BUILDING A SYSTEM OF SYSTEMS FOR DISASTER MANAGEMENT WORKSHOP: JOINT ISSUES STATEMENT

March 2014

BUILDING A SYSTEM OF SYSTEMS

DISASTER MANAGEMENT WORKSHOP

EXECUTIVE SUMMARY

A complete picture of National Situation Awareness (NSA) in natural hazard based disaster management at any time is a challenge. Disaster managers need to integrate information from multiple disparate systems, used by a multitude of agencies across the country. . To create a useful environmental picture to underpin national planning, preparedness, response, and recovery (PPRR) activities for natural hazards, it would be helpful if we were able to exchange data, models and services across organisational boundaries. Seamless exchange and integration of data would provide better support in decision-making. Although this is typically seen as an Information and Communication Technology (ICT) issue, there is a significant 'social' dimension to this challenge, the policy, governance and organisational and institutional arrangements that contribute to realising a solution to this issue.

This Statement outlines the key findings from a two-day workshop "Building a System of Systems for Disaster Management" hosted by CSIRO at the Australian Emergency Management Institute facilities in Mt Macedon (27-28th November 2013). It is built on the collective views of 60+ individuals from 35 organisations. The Statement covers the key areas that enable a comprehensive and timely picture of Situation Awareness (SA) and highlights some of the research/organisational opportunities for the disaster management (DM) community. A clear demand emerged for a system comprising the multiple other systems that enable the integration of services and information across the breadth of agencies and stakeholders involved in disasters in all stages of the PPRR life cycle. There is therefore a need to develop a high level roadmap to gain broader commitment to the concept of a 'System of Systems' and leverage efforts of many in collaboration to make this a reality.

1. INTRODUCTION

CSIRO held a workshop entitled "Building a System of Systems (SofS) for Disaster Management" at the Australian Emergency Management Institute on 27 and 28 November 2013. More than 60 people from over 35 organisations attended, from all levels of government, private companies and emergency service organisations (ESO). It included a forum for participants to exchange ideas and current practices. The first day was allocated to identifying the current picture. More than 15 participants made presentations, establishing a picture of efforts to improve SA. Breakout groups were formed to discuss issues associated with SA and a SofS approach. These groups' key findings issues associated with achieving NSA.

The workshop was aimed at gaining an understanding of the issues associated with achieving situational awareness, and producing a joint statement addressing the research and informatics factors that hamper national-scale SA. The workshop provided a forum for stakeholders to exchange experiences, opinions and concerns. It also identified interested individuals/ agencies with an interest in guiding the efforts of Australia's Research and Development sectors efforts to support emergency and disaster management activities and created this Joint Statement.

For natural hazards, achieving a coherent picture of the situation is vital. It requires access to timely, interoperable information and services. Solutions exist to address the ICT challenges at an organisational level, however across organisational boundaries, many issues exist. Examples of these include:

- consistent data standards and terminologies
- data and information exchange and usage
- ability to discover, understand and use data
- where and when to use computational models/ simulations to acquire predictive or (near) real- time information – communicating uncertainties and fitness for purpose of the derived information.

This statement is based on outcomes from the workshop and is intended to clarify current barriers to fully realising effective and efficient NSA.

1.1 WHAT IS NATIONAL SITUATIONAL AWARENESS?

"Situation awareness is the perception of environmental elements with respect to time and/or space, the comprehension of their meaning, and the projection of their status after some variable has changed, such as time, or some other variable, such as a predetermined event. It is also a field of study concerned with perception of the environment critical to decision-makers in complex, dynamic areas" (such as disaster management and emergency services).

SA has several elements:

- Collecting and processing (including validation, geo-location, time series analysis, etc) dynamic data from disparate sources (such as reports, phone calls, social media, observations and monitoring activities, etc) and relating these data to information on communities, assets, natural features, local government jurisdictions, etc;
- Visualising the resultant information to support emergency management decisions. In short, answering the simple question: "what's happening?"
- Providing accurate, up-to-date, information for dissemination to other services and the community;
- Using forecast data and real-time simulation to create probable scenarios, generating and visualising quantitative assessments of consequences to further support planning and mitigation decisions. This is the other simple question: "what's going to happen and what will the impact be on communities and assets?"

All this needs to be considered at a national level, with cross-organisational exchange to ensure that authoritative information is delivered in a suitable/timely manner. This will ensure that governments and ESOs have the most comprehensive picture for understanding a natural hazard situation before, during and after an event. SA is not solely a national issue: it involves all levels of government, including local councils, agencies and organisations, all of which can benefit from improved technology, data and communication.

1.2 WHAT IS A SYSTEM OF SYSTEMS FOR DISASTER MANAGEMENT?

A SofS includes the various technologies needed for information-sharing across agencies, accompanied by appropriate governance to ensure and enhance sustained interoperability between organisations. A system of systems therefore comprises not only a technical architecture, but the appropriate governance, policy and standards frameworks to enable all stakeholders to collaborate and interact, and ensure the best available information is present at all times during the PPRR lifecycle.

Achieving NSA requires multiple individual systems, people, and processes to link up across organisational bounds. It calls for an understanding of what is required across the patchwork of systems; tools, techniques and processes used by the various agencies providing services within DM. The ultimate goal is to have a complete understanding of all facets of an event – before, during and after the fact. New approaches are needed, and the concept of a SofS is being developed to address the issues hampering SA.

2. KEY ISSUE THEMES

Achieving NSA is a complex challenge, which can only be achieved through collaboration from all stakeholders and levels of government, with a common understanding of the issues and a commitment to agreed solutions. The following sections detail the key issues, challenges and goals for National Situational Awareness that a System of Systems approach could assist with. The themes – synthesized from discussions at the Workshop – include:

- 2.1 Data Interoperability and Standards: Disparate systems - different data sources, formats, timeframes, terminologies, semantics, access constraints are key issues restricting the ability to understand others' data.

- 2.2 Communicating Risk: Inconsistencies in the methods used to communicate risk at all levels of the PPRR lifecycle; channels of communications and lack of consistent terminologies used.
- 2.3 Data and Information Governance: Policies, processes and management around the acquisition, creation, use and provision of data for use in DM lack governance and consensus on roles and responsibilities.
- 2.4 Data Quality: Quality of data is at times unclear. This makes it difficult to identify if it is fit for purpose.
- 2.5 Linkage and Provenance: The process flow relationships between data, models and other information is unclear. There is insufficient provenance or lineage information collected around the process flows to ensure uncertainties are understood.

2.1 INTEROPERABILITY AND STANDARDS

2.1.1 Issues

Understanding data and its application or use case is a key issue within the DM community. To have coherent understanding at all stages of the PPRR, it is necessary to have data from multiple locations, organisations and systems. Unfortunately, we don't work in an environment where all agencies use the same technology to deliver or access their data holdings, modelling software or information. They use neither the same approaches and techniques to service delivery nor the same data standards, formats and vocabularies. These differences in systems and processes are inherent in the way we work. At present, this situation is acceptable, because of funding, backgrounds, organisational mandates etc. Nevertheless, an ability to exchange and share data and information across organisational bounds is mandatory for effective and efficient decision-making in DM.

Interoperability and Standards affect many aspects of DM including data, information, models and technology. Examples include:

- Data standards and best practice guidelines. These should be applied through all stages of the data lifecycle from acquisition and aggregation to delivery. There needs to be a greater understanding of the data and what it can be correctly used for. As individual stakeholders have differing data needs, there is a need to provide different views of data for respective audiences. It's a situation of understanding ours versus others' needs and providing the mechanisms to get what we need from data and enable others to exploit it to its full extent.

- Model uncertainty acknowledgement (validation). Individual scientists, researchers, agencies etc all use different techniques. There is a high-level of disparity between modelling techniques, which hampers comparison and communication of outcomes across groups. In cases where standardisation is not possible or preferable, acknowledgement, or even standard methods to detail the uncertainty associated with a model, would help understanding and correct usage
- Many unknowns exist when "fusing" models across domains. Models developed for a singular purpose are difficult to connect to others. As an example, developing an evacuation model requires the linking of various models: the hazard event, population evacuation optimisation models, pedestrian motion and crowd dynamics.

When communicating between agencies, consistency of terminologies/vocabularies is an issue. A mismatch between government, ESOs, agencies and researchers on what terms mean makes common understanding difficult in high-pressure situations.

2.1.2 Goals

The key goals for interoperability and standards in DM would be the establishment of common DM data best practice standards and vocabularies across all phases of the hazard lifecycle. This would be a vital aspect of effective communication within agencies, between agencies and to the general public (see Section 2.2). The issue of common vocabularies is highlighted

during extreme hazard events, where interstate ES personnel cross borders to assist response efforts. Unfortunately, vocabularies in use can be confusing to interstate personnel, and a potential source of error or productivity loss.

- Collaboration to develop, improve and promulgate data standards through recognised communities of practice
- Education on consistent data standards and the benefits will aid governments and agencies in appropriate data use and timely interpretation.
- The formation of a suitable governance structure for interoperability is needed to oversee the standardisation of data exchange across organisation bounds (see governance)
- Establish Systems that enable the interoperable and standardised exchange of data between agencies

2.2 COMMUNICATING RISK

2.2.1 Issues

The DM community accepted that ESO messages lack consistency and at times, clarity, on the real consequences of actions throughout the PPRR life cycle. ESOs have differing communication policies and approaches, and their use of technology varies considerably. Further, the focus of risk communication is on the severity of the hazard as opposed to the consequence. The result of this is that stakeholders do not receive clear messages about the probable consequences of their actions if they don't act at the appropriate time.

ESOs are using an increasing mix of communication techniques which are not consistent across departments or state/territories. An example is social media technologies: some states use these to communicate messages to the public whilst others do not. Further to this, in the face of increased use and expectation of mobile technologies and the exponential growth of social media, many ESOs are struggling to identify how to most effectively get messages out to stakeholders. Currently, very few ESOs have guidelines on the use of new technologies in DM. Many ESOs have difficulty indentifying how to exploit this. Mobile technology has market saturation and there is real potential to use this to get better messaging out to and from the public.

A challenge of using social media in risk communication is that platforms change at a rapid rate. Today, many ESOs are using Facebook and Twitter to communicate response and recovery information. However, these platforms attract varying demographics. At present (2014), the younger generations are shying away from Facebook, while the 65+ age group is growing in numbers.

2.2.2 Goals

One of the clear goals for ESOs is to stay on top of risk communication and reach all of the affected community through the most appropriate communication channels and technology available. A recent challenge is utilising social media and integrating this channel within an agency's core business. The public is already communicating detailed information on hazard impacts via social media, and ESOs must explore ways to exploit this valuable resource. Further, ESOs must explore ways to increase their two-way communication in social media. This could be aided by the creation of state/territory/national guidelines on appropriate use: at present the technologies are not used consistently across the country. Adequate personnel and resources must be allocated to social media, so ESOs can

- communicate information in a timely manner;
- ensure messages target vulnerable demographics (e.g. age appropriate messaging, messaging in different languages, etc);
- address any rumours circulating through the public;
- manage the surges in usage during large events; and
- address community expectations of receiving an immediate response, etc.

Finally, research is required to explore the usefulness of social media in DM and answer the question of whether it would be acceptable in future to use the technology in place of calling 000.

Secondly, ESOs must move from hazard severity-based communication to a focus on the consequences of actions once they have an understanding of the level of impact, for example, the consequence of doing nothing during a bushfire event. Establishing framework/guidelines to educate and transform the manner of communication is essential in improving the effectiveness of communicating hazard consequence. These guidelines would then be used to inform ESO's Common Operating Picture (COP), which would embrace all activities as a "high level linking hub". The COP would embrace all user types and needs to assimilate language in all phases of PPRR.

2.3 DATA AND INFORMATION GOVERNANCE

2.3.1 Issues

Within this theme, data and information require governance so that a community can work efficiently and effectively together to provide information and services. Governance is required at all stages of the data supply chain, and most importantly at the data exchange stage (where someone else wants to use the data).

Understanding and agreement on key/fundamental datasets required by the disaster management community is lacking. Delivery of such data is fragmented and non-consistent which makes integration and interpretation difficult, particularly in high pressure situations.

In the hazard modelling domain, there is no peak body to influence and establish a consensus on who does what in DM in Australia. Many organisations provide modelling services, however, they take differing approaches and either the techniques or workflows are not shared (along with the provenance information about how the model was created). Therefore they are neither interchangeable nor comparable.

A set of clearly articulated hazard science modelling methodologies and model standards would be very useful; including model code, input datasets and representation of model outputs (akin to ISO standards). Managed and agreed benchmarking data are also lacking. These could be defined for each hazard (whether this be flash floods/fires/storm surges). This would allow the universalisation of model outputs irrespective of the source of modelling.

As stated in previous themes, there is a lack of guidance across the DM community on suitable use of social media. Privacy is a key issue: what information is appropriate to access/use during a hazard event? At present the use of Social Media is limited during hazard events, for example, could disclosing information such as location to nationally authorised ESOs be mandated? ESOs are also struggling with the public's belief that they should be able to tweet or "post" for assistance. At present this isn't universally accepted in the DM arena – should it be? Could it be? Further work needs to be completed to investigate suitable, effective use of this technology and establish appropriate governance for its use.

2.3.2 Goals

The goals for this theme would be to establish governance committees or agreed processes for the DM community. In particular, roles and responsibilities need to be defined and accountabilities established. The intent of governing bodies would be to aid in reducing duplication of effort, and to establish a notion of "shared responsibility" across the country. A key effort would be to either establish a new governance body or provide additional legislative capabilities to existing bodies.

Standardisation on key/fundamental datasets would be an achievable and effective outcome for the disaster management community in Australia. A similar standardisation is already underway in the Foundational Spatial Dataset Framework (coordinated through the Office of Spatial Policy - http://anzlic.org.au/FSDF) which aims at to provide seamless exchange of information. Targeted at specific themes, these could be extended or the model could be used for datasets of interest to the Disaster Management community

Much needs to be done in the social media space: no governance policies exist, apart from agency-based ones. We would strongly encourage an effort to establish a governing body for the effective/efficient use of social media by ESOs. Such a governing body would be responsible for defining acceptable use policies and consistent operating guidelines across organisational boundaries.

2.4 DATA QUALITY

2.4.1 Issues

This theme expressed the need for improved data quality across the entire DM field, to strengthen understanding and therefore allow our systems aid us in achieving a clear picture of a situation.

Data and its uncertainty (accuracy, reliability, and timeliness) was a key issue. Not knowing the data custodians' level of confidence in the accuracy of data makes it difficult to determine whether the data is fit for purpose. Sometimes low resolution data is used for coarse-grained analysis and determination, however, when more clarity is required, higher resolution data is required and the level of uncertainty needs to be known.

From a hazard modelling perspective; high quality data is preferable for producing useful outputs. However, access to high quality data is not always available and in these cases the uncertainty of data needs to be known. High quality data is a relative term and should always be linked to the outcome and output desired. A set of clearly defined criteria for different modelling needs would be useful. For example, a flood simulation might require a much higher quality LiDAR-based terrain input than a fire spread model simulation. This is also true in relation to data clean-up issues: It would be helpful to specify what data quality and clean-up requirements exist for different models. One possibility is to categorise the data quality requirements together with output needs and grade the quality requirement (for example on a scale of 1-5 or 1-10) on this basis.

Data outcomes from research and applied science are not meeting all of the DM communities' expectations – there is either a gap in understanding or the results are not "fit for purpose". More needs to be done to bring research outcomes closer to stakeholder expectations.

One reoccurring issue in relation to data is provenance – the traceability of data throughout its life. Knowing the origin, the processing completed on the data, the who, where, what, how, etc, is important when making decisions on whether data is fit for purpose and whether it can be trusted. Provenance data is needed to accompany data, so researchers and practitioners (ESOs) can determine whether data is fit for their needs

Finally, valuable data (and potentially) information can be extracted from social media sources. A challenge is filtering and "vetting" content – determining what is useful and what is noise. Effort is required to assist ESOs in filtering social media content, so they can extract useful information to use within operations at all phases of PPRR.

2.4.2 Goals

The key goals for data quality would be the establishment of a national guide for data, information and model best practice, and assessing and communicating uncertainty against the hazard, impact and risk processes. This would aid the DM community in determining whether they could trust the result, whether it's fit for purpose and useful in the context of their decision-making processes. This would also be coupled with developing a culture that accompanied all data/information/model outcomes with statements on accuracy and uncertainty. Mechanisms to include provenance information along with the metadata of data products would also be extremely useful.

Social media and its role in painting a picture of a given situation is still a great unknown, and requires exploring. It requires a policy for usage, and tools to support extracting "useful" content are strongly needed.

2.5 LINKAGE AND PROVENANCE

2.5.1 Issues

The theme associated with Linkage and Provenance details how things are related to each other, in the context of the "Internet of Things". Linkage relates to how some piece of data or information, a model or service is related to another. There needs to be greater clarity around which models can be used for a particular purpose when utilising models or simulations for scenarios, as often there is no context or use case provided. When utilising models or simulations for scenarios, it is similarly unclear whether models can be used for a particular purpose, as no context or relation is provided. Further information that provides details on how a model relates to another or context is needed. At present there is a lack of "linkage".

Further understanding how one bit of information relates to another is difficult, since most data is created for a specific purpose and is not intended to be "linked" or utilised in the context of another. Provenance is required to clarify the processes involved and provide transparency how data, models and information have been produced.

2.5.2 Goals

There is a clear need to provide mechanisms to identify the relationship between data, information, models and services. Providing some functionality that can be included when distributing information is a challenge, and a standardised approach would enable better use of information beyond its original intent.

3. OUTCOMES AND RECOMMENDATIONS

This statement highlights some of the key issue themes articulated by over 60 individuals from 35 organisations over two-day workshop (November 2013). The statement serves as a reference point highlighting issues hampering situational awareness, and a need for a system to aid in improving it. Key issues and goals for the disaster management and associated research communities are outlined and provide challenges within the areas of:

- Data interoperability
- Communicating risk
- Data and information governance
- Data quality
- Linkage and provenance

The next step would be for the community and associated researchers to use this document as a guide for formulating solutions and working with respective bodies to put solutions into action.

APPENDICES

APPENDIX A: CONTRIBUTORS

A.1 System of Systems for Disaster Management Joint Statement Working Group (Contributing Authors)

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A.2 Organisations who partook in the System of Systems for Disaster Management workshop and contributed views to this document

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Attorney Generals Department (Commonwealth)	APCO
Bureau Of Meteorology	University of Melbourne
Geoscience Australia	Fire Services Commissioner (Victoria)
Data Agility	Centre for Australian Weather and Climate Research
NICTA	Fire & Rescue NSW
Macquarie University	ANZEMC RSC
Queensland University of Technology	NSW State Emergency Services (SES)
Office of Spatial Policy (Dept of Communications – Commonwealth)	Victorian State Emergency Services (SES)
NSW Rural Fire Service	CRC for Spatial Information
Motorola Solutions	Department of Primary Industries, Parks, Water and Environment (Tasmania)
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