

2022 RfP Guidelines

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Te Hiranga Rū QuakeCoRE: Centre for Earthquake Resilience

Issued: Wednesday 21 September 2022

Proposals Due: Noon (NZT) Friday 21 October 2022

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1. Key Information: 2022 RfP Guidelines

Below is the key information about the 2022 QuakeCoRE Request for Proposals (RfP):

- Request for Proposals (RfP) Summary
- Project proposals are invited in three key areas:
 - A: Disciplinary Theme (DT) & Inter-Disciplinary Programme (IP) Research Projects
 - B: Proposal Development Grants
 - C: Workshop Grants
 - D: Co-ordination Mechanism Grants
 - E: Māori Capability Development Grants

Project funding will be for up to two years - and will cover the period from 1 April 2023 – 31 March 2025.

A: Disciplinary Theme (DT) & Inter-disciplinary Programme (IP) Research Projects:

- Disciplinary Theme (DT) & Inter-disciplinary Programme (IP) Research Programmes are comprised of non-contestable Coordinated Projects and contestable Research Projects funded under this RfP.
- The Programme Area Leaders (PALs) have submitted a non-contestable Coordinated Project for review and endorsement. We encourage investigators to engage with the Programme Area Leaders to understand the opportunities to contribute to or align with this critical component of the overall Research Programme.
- Contestable Research Projects (funded under this RfP) will complement the Coordinated Projects while still meeting the objectives of the Research Programmes described in Section 7 of the 2022 RfP Guidelines below.
- Contestable Research Projects (funded under this RfP) can include support for research assistants, masters and PhD students. Funding for outstanding masters and PhD students is also available specifically through the two-year masters and three-year PhD scholarship round. Details on the Scholarship application process are available [here](#).

B: Proposal Development Grants

- Applications from early-career researchers toward research-related costs for the development of contestable external research proposals targeting specific contestable funding programmes.
- Applications in this category are particularly encouraged for potential applicants who are in the early-career stage, and may not yet have developed a comprehensive research portfolio.

C: Workshop Grants

- Applications to host a workshop aligned to the QuakeCoRE Mission between 1 January and 31 December 2023. Workshops can be held directly in conjunction with the QuakeCoRE Annual Meeting (28-31 August 2023), or at a separate occasion.
- Workshops in the following areas are particularly encouraged: (i) interactive workshops that advance multi-disciplinary collaborations, coordinate and develop capability across different Disciplinary Theme / Interdisciplinary Programme areas, and seek to identify co-funding agencies are strongly encouraged; and (ii) workshops which engage end-users, partners, and non-earthquake specialists in QuakeCoRE-funded research.

D: Co-ordination Mechanism Grants

- Applications should be submitted by a co-ordination mechanism leader to request funds for the period 1 January – 31 December 2023 to advance activities related to the development activities in the specific area.
- Applications are strongly encouraged from Regional Network Area 5 (South Pacific) as well as from Coordination Mechanisms that are further developing activities from the previous QuakeCoRE research programme (Research Area 1 (Alpine Fault) and Research Area 2 (Wellington)).

E: Māori Capability Development Grants

- Applications to facilitate the participation of Māori researchers in the QuakeCoRE research programme and community activities. This funding will support the engagement of Māori researchers throughout Te Hiranga Rū QuakeCoRE. Māori researchers looking to fund specific research projects aligned to the QuakeCoRE mission should consider funding categories A and B.
- Funding can be used for activities such as: travel support for networking to interact with existing researchers in the QuakeCoRE community; attendance at the QuakeCoRE Annual Meeting and summer student support for pilot research.

Travel

- No applications for stand-alone travel grants to attend the QuakeCoRE Annual Meeting will be accepted as part of the RfP in 2022. Instead Annual Meeting travel grant applications will be aligned to the registration for the Annual Meeting each year. Annual Meeting travel should be included in all project applications.

2. Introduction

Te Hiranga Rū QuakeCoRE supports and co-ordinates research in earthquake resilience, providing a focal point for national and international collaborations. QuakeCoRE is a Centre of Research Excellence (CoRE) funded by the Tertiary Education Commission (TEC) from 1 July 2021 – 31 December 2028.

QuakeCoRE's mission is to place Aotearoa New Zealand at the worldwide forefront of earthquake disaster resilience by utilising Aotearoa New Zealand as a natural earthquake laboratory, producing new knowledge on the seismic response of the built environment, developing models to understand vulnerabilities within this environment, and designing innovative technologies and decision-support tools enabling rapid recovery of Aotearoa New Zealand communities.

QuakeCoRE's vision is an earthquake-resilient Aotearoa New Zealand where thriving communities have the capacity to recover rapidly after major earthquakes through mitigation and pre-disaster preparation informed by internationally-leading research excellence.

Building on achievements during 2016-2020 (Phase 1), the second phase of Te Hiranga Rū QuakeCoRE will establish multi-institutional research programmes with international networks. The research programmes (Figure 1) will advance the science and implementation pathways of earthquake resilience through system-level science with deep collaborations coordinated across engineering, physical and social science disciplines and research institutions. The primary research structure is two-tiered in nature with: (i) Disciplinary Themes; and (ii) Inter-disciplinary Programmes, the latter representing the convergence of several themes toward the vision of earthquake resilience.

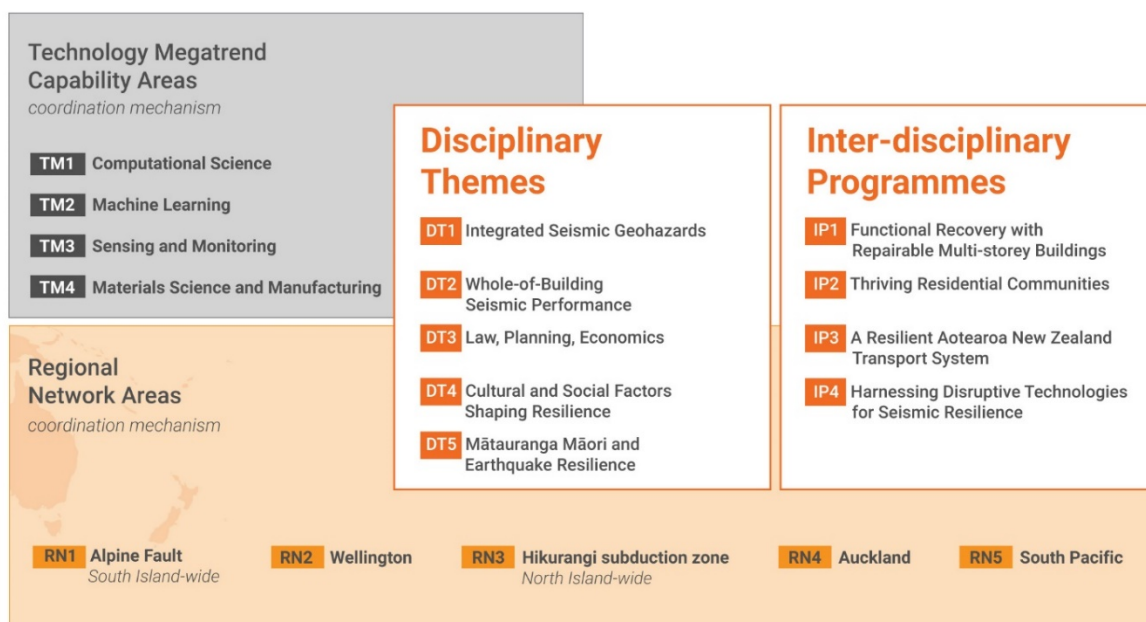


Figure 1: Te Hiranga Rū QuakeCoRE (Phase 2) Research Structure. Disciplinary Themes collectively span the disciplinary pipeline of earthquake resilience research and focus on transformative research questions; Inter-disciplinary Programmes leverage Aotearoa New Zealand's unique challenges and opportunities toward the global vision of earthquake resilience using Aotearoa New Zealand as a natural earthquake laboratory; Coordination Mechanisms enhance the Disciplinary Themes and Inter-disciplinary Programmes through accelerating capability development and utilization of research technologies, and regional networks that provide connectivity and a pathway to impact.

Key Initiatives

Disciplinary Themes: Research areas that collectively span the disciplinary pipeline of earthquake resilience and focus on transformative research questions in which Aotearoa New Zealand researchers have shown global leadership.

Inter-disciplinary Programmes: Inter-disciplinary research that leverages Aotearoa New Zealand's unique situation and challenges to advance the vision of earthquake resilience. These programmes draw on expertise in multiple disciplinary themes.

2022 RfP Guidelines: This document, referred to as the 2022 RfP Guidelines, describes the mechanisms for collaboration and solicits proposals from investigators to participate in the QuakeCoRE programme.

Feedback from the 2021 RfP is available [here](#) and a list of projects that were funded under the 2021 RfP is available [here](#).

3. Proposal timelines

The timelines for all project proposals submitted under this RfP are:

- 21 September 2022: Request for Proposals (RfP) released
- Friday 21 October Noon NZT: Applications close. Late proposals will not be accepted
- November: Evaluation and review process
- Mid-December: Outcomes advised
- 1 April 2023: Projects commence

4. Guidelines for proposal submission

Submission Instructions: Proposals must be submitted via email to: quakecore@canterbury.ac.nz.

Application Forms: All proposals must use the relevant QuakeCoRE RfP Application Template and budget template, where applicable. All forms are available on the QuakeCoRE website [here](#).

Investigator responsibilities: To achieve the QuakeCoRE mission, QuakeCoRE investigators are expected to interact with the QuakeCoRE community on a regular basis (eg attending the Annual Meeting and presenting QuakeCoRE-funded research in the poster sessions, attending monthly Research Programme meetings and the QuakeCoRE Seminar Series), and to contribute all relevant data, experimental and analysis results and computational codes/models to the appropriate open-source repositories. Publications resulting entirely or partially from QuakeCoRE funding must include

a QuakeCoRE publication number and funding acknowledgement. By submitting a proposal, investigators are agreeing to these conditions, and performance in this regard will be considered in future QuakeCoRE proposals.

Eligibility: Specific eligibility is as follows:

A: Disciplinary Theme (DT) and Inter-disciplinary Programme (IP) Research Projects

- Limit of one application or project per investigator as the project lead and listed as a researcher on a maximum of two projects at any point in time, including the application stage and projects funded under previous QuakeCoRE RfPs.
- Proposals should be submitted by QuakeCoRE Associate Investigators (AIs) as the project leader.
- Programme Area Leaders are not eligible to apply.

B: Proposal Development Grants

- Limit of one application per investigator as the project lead and listed as a researcher on a maximum of two projects at any point in time, including projects funded under previous QuakeCoRE RfPs.
- Proposals will primarily be submitted by QuakeCoRE Associate Investigators (AIs); however, consideration will be given to researchers who are newly engaged with the Te Hiranga Rū QuakeCoRE Research Programme and those researchers starting academic employment.
- Applications in this category will only be accepted from early-career researchers, for the purposes of this RfP, these are considered to be researchers that completed their PhD no more than 7 years ago, as at 30 September 2022, extensions to this timeframe will be considered for parental leave or similar career breaks.
- Proposals must include a mentor that is currently either a QuakeCoRE Programme Area Leader (PAL) or Associate Investigator (AI).

C: Workshop Grants

- Limit of one application per investigator as the project lead and listed as a researcher on a maximum of two projects at any point in time.
- Proposals will be accepted from all QuakeCoRE researchers (AIs and PALs); consideration will also be given to researchers who are newly engaged with the Te Hiranga Rū QuakeCoRE Research Programme.
- Programme Area Leaders (PALs) must demonstrate clear and compelling reasons as to why the workshop is not being supported from existing Coordinated Project funding.

D: Co-ordination Mechanism Grants

- Applications should be submitted by a co-ordination mechanism leader, with a limit of one application per investigator as the project lead

E: Māori Capability Development Grants

- Proposals are welcomed from any Māori researcher who wishes to engage with the Te Hiranga Rū QuakeCoRE research programme or community. No prior involvement with QuakeCoRE is necessary for this funding application category, but those who have previously engaged with QuakeCoRE programme and would like further support are also encouraged to apply.
- Programme Area Leaders are not eligible to apply.

Budget guidance: Disciplinary Theme (DT), Inter-disciplinary Programme (IP) Research Project proposals funded under this RfP should be of a reasonable scale; between \$20,000 and \$70,000. Proposal Development Grants should be for total project budgets of less than \$15,000. Proposals submitted under categories C (Workshop Grants), D (Co-ordination Mechanism Grants) and E (Māori Capability Grants) should be for a maximum of \$5,000.

Note that budgets cannot include investigator salary or CapEx. Postgraduate student stipends should be at the following annual rates:

- 1) \$15,000 for a fulltime Masters stipend with compulsory domestic tuition fees or
- 2) \$28,000 for a fulltime PhD student stipend with a contribution of \$8,000 for fees.

A contribution of up to \$1,000 per year for QuakeCoRE Annual Meeting Travel funding of should be included in the budget for all key research contributors that do not already have funding from another QuakeCoRE source.

Award procedures: QuakeCoRE is funded by the TEC as a Centre of Research Excellence (CoRE). All dispersed funding will be in the form of a standardized subcontract from the University of Canterbury as Host institution, and subject to the conditions of the funder, TEC.

Review and Evaluation: Review coordination and evaluation of proposals is performed by the RfP Review Panel (comprising the QuakeCoRE Research Planning Committee and industry representatives for each Programme area, or delegates as well as members of the DEWI and CEE Committees), and proposals will be either funded or rejected, without negotiation with the project leader.

5. Evaluation process and criteria

Proposals submitted should respond directly to the 2022 RfP Guidelines. A primary consideration in evaluating proposals will be how directly the proposal addresses the mission and vision of QuakeCoRE.

Proposals will be evaluated against basic eligibility criteria:

Budget: Budget is in line with funding guidelines and includes only eligible expenditure

Eligibility: Project is led by an eligible member of the QuakeCoRE community

Vision Mātauranga: Project demonstrates an appropriate consideration and incorporation of Vision Mātauranga

Fit: Project is within programme scope

Projects that meet the basic eligibility criteria listed above will be sent to the review panel for assessment. The specific evaluation criteria for Categories A and B used by the panel and their weighting are:

Research Excellence (40%)

- Quality of proposed research
- Track record and ability to deliver proposed research

Human Capability Development (30%)

- Involvement of students and emerging researchers
- Development and support for all, including but not limited to, Māori as tangata whenua and / Pasifika people, engineers who identify as women, and those who identify as gender diverse.

Fit with QuakeCoRE Mission and Values (30%)

- Priority of the proposed research for the QuakeCoRE Research Programme
- Commitment of investigators to the QuakeCoRE mission and values, including strong collaboration
- Value of research relative to its cost
- Relevance and translation to practice including direct and active involvement of end-users and stakeholders

Vision Mātauranga

The consideration of Vision Mātauranga will follow that of Royal Society of New Zealand Te Apārangi.

Proposals are requested that are developed to reflect Māori research needs, interests, objectives and priorities concerning Māori and national built, social, economic and environmental resilience to earthquakes. Applicants may find further guidance and information at the following links:

- MBIE Vision Mātauranga Policy ([Link](#))
- MBIE Vision Mātauranga Booklet ([Link](#))
- Royal Society Vision Mātauranga Guidelines ([Link](#))

This Vision Mātauranga policy is about innovation, opportunity and the creation of knowledge that highlights the potential contribution of Māori knowledge, resources and people.

There are four themes:

- Indigenous Innovation, which involves contributing to economic growth through distinctive research and development;
- Taiao, which is concerned with achieving environmental sustainability through iwi and hapū relationships with land and sea;

- Hauora/Oranga, which centres around improving health and social wellbeing; and
- Mātauranga, which involves exploring indigenous knowledge.

Vision Mātauranga is now included as an assessment criterion for all QuakeCoRE projects.

Proposals should consider the relation of the research to the themes of Vision Mātauranga and, where relevant, how the project will engage with Māori.

Where research projects are of relevance to Māori or involve Māori, QuakeCoRE expects that applicants are in consultation with Māori at the planning stage, so as to achieve the best possible outcomes.

Up to one additional page will be available for statements on Vision Mātauranga. This is to enable Vision Mātauranga to be more easily integrated into the conceptual framework and/or research design. Where Vision Mātauranga is appropriate to a proposal, it can contribute to the assessment of its overall excellence.

How do I decide whether to include a Vision Mātauranga statement in my proposal?

A Vision Mātauranga statement must be included for all research that has relevance for Māori. The research category descriptions outlined in the next section may help you decide if this applies to your project. Please note, however, that those categories are fluid, there may well be overlap between them, and not every point in each category need apply.

Categories of Research

The five categories identified below have been adapted from those on the National Science Challenge, Biological Heritage website hosted by Manaaki Whenua Landcare Research ([Link](#)). Please note that there may well be overlap between categories as in categories 2 and 3 in terms of the nature and degree of relevance to Māori.

The original categories were set out by MBIE in information for the Endeavour Fund c. 2015. Further details on each category and further guidance on developing a Vision Mātauranga statement are available [here](#):

1. Research with no specific Māori component
2. Research involving Māori
3. Research specifically relevant to Māori
4. Māori-centred research
5. Kaupapa Māori research

Key Criteria for 2022 RfP

Proposals will be assessed on the RfP selection criteria, however we have identified areas where priority will be given to proposals that appropriately support our focus on the following areas:

A: Disciplinary Theme (DT) and Inter-disciplinary Programme (IP) Research Projects

- Support projects aimed at securing future external funding.

- Support research activities that leverage existing research projects
- Support Associate Investigators and project leaders that identify as Māori or Pasifika; Associate Investigators in engineering disciplines that identify as women, early-career researchers¹, those returning from industry, and those who identify as gender diverse.
- Include students that identify as Māori or Pasifika, or female students in engineering disciplines.

B: Proposal Development Grants

- Support Associate Investigators and project leaders that identify as Māori or Pasifika; Associate Investigators in engineering disciplines that identify as women, early-career researchers¹, those returning from industry, and those who identify as gender diverse.

C: Workshop Grants

- Support workshops aimed at securing future external funding
- Support workshops that increase capability development for the Te Hiranga Rū QuakeCoRE community
- Support the participation and engagement of Associate Investigators and project leaders that identify as Māori or Pasifika; Associate Investigators in engineering disciplines that identify as women, early-career researchers¹, those returning from industry, and those who identify as gender diverse.

D: Co-ordination Mechanism Grants

- Support the participation and engagement of Associate Investigators and project leaders that identify as Māori or Pasifika; Associate Investigators in engineering disciplines that identify as women, early-career researchers¹, those returning from industry, and those who identify as gender diverse.

E: Māori Capability Development Grants

- Enable Māori researchers to engage in all areas of the Te Hiranga Rū QuakeCoRE research programme and community activities

The RfP Review Panel includes representation from the Research Programme Area, end-users and stakeholders.

All proposals will be reviewed by multiple RfP Review Panel members, avoiding any conflicts of interest. The RfP Review Panel members will be assigned proposals to independently review against the evaluation criteria above. A conflicts register will be kept to ensure that the review process has transparent conflict management. An independent observer will be present during the review meeting to provide an impartial view and ensuring that fair review processes are followed for all proposals.

The RfP Review Panel is responsible for recommending a balanced research programme and budget to the QuakeCoRE Director, which will be combined into an annual spending plan for submission to the QuakeCoRE Board.

The review process is planned to be completed and applicants notified by mid-December 2022 for project funding which will commence on 1 April 2023.

6. Co-ordination with other research support

Earthquake resilience research in Aotearoa New Zealand is supported by both QuakeCoRE and numerous other funding agencies, including the: NZ Earthquake Commission (EQC), Resilience to Natures Challenges National Science Challenge (RNC-NSC), MBIE, Callaghan Innovation, NZ Transportation Agency, Building Research Association NZ (BRANZ), Natural Infrastructure Unit (NIU), among others. Earthquake resilience-related research in Aotearoa New Zealand has also been actively supported by numerous ‘general’ NZ funding agencies (e.g., Marsden Fund, Rutherford Discovery Fellowships, MBIE Contestable Round), international partnership funding (e.g., US NSF, JSPS, EU Framework Programme), and direct industry funding by numerous private companies.

It can be seen from the numerous and diverse range of funders above, that the annual funding provided by QuakeCoRE represents a small portion of the overall annual Aotearoa New Zealand spending on earthquake resilience R&D. QuakeCoRE will also focus on providing enabling funding which will, among other things: (i) establish and foster collaborative research across institutions and disciplinary boundaries; and (ii) establish new research directions, enhance existing research funded by other agencies through strategic directed funding, and deliver tangible end-user outcomes.

In the context of those comments above, investigators should ensure that submitted proposals ‘fit’ the QuakeCoRE vision, mission and evaluation criteria, and that their proposal identifies aligned funding from other funding agencies in Aotearoa New Zealand. Investigators should also ensure the proposal is not better suited to one of the other Earthquake Resilience R&D funders noted above. Additional support and guidance on the research funding landscape and bid-writing process is available to early career Te Hiranga Rū QuakeCoRE researchers through the Research Identification Committee.

7. Research Programmes

The QuakeCoRE research programme structure is comprised of Disciplinary Themes (DTs) and Inter-disciplinary Programmes (IPs), as described in earlier sections. The sections below outline the priorities and requirements pertaining to the research programme, which investigators should utilize in developing proposals in response to this 2021 RfP. The information below is taken from the Te Hiranga Rū QuakeCoRE Three-year Plan 2021 – 2024. It is recommended that proposal Project Leaders review the summaries below to identify how their proposal aligns with, and contributes to, this programme of work to support the QuakeCoRE mission. Additional information and guidance on how research project proposals can be aligned with current activities within the Research Programmes is

available from the relevant Programme Area Leader(s) and applicants are encouraged to get in touch to discuss this prior to submission.

Disciplinary Theme 1: Seismic demands and consequent Geohazards

This Disciplinary Theme focuses on the principal research question - what are the salient physics and mechanics that govern seismic geohazards and how can we advance prediction accuracy and precision through integrated observational, empirical and physics-based datasets, methods, and associated tools? These geohazards span the traditional disciplines of engineering seismology, geotechnical engineering, and engineering geology, which this disciplinary theme will synthesise to enable significant advances in understanding and predictive modelling. Furthermore, utilising modern tools and methods also provide new avenues, in particular: (i) monitoring and sensing (both explicit and remote sensing); (ii) application of machine learning methods to data-rich problems to infer salient physics that is currently poorly understood; and (iii) physics-based models that attempt to honour governing mechanics. Targeted laboratory and field experiments will be undertaken toward achieving the overall aims within this theme.

Objectives	Deliverables
1.1 Ground-motion modelling	Advance the validation of ground-motion simulation methods and perform simulation-based hazard analysis for all of NZ as an illustration of future hazard analysis
1.2 Liquefaction impacts	Improve the characterization of NZ-specific soils, develop and implement advanced numerical models for soil behaviour using effective stress analysis for practical applications
1.3 Fault rupture and co-seismic landsliding	Development and application of empirical and simulation-based models of surface fault rupture displacement to major faults in NZ that impact urban areas and critical infrastructure
1.4 Geohazard integration	Develop and implement integrated computational tools for simulation of ground motion, liquefaction, landsliding and fault rupture hazards

Disciplinary Theme 2: Whole-of-building seismic performance

This Disciplinary Theme will address the following primary research questions: (i) How do component interactions ignored during conventional design affect the seismic response and damage that occurs to buildings? (ii) What are the demands imposed on acceleration- and displacement-sensitive non-structural components attributed to interaction with structural components? (iii) How does improved understanding of whole-of-building response affect the seismic performance and loss estimates over the life of a building? The mechanics of component interactions will be investigated using a combination of large-scale structural testing, data from international collaborative building tests, and field measurements from instrumented buildings. These data sources will be used to develop, calibrate and validate methods of modelling component interactions using state-of-art numerical simulations. Lastly, synthesis and translation of these models to design methods will result in immediate improvements in building performance in future earthquakes.

Objectives	Deliverables
2.1 Component interactions	Quantification of the effects in assessment and conventional design of non-seismic components of a structure that affect behaviour
2.2 Demands on acceleration- and drift-sensitive non-structural components	Quantification of the seismic demands that different non-structural components are subjected through numerical modelling calibrated with experimental testing.
2.3 Seismic performance and loss estimation	Performance and loss estimation studies to benchmark the seismic performance of different structures using conventional and emerging technologies.

Disciplinary Theme 3: Planning, law, and economics

This Disciplinary Theme provides a focal point for economists, planners, and legal scholars to deliver the key expertise required for the translation of science into policy that is necessary for the implementation of many of the innovations being developed across the QuakeCoRE community. Specifically, the theme will create an evidence-based approach to seismic resilience policy which links risk measures to the formulation and implementation of holistic policy frameworks across three distinct but linked research objectives: (i) Spatially-detailed modelling of economic damage from seismic hazards, and statistical assessment of previous earthquake impacts; (ii) Improved legal and planning frameworks to enable the mainstreaming of seismic resilience in NZ; and (iii) Design, and testing of specific resilience-building tools and processes, such as those developed in the second objective, and including behavioural ‘nudges’ to incentivise resilience.

Objectives	Deliverables
3.1 Econometric analysis of historical earthquake impacts	Adapt probabilistic methods for quantifying seismically-induced damage to individual infrastructure assets through the integration of seismic hazard, infrastructure response, and damage and loss with quantification considering of the impact on all the Four Capitals, and implicitly include broader definitions of wellbeing
3.2 Legal and planning frameworks	Mainstreaming of seismic hazard management through the development of ground-breaking holistic legal and planning frameworks
3.3 Resilience-building tools	Analyse incentives and policies in seismic risk reduction based on the quantifications obtained in objectives 3.1 and 3.2.

Disciplinary Theme 4: Cultural and social factors shaping resilience

This Disciplinary Theme comprises three objectives that will investigate human behaviour immediately prior to and during earthquake shaking; the linkages between risk interpretations and actions; and the role of national and regional hazard initiatives in NZ in the production of tools for resilience, including response plans and frameworks, and increased awareness through community outreach. Key research questions include (i) How do people respond to earthquake shaking and earthquake warnings? (ii) Do responses vary across different temporal, spatial, social and cultural contexts? (iii) How can we evaluate the efficacy and effectiveness of earthquake resilience-building programmes?

Objectives	Deliverables
4.1 Investigate human behaviour immediately prior to, during, and immediately after earthquake shaking to develop strategies to reduce earthquake deaths and injuries	Experiments to explore human responses to earthquakes through laboratory testing
4.2 Understand how human interpretations of, and responses to earthquake risk can shape the development of earthquake risk reduction strategies, including the temporal and spatial variation of understandings of earthquake risk across Aotearoa New Zealand	Co-design a community engagement strategy with councils and central government around seismic risk education in lower seismic hazard zones
4.3 Improved understanding of the effectiveness of earthquake communication, education and engagement activities through collaboration and evaluation	Develop a programme to enhance the use of the CEISMIC digital archives

Disciplinary Theme 5: Mātauranga Māori and earthquake resilience

This Disciplinary Theme will undertake community-led and co-designed participatory research to create and innovate Mātauranga Māori (Māori knowledge) that will facilitate achievement of the earthquake resilience aspirations of tangata whenua. Knowledge translation of research findings will encourage increased understanding within QuakeCoRE of iwi, hapū and whānau perspectives on earthquakes and disaster risk reduction. Innovative earthquake hazard management tools, including earthquake preparedness, response and recovery strategies, will also be created to enhance earthquake resilience.

Specific research objectives will be underpinned by a Te Ao Māori perspective, and driven by Māori research partners in order to ensure that the design and conduct of research projects remain culturally relevant and appropriate. Acknowledgement and respect for Māori research partners' tino rangatiratanga will likely highlight new foci for research. Kaupapa Māori research methodologies will shape the majority of Mātauranga Māori research as such approaches are preferred by iwi, hapū and whānau. Thus, projects are also likely to be community-led and determined rather than community-based and researcher determined. The research discovery process will involve the following key steps: (i) Commencing the process of Whakawhānaungatanga (establishing connections and points of engagement); (ii) Documenting community resilience-related needs from a cultural perspective; (iii) Mapping Māori aspirations in relation to earthquake resilience; (iii) Identifying culturally appropriate mechanisms for up-skilling iwi/Māori community resilience research capability, including the development of rangatahi (youth), and a conduit for young Māori into tertiary education programmes; and (iv) Eventually negotiating a selection of Kaupapa Māori community-led research projects that are relevant to QuakeCoRE and selecting appropriate research teams with input from iwi stakeholders to conduct the research.

Objectives	Deliverables
5.1 Whakawhānaungatanga	Establishing connections and points of engagement with iwi, hapū and whānau

5.2 Documentation	Documenting community resilience-related needs from a cultural perspective
5.3 Aspirations	Mapping Māori aspirations in relation to earthquake resilience
5.4 Capability development	Identifying culturally appropriate mechanisms for up-skilling iwi/Māori community resilience research capability, including the development of rangatahi (youth), and a conduit for young Māori into tertiary education programmes
5.5 Project selection and execution	Negotiating a selection of Kaupapa Māori community-led research projects

Inter-disciplinary Programme 1: Functional recovery with repairable buildings

This Inter-disciplinary Programme will provide the underlying science to support the development of the world's first functional recovery-based seismic design standard. It will build on understanding of whole-of-building seismic performance from DT2. Focusing on the functional recovery of multi-storey buildings, this Inter-disciplinary Programme will include three objectives, each seeking to answer research questions key to achieving functional recovery: (i) What low-damage solutions provide high confidence in maintaining functionality for even rare seismic demands? (ii) What is the expected performance of a damaged building in subsequent earthquakes (with or without repair) and what level of damage requires repair? (iii) What timeframes for restoration of function are achievable and acceptable considering external constraints and stakeholder requirements?

Objectives	Deliverables
6.1 Drivers for change	Documentation of the broad drivers for change in the seismic design of buildings and consideration of functional recovery
6.2 Maintaining functionality	Development of design factors and methods for creating building systems that maintain functionality through moderate to large earthquakes
6.3 Repaired buildings	Development and documentation of a means to address social and technical barriers to repair of earthquake-damaged buildings
6.4 Timeframes for restoration of function	Documentation summarising the complexities influencing functional recovery timeframes and quantification of those parameters that drive the step changes in functional recovery timeframes for multi-storey buildings

Inter-disciplinary Programme 2: Thriving residential communities

This Inter-disciplinary Programme will consider the following research questions toward achieving thriving residential communities following major earthquakes: (i) What are the structural and geotechnical engineering innovations that can lead to a drastic reduction in earthquake-induced physical damage to housing? (ii) How can land use planning and geotechnical engineering be synthesised to avoid the construction of new housing in highly vulnerable areas? (iii) How can lifeline infrastructure servicing residential areas be fortified in a cost-effective manner? (iv) What are the policies that can drive the development of new earthquake-resilient housing and communities; and incentives, or public awareness initiatives, for owner-funded retrofit of existing housing? (v) Is there

a mismatch between owner/tenant expectations of housing earthquake resilience, and, if so, how do communities feel that addressing this should be financed? The research to answer these questions will lead to a broad range of improvements, including the development of innovative engineering, land-use, social and policy provisions. Through leveraging NZ's recent experiences, expertise, and access to essential datasets, our research will be applicable in both national and international settings.

Objectives	Deliverables
7.1 Traditional housing and foundations	Identify transformative changes to traditional housing and foundation systems that mitigate losses and disruption in future earthquakes
7.2 New construction solutions	Identify new single-dwelling and medium density housing construction solutions that offer the potential of accelerated construction speed and quality control
7.3 Cost-effective retrofit solutions	Develop cost-effective retrofit solutions for existing buildings. This research will draw on developments made for commercial buildings, including value-propositions for new technologies in the construction sector

Inter-disciplinary Programme 3: A resilient New Zealand transport system

A multi-modal system approach is critical to understand how transport modes interact and to explore options to improve the resilience of transport networks and the energy networks that support their functionality, now and into the future. This programme seeks to integrate our understanding of components, networks and users of the transport system to evaluate pre-event resilience investments and develop post-event adaptations and recovery strategies that can support the range of future growth and consolidation pathways. This requires an understanding of the wider networks and their users, the interfaces between transport modes, the energy sources that support each transport system, and how our resilience to disruption may change as our communities, technology, economy and environment change over time. Research will seek to answer the following central questions: (i) How can a transport-as-a-service modelling paradigm allow efficient decision making under deep uncertainty? (ii) What is the interaction of strategic transport hubs in the system-level resilience of transportation networks? (iii) How can resilient transportation networks and logistics play an enhanced role in post-disaster response and recovery? Research will be framed around multiple earthquake scenarios that result in severe regional and broader national transport disruption.

Objectives	Deliverables
8.1 Transport-as-a-service	Quantify the effects of the emerging transportation-as-a-service paradigm as a means to allow efficient decision making under deep uncertainty
8.2 Network interactions	Develop network models to quantify the interaction of strategic transport hubs in the system-level resilience of transportation networks, and apply to case studies
8.3 Logistics post-event response and recovery	Using NZ as a case study, explore the balance of efficiencies and resilience of these hubs, including beyond just internal economic drivers

Inter-disciplinary Programme 4: Harnessing disruptive technologies for seismic resilience

This Inter-disciplinary Programme focuses on three exemplary objectives of disruptive infrastructure technologies (renewable distributed energy, smart cities, electric autonomous transportation) under a range of plausible forward-looking scenarios to 2030, 2040 and 2050. We will investigate how these technologies may be harnessed to maximise not only economic objectives, but also to create seismic resilience co-benefits while minimising societal and environmental costs associated with increased inter-connectedness, 'lock-in' path dependencies and inequitable distributional impacts. Through these case studies we will develop novel integrated dynamic models, which sit at the convergence of data and system science, widening the investment evaluation lens to capture economic and wellbeing indicators through time for multiple stakeholders.

Objectives	Deliverables
9.1 Renewable distributed energy	2050 scenarios for the landscape of earthquake resilience based on the rapid changes in decentralized electricity generation, transmission and distribution
9.2 Smart cities	How can real-time sensing enable early detection of network degradation pre-event, and situational awareness in the immediate post-event environment for rapid restoration
9.3 Electric autonomous transport	Quantification of the trade-off in electrification of transportation, reducing vulnerable reliance on liquid fuels, but increasing resilience requirements for electricity, play out over time; and how autonomous transportation modes function in a non-business-as-usual environment