NATURAL HAZARDS PLATFORM — INTERIM RESEARCH STRATEGY
October 2009

INTRODUCTION

New Zealand lies on the boundary between two of the fastest-moving major tectonic plates in the midst of the Roaring Forties and Fifties. As a consequence of this physical setting, our society is exposed to a wide range of geological and weather hazards ranging from events with frequent, but modest impact, through to rare, but devastating events.

This 'natural laboratory' has created a strong research culture that has delivered many benefits to society through contributing to a significant level of resilience to the impacts of these hazards. On-going hazard impacts, changing risk due to increasing development and climate change, and the realisation that national exposure to some more infrequent impacts is extremely high demonstrates that there is much more that can be done to develop a more resilient society.

For some time a more stable funding environment has been recognised as essential for nurturing long-term research and providing the collaborative and coordinated environment necessary to answer complex research questions that deliver beneficial national outcomes. To this end, the Foundation for Research, Science and Technology (FRST) has developed the concept of Research Platforms to provide long-term, stable funding for core areas of science that are important to New Zealand.

Natural Hazards research had been identified as a research area of critical strategic importance to New Zealand, with outcomes that directly support the achievement of government endorsed strategies. Thus, it was selected to be the pilot Platform. The Platform will be highly collaborative, so as to provide the framework for integrating research and funding across agencies and disciplines, together with research users to achieve our aim of a New Zealand society that is more resilient to natural hazards.

The direction of research within the platform will be guided by a Research Strategy that is closely linked with the National Civil Defence Emergency Management (CDEM) Strategy, which has been identified as providing the government's strategic direction for the Platform. A comprehensive research strategy will be developed by Platform members and research users over the first year of the Platform's existence, but an interim strategy is required for Platform inception — that is the purpose of this document.

CONTEXT AND DRIVERS

New Zealand's plate boundary location and the associated high rates of earth deformation mean that the country is highly exposed to earthquakes. The high rates of deformation have also resulted in a rugged topography due to mountain building. This rugged topography, coupled with an oceanic location in the Roaring Forties, means that the country is also exposed to intense, variable and highly localised weather with accompanying storms, river and coastal flooding, and erosion. The plate boundary location, with associated subduction zones, also means that there are active volcanoes

and local-source tsunami to contend with, and New Zealand's relatively young rocks are prone to landslides triggered by intense rainfall and by earthquakes.

As a consequence of New Zealand's physical setting, towns and cities are frequently affected by storms and flooding. Similarly, landslides commonly affect road, rail, and other infrastructure as well as buildings. At the upper end of the scale, earthquakes, tsunami and volcanoes are capable of great destruction but they are rare events for which there is little historical data and much uncertainty about the distribution, frequency and magnitude.

In terms of risk there is much fundamental research to do to evaluate the risk arising from different processes on an equal basis. Furthermore, the physical processes shaping New Zealand are relentless, so the possibility that large hazardous events may occur simultaneously, for example volcanic eruption and major rainstorm, or major earthquake triggering large landslides, must also be considered to fully appreciate future hazard, vulnerability and risk, and the associated economic and social impacts.

Given the broad hazard and risk exposure in New Zealand, effective civil defence emergency management is critical. The National CDEM Strategy articulates the Crown's vision for a 'Resilient New Zealand: communities understanding and managing their hazards'. The approach to realising the vision of Resilient New Zealand derives from the CDEM Act (2002) and requires a comprehensive risk management approach in addressing the consequences of hazards, across the four elements of emergency management — Reduction, Readiness, Response and Recovery. By definition, compr1ehensive risk management must be evidence-based and so is reliant on well promoted, coordinated and accessible hazards and disaster research. Enhancing resilience requires the development of new tools, knowledge and understanding, and a range of capabilities across a wide range of disciplines.

The insurance sector is an important contributor to resilience through the provision of financial resources after a disaster to support recovery. Insurance (and especially re-insurance) rates are highly dependent on the levels of risk exposure and the associated uncertainties. For this reason, agencies such as the Earthquake Commission (EQC) and the Accident Compensation Corporation (ACC) also support and have a strong interest in natural hazards research.

New Zealand's physical context and exposure to earthquakes, in particular, has led to a strong tradition of earthquake resistant design. Informed by scientific inputs and developed through sound engineering, New Zealand has been a world leader in developing its building code, reinforced concrete construction and base isolation technologies. As a result of these achievements, our modern (post-1980) buildings are unlikely to collapse in even the strongest earthquake shaking or in extreme winds and so are expected to cause relatively few casualties. There is room for improvement, however, because many buildings, associated essential services, and critical infrastructure will be so badly damaged in a large earthquake as to be unusable. For this reason New Zealand's cities could be rendered non-functional by earthquake damage to buildings, their contents, and to infrastructure. While current earthquake resistant design also allows for severe winds, future design should also take into account impacts from tsunami and other natural hazard events.

DESIRED OUTCOME

The aim of the research both supported by and aligned with the Platform will be to directly contribute to improved economic, infrastructural and social resilience to natural hazards in New Zealand. The science capability supported by the Platform will also be available to assist decision makers during significant hazard events.

SCOPE

To achieve the desired outcome, the Platform will include long-term basic targeted research as well as more short-term applied research that aligns with identified research user needs.

The Platform will support capacity building to achieve research capabilities that provide an ability to understand, identify, predict, avoid or mitigate potential, well-defined catastrophic or cumulative risks (significant economic, social and/or environmental impacts) to New Zealand, (specifically physical hazards stemming from earthquakes, landslides, volcanic eruptions, tsunami, floods, severe winds, snow, coastal erosion and social, economic and infrastructural resilience relating to natural hazards). The capability in the Platform will also be available to assist decision makers during significant hazard events.

The Platform research will focus on:

- Avoidance or mitigation of natural hazard risks that are likely to result in a civil defence state of emergency (either local or national)[1];
- Avoidance or mitigation of natural hazard risks that could potentially cause catastrophic impacts on New Zealand's economy, environment or social well-being, but may not result in the declaration of a national state of emergency; and
- Community, organisational and infrastructural resilience to natural hazard events;

The Platform research will be aligned with strategies of government agencies responsible for reduction, readiness, response and recovery from natural hazard events.

Both the outcomes resulting from the research undertaken and the capabilities developed through the Platform must link clearly with key needs identified in national and regional strategies, in particular the National CDEM Strategy.

Although recognised as important national risks, the following research activities are out of scope for the Platform:

- Research relating to man-made (technological or social) hazards including major transport accidents, infrastructure failures, terrorism and biological accidents;
- Bio-security research, as this is covered in the Ecosystems, Sustainable Resource Use (SRU) and Sustainable Production Systems (SPS) portfolios;

[1] A civil defence state of emergency is declared for events which are beyond the normal emergency services response and require elevated levels of coordination and resources. Declaration may be at the local or national level.

- Climate variability and change research funded outside the Resilient Infrastructure and Communities (RIC) portfolio, recognising that the outputs from that research could be inputs to the Platform;
- Initially, other natural hazards-related research that is funded from Foundation portfolios other than the Resilient Infrastructure and Communities portfolio;
- Infrastructure research, including new building solutions, that does not specifically relate to mitigating impacts from hazard events and better aligns with the Optimising Resource Infrastructure (ORI) portfolio;
- Research where the benefits are specific to a discrete sector, rather than having widespread national benefits; and
- Hazards-related research and translation of hazards research outputs that are expected to be funded by other public sector or private sector agencies to meet local needs or immediate operational requirements.

GUIDING PRINCIPLES

In a dynamic research culture, an effective strategy needs to establish a few simple principles guiding and influencing the behaviour of researchers to achieve joint objectives. Leadership within science also has a key role to ensure alignment between research outcomes and national strategic objectives. The guiding principles of the Hazards Platform are:

- **Research that Meets National Needs**

Whether it be targeted basic, or more applied, Platform research must be relevant to national strategic objectives for developing disaster resilience. Research priorities must be established with consideration of the knowledge needs across the '4Rs' and in the context of the four environments of communities (natural, built, economic and social).

- **Research that is Responsive**

  The basis for the Platform is long-term research. However, the Platform research capability must be open and responsive to changing government priorities as well as evolving science needs. The Platform research capability will also be available to assist the nation in responding to significant hazard events. Given that significant hazard events are an important opportunity for learning, the research culture must also be responsive so as to capitalise on the opportunities presented by hazard events and must be cognisant of changed priorities post-event.

- **Research that is of the Highest Quality**

Science excellence is paramount to the success of the Platform, for both science capability building and for ensuring the highest quality research outcomes. Scientific excellence can only be maintained over the long term if high-performing researchers can devote a significant proportion of their effort to basic research. In this context, national and international collaborations are important to ensure New Zealand has good access to vibrant contemporary global research. Platform research quality also needs to be assured by undertaking periodic technical reviews.

- **Research Capability that is Enduring**

Achieving important national outcomes through natural hazards research is a long-term endeavour, so the Platform must maintain certain critical science capabilities and

develop new capabilities where needed. The involvement of graduate students in research programmes will provide a source of future scientists and will also invigorate established research programmes. For this to work effectively, involvement of Universities is essential. At the same time, essential science infrastructure (e.g. monitoring networks, high performance computing) must also be well-supported.

- **Research that is Connected and Coordinated**

Achieving national goals for resilience from natural hazards is a complex challenge that requires a strong, connected and coordinated research environment, including interdisciplinary approaches. For the Platform to deliver national benefits, it must actively foster productive collaborative relationships and improved connectivity between researchers across organisational and discipline boundaries.

- **Research that is Communicated**

Research programmes within the Platform need to work collaboratively with research users, where there is relevance, at the earliest stages of programme development through to consideration of pathways to implementation. Research users, in turn, need to support sufficient capability for the effective uptake of research findings. Platform research outputs must be delivered in a form suitable for uptake or adaptation by research users, so that measurable progress is made towards achieving outcomes.

CRITICAL LINKAGES

National Strategies and Key Research Users

A research platform must: (i) address the research issues raised in a strategy developed by a major sector or government agency; (ii) be endorsed by relevant users, including government agencies; (iii) identify a need for ongoing research that is significant in scope, size and duration; and (iv) provide research that would focus on developing a key area for New Zealand, one of which is the ability to respond to natural hazards.

The National CDEM Strategy[2] has been identified as providing the overarching strategic direction for the Platform under criterion (i). This strategy articulates the Crown's vision for a 'Resilient New Zealand: communities understanding and managing their hazards'. The approach to realising the vision of Resilient New Zealand derives from the CDEM Act (2002) and requires a comprehensive risk management approach in addressing the consequences of hazards, across the four elements of emergency management — Reduction, Readiness, Response and Recovery. MCDEM is the custodian of this all-of-nation strategy, and as such is a key stakeholder in the Platform as well as representing interests of CDEM research users.

The goals of this strategy are aimed at:

1. Increasing community awareness, understanding, preparedness and participation in CDEM;
2. Reducing the risks from hazards to New Zealand;
3. Enhancing New Zealand's capability to manage civil defence emergencies;

[2] http://www.civildefence.govt.nz/memwebsite.NSF/Files/National_CDEM_Strategy/$file/National-CDEM-strategy-2008.pdf

4. Enhancing New Zealand's capability to recover from civil defence emergencies.

In a later section within this document we describe in detail the Platform Research Themes and relate these to the goals listed above.

Across New Zealand, delivery of CDEM is the responsibility of the regional CDEM Groups, while knowledge of hazards is a responsibility of regional councils. Recently, regional councils have worked together to develop their own research strategy[3] that, while focused mainly on environmental responsibilities, is also relevant to Platform research. MCDEM also facilitates meetings of regional council hazard analysts and interacts regularly with the CDEM Group offices — these groups can potentially interact directly with the Platform.

EQC makes major investments in support of geological hazards infrastructure and research through the GeoNet project[4], their biennial funding round, and support of capabilities in Universities. These investments are guided by the EQC research strategy[5]. Because of its mandate to support research to reduce the risk from the hazards EQC insures against, it too is a key stakeholder for the Platform.

Additional guidance from government agencies will be available from the Flood Risk Management Review (*Meeting the Challenges of Future Flooding in New Zealand*) being prepared by Ministry for the Environment. This will be accompanied by a Flood Standard, and a National Policy Statement on flood risk, due for completion in 2009. The related Coastal and Freshwater Policy statements in preparation will also have implications for hazards research.

Relevant International Programmes

For geological hazards, relevant international programmes include: the Incorporated Research Institutions for Seismology[6] (IRIS — global seismograph network and portable instrument pool); UNAVCO[7], a consortium of research institutions that to support and promote the use of high-precision techniques for the measurement and understanding of earth deformation; the Southern California Earthquake Center[8] (SCEC); Pacific Tsunami Warning System (PTWS); and the Global Earthquake Model[9] (GEM).

For weather-related hazards, major relevant international programmes include THORPEX[10], the meteorological component of the World Meteorological Organisation Natural Disaster and Mitigation Programme and the companion programme HEPEX[11], the Hydrologic Ensemble Prediction Experiment. HEPEX aims to demonstrate reliable

[3] http://www.envirolink.govt.nz/documents/researchfortheenvironmentmar09.pdf
[4] www.geonet.org.nz
[5] http://www.eqc.govt.nz/research/Researchstrategy.aspx
[6] http://www.iris.washington.edu/hq/
[7] http://www.unavco.org/aboutus/aboutus.html
[8] http://www.scec.org/
[9] http://www.globalquakemodel.org/
[10] http://www.wmo.int/thorpex
[11] http://hydis8.eng.uci.edu/hepex/HEPEX_Implementation_20061007.pdf

hydrological ensemble predictions that can be used with confidence by emergency management and water resources sectors. Other studies that inform our research are the UK Pitt report *Learning Lessons from the 2007 Floods (2008)* and the companion report *The Government's Response to Sir Michael Pitt's Review of the Summer 2007 Floods*, and the *Australian Water Information Research and Development Alliance (WIRADA) Science Plan (2008)*.

Related Research

The Foundation invests in several non-Platform programmes that are relevant to hazards research, including: Consequences of Earth-Ocean Change (NIWA, C01X0702); Impact of Plate Tectonics (GNS Science, C05X0702); QMAP: Geological Map of New Zealand (GNS Science, C05X0401), Nationally Significant Database: Water Resources and Climate (NIWA, C01X0303), Adaptation to Climate Variability and Change (NIWA, C01X0701), Regional Modelling of Future New Zealand Climate (NIWA, C01X0804). The outputs from these programmes are already well-integrated with Platform activities.

EQC support of the GeoNet Project plus other hazards research and associated capability development is guided by an existing research strategy. Achieving alignment with Platform activities should thus be relatively easy.

Significant research funding flows to Universities via Vote Education and the PBRF. For their part, CRI's receive Capability funding from Government for the maintenance and development of national research capabilities. Significant Capability funding is applied in the natural hazards area.

Central and Local Government (e.g. MCDEM, Regional Councils) also undertake and/or commission research that is related to specific natural hazards issues. In engineering, industry funding is often used for short-term research projects. One aim of the Platform will be to align these relatively diverse research efforts under the umbrella of the Platform Research Strategy.

The Marsden Fund, administered by the Royal Society of New Zealand, is for curiosity-driven research. For this reason it is not realistic to expect true alignment with Platform research, but information sharing with Marsden-funded researchers would be desirable to prevent duplication of effort.

PLATFORM CAPABILITIES

The comprehensive Research Strategy that is to be developed by 31 July 2010 will include a summary of the research capabilities that exist within each of the research organisations that are a part of the partnership agreement. Producing such a capability summary is not feasible in the time available for producing the interim strategy.

SUPPORTING INFRASTRUCTURE

Whereas Platform research will sometimes involve data collection in its own right, it will also be critically dependent on data from national networks for:

- Earthquakes, volcanic activity, tsunami and landslides (GeoNet).
- Earth deformation (GeoNet, supported by EQC and LINZ);
- Weather and climate (NIWA and MetService);
- Hydrology (NIWA, regional councils and energy companies);
- Satellite remote sensed data (NIWA receiving stations); and
- Sea level (NIWA and port companies).

The geological hazard data relies on national monitoring networks (e.g., seismographs, GPS, and strong motion accelerographs) set up by the GeoNet Project, and supported by EQC. The modelling and forecasting within the weather theme is critically dependent on access to ground based weather, aircraft, radiosonde, ocean and satellite data. High performance computing (HPC) capability is required to support the development of individual models, the development of linked models in an operational environment (so they can be readily deployed without re-engineering), and the operation of hazard forecasting systems. These are part of a larger environmental forecasting effort, so while the focus here is on hazards, the capability has much wider applicability.

IWI / MAORI RESPONSIVENESS

Iwi/Māori have a special relationship with the land, and natural hazards play a critical role in their culture, identity and spirituality. This relationship has formed over hundreds of years of continuous habitation, where iwi/Māori have established and demonstrated environmental mātauranga. Research programmes within the Platform will seek to work collaboratively with iwi/Māori, where there is relevance, and to develop pathways to implementation to deliver outcomes for New Zealand. In these areas iwi/Māori, are both environmental managers and research users.

The Platform should:

- identify iwi/hapū that are key stakeholders/research users and determine the nature and extent of that relationship;
- determine how the research teams will work with iwi/Māori to ensure the research delivers practical and pragmatic results for New Zealand; and
- identify the methodology around how the uptake of the research will occur, and how the research team will work collaboratively with iwi/Māori and other research users to develop an approach that supports the uptake of the research in a practical way.

Effective engagement with iwi/Māori is important in the delivery of national outcomes for hazards research. Iwi/Māori have expressed a desire to work more collaboratively with research teams not only in the development of research plans but also in the delivery and implementation of the research. This includes exploring how traditional Māori knowledge systems (mātauranga) can be utilised and integrated to strengthen and complement research programmes, while ensuring protection mechanisms for that knowledge including intellectual property.

INTERIM RESEARCH THEMES

The Platform research is organised into five interim themes

1. Geological hazard models;
2. Predicting weather, flood, and coastal hazards;
3. Developing regional and national risk evaluation models;
4. Societal resilience: social, cultural, economic and planning factors
5. Resilient buildings and infrastructure

The themes have significant links between them. For example, the basic research conducted in the Geological and Weather Hazard themes provides information for application in the evaluation of Risk in Theme 3. That basic research also informs Building and Infrastructure Resilience research (Theme 5) and engineering design nationally. Research pertaining to Societal Resilience (Theme 4) can potentially contribute across all themes in terms of improving uptake of information.

Across the Research Themes, intermediate outcomes will be achieved through:

- Rigour in the scientific investigation;
- Proactive engagement with stakeholders who operate utilities, maintain infrastructure, protect people, insure assets and plan for future growth; and
- Collaboration with other scientists, planners, risk specialists and engineers.

Theme 1: Geological Hazards

Geological Hazard Frequency and Magnitude Models

In order for New Zealand to mitigate natural hazard impacts it is critical to understand why volcanoes, earthquakes, landslides and tsunami occur where they do, at what frequency, and in what magnitude range. From this fundamental understanding, quantitative comparisons between different hazards (a "multi-hazards" approach) will be developed using probabilistic modelling methods for individual, and integrated, perils. These models provide the hazard component of the risk equation.

This research theme directly contributes to Reduction, Readiness and Response through the National CDEM Strategy goals of *Reducing the risks from hazards to New Zealand* and *Enhancing New Zealand's capability to manage civil defence emergencies*

Volcanic Eruption

Impacts from volcanic eruptions can only be mitigated by first understanding the complicated workings of the volcanic system and its products and then providing pragmatic solutions to reduce the effects of eruptions. Our strategy to understand volcanic systems and mitigate their hazards includes four basic components. These are: (i) to understand the size, frequency of occurrence and style of past eruptive activity; (ii) to understand the most likely character and size of future eruptions through current monitoring indicators (earthquakes, gas release, ground motions, etc.) and the record of past activity, and examine potential precursory activity to provide better eruption forecasting; (iii) to characterise impacts from consequent hazards (lahars, lava flows, pyroclastic flows and ashfall, etc.); and (iv) to improve automated warnings (eruption detection systems, lahar warning systems, ashfall warning systems) for volcanic hazards.

Land Instability Research

The primary research goal is the understanding of landslide formation and movement processes. This requires inputs from engineering geological mapping (including techniques such as laser scanning), dedicated monitoring (increasingly in near-real time)

and laboratory determination of physical and mechanical properties (including techniques currently not available in New Zealand) to facilitate numerical evaluation of landslide stability and deformation patterns. Included in this are some of the equivocal research problems, such as (i) what is the role of fragmentation in long run-out landslides, (ii) what causes a block slides to accelerate, and (iii) what are the range of conditions that can initiate a debris flow. Landslide process knowledge contributes to wider research goals such as development of robust landslide magnitude-frequency (scaling) relationships. The research draws on the GeoNet catalogues and databases collected for recent and paleo events and also forms a cornerstone for the development of landslide models using susceptibility and probabilistic approaches, both of which are in their infancy.

Tsunami Research

New Zealand is exposed to potentially devastating impacts from a range of tsunami sources. Research related to tsunami hazard seeks to provide an understanding of the geophysics of tsunami sources, the dynamics of tsunami propagation, and the processes of inundation, so that the risk from tsunami can be understood and mitigated against. This aims to put tsunami hazard into a quantitative frequency-magnitude framework comparable to the other natural hazards, via two main research strands: tsunami modelling and tsunami source identification.

Earthquake Hazard Research

New Zealand's plate boundary location means that it is particularly vulnerable to earthquake hazard, especially since several of our large cities are situated close to active faults. From New Zealand's historical record, we also know that earthquakes are an important trigger for local tsunami, landslides, and liquefaction. Earthquake effects possibly represent the most severe, but infrequent, natural hazard in New Zealand, yet are also the most amenable to mitigation via zoning, building codes, and other social measures. For these reasons, earthquake research is critical, and has very high uptake by research users.

Key Research Questions

1. Why do volcanoes of different type occur where they do in New Zealand, is this a stable configuration, and what is the average and maximum scale to different types of volcanism.
2. What timescale is typical for volcanic crises at different types of volcanoes, and what is the range of collateral hazards associated with this volcanism. What are typical timescales of these collateral hazards.
3. What are the best precursory signals of volcano unrest, what combination of monitoring tools are likely to be most useful at different types of volcanoes, and how can modelling of magma genesis and volcano plumbing systems inform forecasting.
4. What are the thresholds for landsliding related to earthquake and rainfall triggers, what are the parameters controlling surging of block slides, and how far and how fast do rapid landslides pose a hazard.
5. What controls the variation in occurrence and size of landslides through time
6. What are the magnitude – frequency characteristics of landslides in different parts of New Zealand and can this data be developed as robust probabilistic and susceptibility models.

7. What properties that control the stability of slopes in different rock types.
8. What is the variation in frequency and magnitude of tsunami attack around New Zealand, and can probabilistic inundation models be developed.
9. Are undersea landslides and volcanoes a significant contributor to tsunami hazard in New Zealand.
10. Is debris and pollutants caught up in tsunami inundation a significant and under-appreciated component of tsunami hazard.
11. How effective are typical New Zealand natural coastal landscapes at buffering tsunami attack.
12. How accurately known does coastal terrain, including the built environment, need to be known before accurate tsunami inundation be modelled.
13. To what extent can the past record and effects of New Zealand earthquakes, from instrumental recordings, historical accounts, and studies of active faults accurately forecast future events.
14. Can future location, size, and temporal clustering of earthquake activity be understood by investigating the physics of earthquakes in the New Zealand tectonic context, including the role of stress triggering and fault communication; the interplay between stress build-up and release in the crust; rupture mechanics; and statistical of earthquakes activity.
15. Can robust understanding of the influence of the earthquake path and regional soil properties on seismic wave attenuation and the interaction of earthquake shaking with human structures reduce uncertainty is hazard estimates.
16. Is real-time statistical forecasting of earthquake probabilities an achievable goal for New Zealand.

Theme 2: Weather, Flood and Coastal Hazards

Predicting weather, flood and coastal hazards

New Zealand communities and related infrastructure will have increased resilience to natural hazards through being able include relevant information on weather related hazards into long term planning, and through short term response to forecasts of the whole range of weather related hazards. This will be achieved through the uptake of climatological information on weather related hazards (e.g., return periods and intensity) by planning agencies, and the adoption of integrated hazard forecasts by weather sensitive industries and emergency response practitioners.

The key science goals to achieve this outcome are obtaining magnitude and frequency data on historical events, now and within a changed climate, and the development of improved weather prediction models, linked to downstream flood and river and coastal inundation models at the scale of the New Zealand landscape. The collection and incorporation of relevant ground based and satellite weather, river and coastal data are critical to both the analysis of past events and for assimilation into predictive models.

The statistical and forecast model output will in future be combined with the RiskScape model (theme 3) to provide an integrated assessment of impacts and possible long and short term mitigation options. Hence this theme contributes to the outcome of a reduction in the impacts of hazard events through planning and emergency response to extreme events based on advance knowledge of the likely events and their impacts.

By adopting the tools developed in this research, local government river managers and CDEM practitioners will incorporate new nationwide flood and inundation forecasting outputs into their operational management of river flow and floods. Weather hazard sensitive industries in New Zealand will incorporate decision support tools based on more accurate weather drivers to optimise returns and minimise risk to their operations. Hazard impacts and risk are an integral part of central and local government planning, and plans and development will incorporate updated information on hazard event magnitudes and return periods, including provision for the effects of climate change. Coastal planning will incorporate updated hazard information, including sea level change, combined with model predictions of the longer term evolution of coastal margins.

This research theme contributes to Reduction and Readiness through the National CDEM Strategy goals of *Reducing the risks from hazards to New Zealand* by quantifying the magnitude and frequency of past weather and flood events (and contributing to estimating future events in a changed climate) and *Enhancing New Zealand's capability to manage civil defence emergencies* by creating forecast products to assist in warning of events, and specify their magnitude and duration during an emergency.

Weather Research

The focus of weather research is on the improvement of forecast model accuracy through increasing model fidelity and spatial and temporal resolution, the assimilation of data into the model, and the evaluation of ensembles of model runs. Research will also address the issues of providing forecast uncertainties via probability models and developing methods to determine forecast accuracy.

Flood Research

As New Zealand's most frequent natural hazard, flooding occupies a central place in research efforts, also linking weather research, via inundation modelling, to the impacts modelled in Riskscape. The aims here are to determine the magnitude and frequency of past events, reviewing the statistics as longer time series and more extremes become available, and creating forecast tools. The latter require increased knowledge of catchment processes to ensure the fidelity of flood models, and of fluid modelling and topographic interactions to accurately simulate flood inundation.

Coastal Hazard Research

Coastal hazards range in scale from inundation and erosion due to individual storm (wave and surge) events, to longer term erosion. This research seeks to determine the occurrence statistics for extreme events, and to create models linked to the driving weather that can be used to forecast the hazards, and via Riskscape, their impacts. There is also a strong link to climate change research, where the hazards events modelled here increase the risk as sea levels rise.

Key Research Questions

1. What are the frequency and magnitude of damaging weather, flooding and coastal hazard events, now and in a changing climate.
2. What are the key processes driving weather-related hazards (storms, floods, coastal, maritime, drought, snow/avalanche/hail, landslides [hydrological trigger] and volcanic ash-fall, and marine-geological hazards (submarine faults,

volcanoes, underwater landslides and tsunami) and how can we include them to improve predictive models.
3. What are the optimum data types, data assimilation methods and model structure to improve weather forecast model initialisation and hence accuracy for New Zealand.
4. What is the optimum way to implement ensemble forecast models and represent uncertainty for hazard predictions.
5. What improvements to model processes, data assimilation and verification are required to improve flood forecast accuracy and forecasts of inundation depth in advance of and during flood events.
6. What coastal process information and data are required to develop and implement models that simulate hydrodynamic and morphodynamic interactions in the near-shore and foreshore, and that simulate the evolution of coastal margins.
7. Can we develop and verify deterministic and probabilistic forecasting systems for sea-level, coastal inundation, sea-state and tsunamis.
8. What are the best tools providing forecast output to users and for communicating risk and uncertainty to hazard practitioners.

Theme 3: Risk Evaluation Models

Developing Regional and National Risk Evaluation Models

Use of Riskscape as a national tool, along with related models, by emergency management authorities, response planners, and lifeline utility operators, will underpin emergency management and response decisions with consistent, rational, risk-informed information, enabling prioritisation of both mitigation and response planning measures.

As a consequence, New Zealand society will have enhanced its overall resilience to natural hazards through prioritised expenditure and reduction of both social and economic impacts of at-risk communities.

The outcome will be achieved through partnering with local and central government agencies, engineering and lifeline operators and insurance industries responsible for emergency management, land-use planning, public and private utilities and risk transfer.

This research contributes to Reduction and Response through the National CDEM Strategy goals of *Reducing the risks from hazards to New Zealand* and *Enhancing New Zealand's capability to manage civil defence emergencies* by providing tools to perform quantitative risk assessments and providing near real-time estimates of hazards event impacts.

Key research questions

1. What are the options and limitations for defining and implementing scenario and probabilistic hazard exposure models across a range of New Zealand natural hazards.
2. How can existing fragility and vulnerability data for natural hazards in the New Zealand be used to model hazard exposure to potential impacts.
3. How can lifeline and essential utility systems be modelled to reflect damage and functional outage during severe events.

4. How can direct damage to communities (buildings, lifelines and social disruption) be incorporated into risk models to enable overall impacts of community losses from natural disasters to be meaningfully presented.
5. How can complex scientific concepts and engineering response parameters best be combined and reported to end-users so as accurately reflect exposure and impact of natural hazards on New Zealand communities.

Theme 4: Societal Resilience

Societal Resilience: Social, Cultural, Economic and Planning Factors

This IO contributes to the creation of well-prepared and resilient communities, identifying success factors so that individuals and organisations are motivated and able to prepare, respond, and recover from natural hazard events. A key to successful outcomes is the participation of communities in the scoping and design of the research and application of research findings to evidence-based policy and practice. This is done both formally through advisory groups and through direct discussions with specific research users at an individual project level.

The outcome will be achieved through; (i) quantification of the hazard event in terms of physical, social and economic impacts (in concert with other IO's); (ii) engagement with communities of all types and stakeholders at all levels to understand functions, needs, cultural and economic contexts: (iii) development of improved disaster management strategies: (iv) development of improved organisational systems to recover economic competitiveness after hazard events; (v) development and quantitative assessment of sound, pragmatic, reasonable, options for hazard mitigation – advocacy of the appropriate mix of reduction, readiness, response and recovery activity, in concert with other IO's.

This research theme directly contributes to Reduction, Readiness, Response, and Recovery through the National CDEM Strategy goals of *Increasing community awareness, understanding, preparedness and participation in CDEM, Reducing the risks from hazards to New Zealand, Enhancing New Zealand's capability to manage civil defence emergencies,* and *Enhancing New Zealand's capability to recover from civil defence emergencies* by applying social science research across the 4Rs.

Key Research Questions

1. What are the social, cultural, and economic factors that lead to strong communities, resilient to the impacts of natural disasters, and what planning, policy, and organisational frameworks are necessary to mitigate potential hazard impacts.
2. How can hazard data be better understood, applied and utilised by policy makers, planners, emergency managers, organisations, individuals and communities, as an integral part of the planning and risk management processes.
3. What are the key factors that contribute to individuals, communities and organisational resilience in the face of adversity, and what are the best strategies for improving resilience.
4. How effective are emergency management procedures, and crisis management practices for managing societal response to warnings and disasters.
5. How do we evaluate the effectiveness of emergency management planning and response to events.

6. What is the range of physical, cultural, economic, psychosocial, and political, impacts of disasters on individuals, communities and organisations, over varying time frames, and how can this knowledge optimise the recovery process.
7. What are the key steps by which society transitions back towards a new equilibrium after the disruption caused by a natural hazard event.

Theme 5: Resilient Buildings and Infrastructure

Resilient Buildings and Infrastructure

Enhancing the resilience of our communities to the effects of natural hazard events involves application of sound engineering principles to address both building collapse avoidance and the preservation of key lifelines in order for them to remain operational. Engineering research will provide a performance-based framework within which both life safety and operational functionality are achieved in a cost-effective manner. When implemented, community impacts experienced during an event will remain within tolerable limits, people will, in the main, be able to continue living within their homes. Critical services, although they can be expected to be disrupted, will be restored, within acceptable timeframes to avoid lengthy societal disruption with consequent economic impact.

A performance-based framework will be used to provide damage control to both new buildings (and infrastructure) and to establish mitigation and strengthening (retrofit) provisions for our existing built environment, including buildings, bridges, dams, water supply and waste networks, and energy and communication networks.

This research theme directly contributes to Reduction, Readiness, Response and Recovery goals of the National CDEM Strategy, and specifically *Reducing the risks from hazards to New Zealand* and *Enhancing New Zealand's capability to recover from civil defence emergencies* by improving the resilience of the built environment to natural hazard impacts so that damage is lessened and post-event services are less disrupted.

Key Research Questions

1. Can a suitable, probabilistic, performance-based engineering framework be established that will ensure existing and future buildings and infrastructure meet target performance levels so as to enable rapid and cost-effective restoration of fully functioning communities following a natural hazard event.
2. How can buildings be economically designed, built and/or retrofitted so as to match the societal performance expectations, both during and following, a natural hazard event.
3. How can critical infrastructure lifelines systems be designed, built and/or upgraded so as to maintain their life support function following a natural hazard event, being cognisant of the high level of interdependency between such networks.
4. What decision support tools are available to evaluate cost-effective mitigation to ensure adequate future resilience of the built environment.
5. Can alternate approaches to performance based design, current building stock analysis, and retrofit options be accurately quantified as input to holistic natural hazard risk assessment.

ACHIEVING THE OUTCOME

Realistically, achieving the desired outcome of a more resilient New Zealand will take time and a number of interdependent actions by a wide range of organisations. A first step for the Platform is to build more effective links with research users so as to better understand their research needs and at the same time educate users about what science and engineering can deliver and the context we work in and constraints we face within the science environment. At the same time there needs to be alignment of research effort within and around the Platform, as well as increased collaboration and integration across organisations and science disciplines, so that the best science is delivered.

Closer research user relationships and better awareness of needs will lead to an improved ability to deliver relevant research in the right form. The EQC *Science to Practice* programme is relevant in this regard. A potential barrier to achieving better research delivery is lack of science funding, given that it is essential that the basic research effort is preserved so that national capabilities are maintained to deliver benefits in the long term. A natural consequence of a tight financial climate is that research providers look to research users to provide funding for research transfer, thus creating a barrier to uptake. While the Envirolink[12] funding scheme helps to overcome this, it does not address the underlying problem.

Key applied research projects are another mechanism for 'making a difference'. There are many examples of engineering research projects carried out by Engineering Schools where industry and Vote Education co-funding have been used to solve a particular construction issue relevant to earthquake resistant design. In a similar way, The *It's Our Fault* project assessing the earthquake risk in Wellington is poised to deliver early results that may fundamentally change the way the earthquake threat to New Zealand's capital city is viewed. The Platform will continue with this tradition of flagship applied research projects.

The steps outlined above should be viewed as the start of a longer journey that has great potential. New Zealand is a small but well-developed country with a well-educated population. While its physical setting means that the level of hazard exposure is high, through a well-integrated effort within a relatively small community of interest, the challenge of making New Zealand highly resilient to natural hazard impacts is definitely achievable.

APPENDIX 1: FOUNDATION PROGRAMMES INCLUDED IN THE PLATFORM INTERIM STRATEGY

Organisation	Contract ID	Title	Primary Research Theme	Total value p.a. (incl. GST)[1]	Start date	End date
Anchor Contracts – SFE1 assessment						
GNS SCIENCE	C05X0804	Geological Hazards and Society	1, 4	$4,161,500	1/10/2008	30/09/2016
NIWA	C01X0812	Reducing Impacts of Weather Related Hazards	2	$2,154,000	1/10/2008	30/09/2016
RISKSCAPE	RISK0801	The Regional RiskScape Model	3	$2,000,000	1/10/2008	30/09/2016
Contracts assessed in 2009 (Foundation Terminating Contract Review)						
GNS SCIENCE	C05X0402	NZ Hazardscape	1	$157,549		30/09/2009
GNS SCIENCE	C05X0301	Post-Earthquake Functioning of Cities	5	$635,000	01/07/2003	30/09/2010
GNS SCIENCE	C05X0403	Immediate Surveillance and Damage Assessment Following Natural Disasters	3	$145,000	01/07/2004	30/09/2010
Massey University	MAUX0401	Living with Volcanic Risk	1, 3	$707,940	01/07/2004	30/09/2010
OPUS	OPSX0401	Community Resilience	4	$420,000	01/07/2004	30/09/2010
University of Auckland	UOAX0411	Retrofit Solutions for NZ	5	$600,000	01/07/2004	30/09/2010
University of Canterbury	UOCX0302	Future Building Systems	5	$520,000	01/07/2003	30/09/2010
University of Canterbury	UOCX0401	Resilient Organisations/Organisational Systems	4	$299,011	01/07/2004	30/09/2010

[1]The p.a. contract values exclude funding for nationally significant databases and collections which are now funded through Backbone funding.