New Zealand National Seismograph Network

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Introduction

During the last year the broadband New Zealand National Seismograph Network (NZNSN) has grown from the original eight to 33 sites, after delays of more than a year caused by telecommunications difficulties. The final five, of the planned 38 stations, are due to become operational in the coming year.

Up until 1998 the New Zealand National Seismograph Network of 34 stations was equipped with only short period sensors and triggered digital tape seismographs. The Institute of Geological and Nuclear Sciences (GNS), a government owned research institute, operated this network with funding from government research grants. After receiving a special grant from the New Zealand Earthquake Commission (EQC), the organisation charged with providing natural disaster insurance in New Zealand, a pilot four-station broadband network was installed. The installed stations employed both weak and strong motion sensors, continuous Very Small Aperture Satellite Terminal (VSAT) communications and Internet Protocol (IP) data transfer. The size of this network was doubled to eight stations in 2001.

In 2001 GNS received funding from EQC to partially fund the New Zealand GeoNet project. This project includes the upgrade of the short-period NZNSN to continuous broadband operation with a modest increase in the number of stations. Currently data from the original eight NZNSN broadband stations are available via AutoDRM and all the data will be available by early in 2005.

The New Zealand GeoNet Project

The New Zealand GeoNet is a strongly integrated data collection and analysis project consisting of national seismograph, strong ground motion and continuous geodetic GPS networks, combined regional seismic and CGPS networks, and an enhanced volcano-chemistry and remote monitoring capability. It is a 10-year project to design, install and maintain an enhanced geological hazard monitoring and data collection system for New Zealand.

The National Seismograph Network will be described in detail in the next section. The strong ground motion networks consist of almost 200 Kinemetrics Etnas and over 200 cheaper locally produced instruments to monitor near-fault ground motion, regional attenuation, microzone effects, and the response of built structures. The National Reference Station continuous GPS network will provide regional deformation data for the New Zealand dynamic datum. This network, which is funded by Land Information New Zealand (LINZ), uses Trimble 5700 and NetRS GPS receivers.

The regional networks (both seismic and GPS) are used to provide enhanced volcano monitoring in the volcanic regions and precise depth control for subduction-related earthquakes along the Hikurangi margin. These networks employ Quanterra Q330 digitisers and mainly 3D short period sensors for seismic recording, and Trimble NetRS GPS receivers. Much of the Ethernet bridge radio telemetry is shared by the seismic and CGPS systems. Currently 22 seismic sites and 10 CGPS sites have been established of the projected totals of approximately 70 and 76 respectively. Two of the installed volcano-seismic regional stations have broadband sensors, and it is intended to have a small number of broadband seismometers in each regional network. The GeoNet project also includes an upgraded fluid and gas analytical capability and portable instruments for baseline monitoring and remote sensing (including InSAR) for volcano monitoring and research.

Two data centres (at Gracefield near Wellington and Wairakei near Taupo) provide backup in the event of a large earthquake near Wellington or an eruption in the volcanic region. All seismic and GPS data are telemetered continuously to the two data centres using radio, land-based and VSAT systems employing Internet Protocol data transfer techniques. Strong motion data is sent from remote sites to the data centres when acceleration thresholds are exceeded using mobile phone or landline systems, some of which also use IP techniques.

The New Zealand National Seismograph Network

The New Zealand National Seismograph Network (NZNSN) stations employ six-component (3D broadband and 3D strong motion) recording and are located throughout the country (see Figure 1) to provide a uniform location and data collection capability for the study of New Zealand and international tectonic problems. They are also used, along with the regional seismograph stations, to provide rapid earthquake locations for public information and responding agencies. The data is transported via IP telecommunications networks mainly based on a VSAT platform provided by Optus of Australia. The currently funded network, shown in Figure 1, has 38 stations with approximate station spacing of 100 km on land throughout New Zealand. However, there are still several gaps in the network and five or six extra stations are required to achieve the required average spacing. At the time of writing five of the 38 sites are still to be installed, although two have been built. The final three sites (Deep Cove, Milford Sound and Stewart Island) are in very remote regions in the south of the South Island. The details of the 38 stations are given in Table 1.

Almost all of the NZNSN stations are of a similar physical design and include an instrument vault, equipment hut, and VSAT antenna pole (Figure 2). The sensor vault is of solid concrete construction with additional insulation and a steel lid. The vault houses a Guralp CMG-3ESP or a Streckheisen STS2 broadband seismometer as well as a Kinematics Episensor (2g) strong motion accelerometer (Figure 3). The earlier pilot network stations have Gurlap GMG-40T seismometers, although the intention is to replace these with CMG-3ESP sensors. The equipment hut is of the “portacom” design made of pre-assembled insulated aluminium panels on a concrete pad. The VSAT dishes range in size from 1.2 m to 2.4 m in diameter. Some of the smaller 1.2 m dishes are mounted on the equipment huts rather that on a separate pad.

The equipment hut houses the digitiser, VSAT indoor unit and backup power supply (Figure 4). The digitiser used is usually a Quanterra Q4120, although some of the newer sites are now using the six-channel version of the Quanterra Q330 and baler 14F data recording systems. The digitisers are operated at a sampling rate of 100 Hz, and this and a 1 Hz stream is sent in real time to the data centres. Data is also recorded on hard disks within either the Q4120 or the Baler 14F units and can be retrieved later if the data communications is lost.

A small number of stations are at very remote locations and use Q330 digitisers to achieve low power operation (Figure 5). Ethernet radio bridges or cables are used to transport the data from the recording sites to a location where power and long distance communications are available (either VSAT or Frame Relay). In these cases the Baler 14F is placed at the site where power and long distance communications are available.

Data Acquisition and Availability

The Optus VSAT system, which carries data from the remote NZNSN stations, is connected to the GeoNet data centres via an earth station at Belrose, just outside Sydney in Australia, and trans-Tasman terrestrial data connections. The NZNSN stations throughout New Zealand send continuous data to one of the two data centres via one VSAT hop and a terrestrial data link, with adjacent stations sending data to different data centres. As a backup triggered strong motion data is sent to both data centres, via two VSAT hops, to the VSAT terminals at the data centres to guard against terrestrial network failures likely in a major earthquake.

Data from the NZNSN stations are acquired by computers at the two GeoNet data centres using a combination of COMSERV and SEEDLINK server software. Sites equipped with Quanterra Q4120 data loggers use the manufacturer supplied COMSERV routines to acquire the data which is then inserted into a SEEDLINK server, while sites with Q330 data loggers have their data streams fed directly into the SEEDLINK server using locally written software. The SEEDLINK server allows the continuous data to be transferred between the data centres. The data handing and processing system is based around clients written for SEEDLINK making extensive use of the LIBSLINK software library.

All of the continuous NZNSN data is kept on RAID hard disk arrays as well as backed up on DLT magnetic tape. New hard disks systems are purchased as required, with increases in disk sizes easily keeping up with the increase in data volume as more stations come on line.

The GeoNet web site (www.geonet.org.nz) provides a portal for GeoNet data and information. This site provides general GeoNet information, listings of recent earthquake locations and the status of active New Zealand volcanoes. It provides a facility to search the New Zealand Earthquake Catalogue, and makes NZNSN, CGPS, and strong ground motion data available for download.

The GeoNet policy is to make all data collected by the project freely available for research purposes. Currently data from the original eight NZNSN broadband stations are available using AutoDRM via the web site and all the data will be available by AutoDRM once a major database project is complete early in 2005.

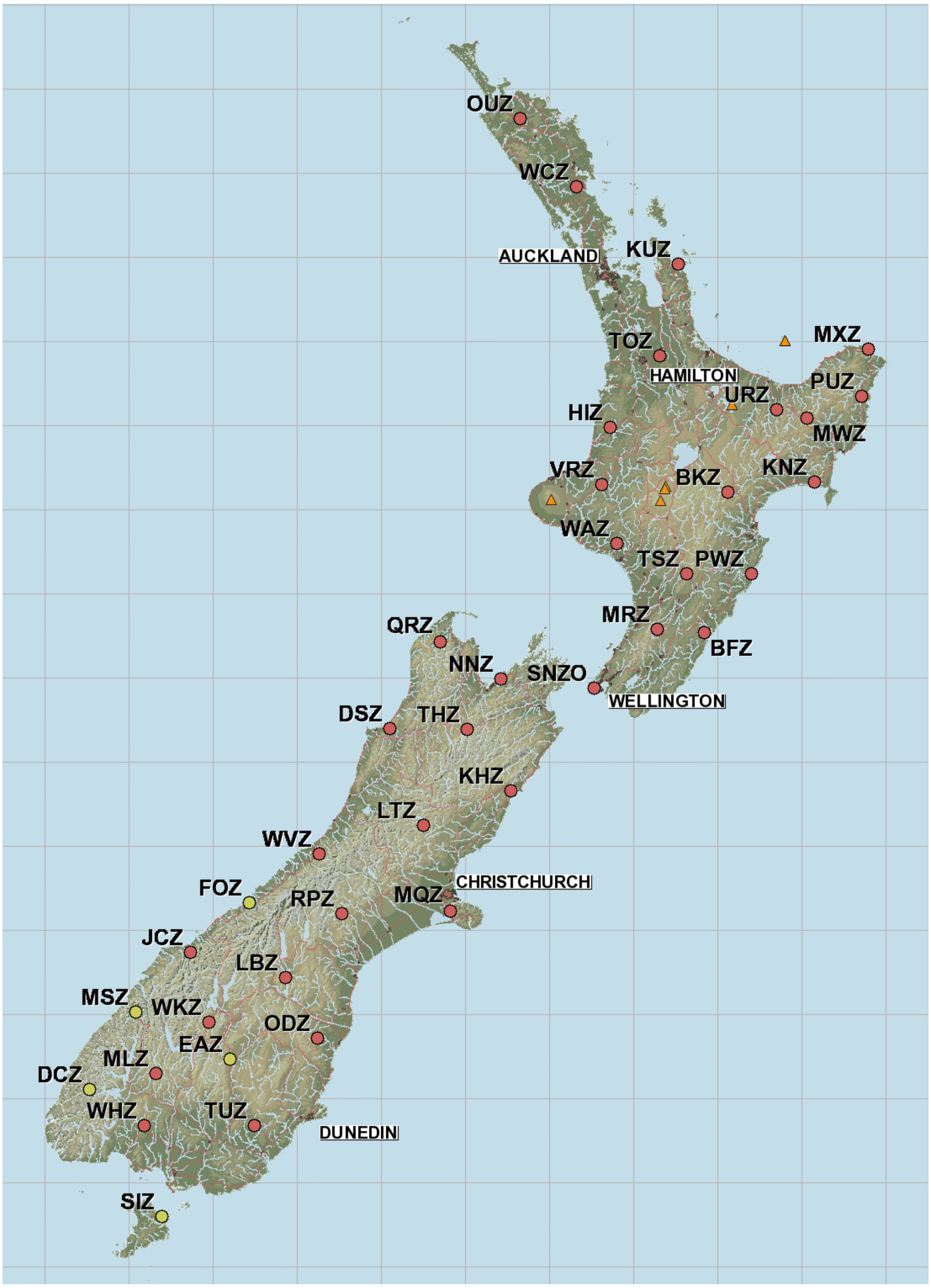

Figure 1. The New Zealand National Seismograph Network. Operational stations are orange, while those that are still to be commissioned are yellow.

Figure 2. Photograph of a NZNSN station showing the VSAT dish (left) and equipment hut, with the top of the sensor vault just visible on the top of the rock outcrop to the right.

Figure 3. A view of a NZNSN vault with a Guralp CMG-3ESP broadband seismometer and Kinemetrics Episensor installed.

Figure 4.A photograph of the inside of a NZNSN equipment hut showing the orange Quanterra Q4120 to the left and the VSAT indoor unit to the right on the bench. The digitiser and VSAT communications equipment have separate power supplies with backup batteries on the floor of the hut. This site also records the data from a CGPS station (using a Trimble NetRS) via a Freewave Ethernet Bridge radio to the left of the Quanterra.

Figure 5. The remote NZNSN site above Jackson’s Bay in South Westland. This is a joint CGPS site. The vault is in foreground, the CGPS pillar and equipment cabinet in background with Jackson's Bay in the far background. The data is radioed via Ethernet bridge to Neill’s Beach where a VSAT installation transmits the data to the GeoNet data centre.

Table1. The details of the New Zealand National Seismograph Network stations. The digitisers are either Quanterra Q4120s or Quanterra Q330s. All sites have both broadband seismometers and accelerometers. The broadband sensors are made by Streckheisen (STS2), or Guralp (CMG-40T or CMG-3ESP, or CMG-3TB). The communications all use Internet protocols, over Ethernet radio bridges (Radio), Very Small Aperture Satellite Terminal (VSAT), and Frame Relay (FR). Stations marked with a "*" in the date installed column are still to be installed, and an approximate install date is given.

Station Name	Code	Latitude (deg.)	Longitude (deg.)	Altitude (m)	Digitiser	Sensors	Data Transfer	Date Installed
Omahuta	OUZ	-35.2214	173.5961	40	Q4120	STS2/Episensor	VSAT	26/08/2003
Waipu Caves	WCZ	-35.9411	174.3444	140	Q4120	3ESP/Episensor	VSAT	27/08/2003
Kuaotunu	KUZ	-36.7472	175.7200	40	Q330	3ESP/Episensor	VSAT	5/02/2004
Matakaoa Point	MXZ	-37.5640	178.3066	126	Q330	3ESP/Episensor	VSAT	19/02/1004
Tahuroa Road	TOZ	-37.7308	175.5019	109	Q4120	40T/Episensor	VSAT	16/10/1998
Puketiti	PUZ	-38.0733	178.2572	420	Q4120	3ESP/Episensor	VSAT	20/08/2003
Urewera	URZ	-38.2603	177.1103	100	Q4120	3TB/Episensor	VSAT	25/05/2001
Matawai	MWZ	-38.3359	177.5275	600	Q330	3ESP/Episensor	VSAT	18/02/2004
Hauiti	HIZ	-38.5147	174.8555	266	Q4120	STS2/Episensor	Radio/VSAT	3/02/2004
Kokohu	KNZ	-39.0214	177.6736	49	Q4120	40T/Episensor	VSAT	19/10/1998
Vera Road	VRZ	-39.1263	174.7584	182	Q4120	3ESP/Episensor	VSAT	26/11/2003
Black Stump Farm	BKZ	-39.1675	176.4923	729	Q4120	STS2/Episensor	VSAT	11/02/2004
Wanganui	WAZ	-39.7563	174.9852	401	Q4120	3ESP/Episensor	VSAT	27/11/2003
Pawanui	PWZ	-40.0314	176.8617	65	Q4120	3ESP/Episensor	VSAT	22/03/2001
Takapari Road	TSZ	-40.0603	175.9610	547	Q4120	3ESP/Episensor	VSAT	27/01/2004
Mangatainoka River	MRZ	-40.6625	175.5792	320	Q4120	3ESP/Episensor	VSAT	31/07/2003
Birch Farm	BFZ	-40.6817	176.2461	318	Q4120	STS2/Episensor	VSAT	30/07/2003
Quartz Range	QRZ	-40.8275	172.5289	260	Q4120	STS2/Episensor	VSAT	11/08/2003
Nelson	NNZ	-41.2166	173.3666	145	Q4120	3ESP/Episensor	VSAT	12/08/2003
Denniston	DSZ	-41.7469	171.8025	661	Q4120	40T/Episensor	VSAT	31/08/1998
Top House	THZ	-41.7639	172.9036	760	Q4120	3ESP/Episensor	VSAT	8/08/2003
Kahutara	KHZ	-42.4181	173.5403	70	Q4120	STS2/Episensor	VSAT	6/08/2003
Lake Taylor	LTZ	-42.7833	172.2667	640	Q4120	3ESP/Episensor	VSAT	27/02/2004

Waitaha Valley	WVZ	-43.0764	170.7361	75	Q4120	3ESP/Episensor	VSAT	6/09/2003
Fox Glacier	FOZ	-43.5655	169.6886	10	Q330	3ESP/Episensor	Radio/VSAT	Q3 2004*
McQueen's Valley	MQZ	-43.7078	172.6522	61	Q4120	40T/Episensor	VSAT	31/08/1998
Rata Peaks	RPZ	-43.7192	171.0539	412	Q4120	3TB/Episensor	VSAT	6/06/2001
Jackson Bay	JCZ	-44.0750	168.7853	1072	Q330	3ESP/Episensor	Radio/VSAT	2/06/2004
Lake Benmore	LBZ	-44.3872	170.1842	423	Q330	3ESP/Episensor	VSAT	5/06/2004
Milford Sound	MSZ	-44.6753	167.9275	90	Q330	3ESP/Episensor	VSAT	Q1 2005*
Wanaka	WKZ	-44.8285	169.0176	564	Q4120	3ESP/Episensor	VSAT	3/06/2004
Otahua Downs	ODZ	-45.0453	170.6444	270	Q4120	STS2/Episensor	VSAT	12/09/2003
Earnscleugh	EAZ	-45.2327	169.3082	320	Q330	3ESP/Episensor	Radio/FR	Q3 2004*
Mavora Lakes	MLZ	-45.3481	168.1728	640	Q4120	3ESP/Episensor	VSAT	9/09/2003
Deep Cove	DCZ	-45.4678	167.1542	50	Q330	3ESP/Episensor	VSAT	Q1 2005*
Wether Hill Road	WHZ	-45.8939	167.9467	320	Q4120	40T/Episensor	VSAT	20/03/2001
Tuapeka	TUZ	-45.9561	169.6322	110	Q4120	3ESP/Episensor	VSAT	10/09/2003
Stewart Island	SIZ	-46.8750	168.1331	60	Q330	3ESP/Episensor	Radio/FR	Q2 2005*