Situation Awareness for Disaster Management in the Information Age

Ken Moule, Global GBM, 2012

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**Abstract**
Well informed decisions lead to good outcomes. This article looks at how advancements in information systems affect situation awareness in disaster management. The article considers the collection of intelligence, the collation of those observations into a common operating picture and distribution of awareness updates in a form that can drive effective action. The article commences with a review of the information needs of those impacted by disasters and those involved in the larger scale disaster management and recovery processes. The analysis is used to design an information system that recognizes the operating environment and the information needs of these diverse stakeholder groups.

It identifies that the challenges of the physical environment, changes in work focus as we progress through the disaster life cycle and the decentralized nature of disaster management all favour an information system design based around a federation of stand-alone computing components that post information updates to an out-of-area data centre.

Much of the data identified in this study have location as a core element. Information systems that can use geographical location to fuse data from multiple sources are likely to increase the value of these data in disaster management.

**Biography**
Ken Moule, BSc, MSc - Ken is an information system specialist with a lifetime interest in building decision models from field observations. He has first-hand experience in providing information systems support to small technical teams in remote areas and also with enterprise level integrated systems.

Ken’s keen interest in disaster management stems from experiences with the Brisbane tornado of 1973 and floods of 1974. In more recent times he assisted defence with situation awareness projects and provided mobile computing support to operational policing.

These days Ken is Chief Technical Officer for Global GBM, a company that delivers location intelligence, crowd sourcing and work crew management solutions across the globe.

**Background**
We have moved through the Stone Age, Bronze Age and the Iron Age and are now clearly in the Information Age. Information technology has changed the way we operate in almost all areas of our lives. Disaster management is no exception.

The 24 hour news cycle means the world learns about disasters as they unfold. Communication networks are constantly improving and delivering more information more quickly. Social networking has democratized information to the extent that anyone can publish information, and that information no longer goes through defined channels and may not be independently verified. The challenge is to manage this information flow in a way that does not overwhelm the primary objective of minimizing human harm and speeding the road to recovery.

This document models some of the information flows associated with a disaster that spans a large geographical area and extended time scale. It considers the information cycle across the full disaster management time frame, from pre-disaster planning to full recovery as illustrated in figure 1.

The Australasian Inter Agency Incident Management System (AIIMS) provides a framework for coordinating the efforts of multiple response agencies (Australasian Fire and Emergency Services Council, 2011). That doctrine assumes teams are coordinated through as incident room (or disaster coordination centre) that manages Planning, Public Information, Operations and Logistics functions. Large scale events may be managed through multiple co-ordination centres, each with its area own of operation and responsibilities for upwards and outwards reporting as well as reporting across to other agencies.

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**Figure 1 – Disaster Management Time Scale**
Linford (2012) provides a discussion on the integration of information systems on operational processes. By contract, this article has a stronger focus on the information flows between coordination centres, higher command and the community and technologies to manage that information flow.

**Information System Design**

Good information system design commences with a review of stakeholders and their expectations (Chevalier, 2001) before examining the information flow needed to service those expectations. A designer of information systems also needs to consider the business processes around collecting, analysing and distributing that information.

A partial list of Disaster Management stakeholders is presented in Table 1.

Disasters impact at both the personal and property level. They affect business continuity and place stresses on the community. Table 2 summarizes some of the information that the extended community needs to speed the road to recovery.

**Business Processes**

This section reviews the information management processes relevant to the full life cycle of a disaster as it progresses through the prevention, preparation, response and recovery phases presented in figure 1.

**Table 1 – Disaster Management Time Scale**

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**Table 2 – Information Needs**

| **Information Needs** | Individuals need situation updates so they can take timely action to manage their personal safety and to assess the likely impact of the evolving situation on their friends, associates and loved ones. Post incident they seek information on the actual effect the disaster has had on people and places of interest. Members of both the immediate and extended community look for information that gives them confidence that the disaster is being managed effectively, that their personal needs are not being overlooked in the ensuing chaos and that lessons learned will be applied to effectively mitigate the effects of future disasters. |
| **Personal** | This is the information that formal and informal disaster management teams use to manage response and recovery efforts. This includes information on the pre-disaster physical and human environment as well as intelligence reports on unfolding events sufficient for them to assess current and future impacts, to provide information updates to other stakeholders and to make effective decisions about the deployment of response and recovery assets. |
| **Operational** | Disasters impact the property of individuals (houses, cars, boats), businesses (shops, offices, factories, utility infrastructure) and the community (roads, water reticulation, drainage, community facilities etc). Asset owners expect timely information to allow them to minimise the impact of impending events on their property. Post event they need information resources that support them in planning and effecting repairs to their assets. Before an incident individuals and businesses also need this information to conduct their own risk assessment and make decisions regarding their need for insurance. Businesses will also use this information to develop their own Business Continuity Plan (BCP). |
| **Assets** | Businesses seek information that supports them to mitigate the effect of the disaster on their commercial operation and their ability to deliver services to disaster affected customers. High on the agenda is information on the effect to which the community and logistics networks have been disrupted and the likely time scale for restoration of services and for the return of community members who may have relocated. |
| **Commercial Sector** | This group operates outside the disaster area but has a personal or business relationship with those affected by the disaster. Included here are friends and family of disaster affected individuals, businesses with customers in the disaster area and businesses that rely on goods and services sourced from the disaster area. |
| **Indirectly Affected** | These personnel and businesses support the direct responders. They include those who operate outside the disaster to deliver goods and services in support of the direct responders. |
| **Direct Responders** | These personnel have a direct and immediate role in the disaster Response or Recovery operations. They include Emergency Services Organizations (fire, police, ambulance, rescue teams). Businesses and members of the public may also contribute directly to Response and Recovery. |
| **Indirect Responders** | Included here are local officials and representatives of central governments as well as political representatives of local, regional and national administrations. |
| **Adminstration Representatives** | Local and General Media – Local media has an important role in keeping personnel in the disaster areas informed of steps they should take to protect their personal safety or to access support resources. Other media services address information expectations of the wider community. |
| **Local and General Media** | – Included here are those who have the capacity and willingness to contribute directly or indirectly to the recovery operations. |
| **Potential Supporters** | – Those with a desire to be informed on the unfolding disaster but who will not participate. |
| **Other interested Parties** | – Personnel whose presence may hamper the recovery operation or affect public order in the disaster area. |
| **Sightseers and Detractors** | – Disasters impact at both the personal and property level. They affect business continuity and place stresses on the community. Table 2 summarizes some of the information that the extended community needs to speed the road to recovery. |
| **Disaster Responders** | – This section reviews the information management processes relevant to the full life cycle of a disaster as it progresses through the prevention, preparation, response and recovery phases presented in figure 1. |
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Military theory describes the sequence of Observe, Orientate, Decide and Act (OODA) as steps that lead to optimal outcomes in rapidly evolving incidents. This is an iterative cycle that can be applied as disaster managers scramble to make good decisions in the face of changing circumstances and new revelations about conditions in the disaster area. They need to receive observations from the disaster area and understand those observations to properly inform decisions that give rise to actions.

A good information system can improve outcomes by speeding the OODA loop cycle. Information technology can streamline the timely collection of intelligence, provide a framework to quickly synthesise that intelligence into ‘actionable knowledge’ (Lubitz, Beakley and Patricelli, 2008) to support good decisions and manage the execution of actions arising from those decisions.

Operational processes around each of the disaster management phases make special demands on our information systems.

**Prevention and Preparation**

Risk assessment and hazard analysis are important early steps in any program to provide the situation awareness a community requires to prepare for a disaster and to mitigate its likely effects. These topics could reasonably fill several books and cannot therefore be given justice in this article. Suffice to say, this is the work of specialists who understand the profiles and modelling techniques relevant to specific classes of risk. Risks are assessed in terms of the severity of their potential outcomes and likelihood of occurrence, so they can be prioritized for subsequent attention in the disaster management plan.

Much of this analysis is about the relative geographical location of critical assets, sensitive environments, population centres, potential trigger events and details of past events (Granger, 2000). It draws on a representation of the pre-disaster state of the natural and built environment.

Over much of the world, the core information will already exist in the electronic files of municipal services organizations, government offices and utility companies. This information is commonly spread across multiple Geospatial Information System (GIS) databases. GIS is the valid successor to military tactical and logistical command overlays (TALC). These are traditionally clear overlays hung over an easel copy of the local topographical map. They present the common operating picture through a set of hand drawn overlays. Separate overlays summarize important topics such as situation awareness, course of action alternatives and tasking.

These days the Geospatial industry applies the term Location Intelligence to describe the linking of multiple sets of data based on their geographical location or relative proximity. Location Intelligence embedded in back room information system processes or desktop GIS systems can quickly answer complex spatial queries such as requests for information on the break-up of population or the number of critical infrastructure assets in a disaster zone. The AGSO Cities Project (Granger et al, 1999) is a good example of multi-hazard risk assessment developed through careful scientific study. GIS provided the information technology framework for much of that analysis.

**Call to Action**

Ideally the analysis phases will lead to the development of a comprehensive disaster management plan such as Cairns District Disaster Management Plan (Qld Police Service, 2011). This plan describes vulnerabilities and details response strategies.

Once a disaster management plan has been established, the next challenge is to recognize events that require those plans to be put into action or require the immediate execution of an alternative course of action.

In the immediate lead up to a disaster we need a dynamic situation awareness system that presents intelligence observations in a form that they can be quickly integrated into the disaster coordinator’s mental model of what is happening and what is likely to happen (Whitehurst, 2002).

GIS technology is again relevant as it allows new developments to be quickly posted onto a map where they can be viewed in the context of known risk profiles, infrastructure locations and population centres.

This phase of operations requires a command centre that is connected to external data feeds such as weather reports, breaking news and situation updates from authoritative sources. The challenge is to manage these information feeds with minimal interference from a storm of irrelevant detail.

**The Information Storm**

In today’s information age, members of the public have instant access to an enormous amount of timely intelligence (social media, news broadcasts, weather radar). This places professional disaster managers under increased scrutiny, but does not necessarily assist their crucial role of predicting events and issuing timely warnings.

Contrary to popular opinion, a constant feed of publically sourced observations does not necessarily assist a disaster coordination office. E-mails and social media messages are commonly voluminous, unstructured and contradictory.

Social media has been used successfully to broadcast disaster information (Queensland Police Service, 2011) but it is extremely difficult to harvest intelligence from social media in rapidly evolving situations and there are always uncertainties around the veracity of that information.

Technologies such as Facebook connect members of the wider community but the linkages are very diffuse and observations hard to extract. Twitter feeds can be better directed through a hashtag, but is again difficult to harness in a fast paced disaster as it is relatively unstructured and observations are not easily connected to precise geographical locations.

A 1998 study identified incomplete and conflicting information as a significant source of stress that impacted the performance of Navy crews (Canon-Bowers and Salas, 2000). Schmitt (1966) describes uncertainty as ‘doubt that threatens to block action’. He identified four basic causes of uncertainty: ‘missing information, unreliable information, ambiguous or conflicting information and complex information’.
Klein (1966) observed that:
Information overload will not only result in information missing in a sea of messages. It will also increase the amount of unreliable, irrelevant, ambiguous and conflicting information and will certainly exacerbate the complexities of interpretation.

In an earlier era, disaster coordinators worked within earshot of the two way radio that delivered the bulk of their field intelligence. Work patterns that performed well in small incident rooms do not necessarily scale well to wide area disasters in the information age.

These days, command centre personnel sift through multiple information channels (phone, e-mails, web reports, two way radio reports) to methodically validate situation reports and prioritize their stretched resources to address the most critical needs first. These operators are best supported by databases systems that assist them to standardize incident reporting, record priorities and reliability assessments, and to track follow-up actions.

These database systems support the operational section of a disaster coordination centre. Their primary outputs are lists of prioritized tasks for dispatch to response agencies along with statistical summaries for upward reporting.

In contrast, the focus of the situation unit in the planning section is to consolidate and interpret the observations rather than to track each call for assistance. Those making strategic decisions are more likely to be looking for emerging patterns than fine levels of detail (Whitehurst, 2002). The role of decision support systems is to organize the situation information and present it in context for easy analysis.

Today’s tech savvy public are very quick to dispatch mobile phone messages. Unless properly channelled these have the potential to jam communication channels and confuse interpretations.

Public comment may be better channelled in the form of a standardized electronic situation report (SITREP). This could be managed through a mobile phone app that assists the public to photograph significant events, categorize their observation and forward them electronically in a form that posts automatically on the intelligence officer’s map. Automated harvesting of time, GPS location and contact details would elevate this category of information feed from questionable to reliable.

With the right information system linkages, standardized, validated and map located references from the operations database (and possibly validated crowd sourced observations) can be directly plotted onto the intelligence operator’s GIS console in near real time. This will make the observations easier to access by those developing the larger scale situation awareness pictures.

Once observations are plotted on a GIS map, it is the job of the situation unit to prepare interpretative overlays to highlight information that drives operational decisions. These overlays, together with plots of known hazards and response plans combine to produce a map presentation of the common operating picture to be used in the command centre, sister agencies, higher command and outward reporting to the public.

Delivering the Message
The importance of warning the community of impending threats has been well discussed in documents such as the Victorian Bush Fires Royal Commission (Krester et al 2009) and the Queensland Floods inquiry (Holmes, 2012).

There are many historical accounts where general warnings have been successfully issued to large groups of people. In earlier times, alarms were raised by sounding a siren or ringing a bell. Today we use radio broadcasts and text messages with varying degrees of success. The ongoing challenge is to deliver more specific alerts to targeted recipients and to streamline follow-up to ensure urgent evacuation orders are heeded.

Specific warnings need to be triggered by the recognition of a specific threat. An effective information system will be one that mitigates the effect of the information storm (above), presents intelligence in a context that aids interpretation and then ensures the interpretations are passed on to those who can act on them. Our ideal system needs to link disaster co-ordination centres, as the response phase in one area of operation may well be the early warning phase for a downstream or downwind community.

The next challenge is to ensure appropriate warnings are relayed to the right individuals in the potential disaster area and that those warnings are actually received. Fortunately software is now available in the commercial market that allow community members to link their contact details to their geographical location so they can be accurately targeted for specific warnings.

This type of system is triggered by entering the outline of the target area (as a GIS boundary or polygon) which is then intersected with the map referenced subscriber list. These products will issue messages, monitor responses and escalate contact as necessary.

For example, the system may be instructed to start with a low cost e-mail message. In the absence of a return e-mail, the system may automatically issue a SMS message which can be followed up with a voice call or tasking of an evacuation coordinator if no response is received. This type of automated system is designed to reduce disaster team workload, improve message delivery and promote public confidence.

Ground Truth
While potentially useful, publically sourced intelligence will be biased towards areas where communications networks are intact and residents are technology empowered. This may not be the epicentre of need.

In the early stages of a disaster the commander will be working to characterize the extent and intensity of the disaster impact and to access search and rescue requirements. These will be quantified in terms of the area of impact, number of residents affected, and metrics on damage to essential services (water, sewerage, power etc).

This intelligence is gathered through a Rapid Assessment Program that requires field crews to characterise the impact of the disaster on each region or assessment sub-areas. The rapid assessment team is also charged with identifying hazards so action can be prioritised and planned to protect public safety (Linford, 2011).

1. Publically sourced intelligence is also referred to as crowd sourced information.
While general guidelines suggest this work be carried out in the first 48 hours (Commonwealth of Australia, 2011), earlier completion will obviously improve outcomes by supporting decisions that direct response efforts to the areas of most urgent need.

The Rapid Assessment program needs to be followed up by the more detailed inspection required to build an inventory of human impacts, property damage and the impacts on community infrastructure. This is the information that supports recovery planning and post event analysis.

Four years after Katrina, some New Orleans residences still show markings that testify to the house to house searches we all saw on our television screens (figure 3). Since then, many residences have been rebuilt and others demolished.

It is easy to imagine the regime of systematic house-to-house inspections in the search and rescue phases continuing to refine the damage inventory and trace the progression to full recovery. Critical community assets (water, power, drainage and roads) also require inspection in the immediate disaster aftermath, with repair works prioritized, commissioned and checked.

The wider community is embracing mobile workforce technology to manage field operations such as systematic inspections. Disasters require map and GPS enabled mobile devices as navigating by street addresses is problematic in the post disaster environment.

Systematic site inspections may be better served through the operating protocols of municipal services organizations rather than those of emergency response agencies.

Outside disasters, emergency response assets are commonly dispatched to a sequence of prioritized incidents. As each assignment is completed, crews update their availability status and receive new tasking from the dispatcher. This is all about incident priority. It works well when there is a reasonable match between resources and work load and strong command and control infrastructure.

In the municipal services environment inspectors are issued batches or works (e.g. all the residences in a sector) and provide with some latitude to sequence work within the batch. Inaccessible sites or complex tasks may be tagged for follow up action, either when conditions improve or crews with special equipment become available. These processes are designed to maximise operator productivity when faced with a large list of tasks of similar priority. They assume a level of on-the-spot management and incur a much lower command centre overhead.

These days, wireless networks speed the issue of work instructions and speed the return of field observations and work progress updates. Map enabled mobile computers assist inspectors to navigate to inspection sites, to standardize recording and to validate observations while operators are still in the field.

The disaster situation requires mobile computers that operate autonomously when out of communications range, batching data transfers for when communications are re-established. Work instructions, situation updates, hazard locations and road closure details need to be pushed to the mobile computers.

Mobile computer updates showing work completion status and field observations need to be noted on command centre maps as they are received from the mobile crews.
**Information Systems Framework**

Information system designs commonly used in the regular IT world may not be suitable for disaster management due to challenges of the post-disaster landscape.

We must assume that web servers and support systems in the affected area are disaster affected. Operators, at least in the early response phase are likely to be overworked, under resourced and stressed. They may need to manage significant incidents without mobile phones or even regular internet services.

In the disaster area we need information systems that are robust, able to operate without internet or external servers and without reliance on local technical staff. Despite restricted communications in the disaster area, the team needs to find a way to service information needs of the stakeholders listed in tables 1 and 2.

**Geospatial Technology**

While GIS desktop technology is well accepted as a valuable tool for risk assessment and hazard analysis work, high-end GIS consoles are not necessarily the ideal tools for delivering geospatial services at the operational level.

Today’s desktop GIS consoles have evolved to service the needs of specialist analyst. This software is flexible and powerful but necessarily complex to operate and normally entrusted to specialist operators.

By contrast, the general public has become increasingly map aware, particularly over the past five years with the widespread adoption of personal navigation systems and web maps. This has driven the delivery of software systems that focus on ease of operation.

In a modern disaster coordination centre, the old map overlays are represented by layers on a GIS map. Together these layers present the common operating picture that is ideally shared by all participants. While the obvious way to share this information with mobile crews and across command centres is by exchanging interpretations and plans described in these GIS layers, there are a number of challenges.

Despite the existence of open standards, much of the world’s geospatial data is held in proprietary file formats and siloed information systems. For example, the Queensland floods of 2011 spread across jurisdictional boundaries and required collaboration between adjacent disaster coordination centres, serviced by personnel who operated GIS products from different vendors.

While specialist GIS analysts have an important role to play, there are also definite advantages from delivering geospatial services directly to operational personnel without those personnel needing to divert their attention to the technology issues.

Information systems of the future need to present a user experience that is not dissimilar to popular web mapping systems while harnessing the real power of GIS technology.

This is the role of location intelligent business systems where routine operations are managed through geospatially aware background processes that are not necessarily operated by a GIS specialist. To be effective, these automated processes and the business rules that manage their operation need to be established well ahead of disaster onset.

**Figure 4 – Common Operating Picture as Stacked GIS Map Layers**

Representative layers only

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Standard commercial databases (Oracle, SQL Server etc) now hold geospatial data in vendor independent formats. These databases are becoming mainstream but require computer servers and specialist support that may be difficult to maintain in a small disaster coordination unit.

Fortunately the INSPIRE project of the European community is breaking down the artificial barriers between GIS systems (Winslow, 2010). That project provided the impetus for commercial products that allow organizations to upload spatial data to central catalogues, document that data for discovery by standards based metadata search systems and allow authorised users to download heterogeneous content for direct consumption by their preferred GIS product.

Agencies can now work with the commercial-off-the-shelf GIS packages of their choice and easily publish data by uploading GIS files to a remote server. Authorised users can download that data, from anywhere in the world, and in the form required by their internal GIS systems. These services have a very low IT footprint in the disaster area. They support easy sharing of situation updates between agencies without the normal systems integration overhead.

Field Computers
Mobile workforce management systems are becoming the norm. Outside of Emergency Services Organisations, two-way radios and paper based instructions are disappearing in favour of electronic records on mobile computers.

While the consumer market is starting to embrace smart phones and tablets, field services organizations are favouring ruggardised PDA units. GPS, mobile internet, cameras and wireless networking are standard inclusions in today's devices. These days, is it is only specialist applications that require high-accuracy GPS units. Routine inspections are well served with standard devices that can be relied on for positional accuracies in the order of a few meters, more than enough to locate a specific residence or pumping station but perhaps not good enough to find a buried fire hydrant.

Disaster management requires mobile computers that are map and GPS enabled to mitigate the effect of disaster on house numbers and signage. In addition to GIS map layers showing the infrastructure locations and property outlines that were assembled in the preparation phase, operators need map presentations of their tasking to speed their navigation to work sites.

For their personal safety, operators also need regularly updated map layers that show known hazards and exclusion zones. Mobile GIS systems can now easily handle large raster images such as pre-disaster aerial imagery. These are useful as background layers at the bottom of the GIS layer stack.

Mobile workforce computers need to operate on the "sometimes connected" model. That means they are able to operate autonomously and will automatically synchronise data when connectivity is available. Robustness is improved by caching data transfer packages at the remote server, to support the common

Figure 5 – Rugged mobile computers with maps and data form (GBM Mobile)
case where both the coordination centre and mobile devices achieve intermittent internet connectivity, but not necessarily at the same time.

Mobile computers that support search, rapid assessment and post disaster inspection tasks are also suited to field works in the preparation and prevention phases. For example, a number of local government organizations in Victoria, Australia, use mobile computers in a program to mitigate risk from wild fires. Fire rangers visit properties ahead of each fire season, and where appropriate, issue notices to landholders to carry out fire mitigation works. The programs work with a map enabled management console supported by GIS enabled field computers similar to those shown in figure 5.

One advantage of this type of GIS enabled mobile computer is that it is already widely supported in the community. For example, there are many thousands of these units, and experienced operators, among Australian Local Government organizations. These are the people experienced in maintaining municipal assets in their local area and who control much of the equipment that will be pushed into service to support recovery operations.

Integrating the Network
This section considers the information flow across the full range of response and recovery agencies and looks at technologies available to support those information flows.

Prevention and Preparation phases are commonly carried out by small specialist groups over an extended time period. These are stand-alone processes that are well served through desktop GIS software and spread sheets.

As the disaster approaches, our information systems are increasingly asked to deliver command and control functions rather analysis and planning. The increased tempo of operations requires a more integrated approach. We need more automated processes that share information across operational areas and those processes require standardised procedures and data sets.

Much of today’s IT space works with inter-dependent computer systems that assume reliable communications networks. The design challenge for disaster management is to reap the benefits of electronic messaging when available, while ensuring continuity by minimising external dependencies. Our computer systems need to run stand-alone pending restoration of power and communication networks and the re-establishment of IT services in sister agencies.

The general IT community is beginning to embrace cloud computing to deliver IT services across the internet. These systems run on remote servers, reducing the dependency on local infrastructure or technical support. The larger service providers (Amazon, Microsoft Azure) offer systems that scale dynamically, reducing the likelihood of a systems crashing when hit with a spike of service requests as disaster strikes.
Cloud computing depends on internet connectivity, making it less than ideal for on-site incident centres. For disaster management, the conflicting needs for system integration and robustness are best serviced through a loose federation of independent modules that can exchange electronic messages when communications are available and operate autonomously when necessary.

The minimum working unit may be a single laptop computer in a mobile incident centre, supported by one or more field mobile computers. Mobile computers may need to be pre-loaded with situation maps and work instructions in the command centre and download observations through a wired connection at the end of each work shift until wider communications are re-established.

Figure 6 presents an integrated information network that connects individual coordination centres with the wider world. Discussions below refer to the communication connections marked in black circles.

An individual coordination centre may exchange situation updates and tasking instructions with mobile computers through wired, wireless LAN (Connection A) or by exchanging data packages through an out-of-area staging server (Connection B).

This communications model works for field crews that report directly to the coordination centre. Interaction with regular emergency response agencies (Fire, Police, Ambulance) is likely to be more effective when information packages are forwarded through the command centres that traditionally manage those assets, as the disaster response phase is no time to be adjusting command structures.

Standards exist for the electronic interchange of emergency management information (OASIS, 2009). The challenge is to integrate computer-driven mechanisms with approaches that also work at the human level.

Command centres may upload situation updates to a shared intelligence store (Connection C) where it will be available for sister agencies to import directly into their GIS systems along with background data and management plans that were prepared ahead of disaster onset. This link may also be useful for downloading the latest copy of base maps and planning details at disaster onset, especially if asset owners such as local government organisation and utility companies can be encouraged to post regular updates to the map layers that represent their assets.

At the technical level, standards based Web Map Services (WMS), Web Map Tile Services (WMTS) and Web Feature Services (WFS) are emerging as the technology for feeding map-related data into web sites (Connection D) and directly into desktop GIS products (Open Geospatial Consortium, 1999). Direct or indirect download of GIS files is the reliable fallback.

As most of these are graphical products, interoperability across agencies depends on the adoption of standard conventions for the way the different classes of feature present on maps (National Wildfire Coordination Group, 2006).

Potential connectivity problems favour PC-based systems for coordination centres near the disaster site. Browser-delivered information systems, supported by out-of-area data centres are more suited to servicing established offices (Connections E and F). The latter is the classic cloud computing regime finding favour in the commercial world.

This infrastructure will assist multiple agencies to share a common operating picture across the globe, quickly upscale computing resources to meet demand and provide a high level of information system support without distracting operational personnel from their core duties.

Analysts, such as those involved in flood modelling or plume analysis work with specialist software are best served by allowing them to download the raw data and upload their completed models (Connection H).

Map presentations of output from these analysis models need to be accessible to both local and regional coordination centre personnel (Connections C and E) where they can be combined with situation updates to inform decisions about triggering citizen alerts.

Both crowd sourced intelligence (Connection I) and citizen alerts (Connection I) need to operate from the replicated out-of-area disaster centre to insulate those activities from the effects of a local disaster.

Shared intelligence that accumulates at the data centre will become a useful resource for post-event analysis and feed back into future preparation and prevention plans (connection H). Interpretations developed by these specialist analysts may be uploaded back to the central server for publication to both disaster specialists and the general public.

Public information is also best served through an out-of-area server, ideally using scalable infrastructure that is not likely to be overwhelmed by peak demands (connection G).

The Wider Community

Disasters, by their very nature are events that overwhelm the resources of those in the disaster area. Recovery is a whole of community process requiring both private and public sector collaboration. All parties need reliable information to manage their efforts.

Outwards reporting can be serviced through a public website operating on the infrastructure presented in Figure 6. The challenge is to provide appropriate information summaries for general media release and also service the more detailed information needs apparent from an analysis of Tables 1 and 2.

Rapid recovery and service restoration depends as much on resources of the wider community as it does on the emergency response agencies. Commercial service providers (utility companies, construction companies and retail outlets) have similar situation awareness needs to those of a disaster coordination centre and have the computer systems and personnel to use that information effectively.

For example, the “just in time” philosophy in today’s retail system means that supermarkets in many developed countries hold only enough stock for a few days. The flip side is that companies who manage these stores have very sophisticated logistics networks. They establish internal disaster management teams to coordinate the restoration of services to their disaster...
affected customers. Company implemented rapid recovery plans depend on specific details about the level of damage to individual buildings, access restrictions and likely relaxation dates, road closures and population relocations.

Brisbane mobilised a “mud army” of over 25,000 volunteers to clear debris following the 2011 floods (Clover, 2011). Rapid recovery efforts were more limited by public safety officials’ ability to task such a large group of volunteers rather than the availability of labour and resources. Ready access to reliable and detailed situation updates and a register to coordinate requests for assistance are invaluable resources for harnessing volunteer contributions.

Community services groups, building maintenance companies and a wide variety of non-government organizations play a major role in speeding the road to recovery. Individuals and organizations are becoming more tech savvy and map aware. In an advanced society these groups can now absorb and responsibly use much more detailed information than contained in the press release of an earlier era.

Globalization and our increasingly connected world add an international dimension to what were once local disaster events. The Japanese Tsunami disrupted vehicle manufacturing on a global scale through its effect on critical component suppliers (Canis, 2011) and the Thai floods had a similar effect on the electronics industry. World commodity prices and financial markets across the globe react to disaster events and seek more and more detailed information to assess the direct and indirect economic impact. Information systems that report damage assessments and monitor restoration works are now important tools for minimising economic fallout and building resilience into the global economy.

On the humanitarian side, international aid agencies (such as the international Red Cross and Red Crescent) are sophisticated organisations that will swing into action to support disaster affected communities if provided with timely and reliable situation updates.

Personnel in these agencies do carry out routine site inspections in much the same manner as regular response crews and deserve situation updates to support those operations. Planning teams in these organizations are potentially affected by the same information storm that can swamp a regular incident room. Effectiveness will be improved when these organizations are given access to the same authoritative situation updates that a disaster coordination centre would normally provide only to sister agencies.

The days when the public was satisfied with a relatively sanitized press release are gone. There will certainly be some sensitive details that are best held within the confines of law enforcement or the immediate management team, but disaster management organizations of the future will need to respond to the unstoppable trend to liberate more and more information for public consumption.

**Conclusion**

This document details the design of a comprehensive information system that can integrate all aspects of Disaster Management from preparation to full recovery. This type of system has potential to mitigate the effects of large scale disasters on the local, regional and international community.

To be really effective, this information system will need to work across jurisdictional boundaries and integrate the expectations of the public sector, commercial sector and the wider community.

From a technical viewpoint, the system could be fabricated relatively rapidly from existing off-the-shelf components. The project could be progressed by setting up an environment that encourages contributions from various private and public sector players by giving them surety that their individual works will integrate directly into a shared framework.

The project may well commence with a community consultation phase intended to reach consensus on standards and interfaces. As a minimum, this project will need to consider map symbology standards, dataset classifications (metadata) and data sharing agreements. As outlined early in this article, many of the underlying standards already exist though they are not bound together as one easily accessible body of knowledge accepted by the disaster management community.

It is concluded that interested players should consider collating a set of operating principals that describe how the individual items in this federation of components (figure 6) might share data and exchange messages.

This work may be progressed most effectively under the auspices of an international disaster management interest group that cooperates with various national spatial infrastructure initiative and geospatial industry standards committees.

Establishing this interest group will be a good first step in giving those interested in developing components of this system the confidence that their contribution will be compatible with an international framework as the larger picture evolves.
References


