FP1: Ground Motion Simulation & Validation (GMSV)

Flagship Leader: Brendon Bradley (Brendon.bradley@canterbury.ac.nz)

Flagship Deputy Leaders: David Dempsey (d.dempsey@auckland.ac.nz), Seoho Jeong (seokho.jeong@waikato.ac.nz)

Flagship Industry Rep: Didier Pettinga (DidierP@holmesgroup.com)

Flagship Summary

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

The key thrust areas are:

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

Thrust Areas	Key tasks/Deliverables	Start	Finish
FP1.1 Simulation methods	1. Integrate existing codes used in New Zealand into NeSI computational resources	1/01 /2016	31/12 /2016
	2. Validate simulations using historical New Zealand earthquakes	1/01 /2016	31/12 /2020
FP1.2 Velocity model development	1. Develop enhanced 3D velocity models in two regions of New Zealand	1/01 /2016	31/12 /2018
	2. Utilize full waveform tomography for high-resolution velocity modelling	1/01 /2018	31/12 /2020
FP1.3 Nonlinear site and topographic response	1. Directly integrate site response and topography into ground motion simulations vs. the use of Vs30. Examine the effects in Canterbury and Wellington	1/01 /2016	31/12 /2019
	2. Perform detailed analysis on when site-specific account for nonlinear and topographic effects is justified vs. simplified approaches	1/01 /2018	31/12 /2020
FP1.4 Application for major New Zealand scenarios	1. Perform ground motion simulation case studies for cross-flagship research and outreach and compare with empirical predictions	1/01 /2016	31/12 /2018
	2. Develop a 'Ground motion simulation atlas' illustrating seismic intensity over a region for 50 earthquake ruptures which are greatest risk to New Zealand	1/01 /2017	31/12 /2019
FP1.5 Uncertainties and PSHA	1. Develop advanced ground motion simulations with treatment of modelling uncertainties	1/01 /2017	31/12 /2020
	2. Perform 'Cybershake' simulations performed for T>1s in New Zealand. Compare with hazard from codes and GMPEs	1/01 /2017	31/12 /2020
FP1.6 Use of simulations in earthquake engineering analyses	1. Develop a co-created industry working document on the use of ground motion simulations in engineering design	1/01 /2016	31/12 /2018
	2. Compare and assess simulated vs. recorded ground motions with archetype engineering structures used to determine bias in simulation methods for feedback to developers	1/01 /2017	31/12 /2020

Current Projects

Projects in 2018-2020 include the flagship coordinated project, projects funded through the QuakeCoRE RfP, and students with QuakeCoRE or other university scholarships.

- 18FP1 - Flagship 1 coordinated project, containing the following sub-projects:
  - 1a. Validation of simulations for NZ-wide shallow crustal events (Lee, Bradley)
  - 1b. Ground motion simulations with multi-segment rupture (Vyas, Razafindrakoto, Bradley)

- - 2a. Development of basin models in Wellington and Auckland using 1st order methods (Wotherspoon, Bradley, Kaiser, Jeong, Cox, Foster, Lee)
    - 3a. Explicit site response analysis in simulations of the Kaikoura earthquake (Bradley, Wotherspoon, Cox, de la Torre, McGann, Dismuke)
    - 3b. Topographic modelling for Alpine Fault and Kaikoura earthquakes (Taborda, Asimaki, Jeong, Bradley, Wotherspoon)
    - 4a. Simulation of Wellington Fault earthquakes (Bradley, Tarbali, Lee)
    - 4b. Simulation of Hikurangi subduction zone earthquakes (Somerville, Bayless, Skarlatoudis)
    - 4c. Simulation of moderate magnitude earthquakes in the Auckland region (Dempsey, Riffault)
    - 5a. Analysis and propagation of modelling uncertainties in ground motion simulation (Bradley, Vyas, Lee, Tarbali)
    - 5b. Simulation-based seismic hazard analysis for New Zealand at 400m resolution (Tarbali, Bradley)
    - 6a. Application of code-compatible simulation vs. recorded ground motions for structural and geotechnical systems (McGann, Hayden, Chandramohan, Bradley, Pettinga, Tarbali, Loghman)
    - 6b. Guidance on the selection of simulated ground motions as an alternative method for use in NZ (Pettinga, Fraser, Bradley)
- 18AF8 - Ground motion simulation of Alpine Fault (incl Wairau as 'Northern AF') earthquakes (Tarbali, Bradley + AF8 project)
- 18QCS - Ground motion simulations for the Dunedin-Mosgiel urban area (Stirling, Kowal)
- 18207 - Soil-foundation-structure interaction analysis of an instrumented Wellington building (McGann, Chandramohan, Hayden, Pettinga, Jeong)
- 18213 - Incorporating the influence of ground motion duration and response spectral shape in NZ structural design and assessment practice (Chandramohan, Horspool, Bradley)
- 18KF - Development of a NZ-wide Vs30 model for use in regional ground motion simulations (Foster, Bradley)
- 18ET - Parametric models for velocity characterisation of inter-bedded sedimentary deposits in the Canterbury basin (Thomson, Bradley, Wotherspoon, Wood)

Related Efforts

- Southern California Earthquake Center (SCEC) Ground Motion Simulation Validation (GMSV) Technical Activity Group (TAG)
- SCEC Broadband Platform: https://scec.usc.edu/scecpedia/Broadband_Platform
- Modelling earthquake engineering parameters (Holden and Kaneko; NHRP contestable round 2015-2017)
- Reconstructing complex ground motion effects in Christchurch during the Canterbury earthquakes: what does this mean for future ground motion prediction? (Kaiser; Marsden round 2013-2016)

Workshops

2021

- All 2021 workshops

2020

- All 2020 workshops

2019

- 22 August Webconference
- 27 June 2019 Webconference
- 23 May 2019 - Webconference

- 28 March 2019 - Webconference

- 28 February 2019 - Webconference

2018

- 22 November 2018- Webconference - Coordination of GMSV projects
- 25 October 2018- Webconference - Coordination of GMSV projects
- 20 September 2018- Webconference - Coordination of GMSV projects
- 26 July 2018- Webconference - Coordination of GMSV projects
- 28 June 2018- Webconference - Coordination of GMSV projects
- 24 May 2018 - Webconference - Coordination of GMSV projects
- 26 April 2018 - Webconference - Coordination of GMSV projects
- 22 March 2018 - Webconference - Plans on projects for 2018 GMSV projects
- 22 February 2018 - Webconference - Plans on projects for 2018 GMSV projects
- 25 January 2018 - Webconference - Plans on projects for 2018 GMSV projects

2017

- 28 September 2017 - Webconference - Planning of projects for 2018 RfP
- 24 August 2017 - Webconference - Coordination of QuakeCoRE GMSV projects

- 27 July 2017 - Webconference - Coordination of QuakeCoRE GMSV projects
- 22 June 2017 - Webconference - Coordination of QuakeCoRE GMSV projects
- 25 May 2017 - Webconference - Coordination of QuakeCoRE GMSV projects

- 23 March 2017 - Webconference - Coordination of QuakeCoRE GMSV projects
- 23 Feb 2017 - Webconference - Coordination of QuakeCoRE GMSV projects

2016

- 25 Feb 2016 - Webconference - Coordination of QuakeCoRE GMSV projects
- 24 March 2016 - Webconference - Coordination of QuakeCoRE GMSV projects
- 28 April 2016 - Webconference - Invited presentations on projects related to GMSV projects
- 26 May 2016 - Webconference - Coordination of QuakeCoRE GMSV projects
- 23 June 2016 - Webconference - Coordination of QuakeCoRE GMSV projects
- 15 July 2016 - Stakeholder workshop on "Guidance on the utilization of ground motion simulations in engineering practice"
- 28 July 2016 - Webconference - Coordination of QuakeCoRE GMSV projects
- 31 August 2016 - GMSV Workshop in conjunction with QuakeCoRE Annual Meeting
- 11-14 September 2016 - International Workshop on Ground Motion Simulation and Validation at the SCEC Annual Meeting
- 15 December 2016 - Webconference - Final presentation of 2016 QuakeCoRE GMSV projects

2017 Funded Projects

- 17084 - Development of a NZ-wide Vs30 model for use in regional ground motion simulations (Bradley, Foster - UC; Wotherspoon - UA; Somerville, Hosseini - AECOM; Thompson - USGS)
- 17085 - Waveform tomography of a South Island Velocity Model and simulation of major Hope Fault earthquakes on the South Island, NZ (Bradley, Lee, Thomson, Pettinga - UC; Wald - USGS; Horspool - GNS)
- 17086 - Response history analyses of structural and geotechnical systems using simulated and recorded ground motions (Pettinga - Holmes; Fraser - Golder; Bradley, Tarbali - UC; Baker - Stanford)
- 17088 - A 3D shear wave velocity model for Dunedin: Data gathering and interpretation (Stirling, Gorman, Holt - Otago; Wotherspoon - UA)
- 17114 - Development of a seismic velocity model and site characterisation for the Nelson/Tasman region (Wotherspoon - UA; Ryder - MWH/UA; Bradley, Foster - UC; Ghisetti - TerraGeologica)
- 17133 - Ground motion simulations for Hauraki rift earthquakes (Dempsey, Eccles - UA)
- 16/17FP1 - Ground motion simulation of Porters Pass earthquakes in the Canterbury region (Nazer, Bradley, Razafindrakoto, Pettinga - UC)
- 17AF8 - Ground motion simulation of Alpine Fault earthquakes (Bradley, Bae + AF8 project)
- 17KAIK - Ground motion simulation of the Mw7.8 Kaikoura earthquake (Bradley, Razafindrakoto, Polak)
- 17CYB - Cybershake: Simulation-based seismic hazard for the Canterbury region (Tarbali, Bradley)

2016 Funded Projects

- 16002 - Validation of Strong Ground Motion Simulations of two Historical New Zealand Subduction Zone Earthquakes on the SCEC BBP (Somerville, Bayless, Hossenini, Skarlatoudis - AECOM; Bradley, Foster - UC)
- 16006 - Validation of Ground Motion Simulations using Fragile Geologic Features (Stirling, Bowie - UOtago; Van Houtte - GNS)
- 16027 - Dynamic Site Characterisation of the Nelson/Tasman Region (Wotherspoon, Ryder - UA; Bradley - UC)
- 16030 - Advancing ground motion simulation methodologies through further insights from the 2010-2011 Canterbury earthquakes (Bradley, Thomson, Lee, Razafindrakoto, Jeong - UC; Wotherspoon - UA; Massey - GNS; Asimaki - Caltech; Baker - Stanford; Rodriguez-Marek - VTech; Graves - USGS)
- 16035 - Guidance for the utilization of earthquake-induced ground motion simulations in engineering practice (Pettinga - Holmes; Fraser - Golder; Bradley - UC)
- 16057 - Further coordination between QuakeCoRE and SCEC on ground motion simulation validation (Luco, Rezaeian - USGS; Bradley - UC)
- 16/17FP1 - Ground motion simulation of Porters Pass earthquakes in the Canterbury region (Nazer, Bradley, Razafindrakoto, Pettinga - UC)

Requests for Proposals

- 2017 QuakeCoRE Collaboration Plan - This will be released mid/late-Sept following the 2016 QuakeCoRE Annual Meeting

- 2016 QuakeCoRE Collaboration Plan - See page 9-10 for GMSV priorities. Proposals are due November 20, 2015.