Surveying a Broken City - A Story of Innovation and Collaboration

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SUMMARY

It's not often you get a request to survey the infrastructure for a whole city. Following the Christchurch earthquakes that was pretty much the task. We threw away the rule book in search of a model that could procure, manage and deliver enough geospatial data to support a rebuild within a few years.

The events in 2010 and 2011 left about 3 billion dollars of damage to the City's infrastructure over an area of about 24,000 hectares. Hundreds of kilometers of roads, bridges and underground pipes were broken and in need of repair.

The 'Stronger Christchurch Infrastructure Rebuild Team' (SCIRT) was formed with the ambitious goal of rebuilding 150 years of horizontal infrastructure development in only 5. The project was complex, uncertain, and was going to take different way of thinking. Within months an alliance model was formed to pull parties together and create a single goal – Create Resilient Infrastructure.

The land surveying contribution to this project was enormous and critical to the success of this huge project. The collective efforts of 150 surveyors and about 200,000 hours have resulted not only in a city's infrastructure nearly rebuilt, but a legacy of remarkable innovation. We've created a model that successfully brought together 16 survey consultancies and supplied 200 civil designers with a city's worth of geospatial data on a single federated digital platform.

This presentation tells a story about how throwing away the rule book has inspired innovation in the way we procure, manage and deliver precise geospatial data, and how it has left us with a model that exploits the power of collaboration, mindsets and values.

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1. THE SCALE

The 4 major earthquakes and 11,000 aftershocks left our city's infrastructure in ruins. Over 1300 km of road, 660km of sewer, 96 pump stations, about 150 bridges and culverts, 250 retaining walls and 70 km of freshwater pipe were shattered leaving an estimated damage bill of over 3 billion dollars and a repair programme of approximately 5 years.

The Stronger Christchurch Infrastructure Rebuild Team's (SCIRT) job was to bring the infrastructure back to the level of service that existed pre-quake.

The surveying was considered a relatively small wheel in the bigger SCIRT engine. We needed to establish a panel of surveying firms, develop technical specifications, establish civil and surveying software platforms and form a consistent health and safety culture, all of which there was no lead in time.

2. THE ALLIANCE STRUCTURE

SCIRT was formed as a public and private alliance model. It brought together and aligned 3 government organisations and 5 private construction companies. The model worked in such a way where indiviudal company efforts would be recognised and rewarded, although the combined pain and gain would be shared across the collective, effectively harnessing the competitive drive of the private firms but balanced with an overall incentive to collaborate for the common goal.

An Integrated Service Team (IST) was built under the above alliance participants by selecting individuals from with these teams and various other Christchurch specialist consultancies to provide the required skills (such as engineering, programming, planning, cost estimating, health and safety and land surveying). This team could be described as the rebuild 'Project Management' team. The Survey Manager role sat within this framework and procured surveying resource from the external market.

3. PROCUREMENT

Before SCIRT commenced there were about 17 survey consultancy parties (and circa 150 surveyors) working in one capacity or another for various emergency response organisations. This was a combination of local survey firms and a few from further afield. Each organisation had their own systems, software, methodologies, specifications and quite different ideas about the best way of doing things. We realigned this contracting structure to have each of the firms engaged directly to SCIRT, which gave us the ability to standardise and streamline all workflows in one operation. This resulted in 16 local survey firms engaged into a single entity (SCIRT).

There was a clear mission and purpose that each and every member knew well. The SCIRT mindsets, values and behaviours were on the walls, talked about at meetings and becoming part of every interaction. The blank canvas we had to work with was empowering, the amount of work was daunting and the programme was mind boggling. We understood the goal and the direction we were heading, we just weren't entirely sure how we would get there, which all made for an exciting challenge.

We had the task of establishing a surveying supplier framework that aimed to deliver about 5000 hours of surveying a month. We designed a model where suppliers would be focused against some key result areas (KRA's). We believed that aligning surveying teams to the fundamentals of performance would yield the best results in an environment of uncertainty and urgency.

In seeking a healthy balance of competition and collaboration, suppliers with the highest aggregate scores would be prioritised for work allocation. The KRA's comprised of the following performance attributes:

- On-time delivery
- Quality
- Productivity (output/hr)
- Innovation
- Collaboration and communication
- Health and Safety

Notably, financials were omitted from the list of assessment areas.

This model served its purpose well. It cut the bureaucracy, enabled fast progress and drove value for money.

The 'innovation' KRA gained impressive results. It drove some remarkable innovations, raising productivities, hugely improving quality and safety. One innovation saw a vehicle-mounted prism and GPS antenna reducing cost of data capture by 30%. Another saw a systematic drainage survey procedure with an automated quality assurance report, which reduced the number of human errors considerably. Both of these made a substantial contribution to either efficiency or data quality.

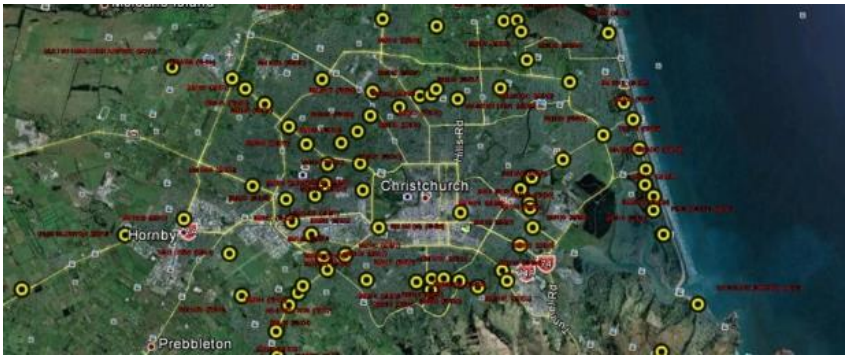
The 'collaboration' KRA was designed to encourage surveyors to find ways of helping each other. In many cases we were simply short of certain resources and wanted to incentivise collaboration between firms. We saw consultants forming teams from different firms, offering assistance, sharing innovations, sharing resources and running improvement workshops. This all unquestionably assisted with progress.

4. THE SURVEY CONTROL

Now that we had a single operation underway we needed to address the question of a reliable survey control network that would underpin our work. Unlike most typical construction projects where a localised datum is perfectly adequate, this city-wide project required a larger perspective with consideration given to managing elevations, and coordinates over the entire 24,000ha site (approximately 20km by 12km).

At the time SCIRT commenced operations the accepted benchmark network was established by the Christchurch City Council (CCC) in June 2011 which coordinated 79 benchmarks and 13 control points. We considered it prudent to provide continuity and kept the same approach, which we built on to meet our growing demands.

In an ideal situation we would have precisely levelled all benchmarks into normal-orthometric terms, however due to the unstable ground and time constraints this was not a practical option.



The network was entirely GNSS generated and relied upon a geoidal correction model and a city-wide vertical datum offset value to derive heights in the CDD (Christchurch Drainage Datum)[1]. We opted to stay with this methodology for its turnaround speed and repeatability. The method gave a precision of +/-20 to 30mm in the horizontal and vertical (at a 95% CI), deemed acceptable for most infrastructure survey and design purposes.

5. THE FIELD SURVEYING

The combined facets of SCIRT have demanded up to 7000 hours per month of survey. In total we've clocked up about 200,000 hours to date including:

- Drainage network survey (stormwater and wastewater)
- Topographic road, retaining wall and bridge surveys,
- Cadastral boundary definition,
- Cadastral mark protection surveys

5.1 Drainage and Topographic Survey

The largest component of our workload was in modeling the damaged drainage networks, which allowed the damage to be assessed and solutions to be designed. This data was captured in custom developed procedure by one of the surveying firms. Survey field teams would lift manhole lids, capture precise heights on all inlet and outlet inverts, record pipe diameters, materials and condition attributes, which would then be converted into 3d intelligent drainage strings. The second largest component was topographic survey for the many kilometres of broken roads, bridges and retaining walls.

5.2 Cadastral Mark Protection Surveys

Most Christchurch suburbs were damaged. Any surveyor in Christchurch would likely have shared the same anxiety as me about the number of valuable cadastral marks in the firing line of impending road reconstruction. We knew that the usual practice wouldn't suffice (relying on contractors to protect, and/or relocate) so we engaged with Land Information New Zealand (LINZ) and formed a panel of cadastral surveyors early on in the program to discuss a practical approach to protecting these marks. It was recognised that full compliance with the Cadastral Survey Act (which requires each mark to be addressed individually with LINZ before destruction) was unreasonable and unlikely, and that our exceptional circumstances warranted a revised approach that would circumvent delays. LINZ subsequently provided us with an exemption from the statutory requirements pending compliance on certain terms and conditions outlined in a purpose developed LINZ specification.

1 CDD = 9.043 metres off-set from the Lyttelton Vertical Datum 1937 as defined by IDS CCC

This approach effectively exempted SCIRT from the Section 55 (5) requirements and left SCIRT to make an assessment on the value of the mark and decide whether it is worth capturing, then incorporate it into an official cadastral survey dataset for lodgment with LINZ.

To date we've carried out approximately 120 mark protection surveys and ensured much of the city's cadastre has been protected.

5.3 The Digital Data Cycle 'Field to Finish'

Perhaps the proudest achievement in the SCIRT survey team was the integrated surveying and civil engineering software system. At the commencement of SCIRT we did not have a single surveying and civil software system. We had 4 design organisations and 17 surveying companies using various packages and methods for surveying and designing, all within their own environment and to their own specification. During the first weeks at SCIRT the need to establish a single platform to integrate all survey and design became apparent. We aimed for a fully integrated 12d Model software system. At that time only about 30% of the designers were accustomed to using 12d Model, of which generated some feelings of anxiety at the prospect of having to become familiar with a new system.

We mapped out a digital data cycle and went to work on the architecture. The theory was that we could achieve a 'field to finish' approach following the steps below;

1. Survey data would be captured in a standard format, and delivered to SCIRT from an external survey team in 12da format.
2. Information would be validated, and made available (via digital sharing) for designers to utilise in their civil design.
3. Digital data would be issued to the construction teams.
4. When construction was complete, an as-built survey would be carried out and delivered back in a simple digital format.
5. As-built information would be delivered back into the digital environment (and compared with the original design data in some cases)
6. Information could be then transferred directly to SCIRT GIS system via a 'Feature Data Object' (FDO) link, and then transferred to the City Council GIS unit electronically.

One of the first design tasks was to teach 160 designers to use 12d Model and become productive within weeks, and at the same time we had to develop libraries and conventions to a standard. This task was bigger than any one person could handle and although led from the survey office required special advice and assistance from a small but tenacious team who invested many hours and passion to bring this vision to life.

6. SUMMARY/CONCLUSION

This project has been a once in a lifetime opportunity to push the boundaries in the way we procure, manage and deliver surveying for large scale infrastructure projects. We've created a framework that has successfully delivered over 200,000 hours of surveying, and brought 16 survey consultancies together to supply 200 civil designers with underpinning geospatial data.

The role of the surveyor on large scale projects is often seen as a commodity to enable civil design and construction. This project has seen the Christchurch surveyors make a crucial and unprecedented contribution. Through collaborating and innovating they've worked with a broken system to deliver a steady stream of information which has enabled the 5 year infrastructure rebuild to stay on track. In doing so we leave a legacy model that will directly benefit the surveyors and engineers tasked with dealing with the next earthquake.

BIOGRAPHICAL NOTES

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