REVIEW OF INTER-UTILITY EMERGENCY COMMUNICATIONS SYSTEMS IN AUCKLAND AND WELLINGTON

PROJECT: AELG-1

Prepared by:

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1. Executive Summary

1.1. Assignment

Consultel Associates Ltd has been charged with providing an independent professional assessment of the emergency communications systems used by Lifeline Utilities which are members of the Auckland and/or Wellington Engineering Lifelines Groups. Lifeline Utilities are defined in Schedule 1 of the Civil Defence Emergency Management Act 2002 and are listed in section 10.8.

A survey was emailed to all known contacts within the Auckland and Wellington Lifeline Groups to assess current and planned emergency communications infrastructure, and to identify dependencies on contractors or other agencies, and on system vulnerabilities. Responses were received from a broad cross-section of utilities, sufficient to provide a good view of current communications infrastructure. A summary of the survey and results is contained in section 4.

Three open workshops were held with Lifelines members and other interested parties, one in Wellington and two in Auckland. The workshops clarified and explored responses from the survey and canvassed possible solutions. The workshops (late February 2004) coincided with a series of storms that resulted in major flooding of areas in the lower North Island. These events caused some disruption to the workshops with participants being required for emergency co-ordination, but also provided valuable insights into requirements and current shortcomings.

A review of available technologies was conducted, along with consideration of other related project activity to determine the most appropriate systems to use for emergency communications.

1.2. Requirements

1.2.1. CDEM Act 2002

The Civil Defence Emergency Management Act 2002 defines Lifeline Utility organisations and their duties with respect to Emergency Management. Relevant sections of the Act are reproduced in section 10.7

Every Lifeline Utility must ensure that it is able to function to the fullest possible extent, even though this may be at a reduced level, during and after an emergency.

1.3. Current Situation

1.3.1. Key Survey findings

Utilities use public networks for most of their communications. These include telephones on PABXs and the fixed-wire telephone network, mobile cellular phones, trunked-mobile radio-telephones, and *Internet* email.

Of organisations that responded to the survey, 73% had some form of independent wireless communications system available that could be used for emergency communications if the public networks were unavailable. However in most cases these systems were designed for internal communications and could not be used to contact other Lifelines or emergency services.

All utilities were highly dependent on contractors to carry out some functions (mostly on-site). Communication with contractors is generally by public networks.

Message volumes within Lifelines organisations are much greater than external volumes (to other Lifelines or to CDEMCs).

1.3.2. Workshop directions

Participants recognised a general dependence on public networks and a subsequent need to understand capability and limitations in the networks particularly under emergency conditions.

Interest was shown in systems that were independent of public networks for use in major emergencies when public networks could be inoperable or overloaded. It was recognised that satellite-based services offered the most comprehensive coverage and services.

There is not, in general, an adequate level of operational documentation of emergency communications networks within utilities.

1.3.3. General

There are various degrees and levels of natural (and otherwise) disasters that could affect Lifelines' operations. Some will be of a local nature, others will be more widespread with a corresponding wide-ranging impact on the operations. There can be network issues that, although local in nature, have a widespread impact on the network's ability to deliver service.

Many Utilities are heavily dependent on the public communications networks, operated by Telecom, TelstraClear, Vodafone, Teamtalk and Broadcast Communications Ltd (BCL). This is particularly so for inter-utility communication. Much of the support and maintenance for these networks is subcontracted to service companies.

1.3.4. Various disaster scenarios and exposures

Exposures to the communications infrastructure from disasters caused by:

- earthquake
- flood
- storm
- tsunami
- volcanic eruption
- fire
- hazardous materials
- terrorist activity
- utility failures

have been considered.

The major public communications networks are robust, with important functions protected by node or component redundancy, and key routes protected by trunk diversity.

Because of this, in general, the impact of disasters is likely to be localised in its effect on the communications networks.

A localised network failure that isolated an important Lifelines Utility control centre would be significant.

1.3.5. Overloading and Priority

The most significant overall risk is that of overloading and congestion, particularly if significant parts of the public networks are disabled.

There is some capability to provide priority for emergency calls, and use of dedicated circuits to route 111 calls. All 111 calls, wherever originated, are delivered to Operators terminated in the Telecom PSTN.

A more detailed and specific study of call prioritisation, and how it has been implemented, in the public networks should be carried out.

1.4. Recommendations

1.4.1. Communications in non-declared emergency

Recommend that Lifelines:

- Use existing public systems (as appropriate for each utility) with provision for backup by not relying on any one system.
- Use private (radio) systems where necessary for coverage outside public networks
- Maintain a master register, co-ordinated by the Lifelines Co-ordinators, of current contact details for all utilities and emergency managers.
- Define processes for establishing communications via the register:

1.4.2. Communications in a declared emergency

In a declared emergency,

1.4.2.1. Between Lifeline Utilities Emergency Operations Centres

In most emergency situations communication with other Utilities Emergency Operations Centres will be possible using normal everyday communications systems.

It is recommended that:

- Each Utility EOC have at least 3 separate means of communication installed and available. These systems need to be compatible between utilities and have sufficient capacity to handle priority communications traffic.
- At least one of these systems should be satellite-based.

Details and examples are given in section 10.2.1.1.

1.4.2.2. Between Lifeline Utilities Emergency Operations Centres and key contractors

Communications between Lifeline EOCs and their contractors will be critical in the recovery and restoration phases of emergencies.

- Contractors should have robust internal communications systems relevant to the geography and nature of the work they undertake.
- Contractors' control centres should have the same level of emergency communications as the relevant Lifelines EOC (see 10.2.1.1), and those systems should be compatible.

Lifelines utilities should ensure these conditions are written into contractor agreements.

1.4.2.3. Between Lifeline Utilities Emergency Operations Centres and a Lifelines Coordination Centre

A Lifelines Coordination Centre may be necessary to provide a link and backup point between Utilities. The Lifelines Coordination Centre will have direct emergency communications systems with the relevant Regional EOC(s) utilising the systems employed by the CDEMG.

- Utilities EOCs should have at least 3 diverse means of communicating with the Lifelines Coordination Centre,
- At least one of which should be satellite-based.

Further work is required to define the scope of a Lifelines Coordination Centre before a definitive communications plan can be proposed. It could be incorporated within the CDEM EOC or be standalone as shown in the following diagram.

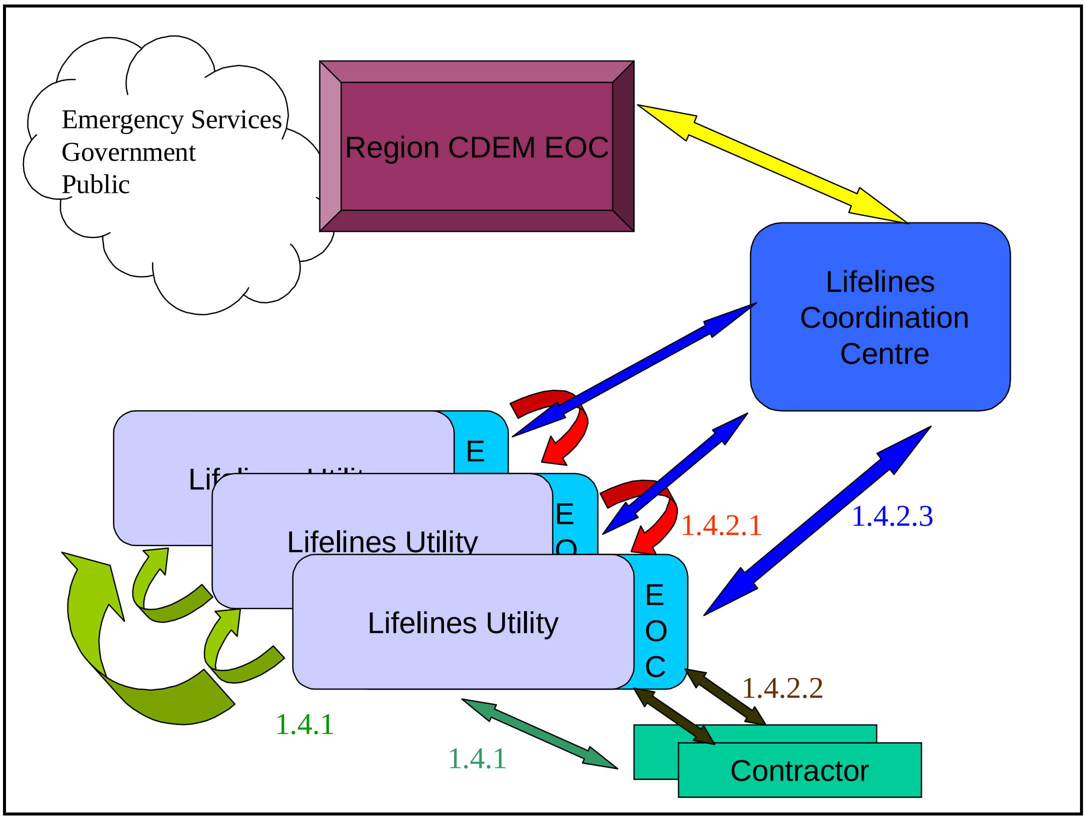


Figure 1 showing communications between Lifelines organisations (the numbers refer to the recommendations above)

1.5. Summary of Recommendations

It is recommended that **each Lifelines utility** should:

1. in general, have at least three separate communications systems available to provide redundant access and each with sufficient capacity to handle all emergency communications
2. ensure that at least one of those systems is satellite-based and capable of delivering voice connections to the public voice networks (PSTN and cellular). Of the satellite services available the Iridium system is recommended, however Lifelines using one of the other services should continue to do so. Future developments in the iPStar and Inmarsat systems should also be closely monitored.
3. ensure that the communications systems of their critical subcontractors are compatible with those of the utility
4. ensure any new or upgraded systems have Internet Protocol capability
5. adopt a set of standard requirements and design guidelines for inter and intra-utility communications systems. A suggested set is included in section 10.9
6. plan for limited bandwidth being available – for example: have low-resolution black & white copies of critical network diagrams, charts, equipment layouts etc for use in emergencies when only limited data or fax capability will be usable.
7. increase the capacity of battery and generator supplies in key control centres and for communications equipment to allow 72 hour standalone operation

It is recommended that the **Lifelines Group(s)** should:

8. develop and maintain a master register of current contact details for all utilities and emergency managers[1].
9. define processes for establishing inter-utility communications via the register.
10. Review in detail the prioritisation of (emergency) calls available within the public networks to ensure this has been implemented to maximum advantage. This needs to be an "end-to-end" view rather than an internal view.

It is recommended that **CDEM Groups** should:

11. Determine, in conjunction with the respective Lifelines Groups, an appropriate holder for the master register (available 7/24 with full emergency communications facilities)
12. Engage, in conjunction with the respective Lifelines Groups, the amateur radio AREC groups to provide "last-ditch" emergency support.
13. Set a target date (say up to a year) by which Lifelines should demonstrate that they meet the above recommendations

Further detailed recommendations are contained in section 10.3.

1.6. Estimated Costs

By utilising existing infrastructure as much as possible, costs have been kept to a minimum.

Most organisations surveyed already utilise three or more separate means of communication and apart from some possible upgrading of handsets to ensure compatibility with contractors' cellular or VHF radio systems, little capital expenditure is likely to be required to meet this need.

Only 2 organisations surveyed currently have satellite-based communications available for emergency use. A number of options are available, including short-term rental, long-term lease, or purchase. Costs for systems range from approximately $2000 per year to rent a satellite phone, to around $10,000 to install a broadband satellite terminal.

Because of the high development costs, relatively low numbers in use, and the need to ensure a reliable and stable platform, satellite communications technology does not evolve as quickly as say cellular telephony. The development plans of the major providers are also generally well communicated allowing a reasonable assessment of the available options for any given user situation. For example with Inmarsat about to launch a new generation of satellites (see 9.4.2) in 2005 it would be unwise to invest in the purchase of handsets for their current system. The suppliers of the handsets can generally advise appropriate options.

[1] There is a list of Lifelines emergency contact details. AELG one is updated and circulated every 3 months.

2. Overview

2.1. About this document

This report covers a review of the emergency communications systems used by the Lifelines organisations in Auckland and Wellington prepared by Greg Barton, Associate Consultant of Consultel Associates Limited.

2.2. Intended audience

This document is intended for use by:-

- Lifelines Project Committee
- AELG and WELG Utility Organisations
- Communications companies and organisations supplying services to Lifelines Utilities
- Key contractors of Lifelines Utilities
- Emergency Management organisations (CDEMG/CEG, MCDEM etc)
- Other emergency management organisations (eg NZ Defence Forces, NZ Police, NZ Fire Service etc)
- Consultel Associates Limited

2.3. Scope of the report

This project includes:

(see Figure 1 at section 1.5 showing relationships between Lifelines organisations)

2.3.1. In a non-declared emergency

- recommending the technology and physical systems to be used between Lifelines organisations,

2.3.2. In a declared emergency

- recommending the technology and physical systems to be used between Lifeline Emergency Operations Centres
- recommending the technology and physical systems to be used between each Lifeline Utilities Emergency Operations Centre and its key contractors,
- communications systems between each Lifeline Utility Emergency Operation Centre and proposed or potential Lifelines Coordination Centre .
- general assumptions and recommendations relating to the processes and protocols for using the systems should be made.

2.4. Objective

Design and/or recommend a preferred communications system and method for implementation to enable effective and efficient dialogue between utilities, contractors and the Emergency Operations Centre (or a Lifelines Coordination System). The system should:

- facilitate recovery of Lifeline services
- be acceptable to and affordable for Lifelines communications.
- ensure inter-operability of all affected parties during and after any emergency.

3. General

3.1. Assignment

Consultel Associates Ltd has been charged with providing independent professional assessment of the emergency communications systems used by Lifeline Utilities. Lifeline Utilities are defined in Schedule 1 of the Civil Defence Emergency Management Act 2002 and are listed in section 10.8.

3.2. Methodology

3.2.1. Survey

A survey was emailed to all known contacts within the Lifeline organisations to:

- assess current and planned emergency communications infrastructure,
- identify dependencies on contractors or other agencies, and
- identify system vulnerabilities.

Responses were received from a broad cross-section of utilities, (see Appendix 10.9) sufficient to provide a good view of current communications infrastructure. A summary of the survey and results is contained in section 4.

3.2.2. Workshops

Three open workshops were held with Lifelines members and other interested parties, one in Wellington and two in Auckland. The workshops clarified and explored responses from the survey and canvassed possible solutions. The workshops (late February 2004) coincided with a series of storms that resulted in major flooding of areas in the lower North Island. These events caused some disruption to the workshops with participants being required for emergency co-ordination, but also provided valuable insights into requirements and current shortcomings.

3.2.3. Review of Documents

Numerous documents were supplied or obtained and those applicable to the review were studied and analysed. Included were the following.

- Civil Defence Emergency Management Act 2002
- Lifelines and CDEM Planning Best Practice Guide [BPG1/03]
- Working Together: Lifeline Utilities & Emergency Management. Director's Guidelines [DGL 3/02]
- Auckland Region Civil Defence Emergency Management Group website http://www.auckland.cdemg.org.nz/index.htm including the working draft of the CDEM Plan.
- Wellington Regional Council Emergency Management website http://www.wrc.govt.nz/em/maneme.htm#manage
- An Emergency Communications System for Lifelines Organisations in the Wellington Region. Stage One Report 16 October 1996
- Wellington Lifelines Group – Overview of Mitigation and Preparedness Measures Undertaken During 2003

3.2.4. Review of Technologies

A review of available technologies was conducted, along with consideration of other related project activity to determine the most appropriate systems to use for emergency communications.

3.2.5. Reports

A draft report was prepared for peer review and consideration by steering committee members, followed by the production of this report.

4. Summary of Survey and Workshop Findings

4.1. Communications within Utilities

4.1.1. When routine communications infrastructure is intact

Most utilities rely on a combination of voice (PSTN and cellular), email, and fax.

In normal operation the separate host networks (Telecom PSTN, TelstraClear PSTN, Telecom and Vodafone Cellular networks for voice; and a range of ISPs for data and email) provide seamless interconnectivity.

Some national and regional organisations with extensive internal voice networks rely heavily on these (internal networks) for normal operations.

A few organisations have radio systems to communicate with field staff and contractors (VHF/UHF and trunked mobile). Although interworking between the radio systems is technically possible, it is generally not used, particularly if cellular access is also available.

4.1.2. When the emergency seriously affects routine communications

Organisations have a wide range of capabilities.

- Emergency Management groups have dedicated radio systems (VHF and HF) and limited satellite phones
- National network utilities have extensive backup: the telecommunications network providers use their own and each other’s networks and satellite phones; Transpower and NGC have extensive VHF networks with coverage over their distribution networks
- Regional utilities generally rely on public cellular phones and trunked mobile networks with some use of Territorial Authority VHF and UHF networks

4.2. Key Contractors

All respondents (with one exception) listed contractors on whom their organisation was *highly dependent* for emergency service and support. The average number of contractors is three with some organisations listing up to eight.

4.3. Communications with Contractors

4.3.1. When routine communications infrastructure is intact

This question was answered in a similar way to 4.1.1 with heavy use of public networks. Some utilities host subcontractors’ control centres within their own facilities so use internal networks.

Email appears to be used more for communication with contractors than for general communications (it was often listed higher in sequence in this question).

There is also less use of “internal” VHF or trunked mobile networks to communicate with contractors. This may be related to how contractors historically came into being – where they were “outsourced” with an existing radio infrastructure this tends to continue.

4.3.2. When the emergency seriously affects routine communications

Lifelines Utilities mostly rely on having several public network systems available assuming that not all will fail at once.

34% relied mostly on public networks;

73% of respondents had some radio capability (VHF, HF or Satellite);

17% relied on ‘face-to-face’ contact while

17% listed no specific fallback

(note figures do not add to 100% because some organisations fall into 2 categories).

Of particular concern are the 27% of organisations that have no independent radio capability, and those (38% within the 73% above) that have only internal radio capability.

4.4. Network diagrams

Only 7 respondents provided details of emergency communication network configurations. It is not clear if this is because diagrams or plans do not exist, or because they could not be provided for this project. Most details that were provided listed only critical radio repeater sites.

4.5. Identified Risks to Communications Systems

All respondents provided information on this question.

VHF transmitter and repeater sites are often identified vulnerabilities (lightning strike, wind damage, electricity supply, building collapse/fire etc). There are also some coverage problems with VHF that are recognised.

Many respondents listed their dependence on access to the public networks as a vulnerability, particularly if interconnection between the networks is restricted. Because of this dependence, Lifelines need to be assured of the resilience and recovery plans of the public network operators.

Because of alternative and redundant routing within the public networks, the most vulnerable part is the connection from the utility into the network (in the case of wired access, the cable to the local “exchange”; in the case of cellular mobile, the availability of cellular radio coverage).

Organisations also need to plan their communications to minimise risks from restrictions on interconnect between public networks. For example, an organisation relying on cellular phones as a means of emergency communications needs to ensure that it has handsets available on the same network(s) as each of its subcontractors and any other Lifelines organisation that it needs to work with. This aspect was not surveyed, but comments during workshops indicate that little consideration has been given to this.

4.6. Stand-alone site capabilities

Most critical network nodes in the public networks have backup power and diverse links. A detailed study would be necessary to identify vulnerabilities specific to events and locations. In general it can be stated that the public networks have a high level of reliability and resilience, particularly when taken in combination.

Most of the Telecom fixed line networks can operate for extended periods without mains power as main switches are equipped with diesel generators. Smaller sites have battery backup which has limited capacity.

Cellular sites in general have limited battery backup, but some larger sites have emergency generators (or can be connected to them).

Most EOCs have some form of emergency power but in many cases capacity is limited or of short duration.

Lifelines need to consider not only emergency power to operate radio transmitters etc, but also to power PCs and essential internal computer, fax, data and voice network equipment, as well as the environmental essentials such as lighting and air circulation. Extended electricity disruptions also make it necessary to have provision to recharge batteries (cellphones, satellite phones, handheld radios, laptops etc).

4.7. Key Operational Centres

These were clearly identified. Utilities with many subcontractors tend to have more critical Operations Centres to connect. Some utilities host Operational Centres within their EOC when it is active.

4.8. Mandated Communications Requirements

This question was not answered consistently. Many referred to the Lifelines requirements of the CDEM Act.

In general, the EOCs need to be able to communicate information to the public, either by broadcast radio and TV, or via web-sites.

Utilities want to keep their call centres operating with current emergency status readily available.

4.9. Future Operational requirements

Again there was reference to the requirements of the CDEM Act. EOCs plan to be compatible with MCDEM systems (eg to retain existing HF radio systems for as long as MCDEM retains them).

Some organisational changes were flagged (eg formation of “Trackco” to manage rail line infrastructure).

Some reconfiguration of VHF networks is planned to reduce site vulnerabilities and improve coverage.

4.10. Planned new technologies

Several organisations are looking at new technologies including:

- GPS
- Wireless LAN
- Replacing rechargeable batteries with readily available dry cells
- IVR
- Increased automation of data collection / distribution
- Ensuring that contractors have compatible systems

These are not expected to have a major impact on this project in the short term (the last point is a recommendation of this report).

5. Impact of Disasters on Communications Systems

5.1. General

There are various degrees and levels of natural (and otherwise) disasters that could affect Lifelines' communications. The nature of the disaster will determine the extent that operations will be affected. Some will be of a local nature and may only affect a limited geographical area; others will be more widespread with a corresponding wide-ranging impact on the infrastructure. There can be network issues that, although local in nature, can have a widespread network impact.

Lifelines Utilities do not operate in isolation. Most have strong dependencies for their communications on Telecom and generally to a lesser extent on the other public network providers.

5.2. Various disaster scenarios and exposures are identified below.

5.2.1. Earthquakes

New Zealand is exposed to broad and complex areas of major active faults. At least seven active faults, capable of producing earthquakes of greater than magnitude 7.0 on the Richter scale, have been identified. The probability of at least one of these faults rupturing in the next 100 years has been calculated as between 55% and 99%. Of particular relevance is that the probability of an earthquake on the Wellington fault is 10 % in the next 50 years. Earthquake affects may be ground shaking, liquefaction, earthquake induced slope failure, fault rupture, fire and tsunami generated by the earthquake.

An earthquake may cause disruption to many Lifelines services concurrently and is likely to provide the most severe and concentrated test of emergency communications systems.

It is likely that buildings housing communications equipment will be affected as well as cables being ruptured (both communications and electricity supplies), and directional antennae used for wireless communication could be misaligned.

5.2.2. Fire

The bush fire threat varies throughout New Zealand. A number of minor (and sometimes major) incidents occur on an annual basis, but few endanger human life. In extreme weather conditions, however, the potential exists for large bush fires to develop. These may threaten remote sites or even cause them to become completely unserviceable; noting that although remote sites are generally above the bush line they could be exposed to scrub fires in parched conditions. Fire following an earthquake or eruption could disrupt a much wider area and severely disrupt services.

5.2.3. Floods

Flooding through out the country is a likely hazard to be experienced in any year. Additional problems are often encountered due to storm water culvert flooding, and coastal flooding. The major impact of flooding on communications infrastructures (as recently demonstrated) is the breaching of buried or suspended cables (copper and fibre-optic) as bridges and roads are carried away. Radio repeater locations are, by necessity, hilltop, removing the threat of floodwater damage to equipment, however access to sites may be limited for some time.

5.2.4. Hazardous Materials

Some New Zealand Regions have areas of storage of hazardous chemicals and also provide many corridors for transportation of hazardous materials. In worst case scenarios any spill, leak or explosion may lead to the evacuation of premises. Unlikely to directly affect overall operation of communications systems although would have some local effect particularly should the operational support centres of major networks have to be evacuated for extended lengths of time.

5.2.5. Storms

By its very island nature many parts of New Zealand are coastal and thus liable to be buffeted by high winds and storms. Heavy rain is generally experienced from the South or the Northwest. Cyclonic events such as the 1968 Wahine storm and those that struck Northland in 1996/97 are not common, but always possible. Climate change impacts may increase the frequency or intensity of severe storm events. Hill top repeater sites can be very vulnerable to such storm stresses with antenna damage being the most likely result. Lightening strikes can be mitigated with good design and construction but may not be eliminated completely. Some existing sites are vulnerable.

5.2.6. Terrorist Activity

New Zealand has been spared significant terrorist activity in the past. Events that target people directly are likely to have a significant impact on infrastructure if they are carried out in public places such as airports. Actions targeting disruption through damage to infrastructure are potentially more serious (in this context), particularly if targets are well-chosen to maximise disruption. High levels of utility network security are generally provided but the remote location of some infrastructure, the fact that the public needs to access service points, the existence of key network nodes, and the growing potential of remote "cyber-terrorism" mean that there are vulnerabilities that could be exploited.

While physical attacks produce situations similar to natural disasters, they can be co-ordinated over wide areas creating resource overloads. Overloading or disruption of communications services through software means (virus, worms, denial-of-service attacks etc) can be potentially as crippling as physical attacks.

5.2.7. Tsunami

Those parts of New Zealand's coastline that are industrially inhabited could provide a commercial or operational risk from Tsunamis. Tsunamis could be generated at distant locations and travel across the Pacific giving hours of warning, or they could be generated by a local undersea landslide or earthquake and give little or no warning. A Tsunami is not expected to pose a significant threat to communications systems because of the redundancy and alternate routings available.

5.2.8. Utility Failure

Disruption to the networks that supply water, electricity, gas, transportation or waste disposal can cause major impacts to the community. For communications systems the most critical utility is that of the stability of the mains power supplies.

5.2.9. Volcanic

Volcanic activity does occur from time to time. Although rated low as likelihood (>200 year return period), an eruption of the Auckland volcanic field would produce local (and possibly widespread) devastation. Key nodes and operations centres in the public networks would be vulnerable if there was widespread fallout. The more likely risk is that the predominant westerly winds could carry ash from eruptions of Mt. Taranaki, or the mountains of the Central Plateau, to more populated areas, or that volcanic activity would damage local infrastructure. The Bay of Plenty is similarly subject to the activity of White Island. Volcanic activity is therefore unlikely to materially affect broader public network operations although the ash can accelerate deterioration of external metal components such as antennas.

5.3. Node or Site failure

5.3.1. PSTN

Failure of a “local” switch within the PSTN will affect customers connected to that switch, generally preventing them from making or receiving calls. Similarly, failure of a “subscriber” cable will completely disrupt access for customers connected to the network by that cable. Failure of a “tandem” switch or “trunk” cable will reduce the capacity of the network to make connections and may lead to overload conditions, but route diversity will generally ensure that some capacity remains operating.

5.3.2. Cellular Mobile Phone networks

Failure of a cell-site (or the link between the cell-site and the Base Station Controller) will prevent calls being processed by that site. In built-up areas there will generally be other cell-sites available to provide coverage but in sparsely populated areas, or areas with poor coverage because of topography, loss of a cell-site will cause loss of service. The networks generally have adequate redundancy and diversity upstream of the controllers, but loss of a switching node or HLR would seriously impact network capacity and lead to overloading.

The service is subject to cell-sites staying intact during a disaster and for their generators (if so equipped) starting upon power failure. Alternatively, if there is no generator then there is dependency on back up batteries being fully charged and still operating within their service life. If a general emergency has caused the power outage then the batteries will be under greater stress and may only last a few hours without support.

5.3.3. Trunked Radio Networks

The trunked mobile radio system has the advantage of having been around for some time and the strengths and weaknesses of the physical repeater stations are understood. These are built to robust specifications but there is third party ownership and maintenance of some sites. It is subject to repeater stations staying intact during a disaster and for their generators (if so equipped) starting upon power failure. Alternatively, if there is no generator then there is dependency on back up batteries being fully charged and still operating within their service life. If a general emergency has caused the power outage then the batteries will be under greater stress (increased transmit duty cycle) and may only last a few hours without support.

5.3.4. Radio repeaters

Exposures for VHF and UHF radio repeaters are very similar to those for trunked mobile repeaters. The antennae are vulnerable to storm damage and the electronics to lightning strikes; the hilltop locations also make continuity of power supply difficult, particularly in adverse weather. Loss of key repeaters severely impacts the coverage of these “line-of-sight” systems.

5.3.5. Congestion and call blocking

The most significant overall risk is that of overloading and congestion, particularly if parts of the networks are disabled.

It is anticipated that in a major emergency, the available public networks will be heavily loaded as people try to establish contact with family and friends. This is a significant risk, particularly on the cellular networks and they should not be relied upon as a primary means of communication in a major emergency.

Priority[2] can be given to defined emergency organisations on the Telecom PSTN if it is operating. This facility is not available on the cellular networks.

- The wireline PSTN has the capability to apply priority to defined (emergency) callers[3],
- the wireline network is configured to minimise the possibility of failure of a 111 call by use of dedicated circuit groups (very limited quantity) and overflow routing.
- The Vodafone cellular network provides priority to calls to 111
- The Telecom cellular networks are configured to minimise the possibility of call failure to 111 by use of dedicated circuit groups (very limited quantity) and overflow routing
- The trunked mobile networks can provide emergency priority to defined users.
- Future IP-based networks are likely to have the capability to provide defined classes of service which could be used to provide priority for specified users.

A more detailed and specific study of call prioritisation, and how it has been implemented, in the public networks should be carried out to ensure that emergency communications take advantage of any prioritisation that is available.

Workshop discussions indicate that relatively low volumes of messaging are required between Lifelines organisations, and between Lifelines EOCs and CDEOCs. Messaging does however take several forms, voice, fax, email, data and it is important that Lifelines ensure that alternate communications systems can handle these if the primary means of communication is disrupted. However it is recognised that in worst-case scenarios, communication may be limited to simplex voice only.

[2] PSTN Priority Service is applied on an individual customer number basis and means that these lines are the last to be denied Dial Tone in an Overload situation and are restricted from making calls by only the final stages of Network Management Controls

[3] PSTN Priority Service is applied on an individual customer number basis and means that these lines are the last to be denied Dial Tone in an Overload situation and are restricted from making calls by only the final stages of Network Management Controls

6. Consideration of Options

6.1. PSTN

Advantages

- resilience managed by the Carrier; viz multiple diverse inter-exchange routes providing diversity.
- copper and fibre routes; fibre is reputed to be more resilient to earth movement than copper and therefore provides an increased chance of still providing connectivity in cases of 'minor' earth movement.
- power supplies at exchanges are equipped with 'no break' battery back up and with generator back up in critical locations.
- 'ordinary' telephones connected directly to the PSTN get their power from the telephone network and hence can work during widespread power outages (subject to limits on battery capacity in the network).
- Lifelines organisations could opt for multiple and diverse routes from Control Centres to provide much higher resilience in a disaster. This could extend even to include multiple carriers (where available). Utilities would need to ensure PABXs were structurally secure and had appropriate power back up.
- relatively easy to fax over the PSTN
- Possible for Carrier to allocate calling priority for emergency caller[4]
- features available which could prove useful such as three way calling, conferencing facilities. (conferencing “bridges” are available for use via PSTN, cellular and trunked mobile)

Disadvantages

- complete dependence on carrier having sufficient level of resilience in place to cater for (varying) disaster levels.
- Limited options to provide redundancy in local cabling between customer site and local exchange
- long distance calls dependent on long haul cable/microwave routes remaining intact.
- overloading of the PSTN will affect access; although there is a facility for obtaining priority in such circumstances.
- dependent on the carrier system software to remain stable in what may be untested situations.
- IP phones (in fact any “powered” phones) connected to the PSTN will become unusable in power outage situations unless there is back up power to the IP phone.
- one to one conversations only; no broadcast 'open' facility although conferencing facilities are available - would need to remain ‘open’ for hours or days if required continuously in emergency.

[4] PSTN Priority Service is applied on an individual customer number basis and means that these lines are the last to be denied Dial Tone in an Overload situation and are restricted from making calls by only the final stages of Network Management Controls

6.2. Mobile Phone network

Advantages

- handsets are portable; not tied to location.
- own handset battery power supply; spare batteries can be available, recharging from car battery possible
- three networks to choose from (though different handsets required).
- ability to send and receive text messages
- ability to send and receive emails (size limited) and browse the Internet. 3G will allow for more comprehensive use including video images.
- may be comparatively isolated from the affects of disaster - some cell phone repeaters are connected by cable which could be damaged, some by microwave which may be operational either as is or with antenna directional tweaking following ground movement. requires cell sites to have sufficient back up power capacity.

Disadvantages

- likely to be overloaded in an emergency situation.
- requires recipients of calls to be on the same network if one network (or interconnect) fails.
- requires data links to cell sites to remain operational in disaster
- more reduced coverage cell sites reducing coverage from phone locations
- each cell site requires access via a high speed data link to either of a pair of cell phone network management database sites (HLRs or Home Locator Registers) for calls to be originated. There are 3 different pairs of HLRs for each of the current mobile networks (021, 025 and 027)
- one to one conversations only; no broadcast 'open' facility; although conference calls can be arranged.
- not practical to fax over a cellular network (because of restricted audio bandwidth and high compression techniques which are designed to work with voice waveforms.

6.3. Trunk Mobile network

Advantages

- wide coverage offered by each repeater
- transportable and handheld units available
- units generally 12 volt driven; battery operation and backup therefore inherent
- open channel operation feature
- Many utilities already use in Auckland and Wellington.
- Priority can be programmed into these systems.

Disadvantages

- repeaters may be damaged, battery backup limited?
- overload during emergency

- annual costs to reserve channels
- As the system is operated by a commercial provider Lifelines may have to queue to access the system.
- Call durations are programmable and limited.

6.4. Satellite Phones

Advantages

- handsets are portable; not tied to location.
- own handset battery power supply; spare batteries can be available.
- three networks to choose from (though different handsets required).
- ability to send and receive text messages
- ability to send and receive emails (size limited) and browse the Internet.
- comparatively isolated from the effects of disaster
- provide connection to public networks (PSTN and cellular)

Disadvantages

- requires connection on commercial satellite; can be relatively costly.
- terminals will cost but are no longer 'expensive'.
- Need clear view of sky – may require external antenna to operate in buildings
- signal can be affected by very heavy rain.
- Latency (delay/echo) with Inmarsat
- Commercial stability of operators

6.5. Internet Protocol (IP)

(This refers to connections using Internet Protocol which may be dedicated links over wire, fibre or radio, or which may be provided by the public *Internet*.)

Advantages

- Internet Protocol (IP) protocol inherently "bullet-proof" allowing data to automatically re-route around network failures.
- capacity to build ‘Voice over IP’ (VoIP) over a private IP network.
- single operating facility possible - namely PC plus headset to cater for data and voice.
- established standard; widespread and increasing penetration.
- can have alternate routing to other networks.

Disadvantages

- requires power to be available at user sites to power IP phone, handset and/or PC.

- despite powerful re-routing facility integrity still depends on local connections to carriers remaining operational - similarly requires local carrier to have inter exchange links operational.
- requires local (access) links to other remote end users (Lifelines) to be intact and operational.

6.6. VHF Radio

Advantages

- operates effectively on low power thereby suited to operating off battery back up systems
- usually frequency modulated (FM) which (as long as the signal strength is in excess of a threshold) results in comparatively ‘clear’ signals (viz high signal to noise ratios).
- coverage range extended through repeaters (e.g. SkyTower, Climie, Belmont, Eringa)
- can also use as point to point with simplex frequencies.
- comparatively easy to use Short Term Special Purpose (STSP) repeaters.
- can have 'desk top' higher power or lower power 'hand held' sets.
- equipment not generally expensive.
- easily fitted to vehicles; antennas are relatively compact.
- no annual usage or channel reservation costs (apart from Ministry of Commerce annual radio licence fees)
- antennas are compact and (including repeaters) non directional. Realigning not required normally.
- May be provided (or augmented) by volunteer services of the Amateur Radio Emergency Communications groups (AREC)

Disadvantages

- operate generally only over 'line of site' paths.
- need a certain received signal strength to avoid noisy signals.
- for wider area coverage via repeaters - requires repeaters to be operational - viz structure intact and electrical power available.

6.7. HF Radio

Advantages

- wide coverage; depending on frequency band, time of day and antenna type. Local coverage enhanced by Near Vertical Incidence Skywave (NVIS) antenna systems.
- coverage can be designed to be 'local area' (around 100 km radius) or can cover all of New Zealand and beyond.
- modern equipment is compact and reasonably powerful.
- MCDEM already has HF sites around selected Territorial Authorities throughout New Zealand with a base station in the Beehive; stations operate in the 5.38 MHz band.

- can always provide communication under 'widespread' destruction; - viz a radio, a car battery and a wire slung over the nearest tree will provide at least a voice channel into the outside world.

Disadvantages

- can suffer from interference from remote stations; depending on frequency and time of day.
- propagation can be affected by time of day - need channel choice in practice.
- Amplitude Modulated and hence can have 'noisy' signals.
- requires more extensive antenna system then VHF, not so easy to have with a vehicle. Depending on location of physical office in commercial buildings - may need extensive feed to roof top aerials. Extra feed line losses can result.

6.8. VSAT Systems

Advantages

- satellite independent of issues at ground level
- terminals can be multi-channel for voice and data
- terminals moderately compact; easily roof mounted
- free from other spectrum interference, signal is 'high quality'
- more satellites being launched giving improved coverage and power over New Zealand; pricing expected to fall.
- very high availability (but see "outages" below)
- planned technology for Wellington Region Civil Defence Emergency Management Group

Disadvantages

- requires reserved spectrum on commercial satellite; can be relatively costly.
- terminals will cost but are no longer 'expensive'.
- dish may need realigning after earth movement or hurricane strength winds
- transportable (can be moved to new location and set up there) but not “portable”
- signal can be affected by very heavy rain.
- battery back up required for earth terminals only; not for satellite "repeater".
- propagation delay needs to be included in system design
- Outage of around 2 minutes each six months during equinox, exact date and time is always known

7. Feature and cost comparisons

7.1. Satellite phones

7.1.1. Geostationary

Geostationary satellites (Inmarsat) are more stable and generally have long design (and in practice) lives. Their very high altitude provides greater coverage from fewer satellites and because they appear stationary from earth there is no need to "handover" between satellites. The high altitude does introduce transmission delay (latency) and requires higher transmit power from ground units.

7.1.1.1. Hardware costs

Inmarsat Mini M (voice, fax and data 2400bps) 2.2kg 2.5 hours talk time (battery)

NZ$7000 (portable) NZ$8000 (vehicle)

7.1.1.2. Operating costs

US$1.80/min (to NZ numbers)

US$2.60/min (typical international)

7.1.2. Low Earth Orbit Satellites

LEOS (Iridium, Globalstar) require more satellites to provide coverage and because they are always moving, a stationary user on the ground will experience "handover" as one satellite moves away and another takes over (approximately every 10-15 minutes). They require less power from ground units and there is no appreciable delay (latency) because the transmission path is relatively short. LEOS are generally more tolerant of antenna orientation than geostationary systems. Handsets are generally smaller than for geostationary systems and some are multimode (work as a standard CDMA or GSM cellphone when in range and switch to satellite mode when out of range).

7.1.2.1. Hardware costs

Globalstar SAT50 handheld AU$1599 Car kit AU$1499

Iridium Motorola 9505 (includes antenna, chargers) NZ$3495

7.1.2.2. Operating costs

Globalstar	Connection fee AU$200
	Monthly access AU$33
	Calls AU$1.50/min (incoming and outgoing)
	(Other "minutes included" plans available)
Iridium	Connection fee US$50
	Monthly access US$25
	Calls US$0.99 per minute to Iridium (voice)
	US$1.50 per minute to Iridium (data)
	US$1.50 per minute to other network (PSTN, cellular etc)

7.2. VSAT System

At this stage indicative prices for the terminal equipment for the iPSTAR system are per site (NZ$, ex GST):

dish, set top box	$1,600
IP phone	$800
hub	$1,000
laptop	$3,000
cabling	$2,500
Total	**$8,900**

Provision to make this system transportable is expected to cost an additional $1000.

Operational (calling) costs have not been established yet but should be comparable to the other satellite systems. Note that the VSAT systems are "always on" like a wireless broadband system so charges are likely to be more like broadband charges – a fee for having access and then a usage charge based on volume of traffic (rather than call minutes).

8. Technology Comparison

Technology	PSTN (fixed line)	Cellular Wireless	Trunked mobile	Internet	VHF	HF	LEO Satellite	VSAT
Voice	*****	****	****	***	***	**	****	***
Data	****	**	*	*****	*	*	***	****
Fax	*****				*	*	***	****
Availability	Mature	Mature	Mature	Well-developed	Mature	Mature	Developing	Developing
Coverage	Extensive +	Extensive -	Wide	Extensive +	Specific (LineofSight)	Wide	Complete (sky-sight)	Complete
Resilience	Cables vulnerable	Congestion vulnerable	Good	Access-points vulnerable	Repeaters vulnerable	V Good	V good	V good
Terminal Cost	Existing	$200-$1000		Existing	$500 - $5000	$5-10k per site	$2000-$3500	$8500

Capacity	Voice priority Data to 56kbps	Voice good Data limited	Voice priority Data to 2.4kbps	Very high - limited by local access	Single channel	Single channel	Voice and data	Voice and data (4Mbps)
Main Advantages[5]	coverage simple to use Standard handset powered from line	Battery handsets Very mobile	Mobile	ubiquity	Low cost independent	Self-contained	Coverage resilience	Coverage capacity
Main disadvantages	Cables vulnerable limited mobility	Congestion	Limited users	Requires PC, power	Limited data/fax	Limited data/fax	Cost capacity	Unproven

Key to chart:

* s indicate capability (more * are better)

[5] From emergency response viewpoint

9. Technical summary

9.1. PSTN

The Public Switched Telephone Network has evolved from the original manually connected system with limited access to become a ubiquitous service with many additional features. Customer equipment is a telephone handset connected either directly (or via a PBX) to a local telephone switch, usually by cable (hence known as "wireline"). Local switches are connected by trunk circuits through a hierarchy of switches that allow any-to-any connection of one customer to another by entering a "phone number" dialling code on the keypad. The switches establish a circuit or path through the network for the duration of each call.

Services are progressively being moved to "next generation" networks based on IP (Internet Protocol) communication. This breaks communications (voice/fax/data) into small "packets" and sends each packet, with addressing information attached, into the network. Switches (or "routers") within the network forward each packet to its destination according to the addressing information attached, using whatever paths are available (hence natural resilience). Terminal equipment then reassembles the packets into the correct sequence and presents a copy of the original communication to the receiver.

9.2. Mobile phone network

From a user perspective provides services similar to the PSTN, but with the advantage of mobility. Rapid handset development for mobile phones has also resulted in a rich set of user features (inbuilt directory, one-key calling, short codes, caller display etc). Short Message Service ("texting") has become a popular service and handset design has again been rapid to facilitate this. The capability now exists for email by cellphone, and for access to the Internet and networked servers. Data transmission rates currently available, and screen and keyboard size limitations in a "pocket" device limit usability but are being gradually being overcome. In future video, text, and voice will all be accessible by mobile. With the addition of GPS technology the location of handsets can be determined accurately allowing services like automatic dispatch and remote directions to be utilised.

There are three cellular mobile networks in New Zealand, the Telecom 025 D-AMPS network is gradually being replaced by the 027 CDMA network, and the Vodafone 021 GSM network. The networks are interconnected so users on one can connect with users on another, but each handset will only work with one network.

9.3. Trunk Mobile network

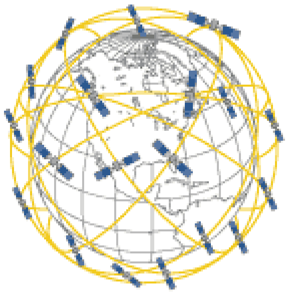
The two trunked mobile radio networks in New Zealand operated by Teamtalk use similar (but not compatible) technology. Service is provided by interconnected VHF radio repeaters. They allow private communication between users over wide coverage areas, and via interconnections to other networks (PSTN and cellular mobile). Handsets are robust and portable, many being vehicle-based. The service allows limited data capability and "one-to-many" broadcast.

9.4. Satellite phones

9.4.1. Globalstar

Globalstar phones look and act like mobile or fixed phones with which you're familiar. The difference is that they can operate virtually anywhere, carrying your call / data over a secure Code Division Multiple Access (CDMA) satellite signal.

Like "bent-pipes", or mirrors in the sky, the Globalstar constellation of 48 Low Earth Orbiting (LEO) satellites picks up signals from over 80% of the Earth's surface, everywhere outside the extreme polar regions and some mid-ocean regions. Several satellites pick up a call, and this



"path diversity" assures that the call does not get dropped even if a phone moves out of sight of one of the satellites. A coverage map is included in section 10.5.2

As soon as a second satellite picks up the signal and is able to contact the same terrestrial gateway, it begins to simultaneously transmit. If buildings or terrain block the phone signal, this "soft-handoff" prevents call interruption. The second satellite now maintains transmission of the original signal to the terrestrial "gateway".

Additional advantages of using Low Earth Orbiting (LEO) satellites within the Globalstar system include no perceptible voice delay and lighter / smaller all-in-one phones.

Gateways process calls, then distribute them to existing fixed and cellular local networks.

Globalstar LP, which was established in 1991 and began commercial service in late 1999, currently offers service in over 100 countries around the world. The company filed for Chapter 11 bankruptcy protection in 2002 and was recently restructured with new financing to exit the Chapter 11 procedures.

Globalstar Australia owns and operates the Australian ground based Globalstar™ network infrastructure providing mobile communications service to 100% of Australia and New Zealand. Globalstar Australia has a commercial agreement with Globalstar LP to acquire satellite airtime on the Globalstar™ constellation of low earth orbit satellites. There is no direct representation of Globalstar in New Zealand.

In addition to dual mode Satellite and Cellular voice communications, enhanced services include:

- Internet and private data network connectivity
- Telemetry
- SMS (short messaging service)
- Voicemail

9.4.2. Inmarsat

Inmarsat's primary satellite constellation consists of four Inmarsat-3 satellites in geostationary orbit. Between them, the main ("global") beams of the satellites provide overlapping coverage of the whole surface of the Earth apart from the poles.

A geostationary satellite follows a circular orbit in the plane of the Equator at a height of 35,600km, so that it appears to hover over a chosen point on the Earth's surface. Three such satellites are enough to cover most of the globe, and mobile users rarely have to switch from one satellite to another.

A call from an Inmarsat mobile terminal goes directly to the satellite overhead, which routes it back down to a gateway on the ground called a land earth station (LES). From there the call is passed into the public phone network.

The Inmarsat-3 satellites are backed up by a fifth Inmarsat-3 and four previous-generation Inmarsat-2s, also in geostationary orbit.

Inmarsat is now building its fourth generation of satellites to support the new Broadband Global Area Network (B-GAN). This will be introduced in 2005 to deliver Internet and intranet content and solutions, video on demand, videoconferencing, fax, e-mail, phone and LAN access at speeds up to 432kbit/s almost anywhere in the world. B-GAN will also be compatible with third-generation (3G) cellular systems. The satellites will be 100 times more powerful than the present generation and B-GAN will provide at least 10 times as much communications capacity as today's Inmarsat network.

Inmarsat was developed as a global ship-to-shore system and so supports a limited range of (generally larger) handsets. There are a number of representatives in New Zealand, mostly with a maritime focus. Because of the longer satellite path (high orbit) there is a delay (latency). Costs are higher than for the LEO satellite systems. Inmarsat has a good track record and mature reliable system. It is likely that the new technology being launched next year will be more competitive and consequently it is recommended that no new investment be made in current Inmarsat technology.

9.4.3. Iridium

The Iridium Satellite System is the only provider of truly global, truly mobile satellite voice and data solutions with complete coverage of the Earth (including oceans, airways and polar regions). The technology is similar to the Globalstar system described above. Through a constellation of 66 low-earth orbiting (LEO) satellites operated by Boeing, Iridium delivers essential communications services to and from remote areas where terrestrial communications are not available. The service is ideally suited for industrial applications such as heavy construction, defence/military, emergency services, maritime, mining, forestry, oil and gas and aviation. Iridium currently provides services to the United States Department of Defense and launched commercial service in March 2001. The original service, backed by Motorola was withdrawn in 2000 with huge financial losses. A group of investors purchased the assets at less than 1% of cost and renegotiated the operating costs at 10% of the original charges, producing a new financial model that is more likely to be successful. (The reported “breakeven customers” is now 60,000 compared to 1 million originally and the US DoD contract provides 40% of this).

Tech Rentals Ltd and a number of other distributors represent Iridium in New Zealand, providing technical support and local invoicing.

9.5. Internet

It is important to differentiate between IP (Internet Protocol) and *The Internet*. *The Internet* is the system we all use for email and to browse websites. It is a public network of servers and is actually many networks interconnected. IP describes the *protocol* (rules, procedures, responses) that govern how data is sent through the network. *The Internet* uses IP, but IP can also be utilised in private networks that do not form part of *The Internet*.

The roots of today's *Internet* come from the US Defence Department’s Advanced Research Projects Agency (ARPA). In the 1960s, ARPA became interested in developing a way for computers to communicate with each other and began to fund research programs at universities and corporations into building an effective network. As part of this the basis of today’s IP was described in an IEE paper in the early 1970s and networks began to use the new protocol during that decade. These eventually grew into *The Internet*, which became visible to the public during the 1990s.

The key features of IP are that it provides a comprehensive set of services, is well defined and documented, is widely adopted and supported, and provides a flexible and resilient network. Many organisations have converted their internal networks to IP to take advantage of these features. *The Internet* is the network that provides these features (via ISPs – Internet Service Providers) to the public. One of the features of IP is that it allows private IP networks to be connected to *The Internet*, usually through secure “firewalls” that manage the flow of data to ensure privacy and security are maintained.

Just as widespread adoption of cellular mobile phones has allowed rapid improvement and advancement of handsets, so the widespread adoption of IP has resulted in rapid improvements and volume efficiencies in IP technology resulting in cheaper networks and a rapidly growing range of services.

9.6. VHF Radio

Traditionally known as RT or Radio Telephony, the service has existed for over 50 years commercially. Very High Frequency radio operates on a line-of-sight basis, which limits coverage, particularly in built-up or mountainous areas. This is partially overcome by the use of *repeaters*, which are usually located on high points with good all-round visibility. The repeaters retransmit the signal providing much greater coverage. Networks may be private, owned and operated by the user, or shared public services. Communications can be broadcast (open for all users with a suitable receiver to hear) or trunked (limited to specific users). Advances have included more compact and portable designs, interfaces to public telephone networks, and provision of data and encryption facilities.

9.7. HF Radio

High Frequency radio utilises both direct and reflected radio waves so is not limited to line-of-sight like VHF. HF utilises the property of certain radio waves to bounce off layers in the atmosphere, or to follow the curvature of the earth, thus increasing coverage. A corollary of this is that there is more interference between such systems because the signals can travel much further, so their capacity is limited. HF radio is used mostly over longer distances where coverage of other communications systems is limited. It is gradually being replaced by satellite-based systems, which offer higher capacity, less interference and more-standard services.

9.8. VSAT systems

Shin Satellite Public Company Limited (one of Asia's leading satellite operators) has for the past 3 years been developing a low cost, high capacity satellite system (the "iPSTAR Broadband Satellite System"). iPSTAR will provide satellite-based Last Mile broadband Internet services.

iPSTAR New Zealand has announced Shin Satellite will partner with Ericsson to wholesale broadband internet, telephone and video conferencing services to businesses and consumers in remote parts of New Zealand.

The company has allocated three spot beams on the first of its new-generation iPSTAR satellites to provide services to New Zealand. The iPSTAR satellite is due to be launched by a European Space Association Arianne rocket from French Guyana in the third quarter 2004.

Construction of the Auckland ground station is expected to start shortly. Coverage map is included in section 10.5.1.

The three spot beams equate to about 3 per cent of the satellite's total capacity - enough to send and receive data at speeds of one gigabit a second. Ericsson advise the three beams will be sufficient to provide broadband Internet to about 100,000 typical consumers. Prices are expected to be 40 to 80 per cent cheaper than other existing satellite services.

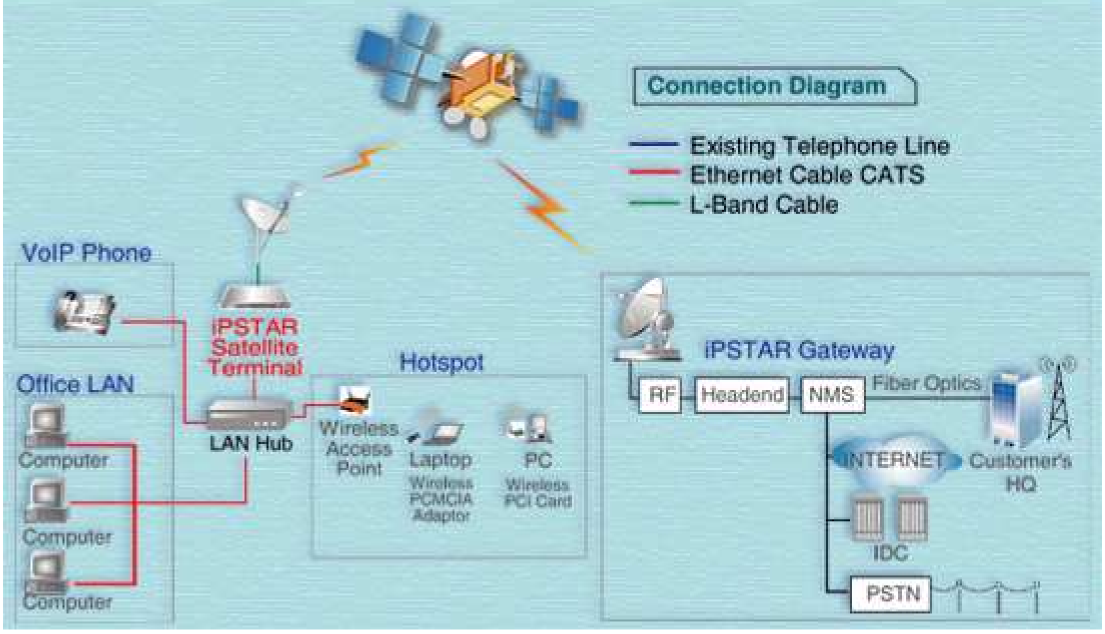
The system will employ Ku band satellite capacity and customers will need a NZ $1660 transponder and antenna to connect to iPSTAR and will be able to plug a phone into the transponder to make internet telephony voice calls.

Shin Satellite will introduce its advanced iPSTAR Gateway in conjunction with high performance iPSTAR Professional Series user terminals capable of providing up to 4 Mbps download capacity and 2 Mbps of upload capacity.

An iPSTAR terminal will be able to access the internet at very high speed, subject to the class of service chosen, up to 8 Mbps forward /2.5 Mbps return per iPSTAR terminal.

The access speed of the iPSTAR system can be classified per Class of Service (CoS) to match the users' requirements and consume bandwidth efficiently.

Connectivity Schematic



9.9. AREC

The Amateur Radio Emergency Communications service is available to provide emergency communications. These volunteers are grouped in regional "sections" and can be called upon to provide radio-based communications links. Working with Police coordinators the service often provides Search and Rescue support, and has the capability to provide either supplementary or primary communications to cover a wide range of incidents. The volunteers are called in via a roster operated by regional section leaders who carry pagers for 24/7 access.

AREC members have their own radio equipment which they will deploy and operate as necessary, or they sometimes operate equipment provided by Police or other emergency services. AREC volunteers are all qualified radio operators familiar with radio communication procedures. The links they provide are generally point-to-point, but with the provision to broadcast to multiple locations

Lifelines (through the relevant CDEM Groups) should initiate dialogue with the AREC service to establish appropriate procedures and standards to engage their services. It is believed that some regional emergency management organisations have already done so. The effort involved to set this up for Lifelines could be substantial and may need to be handled as a separate project. It is likely that there are personnel with Amateur Radio expertise within many Lifelines organisations.

National Director of the AREC service is Brian Purdie,
telephone 06 329-3606 or 025 846-551.

10. Recommendations

10.1. Communications in non-declared emergency

Recommend that:

- existing public systems be used with provision for backup by not relying on any one system. Reasons for this recommendation are the general resilience of the public networks, user familiarity with them, and cost. Recognition that while failure (or access restrictions) to one public network are possible, the likelihood of all public networks being concurrently affected is small.
  - PSTN (allows voice, fax, dial-up data with widespread coverage) backed up by:
  - cellular phones on multiple networks (allows mobile voice, messaging and some data) and/or
  - Broadband Internet (preferably with multiple access with physical diversity) and/or
  - Trunked mobile (may require connection to both systems to allow interworking with other utilities) **and**
  - Satellite phones (Inmarsat, Iridium, Globalstar to provide resilience, independence and complete coverage)
- Continue to utilise internal systems (eg VHF radio) where these are necessary for coverage reasons.
- Maintain a master register, co-ordinated by the Lifelines Co-ordinators of current contact[6] details for all utilities and emergency managers.
- Define processes for establishing communications via the register:

– It is beyond the scope of this review to define the procedures but for guidance the following suggestions for the holder of the master register were canvassed during the workshops:

  - Lifelines Co-ordinators.
    These are not currently operational positions, so this option is not favoured, however as the co-ordinators are responsible for maintaining the register, it would be good practice for them to provide backup to the principle holder.
  - Police Regional Communications Centres.
    Current Lifelines contact lists are circulated to Police, however appear not to be held in Communication Centre emergency procedures with other allied emergency service contacts. Police communications centres become heavily loaded during civil emergencies and may not be able to handle Lifelines contacts in a timely manner. Calls to the 111 service are however given higher level of service than other calls in the public networks. If this option is pursued the matter should be discussed with the Operations and Support Group in the Commissioner's office.
  - a nominated default call centre associated with a CDEMG.
    This would need to be a 24/7 operation with very robust network access. It would be prudent to have a fallback plan and alternate site available.

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[6] there is a list of LL emergency contact details available. AELG one is updated and circulated every 3 months.

10.2. Communications in a declared emergency

10.2.1.1. Between Lifeline Utilities Emergency Operations Centres

In most emergency situations communication with other Utilities Emergency Operations Centres will be possible using normal everyday communications systems. It is recommended that:

- each Utility EOC have at least 3 separate means of communication installed and available. These systems need to be compatible between utilities and have sufficient capacity to handle priority communications traffic.
- At least one of these systems should be satellite-based.

An example of how this would be implemented in practice would be a utility already using:

1. broadband Internet for email and data (including VOIP),
2. PSTN for voice and fax, and
3. cellular for mobile voice and messaging.

For emergency communications with another utility they would need to ensure that physical connection of the broadband and voice networks was not via a common cable and that cellphones were available on both major networks.

As a final backup they would need a satellite based service, at least one handset on the Inmarsat, Iridium or Globalstar system, or a voice-enabled iPSTAR connection.

10.2.1.2. Between Lifeline Utilities Emergency Operations Centres and key contractors

Communications between Lifeline EOCs and their contractors will be critical in the recovery and restoration phases of emergencies.

- Contractors should have robust internal communications systems relevant to the geography and nature of the work they undertake.
- Contractors' control centres should have the same level of emergency communications as the relevant Lifelines EOC (see 10.2.1.1), and those systems should be compatible.

Lifelines utilities should ensure these conditions are written into contractor agreements.

Smaller contractors may be able to relocate their control centre to the Lifelines EOC in an emergency situation, if sufficient infrastructure to support such co-location is in place.

10.2.1.3. Between Lifeline Utilities Emergency Operations Centres and a Lifelines Coordination Centre

A Lifelines Coordination Centre may be necessary to provide a link and backup point between Utilities. The Lifelines Coordination Centre will have direct emergency communications systems with the relevant Regional EOC(s) utilising the systems employed by the CDEMG.

- Utilities EOCs should have at least 3 diverse means of communicating with the Lifelines Coordination Centre,
- at least one of which should be satellite-based.

Further work is required to define the scope of a Lifelines Coordination Centre before a definitive communications plan can be proposed.

10.3. Further recommendations

1. There are concerns (financial stability or technology) with each of the satellite phone systems available that make recommending a single solution difficult. Where organisations have existing technology (eg Inmarsat or Iridium) there is little to be gained from switching to another supplier. Lifelines that will be purchasing their first satellite phone should consider Iridium as the first choice, but also evaluate carefully the next generation Inmarsat service (due 2005) and the iPStar VSAT system (more comprehensive and expensive system due later this year and being considered by CDEM). The Globalstar system is similar to the Iridium system but has no local support, so should only be considered should the Iridium system falter.
2. Under this plan Lifelines are very dependent on the public communications networks having a high level of availability. It would be appropriate for CDEM Groups in reviewing network operators' Disaster Resilience Summaries to identify any major exposures that would impact this dependence. If there are major exposures, further consideration should be give given to building a dedicated Lifelines emergency network using VSAT technology.
3. Adopt a set of standard requirements and design guidelines for inter and intra-utility communications systems. A suggested set is included in section 10.10
4. Ensure any new or upgraded systems have IP (Internet Protocol) capability
5. Increase the capacity of battery and generator supplies in key control centres and for communications equipment to allow 72 hour standalone operation
6. Be familiar with the capabilities of, and contact details for, the AREC. Engage AREC to provide "last-ditch" emergency communications services.
7. Plan for limited communications capacity (bandwidth) being available in emergencies – for example: have low-resolution black & white copies of critical network diagrams, charts, equipment layouts etc for use in emergencies when only limited data or fax capacity will be usable.
8. Lifelines Group(s) should:
   - Develop and maintain a master register of current contact[7] details for all utilities and emergency managers.
   - Determine an appropriate holder for the master register (available 7/24 with full emergency communications facilities)
   - Define processes for establishing inter-utility communications via the register.

[7] There is a list of LL emergency contact details available. AELG one is updated and circulated every 3 months.

10.4. Network coverage – Public Wireless Networks

Current coverage maps are available from the network operators:

Telecom 027: http://www.telecom.co.nz/content/0,3900,201347-201104,00.html

Telecom 025 North Island: http://www.telecom.co.nz/content/0,3900,27057-201104,00.html

Telecom 025 South Island: http://www.telecom.co.nz/content/0,3900,100694-201104,00.html

Vodafone North Island:
http://www.vodafone.co.nz/network/northisland_0_0.jsp?hd=foryou&st=coverage&ss=

Vodafone South Island:
http://www.vodafone.co.nz/network/southisland_0_0.jsp?hd=foryou&st=coverage&ss=

Fleetlink: http://www.teamtalk.co.nz/products/Fleetlink_coverage_maps/default.asp

Teamtalk: http://www.teamtalk.co.nz/products/TeamTalk_coverage_maps/default.asp

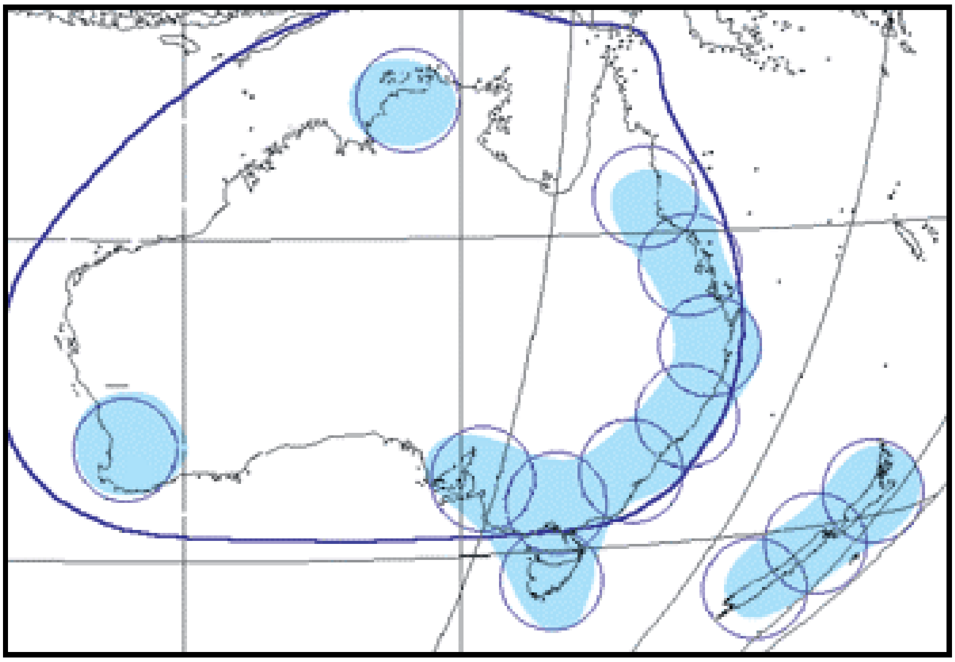
Trunked mobile with its two networks, has more extensive coverage than that of the cellular network operators. However, the trunked mobile networks generally have less network capacity in terms of users per km^2 than the cellular operators.

10.4.1. Ongoing coverage expansion

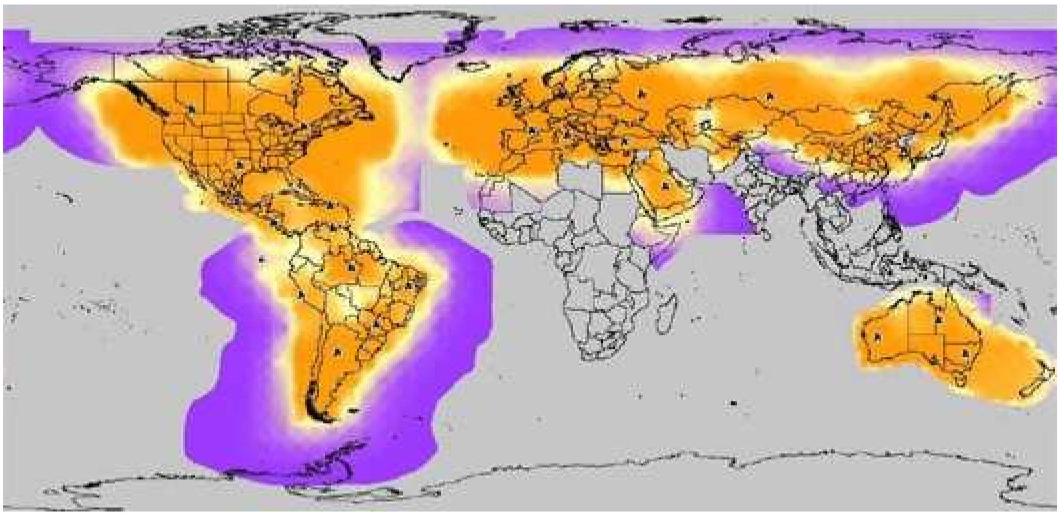
It is expected that ongoing cellular coverage expansion will be focussed mainly on in-fill sites within the existing coverage areas rather than expansion of the wide area coverage.

10.5. Network Coverage – Satellite Systems

10.5.1. IPSTAR VSAT System



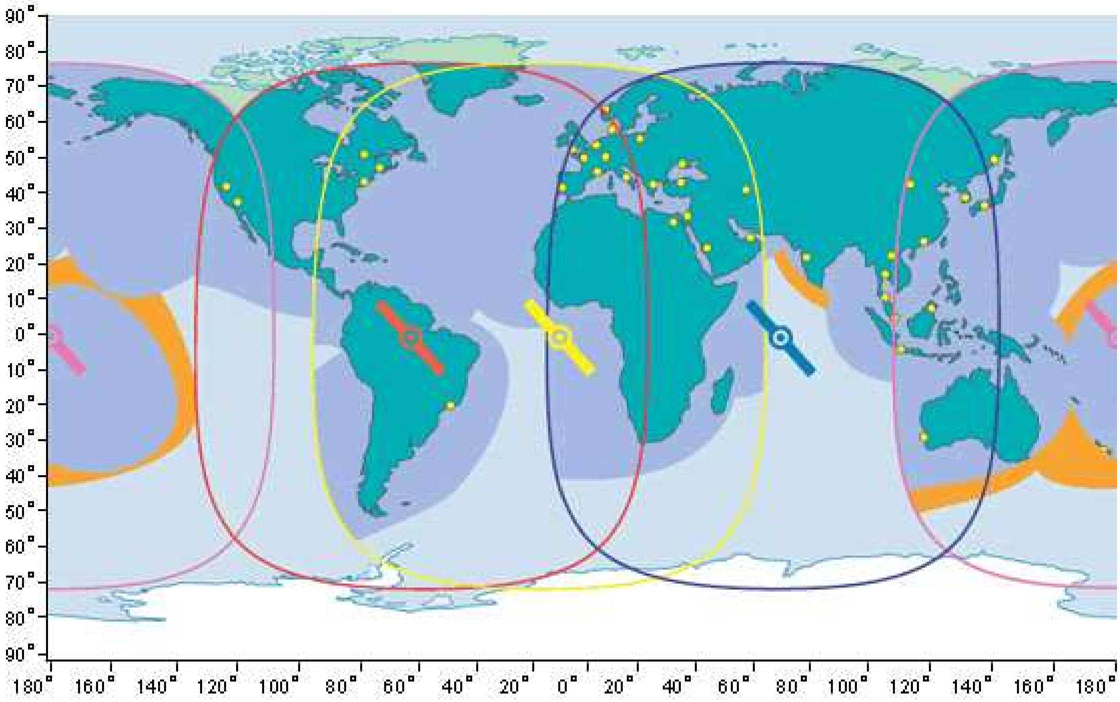
10.5.2. Globalstar satellite phone system



10.5.3. Iridium Satellite phone system

The Iridium system is the only communications system providing true global communications coverage including oceans, and all land areas including the Poles. The Iridium system blankets the Earth, connecting global satellite coverage with local ground-based wireless services.

10.5.4. Inmarsat Satellite phone system



Appendices

10.6. Glossary

Term	Expansion
3G	3rd generation wireless data systems having a capacity of 2 Mbps
AREC	Amateur Radio Emergency Communications – amateur radio group
bps	Bits per second. This is the speed of a data communications link measured in terms of the smallest unit of computer information. Eight bits make up one byte or character (kbps = 1000bps, Mbps = 1,000,000bps)
CDEM	Civil Defence Emergency Management
CDMA 1X	Code Division Multiple Access mobile data service offering a peak transmission rate of 144 kbps
Disaster Resilience Summary	Document outlining an organisation's risk management processes and *readiness* and *response* arrangements
EDGE	Enhanced Data rates for GSM Evolution
EGPRS	Enhanced Global Packet Radio System, also referred to as EDGE
EOC	Emergency Operations Centre
FM	Frequency modulation - varies the frequency of the transmission thereby providing isolation from most atmospheric and ignition interference
GPRS	Global Packet Radio System
GPS	Global Positioning System
GSM	Global System for Mobile Communications
HLR	Home Location Register (cellular phone central database)
IP	Internet Protocol – a communications protocol (standard) that is employed in "the Internet" but is also used in private networks
IVR	Interactive Voice Response – callers use buttons on their phone to select options and pre-recorded voice announcements provide guidance and information
Mbps	Mega bits per second (see bps)
MPT 1327	U.K Department of Trade and Industry specification for an analogue trunked radio system
PABX	Private Automatic Branch Exchange (sometimes just PBX) – telephone switch used within an organisation to provide intra-office and external calling
PSTN	Public Switched Telephone Network
Simplex	Communication using a single channel permitting transmission in one direction at a time only
STSP	Portable, self contained repeaters which can be easily transported and temporary installed in times of emergency

UMTS	Universal Mobile Telephone System
VHF	Very High Frequency – “line-of sight” radio system
VoIP	Voice over Internet Protocol
VSAT	Very Small Aperture Terminals for communication via satellites. Usually dishes of one metre diameter or so, less with newer higher power satellites
W-CDMA	Wideband Code Division Multiple Access

Glossary

10.7. Extracts from the Civil Defence Emergency Management Act 2002

Schedule 1

Lifeline Utilities

Part A

Specific Entities

1 Radio New Zealand Limited and Television New Zealand Limited.

2 The company (as defined in section 2 of the Auckland Airport Act 1987) that operates Auckland international airport.

3 The company (as defined in section 2 of the Wellington Airport Act 1990) that operates Wellington international airport.

4 The airport company (as defined in section 2 of the Airport Authorities Act 1966) that operates Christchurch international airport.

5 The entity (being an airport authority as defined in section 2 of the Airport Authorities Act 1966, whether or not it is also an airport company as defined in that section) that operates the primary airport at Bay of Islands, Blenheim, Dunedin, Gisborne, Hamilton, Hokitika, Invercargill, Napier, Nelson, New Plymouth, Palmerston North, Queenstown, Rotorua, Tauranga, Wanganui, Westport, Whakatane, or Whangarei.

6 The port company (as defined in section 2(1) of the Port Companies Act 1988) that carries out port related commercial activities at Auckland, Bluff, Port Chalmers, Gisborne, Greymouth, Lyttleton, Napier, Nelson, Picton, Port Taranaki, Tauranga, Timaru, Wellington, Westport or Whangarei.

Part B

Entities carrying on certain businesses

1 An entity that produces, supplies, or distributes manufactured gas or natural gas (whether it is supplied or distributed through a network or in bottles of more than 20kg of gas).

2 An entity that generates electricity for distribution through a network or distributes electricity through a network.

3 An entity that supplies or distributes water to the inhabitants of a city, district, or other place.

4 An entity that provides a waste water or sewerage network or that disposes of sewage or storm water.

5 An entity that provides a telecommunications network (within the meaning of the Telecommunications Act 1987).

6 An entity that provides a road network (including state highways).

7 An entity that produces, processes, or distributes to retail outlets and bulk customers petroleum products used as an energy source or an essential lubricant or additive for motors for machinery.

8 An entity that provides a rail network or service.

Extract: Sections Relating to Lifeline Utilities

Duties of lifeline utilities

60 Duties of lifeline utilities

Every lifeline utility must-

(a) ensure that it is able to function to the fullest possible extent, even though this may be at a reduced level, during and after an emergency.

(b) make available to the Director in writing, on request, its plan for functioning during and after an emergency.

(c) participate in the development of the national civil defence emergency management strategy and civil defence emergency management plans.

(d) provide, free of charge, any technical advice to any Civil Defence Emergency Management Group or the Director that may be reasonably required by that Group or the Director.

(e) ensure that any information that is disclosed to the lifeline utility is used by the lifeline utility, or disclosed to another person, only for the purposes of this Act.

61 Schedule 1 may be amended by Order in Council

(1) The Governor-General may, by Order in Council made on the recommendation of the Minister,-

(a) add the name of any entity or description of an entity to Part A of Schedule 1; or

(b) omit the name of any entity or description of an entity from Part A of Schedule 1; or

(c) amend the name of an entity or the description of an entity in Part A of Schedule 1; or

(d) add a description of a class of business to Part B of Schedule 1; or

(e) omit a description of a class of business in Part B of Schedule 1; or

(f) amend the description of a class of business in Part B of Schedule 1; or

(g) otherwise amend Schedule 1 or revoke Schedule 1 or a part of the schedule, and substitute a new schedule or a new part, as the case may require.

(2) The Minister must not recommend the addition of the name of an entity or description of an entity to Part A of Schedule 1 unless the Minister is satisfied that the entity operates a service or system the reduced availability, or non-availability, of which would constitute a hazard.

(3) The Minister must not recommend the addition of a description of a class of business to Part A of Schedule 1 unless the Minister is satisfied that the business provides a service or system the reduced availability, or non-availability, of which would constitute a hazard.

62 Minister may exempt lifeline utility

The Minister may, by notice in the *Gazette*, on any conditions that the Minister thinks fit, exempt a particular entity described in, or carrying on a business described in, Schedule 1 in whole or in part from the provisions of this Act relating to lifeline utilities if the Minister is satisfied that the application of the provisions is not appropriate in the case of that entity.

10.8. List of Utility Organisations in Auckland and Wellington

(from the project brief)

WELLINGTON

Territorial Authority Utility Services

- Wellington City Council (WCC)
- Porirua City Council (PCC)
- Kapiti Coast (KCDC)
- Upper Hutt (UHCC)
- Hutt City Council (HCC)
- South Wairarapa District Council (SWDC)
- Carterton District Council (CDC)
- Masterton District Council (MDC)

GWRC Bulk Water

Nova Gas

Powerco Gas

Natural Gas Corporation

Telecom

Vodafone

TelstraClear

Electra

United Networks

Powerco electricity (Wairarapa)

Transit

Wellington International Airport

Tranzrail

BP, Mobil, Shell, Caltex Head offices - or some joint distribution facility if this exists.

Civil Aviation Authority

Centreport

Transpower

AUCKLAND

Auckland City Council (transport) and Metrowater

Franklin District Council (transport and water)

Manukau City Council (transport) and Manukau Water

North Shore City Council (transport and water)

Papakura District Council (transport) and United Water

Rodney District Council (transport and water)

Waitakere City Council (transport) and Ecowater

Watercare

Broadcast Communications Limited

Radio Network

Telecom

TelstraClear

Vodafone

Natural Gas Corp

Vector

Wiri Oil Services Ltd

BP, Mobil, Shell, Caltex Head offices

Wynyard Wharf (Shell operated)

Auckland International Airport

Ports of Auckland

Transit NZ

Tranzrail

Auckland Regional Transport Network Ltd (ARTNL)

10.9. Survey returns

Survey returns were received from the following:

10.9.1. Territorial Authority utilities

Auckland City Council (Traffic)	Auckland Regional Council
Carterton District Council	Greater Wellington Water Group
Manukau City	Manukau Water
Masterton District Council	Metrowater
North Shore City Council	Porirua City Council
Upper Hutt City Council	Wellington City Council

10.9.2. Other utilities

Auckland International Airport Limited	Broadcast Communications Limited
Radio Networks Limited	Telecom
TelstraClear	Transit
Transpower	Tranzrail
Vector Networks	Vodafone
Wynyard Wharf Terminal (Shell)	

10.9.3. Emergency Management

Auckland City EmergencyManagement	National Rescue Coordination Centre
Waitakere City Emergency Management	Manukau City Civil Defence

10.10. Suggested Design Requirements and System Standards

10.10.1. Design Requirements

a. The emergency communications system chosen must be robust. Appropriate redundancy must be in the system to allow flexibility. Physical hardware must be able to withstand or be protected from likely effects of hazards e.g. earthquakes, fire and flooding.

b. Interoperability of systems is important. It is unlikely that any one system will meet the needs of all users. Therefore it is imperative that the various systems used can talk to each other.

c. The emergency communications system must be able to be used by users at all times during day to day business and during an emergency. It is desirable to have systems that aren’t governed by private access, or technical restraints that limit access to specific users.

d. Adequate maintenance support must be available during and after an emergency.

e. The emergency communications system will be developed based on the principles of risk management.

f. The emergency communications system must reflect the interdependencies of Lifelines organisations.

g. Each organisation on the communications network will be encouraged to make their day to day communications systems (e.g. voice and data) as robust as possible. The emergency communications system is the backup if these normal systems are not available.

h. Separate data and voice channels (or systems) are preferred.

i. If cost is prohibitive in developing the system at one time, voice capability is the priority. The recommended system must be able to be implemented within the available budget.

10.10.2. System Design Standards

a. Lifelines Utilities must be able to make contact with the Emergency Co-ordinator at all times.

b. Two way communications must be possible between all users.

c. Data must be able to be transferred between Lifelines utilities and CDEOCs within 3 hours of an emergency event occurring.

d. The physical elements of the emergency communications system must be robust to withstand Mercalli intensity IX shaking.

e. Emergency co-ordinators should have a broadcast type facility.

f. Coverage must be in place 24 hours a day 7 days a week. This includes the system being operational, access to sites, maintenance and staff support.

g. Each user must be able to meet the information requirements and protocols that govern the use of the emergency communications system.

h. If damaged in the worst case scenario the emergency communications system could be restored within 12 hours.

i. The emergency communications system must be able to operate with a stand alone power supply for at least 72 hours.

j. The emergency system should be future proofed to the extent that it will be operable and able to be technically supported for 10 years after it is brought into service.

k. Security of the information carried over the emergency communications system is not a major issue, however privacy of communications is preferred.

l. The emergency communications system can be supported and maintained during and immediately after an emergency. Evidence can be provided to determine this (e.g. staff within the region for maintenance, business continuity plans in place etc.).

m. The system will not deteriorate over time with low use.

10.11. Risks

Table A1.4: Hazard priorities for the Auckland Region Civil Defence Emergency Management Group Plan (Working Draft 15 March 2004)

Not all of these have been considered in this report as some are unlikely to have any impact on communications infrastructure other than an increase in calling.

HAZARD

Higher Priority Hazards

Biological - animal disease/epidemic

Biological - human epidemic*

Cyclone*

Earthquake

Lifeline utility failure*

Major crash - aircraft

Volcanic - Auckland Volcanic Field

Volcanic - distant volcanic eruption

Moderate Priority Hazards

Biological - introduced species/pests*

Coastal - beach erosion and flooding*

Coastal - cliff erosion/coastal instability*

Coastal – sea level rise*

Coastal – tsunami – distantly generated

Computer systems failure

Criminal acts

Fire – catastrophic wildfire

Fire - urban structure fire

Hazardous substances

Lower Priority Hazards

Coastal – tsunami – locally generated

Dam failure

Drought - agricultural drought*

Drought - water supply drought*

Flooding*

Land instability*

Major crash – rail

Major crash – road

Major collision - marine

Tornado*

*These hazards have the potential to be exacerbated by climate change.

Note: Hazards are listed alphabetically within each category.