Enabling Decision Making through Spatial Conversations

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SUMMARY

It is no secret that Christchurch has moved, especially in the eastern suburbs. The shallow surface movement associated with that movement has far reaching implications on property rights both now and into the future. To make decisions on how the New Zealand cadastral and title system should manage the effects of shallow surface movement it is vital all decision makers and advisors can communicate effectively together and share a common perspective of the extent of the movement. A web based geovisualistion tool played a vital role in enabling decision makers and their advisors, not all of whom are spatial professionals to access, understand and use what is otherwise complex technical planning, geophysical, cadastral and geodetic data. This paper examines the need to transform data into information and introduces the concept of 'spatial conversations' as a key application of geospatial visualisation.

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INTRODUCTION

The earthquakes that the Canterbury region of New Zealand experienced in 2010 and 2011 resulted in significant land movement and destruction of property and infrastructure. To address the issues and problems associated with the earthquakes a wide ranging set of decisions by multiple people and agencies had to be made. Land Information New Zealand (LINZ) was no exception.

LINZ was faced with having to ensure that the Cadastral and Geodetic systems could accommodate the fact the Christchurch moved. A number of decisions had to be made to ensure that these systems were not only able to continue to serve their primary purpose in providing ongoing certainty of property rights (Grant et al., 2014; LINZ, 2010; LINZ,2015d) but to also provide the positional infrastructure to facilitate the recovery and rebuild of Christchurch (LINZ ,2015d).

This paper looks at the collaborative role that a web based geovisualisation tool played in enabling decision makers and their advisors to address a significant cadastral problem. Not all of these decision makers and advisors are spatial professionals yet they needed to access, understand and use what is otherwise complex technical planning, geophysical, cadastral and geodetic data. This paper also highlights the need to transform data into information and introduces the concept of 'spatial conversations' as a key application of geospatial visualisation before examining in greater detail the geovisualisation tool its data, and the role that it played in this case study.

CASE STUDY BACKGROUND

The series of earthquakes that the Canterbury region of New Zealand experienced in 2010 and 2011 resulted in significant land movement and destruction of property and infrastructure. Shallow surface movement was a major contributing factor. The extent and variability of the shallow surface movement was generally dependent upon the proximity to the epi-centre of the individual earthquakes and the geology of the land, manifesting in localized expansion or contraction of the land (Robertson et al., 2016).

To ensure that the replacement infrastructure of the Christchurch re-build is constructed in the correct location, many property boundaries have to be re-established (Robertson et al., 2016; LINZ,2015d). The need for boundary re-establishment is most prevalent in the areas affected by shallow ground movement, including where liquefaction occurred. In these areas the ground movement is quite variable and extensive, meaning that the measurements between survey marks are often no longer within acceptable tolerances of the official record (Robertson et al., 2016). Surveyors face significant challenges to identify reliable marks to base their surveys on. The re-establishment of property boundaries has been made even more challenging because some property

boundaries need to be adjusted to account for distortion associated with the land movement. Surveyors must therefore interpret the relevant rules, regulations and case law in re-establish boundaries affected by shallow surface land movement (Robertson et al., 2016).

As it became increasingly difficult in the worst affected areas for LINZ to reconcile individual surveys with the wider cadastre, Land Information New Zealand (LINZ) began to reconsider whether the existing regulatory requirements, legislation, survey practice and case law was appropriate to meet the emerging issues associated with earthquake induced shallow surface ground movement (Robertson et al., 2016). A key reason is that shallow surface land movement case law largely focused on landslips - not earthquakes (Robertson et al., 2016).

LINZ also recognised that the impacts of shallow surface movement were not just a technical surveying issue. The impacts of ground movement also had consequences for a wide range of parties both now and in the future including property owners, local and central government, lawyers, utility companies and insurance companies" (Robertson et al., 2016, LINZ 2015d). In order to more fully understand the extent of the problem, its impacts and to advise the minister, LINZ initiated a multi-sector working group in March 2015 chaired by the LINZ Chief Executive (Minister for Land Information, 2015).

1 THE OPERATIONAL PROBLEM

The task faced by the sector leaders group as described in the terms of reference was to *"…inform, test and support the department's work to find practical, effective and timely solutions to the problems arising from the difficulties in re-establishing legally sustainable property boundaries on some lands affected by the Christchurch earthquakes"(LINZ, 2015c)*

For the Sector leaders group to fulfill the above task, two primary and inter-related challenges existed. Firstly, a people challenge associated with diversity of skill knowledge and experience; secondly, a data challenge associated with the volume, range and complexity of the data necessary to help develop and test appropriate solutions.

1.1 The 'People' Challenge - Diversity

The sector leaders group was comprised of representatives from the New Zealand Institute of Surveyors , Consulting Surveyors New Zealand, Christchurch City Council, The Insurance Council, The Earthquake Commission, Environment Canterbury and the New Zealand Law Society (Minister for Land Information, 2015) The group were expected to bring their particular perspectives, knowledge and experience to bear in jointly considering and informing LINZ's understanding of the problem, to help develop solutions and to advise on who needed to be consulted or engaged regarding the problem (LINZ, 2015c). Accordingly, it was vital that all members (and other invited attendees to workshops) could communicate effectively together and share a common perspective of the issues. So whilst not requiring people to become experts in each other's field of work, the people challenge was accordingly to quickly build sufficient common knowledge so that all

individuals were able to discuss or debate the issues, understand the technical data available, and be able to see how their skills, experience and knowledge fitted with each other.

1.2 The 'Technical Challenge' - Data, data and yet more data.

The technical challenge was to take very complex and often extensive planning, geophysical, cadastral, geodetic data and transactional data; and to in turn convert it to information suitable for decision making, solution development or communication purposes. Much of the initial data available to LINZ was coming in from cadastral surveys, contract work measuring and re-measuring affected parts of the geodetic network, partner/stakeholders (such as GNS or CERA and their contractors) in categorising land. The data was accordingly in a wide variety of forms and not necessarily designed to be interoperable.

In addition to the initial LINZ centric data, it was expected the sector leaders would offer up additional data to further contribute to understanding, describing or solving the cadastral definition problems.

1.3 Merging the People and the Technological Problems

Given LINZ's history and lineage in the use and application of spatial information, and the strong spatial links that the cadastral problem has, it was a logical decision to take spatial approach to address the people and technical problems outline in section 2.1 and section 2.2.
It was recognised that geovisualisation techniques would provide significant benefits to simplify and transform the vast amount of data available into information. Geovisualisation can be described as "*a loosely bounded domain that addresses the visual exploration, analysis, synthesis and presentation of geospatial data by integrating approaches from Cartography with those from other information representation and analysis of disciplines, including scientific visualisation, image analysis, information visualisation, exploratory data analysis, and geosciences"* (Dykes et al., 2005).

Prior to the formation of the sector leaders group, various LINZ business teams, had already applied significant technical expertise and knowledge in the acquisition and analysis of a wide range of data. Consequently some data had already been spatialised and transformed to information. In the case of the geodetic mark movement, additionally geovisualised in the form of a heat map and published as a map.

While the sector leaders group was forming, LINZ was also in the final stages of the implementation of a web based interactive geovisualisation tool – internally branded as LINZmaps. This system was expected to eventually meet exploratory decision making of a wide range of users.

> *"the system can benefit **anybody** making **any** decision where location matters, LINZ has conceived of the system broadly as the means by which location information is made accessible, shareable and able to be overlaid with other data to uncover new patterns and knowledge" (LINZ, 2014)*

Simplicity and ease of use are key attributes of the system, thus enabling people with less sophisticated geospatial skills to explore and understand preconfigured data without the need of heavy desktop installations, expert knowledge and training in the use of traditional GIS tools. So although not complete and unable to produce reports and large paper maps, LINZmaps was seen as a practical solution to help support the sector leaders group.

1.4 Decision Making

1.4.1 Data transformation

Decision making requires data to be transformed firstly into information then knowledge. To get to the decision, information must be first explored for understanding so that the information can be condensed as knowledge. This requires data analysis that must then be analysed and filtered (for spatial data also be rendered) before being presented as known facts (MacEachren and Kraak, 1997, Clouston and de Róiste, 2016). .

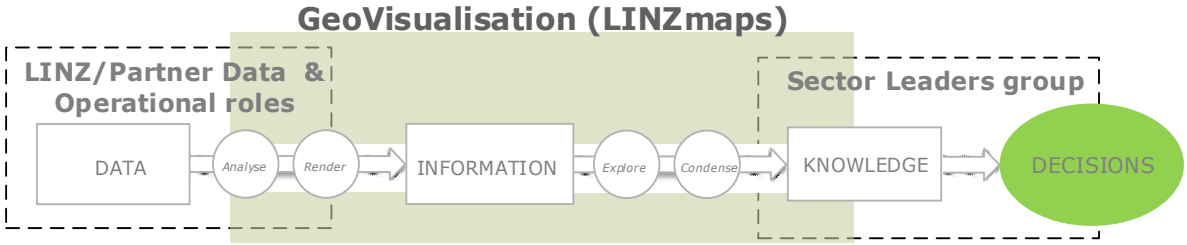

Figure 1 : Role of the geovisualisation tool

However, greater benefits, are obtained when people are able to share and discuss an issue; when they look at the latest data available, and overlay and discuss that new information; and continue to so as the focus of the discussion changes their understanding and therefore knowledge. This is especially the case where the original data or issue being examined has a geographic component because looking at location data spatially is much more intuitive that reading a text description or viewing a spreadsheet (LINZ, 2014). In other words people can work better together when they can have a spatial conversation.

1.4.2 Spatial Conversations

Spatial conversations are where people view and discuss an item through a geo-visual means. Spatial conversations can be facilitated through the use of geovisualisations including traditional cartographic products such as maps or charts. For this case study the data/information that was loaded and configured into LINZmaps specifically for the benefit of the Sector leaders group.

A spatial conversation though is more than just talking. The quality of that conversation plays a key role. A lecture, where one party is predominately silent is not much of a conversation, but will often precede a conversation as one party attempts to impart information or explain the situation or problem. Therefore good conversations are dependant significant interaction between the participants. It is this interaction that in turn fosters good decision making.

2 GEOVISUALISATION SUPPORT

2.1 Spatial conversations needing support

Spatial conversations are dependent upon the data or information that is available for visualization and how well that information has been presented. Spatial experts can develop and design the content thereby leaving the users of that information to focus on interpretation and enhancing their knowledge. However Clouston and de Róiste, (2016) identify that, "new users can be susceptible to misinterpreting the geovisualization, and making poor decisions because they may not have the necessary spatial cognitive skills. This risk can be minimized by having the spatial or data experts initially guiding the users through the information (Clouston and de Róiste, 2016).

Spatial conversations are equally dependent on the perspectives of individuals and the knowledge that those individuals have. Spatial conversations are further coloured by the decisions or problems that the participants in the conversation are looking to address. Accordingly, there are a wide range of factors and associated combinations of factors which will result in different types of conversations. In the case study revolving around the Canterbury boundaries issue, although the end focus was the Sector leaders group, a range of other users had similar informational needs. In addition, the need to collate and transform the data required additional input from a range of business managers (or officials) and their technical staff from across LINZ, the LINZ Geospatial team and the LINZmaps vendor. These conversations were 'internal' - between LINZ staff, or 'external' – occurring between LINZ staff and the Sector Leaders group and their organisations.

2.1.1 Internal Spatial conversations

Business Insight Conversations –LINZ managers or officials across the department are able to review spatial information as it changes. For example, being able to see where cadastral surveys are occurring and see a categorised view of their purpose. These conversations are primarily focused on strategic issues or business decisions that need to be made.

Technical Investigation Conversations - LINZ Technical staff, working with the Geospatial team are able to explore their business data in conjunction with other relevant spatial data to increase productivity and understanding of their data or processes. These conversations are also valuable to determine what additional data is required and how it is best transformed to better support other spatial conversations –especially the non spatial experts.

LINZ Business Team Conversations - LINZ staff are able to share insights and information as it relates to LINZ business through the ability for LINZ business team managers (or officials) and their staff to see and use the same information. These conversations are primarily focused on operational issues and contribute to improved efficiency.

2.1.2 External Spatial conversations

Technical Collaboration Conversations - LINZ technical staff collaborate and share information and spatial insights with technical peers working for parteners or stakeholders. These conversations often enable Data collections for shared purposes or data transfer.

LINZ Conversations - LINZ managers or officals and their peers (external to LINZ) are able to share insights and information as it relates to LINZ business to help solve stakeholders and customers problems.

External Support Conversations – LINZ Geospatial team is able to efficiently provide complex data queries and regular informational visualisations to partners, stakeholders, or customers. The conversations also relate to acquiring and transforming partner/stakeholder data for inclusion in the system to facilitate other spatial conversations.

2.2 Building the Geovisualisation

The primary task in developing the interactive web maps in LINZ maps, for the sector leaders group, was to collate, load and configure the business data that had already been analysed. LINZmaps was designed to extensively use the LINZ data service (LDS) and other public data portals that use open web services such as those specified by the Open geospatial consortium (OGC). The LDS is LINZ's public data portal which provides free and open data to the public and holds more the 40 datasets including data relating to place names, addresses, topography, hydrography and property as well as making available some crown property information and aerial imagery (LINZ, 2015b).

Accordingly, LINZ's core authoritative data required to support the needs of the sector leaders group had already been largely integrated into LINZmaps and was ready to meet the sector leaders group's need. Having LINZmaps already largely prebuild meant that a range of searches designed to help users find specific properties such as address, parcel and title searches already existed and this saved significant time. Additional searches were then built to enable users to visualize the range of cadastral surveys types being received by LINZ The analysis of survey mark movement, and associated heat map, that had been undertaken by the Geodetic team (LINZ, 2015a) was then visually enhanced by applying different symbology at appropriate scales to represent the direction and magnitude of each marks movement. Ground movement data describing the liquefaction and lateral spread that was added to enable comparison and to provide an understanding of the impact on the surface (Tonkin & Taylor, 2012). The styling of this data was modelled on that way it was styled within the Canterbury Geotechnical Database (2012).

The spatial conversations using this information (prior to it being seen by the sector leaders groups) initiated a range of additional data analysis that was subsequently loaded in to LINZmaps. This included the creation of movement contours in 0.2m bands and the creation of an estimate of how many properties lay within each band. A new heat map that enabled the visualistion of relative movement was developed so that relative and absolute movement across Christchurch could be compared.

2.3 Exploring the Geovisualisation

When the sector leaders group first met to discuss the cadastral issue; the interactive map with all its associated groups of layers formed the basis of the contextual briefing to members. The opening map view immediately provided the locational information but quickly high-lighted that although all of Christchurch had moved, it was predominately on the eastern side of Christchurch and the parts the port hills. Phrases like 'out east' then meant something for those not familiar with Christchurch.

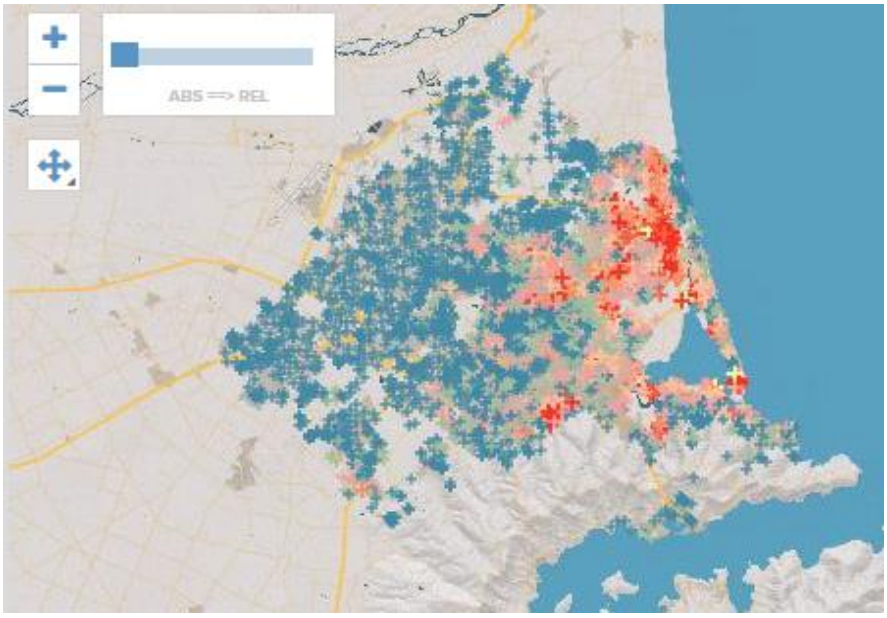

Figure 2 : Providing Ground movement contextual information in LINZmaps

Specific issues and examples of different land movement were able to be quickly located and explained. These specific examples and the ability to 'see' the magnitude and direction of movement then made explaining the problem and underlying cadastral surveying requirements easily able to be understood by those without a surveying or geodetic background. The discussion following highlighted the potential need for additional data/information to enable that the sector leader group to explore the potential links between other activity and drivers. For example:

- is there difference in the impact of movement for different planning zones?
- is there a spatial relationship between the types of building consents issued with shallow ground movement?
- What do the relationship between insurance claims, ground movement and the other information made available on the service?

3 CONCLUSION

The timing of emergencies is rarely known or fully anticipated. Subsequent geovisualisation needs can arise rapidly, requiring an equally rapid response. It is important to have a geovisualisation system in place before an emergency so that it is ready to roll out. This means that only minor configuration changes are required to integrate pertinent data as it becomes available. With a Geovisualisation system in place prior to urgent need, it can play a vital role in enabling decision makers and their advisors in their work.

The use of a web based geovisualistion tool, such as LINZmaps, enables large and diverse datasets to be brought together so that decision makers, and their advisors, working alongside each other can all access the same information irrespective of location. Web based geovisualisation can then

facilitate more productive discussions and provide new ways to look at a problem by enabling 'spatial conversations'. These spatial conversations can be held in context; help develop common understanding of problems and issues across a wide range people and ensure that every party can view the same information at the same time, and in the same way - thereby also fulfilling some communication and education needs.

By enabling users to compare and contrast different sets of data or information, and to explore and analyse specific sub elements of geographically based problems, additional questions or issues may be identified which then need to be addressed. Although additional questions might require even more information, it leads to more informed decision making where the context and ramifications of their decisions are more easily understood.

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