SCIRT Rebuilding Infrastructure — LEARNING LEGACY

Lessons learned from one of New Zealand’s most challenging civil engineering projects: rebuilding the earthquake damaged pipes, roads, bridges and retaining walls in the city of Christchurch 2011 - 2016.

Making the Case for an Award

Story: Geographic Information System Support of the Rebuild

Theme: Finance and Business Systems

A copy of the award application for New Zealand Engineering Excellence Awards 2013.

This document has been provided as an example of a tool that might be useful for other organisations undertaking complex disaster recovery or infrastructure rebuild programmes.

For more information about this document, visit www.scirtlearninglegacy.org.nz

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Making the case for an Award

SCIRT GIS team application to New Zealand Engineering Excellence Awards 2013

Date : 1/07/2013

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MAKING THE CASE FOR AN AWARD

The following is an extract from the application made by SCIRT for the New Zealand Engineering Excellence Awards in the Project and Product Award section - Information, Communication, electrical and Electronic Technology. Workflows

PROJECT DESCRIPTION

GIS FOR UNDERGROUND INFRASTRUCTURE

Following Christchurch's February 22nd earthquake, a large and dedicated team was created to rebuild Christchurch's horizontal infrastructure, including wastewater, stormwater, water supply, roads, bridges and retaining walls. The Stronger Christchurch Infrastructure Rebuild Team (SCIRT) was to be built from the ground up, by the clients and five main delivery contractors utilising resources from a large range of consultants and companies. It was at the forming of SCIRT that a number of systems were chosen to provide value for the rebuild of the infrastructure using modern, accurate and efficient technologies. One of the technologies chosen was Geographic Information Systems (GIS).

Three key components of the GIS were formed.

1. The SCIRT GIS team, directly support SCIRT staff with their immediate spatial data needs.
2. The SCIRT GIS system was then instated, consisting of the database structures, datasets, spatial analysis and maintenance processes required.
3. A SCIRT GIS viewer was created as a portal to all of this information, allowing secure access across the internet to an interactive web-mapping interface displaying up to 600 layers of information, ranging from Renal Dialysis Patients locations through to time-enabled projection of Christchurch Blueprint projects, giving an animated view of the stages of construction by date. Using the SCIRT GIS viewer, all types of spatial information can be displayed, identified, queried, printed, exported, overlaid with other information, and edited. The SCIRT GIS viewer allows users a city-wide view of information for their specific requirements, which is easily interrogated and quickly accessible.

The SCIRT GIS system sources different types of spatial and non-spatial information sources from varying organisations including but not restricted to central government, local government, utility, maintenance and survey companies, uploading into a single database format and projection. This information is transformed and integrated into new data and information meeting specific requirements for the benefit of the rebuild effort, which is then displayed via the SCIRT GIS viewer and passed on to other data systems within SCIRT such as 12d, CAD design and Infonet. Information is also combined and processed from the other main business systems of ASTA, Project Centre and JDE. Appendix B shows the data flows within SCIRT, between teams and databases, and illustrates the central position of the SCIRT GIS system.

The challenge to the SCIRT GIS system was in combining large datasets from over 20 organisations supplying different file formats, coordinating systems and each organisation's internal logic, into a uniform, relevant and understandable future-proof view for all of the SCIRT GIS viewer users.

STARTING POINT IN THE PROJECT

The GIS involvement with the rebuild effort in Christchurch started after the initial earthquake in September 2010. Rebuild areas were set up and assigned to different consultancy partnerships and within one of these the GIS team was established to support the engineering efforts for that area only. Following the larger and more destructive earthquake of February 2011, the project delivery structure was changed and SCIRT was formed. The data collection and dissemination already completed by the GIS team for the smaller area, was continued and up-scaled to meet the needs of the much larger base of engineer-users working city-wide.

PLANNED COMPLETION DATE

SCIRT will complete their work on 31 December 2016. It has been agreed that at this time the GIS information will be passed on to the client, Christchurch City Council (CCC), as the asset owner.

WHY SCIRT GIS FITS THE AWARD CRITERIA

Within a relatively short timeframe and with no previously existing infrastructures, the SCIRT GIS team have used originality and ingenuity to develop from scratch an entire GIS system consisting of hundreds of data sources transformed consistently, and delivered through an accessible online viewer to provide the best solution for the people of Christchurch, and the users of the system within SCIRT. This was, and continues to be run within agreed budget constraints.

Sustainability principles have been applied to the entire system to ensure minimal disruptions in service over its lifecycle. To that end the database structure and software configuration were both designed to be flexible and easily scalable in a changing environment. Use of the SCIRT GIS viewer also supports sustainability in the field, as greater access to spatial project information can reduce, for example, construction clashes and increases the likelihood of SCIRT being able to deliver a ‘one-pass’ approach.

There is a positive impact on the quality of life of the Christchurch community through the successful and efficient completion of SCIRT works, in particular in relation to the SCIRT GIS, when traffic management and construction teams are supplied with enough information to allow the city to continue to run as smoothly as is practicable during construction.

Repairing the damaged horizontal infrastructure of Christchurch is a huge and complex engineering task, and the SCIRT GIS system contributes by providing detailed information and support vital to the repair strategy.

ORIGINALITY, INGENUITY AND CREATIVITY IN ACHIEVING THE BEST SOLUTION

Projects brought about due to disaster recovery and rebuild are unfortunately not unique, but the alliance structure of this project provides the SCIRT GIS team with the unique opportunity to be involved across many work-streams, data flows and disciplines, from asset assessment, design, finance, communications, traffic management, and as-built drawings.

SCIRT has been given a unique responsibility for the underground asset data integrity of a large part of the city, working closely in a trusted role with the Christchurch City Council (CCC) to ensure asset management data meets current specifications and is fit and future proof for changes and growth. Over the course of the project, the SCIRT GIS team will process and deliver an unprecedented length of wastewater, stormwater, water supply ‘as-built’ and roading GIS information meeting stringent specifications, and passing back into CCC for final acceptance quality checks.

Most GIS teams maintain the data they supply within their organisation and therefore change can be controlled and adjusted at a pace that suits that team. Therefore, most GIS systems are not designed for constant changes to data schema and updates and manual processes suffice. A major difference in the SCIRT GIS system is the large amount of data schema changes and updates that occur due to the amount of new information appearing and the changing needs of the organisations. Automation of such processes is paramount to the running of the system.

For the SCIRT GIS team, this has been not only an opportunity to show their passion and what is possible, but also the opportunity to build a system from the start that was not confined by existing company infrastructure and most importantly, to help with the rebuild of their city and community.

This passion has shone through, creating a system that is dynamic, fast, and thorough and continues to be admired and heavily utilised by SCIRT and its rebuild partners. The original vision was a system that would require less than three full-time equivalents, but the uptake by the organisation and partners and the continual embracement of the possibilities to make the best decisions, has meant a team of five highly dedicated, open, efficient and resourceful individuals who now provide support, maintenance and enhancements to the SCIRT GIS system.

As part of SCIRT's remit, all intellectual property (IP) of the GIS remains with the three main clients (CCC, New Zealand Transport Authority (NZTA) and Canterbury Earthquake Recovery Authority (CERA)) and will be passed on at the end of the project. In addition, SCIRT uses an ESRI web viewer that has a large active GIS community, and while specific IP is not passed back, the SCIRT GIS team pass back ideas and suggestions on specific functionality that have been implemented by the GIS community for the benefit of all.

BEST PRACTICE IN APPLYING SUSTAINABILITY PRINCIPLES

While GIS is certainly not a new technology, its use at SCIRT breaks the mould of what has been undertaken in other organisations and other engineering projects in New Zealand. This is largely related to the timeframes required to install the system, the city-wide remit for SCIRT works, and the extremely detailed nature of the datasets, and the ongoing increase of requirements of the SCIRT GIS system. Here, the sustainability of the system can be measured in the flexible and scalable design of both the database structures and software configuration and minimising SCIRT GIS viewer disruptions over its lifespan.

The challenge of this system was not confined to the internal structures and software, but due to holding no existing information, it was reliant on the sourcing of data from external organisations. Those organisations included central and local government, utilities, maintenance contractors and databases, and numerous other organisations. Data quickly became the main priority, as SCIRT was to be a mass consumer of other people's information to help facilitate the best decisions for the rebuild.

The most obvious datasets that needed to be obtained were those of the 'invisible' underground infrastructure including the wastewater, stormwater and water supply from the council, as well as obtaining data and provisioning for updates from utility providers throughout Christchurch.

As described above, while most organisations maintain and display their information in some way, the SCIRT system combined the large datasets from all organisations supplying different file formats, coordinate systems and internal logic, into a uniform, relevant and understandable future-proof view for all of the SCIRT GIS users. There was an opportunity to do this by developing bespoke add-ins to the software that they were using, specifically allowing each of the different formats to be viewed consistently. However this approach would have been unsustainable in that it would result in large amounts of development each time new software was released, and as the pace of release and the advancement of web technology is rapid, it was decided to conform the data at the data structure, rather than software level.

Therefore the approach taken is to use a free community-based GIS web viewer that seamlessly connects into the server software, and provide minor customisation easily rolled into new releases, without repeating significant customisations. Instead, all incoming and outgoing data is processed using customised workflows set up in an easily amended Extract, Transform, Load (ETL) software called FME, to transform the data into our model. This approach allows for quick implementation of new viewer technologies, at low cost; utilising their enhanced functionality while still maintaining some of SCIRT's minor customisations.

With over 600 layers the SCIRT GIS viewer is an immense source of information, but the risk is that it becomes hard to navigate. To reduce that risk, the data has been split into around 35 categories which break down into specific relevant layers. The viewer is also designed to allow for ease of use for the most basic users who can turn on a layer and click on it to get relevant information, through to the advanced user who can write a SQL statement, for example, to find all of the earthenware pipes installed before 1950 within a specific project area.

Training and ongoing user support in the use of the SCIRT GIS viewer is central to the success of the viewer and the user experience. The result of ongoing training and support has had great impact on the uptake of the viewer and this uptake has led to greater feedback to functionality improvements.

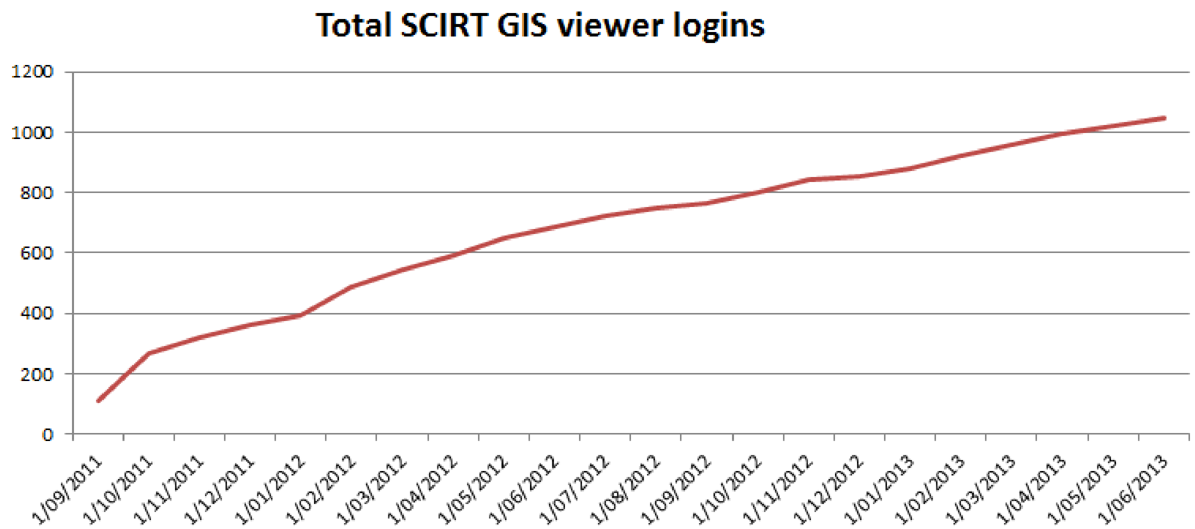

Figure 1: The increase of user registrations with time, illustrating a sharp uptake at the start of SCIRT, and a continual increase in logins.

To ensure a continuous and sustainable supply of data from external organisations, every data supplier was made aware of why data was being requested and the processes that would be undertaken to provide commercial security and, health and safety in relation to their data and network. Security was implemented, not only on the SCIRT GIS viewer but also within the SCIRT network and training provided to address health and safety issues in the field. In particular this ensures those relying on utility location information are made aware of the accuracy limitations and liabilities. It was also important to involve the data suppliers in the SCIRT programme, allowing them to have a view of where and when projects will be working.

In this way, all utilities were given limited access to the SCIRT GIS viewer to help provide a collaborative environment between themselves and SCIRT.

The SCIRT programme has identified a ‘one-pass-approach’ as a way of using resources most efficiently, for instance in locations where multiple networks are damaged - ensuring roads are only dug up once, where practical. For this purpose the SCIRT GIS viewer acts as a hub for collaboration between parties planning works in the horizontal infrastructure rebuild.

Although the SCIRT GIS viewer has a limited lifespan along with the project, a desire for a single-source of up-to-date spatial information relevant to the engineering tasks facing the rebuild of Christchurch has become evident in the requests for viewer access coming from outside SCIRT. While this may not be acceptable by the project, it is easy to see that efficiencies can be gained in the reduction of duplication of effort in data-sourcing and display.

SOUND ENGINEERING IN GIS PRINCIPLES AND PRACTICES

The following principles of sound GIS practices have been met: standardised coordinate systems and formats, data quality assurance, metadata standards, robust IT systems. Also, both the service and utility information has been displayed on the SCIRT GIS viewer using standard and accepted symbols and colours.

The SCIRT GIS system has been implemented in a standard framework by utilising the well-known ESRI software, and due to its dominant position in the New Zealand market, obtaining resources and data sharing is simpler and more reliable. This is supported by FME (provided by Safe Software), which is an ETL software, and provides nearly all the data manipulation in SCIRT’s GIS system.

All data is stored in a consistent spatial format and standard coordinate system, storing consistent and relevant metadata for each layer. The system is running on the latest software with a low level of customisation, able to be easily upgraded.

The SCIRT GIS team has implemented a high level of automation resulting in efficient use of team resources, and greater control over Data Quality Assurance. One example is in the frequent updating of data, schemas and the layer configuration files of the SCIRT GIS viewer. This could be hugely time-consuming and prone to error. Two bespoke Python language scripts have been created to automate the creation of the relevant configuration files which reduces the input required from a few hours, down to several minutes per update. In general, all of SCIRT GIS data update processes have been automated through FME and Python, ensuring data integrity.

Significant time was put into the planning and setup of the system in the early phases of SCIRT to understand the data that was supplied, its accuracy, its limitations and the meaning of specific data attributes. In some instances, reports on data quality were made of important datasets and, anomalies and queries passed back to the originating source for further refinement or clarification.

Metadata information for each layer is entered into a customised form-based tool, is stored and is searchable on the SCIRT GIS viewer. Data currency is important to the viewer users, therefore this information is relayed through the metadata; and when updated on the viewer, on the home page of the GIS viewer.

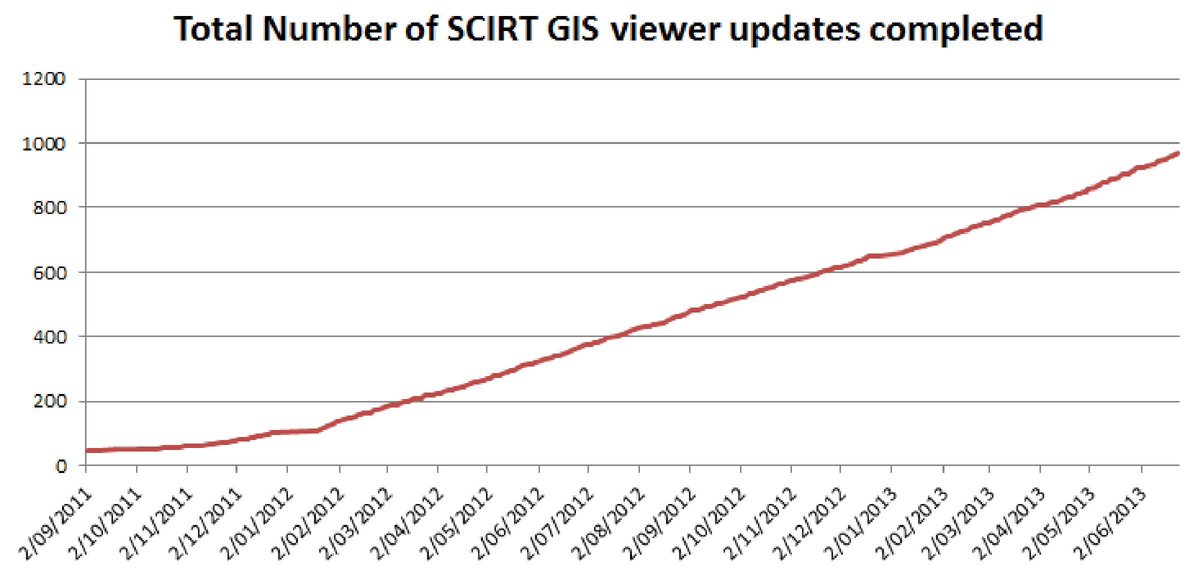

Figure 2: Cumulative total of updates completed for the SCIRT GIS viewer, this is a combination of new data replacements and changes to data structure, new data layers or added viewer functionality.

The web based GIS viewer sits on SCIRT's IT infrastructure. The SCIRT IT team and SCIRT GIS team work together to maintain high levels of uptime and a 'no surprises' approach through testing, backups and maintenance. Updates and maintenance are done outside of working hours, optimising SCIRT GIS viewer access.

By applying these best practice GIS principles within the high pressure and fast paced rebuild environment, the SCIRT GIS were recognised internationally by winning the ESRI Special Achievement in GIS award in 2012.

IMPACT ON QUALITY OF LIFE OF RELEVANT COMMUNITIES

The system itself is not accessible directly by the public but others within SCIRT do utilise it to consult, be aware of, and plan around minimising any perceived negatives of the rebuild, while also maximising the benefits to the public through more informed decisions and improved, more efficient decision making.

Vulnerable individuals in the community are protected from losing crucial services without warning when SCIRT team members in the field implement accepted processes around their particular needs, for example locations of Renal Dialysis users.

Where residents make formal objections to certain processes, these are recorded and allow relevant individuals to see the details of the objections.

Internally, the SCIRT GIS team is receptive to suggestions from our user community with all requests logged and analysed for similarities. Implementation is then prioritised, with support and training given to the users to make their user experience the best possible.

Traffic management has a high-profile impact on the Christchurch community. SCIRT is employing GIS to analyse traffic management time-dependent data to highlight potential clashes in road closures and other traffic impacts for roads where separate project delivery teams indicate they will be working.

Prioritisation of projects is made with the help of the Multi-Criteria Analysis (MCA) tool, and is then used to refine the project scheduling. The MCA is an engineering tool which was designed to weigh up a large number of input variables affecting the prioritisation of work in a repeatable and defendable way. This was developed as a process in the SCIRT GIS system and is run quarterly or whenever changes need to be made on the most up to date data. The outputs are mapped for public distribution. This information is made public through the main SCIRT website as soon as is practically possible, and informs the public on the projected progression of works (see Figure 3).

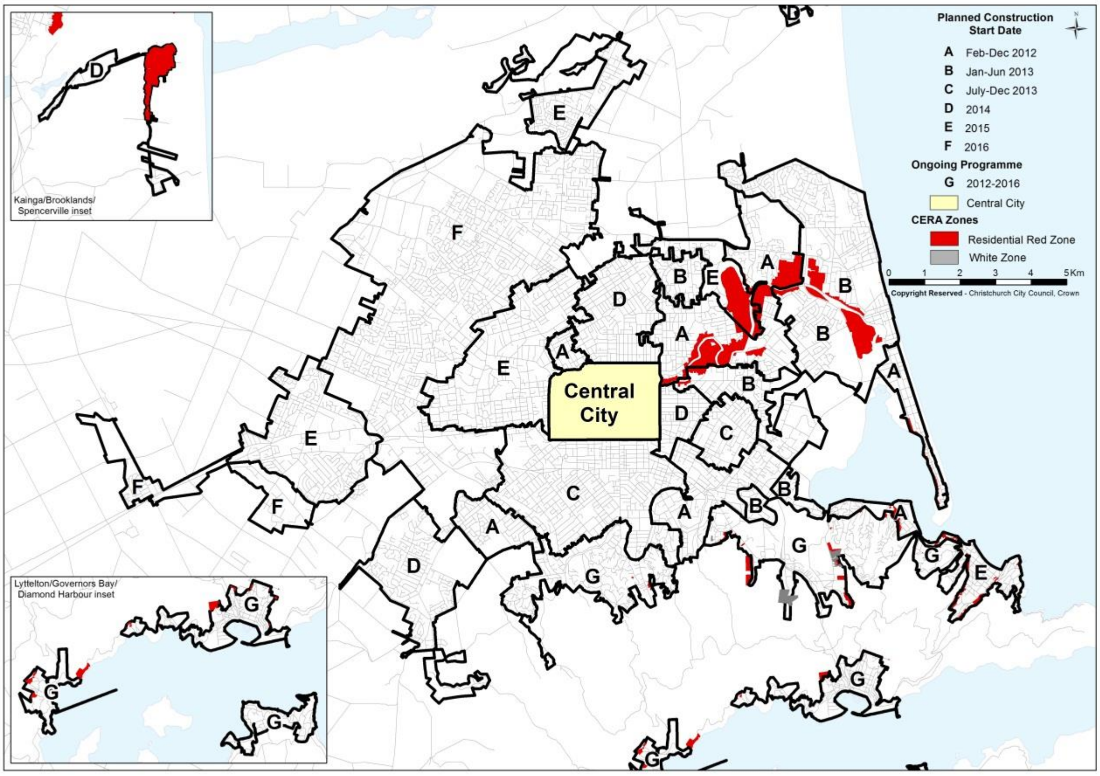

Figure 3: September 2012 Publically Released Rebuild Schedule. ALGIM GIS Symposium presentation, 2013 by Rob Deakin.

Health and Safety is a key priority and in particular is addressed with regard to the use of utility locations. All users of utility information are made aware that the GIS viewer does not replace their usual processes in the field, where they must request specific utility company support before breaking ground, see reference: (http://www.nzuag.org.nz/national-code/ApprovedNationalCodeFeb13.pdf). This is to make doubly sure that they have the most up to date information and at a specific detailed level that might not currently be available through the GIS, so as to reduce infrastructure strikes and maintain the safety of personnel in the field. When the delivery team completes the job, detailed updated and surveyed information is uploaded ensuring further accurate information.

CONTRIBUTION TO BUILDING THE REPUTATION OF NEW ZEALAND ENGINEERING

The breadth of data and functionality of the SCIRT GIS system continues to grow, as does the expectations of its users. The initial expectations of take up and active use have been greatly surpassed. With well over 1,000 users now registered on the system, it is now not a 'nice- to-have' but a 'must-have' tool to help the diverse group of designers, transport planners, business analysts, and others to perform their day-to-day roles in an even more efficient way.

The use of GIS in SCIRT is changing perceptions of what can be achieved for engineering projects, encouraging some to begin the process of looking to implement GIS in their home organisations and providing benefits to the community through better decisions.

Some examples of SCIRT GIS solutions specific to engineering in New Zealand:

- As-built creation from sourcing survey information through to automated quality assurance procedures, providing a base for the project cost allocation against assets completed, and providing this information to engineers back through the SCIRT GIS viewer
- Making non spatial information spatial i.e. assign water loss zone to meter reading data to allow asset assessment teams to see trends or unusual activity on an area basis and show data visually

The SCIRT GIS system is highly regarded both within SCIRT and externally, with SCIRT receiving numerous viewer access, mapping and data supply requests from individuals and organisations not associated with the SCIRT infrastructure rebuild. The system has a reputation for providing the most complete catalogue of GIS information required for engineering and rebuild projects.

A key factor in the success of this is that the GIS system has not been forced upon people as the answer. Instead, it has been introduced in a way to help support their decision making, not take away from existing design tools. The integration of SCIRT's other systems with the GIS allows quick data transfers into the relevant design software and there is a growing recognition that in some areas where SCIRT has the tools, technology and skills to perform complex processes in shorter timeframes, compared to what could be achieved with existing design tools, we are utilised for those processes.

An example of one of the processes designed and managed by the SCIRT GIS team, from the data source all the way through to the 12d and asset assessment teams, and back into the SCIRT GIS system and onto the SCIRT GIS viewer, is illustrated in Appendix C.

The system has been built to budget. However, the initial budget and expectations have grown as the system has progressed. Providing the GIS system in-house at SCIRT through the embedded GIS team is cost-effective and responsive to the changing environment and needs.

FUNCTIONALITY AND ECONOMY OVER THE SCIRT GIS SYSTEM LIFETIME

The functionality of the GIS system continues to change, both as the technology improves and as users become aware of the greater possibilities and efficiencies that they can gain. Both the SCIRT GIS viewer and server software have been upgraded in the last six months and it is likely that the viewer software, which develops rapidly, will be upgraded in the next year to take advantage of new functionality.

Existing functionality is also being advanced, with some users keen to take up the ability to directly edit and update feature geometries and attributes within the internet browser. Also the ability to view time aware data that can highlight the combined impacts of certain projects is another function that is gaining traction.

The way the system has been set up is scalable and flexible to reflect the changing environment and increasing requirements. It is anticipated that the emphasis of the GIS system will change over the remaining years of the SCIRT programme; whereas currently it is mainly used to inform design, it will likely shift emphasis towards reporting, key areas being the amount of construction completed, and issues with transport around future projects.

The components of the system are likely to change and transform over time. However, if that progression is maintained the system will morph to adhere to the latest technology. The system is not constrained by current hardware/software and provides a future-proof framework for growth.

The precedents and techniques put in place by the SCIRT GIS team will not be limited by the life-span of the programme, but are being included as inputs into the Canterbury SDI workgroups. The beneficial outcomes of the Land Information New Zealand Canterbury Spatial Data Infrastructure (LINZ Canterbury SDI) programme, once implemented for Christchurch, will be rolled out nationally.

❶ GIS Interoperability Designing and improving software processes to automate data exchange between agencies involved in the recovery using open standards	**❺ Utilities data access** Improved access to utilities data. Enable more open, effective and efficient sharing of utilities spatial data with recovery partners
❷ Forward works programme Developing a spatial viewer for the forward works programme	**❻ ECan enhanced map viewer** ECan enhanced map viewer helping environmental groups and territorial authorities to connect their data to the ECan viewer
❸ 3D enabled cities 3D enabled cities developing ways for people to see what rebuilt Canterbury will look like	**❼ Open data and openAPI support** Encourage development of smartphone apps through the use of open data to help recovery of Canterbury
❹ Property Data Management Framework Connecting land and property information to make rebuilding as easy as possible	**❽ Geospatial data discovery** Make management of spatial data easy for people to find, share and use

Figure 4: The eight work streams of LINZ Canterbury Spatial Data Infrastructure programme.

NEW TECHNIQUES USED FOR THE FIRST TIME

- Utilising SCIRT's forward works traffic management plans and sourcing other (CERA and NZTA) organisations forward works programmes to allow users to interrogate projects by a specific date, or view changes over time through animation of the same data, by creating the layer as time enabled in ESRI software, and then making some customisations to a Time Slider Widget on the viewer.

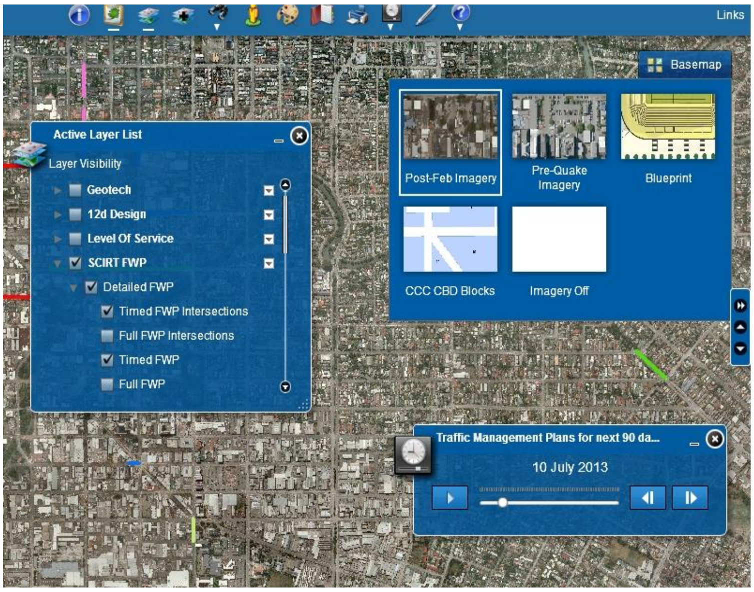

Figure 5: A screenshot of the SCIRT GIS viewer displaying the traffic management time slider tool, which shows the roads with traffic impacts at each point in time throughout the programme.

- Created automation scripts in Python to simplify and reduce manual input into making frequent changes to the complicated set of configuration files required for the Flex viewer.
- Designed a process for regular extracts from 12d modelling data stored in a SQL database to the GIS system, in a format able to display correctly in GIS, while still allowing the 12d data to be consumed by its native software off the SQL server in its requisite schema.
- Automated the processes for frequent and regular outputs of data to 12d and CAD software from GIS, from multiple data formats and organisations.
- Collated specific sources of information to provide an integrated spatial scalable view of total damage assessment information across all network types for the entire city (wastewater, water supply, stormwater and roading).
- Interactive graphic creation through the SCIRT GIS viewer able to be converted through a one-step process into CAD or other GIS data formats, this can also be done in reverse – where a CAD dwg file can be converted into a graphic file able to be shared with other users and displayed directly on the SCIRT GIS viewer
- Engaging utility companies to provide their locational information in bulk for an entire urban city, unusual for engineering projects in New Zealand, where one-off manual data conversion of utility's location information for small project areas is common.
- Geo-tagged photos that can be easily spatially displayed on the SCIRT GIS viewer – the creative solution designed here was a customised photos tab page developed to enable searching and viewing of photos that do not have coordinates, onto the viewer. Likewise non geo-tagged asset photos are spatially linked to the photographed asset and displayed at the position of the asset.

- Fully automated process for project cost allocation using valuations against the spatial data of as-built assets, for direct input into CCC's asset management system.

KEY ELEMENTS OF THE PROJECT

- Being able to communicate vast amounts of detailed, targeted spatial information (whether it has been processed and transformed from its source and stored in the SCIRT GIS system, or consumed live across the internet from other organisations) to hundreds of people consistently and continuously, and rapidly integrating this data with non-spatial information where required.
- Spatialising non-spatial information such as flood complaints, building consents, wastewater lateral repair locations, water supply main renewals, asset photos, communications details, property titles
- Setting up the base GIS database structure in a flexible manner giving us scalability to enlarge the datasets as more information comes into the system, while keeping rigid about the completion of metadata and internal formats to ensure data integrity within the system
- The position of the GIS team within SCIRT at the receiving end of data-streams from many other disciplines and departments enables the creation of integrated solutions linking these datasets and enabling spatial queries and analysis of novel information. The recent whole of programme re-estimate relied heavily on summarising all of the networks damage, constructed data and zone information.
- Two key engineering tools within the SCIRT project have been developed with engineers into GIS analysis processes in order to increase integration with the GIS datasets and enable automation and frequent re-runs of the processes – those being the Project Scheduling Multi-Criteria Analysis (MCA) tool used for prioritisation and scheduling of projects; and the Pipe Damage Assessment tool, used to help target the employing of Closed-Circuit Television (CCTV) crews for physical damage assessment.
- An initial key element of the success of the GIS viewer was the simplicity of use and the functionality supplied to users, which resulted in viewer uptake within SCIRT members increasing steadily and continually over time (see Figure 1).

SUMMARY (in lay terms)

GEOGRAPHICAL INFORMATION SYSTEMS (GIS) AND THE CHRISTCHURCH REBUILD

The Christchurch earthquake response required a great deal of information detailing the spatial position of infrastructure to be collated and disseminated to those assessing the state of assets and planning, designing and constructing horizontal infrastructure repairs and rebuild in the city. Stronger Christchurch Infrastructure Rebuild Team (SCIRT) decided to utilise Geographic Information Systems (GIS) to meet these needs.

The SCIRT GIS viewer was implemented to provide a single source of city wide information in one accessible, current and user-friendly internet portal, with nearly 1,100 users. A user is able to see on screen the same information a series of maps would provide, however, interactive layers (nearly 600) show the location of underground infrastructure such as pipes and cables. Over 20 organisations pass data to the SCIRT GIS team and are able to source appropriate up to date information so it can prompt the best decisions on the rebuild. The functionality of the viewer continues to grow with technology advances and user requests.

The SCIRT GIS system integrates with other disciplines within SCIRT, providing solutions across all departments; Communications, Assessment, Design, Transport, Delivery, Commercial, and Management. Key engineering tools have been migrated into the SCIRT GIS system, the Prioritisation Multi-criteria Analysis Tool, and the Pipe Damage Assessment Tool.

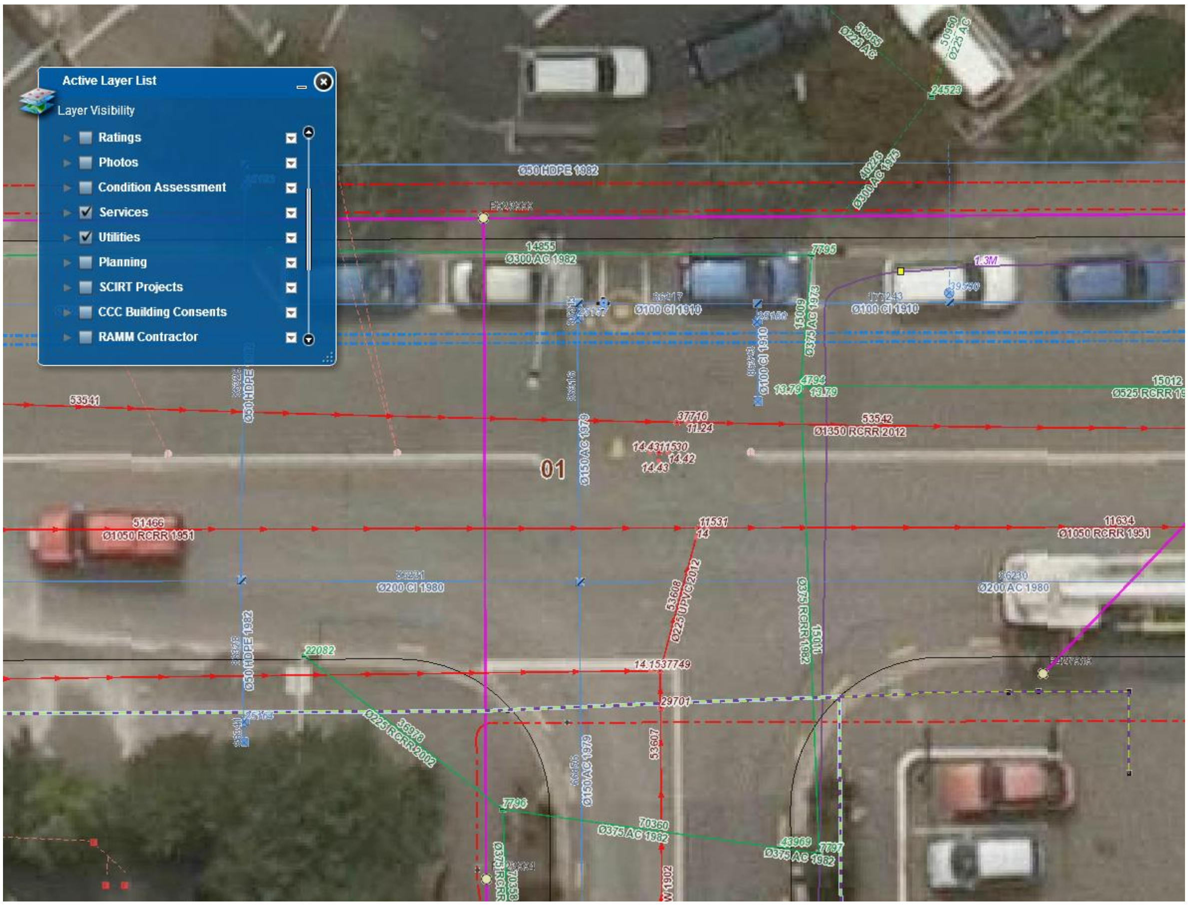

Figure 6: A screen shot of the SCIRT GIS viewer, illustrating underground infrastructure of a typical intersection in Christchurch central city.