Hazards and Infrastructure Fund - 2015 Science Investment Round Successful Proposals

Short Title	Organisation	Term	Total funding (excl GST)	Summary
Waterproof Roads- Improved Methods for the Provision of an Affordable Optimised and Future-Proof Transportation Infrastructure	Opus International Consultants Limited	4	$3,000,000	The aim of this research is to significantly reduce the annual maintenance and construction costs to NZ roading authorities that result from water damage to road surfaces and underlying pavement layers. Our project will research and develop novel waterproofing novel materials and innovative road construction methodologies that will be become the accepted industry standard by NZTA and other roading authorities overseas. Accepted new products and services could generate export revenues for NZ, as well as, domestic road construction and maintenance cost minimisation that allow NZ roading authorities to further optimise and modernise the network. The majority of New Zealand's roads (90% of the network) consist of a compacted gravel (aggregate) basecourse layer over which thin chip seal layers are constructed. The purpose of the seal is to provide a skid resistant surface for traffic and prevent water entering the basecourse. In fact seals are not effective in waterproofing the basecourse layer (i.e. they leak). This is true even when multiple layers of seal are present. A properly designed, dry basecourse will last almost indefinitely even under very high traffic loadings, but is highly susceptible to water damage which under the action of traffic results in deformation and rutting in the vehicle wheel paths and eventually potholes. Water entering the seal layer also damages the seal itself and results in disbonding of the bitumen from the stone surface and migration of the bitumen to the surface, resulting in a condition known as flushing (the riding surface becomes 'slick' with bitumen). The goal of this project is to find novel, cost effective methods to prevent water damage. The work has two key components: • Development of new or modified bitumen materials and methods to construct a flexible, tough, oxidation resistant and water impermeable membrane layer. The membrane layer will impregnate the top 10-15 mm of the basecourse to form a waterproof barrier between subsequent conventional surfacing layers and the underlying pavement. • The research will develop materials that bond chemically and irreversibly to the aggregate, modifying its surface to produce a water resistant aggregate-bitumen interface that will over the long-term, prevent the disbonding of bitumen that leads to flushing. For further information contact: Phil.Herrington@opus.co.nz
Local Demand Control of Electricity Supply	University of Auckland	4	$2,390,181	Local Demand Control (LDC), the technology that this project will develop, improves the ability of any power system to operate with fluctuable loads from renewable sources without compromising the integrity of the grid. It uses small micro grids, independently controlled, to absorb fluctuations seamlessly so that a user is not aware that the fluctuations exist. It does this with low capital investment and operational cost whilst allowing the user control over the loads and the applications that are important to him or her (e.g. a heat pump, a nebuliser, a beer fridge). The system works by switching off non-critical loads when the power supply is stressed but the user can choose those loads that are to be switched, and the order of the switching. The system is completely safe under fault conditions – this safety extends to all loads fail to on or off. It maintains intrinsically high power factor, it allows time of day pricing, in every facility of the micro-grid. The microgrids in the system are all completely independent and operating conditions in one grid have no effect on any others. LDC improves the load factor of the power system making its operation more efficient and reducing the cost of supply to all consumers. One potential application is to manage the loads on the electricity grids serving small remote communities, so that consumers do not suffer power cuts when the local mill or dairy factory switches on. The LDC system can also be directly connected to a variable pitch wind turbine, allowing small communities the option of generating some electricity from renewable sources, thus reducing their power bills. Nationally, the benefit of the LDC technology is to manage demand loads on the national grid (both peak demand, such as the evening peak in winter when people arrive home, and also the steadily increasing average demand) without having to rewire all of New Zealand to accommodate the high loadings. This NZ-developed technology will also be turned into commercial products by NZ companies and exported to the world, since it solves a problem experienced in all developed countries.
Healthy Future Mobility Solutions	Mackie Research &	4	$2,172,000	The objective of this research is to explore how mobility systems in New Zealand can best support active and healthy transport solutions,

	Consulting Limited			and the benefits this offers for social and economic wellbeing. This research is in the context of a globally changing transport environment, stemming from a combination of technological change, social change and new approaches to designing urban form. A mobility system that supports economic and social wellbeing outcomes will need to incorporate active and public transport solutions and integrate with new housing approaches, in ways that are responsive to the disruptive changes underway. The research is centred around four interconnected strands of research: **Optimising routes in towns and cities**: Identifying medium-term road safety and community outcomes from leading edge street design interventions developed in the Future Streets project. This will include monitoring changes in road user behaviour, and qualitative research with local residents and stakeholders. Action research will explore the potential for, and barriers to, uptake of Future Streets principles in street interventions nationally. **The future of the bike**: Identifying the value of shared spaces for safe bike travel and the disruptive potential of e-bikes as a mobility solution. This will make use of literature analysis, qualitative interviews, system dynamics modelling, and empirical measurement of the impacts of e-bike and standard bike use. **Active school travel**: identifying success factors for active school travel as a strategic transport lever to support an optimised transport system, drawing on existing databases, in-depth case study research, and testing enhanced models for active school travel. **Youth mobility for education, employment or training**: Understanding the mobility needs, system barriers and enablers for young people, focussing on those not in education, employment or training, using qualitative peer-led research participatory GIS methods. A range of qualitative and quantitative techniques will be employed to analyse and synthesise data from these individual streams. These will together inform a fifth workstream incorporating a rich dialogue process with key stakeholders from community, policy and transport practitioners to build shared knowledge of the available evidence, and develop consensus on longer-term policy directions. This research will explore trends, challenges and opportunities for transport systems to support the health and wellbeing of New Zealanders. It will identify means by which the transport system can be shaped to ensure active and health promoting access to the people, goods, services and amenities that are intrinsic to our communities and economy, and reflect cultural identity. This is a multi-layered, integrated and achievable research programme that is built on a cost-effective combination of existing datasets and new empirical research. The research team have a strong track record individually and collectively in delivering high quality research. Our existing Future Streets collaboration has established strong and cohesive ways of working to deliver research and translate this into knowledge and practice, in partnership with stakeholders and communities.
Solar Tsunamis: Mitigating Emerging Risks to New Zealand's Electrical Network	University of Otago	3	$1,467,000	Solar Tsunamis, or Aniwhaniwha Komaru, are massive clouds of plasma which explode from the Sun into space. If these clouds are Earth-directed, they can trigger temporary disturbances to the large-scale magnetic field of the Earth called "geomagnetic storms". Basic high school Physics tells us that changing magnetic fields will induce currents in conductors, like wires. These storms lead to geomagnetic induced currents (GIC) in electrical transmission networks and have damaged transformers and disrupted electrical supply on vast scales affecting millions of people over thousands of kilometres. A comparatively modest storm in November 2001 destroyed a transformer in New Zealand, and Transpower now regularly monitors GICs in its network and has protocols in place for similar-sized storms. The project focuses on reducing the possible damage from extremely large geomagnetic storms. The US National Academy of Sciences has warned that extreme geomagnetic storms could produce widespread power blackouts with permanent damage to 10+% of the primary transformers that are the backbone of the U.S. electric grid. Such an extreme storm would have global implications, damaging electrical networks across the world. In 2011 the United Kingdom Government added such storms to its National Risk Register. They are recognised as one of the highest priority natural hazards due to their potentially significant impact on critical national infrastructure. In this proposal we will examine the risk posed to New Zealand's electrical transmission network from extreme geomagnetic storms.

				Supported by Transpower New Zealand Limited, we will analyse their current and historical GIC monitoring data to better understand the space-derived drivers causing GIC in the New Zealand electrical network. This will assist Transpower in developing their real-time GIC security policy to deal with such extreme events, by linking it to potentially predictable space weather activity. Our research will help mitigate the potential impact on the New Zealand electrical network of such extreme solar tsunami events. We will construct a physics-based model of how GIC are produced in the New Zealand network by storms in space. This model will be validated using the Transpower historical data, along with high-resolution in-field measurements conducted during this project. We will use the validated model to determine what will happen to the New Zealand network during extreme geomagnetic storms, allowing Transpower and other agencies such as Civil Defence and emergency services to plan future mitigation strategies. We will also undertake an outreach component to engage the wider public in the science of space weather using GIC's association with spectacular aurora formations. Our team includes the Space Physics group from Otago University, the geomagnetism research group from Victoria University, supported by Space Weather experts from the British Geological Survey and the British Antarctic Survey. The project is lead by Professor Craig Rodger (University of Otago) and Malcolm Ingham (Victoria University of Wellington). Contact: craig.rodger@otago.ac.nz
Emerging anthropogenic slope hazards: Establishing risk assessment methods and remediation approaches for infrastructure-critical slopes	Institute of Geological & Nuclear Sciences Limited - Trading as GNS Science	3	$1,500,000	The emergence of anthropogenic slopes (modified by cutting and filling) began when people started settling in New Zealand. Many of these early modifications were relatively small scale – at the individual house scale – and posed limited risk to early infrastructure. Since the 1950's however, earth-moving machinery and technology (bulldozers and scrapers) became available, and coupled with the increasing demand for more homes and infrastructure as the population of urban centres has grown, larger scale earthworks – at the suburb scale – have been implemented. As a result of this expansion, much infrastructure and lifelines are now sited on or below anthropogenic slopes. This research will provide "New Knowledge" about controls on the response of anthropogenic slopes to earthquakes and changes in groundwater, and how design and construction methods may influence slope performance. Project aim: to assess the performance of anthropogenic slopes in central Wellington under earthquake shaking and significant rain events or cascade due to a combination of both. Project goal: To improve the resilience of New Zealand's infrastructure through better knowledge of the behaviour of anthropogenic slopes and develop strategies for more robust remediation approaches. In Wellington, as in other places, some anthropogenic slopes have performed poorly. Records indicate about 400 documented slope failures on Wellington City Council's road network annually, the majority of which occur in anthropogenic slopes. In 2009 and 2014, two large fill-slope failures occurred at Kelburn and Priscilla Crescent; both triggered by water seeping from cracked services. None of the modified Wellington slopes have been tested under strong earthquake ground shaking. During the 2010/2011 Canterbury earthquake sequence, anthropogenic slopes in Christchurch were tested under strong earthquake shaking and in many cases, cut and fill slopes failed and in some instances posed significant risks to life and critical infrastructure. The knowledge generated from the Christchurch slope failures is also relevant to Wellington, even though Wellington has different geological conditions. The size and scale of slope modification in Wellington, however, is far greater than in Christchurch. The risks associated with such anthropogenic hazards are now emerging given our knowledge of how such slopes in Wellington have performed over the past 60 years, along with results from new research investigating how natural slopes could perform in future earthquakes. Despite this, the scale of the problem and the level of risk to critical infrastructure and nationally significant infrastructure are not well known. There is no definitive inventory of anthropogenic slopes and given the greater than 8,000 buildings and nationally important infrastructure sited on Wellington slopes, the impacts from a strong earthquake are likely to be worse than those in Christchurch. Of particular interest is the potential for hazards to cascade, where for example earthquake induced slope damage could lead to a higher susceptibly of failure in a subsequent rain or earthquake event, in addition processes such as dynamic compaction could rupture critical services and water ingress from broken pipes could exacerbate the extent of slope failure. For information relating to this project please contact Dr Chris Massey: c.massey@gns.cri.nz
Total over 3-4 years			**$10,529,181**	