stage gate. In order to elevate SfTI's desire to support the 'risky' aspect of Seed projects, we will allow and enable one well-reasoned 'pivot' in a Seed project, if justified to the mentor Theme leaders. This is part of our experimenting with a 'fast-fail' ethos, while still providing some certainty for researchers and their students. We will also adjust our contracting mechanisms to enable more rapid decision-making with providers when projects need to be stopped or pivoted. Contracts will also on commence once a student is 'in the building', if that is part of the Seed plan.

However, what about those Seed projects that need to do more research before moving down the pipeline? Some Seeds are a natural fit within parts of new Mission-Lab-developed Spearheads and will be incorporated during the proposal development phase. Some ongoing Seeds will be grouped

together, and with larger Spearheads, and managed as a programme where the work is related. For others, SfTI is considering a 'graduation' process for further support at Seed or (possibly) higher funding level. This would be contingent on going through a market potential assessment, for example, with one of our pipeline partners (KiwiNet or RoS), or alternatives such as a focused Mission Lab with selected industry leaders, or an MBA market validation project.

Meeting our Challenge Objectives Through Evolving Our Current Missions

As described under 'Formulating the Strategy' the proposals from current Spearhead teams (available in more detail) include a new five-year plan, most of which have been accepted by a review panel, with conditions on detailed plans to ensure novelty, NZ stickiness, specific and measurable milestones, and high quality Māori engagement.

SPEARHEAD 1: BUILDING NZ'S INNOVATION CAPACITY (BNZIC)

This Spearhead is key to SfTI and unique. It will be funded for the full term of Tranche 2, with evaluation as per the science quality review process. The **Vision** is for *a high-performing seamless New Zealand commercialisation environment that has enhanced co-innovation capacities within and between physical sciences and engineering teams and a wide range of industry sectors*. The work will build on Tranche 1 as a unique opportunity for real time study of 'success' and 'failure' in collaborative stretch science research. The further five years enables SfTI to identify the distinguishing characteristics of these research processes in New Zealand, and compare them to international studies, and across different commercial and cultural landscapes. Addressing the industry side of what leads to successful engagement with science will complement and extend the insights generated in Tranche 1. Our multi-method research approach and multiple Tranche 2 projects will inform both researchers and funders and help these **end users**, including the SfTI Management Team, to facilitate additional increases in effective research engagement. The focus is on in-depth and reflexive insight to develop models and implement pathways for science researcher and industry engagement; assessing how Capacity Development shifts researchers' perspectives from the status quo and how this then extends beyond SfTI will add further value. **VM** is a priority for BNZIC's projects and for the study of all SfTI projects. BNZIC includes both specific VM researchers and specific projects with a VM component. The focus on *why the transformation of research inputs into outputs* might differ in the New Zealand context **aligns with and complements other country-level analysis of policies** affecting NZ innovation, which highlight differences in particular inputs and (less frequently) outcomes. From a national implementation perspective, New Zealand may be leading the world in some aspects of indigenous innovation research: international comparatives will test this proposition and identify how NZ's unique approach works.

SPEARHEAD 2: INVERTING ELECTROMAGNETICS – A NEW WAY TO MEASURE GROUNDWATER FLOW (Primary Theme: SRA)

Ground water sensing is very challenging, and we have embraced it given that SfTI is about risky, stretch science. An upcoming review of this project's achievement of a key science milestone will enable a final decision about how this work continues in Tranche 2. In addition, we will explore the natural extension of such technologies to monitoring and mitigation for clean water, together with the Our Land and Water Challenge. The project team have developed an initial **Vision**: By 2025, New Zealand's exports of smart, agri- and enviro-tech equipment will have increased from the current

\$1.2 billion to \$1.4 billion annually. This will be achieved via new sensing and remediation technologies.

To co-design this mission we will bring key stakeholders and industry together with the project researchers in a clean water tech Mission Lab workshop to ensure the science is directed toward the best result for New Zealand. **Tranche 1 has already built**, and is continuing to enhance, a solid understanding of how to measure tiny signals for sensing in the presence of large interfering signals. This includes a theoretical understanding of Faraday signals, charged double layer and related electrode effects, and interactions between Faraday and magnetically induced signals. In addition, our Seed project for nitrate sensing in the Waikato river will inform our planning.

In terms of **Addressing the needs of end users**, the intent of the Inverting Electromagnetics research is primarily to help solve the NZ and global impasse in understanding groundwater flow at a (1-100m) scale and ultimately develop a suite of tools for quantifying contaminant flows and enabling mitigation. The **incorporation of VM** is developing and will be stepped up in Tranche 2. Māori are involved in the science creation (e.g. Maui Hudson), delivery (e.g. Takiwa) and end-users (e.g. Te Taumutu). There is a substantial need for this technology, as described to project researchers during a hui at the Ngati Moki marae. The project **aligns with strong interest in other sectors and research**, including the government interest in clean water, exemplified by MPI's Primary Sector Roadmap and the national science challenge Our Land and Water.

SPEARHEAD 3: A SYSTEMS TECHNOLOGY APPROACH TO HOME-BASED TYPE 2 DIABETES TREATMENT (Multi-Theme: SRA, DSDT, MMTD)

This Spearhead will be funded for three years and then reviewed and refined. The **Vision** is to create and implement integrated technology-based solutions for patient-centric, personalised, home or community treatment of chronic disease, with a focus on type 2 diabetes. The solutions utilise advanced technologies across a range of technology and clinical spaces to address key issues in measurement, management, and monitoring (M3), to devolve care, use clinical resources more optimally, and improve patient outcomes. This project is unique in its systems technology approach, in contrast to virtually all other international efforts attacking particular elements of the overall problem. In effect this means that the separate project strands from **Tranche 1** (POC Insulin Sensing, Needle-free Sensing + Delivery, and Modeling + Self-management) converge, creating prototype systems for use first in-hospital (for safety) and then with out-patient cohorts. Tranche 1 outputs thus lead seamlessly into Tranche 2 and create a broad set of integrated technologies for chronic disease treatment.

A key development for **Tranche 2** is a shift in focus from technology elements and science impact, towards clinical translation and systems integration, as well as industrial design engagement. This will be achieved through testing the prototype with Māori and Pasifika people to identify and overcome any barriers to use in real world settings: Waiperiera Trust may assist in clinical trials. Further, bringing external expertise into the team will enhance privacy and security.

For **patient end-users** we will create simple, patient-led, high quality, low cost care for a major chronic disease. For **healthcare payer end users** we will reduce the cost of care, while improving quality and thus productivity. **Industry end-users** will be supported by the human CD and specific technologies developed. **Incorporating VM:** Tranche 2 and its increasing focus on co-design and

dissemination/validation of solutions offers the opportunity for Māori-designed/specific solutions leading to the creation of Māori economic and health delivery capability. In particular, Māori healthcare providers, such as Te Kohao Health (KKM Marae health provider), and Māori Health Service teams at DHBs will be approached to join and/or have input, to ensure Māori-centric and effective solutions. The project **aligns with New Zealand and international focus** on managing chronic disease. The science directly aligns with the MedTech CoRE (creating a synergy that allows a wider focus and wider science than possible for either group alone), as well as with other New Zealand and international research teams, without overlapping. MedTech is a priority growth industry for New Zealand. The specific research addresses unique technologies, and the very early use of insulin to prevent diabetes is (currently) unique, where international research generally seeks to find population health or novel pharmaceutical solutions.

SPEARHEAD 4: R FIVE (Primary Themes: DSDT and VM)

At the completion of Tranche 1, Track 1 and Track 2 of this Spearhead will pivot towards full industry funding and commercialisation, and some researchers in these tracks will aim to continue in the PVC Spearhead (see Spearhead 9). Track 3 will continue into Tranche 2 for three years under the title '*Te Tātari Raraunga: Spearheading economic, social, and cultural revitalization through Māori Data Science*' and will focus on applying data analytics techniques to legacy records to find lost Iwi shareholders. This will move under the banner of a Māori led project such as the Ātea Spearhead, in order to provide the Māori guidance and facilitation that is needed. The **Vision** is that New Zealand organisations create value from large quantities of data through advanced analysis software tools. *Te Tātari Raraunga* exemplifies a new form of Māori Data Science that bridges traditional Māori knowledge with modern western science for a genuine and enriching bicultural future.

The project will **expand on work already undertaken** during Tranche 1, both building relationships and science/technology outputs. Our co-research partnership with Paraninihi ki Waitotara will enable significant engagement and impact. It is a flagship **Mātauranga Māori** initiative, **embracing, embedding, and stretching SFTI's VM** goals. By developing and consolidating a very good working relationship with PkW, one of the top ten Te Ohanga Māori enterprise groups in New Zealand, this project exemplifies how research can be co-produced in a Mātauranga Māori research framework, operating within culturally-specific protocols and tikanga. This project **aligns** with wide scale international interests in deriving value from large scale data, and New Zealand's interest in Māori data sovereignty.

SPEARHEAD 5: ADDITIVE MANUFACTURING AND 3D AND/OR 4D PRINTING OF BIO-COMPOSITES (Primary Theme: MMTD)

This Spearhead will be funded for three years into Tranche 2 and then reviewed. The **Vision** for the sector is that by 2025, New Zealand will be selling new customised products, equipment and materials based on NZ biological resources and distributed manufacturing worth \$300M pa, with up to 10 new companies emerging to fuel the growing global 'green' sector. **During Tranche 1**, the research team saw the early potential to develop 4D printing concepts, with an even greater challenge of using bio-based materials and designing for end-of life. In Tranche 2 the project design concepts, modeling, bio-based materials development, and equipment modifications will lead to at least 2 successfully 4D printed product prototypes by 2024. While New Zealand has significant scientific capability in this area, the science must be driven by **industry end user needs and**

opportunities, with a tight focus on the areas in which New Zealand firms already have, or can build, a competitive edge. There will be applications for industries where New Zealand has already demonstrated market share such as aerospace and marine products, farming equipment and medical devices, and also in established industries with aspirations to diversify into new export product lines. The project is designed to provide skills and tools for the new opportunities to develop products, including the rapidly growing global circular bio-economy concepts which also address climate change. The project now has strong potential for **incorporating VM** and this will be further developed including CD for the team, inclusion of Māori, and exploration of VM opportunities in the use of bio-based materials, 4D printing, and intergenerational design. The project **aligns** well with the MPI roadmap by using primary industry materials and developing bio-economy solutions. It also **aligns** with the MFAT strategy 2030 by impacting on non-tariff trade barriers, and Zero Carbon requirements and New Zealand's compliance needs under the Paris Agreement, and complements the activities of the Bioresource Processing Alliance.

SPEARHEAD 6: KARETAO HANGARAU-A-MAHI: ADAPTIVE LEARNING ROBOTS TO COMPLEMENT THE HUMAN WORKFORCE (Primary Theme: SRA)

This research began late in Tranche 1. It will be funded for three years in Tranche 2 and then reviewed. The **Vision** is to be at the forefront of research for highly flexible and easily adaptable robots within the next 15 to 20 years. To achieve this for New Zealand's smaller niche industry, robots need to (i) easily perceive and understand their environments, which are often harsh and always changing, (ii) automatically learn to adapt and conduct tasks, and (iii) communicate with other robots to share experience. We anticipate that by 2027, New Zealand Industries will be benefitting from using 'workforce robot' technologies to improve productivity and reduce costs, and New Zealand manufacturers will design and export highly adaptable workforce robot technologies. Through the work carried in its **first year in Tranche 1**, and based on extensive consultation with industry, several areas of focus for Tranche 2 have been identified: advancement of AI-methods; features and characteristics for developing new sensors; new structural components of flexible and adaptable robots; and new concepts to integrate the robot control in simulations of the environment and the flow of tasks. Input from **industry end users**, including the **Industry Advisory Group**, has been instrumental in scoping: small, highly flexible and adaptable robots are particularly relevant for (i) smaller lot sizes and (ii) a growing range of variants - typical characteristics of New Zealand businesses, and a trend for industries across the globe. Reducing costs of indirect processes, such as setting up robots to carry out a new task, is a key concern for businesses moving towards automation. We have started and will continue discussions with Māori companies in horticulture (Kono, HortPlus) and other sectors, to incorporate **VM** in our programme and deliver indigenous innovation; including benefits from highly adaptable robots in the typically harsh environments of horticulture, dairy farming and aquaculture. We will include the concepts of whanau as groups of robots working with groups of humans, and Māori intergenerational communication, based on non-written information exchanges using icons and symbols for communication of complex situations (robot to robot, humans and robots). The project seeks to involve Māori scientists and PhD students. The project **aligns** with the primary sector's rapidly increasing focus on precision farming, for example, MPI's technology roadmap, Our Land and Water's interest in precision farming and digital agriculture, and the manufacturing sector's need for factory automation of manual tasks for small scale production.

SPEARHEAD 7: PRECISION FARMING TECHNOLOGY FOR AQUACULTURE (PFTA) (Primary Theme: SRA)

This research began late in Tranche 1. It will be funded for three years, and then reviewed. The **Vision** over the next 20 years, is that New Zealand will become a leading exporter of smart aquaculture technology, spanning advanced autonomous sensors, data analytics, communication, and visualisation technologies that will transform ocean farming worldwide. This will transform New Zealand aquaculture from its traditional experience-based mode of operation to one that is high-tech and knowledge-based, enabling the aquaculture industry to scale-up from 10 ha near shore farms, to 1000 ha offshore farms.

In one year's operation in **Tranche 1** PFTA has focused on technological innovation in three key areas: sensing; communicating; and enabling, to allow offshore farms to be readily 'visible' through accessible, real-time information on the condition of crops and structures. In **Tranche 2**, new researchers will build technical capacity. There will be significant science stretch, particularly in the development of new robust laser spectroscopy for the marine environment and the development of underwater untethered sensor communications, including multi-hop high-rate laser-based video transfer, with AI based image analysis.

Aquaculture end users arguably represent the greatest value proposition for growing New Zealand's blue economy. The growth of offshore aquaculture internationally combined with the transferability of research to **aquaculture technology manufacturers** will open new export markets. The 10-year vision is a scalable technology design facilitating deployment across hundreds of farms and enabling management of farms 'from the desk', and at bay-wide, regional, and national scales. **VM is incorporated through** active participation of Māori-owned companies and an early career Māori researcher now on the team. Secondments are planned with Māori-owned companies such as Wakatū Inc. The **PFTA research is strongly aligned with aquaculture sector strategies** (e.g. AQNZ, MPI, Sanford 'The Power of AND'), and existing and planned research funded by MBIE (including the Endeavor funded Open Ocean Aquaculture and SSIF Cultured Shellfish programmes), Seafood Innovations Limited (SIL) and aquaculture companies. Members of the team and the Industry Advisory Group are either directly or indirectly linked to aligned MBIE and SIL-funded research projects. There are cross-challenge research opportunities with the Sustainable Seas NSC investigating how technological innovation in aquaculture can contribute to NZ's Blue Economy. Established connections with Norwegian-led efforts on precision finfish aquaculture will maximise transferability and position NZ as a world leader in precision aquaculture technologies.

SPEARHEAD 8: ĀTEA (Primary Theme: VM)

This is the last Spearhead to begin during the first Tranche and the proposal is currently being assessed. We plan to fund the project for three and a half years and then review it. As mentioned above, it is intended that *Te Tari Raraunga* (from the R5 project) will come under this umbrella. The **Vision** is a uniquely Māori led project driven by **VM** and building prosperous, culturally thriving and technology-driven Māori economies for future generations. With a particular focus on connecting fragmented communities, the purpose of this Spearhead, with an appropriate Māori governance structure and guided by the SFTI Kāhui Māori, is to create a foundation for the next generation of digital models (encompassed in a Reo Engine), to support Māori, iwi and communities in connecting

to their increasingly distant tribal members to their mātauranga-ā-iwi, reo, tikanga, histories and knowledge.

For the short time remaining in **Tranche 1**, the focus is on scoping, relationship building, access, authentication, security and producing a preliminary set of assets and tools for adding value to how we engage with Māori content and communities. **Tranche 2** will be devoted to research on: expanding a core digital platform to static and dynamic mātauranga content, integrating block-chaining to assist with indexing, traceability and control of content, integrated text and voice recognition for te reo Māori, a comprehensive technological, psychological, cultural and socio-psychological model for virtual avatar interactions, incorporating culturally appropriate design features, and ongoing conceptualisation, through wānanga, of the impact of AI, VR & AR, mixed realities, and machine learning on space, time and place and its effect on culture, language and knowledge.

The project will **provide Māori end users** with a learning environment that connects the past and the traditional, with the future of modern Te Ao Māori (Māori world) as Māori wish to define it. It may be a place to transfer cultural knowledge and values, record history, and create a space where cultural identity and tikanga can be strengthened and transferred intergenerationally. This **research aligns directly within the VM stable**. Aligning experts in AI, VR & AR, mixed realities, block chain, ML, with leading Māori academics engaged in Indigenous data sovereignty and digital repositories, Māori industry partners, tohunga, iwi, rangatahi and collaborators through a collaborative Kaupapa Māori approach, this Spearhead aims to create technologies, opportunities, and knowledge in the interface between technology and culture for Indigenous communities.

SPEARHEAD 9 (proposed): PERSONALISED VALUE CHAIN (Primary Theme: DSDT)

The Personalised Value Chain (PVC) arose from our 2017 Mission Lab and has recently been refined sufficiently to call for Expressions of Interest from researchers based on their interest and capability. At this stage, the project is expected to commence at the beginning of Tranche 2 (or earlier), contingent on the best team being formed and research plan being approved. The direction includes three potential research strands which are aimed at creating novel technology that will help strengthen relationships and understanding directly between sellers and buyers in ways that empower both sides of the market:

- How can we empower consumers to protect their privacy while they are online, thereby creating better ecommerce options and experiences?
- What are the defining characteristics of establishing trust using a Mātauranga Māori approach and how might we apply these principles to establishing online trust to strengthen relationships between (NZ) sellers and global buyers?
- How can we make accurate predictions about consumer behaviour and demand when we have limited and/or poor-quality data?

There is obviously some potential overlap with our new Veracity Mission, so these projects may be aligned or combined. This Spearhead is also of interest to the High Value Nutrition Challenge.

Meeting the Needs of End-users

The term 'end-users' suggests such entities are on the receiving end to 'use' what our projects have developed. SfTI is trying to change that perception through making sure such stakeholder 'users' are not only engaged at the finish of a project but are involved in the initial priority setting and proposal development, as well as in the conduct of the research. Consulting with Māori and industry leaders has enabled the Challenge to understand the specific needs of end-users earlier in our project development process. The Mission Lab has been a key element of this. We have also consulted on an individual basis with organisations such as BusinessNZ and the Federation of Māori Authorities (FOMA). Private businesses are already serving as industry advisors for several research projects, and this model will be continued over the coming years. Our plan is to enhance and extend this engagement to be 'business-as-usual' in the formation of our new mission teams.

SfTI is not alone in working towards our economic growth/well-being vision. During the second Tranche, we are committed to extending our relationships with other NZ research organisations so that we can share capability. This will include other National Science Challenges (there is potential to link with all of them about 'new tech' in their environment) and Centres of Research Excellence. We are already sharing talent with many of these and already have overlapping projects with Sustainable Seas and Our Land & Water. With our future Missions, it makes sense to collaborate, for example, with Biological Heritage (Technology for Biosecurity), with Regional Research Institutes CCST (for our Space and Spatial mission) and PlanTech (for primary sector tech), Te Pūnaha Matatini (Centre of Research Excellence) and the emerging MBIE Data Science Platform.

We have achieved an important shift in the extent to which we now engage with end-user and related stakeholders compared to the early days of the Challenge. A much wider range of people is expressing an interest in the work we are doing. This is in part a result of the Mission Labs as well as a more targeted communication and engagement strategy, particularly focusing on sector groupings such as BusinessNZ, NZTech and other technology organisations to spread our word. We will certainly continue along this apparently successful engagement strategy, albeit balancing engagement with managing our research portfolio.

One area where we have identified for improvement is around early market validation of research concepts. We have assumed that engaging early with commercial stakeholders would provide this, and now we will add an ethos of ongoing external commercial validation along with our science quality review process, to guide SfTI decision-making. We will do this by seeking advice from with our strategic pipeline partners KiwiNet and RoS.

Incorporating Vision Mātauranga

Vision Mātauranga – Our Approach is Māori-led, SfTI-enabled

VM remains a priority for SfTI with many learnings and behavioural changes achieved across the SfTI community in Tranche 1. The Future Strategy for VM is to grow the fundamental nature of VM in physical sciences and engineering from something that is essentially a new, rather fascinating, discovery for most researchers, to business-as-usual as the impact potential is genuinely understood as unique to Aotearoa New Zealand.

SfTI is excellently guided by its well established Kāhui Māori (Māori Advisory Group) of distinguished Māori academics and Māori practitioners, governed by a comprehensive Terms of Reference (see Supplementary Material). SfTI's wider Māori networks extend deeply into Te Ao Māori (the Māori world), with strategic partnerships such as with the Federation of Māori Authorities (FoMA) and the Ātea Te Taumata (a distinguished council of Māori Leaders) which provide guidance and serve as kaitiaki (guardians and protectors) for matters relating to tikanga (Māori cultural practices) and Mātauranga Māori (Māori indigenous knowledge) for our Ātea project.

SCIENCE FOR
TECHNOLOGICAL
INNOVATION

Kia kotahi mai –
Te Ao Pūtaiao me
Te Ao Hangarau

TE AROMATAWAI

Assessing the Quality of Vision Mātauranga

SfTI uses three pou or pillars to assess how well projects meaningfully incorporate VM

POU TAHI: MĀORI KNOWLEDGE

- The incorporation of Māori principles or practices
- Applying Māori knowledge of Māori history or resources
- Tino Mātauranga – an extension in the understanding or application of Māori Knowledge

POU RUA: MĀORI PARTICIPATION

- In the conception or development of the project
- In the execution of the project

POU TORU: MĀORI BENEFIT

- A gain for Māori or Māori capability
- A topic of high impact or priority for Māori

1 POINT

**OUT OF A POSSIBLE SCORE OF SEVEN,
VM QUALITY OF A SfTI PROJECT IS
DESCRIBED AS:**

EXCELLENT	7
HIGH	5-6
MEDIUM	3-4
LOW	1-2

Figure 2.3: Assessing the Quality of Vision Mātauranga Activities

The VM Theme Leader sits on both the SfTI Management Team and Kāhui Māori to ensure alignment and congruence of SfTI’s Māori strategy and implementation across SfTI. All members of the SfTI Management Team have embedded within their roles and responsibilities the development of VM as a requirement so that this is not left solely for Māori within SfTI to implement. The SfTI Director is also a member of the Kāhui Māori ensuring the responsibility for VM is given genuine priority. SfTI has also developed strong advisory capacity and capability within its Programme Office with experienced advisors in the Māori economy, Māori public policy and international indigenous community development (e.g. Aboriginal and Torres Strait Islanders – Australia). SfTI is further supported by a Board Member who is a specialist in Māori development.

The Kāhui Māori is finalising a more deliberate strategy for VM which will see SfTI transform its own approach to a significantly enhanced level in Tranche 2. This framework is based on tikanga principles which will see the development of a VM criterion for supporting, assessing and implementing SfTI research projects (figure 2.3), ensuring the co-construction with Māori of kaupapa Māori (Māori philosophy) based Māori research projects (e.g. Ātea Digital Marae Project and the Iwi Leaders’ Group Māori Data Sovereignty project). This approach will assess the benefits of all research projects to Māori, ensure support for Māori researchers, and build VM capability across the non-Māori SfTI community (e.g. through SfTI resources such as He Ritenga).

This tikanga based framework, SfTI’s ‘VM Cube’ (figure 2.4), is conceptually founded on how the takutai moana (beach/coastline) and the maunga (mountain) are interrelated and provide a stratum for the connection of Māori and non-Māori research reaching through to higher levels. The value add of SfTI’s approach to VM is bringing together the two knowledge systems of western science and Mātauranga Māori in the hi-tech sector, an area with more research capacity and capability potential yet to be realised.

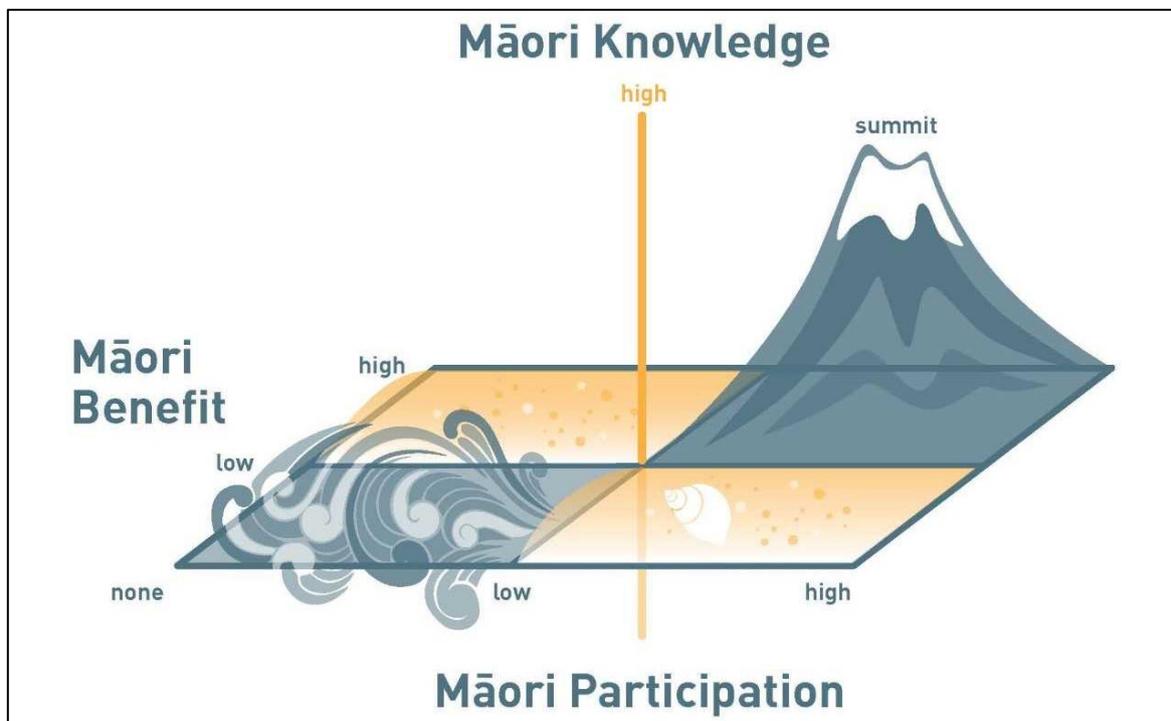


Figure 2.4: VM Cube

2.2.2 Ensuring Highest Quality Research, Science and Technology

Making Best Use of a Range of NZ and International Resources & Introducing New Capability

SfTI’s approach to making the best use of available resources and capability is two-fold. First we identify capacity not currently part of SfTI; we have developed our mission-led processes in ways that enable any researcher or interested organisation to bring their capability to our Spearhead teams as well as put forward risky, Seed project proposals. Second we build the capacity of our SfTI community through our CD programme. Our Future Strategy will build on these but also concentrate on how we can bring more team-based and institutionalised international relationships within SfTI.

Dynamic Introduction of New Capacity

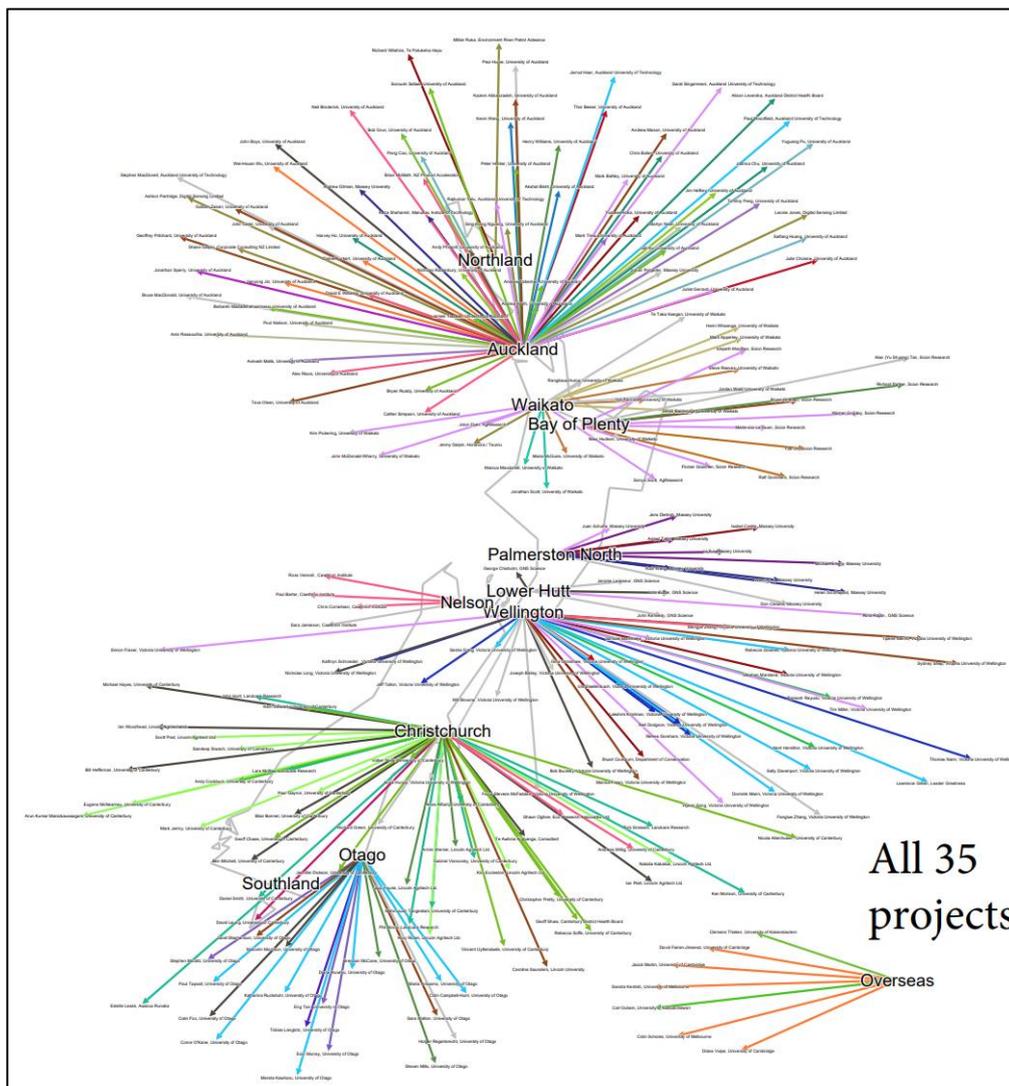


Figure 2.5: SfTI’s Researchers

SfTI aims to ensure the Challenge is accessing the highest quality resources for our research through not assuming we know where all capability might lie. Each of our current seven Spearheads is multi-disciplinary and connected across three to eight research organisations, and our 28 Seed projects bring even more diversity. We now have over 200 researchers, having started in 2015 with around 50, and growing to about 120 in 2016/17 through our new Spearhead and Seed project process. These individuals are mapped in figure 2.5 to give an indicative view of our national (and direct unfunded international) reach. As we head into the second Tranche, existing Spearhead projects will need to demonstrate how they have reinvigorated their teams with fresh capability.

There are many ways we will continue to bring in new capacity, including searching out expertise based on areas of SfTI research focus. The mapping exercise undertaken by Te Pūnaha Matatini using our SfTI Themes to extract data from Scopus has surfaced sixty-seven additional researchers in New Zealand who appear to be a good match for our Challenge. Over the next year we will personally contact each one to make sure they are aware of the expression of interest process for bringing capability to our new missions and how we intend to expand current missions. This is not enough though, as the Scopus project may not capture all, for example, emerging researchers.

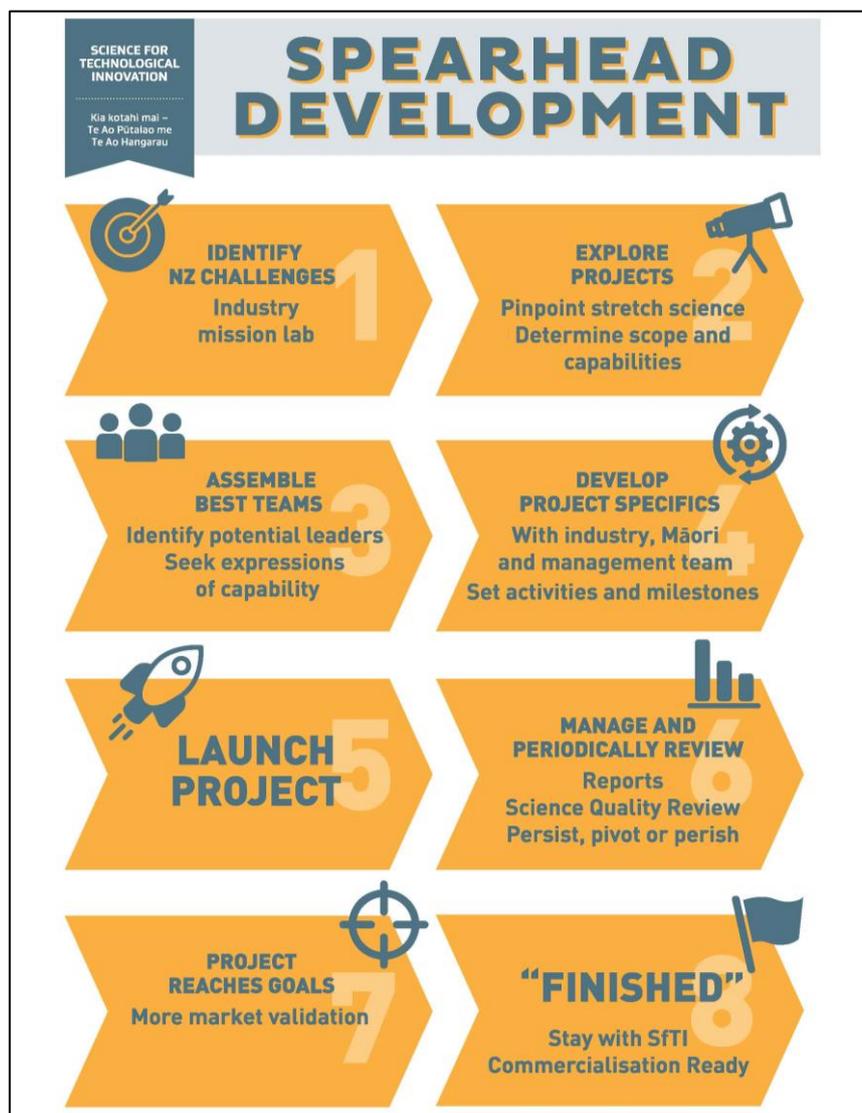


Figure 2.6: SfTI’s Spearhead Development Journey

SfTI's process of assembling large collaborative teams has been prototyped during the first Tranche (as portrayed above) and is continuing to evolve. There has been a growing appreciation that stakeholders (including business and Māori) wish to be involved throughout the process from identifying challenges to refining the research questions, forming teams and beyond. SfTI has built great working relationships with New Zealand research bodies, businesses, and Māori organisations – no one is excluded from signalling interest in a mission. This process of innovating together is best labelled collaborative innovation; it is a truly co-innovation process. We also know that new relationships formed through SfTI have resulted in large pan-NZ MBIE Endeavour bids that have been short-listed.

Our Seed project process brings in new capability through a more traditional contestable process that seeks exciting, risky research, which is often effectively proof-of-concept in nature. Where SfTI adds value is in: firstly, helping the applicants put in place solid, quantifiable critical steps that provide a framework for our experienced Theme leaders to coach Seed project leaders; and secondly, mentoring the projects towards completion. As indicated earlier, we are looking to develop a 'graduation' process to keep promising Seed research inside SfTI. This is part of our continual experimentation with innovating processes.

SfTI's Future Strategy includes accessing capability that exists in other research entities such as NSCs, Centres of Research Excellence, and MedTech CoRE (which brings a range of industry connections). International research teams will also play an important role here. Whilst we already have researchers who are investigators in other programmes, we have plans for sharing capability more explicitly through jointly promoted (and potentially funded) projects, for example, with Biological Heritage, Sustainable Seas, Our Land and Water, Te Pūnaha Matatini, the NZ Law Foundation, and other entities where SfTI can provide the necessary 'tech for' to enable NZ capability to reach new heights. Such projects bring extra additionality by enabling access to each entity's stakeholders to enable a deeper reach for commercialisation.

Building SfTI Community Skills

There are benefits for New Zealand in 'opening' our innovation processes as this can create additional value for enterprises and science. The *BNZIC* Spearhead is expanding SfTI's horizons in terms of what capacities and practices support commercially and socially beneficial science. Not only will BNZIC continue to inform our own policies, but it also constitutes an opportunity to communicate novel learnings to the wider science ecosystem. Later in 2018, SfTI will embark on a series of roadshows to profile our Future Strategy and our learnings from BNZIC.

The Challenge aims to increase the skills of our researchers in several areas including: how to *connect* with industry, Māori organisations and the wider research ecosystem; how to *communicate* with a range of different stakeholders; how to *collaborate* for best outcomes; and how to *incorporate commercial thinking* into their work. Good processes are already in place to achieve these aims (see Impact Section). The move from 'competition around funding' to 'contestability for bringing capability to a genuinely new collaboration' is an important step change for the Challenge and, we suggest, New Zealand! It ensures that diverse researchers and leading industry capability can come together to form best teams, learning from each other as projects progress. SfTI also manages across projects and in this way can identify opportunities for cross fertilisation.

We enhance the capacity of our researchers particularly to engage in up-stream and midstream co-innovation (we have outlined our capacity enhancement in other areas such as VM earlier). This is focused on helping researchers think carefully about how they work with Māori organisations and with business, manage IP early on, and what the impact of their research will be for these groups. New opportunities are constantly being developed for researchers to learn valuable skills. For example, we asked ourselves how do we develop leadership capability to manage large diverse research teams where there is a very flat power structure? We instituted a 'relational leadership' programme with a course around leading through influence (rather than direct power), followed by individual coaching for those that were interested in learning how to apply relational leadership in their research programmes. Our prototype process has nine researchers being coached, and we will expand this in Tranche 2, especially as the coaches will feed back their observations to BNZIC.

One of the great (and unintentional) side effects of our approach to forming new mission-led teams through calling for Expressions of Interest for bringing capability to a team, is that we have greatly increased the number of early career researchers in the challenge. This is one of the great benefits of moving from an Investigator-led process to a Mission-led process.

Early stage researchers, including PhD students, were already part of SfTI research teams. However, our intent going forward is to require Project Leaders to demonstrate how they are involving emerging researchers and thinking about their CD (and succession planning). A second Tranche strategy is to allow recruitment of PhD students and post-doctoral researchers to commence once a project is approved, rather than waiting until after the contract is signed as is currently the case.

Tranche 1 capability building was very much focused on domestic recruitment of required expertise. As the Challenge matures beyond our start-up phase, we will put more emphasis on how we connect with international communities, as described earlier. Exemplar organisations include the Electronics and Telecommunications Research Institute, or the National Research Council of Science and Technology in South Korea, Astar in Singapore, Fraunhofer IPA (Automation Institute) in Germany, and the Chinese Academy of Sciences. We are working with MBIE's international team to initiate these collaborations and to ensure SfTI's activities align with MBIE's policy and plans for nation-wide international collaboration.

We may have more opportunity to connect through overseas national projects (rather than organizations) that are aligned with our Spearhead projects. An early example of this is an embryonic relationship between our Precision Farming Technologies for Aquaculture Spearhead, which is focused on intelligent ocean farming of mussels, and a project in Norway on Precision Fish Farming (SINTEF Ocean), which has similar technology goals but aimed at Atlantic Salmon. We will work with our other Spearheads to identify similarly aligned projects to enhance our international reach.

Ensuring Science Quality and Creating Balance Across the Challenge

SfTI held our first Science Quality Review (SQR) at about our two-year mark, late in 2017. The SQR evaluated the quality of our current science projects, including alignment with our mission, advised where we needed to improve and what future steps we should take (the SQR report is provided in the Supplementary Material). The SQR proved very successful, with recommendations constituting an important resource for SfTI's Board and Management Team, as well as the status of our SQR

panel members giving reputational benefits to SfTI. The SQR report was extremely helpful for SfTI as we refine our processes going forward and has reassured our Board and stakeholders that we are performing well. Thus, SQRs are set to become an integral part of the ongoing SfTI cycle, with the next SQR planned for the second year of Tranche 2 (see figure 2.10) and at regular intervals going forward, especially before funding decisions and Mission Labs.

The Challenge has a range of projects at varying stages along the journey from high-risk to potential high-return in commercialisation and we will continue to invest in research at these different stages. According to the National Statement of Science Investment (MBIE, 2015), National Science Challenges sit on the cusp between Horizon 1 (Generate New Ideas) and Horizon 2 (Developing Emerging Ideas) – a space that might be termed ‘impactful ideas’. We will, though, feed projects into Horizon 3 (Leveraging Proven Ideas) creating a good blend of the three horizons over time.

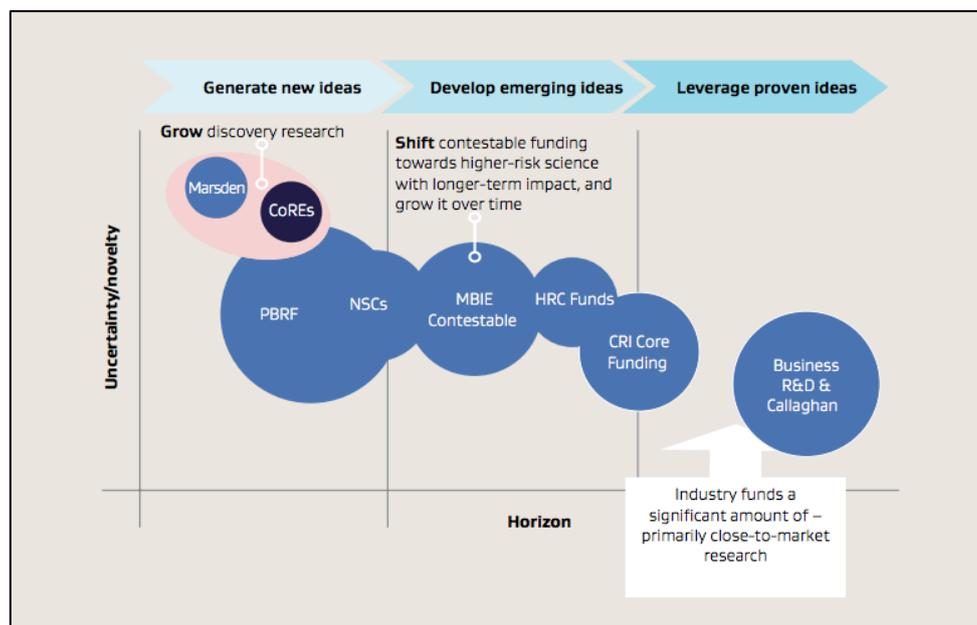


Figure 2.7: New Zealand's Science Research Ecosystem Horizons

In our start-up phase we concentrated on establishing ‘stretchy’ Spearhead and Seed projects of discovery research for which longer-term impact was forecast. As time progresses, these initial projects will move (and are moving) along the horizon continuum as indicated by their annually reported technology readiness levels (TRLs). SfTI will continue to feed the horizon pipeline as we regularly instigate new Spearhead and Seed projects. However, we will need our collaborations with partners in order to complete our horizon pipeline, as already indicated.

SfTI does allow for high risk, stretchy science missions to ‘fail’, although we see this as simply indicating that the research has successfully proven this particular pathway to be not a fruitful one. Importantly, because we form best teams based on strong capabilities, individual researchers whose projects are discontinued remain part of the SfTI community and can in future join other projects as appropriate. Successful failing is not an oxymoron but is a skill set that is hard to develop in a highly competitive system. However, SfTI views it as a necessary capability for stretchy research.

On a more regular review and reporting basis, SfTI has put in place a solid programme that ensures quality is monitored throughout the research process and regularly reported to the Board. Theme leaders implement a very structured monitoring programme for Spearhead and Seed projects to ensure agreed stage gates and critical steps are achieved. Non-achievement warrants focused discussions about additional assistance, external review if needed, and the potential for pivoting or discontinuing the project, as already described.

SfTI decided not to allocate specific amounts to each of our four Themes in order to maintain the flexibility mentioned earlier. Given that our Themes overlap, a predetermined budget split would not make sense, but we try to ensure we are balanced in terms of coverage by constantly monitoring where resources are focused. For example, we noticed that in our 2016 Seed round, successful projects were under-representative of VM, emerging researchers, and ITDAM projects. So in our 2017 round we put a particular emphasis on projects in these categories, complete with a prior roadshow by our ITDAM Theme Leader covering what makes a 'good ITDAM' project, and ensuring the assessment panel had strong ITDAM representation. We were far more successful in the 2017 round on all these counts, so much so that MBIE approached us to ask what SfTI did to encourage the high level of quality ITDAM proposals, in particular, as they generally suffer from a low funding profile in NZ's traditional grant instruments.

2.2.3 Delivering Impact

Our vision for New Zealand to have a vibrant and prosperous technology-driven and inclusive economy was described at the outset. Our (renamed) Themes: VM; Sensors, Robotics and Automation; Data Science and Digital Technologies; and Materials, Manufacturing Technology and Design, are our areas of capability and are arguably some of the most important knowledge areas in which New Zealand needs strength. They underpin many of the global technology trends, and our economy, including the Māori economy, will not flourish without them.

In our original plan, SfTI encapsulated expected impacts and potential economic benefits within a set of economic key performance indicators, given below:

- The number of new commercial products or services directly related to SfTI research that are commercialized or in the process of being commercialized is at least 10 by 2025 and with a combined estimated value of \$NZ 500 million within 10 years of the first sale or implementation. ‘Value’ includes new sales, efficiency gains. (*Stretch*)
- The number of new commercial products or services directly related to SfTI research that are commercialized or in the process of commercialization (at a technology readiness level of at least 6 as defined in Supplementary Material 1) is (*Committed*):
 - at least 3 by 2020 and having a total estimated value of \$NZ150 million within 10 years of the first sale or implementation, and
 - at least 6 by 2025 and having a total estimated value of \$NZ300 million within the first 10 years of sale or implementation.
- Evidence that SfTI research is being used and/or SfTI researchers are being employed by NZ businesses. Evidence may include but is not limited to, successive increases in the number of spill-over commercialization activities that are directly related to SfTI research (this includes patenting, funding through commercialization offices, funding by Callaghan Innovation), and there is a successive increase in the number of SfTI alumni employed in NZ businesses (*Stretch*).
- By 2025, the contribution of medium-high and high tech industry to NZ’s exports is doubled from 2015 figures (*Stretch*).

SfTI remains dedicated to these KPIs, and we are already seeing progress on the TRLs of our current projects. Equally, we are determined to make this country’s research ecosystem more collaborative and connected with industry and Māori than it has been in the past, and thus delivering significantly scaled up economic growth driven by collaborative innovation. None of these impacts can be achieved by SfTI alone. We must work in our ecosystem and with our horizon partners. Our Future Strategy envisages building unique capability in our ecosystem, that is, ‘sticky’ to New Zealand, and generating not only domestic but also global impact.

Creating a Credible Pathway to Impact

SfTI’s vision for creating a credible pathway to impact rests on our underpinning vision of enhancing the capacity of New Zealand’s Innovation System. We have outlined our CD programme, which focuses on creating direct and indirect impact on our SfTI community researchers.

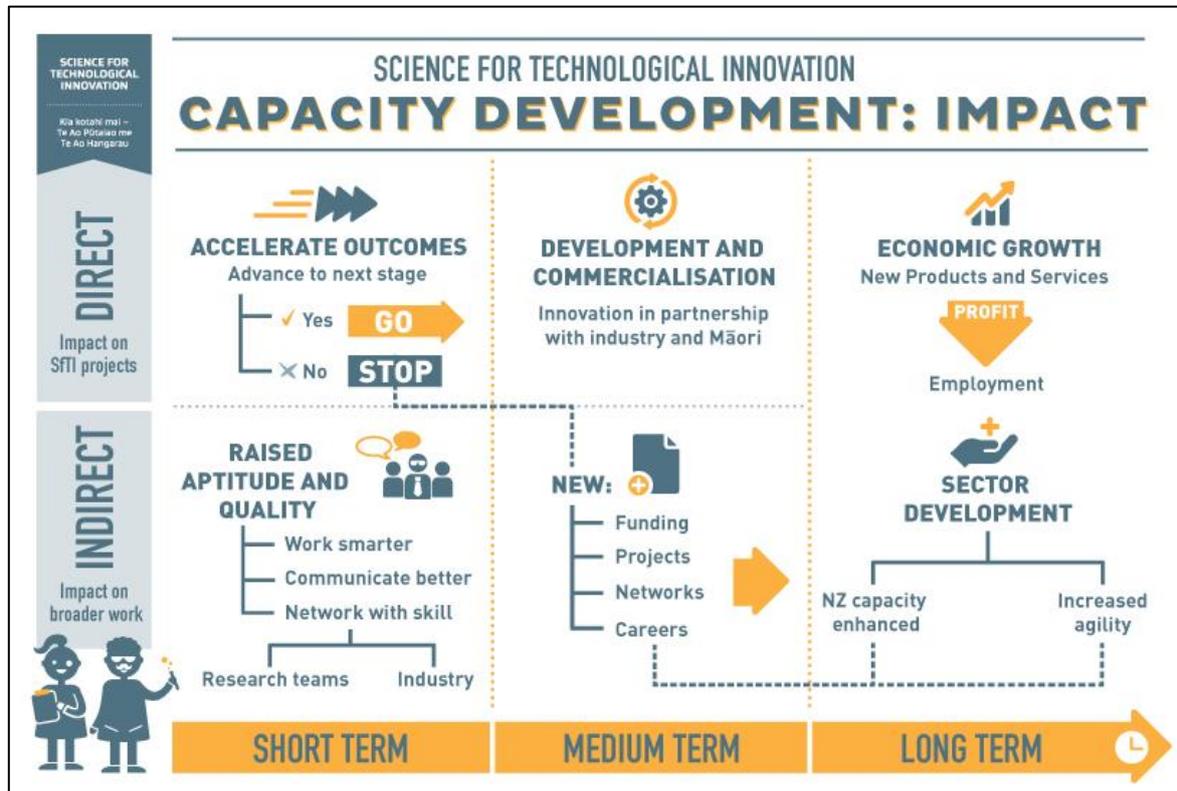


Figure 2.8: Capacity Development Impact Model

However, we are only one part of the ecosystem that will generate impact in the longer-term so we have to work closely with others as our mission-led research projects graduate along the horizon continuum to other industry and Māori led initiatives.

Given that SfTI focuses on the earlier, impactful ideas horizon of the science-technology pipeline, understanding when a research project needs to move on from SfTI is a question we consider, and one that will become more relevant in the second Tranche. While it can be difficult to determine when a project is ‘finished’ in terms of being within the SfTI stable, we will establish a more formalised process for facilitating next steps.

An important element of this is extending and solidifying our connectedness with the rest of the ecosystem. As indicated in the Horizon profile (MBIE, 2015) above, SfTI fits on a scale between blue skies research and commercialisation, deliberately more impactful than Marsden funding but further from commercialisation than projects funded through MBIE Endeavour grants, and well before CI (or Angel and VC) funding to companies.

Creating credible pathways to seamlessly move our research across horizons to outcomes starts with involving industry and Māori organisations as we form Spearhead projects. It ends via partnerships

with a range of others who can take up the commercialisation reins after initial research has proven the concept and is ready to prototype. We also work with strategic partners in order to avoid duplicating the commercialisation and implementation expertise of others. Intellectual Property is a key issue, for example; SFTI is not responsible for IP development, this rests with the lead institution, which is usually a CRI or University, and most are partners of SFTI.

Our partners include CI, KiwiNet and RoS, research organisation commercialisation offices, NZTech, BusinessNZ, as well as individual investors, companies and Māori organisations. We already work very closely with KiwiNet and RoS on jointly developing CD initiatives. CI, as our host, provides excellent networks for us to access the tech sector (and vice versa when CI needs access to our capability). Our future strategy is to further formalise these pipeline relationships as our scale of project flow will double, providing value back into the research and business ecosystems, and significantly enhancing the output of NZ's innovation pipeline.

Delivering Benefits and Additionality

At the outset of the Five Year Strategy we articulated how our additionality model (figure 2.1) underpins how we think about what SFTI does: it must add benefit over and above what other funding programmes might achieve. We add benefit and additionality through enhancing capacity; technical, relational and human capacity.

Focusing on all three capacities illustrates that we are doing more than simply allocating grants (which is technical capacity only). Our capacity building work literally changes behaviour around how researchers develop and manage their projects, how they engage with industry, and how industry can engage earlier in project formation. Equally, learning how research (and commercialisation) processes can be developed with reference to correct kaupapa is a task the Challenge is continuing to elaborate as we move into the Second Tranche.

At this stage we have worked extensively to enhance the capacities of SFTI researchers in gaining the breadth of skills to create the greatest impacts from their research, particularly in terms of collaborating with industry and Māori organisations. When we have had spare capacity, we have invited researchers from other Challenges to attend our programme so the benefits of what we are doing are seen in the wider research community.

It is this behaviour change, which we are beginning to observe in our own community, which could be disseminated more widely to NZ's innovation system, for example, through similar CD programmes or through diffusing the learnings from our BNZIC team. Thus, more wide-spread benefit would accrue to Aotearoa New Zealand's science ecosystem and economy. We will work to diffuse our process innovations more widely in the research ecosystem during Tranche 2.

2.2.4 Decision-Making and Accountability Processes

Governance, Management and Financial Structure

SfTI does not intend to make any major changes to our governance, management or financial structures. The existing governance structure of four corporate governance board members, Kāhui Māori and three science advisors, is working well. The only adjustment expected in terms of SfTI's decision-making framework will be the redeployment of Portfolio Leaders. This decision makes sense for the Challenge given that the growing number of application areas would create a very complex matrix structure:

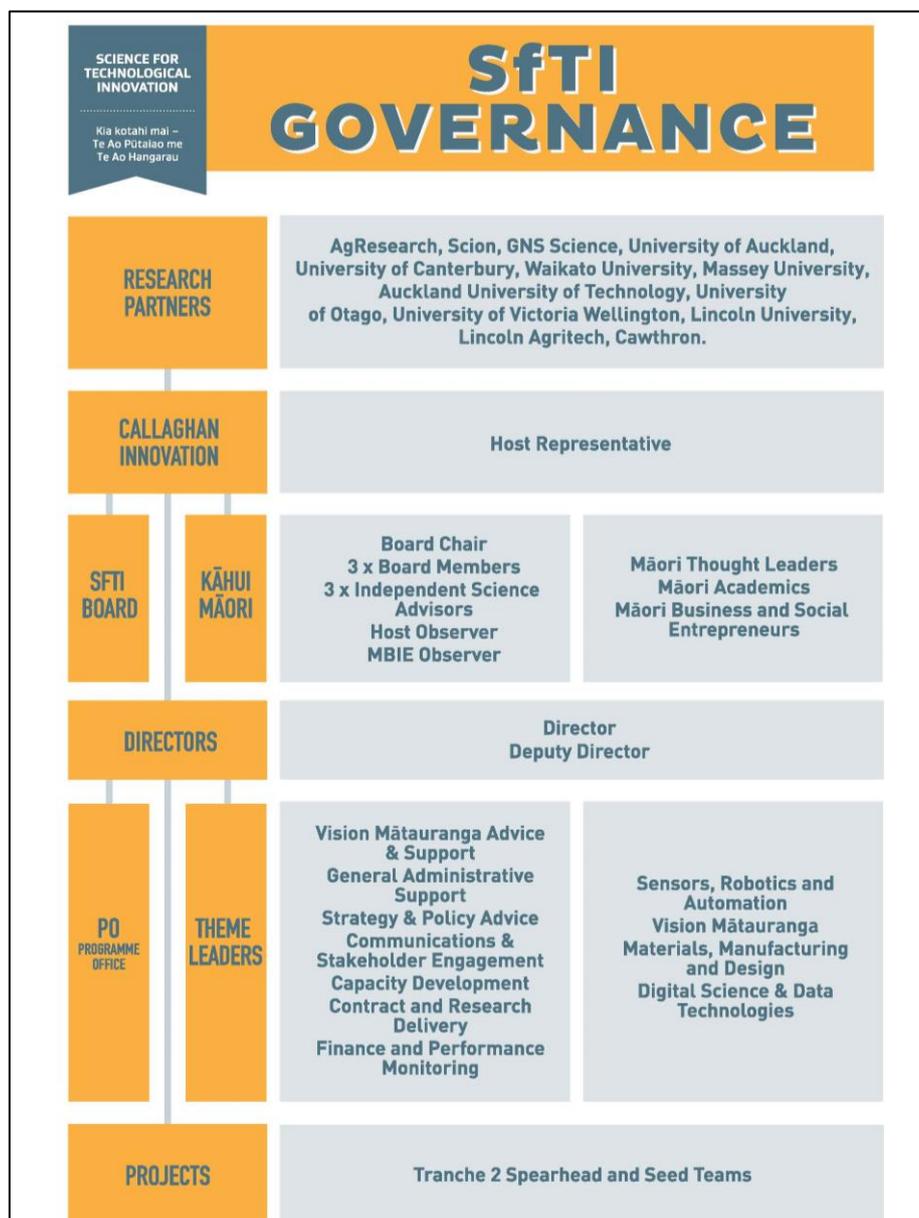


Figure 2.9: SfTI's Tranche 2 Governance Structure

The benefits of the modified structure are to simplify our old matrix and emphasise a more traditional portfolio of projects under programmatic Themes. This will result in a stronger level of attention being focused towards delivering on the four key Themes of SfTI, while managing a dynamic portfolio of projects across the sectors and topics developed by our ongoing Mission Labs and Seed project processes. We need to instigate a more pragmatic grouping as the number of projects scales up, and as the management team Theme members are required to coordinate with multiple projects, stepping away from directly managing single projects.

As described earlier, this structural change sees both the Portfolios and Portfolio Leader role disestablished in favour of Project Leaders having direct relationships with Theme Leaders. In future, each Theme will have two leaders. This retains the current size of the Management team, as the BNZIC Leaders will act as Theme Leaders. Theme Leaders (including transitioned Portfolio Leaders as appropriate) will continue to facilitate New Zealand-wide networking across researchers within their stable and ensure the best portfolio of research is being undertaken, including identifying gaps, to achieve the intended outcomes of their overarching Theme.

The roles of the Theme Leaders will be to:

- mentor and monitor projects under their Theme ambit;
- identify and build the NZ research community related to their Theme (with others);
- encourage and facilitate (through our established project selection processes) new and continuing projects that deliver to the Theme and SfTI ambitions;
- encourage cross-fertilization of ideas and teams between Themes within SfTI;
- feed to CD Manager any team ideas for appropriate new CD initiatives;
- manage the pipeline (3 Planning Horizons) through SfTI partner connections;
- work with other Theme Leaders to maintain balanced investment across Themes;
- manage overall project risk, deviations or pivots;
- work to achieve maximum SfTI benefit and impact;
- maintain good communication between assigned projects and the Management team and Board;
- engage with others outside SfTI who have interests in the Theme, including CI Network Managers, and industry/sector representatives.

The Project Leaders will not be management team members and will focus on project execution, staying well informed on how individual projects are progressing against stage gates. Each project will be assigned a primary Theme Leader.

Theme performance will be reported quarterly to ensure the Management Team and Board are both informed on the range of projects and progress against performance criteria, budget spend and movement towards intended benefits and impacts.

Our excellent Programme Office will continue to be embedded in the Gracefield campus of CI, working together with the key CI groups including finance, people and culture, network managers, and industry-facing researchers. While we have refined the roles during Tranche 1, the scale may need stepping up, and the Programme Office will grow as needed to manage the increased number of projects and the scaled-up interactions we plan with stakeholders. The key roles are programme and contract management, stakeholder and communications management, capacity development management, finance and performance management, and administration support, all overseen by

an experienced senior manager and strategic advisor. The team is small and while CI provides significant help as the host, our team must work broadly across both strategic and “nuts and bolts” activity, and manage multiple, continually evolving activities.

Giving Effect to Vision Mātauranga

SfTI’s VM approach is intimately integrated into all that we do. Because the SFTI Theme areas related to physical sciences and engineering are relatively new to the Māori economy (and vice versa), there is great enthusiasm on the part of Māori representatives we have engaged with to become seriously embedded into what SfTI is trying to accomplish. Our vision for a high-tech NZ economy intimately aligns with Māori aspirations.

There are no major accountability or decision-making arrangements that need to be changed for Tranche 2. VM considerations are already well entrenched in all our decision-making processes, whether that be at a Board or Management team level, or at a project assessment and approval level. We are constantly checking that we are following best-practice with our VM management team members, Kāhui Māori and other Māori partners (FoMA, Iwi Leaders Group etc.). We are humble in how we approach our VM initiatives as there is so much to learn, and SfTI is always open to changing our processes should we find aspects we can improve. Our aim is for such VM considerations to become BAU, that is, all our community understand what is needed, rather than engagement with Māori being a consultation (or worse, a tick-box) exercise.

2.2.5 Indicative Budget

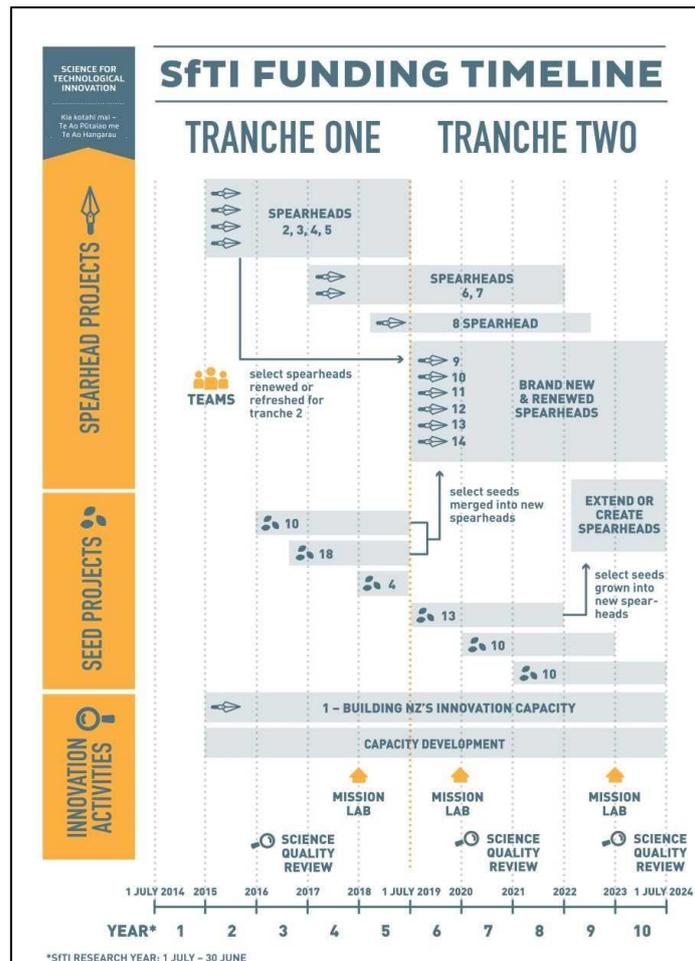


Figure 2.10: SftI Funding Timeline

FIVE-YEAR INDICATIVE BUDGET SUMMARY FY2020 - FY2024						
Science for Technological Innovation						
	FY2020 Budget	FY2021 Budget	FY2022 Budget	FY2023 Budget	FY2024 Budget	TOTAL 2020 to 2024
REVENUE	\$k	\$k	\$k	\$k	\$k	\$k
MBIE Funding	\$ 15,930,684	\$ 16,399,450	\$ 18,584,824	\$ 12,970,866	\$ 9,494,176	\$ 73,380,000
Total Revenue	\$ 15,930,684	\$ 16,399,450	\$ 18,584,824	\$ 12,970,866	\$ 9,494,176	\$ 73,380,000
RESEARCH AND DEVELOPMENT						
Spearhead Projects	\$ 10,000,000	\$ 10,000,000	\$ 12,000,000	\$ 6,500,000	\$ 3,000,000	\$ 41,500,000
Seed Projects	\$ 2,800,000	\$ 3,500,000	\$ 3,500,000	\$ 3,500,000	\$ 3,500,000	\$ 16,800,000
Total Research & Development	\$ 12,800,000	\$ 13,500,000	\$ 15,500,000	\$ 10,000,000	\$ 6,500,000	\$ 58,300,000
MISSION DELIVERY						
Mission Delivery (incl. Capacity Building, Outreach Activities, Mission Labs and Review of Challenge)	\$ 1,914,008	\$ 1,684,089	\$ 1,854,570	\$ 1,725,462	\$ 1,746,771	\$ 8,924,900
Total Mission Delivery	\$ 1,914,008	\$ 1,684,089	\$ 1,854,570	\$ 1,725,462	\$ 1,746,771	\$ 8,924,900
OPERATIONS MANAGEMENT AND GOVERNANCE						
Operations & Governance (incl. Strategic Fund/Contingency)	\$ 1,216,676	\$ 1,215,361	\$ 1,230,254	\$ 1,245,404	\$ 1,247,404	\$ 6,155,100
Total Operations Management & Governance	\$ 1,216,676	\$ 1,215,361	\$ 1,230,254	\$ 1,245,404	\$ 1,247,404	\$ 6,155,100
Total Expenditure	\$ 15,930,684	\$ 16,399,450	\$ 18,584,824	\$ 12,970,866	\$ 9,494,176	\$ 73,380,000

Figure 2.11: SftI's Indicative Budget

2.3 Scenario Planning

Additional funding would have two potential benefits for SfTI in achieving our vision for a New Zealand with a vibrant and prosperous technology-driven economy. First, we would better influence the wider science and innovation ecosystems, and second, we would conduct more of the research we know industry is eager to be part of.

Greater Influence on New Zealand's Innovation System

One limitation for SfTI is our ability to influence across the New Zealand science ecosystem. Our funding covers a small fraction of all projects and activities, and our CD programme and stakeholder interactions are a small fraction of what occurs within NZ's innovation ecosystem. As a result, we focus on our distinctive additionality and activities to attract the attention of others and influence them to follow. However, diffusion in this manner is slow. A step up in scale for SfTI funding would enable us, together with CI, to diffuse our practices by significantly increasing the direct interactions we have with researchers, industry and Māori in funded projects and CD activities. It would enable us to create funded links and effect direct changes at research organization level, for example, by making joint funding decisions with CI (for both business and research).

More Research

If the Challenge were to access additional funding, more Spearhead and Seed research would be undertaken, greatly expanding our reach and ability to impact NZ's economy and society. We already have more impactful ideas than can currently be funded. For example, we cannot fund all seven concepts from our second Mission Lab, let alone our experimental Rangatahi Spearhead. Similarly, we cannot always fund all the excellent Seed proposals that make it to our ballot. Being able to act immediately on promising projects would enhance SfTI's ability to achieve our vision.

As global technologies advance, we would expect new potential missions to arise that would ensure New Zealand is at the forefront in our chosen areas of focus. As the 'tech for' Challenge, we are being lobbied with suggestions for additional missions from a range of sources including other Challenges, industry, and Māori organisations. This is a good sign for SfTI. However, we need to be able to meet expectations of funding and delivering these projects in order to put our SfTI vision into full effect. Additional funding could be used for targeted Mission Labs to further scope areas of high potential and high demand, ensuring investments are strongly signalled. We would be able to bring forward some important new missions already mooted, such as low-carbon tech and water-tech.

Finally, our current funding level places limitations on project size. Additional funding might allow us to accelerate our immediate impact plans, especially as the \$1M pa Spearhead envelope is significantly less than a large MBIE grant and possibly a disincentive for some senior researchers. We would 'scale up' funding of Spearheads and Seeds that are looking particularly promising through industry validation. We could also develop bigger pan-NZ projects where we bring together multiple large projects (for example, MBIE projects with SfTI projects). In this way we could involve nearly all research organizations in one large project, thus increasing our ability to bring researchers together, and to promulgate our SfTI processes for project development across research organizations.

"Ideas are Easy. Implementation is Hard." (Guy Kawasaki)

3. Supplementary Information

- 2018 Researcher Workshop booklet
- Mission Lab Report (2018)
- Kāhui Terms of Reference
- Parliamentary Booklet
- SQR
- Examples of SFTI's Innovate (external) and Aspire (internal) Newsletters
- Technology Readiness Levels