

Maintenance of the spatial cadastre in response to earthquakes

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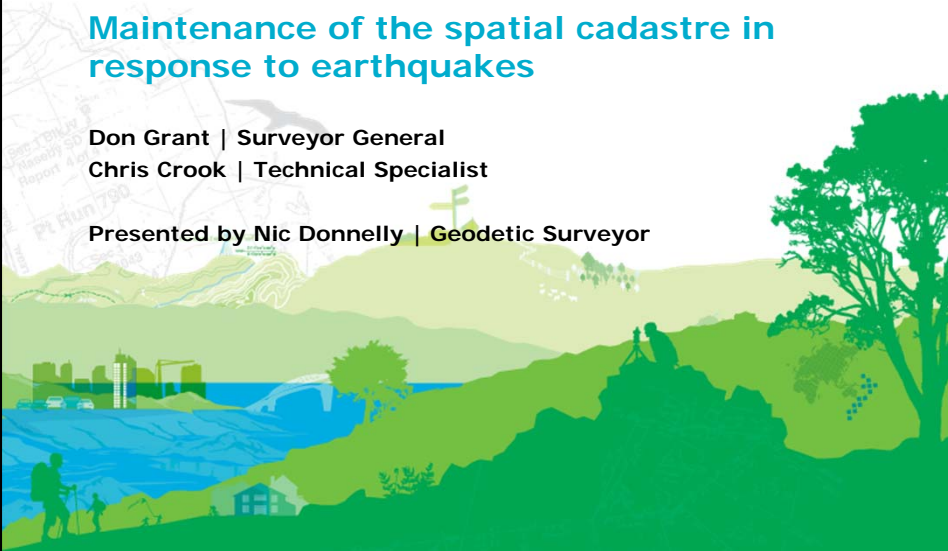




FIG 2012, Rome, May 2012 newzealand.govt.nz



Overview

- The Christchurch earthquakes
- Impact on land ownership – who owns what
- Impact on cadastre as fundamental geospatial data set
- Summary



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Canterbury earthquakes



- Magnitude 7.1 – 4 September 2010
 - 40 km from the city, 11 km deep
 - Significant damage, no deaths
- Magnitude 6.3 – 22 February 2011
 - 10 km from the city, 5 km deep, v. high accelerations
 - Some building collapses, over 180 deaths
- Magnitudes 5.7 & 6.3 – 13 June 2011
 - 10 km from the city, 6 & 9 km deep, high accelerations
 - Further damage, no deaths
- Magnitudes 5.8 and 6.0 – 23 December 2011
 - 20 km from the city, 8 & 6 km deep, high accelerations
 - Further damage and liquefaction, no deaths
 - Not included in following discussion

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Principles: deep seated movement



- Cadastral boundaries are deemed to have moved with the resulting land surface movement
- Same principle as response to slow tectonic movement
- Boundary points retain relationship to physical evidence
- Uniform block shift or low distortion
 - Landowners see no visible change
 - Coordinates change
- Distortion or rupture
 - Directions, distances, boundary angles may change
 - New boundary angle points may be required

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Parcels affected by fault rupture



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Principles: shallow movement



- Common law applies as for landslip
 - Boundaries generally don't move with surface layers
- Liquefaction is only in top few metres of soil
 - Same principle as landslip
- Retain relationship to “undisturbed” survey marks
 - If marks fit each other – call them undisturbed
 - Any deep-seated block shift taken into account

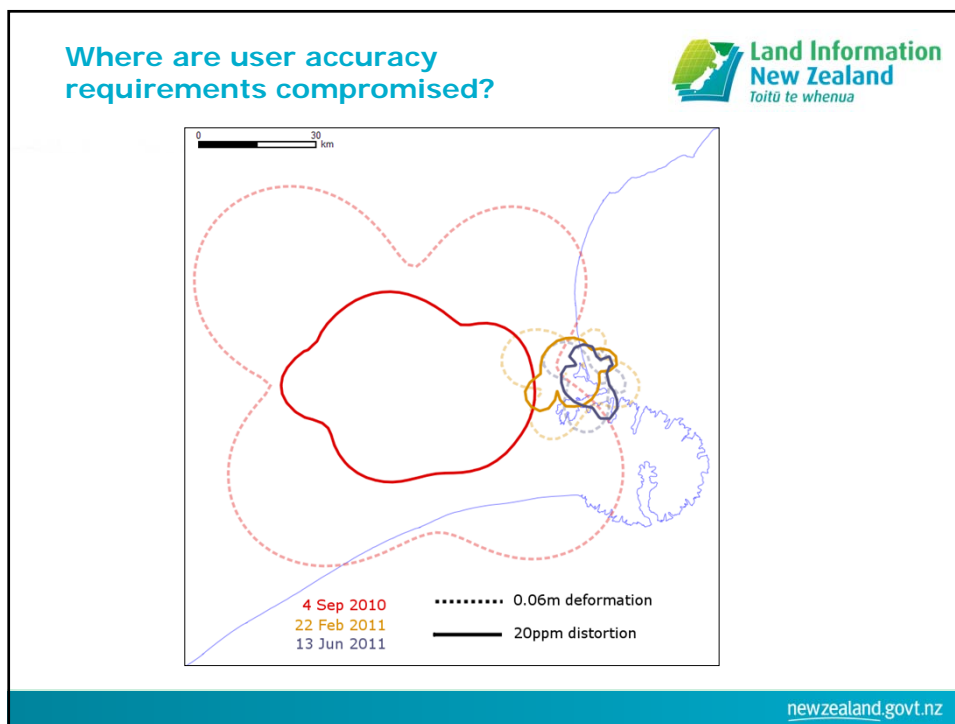
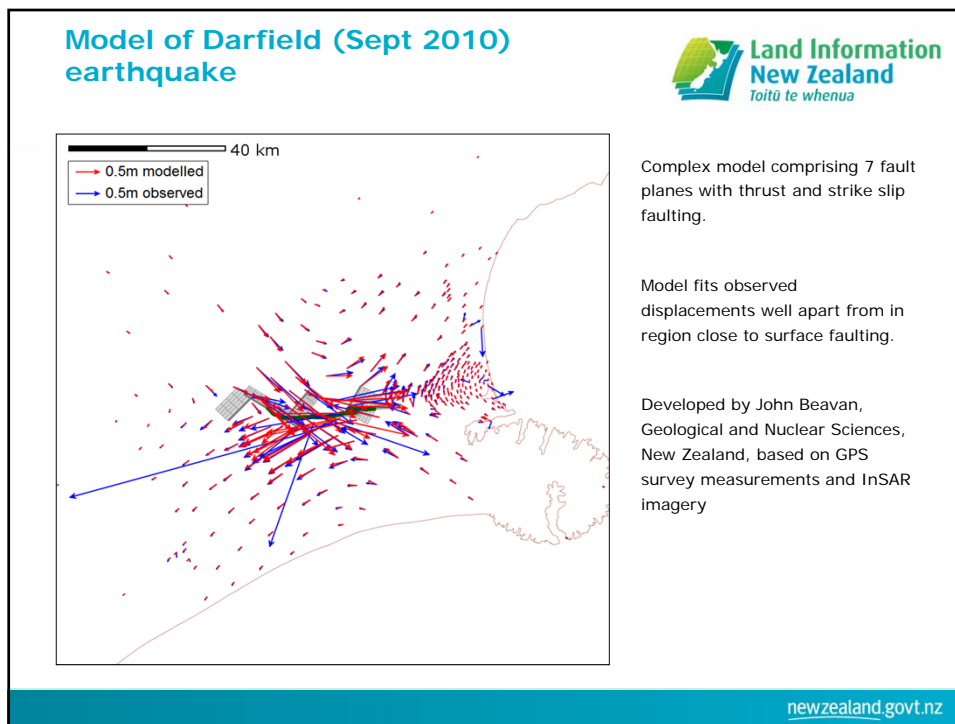
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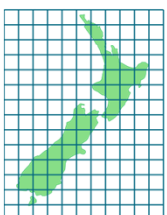
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Deformation model




National deformation model




Applies across entire country

Amount of deformation increases linearly over time



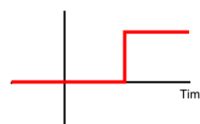
Patch components for earthquakes



Only applies to a limited region affected by earthquake


Only applies to coordinates after the time of the earthquake

May be many patches



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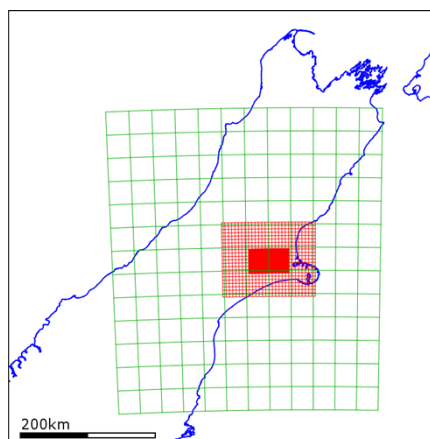
Example patch for Darfield earthquake



Multi-resolution grid to efficiently represent deformation.

Example resolutions 35km, 5km, 0.5km

In outer region movements small, so only compromise accuracy of high order geodetic marks. Do not need to update cadastral coordinates.



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Deformation of cadastre



| Movement Category | Spatial variation | Temporal variation | Parcels distorted | Follow movement | Spatial model |
|---------------------------|--------------------------|------------------------------|----------------------|-----------------|--------------------------------------|
| Tectonic deformation | Continuous - broad scale | Continuous - near linear | No | Yes | Datum deformation model |
| Earthquake - remote | Continuous - broad scale | Instantaneous + post-seismic | No | Yes | Deformation patch |
| Earthquake - near field | Continuous | Instantaneous + post-seismic | Near linear (affine) | Yes | Deformation patch |
| Earthquake - rupture zone | Discontinuous | Instantaneous + post-seismic | Non linear | Yes? | Interpolate across rupture, resurvey |
| Landslip / Rockfall | Discontinuous | Instantaneous | No | No | Not modelled |
| Liquefaction | Generally discontinuous | Instantaneous | No? | No? | Not modelled |
| Natural boundary avulsion | Continuous but localised | Instantaneous | No | No | Not modelled |

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Summary



- Earthquake deformation results in a complex mixture of broad scale deep seated movement and localised shallow disturbance
- The effects on the cadastre are a complex mix of physical movement and legal considerations
- The effects for geospatial users involve complex issues around user GIS systems and user database management