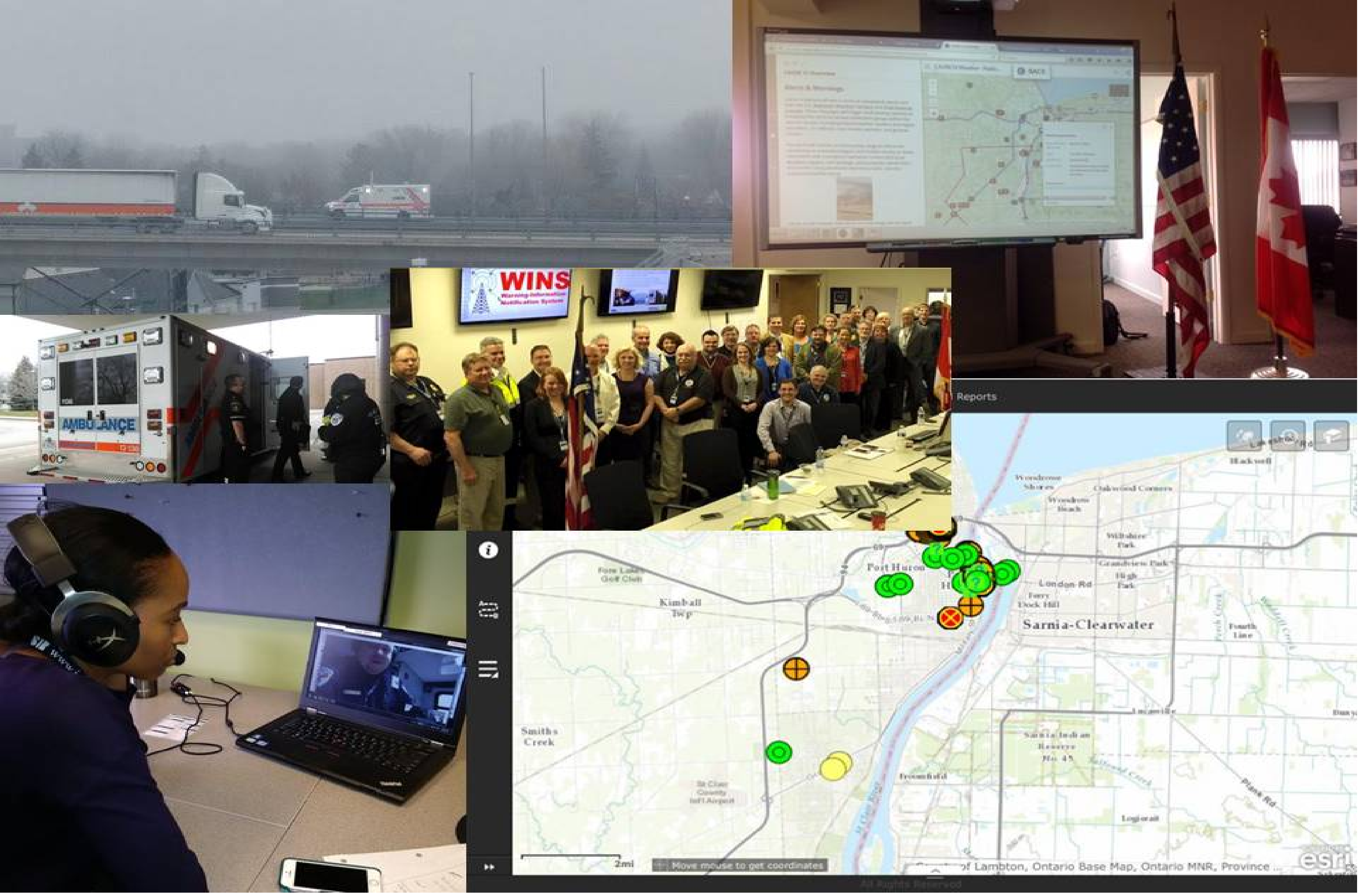

Canada – U.S. Enhanced Resiliency Experiment (CAUSE IV)

Binational After Action Report

June 2016

Homeland Security

Science and Technology

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Prepared for
Department of Homeland Security
Science and Technology Directorate,
First Responders Group

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Abstract

The Canada-United States Enhanced (CAUSE) Resiliency experiment series is a collaborative effort between Defence Research and Development Canada's Centre for Security Science (DRDC CSS), Public Safety (PS) Canada, and the United States (U.S.) Department of Homeland Security (DHS) Science and Technology Directorate (S&T) First Responders Group (FRG). This experiment series addresses the Canada-U.S. *Beyond the Border (BTB) Action Plan: A Shared Vision for Perimeter Safety and Economic Competitiveness*. Specifically, the CAUSE experiment series addresses the Canada-U.S. commitment to improve response coordination during binational disasters. To date, four experiments have been conducted within the CAUSE series. Each experiment shared alerts, warnings and notifications between emergency response organizations. The information sharing was enabled through existing and emerging interoperable technologies.

CAUSE IV was comprised of two vignettes, which evaluated the impact of technologies and applications on cross-border emergency response operations and medical operations. It was hypothesized that the use of the interoperable technologies would lead to improvements in the coordination of cross-border emergency responses.

The first vignette established two linked cross-border 700MHz Public Safety Broadband Networks (PSBN) to enable persistent communications between paramedic services, supporting healthcare organizations, border agents and bridge authorities throughout the entire patient transfer process. Several applications were used to support voice, video, and data communications amongst all participants during the simulated cross-border patient transfer. The second vignette used applications, such as mapping and information sharing tools, to support enhanced situational awareness (SA) and communications between emergency officials on both sides of the border during a simulated emergency response. The enhanced awareness aimed to increase the effectiveness of emergency response planning efforts, public warning and alerting, incident reporting, and the allocation of response efforts. The second vignette also used mapping tools to integrate information obtained from social media and other public domain sources, by engaging digital volunteers and 2-1-1 operators, and through crowd-sourcing.

The results indicate the interoperable technology can facilitate the exchange of cross-border voice, video and data communications, and support decision-making processes for local and cross-border response operations leading to enhanced community resilience. However, formal policies and procedures must be established to guide the appropriate use of these technologies to optimize their benefits.

Significance for Defense and Homeland Security

CAUSE IV involved two unique scenarios that are operationally significant within the defense and homeland security domain. It was identified that cross-border patient transfers pose their own security and patient safety risks for each country involved. The lack of formalized processes and restricted communications once across the border may cause officials to be suspicious of the use of ambulance services. A local mutual aid agreement for paramedics and formalized processes would minimize security risks by allowing for pre-screening of paramedics and promoting the transportation of legitimate resources across the border. Furthermore, the use of mapping and visualization tools to support SA, notifications to the public, and cross-border alerts would facilitate responders' ability to collaborate when responding to emergencies. The introduction of new data sources and publicly derived information via digital volunteers, 2-1-1 operators and publicly submitted damage assessments has the potential to improve response activities, both locally and cross-border through increased knowledge and situation awareness. The findings and recommendations contained within this report will help implement, refine, and improve processes and procedures that will support a wide range of emergency response operations and enhance resiliency of cross-border communities, as per the BTB Plan.

Acknowledgements

The design and conduct of this experiment was made possible through the support and dedication of numerous organizations. A sincere thank you is extended to all the participating organizations that helped make this experiment a huge success:

1. Introduction

1.1. CAUSE Experiment Series

The Canada-United States Enhanced (CAUSE) Resiliency experiment series is a collaborative effort between Defence Research and Development Canada's Centre for Security Science (DRDC CSS), Public Safety (PS) Canada, and the United States (U.S.) Department of Homeland Security (DHS) Science and Technology Directorate (S&T) First Responders Group (FRG).

The CAUSE experiment series addresses the Canada – U.S. *Beyond the Border (BTB) Action Plan: A Shared Vision for Perimeter Security and Economic Competitiveness*. One of the objectives of the BTB Action Plan is to support the development of binational plans and capabilities for emergency management to support rapid response and recovery on either side of the border. [1] This plan focuses on communications interoperability and chemical, biological, radiological, nuclear and explosives (CBRNE) events. The BTB Action Plan has established two cross-border working groups, including the Canada-U.S. (CANUS) CBRNE Working Group and the CANUS Communications Interoperability Working Group (CIWG). In 2012, the CANUS CIWG developed a five-year work plan with specific goals and activities, several of which are addressed through the CAUSE series.

The objective of the CAUSE experiment series is to demonstrate that improvements to shared SA and interoperable communications during emergency events can lead to enhanced community resiliency. Three scenario-based experiments preceded CAUSE IV: CAUSE I, CAUSE II and CAUSE III were conducted between 2011 and 2014 in various Canadian and American cross-border communities.

1.2. CAUSE IV Experiment

DRDC CSS, PS and the DHS S&T FRG collaborated in the development and conduct of the fourth experiment in the CAUSE experiment series, CAUSE IV, held on April 26-28, 2016, at the border crossing between Sarnia, Ontario (ON), and Port Huron, Michigan (MI). The experiment involved over 80 participants and represented over 25 separate organizations.

The CAUSE IV experiment involved two interrelated scenarios or vignettes. The vignettes were designed to evaluate the impact of interoperable communications and the sharing of alerts, warnings and notifications on SA during response operations, while using newly introduced technologies and applications. [5]

Vignette 1 was designed to establish and test cross-border 700 MHz Public Safety Broadband Networks (PSBN), while implementing the use of a variety of voice, video and data communications and information sharing between paramedics and all supporting organizations during the cross border transfer of a patient. A set of common applications was used in conjunction with the network for the purpose of increasing the communications, information access and sharing, and SA of the participating organizations during the cross-border patient transfer.

Vignette 2 was designed to test and compare a suite of mapping and notification tools during a large tornado event. These tools were intended to share alerts, warnings, and notifications both locally and cross-border to improve communications and SA between local governments and emergency management officials on both sides of the border. Digital volunteers and 2-1-1 operators from the U.S. and Canada were engaged to gather and synthesize data in support of emergency officials and their decision-making processes. These tools served to enhance the resiliency of these cross-border communities by improving their overall awareness of response operations and streamlining the necessary process for decision-making.

1.3. Report Objectives

This report documents the experimental design, control, conduct, results, findings and recommendations from CAUSE IV. The experiment was comprised of two distinct but connected scenarios, each of which was associated with a set of unique goals and objectives. This report summarizes the CAUSE IV objectives and results from both vignettes.

2. Experiment Design and Methodology

2.1. Participating Organizations

A variety of organizations participated in the CAUSE IV experiment during each vignette. Vignette 1 participants were primarily from organizations involved in the cross-border patient transfer process. They included members of the paramedic services, hospitals, border agencies and local bridge authorities. Vignette 2 participants were comprised primarily of members of local emergency operations centers (EOC), 2-1-1 operators and digital volunteers.

The following organizations played a key role in CAUSE IV:

Vignette 1

- Canada
    - DRDC CSS;
    - PS;
    - Communications Research Centre (CRC) Canada;
    - Lambton County Emergency Medical Services (EMS);
    - Wallaceburg Central Ambulance Communications Centre;
    - Canada Border Services Agency (CBSA);
    - Federal Bridge Corporation;
    - Bluewater Health;
    - Interdev Technologies; and
    - International Safety Research (ISR) (under contract of DRDC CSS).
- United States
    - Texas A&M;
    - Tri-Hospital Emergency Medical Services;
    - Lake Huron Medical Center;
    - Michigan Department of Transportation; and
    - U.S. Customs and Border Protective Services (CBP).

Vignette 2

- Canada
    - DRDC CSS;
    - PS;
    - Lambton County Emergency Management;
    - City of Sarnia EOC;
    - Sarnia Police Department;
    - 211 Ontario; and
    - ISR (under contract of DRDC CSS).

- United States
    - U.S. DHS S&T;
    - U.S. DHS Federal Emergency Management Agency (FEMA);
    - U.S. DHS FEMA Region V;
    - St. Clair County Homeland Security and Emergency Management (HSEM);
    - Michigan 2-1-1;
    - State of Michigan;
    - G&H International (under contract of DHS S&T); and
    - Spin Global (under contract of DHS S&T).

Members of the above organizations were involved in the experiment in varying capacities. The majority of participants were players, involved in using and testing the technology and applications within the context of the scenarios. A number of organizations performed additional roles or were responsible for the technical design, implementation and operation of the experiment. A brief description of these additional roles is provided below:

- **Vignette Leads:** Provided oversight of the design, development and execution of the experiment. Maintained awareness of overall experiment conduct:
    - DRDC CSS; and
    - U.S. DHS S&T.

- **Controllers:** Maintained awareness of experiment conduct at assigned locations and communicated with the control team on technical and operational aspects in their designated location:
    - Select members of participating organizations listed above;
    - ISR;
    - G&H International; and
    - Spin Global.

- **Evaluators:** Observed and evaluated the experiment conduct according to the evaluation guide and data collection tools at assigned locations:
    - Select members of participating organizations listed above;
    - ISR;
    - G&H International;
    - Spin Global;
    - DRDC CSS; and
    - U.S. DHS S&T.

- **Study Team:** Coordinated the overall evaluation process of the experiment. Following the experiment, completed the analysis of the collected data:
    - ISR.

2.2. Scenario Design

2.2.1. Vignette 1

Vignette 1 was Canadian-led and involved two separate experiment segments concerned with cross-border patient transfers, which took place over multiple trials. The experiment compared and contrasted existing and emerging technologies that enabled the real-time exchange of voice, video and data.

The first experiment (Vignette 1A) involved an inter-facility transfer of a patient from a Canadian hospital to a U.S. hospital to establish and field test a cross-border 700 MHz PSBN wireless capability, which enabled the simultaneous and continuous exchange of data. Vignette 1A began with the initiation of a cross-border patient transfer, including communications between the referring hospital, dispatch and the paramedic crew. In addition, an electronic copy of the Patient Transfer Form was transmitted to border officials, via the PSBN. (Figure 1) Throughout the experiment, ongoing communications took place between participating organizations as the ambulance progressed across the border. These communications included sending electronic patient records [i.e., electrocardiogram (EKG) and 12-lead strip] while en route, as the simulated patient's condition deteriorated. The experiment ended when the ambulance arrived at the receiving hospital, and all remaining electronic patient care records were transmitted.

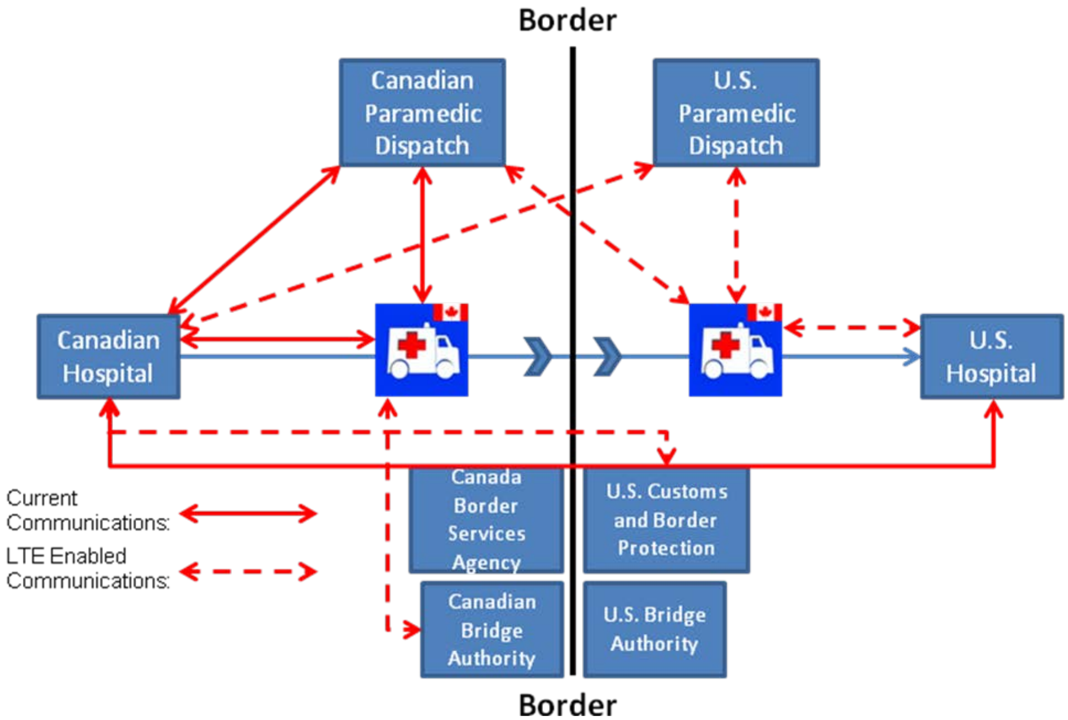

Figure 1: Communications between CDN paramedic and playing organizations during Vignette 1A CDN-U.S. patient transfer

To develop a realistic scenario for the experiment, information was generated to represent a deteriorating health status for the simulated patient, which in turn prompted the need to provide electronic updates to the receiving and referring hospitals. The following provides a summary of the patient's simulated status:

- 52 year-old STEMI (ST Segment Elevation Myocardial Infarction) patient with severe chest pain;
- The patient is transferred with a nitroglycerin IV drip; and
- The patient becomes unstable partway through the transit.

The second experiment (Vignette 1B) tested a concept referred to as 'service continuity,' or 'session persistence,' by establishing a real-time video conference that supported continuous cross-border communications and information sharing using applications over the long-term evolution (LTE) network. This video conference involved physicians from both participating hospitals and the paramedics in transit.

This second experiment did not consider the initiating steps of the patient transfer. It focused on establishing the multi-party video conference and maintaining the call persistence consistently throughout the entire transfer process. (Figure 2) This experiment did not require a pre-determined script, as the quality of voice and video was being tested, rather than the content of the video.

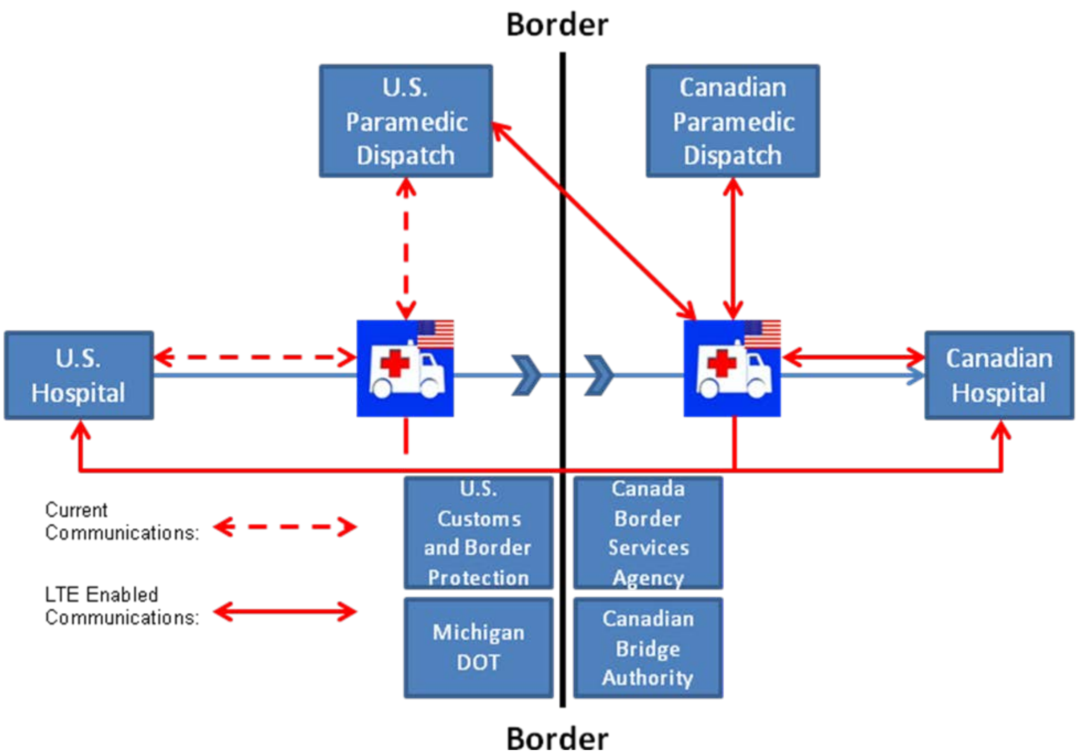

Figure 2: Communications between U.S. paramedic and playing organizations during Vignette 1B U.S.-CDN patient transfer

2.2.2. Vignette 2

This U.S.-led vignette built upon lessons learned and emerging practices that were tested as part of previous CAUSE experiments, and attempted to identify and target areas for new research and development. By design, CAUSE IV sought to address gaps not previously addressed during past CAUSE experiments and focused on consistent integration of the newly introduced technology with planning and operations. This vignette compared and contrasted existing and emerging social media technologies that enabled public alerting, warnings, notifications and cross-border requests for assistance and mutual aid during large-scale cross-border emergencies. Furthermore, this vignette tested a Canada-U.S. cross-border concept of operations (CONOPs), developed based on previous experiments in the CAUSE series, which included the involvement of digital volunteers and Canadian and U.S. 2-1-1 operators. These volunteers used social media to gather and synthesize data in support of traditional emergency management organizations.

One key addition to CAUSE IV Vignette 2, compared to previous experiments, was the inclusion of a planning phase of the emergency management life-cycle intended to examine how technology can improve planning for shared hazards in the border regions. As part of the CAUSE IV design, local alerting systems were tested alongside the binational test of the Integrated Public Alert and Warning System (IPAWS) and the National Public Alerting System (NPAS)/ National Alert Aggregation and Dissemination System (NAADS) since NPAS/NAADS is a comparable system to IPAWS. Rather than using national Virtual Operations Support Teams, as was tested in CAUSE III, CAUSE IV was designed to use the support of two local digital volunteer teams, one in the County of Lambton comprised of county staff volunteers and one in St. Clair County comprised of trained volunteers. Finally, since neither CAUSE II nor III tested the entire lifecycle of the Mutual Aid Support System process, CAUSE IV was designed to test and evaluate the entire mutual aid process. Its systems and policies that facilitate the escalation of requests from local to state and to international, cross-border mutual aid were evaluated.

The second vignette was designed with the use of a playbook that guided this part of the experiment and included 26 specific experiment events (Figure 3). There were six categories of events, including: Planning, Early Warning, Boom, Reporting, Local Response and Cross-Border Response, which were executed over two days of experimental conduct. [3]

CANADA-US ENHANCED RESILIENCY EXPERIMENT 4 PLAYBOOK

MASTER SCENARIO EVENT LIST, PROCESS FLOW DIAGRAMS, STEP BY STEP INSTRUCTIONS & LIST OF INFORMATION PRODUCTS

Unique ID	Experiment Objective	Event Description	Inject Mode	Responsible Actors	Recipient Player	Expected Action - Outcome of Player Action	Information Requirements	Sharing Requirements
Planning - 2	Cross-border planning for mutual assistance	St. Clair County Hazard Plan	Mutual Aid Planner App	HSEMA Planners	SCC Operational Personnel	Develop and share plans in the Mutual Aid Planner app; integrate results into operational GIS	Core Capabilities List; Resource needs; resource shortfalls; resource partners	Share within U.S.

Step 1: St. Clair County Convenes Local and County Planners
Step 2: Planners jointly build and validate hazard plans
Step 3: Build the enter plan in the Mutual Aid Planner App, visualize the plan

List of Information Products:
Mutual Aid Planner (U.S. & Canada) http://bit.ly/1SabTM1

Figure 3: Sample page from the CAUSE IV Playbook

The scenario used for Vignette 2 started with the issuance of severe thunderstorm warnings by the National Weather Service (NWS) and Environment and Climate Change Canada (ECCC).

During these early warnings, participants used a series of applications to monitor the progressing emergency, alert the public and share information with their designated counterparts across the border. Following these early warnings, the scenario indicated that an Enhanced Fujita (EF)-4 tornado touched down in the U.S. city of St. Clair and St. Clair Township, before continuing across St. Clair River into Sarnia, Ontario (Figure 4).

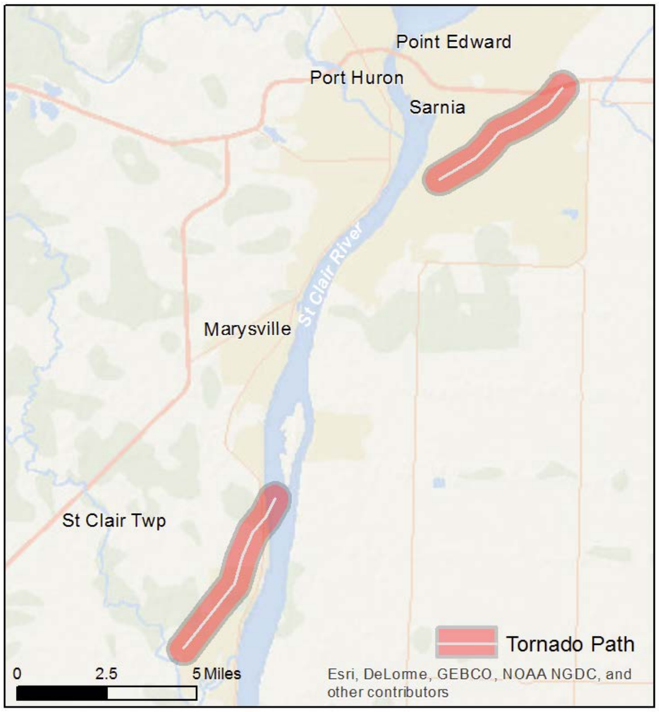

Figure 4: Vignette 2 Tornado Track

Local alerts on both sides of the border were sent to custom notification groups established for the purposes of the experiment (Figure 5). These notification groups represented government officials, digital volunteer groups, trained weather spotters, dispatch, 2-1-1 call centers and the public.

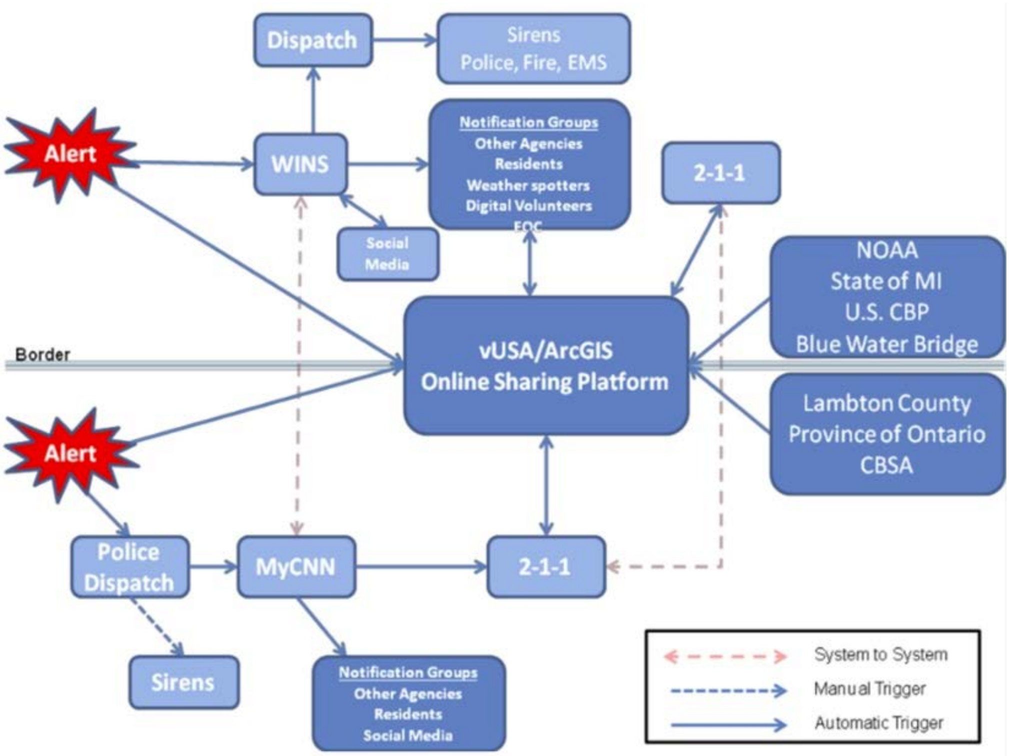

Figure 5: Local alert, warning and notification workflow diagram

CAUSE IV evaluated several different systems used to propagate alerts, warnings and notification (AWN) messages. Table 1 describes the different types of alerts sent through each platform, the associated advantages and disadvantages of each, based on the results of discussions with the WINS/MyCNN administrators participating in the experiment.

START Here- Table 1: Alert/Warning Comparison and Trade-off Matrix

Alert Type	Advantages	Disadvantages
Platform: Everbridge (MyCNN, WINS)		
Opt-In Notification	Ensures targeted messaging to subscribers using preferred method(s) of communication. Can issue request for response to the receiver.	Potentially omits populations in critical need of alerts. May falsely send alerts to registered individuals even if they are not in the impacted area at the time of the event.
Notification of citizens from White Pages	Readily accessible and static list of contacts.	Updated annually and does not include mobile phones. Does not alert individuals if they are not physically in the affected area.
Targeted Notification Groups	Enables targeted alert messaging to closed groups.	Requires planning and coordination to identify participants; unintentional omissions.
Social Media (e.g., Facebook, Twitter)	Enables broad user base that otherwise might not subscribe to an alert or be listed in the White Pages.	Public agency social media accounts do not typically have many followers.
Platform: FEMA IPAWS and NPAS/NAADS		
Collaborative Operating Groups (COG)-to-COG	Enables targeted official-to-official alerts with respect for alerting authorities in neighboring jurisdictions.	Difficult to configure, many technologies are not configured to enable COG-to-COG and operational processes to use this information are not widely vetted.
Emergency Alert System (EAS)	Enables emergency alert broadcast on radio, TV and other mediums.	The percent of population using these mediums (e.g., TV/radio) as a primary source of information is diminishing.

Alert Type	Advantages	Disadvantages
Wireless Emergency Alerts (WEA)	Enables alert messaging to cell phones.	Limited distribution by jurisdiction types; no ability to test. NPAS/NAADS does not currently support WEA-type alerts except to cell phones registered with these systems.

Following the simulated touchdown of the tornado, participants were prompted to use the various mapping applications to track damage, identify areas of immediate attention and track response actions. Digital volunteer teams were activated to monitor social media for information requirements that were pre-defined by emergency management staff. In response to the tornado, 2-1-1 operators received simulated calls for service and the reports were shared with their respective local EOCs.

On the second day of the experiment, local response organizations had damage assessment teams validate reporting of damage through direct observation. The information gathered by damage assessment teams was used to inform requests for assistance that originated locally, and then escalated to state, and then to international, cross-border assistance requests, where appropriate.

Throughout the experiment, the EOC personnel and digital volunteers made use of social media and crowd-sourced data to assist with response efforts. CAUSE IV tested whether integrating digital volunteers and 2-1-1 call centers into EOCs provides more actionable information to support operations. The specific concepts tested during the experiment are depicted in Figure 6 below.

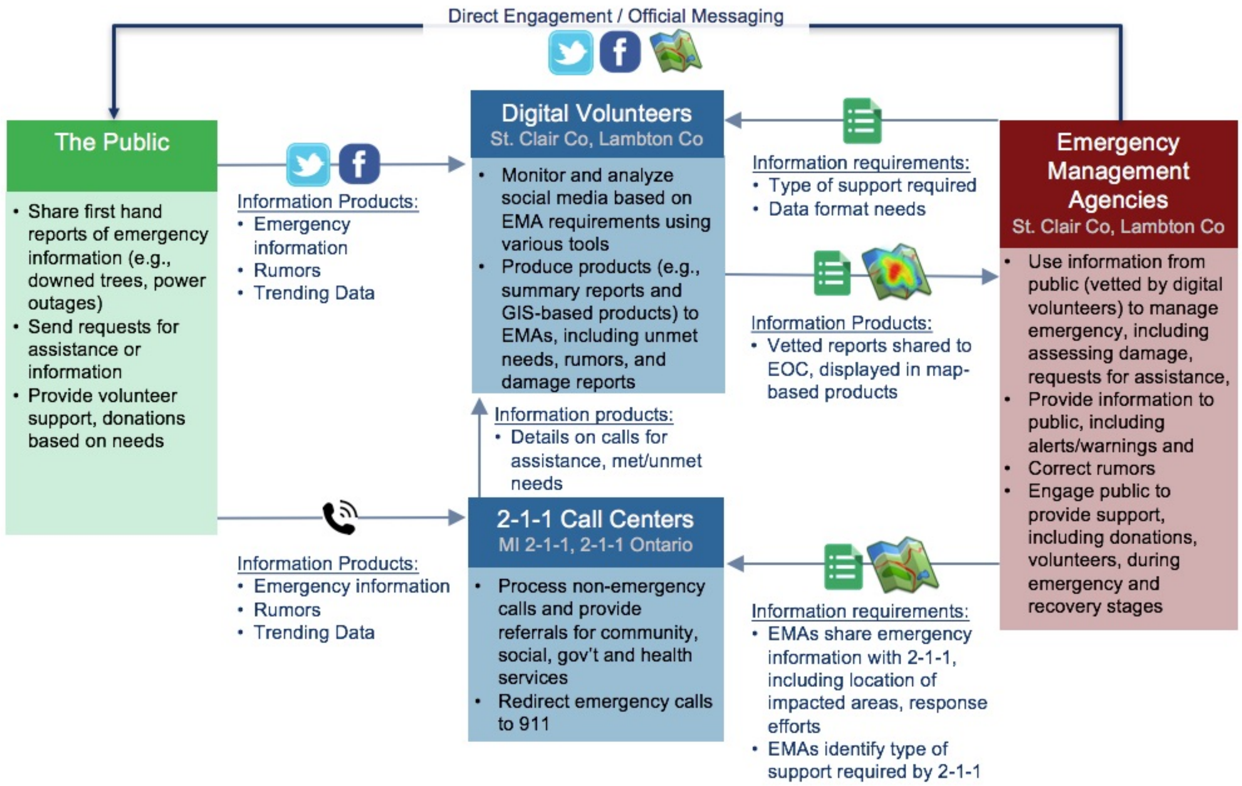

Figure 6: Social media and 2-1-1 workflow diagram

The experiment concluded with a facilitated tabletop discussion focused on international mutual assistance, with participants in Michigan and Ontario.

It should be noted that most of the tools and technologies used throughout the experiment were already in place and within reach in both St. Clair County and Sarnia. However, these technologies are not widely in use beyond a limited number of technical specialists, nor are they used in an integrated way. This is primarily due to the technologies being relatively new and a lack of training opportunities for staff.

2.3. Technology Use at Physical Sites

In CAUSE IV, both vignettes used several technologies and applications to support their cross-border operational and communication needs.

Vignette 1 focused on the implementation of two PSBNs that enabled the use of software applications to maintain cross-border communications, while ambulances transited across the border. Many of the applications that were used to promote voice, video and data communications were examples of the types of common applications that are openly available. Broadband networks enabled these applications (Figure 7). Additional applications were evaluated to determine their capability to support improved SA and interoperable communications during a patient transfer and its effect on the overall process and patient care. These applications included two separate Automatic Vehicle Location (AVL) programs, as well as an application (iMedic GenII) for the updating and transmittal of patient care records and 12-lead strips.

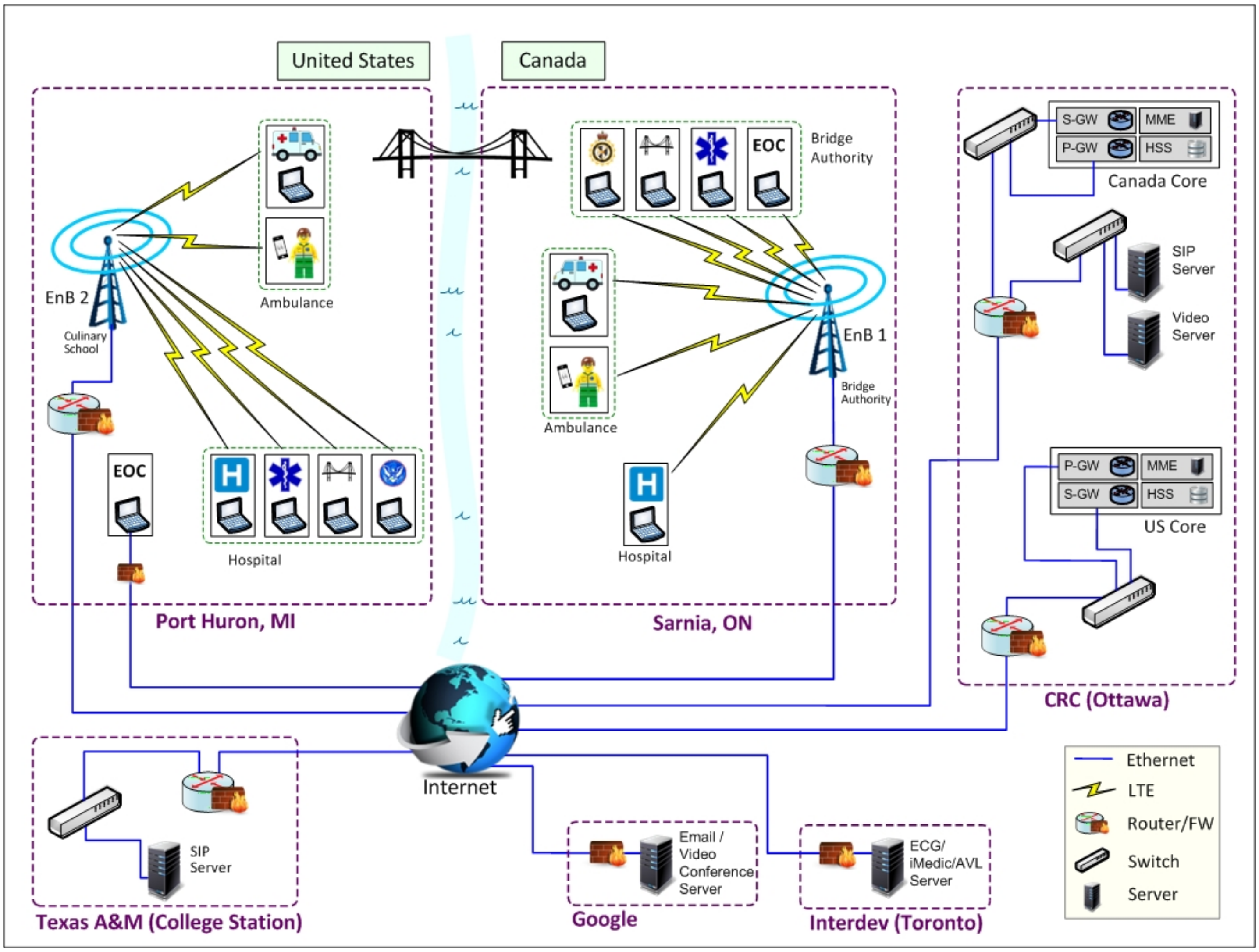

Figure 7: Vignette 1 system level diagram

Vignette 2 focused primarily on the use of resource planning applications, social media platforms, geographic information systems, records management systems, and alert and warning applications to plan for and respond to a large-scale cross-border emergency. These applications facilitated the sharing, visualization and streamlining of a large data set to all Vignette 2 participants in numerous physical locations. A full list of the technology and applications that were involved in CAUSE IV, as well as their intended usage as part of the experiment, is presented in Annex A.

2.4. Evaluation Process

2.4.1. Overall

A three-phase evaluation framework supported by a set of data collection tools was designed by the experiment study team with input from CAUSE IV Vignette Leads. The evaluation framework addressed the CAUSE IV objectives and was used to guide the data collection needed to measure the impact of the interoperable technologies on the cross-border emergency management responses. Data collection tools were developed for use by players as well as for designated members of the participating organizations who were identified as experiment evaluators. Data collection tools gathered both observational data from evaluators and subjective data from the players at designated times prior to the experiment, during experimental conduct and following the experiment. [5]

2.4.2. Vignette 1

Phase 1: Prior to the start of the experiment, study team members conducted interviews via teleconference with Vignette 1 participants from key organizations that are involved in a cross-border patient transfer. Participants were selected based on their unique role during the cross-border patient transfer. The participating organizations included CBSA, U.S. CBP, Lake Huron Medical Center, Lambton County EMS and the Federal Bridge Corporation.

These interviews identified the current organizational roles, processes and documentation (policies, standard operating procedures (SOPs), industry standards) used to guide information exchange, via voice and data communications, during cross-border patient transfers.

Phase 2: Subjective data related to communications and information sharing (CIS), SA and cognitive workload (WL) was gathered from players at specific milestones during the experiment using 5-point Likert rating scales. A rating of '1' was meant to indicate that the participants thought they had 'No SA,' whereas a rating of '5' indicated that the participants thought they had 'High SA.' A rating of '3' was meant to indicate that participants thought they had 'Some SA' during the experimental activities. The term SA referred to the participants' ability to identify and understand the information within their environment and to anticipate, based on this understanding, the events (related to their tasks) that would occur in the future. [6] The term WL referred to the overall demands (e.g., cognitive, physical, psychological, etc.) that were placed upon the participants during the completion of their operational tasks [7]. WL was gathered by the participants using a 5-point Likert scale where a rating of '1' was meant to indicate that the participants thought their WL was 'Too low,' whereas a rating of '5' was meant to indicate that the participants thought their workload was 'Unmanageable.' A rating of '3' was meant to indicate that the participants thought their WL was 'About right.' The data sets gathered using these rating scales were subjected to a descriptive analysis to determine an overall pattern of response.

During the experiment, the study team and designated evaluators recorded observations associated with the experimental events. Where possible, these observations were augmented with qualitative comments provided by the participants throughout the conduct of the experiment.

Phase 3: At the end of each experiment day, the players, evaluators and controllers participated in a brief hotwash session at their respective locations. These discussions gathered feedback about the participants' experiences with the emerging technology (LTE-supported applications) and its impact on their ability to complete the tasks that would typically be performed during the cross-border responses. Upon the conclusion of the CAUSE IV experiment, a formal after action review (AAR) was held to discuss the high level observations and to gather feedback from the participants with regard to the technology usage. In addition, the participants provided their observations related to the successes and the lessons identified during the experiment. A final set of data collection tools was distributed at the conclusion of the experiment that measured system usability associated with the technology [8] and to gather feedback related to the logistics and conduct of the experiment.

2.4.3. Vignette 2

Phase 1: A web-based pre-experiment survey was developed for Vignette 2 participants. One week prior to the experiment, the study team members with assistance from the U.S. control team gathered information from disaster response personnel and digital volunteer organizations. The survey gathered data concerning the participants' organizational roles and responsibilities and the policies associated with the conduct of disaster response. In addition, the survey gathered information related to the participants' experience with emerging technologies and engaging digital volunteers to support the issuance of public alerting, warnings and notifications.

Phase 2: Similar to Vignette 1, players used 5-point Likert rating scales to provide SA and WL measurements at specific milestones throughout the experiment. Experiment evaluators also gathered observational data. Players and evaluators were prompted to complete their data collection tools following each of the main sections in the vignette's MSEL.

Phase 3: Players, evaluators and controllers participated in a brief hotwash session at their respective locations, similar to Vignette 1. These discussions gathered feedback about the participants' experiences with the emerging technology that was used to issue alerts, warnings and notifications during the emergency response. In addition, participants completed the system usability scale and player feedback form. Upon completion of the CAUSE IV experiment, Vignette 2 participants were invited by the U.S. team to complete a web-based post-experiment survey. Data were subjected to a descriptive analysis (e.g., mean, mode, range, standard deviations) to identify overall patterns of response. The responses from both the pre- and post-experiment surveys were also used to identify any changes in the use of technology for cross-border communications or response operations that occurred as a result of participating in the CAUSE IV experiment.

2.4.4. Maturity Model Analysis

Throughout the CAUSE experiment series, the impact of interoperable technology on emergency response and resiliency has been characterized through the use of multi-dimensional models. These models assess the maturity of the interoperable technology and whether it is in a state of readiness to be used by the community. One of these models is referred to as the Canadian Communications Interoperability Continuum (CCIC) model. This model depicts the core elements and key attributes that are needed to develop a mature interoperable capability. [9] It was used as a benchmark in the experiment to measure the impact of exchanging voice, video and data over LTE on the response activities and identify enhanced resiliency through the use of cross-border interoperable applications. There are five dimensions that are characterized by this model, including governance, SOPs, technology, training and exercises, and usage (Figure 8). [11][12] For Vignette 1 and the overarching CAUSE experiment series, a series of individual metrics were developed under each of these five dimensions [5] to capture the maturity and sustainability of the interoperable continuum.

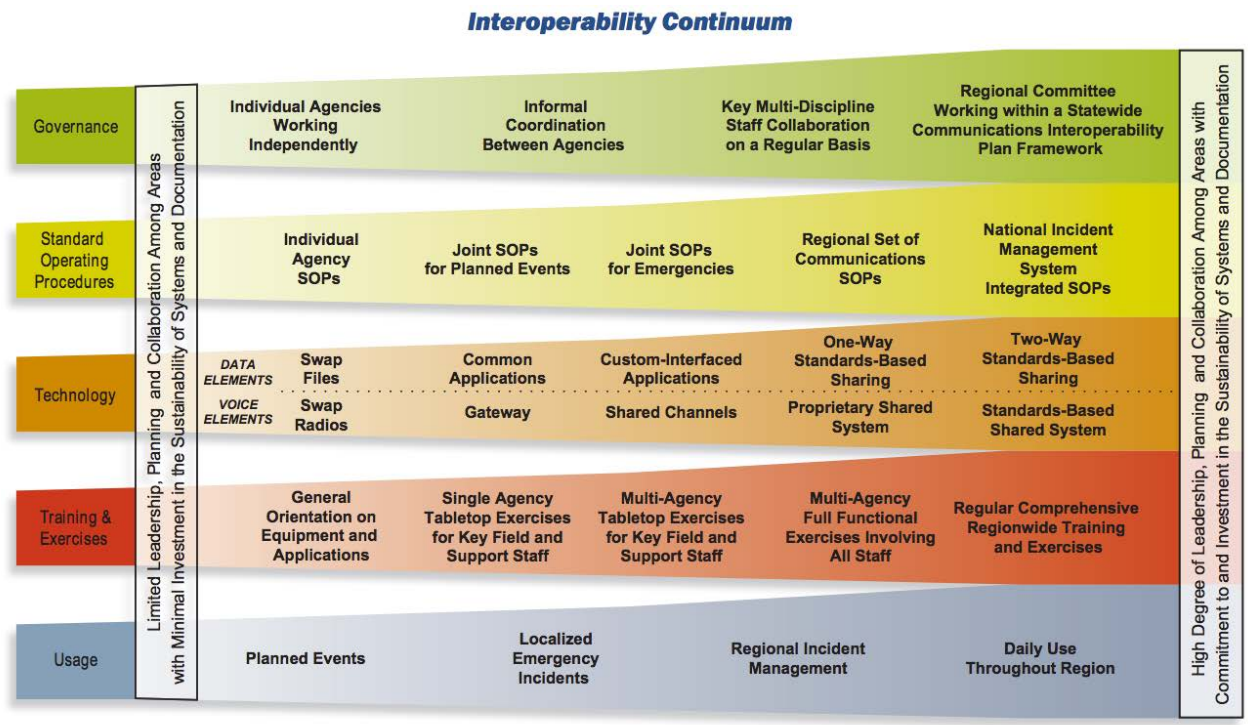

Figure 8: Canadian Communications Interoperability Continuum Model

Similar to the CCIC model, the Social Media in Emergency Management (SMEM) Maturity model (Figure 9) was used to depict the main elements that are necessary to develop cooperation between emergency management and digital volunteers. It was used as a benchmark in the current experiment to measure the impact of emerging social media and crowd-sourcing technologies in decision-making processes of traditional emergency management organizations related to public alerting, warnings and notifications. There are four dimensions that contribute to the development of a mature capability, including people, governance, technology and implementation [10].

Advancements in all four dimensions were expected to lead to improved emergency response and community resiliency. Each dimension’s essential elements, where incorporated into response operations, help to achieve the four maturity outcomes of a resilient community. These outcomes include a networked and resilient community, trusted partnerships and collaboration, accessible data and effective tools, and trained and accredited stakeholders. Each dimension will change and evolve as their essential elements are optimized. A set of individual metrics was developed, which was associated with each of these dimensions [5] and measured the maturity and sustainability of engaging social media within a traditional emergency management organization. Through the introduction of data obtained and shared by 2-1-1 operators, emergency managers were provided access to additional information beyond the scope of ‘traditional’ social media. The metrics for Vignette 2 were developed to capture the impact of the technologies that utilized all crowd-sourcing methods under the SMEM maturity model dimensions.

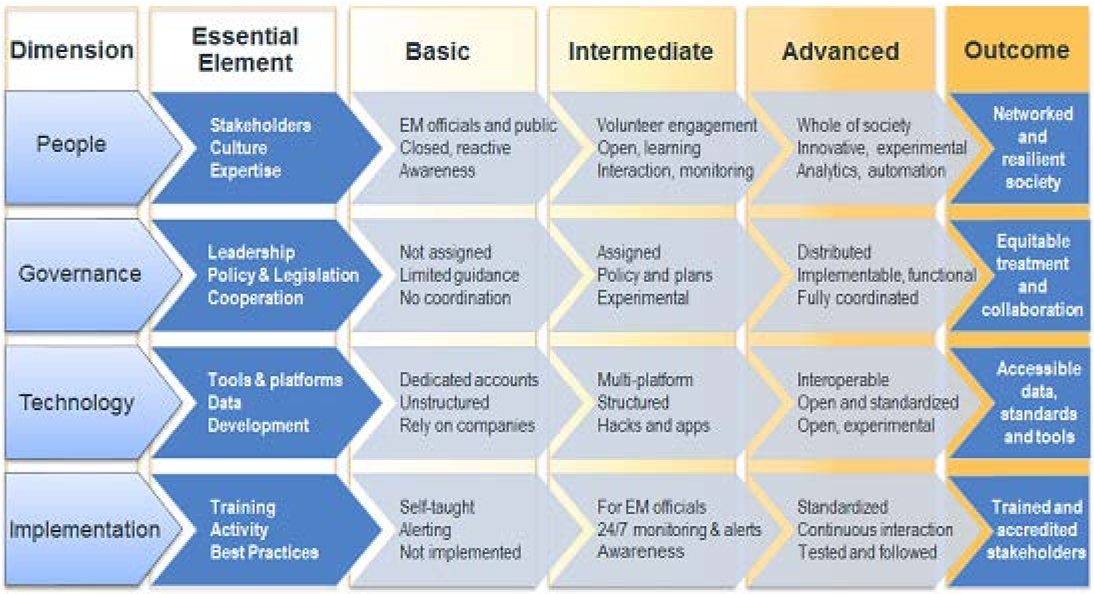

Figure 9: SMEM Maturity Model

The observational data sets gathered using the data collection tools, evaluator-led hot washes and the AAR discussions were subjected to a qualitative analysis. This analysis used the qualitative metrics associated with the maturity model to evaluate the impact of the technology tested during CAUSE IV. The study team assigned a score for each individual metric based on documented observations gathered during the experiment. The assigned scores were compiled to provide an overall score for each of the dimensions within the appropriate model. The following 5-point rating scale and associated language ladder is an example of how measurement was applied during the metrics analysis.

1 = Little knowledge about information exchange, or how SA is generated or enhanced within any organization

2 = Information is monitored and shared within an organization

3 = Information is gathered from other organizations and used to determine actions

4 = Organizations inform others about their plans for action

5 = Multiple organizations plan a coordinated response

3. Results and Discussions

3.1. Observational Findings

3.1.1. CCIC Maturity Model Vignette 1 Metrics

For Vignette 1, the individual metrics (scored on a 5-point rating scale) were considered within the context of the CCIC maturity model. This model depicts the level of maturity associated with the interoperable technology. The mean ratings for each dimension in Vignette 1 were all associated with a moderate level of maturity (Figure 10). These findings suggest that the interoperable technologies supported the exchange of information during the simulated cross-border patient transfer resulting in improved SA between all of the participants engaged in the emergency event.

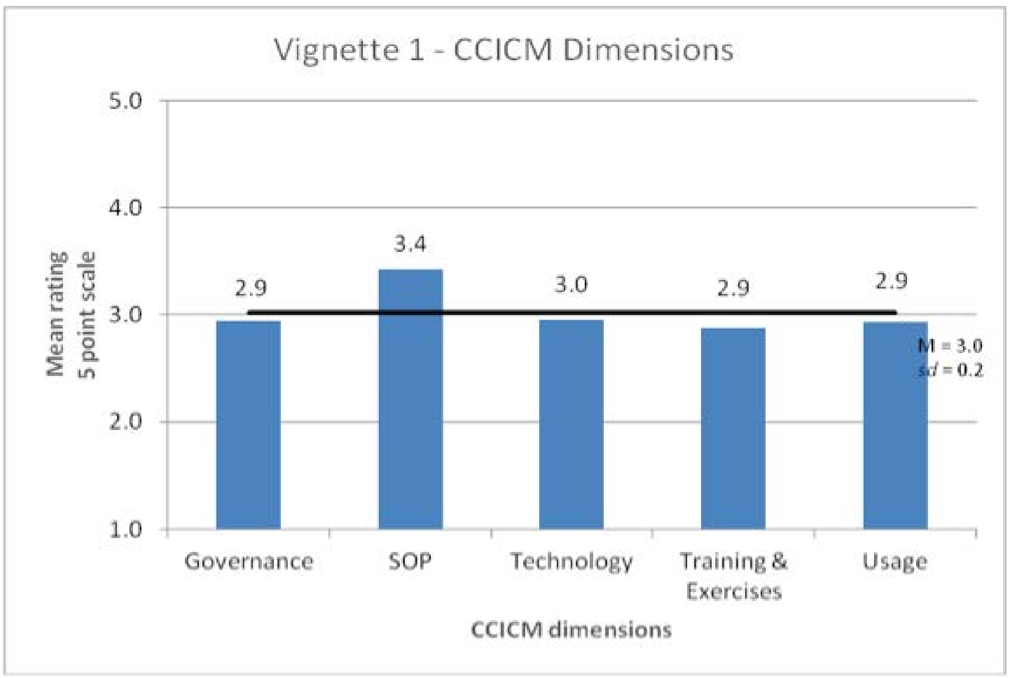

Figure 10: Vignette 1 – CCIC Model dimension ratings

The moderate ratings indicate that the interoperable technology was primarily used to monitor the status of the patient transfer and to determine actions that would be required by the participants, but did not readily support the continuous exchange of feedback. This was supported by observations from dispatch and the paramedics, which identified the need for more continuous communications, rather than individualized calls or data transfer. Although there were some observations that indicated that the technology was used to inform other organizations or to coordinate responses, the technology use was generally associated with gathering information to maintain SA within each organization. These findings may be due to limitations in the experiment, or that the full capability that could be enabled through the use of LTE technology and related applications exceeded the information exchange requirements for this type of simulated healthcare situation.

The analysis of the metrics identified potential strengths in the evaluated processes. Similarly, the analysis identified potential areas for improvement in the processes' maturity. It was identified that the lack of processes, plans and clear leadership were barriers to the use of interoperable technologies for both vignettes. The main strengths and areas for improvement identified through the metric analysis can be found in Table 2 below.

Table 2: Vignette 1 Metric Analysis Strengths and Areas for Improvement

Strengths	The technology and applications supported the near real-time exchange of information between dispatch and paramedics, bridge and border authorities, and healthcare facility officials. This feedback supported decision-making, resulting in expedited border crossings leading to improved patient care.
	Requests for initiating the cross-border patient transfer process can be communicated amongst all supporting organizations with the voice, video and data technologies and applications.
	Tools such as the vehicle-tracking AVL and the applications, which enabled consistent voice and video communications, supported the expedited travel of the ambulance and enabled continuous communications on both sides of the border. This connectivity allowed for updated patient care when required.
	The paramedics were able to stay informed of potential route changes, redirection to hospitals or bridge lane changes, and revise their travel plans as the incident progressed through the use of the interoperable communications technologies and applications.
	Changes in bridge or road conditions were able to be readily communicated to all participating organizations through the same technology in which initial directions were first issued.

	Improved SA was developed and maintained through the use of communications protocols and processes that can be transitioned from existing technologies (radio, fax, phone) to the emerging LTE technology that enables voice, video and data applications.
Areas for Improvement	Currently, there are no local, pre-identified agreements that support cross-border patient transfers or other paramedic cross-border travel. There is a local agreement in place to support the cross-border travel of local firefighters, which may provide a foundation for establishing an agreement concerning cross-border travel by paramedics during an emergency.
	Prior to the experiment, all stakeholders had similar expectations of the patient transfer process. These expectations were based on their experience in their roles and the general guidance provided by their existing processes. However, there did not appear to be any specific documented processes or procedures in place defining requirements for cross-border patient transfer between healthcare facilities.
	The current cross-border patient transfer policies and processes do not readily support the exchange of information (voice, video or data) once the ambulance crosses the border.
	The current implementation of the technology requires significant effort and the proposed applications would not allow paramedics and physicians to perform their primary healthcare tasks while simultaneously using the software.
	The applications used during the experiment did not readily allow for consistent updates or a common operating picture as the patient transfer progressed, especially between the paramedics and dispatch. Dispatch typically maintains regular contact with the paramedics through radio, but the applications introduced in the experiment were primarily used for individual phone calls. This reduces the paramedic's knowledge of the situation by not having access to the information that would be exchanged through radio patches or by using a multi-party call format. Additionally, communications that would currently be logged in the dispatch system would not be accessible through the use of the CAUSE IV applications.

	The technologies and applications used did not readily prompt for acknowledgement of the receipt of non-verbal (data) information. Although data was received either through monitoring of the AVL or through sending patient data, confirmation of receipt and follow-up information was not readily available.

3.1.2. Start hereSMEM Maturity Model Vignette 2 Metrics

For Vignette 2, the individual metrics (scored on a 5-point rating scale) were analyzed within the context of the SMEM Maturity model to evaluate the Vignette 2 objectives. The overall mean rating was observed to be somewhat below a moderate range on the 5-point rating scale. The mean ratings for two of the dimensions (People, Technology) associated with the SMEM Maturity model were consistent with this overall mean rating. In contrast, the remaining two dimensions (Governance, Implementation) were associated with lower mean ratings. (Figure 11) These findings suggest that the interoperable technologies provided inconsistent support to the exchange of critical information during the simulated response to a tornado. Thus, the development and maintenance of SA was not reliably improved for all organizations throughout the experiment. The level of maturity that is inferred by the mean ratings indicates that the emerging social media technologies supported the development and maintenance of SA when they were used within the context of existing governance processes. These processes include both the personnel and technologies that have defined roles within traditional emergency operations. While it was identified that digital volunteers and the use of social media can enhance the execution of emergency response, there is a requirement to determine how this capability can be effectively governed and implemented within the existing organizational structures.

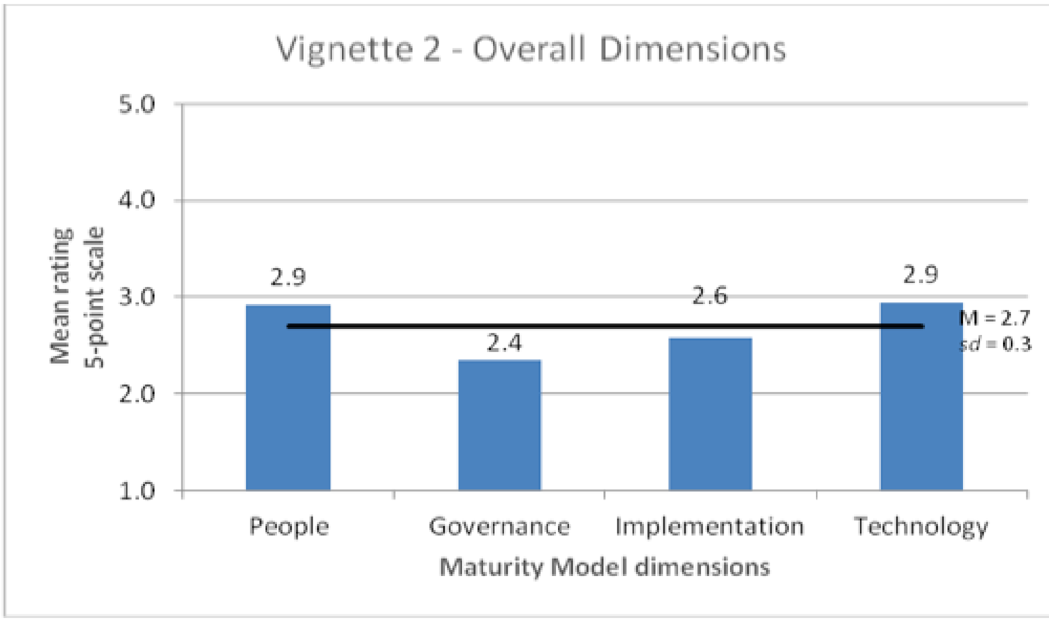

Figure 11: Vignette 2 – Overall dimension ratings

The mean rating for the governance dimension warranted further investigation to identify which aspects were responsible for generating a lower mean rating. The result of this investigation revealed that current governance processes and procedures are not yet mature enough to be supported by the emerging technology. For example, the governance that is required to use emerging technologies to share information between multiple stakeholder organizations to support decision-making and coordinate planning is still in the process of being determined. Without effective governance, such as information sharing agreements and other arrangements, these technologies cannot be fully used.

Although areas for improvement in the use of governance and implementation of SMEM were found to exist during the conduct of this experiment, the training and planning involved in the preparation for this experiment was found to improve the involved organizations' use of SMEM. The experiment demonstrated advances in the levels of comfort and understanding in the use of digital volunteers and social media data during each phase of emergency response, leading to an increase in the overall maturity in emergency management for both Canadian and American organizations. [13]

The analysis of the metrics identified potential strengths and areas for improvement in the evaluated processes. Similarly, the analysis identified potential areas for improvement in the processes' maturity. It was identified that the lack of processes, plans and clear leadership were barriers to the use of interoperable technologies for both vignettes. The main strengths and areas for improvement can be found in Table 3 below.

Table 3: Vignette 2 Metric Analysis Strengths and Areas for Improvement

Strengths	Demonstrated that learning from previous disasters improves emergency response by incorporating lessons learned from the 2014 Flint, Michigan, water crisis, including an electronic request form in use by Michigan 2-1-1.
	The use of damage assessments and messaging regarding siren activation during Vignette 2, alerts citizens and allows them to remain connected and informed during emergency response operations.
	In Michigan, the identification of the potential for 2-1-1 organizations to support the limited digital volunteer contingent within the traditional emergency management organizations was identified. This support includes monitoring social media, synthesizing information and providing updates to the public, while assisting with rumor control.
	The use of public alerts (e.g., Everbridge) and social media (e.g., Twitter, Facebook) to distribute information to the public was facilitated through cross-border communications with local emergency representatives.
Areas for Improvement	Participants were concerned that unless regular exercises are performed, the use and implementation of the applications will be forgotten.
	An improved governance structure for vetting, verifying and confirming messaging and additional guidance through training and volunteer support would benefit the collection and efficient use of social media and crowd-sourcing data in response efforts.
	Limitations in the formal procedures and processes, including the authority to enter into cross-border mutual aid agreements, required to guide the usage of cross-border situational awareness mapping and data visualization tools, was found to hamper their efficiency in cross-border response efforts.
	The mapping and social media data reports resulted in a large amount of data, which was difficult to manage, validate and constrain during response operations.

3.2. Survey Findings

During the Vignette 2 pre-experiment survey, participants were asked to identify which technologies and applications they currently use for their operational response needs. Many participants indicated that they used several types of technologies ranging from online resources to desktop capabilities. The most commonly used technologies included Local Alert/Warning Systems and Incident Management Systems, as identified in Figure 13 below.

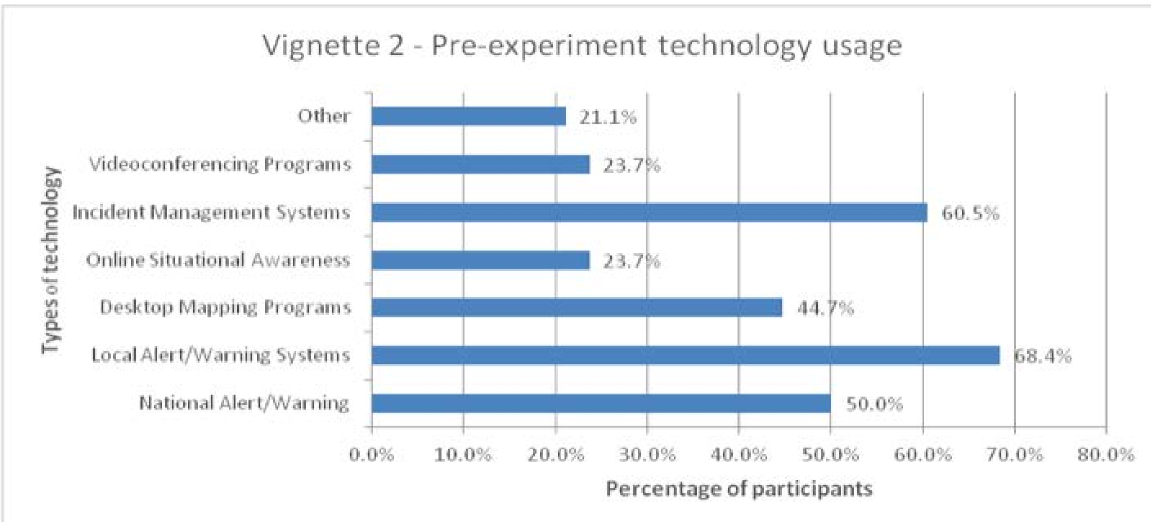

Figure 12: Vignette 2 – Pre-experiment technology usage

CAUSE IV provided the opportunity for these participants to be introduced to new types of technologies and applications. Following the conclusion of the experiment, most participants indicated that there were additional technologies, such as Web-Based Mapping programs and Online Situational Awareness Viewers, that they identified as being used during the experiment and could be used for emergency planning and response, as depicted in Figure 14 below.

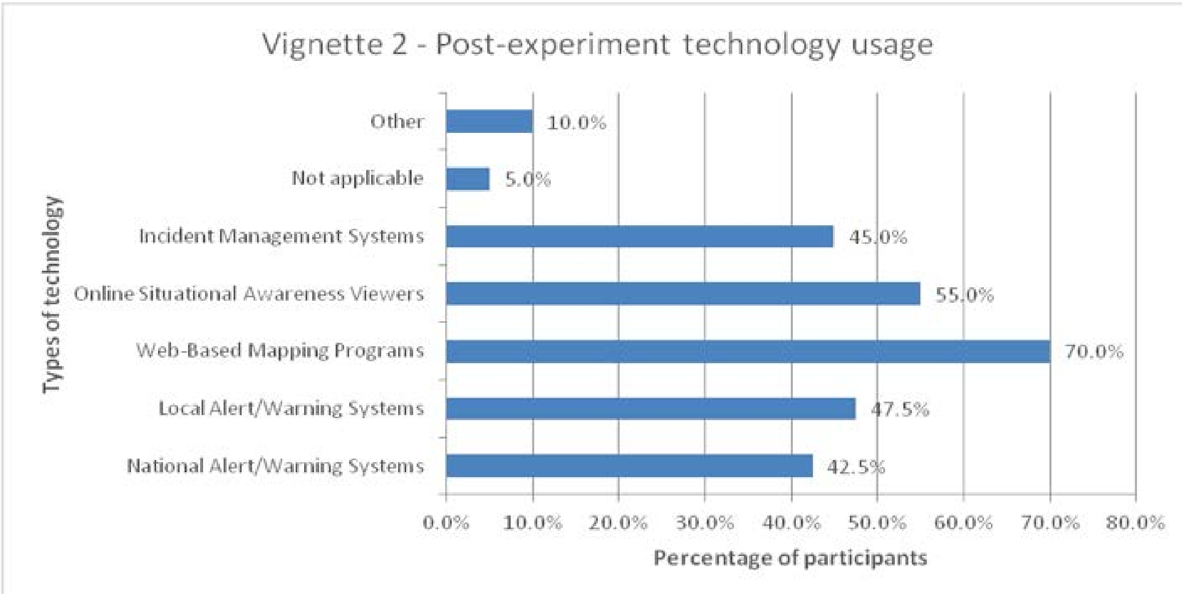

Figure 13: Vignette 2 – Post-experiment technology usage

Participants indicated that these new technologies could substantially improve both interoperable communications and their SA based on their experience in CAUSE IV.

The Vignette 2 participants identified that the technologies and applications introduced throughout the experiment provided support and were beneficial at each stage of the response. The experiment and the multiple training sessions leading up to the experiment supported their ability to learn how to use these technologies and applications.

The participants indicated that the experiment was beneficial in helping to improve their knowledge of technology that can be used to enable cross-border Communities of Practice to jointly plan, as shown in Figure 15; however, following the experiment, participants' knowledge in the use of technology for this purpose remained minimal. Participants identified the most knowledge in using the technology to gather and visualize information to assess damage. Additionally, participants noted a substantial increase in knowledge concerning the ability to use technology to visualize and share plans and monitor calls from vulnerable citizens. Although the survey collected data relating to additional methods in which technology could enable cross-border response operations, Figure 15 reflects a subset pertinent to the experiment objectives.

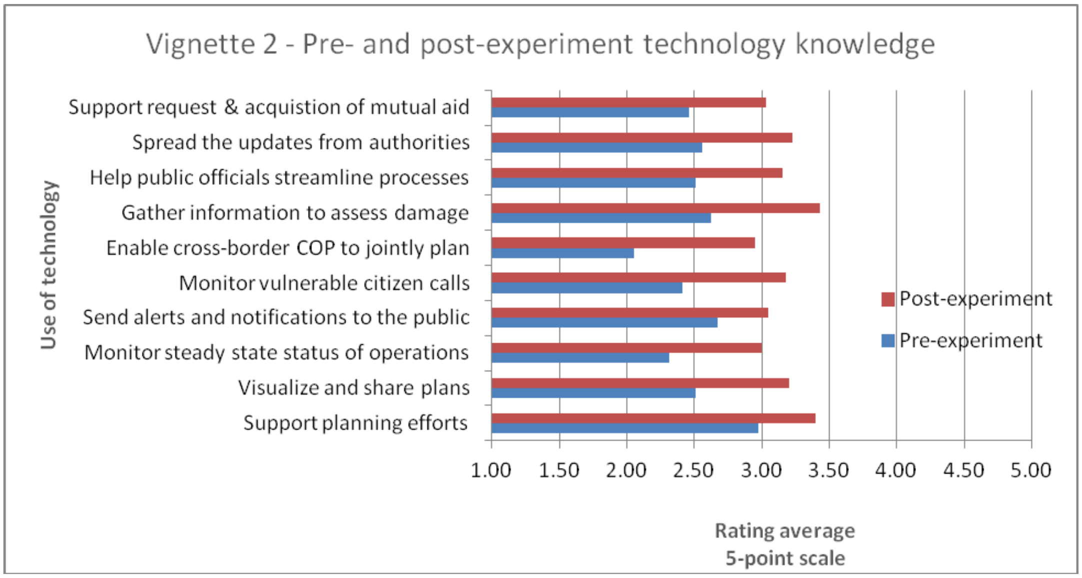

Figure 14: Vignette 2 – Pre- and post-experiment technology knowledge

Prior to the experiment, participants were introduced to a variety of applications to support alerts, notifications and mapping in emergency management. In order for these technologies and applications to be beneficial for conducting the emergency response, they would need to meet and support all of the responders' information requirements. The CAUSE IV Viewer was identified as the most beneficial of the introduced applications, whereas the Latitude AOP was found to be the least beneficial in supporting response information requirements (Figure 16). Supporting data suggests this may be due to certain applications being easier to manipulate (e.g., entering data and navigating through the layers) than others. Additionally, some participants found that some applications were slow to load and required multiple reboots.

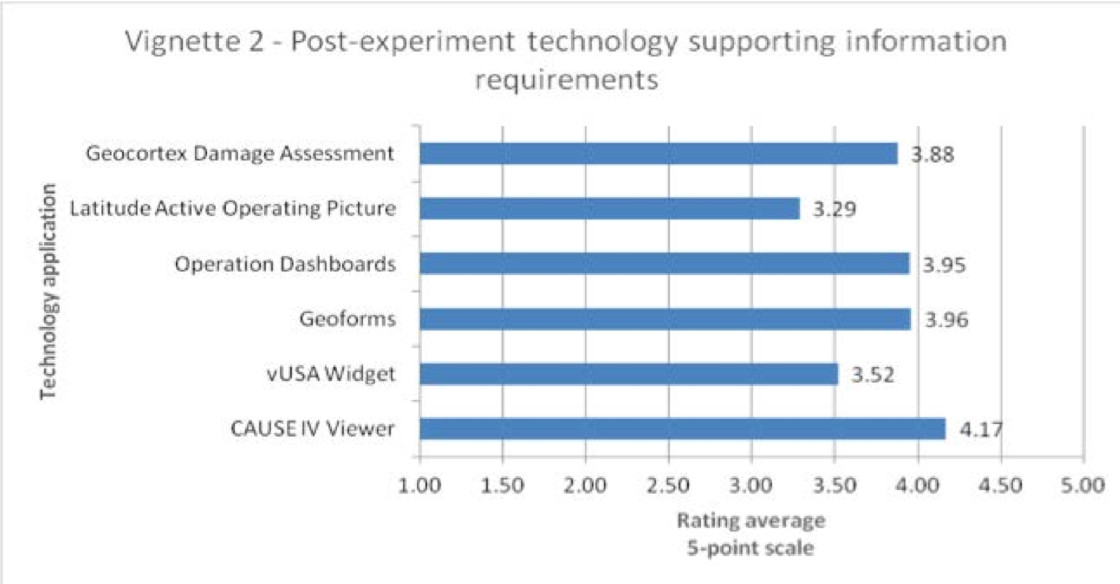

Figure 15: Vignette 2 – Post-experiment technology supporting information requirements

Following the experiment, participants indicated that the technologies and applications introduced during the experiment could be implemented into their current response operations. The features that could potentially be integrated included the use of mobile tablets and damage assessment reports for field teams, the use of community online reporting, the use of mapping capabilities and the use of a resource planner. Importantly, nearly one third of participants did not suggest that the use of the applications would improve the timeliness of response coordination efforts, suggesting that timelines are more likely determined by processes (e.g., decision-making) and resources (assigning the personnel).

3.3. System Interoperability Technology Findings

3.3.1. Vignette 1

During the pre-experiment interviews, the current flow of communications from inception to completion of a cross-border patient transfer was captured. Currently, communications are heavily reliant on radio, phone and fax to complete all required processes. Paramedics and dispatch communicate via radio, while the majority of the remaining communications take place by phone. This is due to the involved organizations all being on different radio frequencies. This results in individual telephone calls between dispatch or the paramedics with the border agencies, bridge authorities, and the receiving and referring hospitals. To initiate the patient transfer, a Patient Transfer Form is faxed to the border agency of the receiving nation and a phone call is made to reduce the risk of missed correspondence from a lack of monitoring.

The participants identified challenges in the existing processes. The majority of these challenges are a result of the lack of communications with the paramedics once the ambulance crosses the border. In the current process, radios and any ministry-issued phones do not function once the ambulance crosses the border. This results in the paramedics being unable to contact dispatch or any other organization once across the border. Therefore, route changes, hospital re-direction, patient care updates and delays are unable to be effectively communicated. Paramedics currently mitigate this challenge by prolonging their route, if necessary, to remain in their country for as long as possible. The introduction of the PSBN to perform these activities was well received by the experiment participants and the value of the technology was understood. The results of the player scales and observational data identified that the PSBN facilitated consistent communications with the paramedics and all supporting organizations on either side of the border. This leads to the potential for improved patient care and quality of life and coordination between organizations to notify of redirections, provide alerts, request feedback and address deterioration in the patient's health status.

Another key challenge identified in the existing processes involves the lack of a legal Memorandum of Understanding (MOU) within the CAUSE IV experiment area that accommodates cross-border patient transfers. The absence of an official MOU results in a lack of authority to use ambulance lights or sirens once across the border or for paramedics to practice medicine outside of their jurisdiction. However, it was identified that the introduction of interoperable technologies that facilitate cross-border communications will provide an increased incentive for the responsible jurisdictions to develop this MOU. [14]

While the use of the PSBN was found to be beneficial in supporting consistent coordination and communication between organizations, many applications were used to support SA among participants throughout the patient transfer process. Several of these applications supported voice and video communications (Linphone and Google Hangouts), while others supported data communications (Gmail and ePCR). In general, Vignette 1 participants responded favorably to the usability of these applications and the system as a whole.

Analysis of the experiment data revealed that the dispatch roles had the lowest SA throughout the entire transfer process. This outcome is suspected to have resulted from the change in the operational process whereby, prior to crossing the border, dispatch typically maintains consistent contact with the paramedics through the use of radio. This allows consistent communications and any communication patches to the hospital are done through this system to enable logging of the information exchange. With the individualized phone calls, the dispatch's level of SA was hampered through reduced ongoing communications with the paramedics and by not having access to the information that would be exchanged when they facilitate communication patches. However, due to the lack of communications once across the border, the dispatcher's SA is found to be significantly lower in the current process. Conversely, the SA of the paramedics was quite high as they typically would have very minimal communications with any organizations apart from their dispatch. The results of the data analysis also indicated that the there were minimal changes in the level of SA noted by participants when the paramedic crew crossed the Canada-U.S. border. This indicates that the implementation of the system was successful in maintaining remote communications with all cross-border organizations throughout the transit between hospitals.

Qualitative comments from the hospital and paramedic participants indicated that using the video capability to allow physicians to view the patient or the 12-lead strip could improve diagnostic capabilities and lead to more effective and timely treatment recommendations. It was noted that there would be privacy issues with the capture and transmission of patient video, and that these would have to be addressed through governing policies and procedures.

The results of the WL analysis indicated most participants found that the technology and applications were associated with moderate or lower levels of WL demands, especially once the planning aspect of the patient transfer was complete and there was a reduced requirement to exchange information with other organizations. However, qualitative feedback suggests that the results of the WL scales are focused on the simulated experiment events, and not necessarily on real-life events. It was identified that although the WL was manageable during the experiment, when providing patient care, the applications and processes introduced during the experiment might be too demanding for some of the participating organizations to use, including the paramedics, and may have a negative impact on the level of patient care.

3.3.2. START HEREVignette 2

During Vignette 2, a moderate to high level of SA was maintained throughout the phases of the simulated emergency response; however, overall SA ratings were found to be lower for the final two phases (i.e., local response, cross-border response) of the simulated emergency response, particularly for the non-government agencies (2-1-1 operators, digital volunteers). This could be due to the design of the second day, which focused on the local damage assessment teams, and the conduct of the mutual aid tabletop, which did not directly involve everyone, particularly participants from non-government agencies.

WL demands were observed to be at a moderate level across all phases of the simulated emergency response. Government players indicated that the technology and applications posed a slightly higher WL demand, especially during the reporting stage, as compared to non-government players. Conversely, non-government players found the WL to be acceptable or slightly low, especially during the local response portion of the experiment. This is likely a result of off-site players having very little involvement in the local and cross-border response portion of the experiment, as it was focused primarily on the damage assessment teams.

Vignette 2 participants indicated that overall, the system usability associated with the introduced technology and applications was favorable; however, the implementation of several new applications leads to a requirement for considerable technical support. This support would be needed to configure and maintain the technology. Training on the systems was necessary to ensure personnel were familiar with how to use it during an emergency.

System interoperability was achieved in Vignette 2 by leveraging and integrating existing systems platforms. While these systems or platforms were already in use prior to the experiment (e.g., Everbridge alerting system, IPAWS, NAADS, ArcGIS, WebEOC and social media platforms), there was limited cross-border interoperability. There are several reasons for this limited interoperability, including the lack of existing procedures guiding cross-border information sharing practices, infrequent use of common platforms for sharing information (e.g., ArcGIS Online), and insufficient policies, agreements and governance to enable cross-border information sharing.

In the AWN component of the experiment, the dissemination of AWN messages using both local and national alert messaging frameworks was tested. For local alerts, participants in St. Clair County and the City of Sarnia generated alerts using the local emergency communication systems. These systems included WINS and MyCNN, respectively.

To improve cross-border interoperability, the experiment evaluated the ability to generate an OASIS Emergency Data Exchange Language (EDXL) CAP-based alert and propagate it between the Canadian NPAS/NAADS and the U.S. IPAWS through an IPAWS Bridge (see Figure 17). In addition, participants on each side of the border were able to send CAP messages between COGs. The IPAWS Bridge successfully translated the CAP-based messages from the Canadian Profile of the CAP to the U.S. IPAWS CAP Profile.

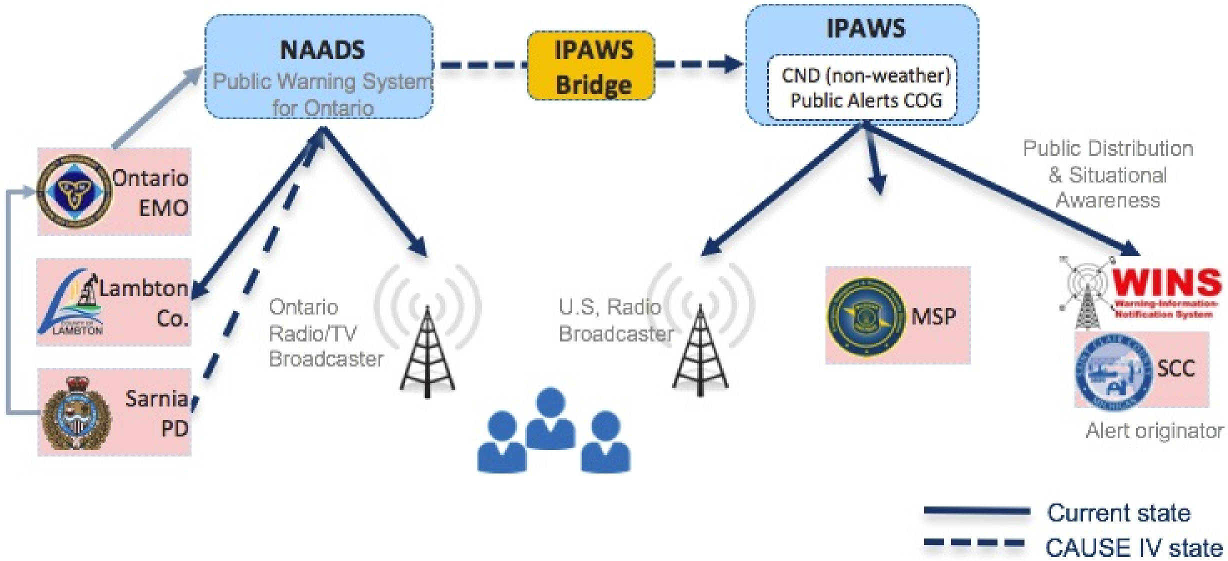

Figure 16: National alert, warning and notification workflow diagram

In addition to the successful implementation of the IPAWS Bridge, the CAUSE IV experiment also enabled alerts to be sent from WINS and MyCNN to pre-established notification groups. These notifications contained links to additional applications that provided additional SA and supplemented traditional alert messages. The implementation of GeoForms was found to be beneficial to the response teams to allow weather spotters, digital volunteers and citizens completing Damage Assessment Forms to submit information to the EOC that was associated with a geographic location. Additionally, the simulated NWS alert triggered a process to identify the outdoor warning sirens in the affected area and send an email notification to dispatch identifying the sirens that should be activated.

During the AWN portion of the experiment, it was identified that the current processes for issuing public alerts over NPAS/NAADS in the province of Ontario is time prohibitive. As a national alerting system, there is a high degree of centralized control. This results in local jurisdictions being unable to directly issue emergency alerts over NPAS/NAADS, and no standard template for issuing local public alerts. During the experiment, it was also identified that local Canadian weather spotters and weather alerts are only activated following an official statement from ECCC. Additionally, while the technical process for issuing cross-border alerts was validated during CAUSE IV, a number of policy and procedural issues were identified. To address the AWN-related procedural gaps impacting effective cross-border alerting, a SOP for cross-border alerts and warnings was drafted prior to the experiment and will be revised based on the lessons identified during the experiment.

During the experiment, the Blue Water Digital Volunteer Team (BWDVT) monitored protected Twitter accounts and closed Facebook groups for information relevant to the EOC information requirements, including transportation, damage, rumors, life/safety and utilities. From the approximately 500 social media injects that were monitored, the BWDVT identified 40 reports that contained valuable information and shared these with the EOC through the Social Media Operations Dashboard (Figure 18). This dashboard provided information on the spatial location of reports, including areas of high activity using a heatmap layer, as well as a breakdown of reports by category (e.g., transportation, utility, life/safety issues, etc.). Officials in the EOC were simultaneously sharing information back to the social media accounts, providing situational updates and responding to specific messages.

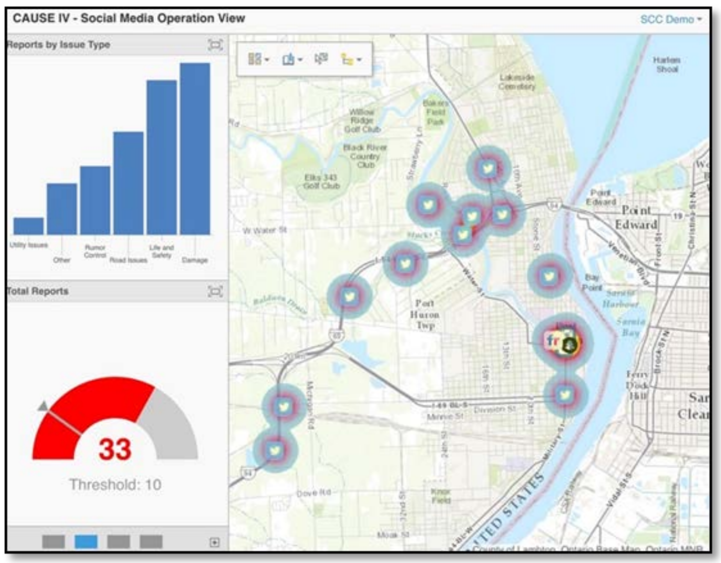

Figure 17: Operations Dashboard for social media reports

Prior to the experiment, Michigan and Ontario 2-1-1 coordinators worked to align their higher-level call types to provide a common view across their two programs when calls were received. These platforms were integrated with ArcGIS Online to enable mapping of the call data to the zip/postal code level. EOC officials indicated that having access to this 2-1-1 data proved helpful to identify potential unmet needs or areas that may need assistance. During the experiment, EOC officials were also able to provide updates to the 2-1-1 operators, including EOC activations, evacuation areas, status of sheltering and reception sites, and transportation status.

Although the use of digital volunteers and 2-1-1 operators was found to be beneficial for response efforts, participants identified a need for additional training to help the volunteers identify, vet and report actionable information during an emergency. Additionally, participants noted that the 2-1-1 call data at a zip/postal code level are too coarse for county-level events, especially in the U.S. where zip code tabulation areas are larger than in Canada.

Following the local reporting component of the experiment, EOC staff in St. Clair County directed damage assessment teams to areas identified as having been impacted by the tornado. The damage assessment field tool was equipped with automated workflows that enabled streamlined data collection, minimized data entry errors and estimated the valuation of damage by leveraging authoritative county parcel and infrastructure data. Information on damaged properties was shared back to the EOC using ArcGIS Online and GeoCortex, which in turn was used as a basis for requests for assistance on the U.S. side using Michigan's WebEOC system and the Michigan Critical Incident Management System (MiCIMS). These requests for assistance were escalated to state level and then an international mutual aid request was issued. The field team collected approximately 100 reports.

At the conclusion of Vignette 2, discussions took place regarding the provision of mutual aid and resources during an emergency. It was identified that based on current-state processes, resources required for the response and recovery phases would first be sought at the local level. After local resources are exhausted, requests for mutual aid would be made to neighboring jurisdictions, including cross-border jurisdictions, based on local agreements. For larger events, mutual aid requests would be elevated to the state and provincial level. Once state resources are exhausted, the Emergency Management Assistance Compact (EMAC) would enable mutual aid requests between states. However, there is currently no established agreement (e.g., the Northern Emergency Management Assistance Compact (NEMAC)) in place that authorizes mutual aid between the State of Michigan and the Province of Ontario. Participants expressed concern that mutual aid requests between the state and provincial levels, if NEMAC was in place, would be time prohibitive for filling short-term needs during the initial response phase. The different levels of mutual aid, and existing agreements, are represented in Figure 19.

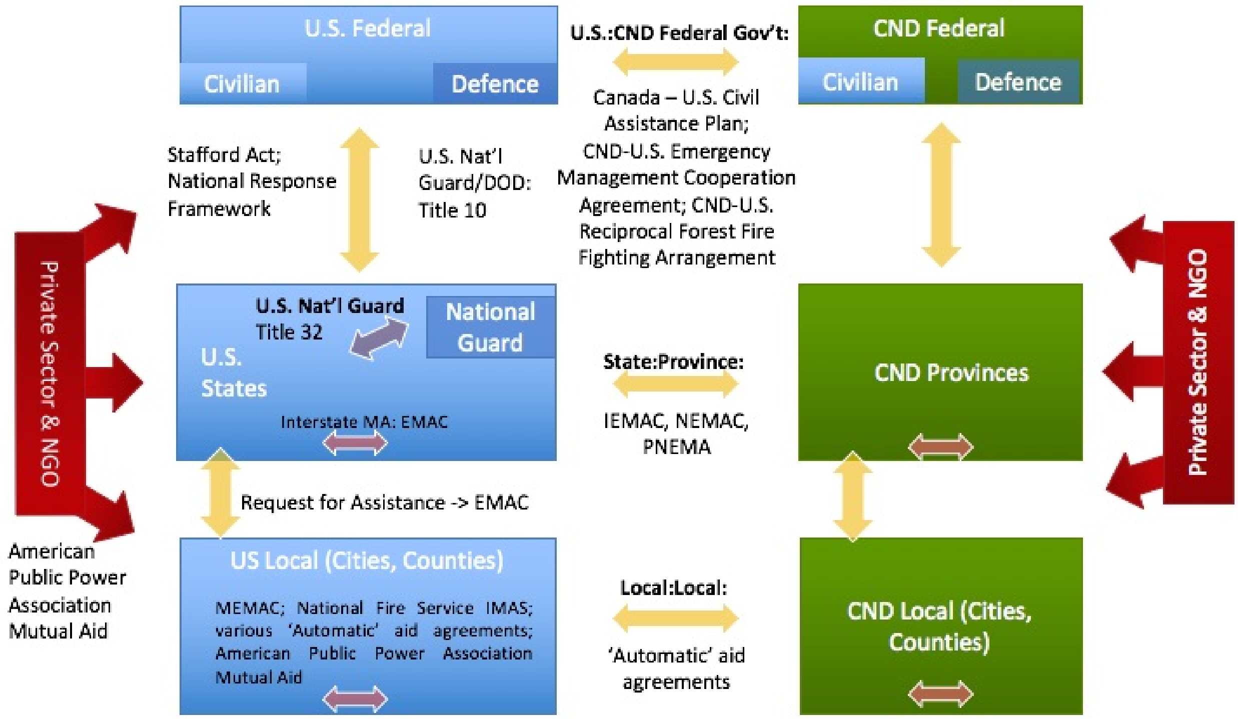

Figure 18: Overview of U.S. and Canadian Mutual Aid systems

During the mutual aid phase of the experiment, St. Clair County presented the Emergency Services Sector Coordinating Council Crisis Entry Response Recovery and Aid Post Event Access Card to evaluate resource movement and access to incidents through the validation of credentials of personnel arriving on the scene to respond to mutual aid requests. The program presented two different scenarios for consideration: the first within the county and the second during a cross-border situation. Upon arrival at the incident perimeter (i.e., the St. Clair County EOC and Blue Water Bridge), law enforcement would be able to quickly scan the responders' identification cards and provide access to authorized personnel. The participants identified that the access control platform could address a number of key challenges faced by St. Clair County, namely providing expedited access after a crisis to emergency responders and essential personnel and allowing the verification of credentials and qualifications (employer, roles, skills) of personnel with approved access.

4. Summary, Recommendations and Conclusions

4.1. Summary

4.1.1. Outcomes

The CAUSE IV experiment provided the opportunity to evaluate the impact of technology on cross-border response operations and communications as part of the ongoing CAUSE experiment series. The findings of the analysis for Vignette 1 suggest that the cross-border PSBN technology enabled the use of common applications that could improve communications, information access and sharing, and subsequently SA, while allowing paramedics to maintain voice communications and exchange video and data with their dispatch, referring and receiving hospitals, bridge authorities and border officials. Many of these communications are currently unavailable within existing communication channels either within their own country and certainly once the ambulance crosses the border. Through the use of these improved communications, participants indicated that this technology would improve patient care, increase long-term quality of life and decrease the rate of mortality. However, the technology and applications presented in the experiment itself may prove impractical for use if unchanged, given that the primary focus is patient care. It is important to note that in a real operational environment, technology and applications would need to be incorporated in a manner that enhances operational duties, which could be accomplished through modifications.

In Vignette 2, the use of the technologies provided the emergency responders with information that could be used to better anticipate and confirm events during the response operation. The applications introduced through this experiment allowed organizations to share more detailed information with increased accuracy and efficiency. Although challenges were identified with the flow of information during the experiment between digital volunteers, 2-1-1 operators and EOC officials, the tested applications can be used to accurately gather and disseminate information to a wide range of organizations in real-world scenarios.

Additionally, the emergency response community benefitted from the use of technologies and applications that enabled responders to share and visualize data between multiple organizations. The local EOCs leveraged new information from multiple sources in their simulated response operations. Data reports from digital volunteers, 2-1-1 and 911 operators were all used to support and guide the decision-making processes for the response actions. Participants indicated that the integration of 2-1-1 and 911 data enhanced the overall SA for the responders and helped distribute consistent messaging to the public. While lessons were identified with respect to the need for improved structure and guidance on the collection and use of this information, overall the use of the technology aided the response efforts. The governance that is required to use social media and crowd-sourcing technologies to share information between multiple stakeholders, support decision-making and coordinate planning is still in the process of being defined and established.

Furthermore, the use of mapping and data visualization tools greatly improved the responders' ability to identify areas of need, areas of risk and areas requiring assistance on both sides of the border. These types of tools are expected to improve the community's response capability and resiliency in emergency events. Although these tools allowed for greater local SA during the response, they did not substantially improve cross-border awareness and cooperation. Limitations in procedures and processes must be identified to effectively guide their application. Participants located within the EOCs on both sides of the border had the ability to share information through the mapping applications, including weather reports, damage and road closures. This enhanced sharing capability assisted with the execution of tasks and the delegation of responsibilities. The use of the maps also allowed for visualization of common concerns to assist with decision-making with minimal analytical effort.

4.1.2. Technology Innovation

The technology that was introduced into the response processes during CAUSE IV improved cross-border communications and coordination in response operations that enhanced resiliency in the cross-border communities. A summary of the various ways in which the technology succeeded in enhancing cross-border coordination is presented below:

- **PSBN:** Enabled continuous communication through real-time exchange of voice, video and data applications amongst all supporting organizations for the duration of the patient transfer. The use of the PSBN in ambulances and supporting organizations allowed the consistent use of formal communication channels for the duration of cross-border patient transfers.

- **AVL:** Improved SA for supporting organizations. The expanded use of the AVL by supporting organizations allowed for estimates of ambulance arrival time and near real-time location updates. This facilitated operations for bridge and border officials.

- **Voice applications (Linphone):** Enabled consistent verbal communications through the PSBN, but was suggested by dispatch participants to be less effective than current radio communications due to the lack of patching and coordination through dispatch.

- **Video applications (Google Hangouts):** Enabled consistent real-time visual and verbal communications through the PSBN. The use of multi-channel communications was found to support SA among many organizations; however, it was suggested that extended video conversations would be too taxing with real-world WLs.

- **Data applications (Gmail, iMedic GenII, iMedic ER):** Improved current processes for sending and receiving data during the cross-border patient transfer. The use of email rather than fax reduced the risk of lost correspondences and minimized the risk of transcription errors through phone calls, but maintained the need for a notification call due to minimal monitoring. The ePCR used to support the transmittal of the EKG from the ambulance allowed for increased SA of the hospitals. The ability to receive updates on the patient's condition throughout the transfer process allows for recommendations to patient care, as required.

- **ArcGIS Online by Esri:** Local, county, state, provincial, federal and non-government organizations were able to access information products shared in the CAUSE IV Group.

- **Geocortex and AOP:** Allowed EOCs at the County level to monitor damage assessments from the field teams in St. Clair County.

- **WebEOC by Intermedix:** U.S. state and local emergency management agencies were able to view the Request for Assistance Board to determine resource requirements.

- **MyCNN and WINS by Everbridge:** Facilitated the retrieval of local alert messages to cross-border U.S. and Canadian notification groups.

- **Social media platforms (Facebook, Twitter, Periscope):** Digital volunteers, Public Information Officers, damage assessment teams and emergency management staff were able to access social media messages to support digital volunteer collaboration. EOC staff were also able to leverage these platforms to release alerts, warnings and notifications to the public.

- **Experiment GeoAnalytics by G&H:** Allowed government and non-government organizations to visualize Siren-Geotrigger Alert Systems. It also enabled the implementation of the IPAWS COG to COG alerts.

- **2-1-1 call tracking and API by RTI and iCarol Call Reports:** Enabled the integration of 2-1-1 data into response operations by EOC officials and aided the use of visualization tools to monitor areas of high call volume.

- **ER-ITN Post-Event Access Control Platform:** U.S. CBP, county officials and local first responders were able to validate access control permissions using the system based on existing user credentials. This system facilitates the movement of legitimate response traffic during cross-border emergencies.

- **Public Alert and Warning Systems (IPAWS, NPAS):** Broadcasters, EOC officials and federal agencies were able to aggregate alert messages. These systems facilitated sending of EAS broadcasts and COG-to-COG messages.

The systems that were evaluated in CAUSE IV demonstrated the benefit in cross-border communications, awareness, planning and response. However, participants identified practical challenges associated with using these introduced technologies and applications. The following sections provide additional insight into the potential gaps or challenges in engaging people, as well as in technology employment and associated processes, while employing these technologies. Recommendations to improve cross-border response and coordination, while implementing CAUSE IV systems, are also listed below.

4.2. Recommendations

4.2.1. People-Focused Recommendations

Recommendation #1: (Vignette 1) Modifications are required to the ways the systems and applications are implemented to minimize operator WL in real-world situations. Although participants found their WL to be manageable during the experiment, in real-world conditions, the implemented applications would not be feasible while maintaining appropriate patient care. The applications would need to be modified to decrease WL, while maintaining exchange of information.

Recommendation #2: (Vignette 1) Modifications to the software applications are required to improve interaction with the technology, especially by the paramedics. The introduced systems involved the use of touch screens, which was hindered by the use of gloves and the motion of the moving vehicle. More stable, permanently mounted hardware that allows users to access the applications would be a potential method to minimize this functionality risk.

Recommendation #3: (Vignette 2) Modifications are required in the systems used to collect, streamline and visualize response data obtained through social media, crowd-sourcing, damage assessments, digital volunteers and 2-1-1 operators. Although the applications were useful for response operations, participants encountered challenges in managing the large amount of data in their response efforts. Modifications to the software that allow layering of information, color coding priority public needs and archiving requests as requirements are met would optimize prioritization and streamline the information. This would also reduce the need for responders to monitor multiple applications simultaneously. Additionally, more extensive training would improve the responders' ability to use the software and manipulate the mapping applications.

Recommendation #4: (Vignette 2) Pre-identified notification groups could be established to ensure all alerts target the relevant officials and citizens. The implementation of these groups would allow for official emergency alerts to be sent more quickly during an incident.

Recommendation #5: (Vignette 2) EOC staff did not receive sufficient training regarding interactions with digital volunteers, their information products and reports. Joint training between EOC staff and digital volunteers could be implemented to strengthen the understanding of this information source and the role of social media in support of emergency management. This training needs to be consistent with the guidance provided in policies and SOPs.

4.2.2. Technology Recommendations

Recommendation #1: (Vignette 1) The implementation of a system to maintain communications across the border would increase the likelihood of cross-border patient transfers by minimizing risks and enhancing patient care. This can be achieved through the introduction of PSBN in the border region. Without this system, dispatch, the receiving hospital, bridge and border authorities are unable to officially communicate with the paramedics once they cross the border. Similarly, paramedics are unable to officially communicate with the physician at either the referring or receiving hospital. With the PSBN, information access and sharing, such as a potential re-routing, request for additional patient information, traffic or border crossing updates, and change in patient status, are now possible.

Recommendation #2: (Vignette 1) It was identified that the communications between the paramedics and dispatch operators were minimized prior to the border crossing as a result of the introduction of the technology used. With the applications used during the experiment, individualized conversations made it cumbersome to maintain consistent communications and resulted in dispatch being unaware of communications taking place with additional organizations. This was primarily due to the experiment construct. Additional voice capabilities over LTE are available that can deliver enhanced communication capabilities. By integrating the systems and networks into existing dispatch systems, this inconsistency in communications could be avoided. This would also minimize the risk of organization approvals for installation and use on existing workstations.

Recommendation #3: (Vignette 1) An increase in the capacity of the network may be necessary to prevent lags or crashes of the system. With multiple applications running simultaneously, especially in real-world events, sufficient bandwidth is required to maintain the system's speed and accuracy to ensure a high level of SA.

Recommendation #4: (Vignette 2) Binational-level alert and warning systems, including the U.S. IPAWS and Canadian NPAS, could be integrated or linked to improve the efficiency of official-to-official broadcast alerts.

Recommendation #5: (Vignette 2) It was identified that local servers were potential single points of failure when monitoring, visualizing and sharing information among stakeholders. Cross-border communications could be more effectively enabled through the use of cloud technologies.

Recommendation #6: (Vignette 2) To streamline and condense information, the mapping applications and information sharing tools could be modified to associate a priority level to operational data to filter out low priority information. The CAP Canadian Profile has a severity field that could assist in this filtering. Additionally, filtering out concerns that have been addressed and filtering outdated information would also benefit the efficacy of these tools.

4.2.3. Process Recommendations

Recommendation #1: (Vignette 1) There exists a requirement for an official local MOU for cross-border patient transfers within the experiment area (ON-MI). Without a formal MOU, there are restrictions on the use of ambulances as special vehicles and on the ability of paramedics to practice medicine once across the border. Without these abilities, the frequency of cross-border transfers will remain minimal and will not be a focus for local hospitals or state/provincial departments/ministries. Advances in interoperable cross-border communications would provide increased incentive for the responsible jurisdictions to reach this MOU by decreasing the health and safety risks to the patient through improvement in SA to facilitate these transfers.

Recommendation #2: (Vignette 1) All privacy concerns that are derived from the exchange of patient medical records through PSBN or a similar network and supporting applications will need to be addressed prior to the implementation into current patient transfer processes. Additional allowances need to be considered for the capturing of video of the patient's status, and the distribution of this video to the referring and receiving hospitals.

Recommendation #3: (Vignette 2) It was identified that there exists the need for local officials to have the authority to enter into cross-border mutual aid agreements. Due to provincial and state officials currently not possessing this authority, local officials are unable to request and provide mutual aid in a timely manner, as required by real-world emergencies. Although the technologies introduced in this experiment would allow officials to share planning and resource requirements, without a cross-border mutual aid agreement, these planning processes would be unable to be implemented.

4.3. Conclusion

The CAUSE IV experiment evaluation identified benefits in using the PSBN, AVL, mapping and visualization technologies in establishing and maintaining cross-border communications. All the results of the CAUSE IV evaluation were considered in the context of the specific CAUSE IV objectives, as well as the overall CAUSE experiment series objectives. Under this set of considerations, the data analysis identified that the technologies were able to maintain or improve communications, information sharing and SA through near real-time voice, video and data exchange, as well as crowd-sourced information gathering and visualization, enhancing resiliency in these cross-border communities. However, there exists room for improvement in the maturity of capabilities identified both within the CCIC and SMEM models.

While the applications used during the experiment were found to benefit SA and response operations, there exists a need for the development and implementation of governing policies and procedures to support the cross-border responses to situations such as those simulated during the CAUSE IV experiment. This includes the development of formal policies and procedures to handle cross-border patient transfers and the coordination and verification of information gathered through crowd-sourcing, social media or through the use of digital volunteers.

The findings from the CAUSE IV evaluation suggest that the interoperable technologies and applications introduced during this experiment can be used to improve and augment current processes, communications and cross-border responses. Some modifications will be required to address the impacts of using these types of technology in a real-world situation (i.e., WL). In addition, the usability of some of the technologies will require improved compatibility to allow health care professionals to perform their primary function of patient care. The applications also need to be more streamlined to identify high priority public assistance. Overall, despite requiring additional modifications to the technology and the supporting policies, the experiment allowed for an opportunity to demonstrate how information can be more effectively exchanged across the border during emergency response and healthcare operations.

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Annex A: Technology Usage in CAUSE IV

Technology	Details
LTE Network – Sarnia and Ottawa, ON, Canada	
Sub-technology: Nokia eNB, Polaris EPC, IPSec Tunnel using Virtual Tunnel Interface (VTI) backhaul over commodity Internet	
Owner:	Government of Canada
Intended Use:	Provide broadband connectivity to maintain cross-border communications
End Users:	EMS, hospital, EMS dispatch, border agency, bridge authority and EOC personnel
LTE Network – Port Huron, MI, U.S. and Ottawa, ON, Canada	
Sub-technology: Nokia eNB, Polaris EPC, IPSec Tunnel using VTI backhaul, backhaul over Internet 2	
Owner:	Government of Canada
Intended Use:	Provide broadband connectivity to maintain cross-border communications
End Users:	EMS, hospital, EMS dispatch, border agency, bridge authority and EOC personnel
Session Initiated Protocol (SIP) Server	
Sub-technology: Broadsoft, Unified Communications SIP client (UC One), Clearspan Communicator, Mitel	
Owner:	Texas A&M University (Provided by: CRC, Linphone SIP client, Android stock dialer)
Intended Use:	Enables voice over IP (VoIP) communication and enables SIP-based audio and video conferencing
End Users:	EMS, hospital, EMS dispatch, border agency, bridge authority and EOC personnel
Multi-party Video Conferencing	
Sub-technology: Google Hangouts Communication Platform (Video Call, VoIP, Instant Messaging)	
Owner:	CRC
Intended Use:	Facilitates the ability to hold a multi-party real-time video conference
End Users:	Paramedics, hospitals, dispatch, border agencies, bridge authorities and EOCs
EMS Application Suite	
Sub-technology: iMedic GenII, iMedic ER, Dispatch Simulator, CadLink, GEM AVL	
Owner:	Interdev Technologies

Intended Use:	Delivers an EMS application suite to improve overall SA and to provide improved patient care. This includes the transfer and viewing capability of Electronic Patient Care Records (ePCR), 12 point EKG and vital signs transfer.
End Users:	Paramedics, hospitals, dispatch, border agencies, bridge authorities and EOCs
AVL	
Sub-technology: DT Tracker from Datatrans	
Owner:	County of Lambton
Intended Use:	Allows for any information on vehicle (ambulance) location to be known and displayed on a map-based application
End Users:	Paramedics, hospitals, dispatch, border agencies, bridge authorities and EOCs
Email	
Sub-technology: Google Gmail email service (via POP3 or IMAP)	
Owner:	CRC Canada
Intended Use:	Allows for information to be exchanged among all experiment participants
End Users:	Paramedics, hospitals, dispatch, border agencies, bridge authorities and EOCs
Internet Portal – Ottawa, Canada	
Sub-technology: CRC external network Internet portal	
Owner:	CRC Canada
Intended Use:	Provides Internet connectivity to all CAUSE IV experiment participants in Canada and the U.S.
End Users:	Paramedics, hospitals, dispatch, border agencies, bridge authorities and EOCs
ArcGIS Online by Esri	
www.arcgis.com	
Owner:	St. Clair County, Lambton County, Sarnia Police Department, National Information Sharing Consortium (NISC)
Intended Use:	Development of information products, sharing of cross-border content in CAUSE IV Group. Supports Base map, Web maps, GeoForms, Operations Dashboards, Story Maps, Map Viewers, Web Application Templates
End Users:	Local, County, State, Provincial, Federal, Non-governmental organizations and volunteers
CAUSE IV Map viewer	
Sub-technology: ArcGIS Online	

Owner:	NISC
Intended Use:	The CAUSE IV Map Viewer is a configured application built using Esri's Web AppBuilder. The application contained the Virtual USA (vUSA) widget, which allows users to easily view map data that is shared through the CAUSE IV ArcGIS Online group, and acts as a jump-off point to access GeoForms and Operations Dashboards.
End Users:	Local, County, State, Provincial, Federal, Non-governmental organizations and volunteers
GeoForm	
Sub-technology: ArcGIS Online	
Owner:	St. Clair County, Lambton County, Sarnia Police Department, NISC
Intended Use:	The GeoForm provides an easy to use data entry form, which also enables capturing the geographic location associated with the record. Includes the following 4 GeoForms: Trained Weather Spotter, Citizen Damage Assessment, County Damage Assessment, Digital Volunteer- Social Media GeoForms.
End Users:	Trained Weather Spotters, Digital Volunteers, Citizens, County Damage Assessors
Operations Dashboard	
Sub-technology: ArcGIS Online	
Owner:	St. Clair County, Lambton County, Sarnia Police Department, NISC
Intended Use:	The Operations Dashboards were configured to allow users to monitor real-time events, operational status, and other reports. The dashboards are configured with multiple widgets (e.g., bar charts, summary lists), which represent the status of key data layers. Includes the following 6 dashboards: St Clair County Operational Status, City of Sarnia Operational View, Lambton Co. Social Media Dashboard, St. Clair Co. Social Media Operation View, MI-211 Operation View, Lambton Co. 211 Operation View.
End Users:	Local, County, State, Provincial, Federal, 2-1-1
Mutual Aid Resource Planning Application	
Sub-technology: ArcGIS Online	
Owner:	St. Clair County, Lambton County, DHS S&T
Intended Use:	The Resource Planning Application enables planners to identify hazard-specific capabilities, estimate the type and number of resources (personnel and equipment) required to mitigate the hazard, and identify partner agencies to fill resource gaps. The Resource Planning Application is based on an ArcGIS JavaScript Application Template.

End Users:	Planners in St. Clair and Lambton County
Active Operating Picture (AOP) by Latitude Geographic Geocortex	
www.geocortex.com	
Owner:	St. Clair County and Lambton County
Intended Use:	The AOP is a common operating picture application configured with map services. The AOP supports editing of applicable data layers and a collaborative feature where users can markup the map with text and sketches. The AOP can leverage content and user-role based permissions from ArcGIS Online.
End Users:	EOCs at the County Level
St. Clair County Damage Assessment Tool	
Sub-technology: GeoCortex	
Owner:	St. Clair County
Intended Use:	The St. Clair County Damage Assessment Tool is built on Latitude Geographic's GeoCortex tool and provides a guided data input workflow, while also leveraging the county's authoritative parcel and other infrastructure data. The Damage Assessment Tool can be used by planners to estimate potential damage to infrastructure based on known parameters, and is configured to provide graphical visualization of data.
End Users:	EOCs at the County Level
WebEOC by Intermedix	
www.intermedix.com/webeoc	
Owner:	State of Michigan
Intended Use:	Request for Assistance Board
End Users:	U.S. state and local emergency management agencies
My Community Notification Network (MyCNN) & Warning Information Notification System (WINS) by Everbridge	
www.everbridge.com	
Owner:	St. Clair County (WINS), Community Awareness/Emergency Response (CAER) Lambton County, the City of Sarnia (MyCNN)
Intended Use:	Local alert messages (including SMS/text, email, and phone), to cross-border notification groups
End Users:	U.S. and Canadian notification groups, citizens
Social Media Analytics and Reporting Toolkit (SMART)	
http://1.usa.gov/1tr32jq	
Owner:	Purdue University

Intended Use:	The system uses topic extraction, combinations of keyword filters, word cluster examination and unusual event detection to provide SA; alert operations staff by email when pre-defined keywords are detected in social media channels
End Users:	St. Clair County Operations Staff
Facebook	
www.facebook.com	
Owner:	CAUSE IV Simcell
Intended Use:	Private Group with simulated social media content and to support digital volunteer collaboration
End Users:	Digital volunteers, Public Information Officers and other emergency management staff
Twitter	
www.twitter.com	
Owner:	CAUSE IV Simcell
Intended Use:	Private Group with simulated social media content
End Users:	Digital volunteers, Public Information Officers and other emergency management staff
Periscope	
www.periscope.tv	
Owner:	CAUSE IV Simcell
Intended Use:	Live-video capabilities integrated into Twitter
End Users:	Damage assessment teams, emergency management staff
Experiment GeoAnalytics by G&H	
www.nisconsortium.org	
Owner:	NISC
Intended Use:	Siren-Geotrigger Alert System; IPAWS Joint Interoperability Test Command (JITC) alert map products
End Users:	Local, County, State, Provincial, Federal, Non-governmental organizations and volunteers
2-1-1 Call tracking and Application Programming Interface (API) by RTI (MI-211); iCarol Call Reports (Ont-2-1-1)	
www.211.org	
Owner:	211 Michigan and 2-1-1 Ontario
Intended Use:	2-1-1 calls for service and reports. Can be quickly scaled during times of peak calls by leveraging the 2-1-1 network. Integration of 2-1-1 data into ArcGIS Online was completed by DHS S&T.

End Users:	Local, County, State, Provincial, Federal, Non-governmental organizations and volunteers
ER-ITN Post-Event Access Control Platform	
eritn.com	
Owner:	St. Clair County
Intended Use:	Access control system based on existing user credentials.
End Users:	Customs and Border Protection, County Officials and Local First Responders
FEMA IPAWS	
www.fema.gov/ipaws	
Owner:	U.S. Federal Emergency Management Agency
Intended Use:	Aggregated alert messages; EAS broadcasts; COG-to-COG messages; (Note: GOTS technology)
End Users:	Radio First (U.S. Broadcaster), County EOC, Federal Agencies
NAADS (NPAS)	
www.publicsafetycanada.gc.ca	
Owner:	PS Canada
Intended Use:	Aggregated alert messages; EAS broadcasts; COG-to-COG messages; (Note: government off-the-shelf (GOTS) technology)
End Users:	Radio First, County EOC, Federal Agencies
NAADS (NPAS)	
https://alerts.pelmorex.com/	
Owner:	Pelmorex Communications Inc. (Pelmorex)
Intended Use:	Aggregated alert messages; EAS broadcasts
End Users:	Radio First, County EOC, Federal Agencies
NAADS-IPAWS Bridge	
http://sarnia-lambton.netalerts.ca/	
Owner:	NetAlerts
Intended Use:	The NAADS-IPAWS bridge provides the ability for bi-directional Common Alerting Protocol (CAP) message sharing between NAADS and IPAWS, enabling both COG-to-COG and EAS type alerts
End Users:	Radio First, County EOC, Federal Agencies

Annex B : Acronym List

AAR	After action review
AOP	Active Operating Picture
API	Application Programming Interface
AVL	Automatic vehicle location
AWN	Alerts, warnings, notifications
BTB	Beyond the Border
BWDVT	Blue Water Digital Volunteer Team
CAER	Community Awareness/Emergency Response
CANUS	Canada-U.S.
CAP	Common Alerting Protocol
CAUSE	Canada-United States Enhanced Resiliency
CBP	Customs and Border Protection
CBRNE	Chemical, biological, radiological, nuclear and explosives
CBSA	Canada Border Services Agency
CCIC	Canadian Communications Interoperability Continuum
CDN	Canada
CIS	Communications and information sharing
CIWG	CANUS Communications Interoperability Working Group
COG	Collaborative Operating Groups
CONOPS	Concept of operations
CRC	Communications Research Centre

DHS	Department of Homeland Security
DRDC CSS	Defence Research and Development Canada's Centre for Security Science
EAS	Emergency Alert System
ECCC	Environment and Climate Change Canada
EDXL	Emergency Data Exchange Language
EF	Enhanced Fujita
EKG	Electrocardiogram
EMAC	Emergency Management Assistance Compact
EMS	Emergency Medical Services
EOC	Emergency Operations Center
ePCR	Electronic Patient Care Record
GOTS	Government-off-the-shelf
IPAWS	Integrated Public Alert and Warning System
JITC	Joint Interoperability Test Command
LTE	Long-Term Evolution
MI	Michigan
MiCIMS	Michigan Critical Incident Management System
MOU	Memorandum of Understanding
MSEL	Master scenario events list
MyCNN	My Communication Notification Network
NAADS	National Alert Aggregation and Dissemination System
NEMAC	Northern Emergency Management Assistance Compact

NISC	National Information Solutions Cooperative
NPAS	National Public Alert System
NWS	National Weather Service
ON	Ontario
PS	Public Safety
PSBN	Public Safety Broadband Network
S&T	Science and Technology Directorate
SA	Situational awareness
SIP	Session Initiated Protocol
SMART	Social Media Analytics and Reporting Toolkit
SMEM	Social Media in Emergency Management
SOP	Standard Operating Procedure
STEMI	ST Segment Elevation Myocardial Infarction
U.S.	United States
VoIP	Voice over IP
VTI	Virtual Tunnel Interface
vUSA	Virtual USA
WEA	Wireless Emergency Alerts
WINS	Warning Information Notification System
WL	Workload