Community mapping – an aid to emergency management

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Introduction

This paper discusses an emerging area of data management within the overall emergency management framework. It is an area that has been slow in gaining the interest of policy makers, partly due to misunderstanding. However, current trends in spatial data management are driving us, perhaps inexorably, down the path to this very area. This is an attempt to clear that path. The fundamental point is that there is a very real gap between some of the datasets provided by statewide mapping and surveying agencies and those required by emergency managers. This is highlighted for our stock-in-trade, the topographic map. In this article we state that spatial data collection at the local level is an effective way of filling in the gap. The local community gets better protection, the emergency managers are better informed and state-level providers have access to accurate datasets that complement theirs. This is made possible by both new technology and new standards for spatial data management.

Why worry about spatial data? The traditional model of the response crew is that they have a lot of local knowledge—they know where they are going and they do the job. While this may be true in large part, there are a lot of new demands for spatial data that require development of spatial databases. Examples include:

- the provision of a fire shed in a small town once its population reaches a threshold value
- the preparation of district risk maps and plans
- interstate response of task forces
- reporting to government on levels of service delivery.

Clearly these are important things to emergency managers.

There are a number of problems with the spatial data with which we work. Rather than discussing technical issues, it is perhaps most useful to focus on the main means of access, during emergencies, to spatial data for most of Australia: the topographic map.

What's wrong with topographic maps?

Topographic maps are the fundamental source of spatial data for response crews operating outside metropolitan areas. They are on-hand at all times and all crews have training in their use. Senior officers often carry large numbers of maps. We use topographic maps all the time and find them an invaluable planning and operational support tool. They would appear to be an indispensable and welldesigned product.

On closer inspection, and from the perspective of the modern information age, topographic maps have some serious shortcomings. The primary issues include:

- they are chronically out-of-date and take too long to be revised
- they are not necessarily synchronised with any digital or other spatial datasets in use
- they do not show all of the data that emergency managers need
- they are not designed to meet the needs of emergency managers

The first two issues relate to *currency*, and the latter two to *relevance*.

Over three decades ago, Australia switched to the metric system of measurement. One of the biggest efforts involved in this switch was the production of new maps in metric units. A new definition of the earth's shape (ellipsoid) was produced, and from this the Australian Geodetic Datum 1966 (AGD66) was created, which gave a better result over which to drape a map grid.

The new metric grid, the Australian Map Grid 1966 (AMG66) was developed. This changed the core scale for topographic maps from 2 inches to the mile (1:31,680 scale) to 1:25,000 scale. This meant that each map in the country needed revision to the new metric scale—a heyday for map users.

Once the transition to metric had finished, the production of maps slowed down. At about this time, the impact of new computerised geographic information systems (GIS) was being felt. The mapping agencies saw the future importance of digital data and committed resources to the digitising of existing mapping data. We saw a switch from the employment of field surveyors (to record changes 'in the paddock') to employment of digitisers (to provide digital data from existing paper maps). The 'digital' changeover was a major undertaking involving heavy expenditure, in resources and in personnel, on the part of all mapping agencies. Very little map updating was undertaken during this process. Most topographic maps in southeast Australia are now in the 15 to 25 years age range. This disturbing fact should be of grave concern to emergency managers.

In the January 1994 Sydney bushfire crisis, the ACT Emergency Services Bureau, along with many other Australian fire services, sent task-forces interstate to help. When tasked these crews were handed photocopies of photocopies of 20-year-old maps, and told to work along fire trails that weren't even on the maps. This scene could be repeated next summer in most parts of Australia. It is a serious, but understated issue. Crews can normally do their job by relying on their pool of local knowledge. But when crews are operating outside their brigade areas, they don't have local knowledge to guide them. This is the very time when the local crews (whom they are assisting) can be guaranteed to be too busy to pass on their knowledge. This is thus a source of risk to out-of-area crews.

The pool of local knowledge, collectively across Australia, is an asset to the community of immense value, but shows up on no balance sheets. It needs to be recorded, and its full value needs to be accessed. Community Mapping is a way to start this.

The Australian mapping and surveying community decided that the geocentric definition of the earth's shape would be adopted across Australia (the Geocentric Datum of Australia 1994, GDA94). This is compatible with the Global Positioning System (GPS), unlike the geodetic definitions that had been used for map making previously in Australia. This makes life easier for surveyors, pilots, mariners and the military. Unfortunately it makes any new maps prepared with the new map grid based on this (the Map Grid of Australia 1994, MGA94) incompatible with any previous maps. To put it another way, all of our maps became out-of-date at once, but unlike the similar event in 1966, the maps are not being revised in bulk. In December 1998, the Federal Government began work on spending $2,000,000 that it had set aside for revision of 1:100,000 scale maps in GDA94, and recognised that emergency managers had the most critical needs. However this is a very small proportion of the total effort needed.

So emergency managers are being diverted towards digital datasets to support their work. As a good example of this, during the 1999 Sydney hailstorm disaster, cadastral databases were brought on-line to assist with logging the tens of thousands of calls for assistance. A Joint Emergency Services Mapping Unit was created to service this capability (Anon 1999). This concept showed its benefits immediately and is being widely endorsed as a standard tool. However, the inner workings raise many fundamental issues. Principal among these is the need for current databases to be on-hand in preparedness for emergencies. While we are not custodians of the available data, we nevertheless need ready, confidential access. Also there is a difference in technology between office-based planners and vehicle-based response crews.

Another issue raised by joint mapping is that of reconciliation of the three key dataholdings of relevance to emergency management: the local knowledge mentioned earlier, the data held by local governments, and the data held by state mapping agencies. It is extremely difficult to ensure that these match, given their diverse histories and the differing updating efforts. Much of the data held by local governments has its origins back in the original development era. Surveyed boundaries from then do not necessarily match those surveyed to modern standards or even collected with GPS. The old data were not necessarily accurate. There is even a fundamental limit to this reconciliation, reflecting the scale dependence of data, its management and its applications. This is summarised in *Table 1*.

Scale	Administrative unit	Data	Sources (examples)	Tasks
Coarse	State	State-wide holdings	Digitised map data	Policy
	Region	Planning data	Broad-area mapping programs	Strategic planning
	LGA	LG data	Surveyors, GPS	Hazard assessment
Fine	Locality	Local knowledge	Community mapping	Operational support

Table 1: scale dependence of data, its management and applications

A number of major shifts in spatial data management in the public sector have coincided in recent years. Firstly, the state-level data agencies have needed to retreat to a well defined set of core datasets, driven by economic constraints. Secondly, the shift towards risk management (Standards Australia 1995) in emergency management has brought a growing recognition of the key role of spatial datasets. The holdings of the former do not match the needs of the latter. The third shift has been the ready availability of field GIS/GPS equipment that allows the collection of accurate and consistent data by unspecialised personnel. [This has been augmented by the recent improvement in precision with the removal of Selective Availability.] The fourth shift is an across-the-board recognition of the value of standards in spatial data. And, finally, all of these have reinforced a trend to devolve risk management down to the local level. (It is worth noting that a new shift, the recognition—in accrual accounting terms—of the value of spatial datasets, is yet to occur.)

So what information do emergency managers require? This is a very difficult question, and perhaps the best attempt at answering it is in Granger & Johnson (1994). They listed a number of 'essential elements of information': location, resources, personnel, weather, hazards, communications, transport, population, tenure, health, community, utilities, terrain, biota, rural use, urban use, and administration. For emergency managers to access all of these broad classes of information is a major task. Further, some of these have, traditionally, not been easy to access. It is only in recent years that a major focus on lifelines has yielded results. Building partnerships over a range of agencies is also yielding results. And traditional information sources, such as maps, are failing to match the ever-increasing demands for detailed information. Maybe part of the problem has been that emergency managers have not been 'in the loop' for designing information products.

Victoria's Country Fire Authority has for some years been producing and revising regional map books, which serve as 'street directories', but for rural areas. They facilitate both emergency contacts and risk management by providing A4-format, indexed access to information about residences. They are extremely popular, and have, to a limited extent, been emulated elsewhere. The key fact is that they give information that is not provided elsewhere. Privacy and other concerns dictate that this information cannot go on standard maps.

The authors have had direct experience with the issue of designing maps to meet the needs of emergency managers. In 1990 AUSLIG invited both authors to assist with the production of a 1:100,000 scale *Special Map* covering the entire ACT. This coincided with the need for a revision of the map. At the time AUSLIG was experimenting with the use of satellite image maps (SIMAP, a registered tradename) on the mainland (Wise 1992). They had been used successfully for some years in Antarctica, and were seen as being a faster way to produce maps 'back home'. They also had the ability to accurately depict vegetation types.

The map used a fully rectified LANDSAT image, with map grid, line work and text superimposed over the image. (The image was a hybrid of thematic mapper and panchromatic data, resampled to 25 m on the AMG.) The image took on the role of terrain shading and vegetation shading. Contours were not shown, as experimental maps with them included have shown that these made the end product too cluttered. The image had to be ghosted back to avoid it swamping all other information on the map—about 30% strength was found best.

The image was carefully selected:

- to be from a time-of-year when the local grasslands were quite different in their appearance in the image (thus giving maximum discrimination of vegetation types), and
- also to be from a time when the sun was high in the sky when the satellite

Question		Main response
How do you rate…	The way that landform is shown without contours?	Poor
	The colours shown in the satellite map?	Acceptable
	Your ability to make practical use of this map?	Acceptable
	The use of purple to show [operational] information?	Poor
	Your understanding of the image map?	Acceptable
How do you rate the new map, compared to the old map?		
	Clarity of the map?	Worse
	The way that vegetation is shown?	Better
	The overall use of colour?	Worse
	The way that land tenure is shown?	Better
	The fire tower compass roses?	Much worse
	The way the map grid is printed?	Better
	Placement of the labels for eastings and northings?	Better
	The way the legend is shown?	On a par

Table 2: views on the useability of the *ACT Bush Fire Council Edition* map and how it compared with the previous traditional edition.

passed over, avoiding large shadows (which show no information) in rugged terrain, such as the Brindabella Ranges west of Canberra.

A special print of the new map titled the *ACT Bush Fire Council Edition*, with a purple overprint of operational information (fire tower compass roses, key land uses etc) was produced. Purple was chosen as an opaque, high contrast colour largely absent from the base map. Grid labels were redesigned to aid the use of a folded map.

We issued the map to all our operational crews with a questionnaire designed to solicit their views on the useability of the map and how it compared with the previous traditional edition of the map. Responses were collated (*Table 2*) and showed some interesting trends.

Clearly there were some strong views expressed. We extracted from this some salient points:

- Use contours — terrain detail is important. These should be at 10 metre intervals, and tagged every 100 metres, to maximise map clarity.
- Land tenure is important.
- Fire tower compass roses are important, but must be clear.
- The design of a grid and its labeling (both in the margins and across the sheet) is important and must be optimised for ease of use. This also facilitates coordination of operational information when faxing and photocopying the map.

Other comments were invited on the questionnaire. One comment that was repeated many times was the difficulty of using the map at night in a four-wheel drive, under torchlight.

The request for contours was in conflict with the technical findings, and would be a major driving force in map design.

What can be done?

Some fundamental changes are needed to address the issues above.

- At all levels, emergency managers should be input to the design of spatial data products. At the end of the eighties, emergency managers were not 'on the mailing list' for mapping agencies. At the end of the nineties we were definitely on the list. The momentum driving this change is still there. If emergency managers, as a national community, pooled our resources we could gain considerable power to influence spatial data managers.
- Emergency managers need to review their needs for spatial data. In order to do this, we need to work around the philosophy of doing it alone that permeates our use of spatial data (McRae 1999). This requires the building of links between states, between the sub-cultures of emergency management (e.g. police, ambulance, and fire, SES) and with the private sector. The first step is to review what we have and what we need. Often the difference between these is outside of our financial capabilities. Cooperation is perhaps the best approach to take here.
- The value of local data must be recognised. It has been suggested that the best way to put a value on knowledge for accounting purposes is to look at its replacement cost. None of us has yet put on our balance sheets the value of the local knowledge of our response crews and planners.
- Priority areas need to be recognised—where the built environment is changing fastest, the data that describes it needs to be updated more often. Areas on the rural / urban interface are notorious for having out-of-date spatial information, especially maps. Yet it is these areas that need the most protection. A rapidly expanding suburban area may not be built to withstand wildfire, yet those houses stranded on the edge during summer may be at considerable risk. The same may be said about floods, with floodways that are unfinished.

Development of a standard approach

During discussions at the recent workshop on *Spatial Data in Emergency Management — Where are we now?*, (see McRae 2000) it emerged that there is a perceived and vital role for community-level mapping.

State or National mapping agencies need to develop and maintain key top-level datasets, addressing core mapping products. Extracts from community-level mapping products are able to assist with the development and maintanence of these datasets. This is an effective method of maintaining and keeping the data 'dynamic', without which the dataset is only a snapshot in time. The datasets need to be constructed in such a manner to ensure that State and National mapping agencies can draw down their data requirements at any time to meet their needs.

The use of the concepts in the Australian Spatial Data Infrastructure (ASDI, see ANZLIC 1997, and Granger 1998) will facilitate the interaction and coordination needed. ASDI allows agencies operating in an area (such as rural fire brigade, National Parks Service or State Forests, Council, or Department of Land & Water Conservation) to jointly ensure that as changes occur to local resources and property, the data describing them are kept up to date. A grader driver with State Forests may upgrade a road. GPS/GIS, computer-based systems make it possible to store these improvements in the database almost immediately.

Quality control of the data is an inbuilt resource: local knowledge will immediately alert those responsible at the local level to any inaccuracies. These can immediately be checked and rectified. Further quality control arises from the use, by Community mapping, of brigade areas as the building bricks for dynamic data sets of a district. Brigade members may be required to put their lives on the line during an incident and therefore have a very real reason to ensure local knowledge of their area is the best available. Give them a map of their area before fire season and they will ensure the information is up to date.

Mechanisms are being developed where the base for all mapping (either very accurate aerial photography or satellite imagery) is regularly updated over those areas where there is continous growth and change. This imagery allows rapid recognition of the location of changes. Cycles for this will vary depending on the amount of change and will vary from 3 to 5 years. All this results in considerable demonstrated cost savings to the community, both in data use, and in data collection by local volunteers in Fire Services and State Emergecy Services, and workers of the various land managers going about their daily business.

The local community now has the capability to produce their own maps during any emergency, such as a major bushfire, flood or hailstorm. It also has the tools to plan for very detailed risk management in future.

To coordinate all of the elements of this a comprehensive standard has been developed to cover data collection, data coding and depiction on maps. The standard, titled the National Emergency Operations Mapping Standard (or NEOMAP), has Emergency Management Australia as its national sponsor under the definitions of ASDI. The evolution of the standard is occurring through use in the field.

Most of this development is now focused on protocols and methods for keeping the data 'dynamic' and up to date, and on the standards for data coding. The latter work will ensure that the depiction of an object is the same in most commonly used desktop GISs and that they are capable of being rendered equally in colour or black and white (to enable faxing and photocopying during operations). While software such as MAPINFO (from MapInfo Corporation) and ARCVIEW (from ESRI) use different user interfaces and data formats, each should be able to produce maps that meet a common depiction

Figure 1: field crew with the North Coast Community mapping project

standard (see *Figure 2*).

A further element necessary to facilitate coordination is the use of a regional supervisor. A regional role is important, as not all agencies share jurisdictional boundaries, and the variable level of overlap that results forces a need for coordination of timetables, sharing of equipment and production of databases and maps.

Having developed the concept, it has been a long process liaising with mapping agencies to see where it can be linked into their mapping programs. It appears most likely that emergency services using a regional approach will be in a position to provide mapping agencies with a continuous supply of up to date accurate mapping data to enable them to produce publicly available maps. They will also probably become 'data warehouses' for other data users.

The current standards

During emergencies it is common practice to photocopy maps, as a tool to aid concise tasking. However, topographic maps do not photocopy well. The use of terrain shading and solid areas of colour to indicate vegetation cover causes large areas of the copies to appear as dark or black, and associated text is often illegible. The purpose of the value-added copy is to show strategic and tactical decisions. Dark 'blobs' hinder the depiction of these decisions.

After experimenting with a number of prototype designs, it became clear that

Figure 2: sample legend from a map generated from data coded to the Community Mapping standard. The standard covers the terms, symbols, symbol sizes and symbol colours.

the best way to show local knowledge on a map for emergency managers is shown in *Figures 3A & 3B*.

This design allows the user to select the most appropriate side to use at any time. The user can simply turn the map over along its short axis — very useful in the field on the bonnet of a vehicle.

While working with stakeholders on map design concepts some other matters have been raised. One of the difficulties in Community Mapping is that the people involved have limited training in spatial data management.

The area that requires the most careful control is ensuring data consistency. This necessitates software that provides a pull-

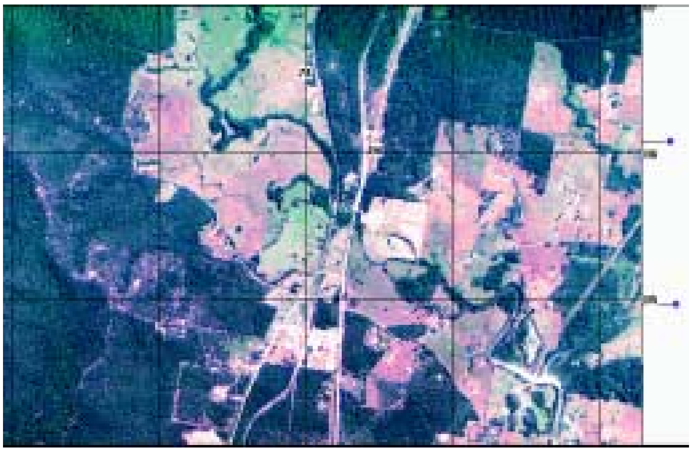

Figure 3a: Map side 1–Map to have full-strength image. The image was to be fully rectified and trimmed to map bounds. A full map grid was to be superimposed, as was a minimum of text to allow orientation. An appropriate legend, with interpretation notes, is included.

Figure 3b: Map side 2–This side of the map is lines, symbols and text only. No shading polygons are to be used except for large bodies of water. Contours are to be used. A full legend is included. (data sourced from field surveys and from project stakeholders.)

Figure 4: examples of the detail that can be coded in Community Mapping.

a. locked gates are a major issue for emergency access, and appropriate symbols should be used on maps.
b. bridges need to described: construction material, width, weight limit, river flood height at which the bridge becomes impassable. This is a wooden suspension bridge, 3.5 metres wide, 8 metres high, and, most importantly, with a load limit of 10 tonnes.
c. crossings–are they suitable for heavy vehicles such as a large fire tanker?
d&e. A rural dwelling can be coded for: address, ownership, and telephone number (for emergency contact); construction material; water supply; difficulty of access.
f. A rural shed (see Fig 5).

down list of phrases from which to chose for any attribution of mapped objects. In free-form text, a dam could be: 'dam', 'farm dam', 'large farm dam' or even 'fram dam' (i.e. a typographic error). A pull-down list could force a choice between 'farm dam – large' and 'farm dam – small'.

This then makes it easy to build the lists to use from standard data dictionaries. In turn this facilitates the building of a comprehensive database that describes the mapped object. In this we could include other features, such as (for dams) their permanency, ease of tanker access, presence of a pump or overhead filler, and usefulness in dry times. (*Figure 4*.)

This work has been progressing since early trials in the Yarrowlumla Shire area in 1994. Coding for building type allowed a direct match against the codings of the Australasian Fire Authorities Council's (AFAC) Australian Incident Reporting System (AIRS) codes.

It is also important to code against standards for mapping. The conclusion is to produce a super-coding that can be collapsed down to either mapping or AIRS codes (*Figure 5*).

Product development has been ongoing for community mapping data. Once the dataset is established, there are three main products that can emerge.

- A means for state or local government data agencies to reconcile their own holdings. The provision of current differential GPS standard data can allow an assessment of the accuracy of older data holdings.
- The production of large-scale maps. Maps at a scale of 1:25,000 or 1:50,000 can be produced with a GIS package and a suitable plotter. While considerable effort is required to build these at first, the effort afterwards is much less. Most of the initial effort is involved in the art of placing labels so that they are clear and do not obscure other information.
- Local area directories can be produced.

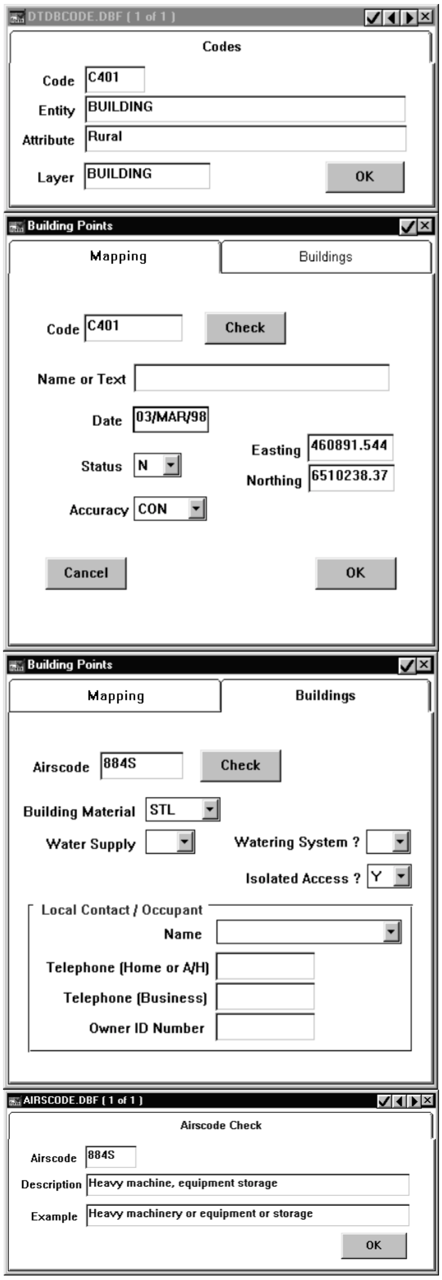

Figure 5: Data entry screens in the FieldNotes system for coding a building. The screens show attribution of the same structure for both mapping depiction and AIRS. (FieldNotes software is used for field data coding – produced by PenMetrics Inc and supplied by Rapiid Map Australia.)

It is relatively easy in a GIS to produce a directory along the lines of those produced by Victoria's Country Fire Authority (for example CFA 1998). With a detailed database at hand, additional information can be added. Once the 'macros' are built, revision is easy.

Community Mapping can be defined as a combination of the following:

- local agencies take on custodianship of local datasets, relying on local knowledge of their staff and volunteers to update and verify the datasets
- these agencies provide their datasets to agencies at the local government and state government level to ensure compatibility with their datasets and maps
- adherence to nationally sponsored standards for data collection, data coding and depiction, and to the principles of ASDI
- an ability to locally produce spatial analyses and map products to meet local needs.

The future

Thus it seems that there is a future for the concept of Community Mapping. In this future, a broad-range of stakeholders gain considerable benefits. Local volunteers gain recognition of their local knowledge and also gain access to a range of map products that better suit their specialised needs. Local Government and local land managers gain access to these datasets and the maps, as well as an ability to reconcile their own spatial data holdings. State Governments gain an ability to ground truth their data holdings, and accelerated topographic map revision.

The application of the principles of ASDI causes many potential problems to evaporate. Application of data custodianship principles, recognition of national sponsors, and the use of metadata dictionaries will lead to considerable efficiencies.

They will also facilitate progressive adoption of 'hyperspace' as a way to manage Community Mapping. This will, in turn, give access to: value-added resellers, who can improve the usefulness of datasets without requiring the custodians to acquire expensive processing or storage infrastructure; remote data and mapping systems, that allow data transfer to mobile vehicles; and 'maps on demand', that allow better informed emergency management, and thus service to the community.

Finally, Community Mapping can forge better links between planning and response needs. A strong focus on the Australian Standard for Risk Management will facilitate this.

All of the factors listed above require an adherence to standards and thus a level of discipline to which many of us are not accustomed. This discipline will enhance the various levels of interaction within Australia's emergency management industries, and also the interactions with private sector providers.

Community Mapping continues to develop. If this is kept to a national standard and retains standards for depiction, Australia will be better prepared for most emergencies. Experience so far suggests that the concept readily sells itself to those who see it in action.

The project in Hastings shire has done a lot of the hard work in defining Community Mapping. It now needs to be taken up in other jurisdictions. Only then will the benefits of interoperability come to the fore.

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