

Developing a regional approach and strategy for geographical information systems for emergency management

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ABSTRACT

This paper outlines practitioner work-in-progress in Canterbury, New Zealand, to develop a regional approach for geographical information systems (GIS) for emergency management. This is based upon recent events in Canterbury including earthquakes, floods, and fire; as well as New Zealand-wide work that is being done under the NZ GIS4EM banner. It introduces our approach, discusses a mind map that is being used to track desired data sets, plans to develop applications to support response functions in emergency operations centres, and the goal of using the common data sets as the basis of a common operating picture for Canterbury. Risks and issues associated with this work are highlighted, and then the draft strategy is introduced with desired outcomes and principles to achieve this goal. While initial work is primarily focused on GIS, the expectation is that the approach will be expanded to take a broader information management perspective in future.

Keywords

Emergency management, geospatial information systems, information management, common operating picture, interoperability.

INTRODUCTION

The Canterbury Civil Defence Emergency Management (CDEM) Group is geographically the largest CDEM group in New Zealand, and second largest by population. It is bounded by the Alpine Fault in the Southern Alps to the west, and the Pacific Ocean to the east. The Canterbury CDEM Group Plan identifies a wide range of risks including earthquakes, tsunamis, rainfall and flooding, fire (urban and rural), land instability, wind, snow, hail, tornados, electrical storms, drought, storm surge, pandemics, biological pests and diseases, transportation incidents, and lifeline utility failure.

In recent years Canterbury has experienced numerous significant events, including the 2010-2016 Canterbury earthquake sequence (Darfield Mw7.1 earthquake of September 2010), 2016 Kaikōura earthquake (Culverden Mw7.8 earthquake of November 2016), February 2017 Port Hills Fire, and the July 2017 Canterbury floods.

The CDEM Group consists of 9 local authorities that are responsible for providing services to their local communities; emergency services including NZ Police, Fire and Emergency NZ, and St John; and other partner agencies covering areas such as the local Iwi (Maori representation), health, social and rural interests. The CDEM Group's interests cover the four Rs of comprehensive emergency management – risk reduction, readiness, response and recovery.

Wider stakeholders in information management for emergency management include:

- Territorial authorities (primary responsibility for CDEM; provides response leadership (Controllers) and emergency operation centre personnel)
- Response and partner agencies (other partners in response)
- Emergency managers/Emergency Management Officers
- Information Management and GIS personnel
- Coordinating Executive Group (CDEM Group governance)
- Chief Information Officer forum (for Canterbury territorial authorities)

In November 2016, the Kaikoura earthquake occurred and GIS expertise from around the country was applied locally, regionally and nationally to assist response. This event covered a large geographical area, significantly impacting three CDEM groups (Canterbury, Marlborough, and Wellington), and generated a considerable amount of geospatial information. From Canterbury's perspective, it was probably the first event where significant web-based mapping tools, such as ArcGIS Online (AGOL) were widely available and had matured to have significant capabilities. No pre-event work had been undertaken to utilise these tools, so the full benefits and capabilities of AGOL were not able to be utilised. There was very little opportunity for the development of emergency management geospatial tools between the earthquake and the fire.

Between November 2017 and February 2018, several agencies started moving into the Justice and Emergency Service Precinct (Justice Precinct) in Christchurch. The Justice Precinct is an anchor project in the rebuild of the Christchurch central business district, designed to "build back better" justice and emergency services presence and co-locate key response agencies in the city and region. A significant element of the Emergency Services Building in the Justice Precinct is the Emergency Operations Centre (EOC) that acts physically and logically as a central hub for significant events. Civil Defence, Police, Fire and Emergency, and St John, all surround and connect to the EOC physically from their business-as-usual workspaces.

While the importance of GIS for emergency management has been known for some time, the ability to invest significant development work during readiness has been sporadic and lacked co-ordination and resourcing. This paper provides a high-level perspective on work within Canterbury over the past couple of years to establish a more integrated approach to Geospatial Information Systems (GIS) for emergency management and ensuring that it fits within a broader national approach taken by the New Zealand GIS4EM community. Phyn (2018) discusses the formation and development of the NZ GIS4EM community in more detail.

THE TECHNICAL ADVISORY GROUP REVIEW

Following significant events in Canterbury, particularly the 2016 Kaikoura earthquake and the 2017 Port Hills fire, and other events elsewhere in New Zealand, there have been several reviews into response. In 2017, the then Minister of Civil Defence announced a Technical Advisory Group (TAG) formed to review recent responses to emergencies and make recommendations to the Minister. This resulted in the Technical Advisory Group (2017) Ministerial Review - Better Responses to Natural Disasters and Other Emergencies. This report contained many options and recommendations on ways to potentially improve general emergency response in New Zealand. This review grouped recommendations into 8 key themes - two of these are fundamental to this work - Intelligence; and Information and Communication.

The key relevant recommendation identified in the Intelligence chapter recommends investing in technology that supports a Common Operating Picture (COP).

Recommendation 2.0: Invest in the technology to ensure a fit-for-purpose Common Operating Picture

2.1 Investigate technology needed for a Common Operating Picture based on international best practice models as a strong contender for New Zealand's common operating model.

2.2 Expect all entities with emergency operations functions to collectively solve the challenge of cross agency systems to share intelligence, and situational assessment.

Further support is provided in Recommendation 4.0 from the Information and Communication chapter.

Recommendation 4.0: Ensure timely, consistent, and proactive use of the range of appropriate media channels both for communication, and for gathering intelligence.

The TAG review provided additional guidance and direction for the initially ad-hoc work that NZ GIS4EM was undertaking, and provided a reason to start the process to formalise the community, particularly on the point of "collectively solv[ing] the challenge of cross agency systems to share intelligence, and situational assessment"

as well as "ensur[ing] timely, consistent and proactive use of the range of appropriate media channels both for communication, and for gathering intelligence". These are two sides to the same coin, and any system developed for building a multi-agency common operating picture, also needs to integrate with providing and receiving intelligence from the public and affected communities. Volunteered information, including geographic, is likely to play a role in supporting intelligence gathering from impacted communities as indicated in recommendation 4.0, but Canterbury has not yet explored this in detail.

CANTERBURY'S APPROACH

Canterbury's approach to developing greater information management capability for emergency management is broadly:

1. Identify and prioritise key information driven capabilities and functions.
2. Identify, prioritise, obtain, and determine architecture for the datasets identified in [1]. This includes ownership/custodianship, hosting, and data flows.
3. Develop key special purpose applications built upon the prioritised capabilities identified in [1].
4. Develop COP tools such as a shared situational awareness application, that integrates information from the special purpose applications developed in [3].
5. Repeat 2-4, expanding the datasets and tools.

The intention is that this will be an approach focused on the use of agile development methodologies. The data and applications developed will be subject to continuous improvement cycles.

As a simple example, roads and street addresses were identified as a high priority dataset. Once that data is hosted, then it is possible to develop an application for managing road status – particularly road closures, and restrictions (such as hours, vehicle types). In Canterbury we are prototyping an ArcGIS Online (AGOL) application to manage road status. It is important that a tool is developed for maintaining event data, such as road closures, as these may not always be available in a business-as-usual system. Where existing solutions may exist, attempts should be made to leverage of existing national schemas and datasets that may be hosted by another agency, e.g. Land Information New Zealand's Property Data Management Framework (PDMF) and Address Information Management System (AIMS).

Prioritising applications for development are likely to focus on those that have the widest applicability to the hazards outlined in the Canterbury CDEM Group Plan (2018), these will result in applications specifically designed for high priority hazards such as tsunami or flooding. Other high priority applications will be those that have utility for a wide range of hazards and are generally focused on managing a specific response function such as road or lifelines status, build assessments, and welfare and needs assessments.

MINDMAPPING CANTERBURY DATASETS

One of the key elements of the work in Canterbury to date, has been the evolving development of a mind map to track and visualise needs and gaps. In its current form it represents our common understanding for spatial and attribute information to be available across all four phases of comprehensive emergency management across a wide variety of themes. Formative work has started on supporting metadata including aspects such as source, custodian, update frequency, quality, currency, and more.

This project started in 2016, when an initial attempt was made to consult with response agencies planning to move into the Justice Precinct in Christchurch about their mapping and information board desires in the Justice Precinct EOC. The initial mind map consisted of several information products and tools to assist decision making in the Justice Precinct EOC.

In June 2017, Environment Canterbury and the Canterbury CDEM Group hosted a two-day GIS4EM workshop in Christchurch. There were 50-60 participants from around the South Island, and some from the North Island. The participants were mostly GIS personnel from local authorities, but around one third were emergency managers or from response agencies. This mirrored two other similar workshops held in Auckland and Wellington. One of the facilitated sessions involved identifying what was needed from a GIS perspective to support emergency management. As this workshop identified more detailed needs and actual data layers, the decision was made to transition the mind map into a conceptual map of the types of data (themes), and the actual data layers ideally needed for comprehensive emergency management in Canterbury.

Figure 1 gives an overview of the size and complexity of the mind map, after just 4-5 key iterations. It currently

Canterbury. As a result, one of the first pieces of work undertaken was to develop a schema that could be applied to all the community response facilities in Canterbury. This prototype dataset is now hosted by at the regional level by Environment Canterbury, while enabling territorial local authorities to view and edit their own centres, making this a single authoritative dataset for Civil Defence Centres in Canterbury. Many elements of the data schema were able to be duplicated in a related dataset, that of agency response facilities - the locations of EOCs in Canterbury.

The importance of the mind map is that it acts as a common frame of reference for the spatial, and in some cases non-spatial attribute, data as we attempt to build a common pre-event model of Canterbury that could be used in any of the four phases of comprehensive emergency management.

The majority of the identified information does not belong to CDEM and has many uses outside of emergency management. Most of the information is best maintained and curated by business-as-usual functions, and significant portions of the data should be openly available to the public, businesses, and community organisations. In these cases, it is about generating awareness around a use case for the organisation's data, that the data's curator may not have been previously aware of.

The long-term focus in Canterbury has strongly been on working towards having as much data as possible hosted by the owner/curator of the dataset - the organisation that is effectively the "single source of truth". Many organisations however may not have yet matured to the point where they have their data in a spatial form or can host their own spatial data. Making it available to other agencies or the public as appropriate could be challenging for several reasons including a lack of internal capability, awareness of need, and funding. Canterbury is working on a "bootstrap" approach whereby Canterbury Maps can be used in transitional manner to host datasets until their curating organisation has the capability.

BUILDING APPLICATIONS TO CURATE THE DATASETS

While it is possible to utilise static datasets, many of them are dynamic in nature. The real-world objects or situations the data represents change or may be removed. There are two approaches that need to work together for process and updating data:

1. Leverage business-as-usual – where appropriate, attempt to leverage business-as-usual (BAU) process, systems and tools, otherwise identify opportunities to recommend improvement to BAU. One example may be managing road status in existing road management systems. This then relies on the information being made available by a live Application Programming Interface (API) feed to be ingested into other systems as a read-only source. Leveraging BAU increases resilience and reduces the burden on CDEM.
2. The role of CDEM – when a business-as-usual process or application does not exist or is not fit for the scale of use required, then CDEM needs to have in place an appropriate process and tool to fulfil the required function. Having an acute understanding of the regional maturity, gaps and risks across agencies, processes, systems and technology is critical to ensuring development under this approach is prioritised, cost effective, and targeted.

Management of the data comes back to identifying which organisation is best placed to curate the data. In some cases, this can be challenging, and lines may blur during response. Road Control Authorities generally curate roading information, but during a fast-moving storm event, other agencies such as the emergency services, may be identifying issues with roads faster than the roading contractors. This could lead to issues with business-as-usual tools, if they are not designed to handle streamlined reporting from the emergency services. Some business-as-usual tools may not support easy and rapid publishing of information to the public, and this could result in an inefficient but necessary parallel model where business-as-usual tools are used for what is effectively internal asset management, and CDEM tools are used by emergency services, CDEM, and for communicating to the public. This is a challenge that Canterbury CDEM has not yet fully worked through or come to an appropriate resolution.

There is a risk that as GIS4EM has mostly been driven by response to actual events, that systems developed, and data obtained, may focus too much on response and not enough on either business-as-usual activities, or the other aspects of comprehensive emergency management - risk reduction, readiness and recovery. For the data and applications to be successfully embedded in emergency management usage, they need to be used across the four Rs. This is particularly the case once the logistics of where data is best owned and hosted is investigated in more detail.

ACHIEVING A COMMON OPERATING PICTURE

It is the authors belief that a Common Operating Picture will not be achieved by a single centralised software application. This is partly because of the following issues:

- **Data types.** There are a variety of data types, including geospatial and non-geospatial information. One software application that may be good for managing and displaying geospatial information, may not be capable or appropriate for displaying non-geospatial information.
- **Extent of data.** The quantity of data that is needed to form a picture may result in information overload with too much information to be displayed in a single application. One solution may result in different COPs for different themes, for example, a COP viewer for lifeline utility status, response agency status, event information etc.
- **Number of organisations and their perspectives.** The number of organisations that have a stake in emergency management, that all have their own information systems, and all have different information management needs and operating arrangements.

The approach within Canterbury has been to work towards common datasets and standards-based API access, when taken together, to effectively be the common operating picture. Agencies can then select the datasets that are relevant to their organisations and incorporate those into their organisations own platform using standards-based protocols. If they don't have that capability, then organisations will be able to use the appropriate web applications designed to curate the relevant datasets.

DEVELOPING A DRAFT STRATEGY FOR GIS FOR EMERGENCY MANAGEMENT IN CANTERBURY

In 2017-2018, the authors became aware of several distinct projects and efforts underway to better incorporate mapping and GIS into EOCs in Canterbury, encouraged by reviews and awareness of NZ GIS4EM work elsewhere in New Zealand. These efforts, whilst productive and well-intentioned, were not part of a Canterbury-wide and more coordinated and collaborative approach.

To work towards a truly regional approach, A draft strategy is being developed to set out the basis for a collaborative and coordinated approach to solving intelligence and public information issues previously identified in the TAG review. The strategy here is an early draft and has not been widely socialised or received formal approval at time of writing.

Risks and Issues

Some of the initial drivers below were the catalyst for a shared approach to how GIS and emergency management could more closely work together in Canterbury. Unless these are properly managed or resolved, these present a considerable risk to the success of a collaborative approach.

- **Individual's capacity.** The work done to date has been by goodwill and fitted around other work commitments. This is significant as it is limiting work needed to be done.
- **Work priorities.** Working on GIS for emergency management is not formally recognised in many roles, and managers may focus individuals work on more immediate priorities.
- **Reliance upon key individuals and organisations.** A few key individuals, often with tacit support from their organisation, are doing the bulk of the work. There are risks associated with workload, and knowledge being lost when they move on.
- **The TAG review.** The TAG review has publicly set expectations about improvements to be made in intelligence, and public communication. A failure to meet these expectations, especially in review of a future event, will fall on the shoulders of the leaders of the GIS personnel and emergency managers. There is a very clear expectation that significant improvements are required.
- **Lack of coordination and collaboration.** Until collaborative project management occurs, there will be inconsistent and ineffective solutions developed.
- **Resistance to interoperability.** Existing and future solutions may "push back" against efforts to increase interoperability, and standards-based API access to data.

Desired Outcomes and Principles

This has helped the authors identify the following outcomes for the Canterbury:

1. **Implement a Common Operating Picture** and shared situational awareness within Canterbury, that is integrated with our neighbours and central government, leading to improved intelligence and information for decision making, and communicating with the public.
2. **Build on a standards-based architecture** that enables frictionless interoperability between organisations and systems.
3. **Develop our regional capability** in information management and geospatial disciplines through sharing design and development knowledge.
4. **Integration with other programmes** and projects within Canterbury, and nationally, such as the C10 programme, and efforts to standard EOC arrangements and resources (e.g. templates).

The authors have established the following principles to steer work towards the outcomes listed above.

- **Standards-based interoperability.** Solutions should be based on standards for interoperability. We should take a leadership role in promoting the need for new standards and leverage cross-pollination i.e. use what is effective and emergent, on agreement and not at the detriment to other parties. E.g. promote development of an Emergency Data eXchange Language (EDXL) extension for portability of assessments between systems.
- **Application and platform agnostic.** The architecture should work with a variety of software applications and not tied to a single tool/platform. Applications/tools need to be loosely coupled to enable adopting best-of-breed solutions by swapping out components.
- **Scalability and consistency.** Solutions should be scalable to support use at local, regional and national levels and should include application appearance, the user interface, terminology, cartography, and operating procedures.
- **Identify the best owner and curator.** Often the best information curator will be a business-as-usual role, rather than CDEM. CDEM may have to advocate for both CDEM and business-as-usual benefits.
- **Expectation management and honesty.** Clear and honest communication between information management/GIS professionals and emergency managers is needed to set clear expectations and common understanding.
- **Encourage competition and innovation.** Competition in application development is encouraged to support innovation and experimentation, but balance is needed to ensure that innovation is not suppressed, whilst respecting limited resourcing.
- **Systems-based approach.** Problems should be clearly defined and framed, broken down into sub-systems if possible, and clearly documented.
- **Continuous improvement and agile methods.** Focus on maturity model/gap analysis – assessment of current capability, and prioritised steps required to get to the desired end state. Use agile methodologies to management small and frequent quality and capability improvements.
- **Maximise the investment and spread the benefits.** Solutions should be cost-effective. Every effort should be made to maximise re-use – this is complemented by the systems-based approach. The benefits of the work should be spread far and wide.
- **Shared responsibility.** Ownership, action plans and work programmes should be shared for co-ordination and transparency.

NEXT STEPS

Some of the next steps towards develop a common operating picture for Canterbury are outlined below:

1. The draft strategy needs to be communicated to the Canterbury stakeholders that have a governance role, strategic or operational interests, or will benefit from this approach. To date, work has been done by a small group, but the work and approach needs to be socialised and formalised to become a successful and sustainable long-term approach to information

management. This should include visible governance support for the approach, and well as resourcing commitments.

2. An assessment of Canterbury's current capability, our desired end state, and existing and planned projects to create step changes needs to be developed. This should include a survey of existing disparate projects and providing high-level visibility of them in a shared work programme.
3. The strategy needs to be tightly-coupled with two closely related elements of response strategy in Canterbury – the C10 project that provides a common Canterbury approach to intra-regional support (fly-in) teams, and a project to align Canterbury EOC processes and supporting templates.
4. Specific problems and solutions need to be identified, scoped, and documented. Solutions need to be documented in business plans that can be taken to governance for resourcing, and eventually spawn projects to undertake the work. The identification of gaps and solutions should take a systems-based approach.
5. The draft strategy needs to take a wide information management approach, to incorporate non-GIS systems and data, such as commercial EOC applications such as D4H Incident Management and WebEOC, non-spatial data used for analytics, and traditional office applications such as Microsoft Office365.
6. There needs to be significant engagement between CDEM Groups, MCDEM, and other national agencies (such as Police, Fire and Emergency) to come to agreement on what a true common operating picture should look like in New Zealand. This will be challenging as the makeup of CDEM Groups will in some cases shape their perspective of a common operating picture, and how information should be shared. Two competing perspectives are the application-centric COP versus a data-and-standards-centric COP. Canterbury currently believe that the data-and-standards approach to a common operating picture is preferable. The Minister of Civil Defence has indicated that a business case for a national COP will be investigated.

CONCLUSION

This work in Canterbury has been undertaken on a “best efforts” basis by a limited number of individuals and organisations using what available time they have in their existing jobs. Those involved have already taken considerable steps forward for their organisation, and collectively for Canterbury. This is already proving to be unsustainable in terms of the amount of work that needs to be done, especially given the criticality of the work, but also the rapidly expanding scope of what is involved.

Indirectly, a large part of the mind map has reflected the indirectly stated desire to build a data-centric model of Canterbury. While this was initially focused on a comprehensive data atlas for emergency management purposes, it has become apparent that there is as much value, if not more, in creating comprehensive regional and national atlases for business-as-usual purposes (for democracy, governance, business, community groups, individuals; and their myriads uses), that also provide a significant baseline upon which to build emergency management atlases and applications.

With the Alpine Fault past its average recurrence interval for a magnitude 8+ earthquake, and the impacts forecast to have direct physical consequences for two-thirds of New Zealand, this work cannot be left to wither due to a lack of resourcing. This reinforces the significance of the work that has been started, in Canterbury and elsewhere in New Zealand, and the importance of working collaboratively towards a common solution for all – for good times and bad.

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