NATURAL HAZARDS PLATFORM —

RESEARCH STRATEGY 2010-2011

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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, and more broadly to sustainable land management. 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 hazards, in particular to earthquakes, 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 as a result of strong 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.

While there are advanced design and regulation for earthquake and some frequently-occurring hazards such as river flooding or severe wind, the mitigation instruments for other perils are lagging. Evaluation of risk, particularly with respect to indirect economic loss and social impact are in their infancy. A cornerstone of our research must be a risk management framework because in a country such as New Zealand the physical

processes are such that it is unrealistic to reduce risk to zero. Thus, we will advocate risk evaluation underpinned by probabilistic methodologies, recognising that tolerable impacts of hazards will vary depending on land use, numbers of people and assets exposed, importance categories of buildings (Dept. of Building and Housing), and expectations or requirements of operability during and following natural hazard events. Considerable work is required to clarify acceptable risk and tolerable impacts in New Zealand society with respect to natural hazards.

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 and engineering 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:

- Identification of the location, severity and frequency of natural hazard events and processes throughout New Zealand.
- Development of potential avoidance or mitigation strategies for natural hazard risks such that civil defence emergencies (either local or national)[1];do not exceed tolerable impacts or acceptable risk levels.
- 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:

[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.

- 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;
- 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

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

2. Reducing the risks from hazards to New Zealand;
3. Enhancing New Zealand's capability to manage civil defence emergencies;
4. Enhancing New Zealand's capability to recover from civil defence emergencies.

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, as do performance guidelines of the Dept. of Building and Housing, and the NZ Transport Authority.

Key Research Users

The research conducted by the Platform and associated programmes encompasses all of the government's investment in natural hazards research, much of it being undertaken by GNS Science and NIWA, two of the government-owned Crown Research Institutes. Thus, the Platform is responsible for conducting research in the national interest in accord with the Crown Research Act 1992. All government agencies, New Zealand business and State Owned Enterprises and indeed the public of New Zealand are the expected users of Platform research.

Key government agencies whom we expect to use Platform Research include the Accident Compensation Commission, Ministry of Agriculture and Forestry (particularly with respect to the influence of natural process on sustainable land management), Department of Building and Housing, Civil Aviation Authority (with respect to volcanic ash hazard), Department of Conservation, Ministry for Economic Development, Ministry of Foreign Affairs and Trade (with respect to Pacific Island nations responsibilities and natural hazards, as well as science for diplomacy), Ministry of Health (with respect to response and recovery to natural hazard disasters), Maritime New Zealand (for advice on tsunami and severe weather advice), and New Zealand Transport Authority (with respect to transport planning taking account of natural hazards).

[3] http://www.envirolink.govt.nz/documents/researchfortheenvironmentmar09.pdf
[4] www.geonet.org.nz
[5] http://www.eqc.govt.nz/research/Researchstrategy.aspx

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 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); Nationally Significant Database: Water Resources and Climate (NIWA, C01X0303), GNS Nationally Significant Database; earthquake, volcano, and geological mapping (GNS Science C0X0906), Adaptation to Climate Variability and Change (NIWA, C01X0701), Regional Modelling of Future New Zealand Climate (NIWA, C01X0804), Paleoseismicity of the Alpine fault and Hikurangi Subduction Margin (NIWA, C01X0801), and MARGINS Source-to-Sink New Zealand (GNS Science C05X0705). The outputs from these programmes are 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, CRIs 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

[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

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 30 June 2011 will include a summary of the research capabilities that exist within each of the research organisations that are a part of the Platform.

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).
- Backbone funded Nationally Significant Databases

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.

MAORI POLICY

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, interaction and adaptation with the natural environment. Iwi/Māori have established and demonstrated traditional knowledge (mātauranga Māori) associated with this interaction and adaptation to the natural environment. This knowledge base can make a valuable contribution to the research outcomes within the Hazard Platform. The Platform Management Group is committed to supporting research which seeks to unlock this potential within Iwi/Māori communities to contribute to research outcomes. This will begin with the development of a Māori Research Policy (MRP) which will feed into the Natural Hazard Platform Research Strategy and be implemented alongside the overall Platform objectives. The MRP will be developed with the support of Iwi/Māori, researchers and Platform Management and will be undertaken through a series of hui which will identify the key strategic outcomes the Platform should

address. The timeline for the development of the MRP will be 12 months and will be lead by GNS Science, NIWA and the partner organisations with the support of key stakeholders and end-users.

Relevant research programmes within the Platform will seek to work collaboratively with iwi/Māori, to develop pathways for implementation and delivery of outcomes for New Zealand. Effective collaborations 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 strategies and plans, but also in the delivery and implementation of the research.

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.

Theme 2: Weather, Flood and Coastal Hazards

Modelling Weather, Flood and Coastal hazards

Including accurate information on weather related hazards into long term planning, and through short term response to forecasts of the whole range of weather related hazards will improve the understanding of the exposure of New Zealand to 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.

Theme 3: Resilient Buildings and Infrastructure

Resilient Buildings and Infrastructure

The application of sound engineering principles to provide a performance-based framework within which both life safety and operational functionality are achieved in a cost-effective manner are the cornerstones of the research.

Theme 4: Risk Evaluation Models

Developing Regional and National Risk Evaluation Models

Assembly of nationally consistent information on hazard exposure and vulnerability, coupled with hazard analysis made on a probabilistic basis will enable comparison between equally likely hazard events and consider complications arising through cascading hazard impacts and interdependencies in infrastructure networks. This comparison using the Riskcape tool along with further modifications and innovations can support decision-making by: a) helping to prioritise investments in specific measures that reduce the risk.

Theme 5: Societal Resilience

Societal Resilience: Social, Cultural, Economic and Planning Factors

The research investigates the characteristics 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.

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.