2018 Collaboration Plan

QuakeCoRE: Centre for Earthquake Resilience

Issued 20 September 2017

Proposals Due Noon (NZT) 20 October 2017

1. Changes to the 2018 Collaboration Plan

There are significant changes across the research programme for 2018; some of the key updates are:

- Coordinated Flagship Projects and RfP Flagship Projects:
    - Flagship Programmes are comprised of non-contestable Coordinated Flagship Projects and contestable RfP Flagship Projects.
    - The Flagship Leaders will submit an annual non-contestable Coordinated Flagship Project for review and endorsement. We encourage investigators to engage with the Flagship Leaders to understand the opportunities to contribute to or align with this critical component of the overall Flagship Programme.
    - RfP Flagship Projects (funded under this RfP) will complement the Coordinated Flagship Project while still meeting the objectives of the Flagship Programmes described in Section 9.*

- Special Projects:
    - Special Projects are major long-term externally-funded research programmes which are aligned with the QuakeCoRE mission. Special Project designation enables a programme to be included in the Annual RfP, allowing QuakeCoRE contestable funding to be used to support research synergies through aligned projects that contribute toward the QuakeCoRE mission, as well as its core values and culture.
    - Spatially-distributed Infrastructure (formerly Flagship Six) has been designated as a Special Project to reflect the relationship and coordinated research synergies with the Resilience National Science Challenge – infrastructure toolbox.

- Technology Platforms & Outreach:
    - In 2018, no Expressions of Interest (EOIs) for Technology Platforms and Education, Outreach and Training projects are being solicited through the RfP process, instead investigators are encouraged to contact Technology Platform Leaders and our Outreach Coordinator at any time with ideas for collaboration. Both the Outreach and Technology Platform Leaders will submit an annual non-contestable programme for review and endorsement.*

- Relationships:
    - We are inviting investigators, end-users and stakeholders to join the QuakeCoRE community as either an Associate Investigator (AI) or Industry Affiliate; the benefits of these positions are detailed below.

* Summaries of the draft Flagship Coordinated Project and Technology Platform plan will be available on the QuakeCoRE Wikipages during the RfP process.

- Travel:
  - Applications for travel funding to attend the QuakeCoRE Annual Meeting will be limited to NZ based researchers, stakeholders and industry practitioners. International investigators may still receive travel support through the Flagship Programmes directly.

- Workshops:
  - Expressions of Interest (EOIs) for workshops have been simplified; investigators are invited to apply for one of two standard workshop slots aligned with the QuakeCoRE Annual Meeting.

2. Introduction

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 funded by the Tertiary Education Commission (TEC) from 1 January 2016 – 31 December 2020.

QuakeCoRE's mission is to place NZ at the worldwide forefront of earthquake disaster resilience by utilizing NZ 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 NZ communities.

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

The first five year phase of QuakeCoRE (2016-2020) will advance earthquake resilience through highly integrated multi-disciplinary and multi-institutional collaborations that are enabled through experimental, data and computational Technology Platforms. The scope of QuakeCoRE research encompasses areas in earthquake resilience that are inter-related and require an inter-disciplinary, multi-institutional approach. Interdisciplinary research initiatives focus on multi-thematic Flagships, and the development of Technology Platforms which provide community facilities, data, and modelling environments to efficiently facilitate collaborative world-class multi-disciplinary and multi-institutional research.

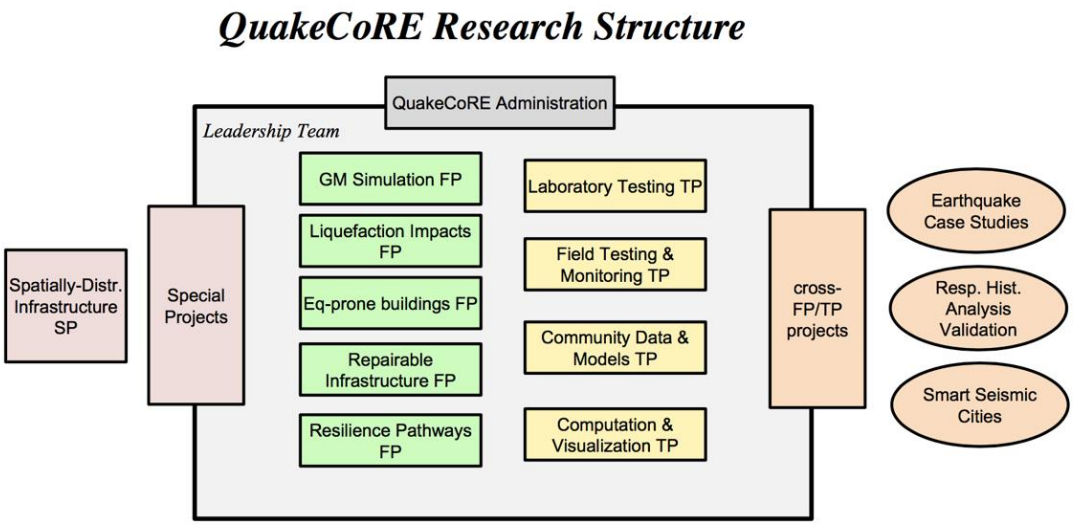

Figure 1: QuakeCoRE's research structure comprising Technology Platforms, Flagships Programmes, Special Projects, and cross-FP/TP projects.

Key Initiatives

Technology Platforms: Four Technology Platforms provide the underpinning experimental (lab and field), data, and computational infrastructure which are necessary for realizing QuakeCoRE's vision and mission, and involve cross-institutional and industry collaborations.

Flagship Programmes: Flagships include a long-term non-contestable Coordinated Flagship Project led by the Flagship Leader. This Project is supported by RfP-funded Flagship Projects that are research excellent, have strong collaboration, build human capacity, and are coordinated with other funding support. The Flagship Programmes described in this Collaboration Plan integrate successful on-going projects by QuakeCoRE investigators and leverage additional funding to achieve significant impacts for NZ.

Special Projects: These are major long-term externally-funded research programmes are aligned with the QuakeCoRE mission. The first Special Project "Spatially-distributed infrastructure" (formerly Flagship 6) has been included in the RfP, further details can be found in Sections 5 and 9.

Cross Flagship / Technology Platform Projects: These multi-disciplinary projects provide an opportunity for interaction between Flagships and Technology Platforms around a research topic. Applications for Cross-Flagship / Technology Platforms are not currently being accepted.

Education, Outreach and Training: QuakeCoRE's research activities aim to address the full education pipeline from primary school to PhD student research and internship experiences.

Opportunities for QuakeCoRE research to participate in Education, Outreach and Training (EOT) activities are described in Section 5.

Annual Collaboration Plan: This document, referred to as the *Annual Collaboration Plan*, describes the mechanisms for collaboration and solicits proposals from investigators to participate in the QuakeCoRE programme.

3. Proposal timelines

The timelines for RfP Flagship Projects, workshops and Annual Meeting travel proposals are:

- 20 September 2017: Request for proposals released
- Friday 20 October Noon NZT: Applications close. Late proposals will not be accepted
- November: Evaluation and review process
- Mid-December: Outcomes advised
- 1 January 2018: Projects commence

4. Guidelines for proposal submission

Submission Instructions: Proposals must be submitted via the online application form. The online application form can be found here.

Formatting Instructions: All proposals must use the QuakeCoRE Proposal Templates 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 (e.g. attending the Annual Meeting and presenting QuakeCoRE-funded research in the poster sessions, workshops, and working group meetings), and to contribute all relevant data, experimental and analysis results, and computational codes/models to the appropriate QuakeCoRE Technology Platforms. Publications resulting entirely or partially from QuakeCoRE funding must include a QuakeCoRE publication number (numbers can be obtained via the QuakeCoRE Portal: http://www.quakecore-portal.nz/). By submitting a proposal, investigators are agreeing to these conditions, and performance in this regard will be considered in future QuakeCoRE proposals.

Eligibility: Proposals can be submitted by QuakeCoRE Associate Investigators (AI) or Principal Investigators (PI). Information on becoming a QuakeCoRE AI can be found on the QuakeCoRE website (here). AIs and PIs are based at NZ research institutions. Due to limited funds, grants cannot be used to support international conference travel (i.e. grants are for direct research-related costs and QuakeCoRE Annual Meeting attendance only). For researchers from international institutions, support for travel to the Annual Meeting may be provided under the

coordinated Flagship Project, investigators interested in this opportunity should contact the relevant Flagship or Technology Platform Leader.

Collaborative proposals: Proposals involving multiple investigators and/or institutions are strongly encouraged. A collaborative proposal should be submitted only by the project leader who must be a QuakeCoRE Investigator (PI or AI). Information on all investigators (including budgets and current external support) must be included in the proposal submission. Each QuakeCoRE investigator can only lead a single RfP Flagship Project.

Budget guidance: Typical QuakeCoRE funding levels for RfP Flagship Project proposals funded under this annual Collaboration Plan will be indicatively in the range of $15,000-50,000 NZD. This is not intended to limit specific award amounts, or number of awards, but to calibrate the expectations for proposals written by QuakeCoRE investigators. Note that, based on TEC restrictions, this Collaboration Plan will not support capital expenditure (CapEx).

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.

Proposals vs. Expressions of Interest: The 2018 RfP will include different types of application; 'proposals' for RfP Flagship Projects and domestic Annual Meeting travel applications, and 'expressions of interest' (EOIs) for workshops and each will follow a different review process.

Review coordination and evaluation of proposals is performed by the RfP Review Panel (comprising the QuakeCoRE Leadership Team and industry representatives for each Flagship Programme), and proposals are either funded or rejected without negotiation with the project leader.

5. Proposal categories

Proposals for one year of funding are encouraged across the following four categories.

RfP Flagship and Special Projects: RfP Flagship Projects are high-impact research projects that are advanced to the next level through strong research collaboration, engagement with end-users, and coordination with other funding support. RfP Flagship Project Proposals in this category should identify the specific Flagship Programme and associated research thrust their proposal contributes to (see Section 9.1). RfP Flagship Project proposals should consist of a single objective.

Special Projects are major long-term externally-funded research programmes, for example a national science challenge, which are aligned with the QuakeCoRE mission. Special Project designation enables a special project programme to be included in the Annual RfP, such that QuakeCoRE contestable funding, RfP Special Projects, can be used to provide support for research synergies through aligned projects that contribute toward the QuakeCoRE mission, as well as its core values and culture.

Spatially-distributed Infrastructure (formerly Flagship Six) has been designated as a Special Project to reflect the relationship with the Resilience National Science Challenge. RfP

proposals under this Special Project follow the same process as the Flagship projects described above.

Annual Meeting travel participation: We encourage broad participation in the QuakeCoRE Annual Meeting, planned for the first week in September 2018, where the QuakeCoRE community will come together to share ideas and plan collaborations for the following year. Proposals in this category support travel funds for New Zealand-based researcher and end-user participation in the QuakeCoRE Annual Meeting. In particular, contributors who are new to QuakeCoRE and would benefit from exposure to the QuakeCoRE Annual Meeting in order to fine-tune future proposals. Early career researchers are encouraged to apply. Currently funded QuakeCoRE researchers must fund Annual Meeting travel from their project budget. International researchers interested in receiving support to attend the QuakeCoRE Annual Meeting should contact the relevant Flagship or Technology Platform Leader.

For travel proposals you must indicate which Flagship(s) and/or Technology Platform(s) your proposal best aligns to. Those funded under this category are expected to contribute to QuakeCoRE activities over the course of the year via attending monthly video calls in relevant QuakeCoRE areas. This proposal category is not intended for graduate students or postdoctoral fellows, whose participation is expected to be supported by project funding or other means.

Workshops: QuakeCoRE Principal Investigators (PIs) or Associate Investigators (AIs) are invited to submit proposals for workshop sessions aligned with the QuakeCoRE Annual Meeting. Applications will be considered for one of two workshop slots, each slot will be for a full day workshop for up to forty five participants and will include venue, catering and standard AV. (Workshops at other times of the year must be covered within the budget of Coordinated Flagship Projects.) Workshops in the following areas are particularly relevant:

- Workshops which organise collaborative research efforts for the QuakeCoRE programme (2016-2020). In particular, interactive workshops that advance cross-Flagship Programme collaborations, coordinate and develop capability across different Technology Platform areas, engage more than one disciplinary group, and seek to identify co-funding agencies are strongly encouraged.
- Workshops which engage end-users, partners, and non-earthquake specialists in QuakeCoRE-funded research.

In 2018, no applications or expressions of interest are being sought via the RfP for the following two categories.

Technology Platforms: No applications or Expressions of Interest (EOI) are being sought via the RfP. The Technology Platform Leaders are responsible for delivering a long-term coordinated Technology Platform Programme; investigators are encouraged to engage with the Technology Platform Leaders to see where they may contribute to the Technology Platform Programme.

Education, Outreach and Training (EOT): No applications or Expressions of Interest (EOIs) are being sought for education, outreach and training via the RfP. Investigators with ideas for initiatives in this area are encouraged to contact the QuakeCoRE Outreach Coordinator

(brandy.alger@canterbury.ac.nz) at any time with their proposals.

6. Evaluation process and criteria

Proposals submitted should be directly responsive to the Collaboration Plan. A primary consideration in evaluating proposals will be how directly the proposal addresses the mission and vision of QuakeCoRE. The specific evaluation criteria and their weighting are:

- Research Excellence (40%)
  - Quality of proposed research
  - Track record and ability to deliver proposed research
- Human Capacity Development (30%)
  - Involvement of students and emerging researchers
  - Development and support for members of under-represented groups (e.g.: women, Maori/Pasifika)
- Fit with QuakeCoRE Mission and Values (30%)
  - Priority of the proposed research for the QuakeCoRE Flagship objectives as stated in the relevant section of this Collaboration Plan and connection to the Flagship 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
- In addition to the criteria listed above, proposals will also be reviewed for their contribution to Mātauranga Māori. A formal framework for this assessment will be introduced as part of the 2019 RfP.

The RfP Review Panel includes representation from Flagships, Technology Platforms, 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 review process has transparent conflict management. An independent observer will be present during the review meeting to provide an independent view and ensuring that fair review processes are followed for all proposals.

The RfP Review Panel is responsible for recommending a balanced Collaboration Plan research 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 2017 for 12 month funding which will commence on 1 January 2018.

7. Co-ordination with other research support

Earthquake resilience research in New Zealand is supported by both QuakeCoRE and numerous other funding agencies, including the: Natural Hazards Research Platform (NHRP), NZ Earthquake Commission (EQC), Resilience to Natures Challenges National Science Challenge (RNC-NSC), MBIE Building Performance Branch, Callaghan Innovation, NZ Transportation Agency, Building Research Association NZ (BRANZ), Natural Infrastructure Unit (NIU), and UC Quake Centre (UCQC), among others. Earthquake resilience-related research in NZ 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 NZ spending on earthquake resilience R&D. QuakeCoRE thus focuses on providing enabling funding which will, among other things (see Section 6): (i) establish and foster collaborative research across institutions and disciplinary boundaries; (ii) establish new research directions, enhance existing research funded by other agencies through strategic directed funding, and deliver tangible end-user outcomes; and (iii) support underpinning Technology Platform Programmes which provide the experimental, data, and computational infrastructure necessary to develop and accelerate collaborative research that addresses 'system-level' problems toward achieving earthquake resilience.

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 NZ. Investigators should also ensure the proposal is not better suited to one of the other Earthquake Resilience R&D funders noted above.

8. Proposal budget and budget justification

8.1 Proposal budget

Flagship Project and Special Project proposals: A budget template is provided for use in specifying the project budget for Flagship Project and Special Project research proposals.

Annual Meeting travel proposal budget: No budget is required. Support will be provided to a maximum of $1,000 for New Zealand based researchers.

Workshop EOI budgets: No budget is needed for workshop EOIs as the application is for a standard workshop session which includes venue hire, catering and audio-visual (AV) supplies.

Any additional costs (e.g. travel to the Annual Meeting) must be covered by the investigator and are considered outside of the workshop Expression of Interest.

8.2 RfP Project proposal budget categories

The budget template follows standard terminology set by the Minister of Science and Innovation. In particular, the two high-level sections are: (i) Salaries and salary-related costs; and (ii) Other costs. Examples of line items in each section have been provided to assist applicants.

As a Tertiary Education Commission-funded Centre of Research Excellence, QuakeCoRE has a commitment to the TEC CoREs mandate:

"To encourage the development of excellent tertiary education-based research that is collaborative, strategically focused and creates significant knowledge transfer activities." – Tertiary Education Commission.

FTE time for QuakeCoRE Principal Investigators (PIs), Associate Investigators (AIs) and Affiliates is not eligible for inclusion in Flagship Projects. In line with TEC regulations, no funding may be allocated to capital expenditure (CapEx).

8.3 Proposal budget justification

This section of the RfP Flagship Project proposal requires discussion of the project personnel roles and resources in order to justify the submitted proposal budget.

Roles: The contribution that each named team member will make to the proposed research. This should clearly explain the FTE requests for technicians, post-doctoral fellows and research assistants. If un-named personnel are included in the proposal (e.g. technicians, students, post-doctoral fellows, etc.) please indicate role, what skills are being sought, and what steps will need to be taken to fill these positions. This section should additionally include a description of the role of team members for which no FTEs are being sought, such as international collaborators.

Resources: Clearly state the resources required for the proposed research that the team will have access to. This is an opportunity to discuss the practical requirements of your proposed research.

For example: Access to required datasets/instruments/equipment/techniques/ materials; ability to do fieldwork (e.g. site access, assistance, etc); access to pools of participants.

9. Research priorities and requirements

The QuakeCoRE research programme structure is comprised of Technology Platforms and Flagships, 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 Collaboration Plan. Flagship Projects are encouraged to review the Coordinated Flagship Project summaries to identify how their RfP Project

proposal aligns with and contributes to this programme of work to support the QuakeCoRE mission. Further details can be found on the QuakeCoRE Wiki pages.

9.1 Flagship programmes

Flagship 1: Ground motion simulation and validation

Additional information, including the draft Coordinated Flagship Project Plan and Flagship deliverables can be found on the QuakeCoRE Wiki pages here.

This flagship will provide a paradigm shift in strong ground motion prediction in New Zealand and internationally through the use of high-fidelity physics-based prediction methods, which merge state-of-the-art knowledge in strong motion seismology and geotechnical earthquake engineering. The impact of this flagship will result from the reduction in the design level seismic hazard in many regions through an increased prediction precision, identification of regions with an increased seismic hazard resulting from systematic basin and topographic ground motion phenomena; quantification of ground motion intensity affecting spatially distributed infrastructure networks.

The key thrust areas are:

- FP1.1 Development and refinement of ground motion simulation methods that enable the generation of acceleration time series for the seismic response analysis of infrastructure.
- FP1.2 Development of 'velocity models' of the earth's crust in new regions of New Zealand, or improvements in existing regions.
- FP1.3 Develop, validate, and apply models for nonlinear near surface site and topographic response for use in conjunction with ground motion simulation methods.
- FP1.4 Utilize ground motion simulations to forecast the severity of ground shaking over spatially-distributed regions in future major New Zealand earthquakes.
- FP1.5 Examination of modelling uncertainties in ground motion simulation methods and utilization for probabilistic seismic hazard analysis.
- FP1.6 Explore the role of simulated ground motions for use in seismic response analysis of engineering infrastructure, including comparisons with as recorded ground motions and development of procedures for simulated ground motions in infrastructure seismic design guidelines.

Flagship 2: Liquefaction impacts on land and infrastructure

Additional information, including the draft Coordinated Flagship Project Plan and Flagship Deliverables can be found on the QuakeCoRE Wiki pages here.

This flagship will develop new approaches and methodologies for quantification of impacts of soil liquefaction on land and infrastructure through a fundamental understanding of onset and consequences of liquefaction; and use these methods to assess liquefaction impacts throughout New Zealand and their potential to be mitigated. These novel methods will represent a major

advance in the field, and will provide means for a robust assessment and treatment of liquefaction hazards at both site-specific and regional levels.

The key thrust areas are:

FP2.1 Development and improvement of liquefaction assessment methods (Liquefaction Evaluation: Beyond Current State-of-Art and Practice). Utilize the exceptional databases compiled during Canterbury and Kaikoura Earthquakes, and obtain additional high-quality data where needed, to develop new or improve existing liquefaction evaluation procedures (field, laboratory and analytical tools and methodologies) that will adequately address current and future society needs for performance of land and infrastructure during earthquakes.

FP2.2 Identify critical issues and ground conditions related to liquefaction impacts on infrastructure, including characterization of important but challenging New Zealand soils, and the development of adequate assessment procedures and cost-effective mitigation strategies.

FP2.3 Development of performance based criteria for micro systems (e.g. soil deposits; soil-foundation-building systems) and macro systems (urban areas; land use and development) and lifeline networks, integrating geotechnical engineering knowhow within cross-disciplinary tools and methodologies.

Flagship 3: Addressing earthquake-vulnerable buildings – A multidisciplinary approach

Additional information, including the draft Coordinated Flagship Project Plan and Flagship Deliverables can be found on the QuakeCoRE Wiki pages here.

This flagship will result in the development and validation of procedures to forecast the socio-economic impacts of building demolitions and retrofits that are legislated to occur within the coming decade. Improved assessment guidance will mitigate conservative seismic assessments that result in unnecessary demolition of existing buildings, including the country's built heritage, enabling economically-viable policy solutions. Proven cost-effective and architecturally-appropriate earthquake strengthening solutions will be developed and communicated to structural engineers nationwide so that results can be immediately implemented. Consideration will be given to the range of existing buildings posing a risk in New Zealand's cities, not just those classified as earthquake-prone by legislation.

The key thrust areas are:

FP3.1 Development of validated methodologies for detailed assessment and improvement of earthquake-vulnerable buildings such as unreinforced masonry and reinforced concrete buildings. Where possible, validation may be achieved via field testing in buildings scheduled for demolition.

FP3.2 Development of methodologies for economic assessment of options for addressing earthquake-vulnerable buildings, namely: mitigation, demolition, or no action.

FP3.3 Understanding the development of policy and initiatives regarding earthquake-vulnerable buildings, including understanding societal involvement and expectations in such policy.

Flagship 4: Next-generation infrastructure - Low-damage and repairable solutions

Additional information, including the draft Coordinated Flagship Project Plan and Flagship Deliverables can be found on the QuakeCoRE Wiki pages here.

This flagship will seek a new design paradigm whereby reparability and damage-control is explicitly considered in the design process. This requires the development of new low-damage systems, quantification of the reparability (cost and time) of conventional systems, and design process methodologies for implementation. This flagship will also result in important changes to implementation standards; which provide the mainstream technology transfer mechanism given that all future designs must satisfy these standards. Significant economic benefits are also expected through both reductions in future earthquake losses and increased international competitiveness of New Zealand engineering consultants and marketing of new seismic protective devices.

The key thrust areas are:

FP4.1 Development of new technologies for buildings (structural and non-structural) to control damage in future events and enable rapid recovery.

FP4.2 Development of procedures to reliably assess and communicate the performance of new and conventional systems, including consideration of residual capacity of earthquake-damaged infrastructure and cost-effective repair techniques.

FP4.3 Integration of reparability performance objectives into implementation standards and alignment with insurance policies optimised for rapid recovery.

Flagship 5: Pathways to improved resilience

Additional information, including the draft Coordinated Flagship Project Plan and Flagship Deliverables can be found on the QuakeCoRE Wiki pages here.

Our goal in Flagship 5 is to identify how societal decisions and choices affect the social, culture and economic resilience of communities, at local, regional and national scales. QuakeCoRE will bring together expertise from a range of disciplines, including tangata whenua knowledge to develop a holistic understanding of social, cultural and economic impacts from earthquakes; thus, providing key input to policy decisions at all levels of government and building a resilience community of practice.

The key thrust areas are:

FP5.1 Addressing key knowledge gaps to improve our ability to holistically evaluate impacts of earthquakes, to understand and model system effects, and to advance our capability to evaluate the case for investment.

FP5.2 Analysis and sharing of current tools and methodologies used for the evaluation of resilience-building policies and practices in order to identify opportunities for innovative cross-sectorial and organisational research collaboration.

FP5.3 Development and evaluation of up to 6 Wellington case study activities which critically assess potential investment policies and practices to improve New Zealand's resilience to earthquakes; and their use to provide inventive recommendations and advice for practical implementation.

9.2 Special project

Special Project: Spatially-distributed infrastructure[i]

Additional information can be found on the QuakeCoRE Wiki pages here.

This Special Project seeks to develop tools to assess the seismic performance of spatially-distributed infrastructure networks subject to extreme natural hazards. In this RfP round there will be a focus on the transportation, electricity distribution and the three waters networks, and projects should look to align with other regional studies where possible.

The key thrust areas are:

FP6.1 *Components:* Performance of individual network components and assessment of their vulnerabilities.

- Assess the applicability of distributed infrastructure fragility functions developed for the Christchurch earthquakes for other areas in New Zealand. Development of guidelines from the lessons and repair/retrofit techniques from Christchurch.
- Development of New Zealand specific infrastructure fragility functions based on experimental and computational modelling.
- Define tipping points and service outage levels for critical infrastructure components and how this translates to system level performance.

FP6.2 *Networks:* Development and application of methodologies to quantify the performance of spatially-distributed networks.

- Quantification of the interaction between individual components of networks.
- Assess the effect of multi-hazards and cascading impacts on network performance.
- Quantify interdependencies between different networks.
- Development of methodologies to link individual component performance and level of service with distributed infrastructure network models.

FP6.3 *Implementation:* Incorporation of resilience concepts into network decision making.

- Quantify the effect of pre-event mitigation and post-event prioritization decisions on resilience of networks.
- Development of methodologies to link distributed infrastructure network performance measures with economic and social impact metrics/models.

[i] This Special Project was formerly known as Flagship 6: Spatially-distributed Infrastructure