Canada's Multi-Agency Situational Awareness System – Keeping it Simple

Jack Pagotto
Centre for Security Science
jack.pagotto@drdc-rddc.gc.ca

Darrell O'Donnell
Continuum Loop Inc.
darrell.odonnell@continuumloop.com

ABSTRACT

The Canadian Multi-Agency Situational Awareness System (MASAS) is rapidly becoming Canada's national system for exchanging emergency management incident-relevant information amongst multiple agencies and jurisdictions. Through the use of structured information aligned with open standards, and a centrally managed open architecture, MASAS provides a trusted virtual community with the ability to seamlessly exchange emergency management information. MASAS offers an information exchange architecture that is based around a highly resilient system of data aggregation hubs that are easily accessible directly or through third party commercial tools by emergency management officials at all levels, from the smallest community in the most remote areas of Canada's north to key federal stakeholders such as the federal Government Operations Centre or the Canadian military. This paper highlights the key design principles, experimental activities, and technology implementation strategies that are positioning MASAS as a Canadian success story in the making – from coast to coast to coast.

Keywords

Emergency management, collaboration, information exchange, open standards, common alerting protocol , situational awareness, geographic information system, geographic information system, map, incident, hub, data aggregation, multi-agency, system-of-systems, Atom, GeoRSS, CAP.

INTRODUCTION

This paper presents a first published opportunity to describe a rapidly evolving and emerging Canadian national capability that is enabling emergency management officials from coast to coast to coast with a means to share trusted real-time incident-relevant information with each other and with our neighbors to the south. Despite common first misperceptions upon reading the name, the Multi-Agency Situational Awareness System (MASAS) is actually a system of systems supported by an interconnected exchange service that provides real-time, location-based authoritative information using an open architecture and geospatial standards. The initiative is led by the Defence R&D Canada – Centre for Security Science (CSS) with a National Implementation Team comprised of partners from Public Safety Canada's Interoperability Development Office, Natural Resources Canada's Mapping Information Branch (MIB) and industry professionals. If we consider Endsley's model (Endsley, 1995) of the three functional pillars for Situational Awareness, MASAS is currently addressing the level 1 pillar of "Perception", essentially providing the information flow to answer the question: "what is happening?"

MASAS is not a public-facing alerts and warning system. It supports an exclusive user community of emergency management public safety officials and their supporting agencies. It is also currently restricted to sharing information that is not sensitive for national security, personal privacy or criminal investigation reasons and therefore can be distributed widely and easily as official-use unclassified information. The decision to constrain MASAS to unclassified official-use information was made for strategic and pragmatic reasons. Based on many recent Canadian disaster scenarios we have found that the great majority of information that is required during an incident could have been open to the public had there been the authority to disseminate it further. We found that often the reluctance to share information is driven by concerns that reflect an extremely small fraction of the overall volume of valuable information that emergency managers would benefit from. As a first iteration

of establishing itself as a national capability, MASAS is creating the means for efficient flow of this useful and trustable information amongst emergency management agencies.

In essence, MASAS provides the foundation layer of an emergency management 'information infrastructure' (Alberts, 2000, pp. 33-36), which allows organizations to leverage their own investment in network-centric approaches to enhance how they prevent, prepare, respond and recover from emergencies. Three years after its inception MASAS is already recognized (Communications Interoperability Strategy and Action Plan for Canada, 2011), as Canada's national Situational Awareness (SA) system for emergency managers. The information exchange service (MASAS Information Exchange Operations services, 2011) provides the emergency management community with SA that supports the Perception (*what is happening*?) component of Endlsey's model, and builds towards the higher level SA functions of Comprehension (*why is it happening*?) and Projection (*what might happen next*?) by providing a bus or conduit for sharing information between the many applications associated with a more comprehensive SA system-of-systems.

The MASAS information exchange architecture is intuitive, deceptively simple and based on the following:

1) Open source implementations of an Application Protocol Interface (API) and, basic posting and viewing tools – all available for free encouraging usage, development and integration.
2) A nationally managed network of high resilience data aggregation hubs to provide a common, reliable and interoperable data source structured in accordance with open standards messaging such as the Canadian Profile for the Common Alerting Protocol (CAP-CP), (OASIS).
3) A business model and implementation strategy based on maximizing inclusiveness, minimizing cost and avoiding information-sharing barriers relating to sensitive content and non-interoperable proprietary systems.

THE PROBLEM

Despite living in the information technology (IT) age, many emergency operations centers (EOC) in Canada still rely on whiteboard, fax/telephone/email and some form of a posted map, often hand-annotated with add-on notes/push-pins to identify key points of interest or incident-relevance (Randall, 2011). These tools are simple, reliable and effective for those that can access the EOC but, equally, encumbered by slow cascade information transfer processes that require manually intensive supporting operations such as telephone call-out trees or email broadcasts to a large group.

What factors have and continue to inhibit the Emergency Management community from better exploiting IT for information sharing? We contend that two contributing factors are *information overload* and *closed* (non-interoperable) *information systems*. Interestingly these factors are diametrically opposed in that one speaks to the challenge of handling 'too much information' while the other relates to the challenge of timely transfer of enough good information to those that need it to take action. In an increasingly interdependent environment, the abundance of useful information and diversity of valuable sources to emergency managers continues to proliferate at an overwhelming rate. Compounding the information overload problem from unstructured data imbedded in email is the evolution of Web 2.0 to Web 3.0 and the resulting explosion of social media information sources. At the same time, rising concerns over cyber threats have raised data integrity concerns and are prompting us to take action to ensure access into our systems are appropriately controlled, and that we base decisions on trustable indicators.

Exacerbating the problem is the legacy of proprietary systems that often inhibit interoperability by design. The tool vendor's solution to interoperability is often that every agency should simply buy their system. Since IT will continue to progress, any system reliant on interfacing with other systems will be faced with the daunting (and expensive) challenge of maintaining and updating a growing number of evolving interfaces. Information security policies further exacerbate the challenge particularly when legacy systems contain unstructured (e.g. email) information that is difficult to filter so as to segregate the sensitive or urgent elements that need special handling or priority attention.

As more and more information sources (sensors, interoperable systems, etc.) become available, the value of the created network of information (Alberts, 2000) can either be harnessed for benefit (a network-centric enterprise) or ignored at peril (Brady, 2009).

THE MASAS SOLUTION

Incident management system and information providers have a common challenge - how does one move information across multiple unique system interfaces and through firewalls each of which are inherently in a constant state of change as technologies and security requirements continue to evolve. Based on an environmental scan of this domain we determined that there are two basic configurations to multi-agency information exchange architectures. One can either establish interfaces with all entities with which there is a need to exchange information (a peer-to-peer approach) or adopt a spoke and hub arrangement where a 'data aggregation' system provides a common repository of structured information from which collaborating entities can feed and/or pull information. The former approach is inherently challenged by the need to manage multiple changing interfaces and the constant possibility that valuable new information sources may become available, unbeknown to potential users. These inescapable deficiencies in a peer-to-peer construct make the preferred solution relatively obvious, providing some of the deficiencies with hub and spoke can also be mitigated – the most significant being that the hub must be accommodated within a highly robust and disaster resilient environment (lessons learned from Hurricane Katrina). The MASAS architecture is also being augmented to low distributed hubs, which will allow for increased resiliency.

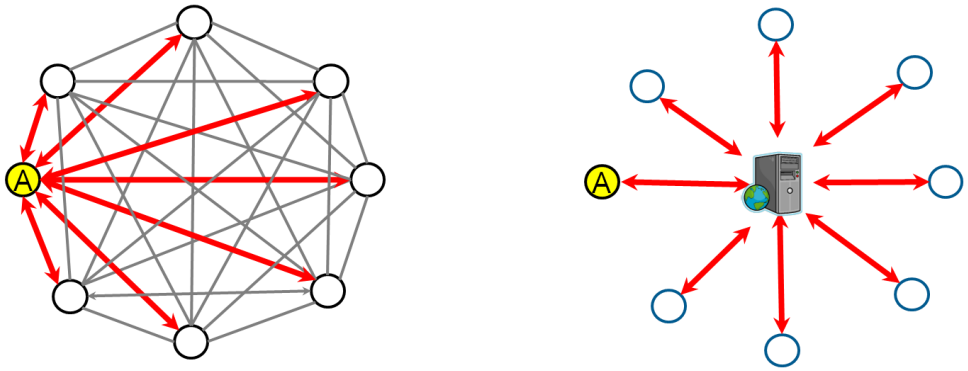

Figure 1. A peer-to-peer information exchange architecture requires maintaining a growing number of ever-changing systems interfaces and risks missing new information sources that may arise. Data aggregation hub based architecture simplifies the number of interfaces and the cost of integrating new data sources.

Recognizing that the inability to connect the incident management tools across Canada was greatly hindering emergency responder interoperability, the Government of Canada is demonstrating progress with a solution that will facilitate interoperable communications amongst all of these situation awareness tools while providing an interface for agencies without such tools. In 2009, CSS began the development of a Multi-Agency Situation Awareness System that would pursue the data aggregation hub approach to information exchange for emergency management. Building upon concepts and experiences developed with New Brunswick Emergency management through a National Resources Canada GeoConnections Program, the Centre for Security Science (CSS) undertook in 2009 to advance the development of a Multi-Agency Situation Awareness System that would explore the data aggregation hub approach to information exchange for emergency management.

The New Brunswick (NB) experience was further stimulated in part, by the tragedy of a 14 year old boy (Brady, 2009) who had died of respiratory failure because emergency medical services responding to the incident were unaware of road closures during a spring flood – information that could have been assembled from a number of sources, but not from a single aggregated collection. Incidents such as this and the annual threat of severe flooding have prompted NB emergency management officials to work at improving their ability to acquire and disseminate the necessary situational awareness. It is one of the reasons NB emergency management officials are recognized nationally as leaders in the domain. Further analysis of information requirements during several successive NB floods have highlighted that the great majority of information useful to emergency managers has little or no sensitivity. The combination of these two observations and the disadvantages of supporting a peer-to-peer system intuitively led to our selecting a common data aggregation hub as the most viable solution for MASAS.

Given a means to expedite information sharing, how can MASAS help with the information overload problem? The work of Eppler and Mengis in the field of information overload is instructive (Eppler & Mengis, 2004) and so we considered their framework of causes of information overload and which aspects might be mitigated by the use of MASAS:

Causes of Information Overload*		Mitigating Aspects of MASAS
Personal Factors	Inadequate IT skills and experience. Slow to adapt to using IT. Insufficient ability to screen information. Decision scope and documentation needs.	Simple basic tools – ~1 hour training. Able to use current (familiar) tools. Structured, filterable information facilitates automated screening. Geo-referenced MASAS supports visual presentation. Accommodating hyperlinks and attachments (situation reports, pictures etc) adds content relevant to incident.
Information Characteristics	Ambiguity, novelty, complexity of (unstructured) information.	Structured, simplified message standard (Common Alerting Protocol). Exclusively authoritative (trustable) information sources.
Task & Process Parameters	The less a process is based on reoccurring routine and the more complex it is in terms of the configuration of its steps, the higher the information load and the greater the time pressure.	MASAS integration allows operators to maintain their legacy systems. No need to change current tools. Suitable for daily routine use.
Organizational Design	Hierarchical centralization bottle necks. Accumulation of information as a means to demonstrate power. Slow update of new information and communication technologies	Share non-sensitive information with all stakeholders at same time (real time). Share non-sensitive information with all that determine they have a need to know
Information Technology	Information push systems. Email, intranet, extranet, internets. Multiple distribution channels for the same content.	Customized information pull. Receive only the information you need to see and in your own tool. Transport information through structured, filterable and geo-tagged information 'envelopes'.

*Excerpt from Table 3 of *'A Framework for Information Overload Research in Organizations'*, 2003. (Eppler & Mengis, 2003)

Building from lessons learned in New Brunswick (Stewart, 2010) and additional research conducted by CSS (summarized at the end of this article), MASAS development has advanced steadily and is now recognized nationally (Communications Interoperability Strategy and Action Plan for Canada, 2011) and internationally (CA/US Beyond the Borders Action Plan, 2011). The 2011 Manitoba flood season provided an opportunity to immediately engage MASAS in a real operational scenario (Fig 2) and validate ease-of-implementation assertions under worst case conditions i.e. during an actual crisis response. With a very brief online training session emergency management officials in Brandon Manitoba were successful in populating and sharing invaluable road closure information through MASAS. MASAS achieved its initial national operating capability as an information exchange system, in November 2010 through the MASAS Information Exchange Operations service and is now being engaged by most federal, provincial and territorial emergency management agencies in Canada and numerous municipal organizations that are becoming operational with it during the early part of 2012.

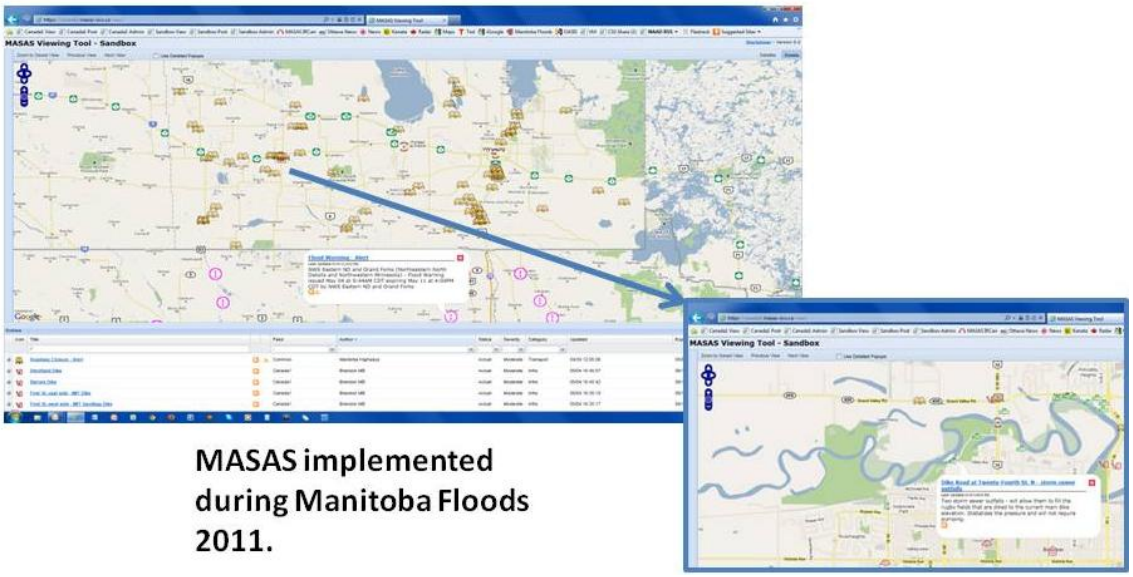

Figure 2. As evidence of MASAS ease-of-use, MASAS was rapidly brought into operational use during the peak of the Manitoba flood season in 2011. Illustration shows a screenshot of the basic viewing tool, MASAS viewers are also available for free through other platforms such as ESRI Flex. A common alert of interest, particularly during a flood are road closures. Also of high interest are first responder initiated incident alerts and automated weather alerts and warnings. The number and types of alerts and warnings that can be included in MASAS are virtually limitless.

KEY DESIGN PRINCIPLES

Geolocate All Incident Information: Emergencies happen "somewhere". Hence to add context and relevance to information, MASAS requires all information be tagged to a location using open international standards such as the Common Alerting Protocol - Canadian Profile (CAP-CP Working Group, 2010) and GeoRSS. Canada is widely recognized as a leading nation in the implementation of CAP which appears to be the result of a comprehensive event coding scheme and the addition of an event location which supports accurate placement on a map.

Open Source API, Posting and Viewing Tools: Maximize Interoperability and Leave No-one Behind To assist the development of MASAS-enabled capabilities, CSS has funded the creation of two sets of open-source tools, available at Intellectual Resources Canada (http://tbs-sct.ircan-rican.gc.ca/). These tools have been integrated into multiple open-source and commercial software as final or transitional capabilities. The tools serve two mutually beneficial purposes: they provide basic tools for emergency managers that don't have their own systems; and they provide working examples of integrations for other developers to use as exemplars.

Simplify Systems Integration: MASAS provides a basic, RESTful API, based on the popular AtomPub (IETF, 2007) protocol, for systems to publish and consume information. The use of geospatial/GeoRSS and Common Alerting Protocol messages contribute significantly to MASAS' functionality. The concept is simple: MASAS provides an "envelope" for the data (an Atom entry with MASAS specific tags) and allows data to be inserted into this envelope. For Common Alerting Protocol (OASIS, 2010) messages a document type is specified and supported explicitly. The system fills out the MASAS entry for the publisher, based on information contained in the CAP message. Multiple commercial and open-source integrations have been realized to date with integration costs averaging only 1-2 weeks for full, production-quality code. Early efforts indicate that data can flow within hours of integration - the bulk of the work required being in the User Interface/User Experience side of the integrated applications.

Central Stewardship - not Centralized Control: The Canadian government will likely continue to serve as steward for the core MASAS architecture to ensure that it maintains its focus on interoperability and addresses the needs of the emergency managers it serves nationally. With adequate measures in place to maintain configuration alignment, the need for centralized control of the system diminishes. Further, evidence in the literature points to the desirability of a non-centralized management of any such information sharing system (Savard & Stevens, 2010).

Modify Stove-piped Information Flow – Share it Once with All: As with most nations having layered levels of government, Canadian emergency managers are often bound to adhere to a typical hierarchical information flow-path. Information flows from first responders at the municipal level to successively higher levels of

government, largely as dictated by the nature and scope of the emergency and by legislation and policy. Figure 2 shows a conceptual workflow that involves multiple jurisdictions.

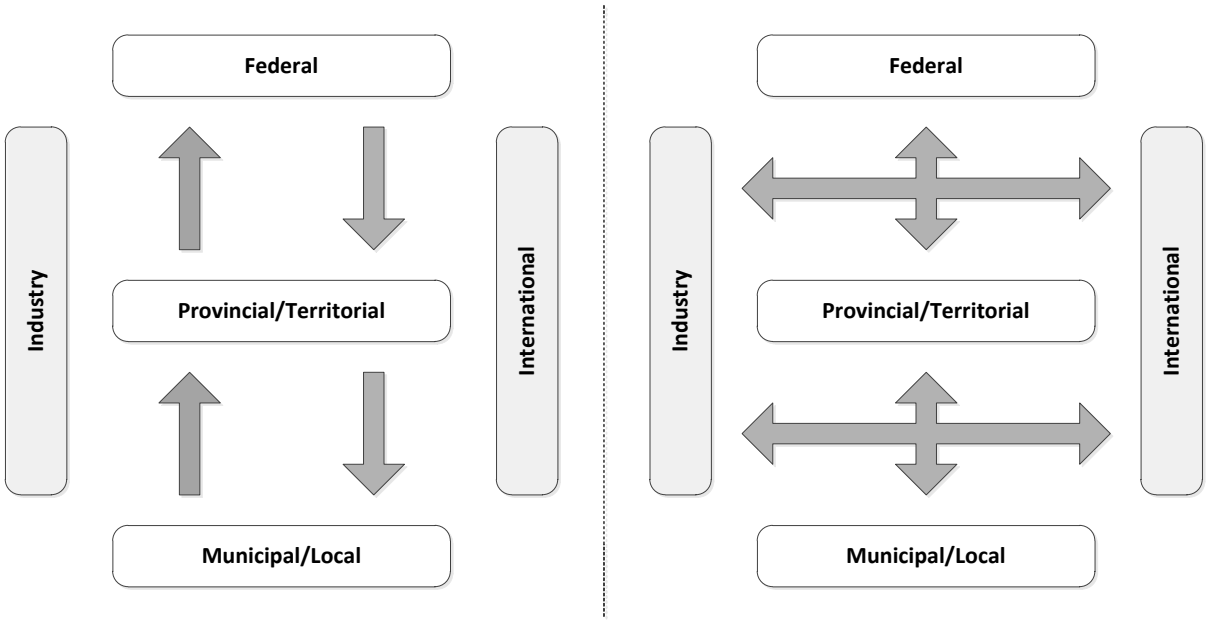

Figure 3 - Information Flow Models comparing non-MASAS (left panel) and MASAS-enabled (right).

Information flow using traditional means (email, phone, fax, etc.) follows a serial path from first responder up through the Canadian government (local → province/territory → federal). At each step of the communications pathway, human intervention is typically required to either repackage or add data. This pathway results in substantial time delay. In MASAS, information is shared simultaneously across all members of a particular MASAS Hub. Though policy and legislation may prevent a higher-level government agency from jumping in immediately they are at least able to begin "leaning forward" (anticipatory actions) by preparing a response in the event that they are needed.

In the event, for example, of a terrorist-delivered chemical agent attack, information would generally originate with the local first responders and pass to their own services (police, fire, and medical), then to the local authority EOC. From there information would be relayed to the provincial then federal levels. The amount of time that this process takes imposes significant delays in preparing a coordinated response. Using MASAS allows any interested party to access raw non-sensitive information immediately, facilitating shared situational awareness and collaboration. Supporting organizations can "lean forward" (anticipate calls for assistance). This should result in a more rapid and coherent response. Information can be filtered to ensure that organizations receive the information that is relevant to their successful management of an emergency instead of relying on other agencies assumptions of what is relevant to them (Mendonca, Jefferson, & Harrald, 2007).

MASAS DESIGN CONCEPT - KEEP IT SIMPLE

Emergency managers are used to dealing with confusion and uncertainty. They deal with them by using simple tools to order information: maps with pin-up notes or markers to annotate and share "what is happening and where"; clipboards and paper for information logs and Situation Reports (SITREPs); and phones, fax, radios, and email to get the information in and out. Conceptually MASAS enhances the capability to serve similar functions, but to do so much more efficiently. Figure 4 shows the collaborations that occur with a multi-agency and multi-jurisdiction environment. MASAS is being used at various levels to enable information exchange in parallel fashion. Information from the front line First Responder can be made available simultaneously at the federal, provincial-territorial, and/or municipal levels if desired. For example a terrorist related event,

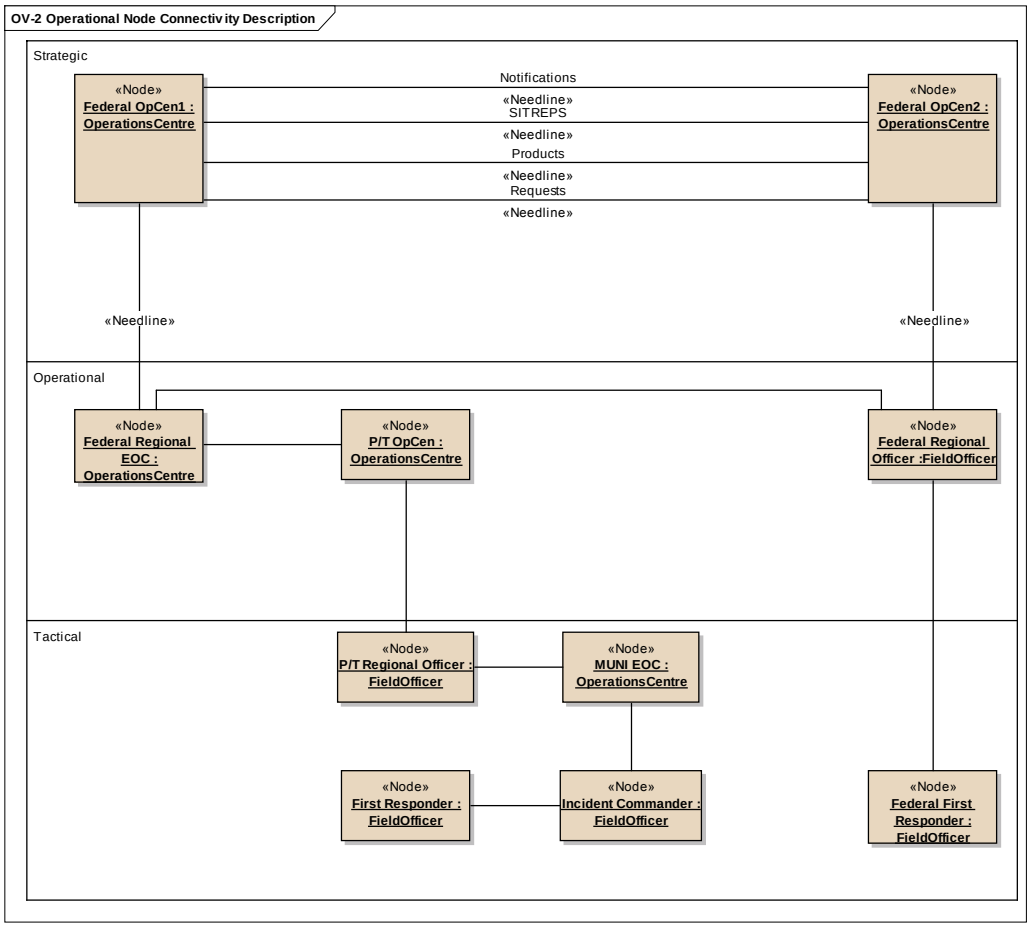

Figure 4 - Multi-Agency & Multi-Jurisdiction Information Sharing Pathways

by default will attract immediate interest at the federal level, while other more routine municipal level emergency information would be filtered from view (e.g. local road closures are rarely severe enough to be of interest at the federal level). The use of filters and tags from the community provide a collaborative filtering capability (Goldberg, Nichols, Briam, & Douglas, 1992).

Map with Pushpins - During a crisis, a map provides an incredible situational awareness capability (Kevany, 2005). The information that is attached using pushpins, markups (drawings on map), and the notes that are related are valuable. The problem is that all groups involved need to see the map, which requires constant face-to-face meetings around that map - and not everybody can be there. In any significant crisis this means that many key parties aren't able to share and maintain SA. Simple data such as road-closures and extreme weather alerts can be shared via MASAS through the use of geotagged information in a format that is readily accessible by a wide variety of tools and with any electronic mapping data layer.

Structured Information - The sharing of SITREPs has become the norm between EOCs in Canada. It provides a means to update SA and align plans. Information is shared, usually through a PDF report that is emailed. This provides rich but unstructured source of information. However any larger organization that collaborates with many other organizations can quickly become inundated by hundreds of pages of information. Undoubtedly there is value to some information in those SITREPs, but often key pieces may be obscured amongst the noise. MASAS allows and enforces a degree of structure to time-sensitive information (through the CAP-CP standard). This allows groups to filter out the noise, and focus on information that is relevant to them in a timely manner. Basic information categorizing the urgency and relevance of the incident and 1-2 paragraphs describing a situation, shared amongst a broad community imparts meaning to participants (Randall, 2011).

Information Collection and Dissemination – sharing it once for all to use becomes possible through the use of a centralized data aggregation hub. This allows for the rapid dissemination from information centres to the field (Savard & Stevens, 2010) and removes time-consuming and potentially error-prone manipulation of long lists of distribution addresses. Furthermore the common hub simplifies systems integration for user agencies by doing the engineering once for all to share through a single API.

MASAS OPERATIONAL EXPERIMENTATION

Special Access Hubs

In March 2010, multiple federal, provincial, industry, and international partners conducted a command-post exercise centered on a notional scenario involving seismic damage at the Point Lepreau nuclear power plant in New Brunswick. The challenge that this use-case faced is that national protocols for assessing a radiation event require that the sensor data be evaluated quickly by specialists to confirm the validity and determine the extent of the radiation hazard before any alert is broadcast further. In order to accommodate this requirement, the stakeholders, ranging from scientists, military, police, and emergency managers were provided the ability through MASAS to exchange information in restricted-access data hubs. This experiment (DRDC/CSS, 2011)demonstrated the need for "Special Access Hubs - a capability analogous to the break-out rooms that are used in most EOC environments where the incident commander may decide that a sensitive situation merits a sidebar discussion by a smaller group of specialists, prior to opening up to the broader team.

Central Gateway Exercise

During the spring of 2011, multiple municipal, county, provincial, and federal agencies from Canada and US participated in a joint exercise called the Central Gateway Exercise (CBC, 2011). The event included a simulated terrorist scenario involving an explosive device located on the international bridge between Detroit, Michigan and Windsor, Ontario. The key finding (Sutton, 2011) relating to MASAS usage in this exercise was that, given the volume of local information being shared, higher levels of government run the risk of being inundated in a flood of information. Because MASAS uses structured information in the form of Atom Entries and CAP messages, this torrent of information can be filtered easily. This enables a long-desired collaborative information tailoring and filtering capability (Goldberg, Nichols, Briam, & Douglas, 1992). The exercise also illustrated the value of having information automatically fed onto a map allowing observers to associate incidents occurring 70 km away at another bridge crossing might have relevance that would not normally have been noticed.

CAUSE Resilience West Coast

A joint Canada-US initiative called the Canada US Enhanced (CAUSE) Resilience experiment was held in June 2011 on the West Coast of Canada (Childs, 2011). This series of systems integration experiments included showcasing how MASAS could be interfaced with an equivalent system in the US called the Integrated Public Alerting and Warning System (IPAWS). As a result of this experiment series, MASAS has now been formally connected to IPAWS (Pagotto, 2011). This experiment also demonstrated that with very little effort, key information like the federal earthquake feeds could be engineered in a matter of a few weeks to interface through MASAS.

ON-GOING MASAS RESEARCH

While still relatively nascent, the opportunities for building new capabilities upon the foundation of information exchange services that MASAS is currently providing are exciting, some examples are listed below:

Information Flow: Research is required to investigate the psychosocial and organizational behavior impacts that will result from shifting the paradigm of information sharing from a very tightly controlled and hierarchical chain to one where all stakeholders can receive information at the same time. We have seen MASAS provide SA that can prompt a stakeholder to "lean forward" (prepare to act) in anticipation of a call for assistance. How will this affect incident command management constructs and what are the advantages and disadvantages in optimizing response and recovery efficiency?

Sensor Integration: With the increasing number of potential automated sensor information feeds, what standards and protocols should be applied to facilitate the transition of various sensor data into automated alerts and warnings (CAP)?

Precinct MASAS: While originally intended to provide SA on a geographically substantial area of interest, there is no reason MASAS could not be contracted and readily applied on a microcosm such as within an airport or port precinct for example. In Canada this concept is being explored by an airport authority and a federal government precinct in the downtown core of Ottawa. How well do MASAS constructs work at the micro level? How would the technology accommodate location in a multi-floor facility?

Mobile MASAS: How can a SA capability supported by MASAS best be deployed to mobile units including smartphone equipped responders? The human factors design of mobile devices and the policies and procedures best suited for implementing MASAS-enabled devices to offer direct support to front line responders is the subject of at least one CSS study in Canada that is being lead out of the Lambton County and City of Sarnia.

Decision Support - Visual Analytics: MASAS will enable an increased number of information sources, all of which will be presented visually on a map - the emerging science of "Visual Analytics" poses many promising avenues to pursue with a view to simplifying the presentation of this increasing richness of content available to the EM. An immediate requirement relates to the selection and application of map symbology to offer best fit and satisfy the diverse variety of emergency management and public safety officials that are using MASAS. We are also assessing the ability to include alerts and warnings of weather conditions based on prediction models that look weeks if not months into the future – how can this new information be presented clearly on a map so as to enhance SA rather than add to information overload?

Enhancing Incident Relevant Information Sharing through MASAS: First responders and emergency managers rely heavily on gathering basic SA from the public during an incident so as to assess their state of need and appropriately prioritize the deployment of response resources. Information such as "*Where are you and are you ok?", and "what do you need?"* is critical yet difficult to gather quickly and efficiently. Similar queries are exchanged between partnering agencies -- "*What do I have that* you need?", "*How can I help*?". These simple yet critical questions currently consume an inordinate amount of effort through communications over radio, telephone and email. MASAS information exchange services and emerging messaging standards can enable capabilities to address this information flow much more efficiently through a geospatial interface.

Social Media for Emergency Managers The emergence of Twitter and related social media poses a still untapped resource. How can emergency managers capture and exploit community derived information in a manner that can inform and support decisions? An interesting analogy is that this new community is equivalent to the *new age HAM radio volunteer operators*. EOCs have historically made special exception for HAM radio operators to be part of the EOC team, some to the point of installing radio centres and inviting HAM radio operators into the EOC. How can we take advantage of volunteer mappers and their interest in mining social media so that we can bridge trustable and decision-supporting information into a MASAS environment?

CONCLUSION

In summary, while empirical data to comprehensively assess the impact MASAS is having on national situational awareness is still being collected, it is encouraging to see the rapid uptake of MASAS information exchange services. In just 6 months after declaring initial operating capability more than 120 public safety stakeholder agencies (including approximately 10 of 13 provincial/territorial emergency management agencies) with local to national and international scopes of interest, from coast to coast to coast, and across borders have registered and initiated staff training and transition to operational use. Significant evidence of the ease-of use and value to operations was provided by two emergency management agencies (Manitoba and Yukon) that successfully put MASAS into operational use during the peak of their response to flood emergencies in 2011. This rapid and all inclusive move to a new communications paradigm may be unprecedented. While still embryonic in terms of experiential evidence, the rapid uptake by practitioners and vendors alike strongly suggests MASAS is already measurably improving situational awareness and cross-jurisdictional information sharing. However until our assessment studies are complete we can only conclude that MASAS appears to be filling a national capability gap. Canada and the US are now able to share messages between developmental systems, and MASAS has been officially accepted as offering a national solution to improving interoperability amongst Canadian emergency management and with bordering agencies in the US. The 'perception' dimension of SA is being well addressed; we now must turn our attention to developing national interoperable capabilities that build on this to enhance 'comprehension' and 'projection'.

ACKNOWLEDGEMENTS

The authors would like to extend thanks to the MASAS National Implementation Team Members: Richard Moreau and Kelly Morris of the Public Safety Canada Interoperability Development Office; Phil Dawe, Ken Marshall, and Yannick Blain of Natural Resources Canada; Jacob Westfall (NetAlerts), Doug Allport (Allport Group), and many others that work on MASAS in the background, making it the success that it is thus far.

BIBLIOGRAPHY

Communications Interoperability Strategy and Action Plan for Canada. (2011, January). Retrieved from Public Safety Canada: http://www.publicsafety.gc.ca/prg/em/_fl/cisc-eng.pdf

MASAS Information Exchange Operations services. (2011, Nov 04). Retrieved from www.masas-x.ca

UNITED STATES–CANADA BEYOND THE BORDER ACTION PLAN:A SHARED VISION FOR PERIMETER SECURITY AND ECONOMIC COMPETITIVENESS. (2011, December). Retrieved from Embassy of the United States. Ottawa Canada: http://photos.state.gov/libraries/canada/303578/pdfs/us-canada-btb_action_plan.pdf

Alberts, D. S. (2000). *Network-Centric Warfare* (2nd ed.). DoD C4ISR Cooperative Research Program.

Brady, R. (2009). *Inquiry Into the Events Affecting Ambulance Service on April 2, 2009 in Fredericton Junction*. Fredericton: Ministry of Health and Long-Term Care - Emergency Health Services Branch.

CAP-CP Working Group. (2010, October). *CAP Canadian Profile v0.4 ((see also National Common Alerting and Notification Protocol. Public Security S&T Summer Symposium 2011 Proceedings. Accessible at http://www.css.drdc-rddc.gc.ca/publications/symposium/2011/PSTP_02-0327EMSI-eng.asp)*. Retrieved from CAP-CP Working Group: http://capan.ca/uploads/CAP-CP/CAP-CP_Intro_Rules_Beta_0.4.pdf

CBC. (2011, 02 22). *Windsor Emergency Response Training*. Retrieved from http://www.cbc.ca/news/canada/windsor/story/2011/02/22/windsor-emergency-response-training568.html

Childs, P. (2011). *CAUSE Resilience West Coast Final Report*. Ottawa: Centre for Security Science (in press - will be publicly accessible at http://drdc-rddc.gc.ca by May 2012).

DRDC/CSS. (2011). *Multi-Agency Situational Awareness - Standard Access Methodology*. Ottawa: Defence Research and Development Canada (in press - will be publicly accessible at http://drdc-rddc.gc.ca by May 2012).

Endsley, M. R. (1995). Toward a Theory of Situation Awareness in Dynamic Systems. *Human Factors, 37*(1), 32-64.

Eppler, M. J., & Mengis, J. (2004). The Concept of Information Overload: A Review of Literature from Organization Science, Accounting, Marketing, MIS, and Related Disciplines. *The Information Society, 20*(5), 325-344.

Eppler, M., & Mengis, J. (2003). *A Framework for Information Overload Research in Organizations*. From Universita Della Svizzera Italia, Lugano Switzerland: www.bul.unisi.ch/cerca/bul/pubblicazioni/com/pdf/wpca0301.pdf

Goldberg, D., Nichols, D., Briam, M. O., & Douglas, T. (1992). Using Collaborative Filtering to Weave an Information Tapestry. *Communications of the ACM, 35*(12), 61-70.

IETF. (2007, October). *The Atom Publishing Protocol*. Retrieved from http://datatracker.ietf.org/doc/rfc5023/

Kevany, M. J. (2005). Lessons from 9/11. In P. van Oosterom, S. Zlatanova, & E. M. Fendel (Eds.), *Geo-Information for Disaster Management* (pp. 443-464). Springer.

Mendonca, D., Jefferson, T., & Harrald, J. (2007, March). Collaborative Adhocracies and Mix-and-Match Technologies in Emergency Management. *Communicatons of the ACM, 50*(3), 45-49.

OASIS. (2010, July 01). *Common Alerting Protocol v1.2*. Retrieved from http://docs.oasis-open.org/emergency/cap/v1.2/CAP-v1.2.pdf

Pagotto, J. (2011, 11 16). *FEMA IPAWS Approves COG for MASAS*. Retrieved from http://tbs-sct.ircan-rican.gc.ca/news/1082

Randall, T. (2011). *Analysis of Requirements for Tools to Support Inter-Agency Unclassified Collaboration for Emergency Management*. Dartmouth: Defence Research and Development Canada - DRDC Atlantic.

Savard, D. R., & Stevens, G. (2010). *Fusion Centers - A Canadian Perspective*. Quebec: Province of Quebec.

Stewart, M. A. (2010). *GeoConnections Geospatial Return on Investment Case Study: Multi-Agency Situational Awareness System (MASAS)*. Ottawa: Government of Canada - Natural Resources Canada.

Sutton, N. (2011, July 18). Operation Central Gateway. *Canadian Security Magazine*, pp. 18-21.