INTRODUCTION

The number of Active Shooting Events per year have increased from 2000 to now (Blair, Martaindale, & Nichols, 2014). With the increased number these incidents the number of deaths of innocent victims also has increased. Post incident analysis reports suggest improvements in situational awareness could have reduced the number of deaths during the incident. The FBI, along with other US government agencies, defines an Active Shooter Event as an incident where “an individual actively engaged in killing or attempting to kill people in a confined and populated area” (Blair & Schweit, 2014).

Situation awareness is the perception of environmental elements with respect to time and/or space, the comprehension of their meaning, and the projection of their status after some variable has changed, such as time, or some other variable. Situational Awareness is critical for decision making especially in the context of emergencies and disasters as delay and mis-information may lead to increased loss of life and property. The most common means of obtaining situational awareness would be to identify what information is required for the mission. This information may be gathered through sensors, news media, voice communication and manual entry systems (ESRI, 2008). In many dynamic work situations, no single individual can acquire the varied and often rapidly expanding information needed for success. Individuals must work together to collect, analyze, synthesize and disseminate information throughout the work process (Sonnenwalda & Pierceb, 2000). Frequent communication between participants about the work context and the evolving situation, is needed.

Response efforts to ASEs (Active Shooter Events) tend to be law enforcement centric, and compartmentalized by agency. In the context of a shooting incident, the on-scene incident commander responsible for managing victims is typically interested in the following information:

a) number of victims,
b) location of victims,
c) the extent of medical intervention needed for each victim,
d) the shortest path for emergency medical technicians to reach victims,
e) best way to transport victims to ambulances,
f) supplies and resources needed for triage,
g) hospitals in the vicinity that can accommodate the victims,
h) distance to the various hospitals,
i) congestion maps to hospitals.

All the above information is not gathered by a single agency, nor is it available in a central repository that would allow the Incident Commander to make the fastest most effective victim management decisions.

This project proposes the development of a system that will combine all the above elements, to allow a more efficient process of decision making during the response efforts to an ASE, especially for decisions that directly impact victim management. The proposed system
provides mechanisms for the input of relevant information by different responding agencies through the use of web and mobile apps. The tool will facilitate situational awareness during the response efforts to shooting incidents, extending primary triage as an input to situational awareness. The system provides an inclusive response process to ASEs (Active Shooter Events) from the point when such an incident is identified by a police agency (at the time of the first 911 call), to the time when the last victim is released from the hospital, from the vantage point that allows efficient victim management to be at the forefront of the efforts.

This project will yield an artifact with the following features:

- Triage and tagging of victims at disaster site;
- Real time update of triage data to command center.
- Assist EMS Providers with the weighted shortest path to reach injured victims.
- Availability of beds in Trauma Centers
- Dashboard for Command center with real time situational assessment of victims, resources available, and resources at the scene
- Overlay of the building blueprint with optimal victim extraction route

SCOPE

The study does not encompass all mass killings or shootings in public places and therefore is limited in its scope. This is a study of ASEs - a specific type of shooting situation law enforcement and the public may face. In addition, this project focuses on incidents that occur indoors.

The grand majority of ASEs occur in closed spaces, i.e. inside buildings. According to a recent study of ASEs (Blair & Schweit, 2014), only 9% of the 160 incidents studied occurred in open spaces, with commerce (open to pedestrian traffic) and education locations being the target of 56% of the incidents. This narrows the scope of the development of a response system to one that will be used indoors.

DESIGN OF THE ARTIFACT

The design of the artifact proposed follows a multi-phase methodology. Each phase will follow a specific process that will result in a tangible outcome.

Phase 1

Phase 1 is a requirements gathering phase that consisted of interviews with members of different agencies that would participate in the response efforts to an ASE, if one were to occur within the jurisdiction of the Town of Amherst, NY. The area has several grade schools, large indoor shopping areas, and a few higher education campuses. The responders interviewed have received specific training to respond to Active Shooter Events.
The objective of Phase 1 is to gain a deep understanding of the timeline of Active Shooter Events, and to develop an ontology based on the timeline elements identified.

The timeline below shows how an ASE unfolds from the time the 911 call is received at the dispatch center:

![Timeline of Participation Points in an Active Shooter Event](image)

Each participation point identifies which responding agency participates, in the response efforts of an ASE. Some of the processes identified on the timeline overlap other processes and can span longer periods of time. The timeline is a simplified graphical description of how the response efforts to an ASE occur.

**Subsequent Phases**

Subsequent phases will include surveys administered to responding agents from several agencies, with the objective of studying each of the participation points mentioned above, to identify what tasks, decisions and communication processes occur at each one.

The system prototype will be built, and tested in a table top exercise, and refined based on the testing.

The outcome of the project will be a full working, tested prototype; based on the ontology developed, that can be expanded to outdoor ASE, as well as other types of events with the potential to require mass victim management efforts.
PURPOSE AND USE

The response efforts in an ASE tend to be law enforcement centric, and cooperative efforts among responding agencies are often hindered by factors such as: the lack of a common information repository; mutual aid rules that determine the involvement of each agency; HIPAA boundaries on victim information that can be shared; and, gaps in communication from hand-offs between agencies.

This ontology aims to fill the void that provides coverage to all efforts related to victim management, and to expand the shared understanding that each one of the agencies has of what is comprised in response efforts to an ASE. The ontology will also create interoperability between agency systems, and allow a common communication framework to be re-used every time an ASE occurs.

Having a formal representation of all the elements that occur in the response efforts to an ASE, will increase the reliability of the decision making processes that occur, in an otherwise informal network of responders. Therefore created a more sound system, as proposed by this project.

EXISTING BODIES OF DATA

There are several bodies of data that contribute to the shaping of this ontology. Some of them are formally defined exchange languages, while others just reflect the industry standards that rule the response efforts in emergency situations.

NIEM

The National Information Exchange Model (NIEM) is the result of a collaborative effort between several governmental agencies in the U.S. with the purpose of sharing key elements in emergency management initiatives (NIEM, 2014), among others that are not relevant to this project. The information exchange standards covered by NIEM, include core components that cover elements that are shared among most domains; as well as, namespaces for domain specific elements.

This ontology covers elements that are not included in the NIEM body of data, but relates to some of the domains. For example the FBI namespace defines a multitude of events, but none of them are of the Active Shooter Event type.

EDXL

The Emergency Data Exchange Language (EDXL), is a collection of messaging standards created to facilitate information sharing between emergency related organizations (OASIS, 2014). The EDXL has several components, which contribute to the definition of some of the elements in this ontology, as well as some of the properties of these elements. This ensures that the ontology is applicable in real life situations because governmental accepted naming conventions are followed.
<table>
<thead>
<tr>
<th><strong>EDXL Component</strong></th>
<th><strong>Overview</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Distribution Element (DE)</td>
<td>XML header that provides message distribution for data sharing among emergency information systems</td>
</tr>
<tr>
<td>Resource Messaging (RM)</td>
<td>Set of standard messages that relate to the coordination of requests for emergency equipment, supplies and human resources</td>
</tr>
<tr>
<td>Hospital Availability (HAVE)</td>
<td>Enables the communication of bed capacity, ER status and availability of services covered by hospitals</td>
</tr>
<tr>
<td>Situation Reporting (SitRep)</td>
<td>Standard format for sharing information about incidents that require some kind of emergency response by governmental agencies</td>
</tr>
<tr>
<td>Tracking of Emergency Patients (TEP)</td>
<td>Messaging standards to track information from the patient encounter moment through hospital release. Relates mostly to patient transportation</td>
</tr>
</tbody>
</table>

Table 1 - EDXL Components

**START Triage**

The Simple Triage And Rapid Treatment (START) method is widely used in the U.S. and is used to quickly classify victims of mass casualty incidents according to an algorithm (Radiation Emergency Medical Management, 2014). Victims are classified into one of four statuses, each of which is associated or identified by a color:

- Expectant/Deceased (black)
- Immediate (red)
- Delayed (yellow)
- Minor/Walking (green)

**NIMS**

The National Incident Management System (NIMS) defines a common approach to managing incidents with the objective of reducing loss of life, property and harm to the environment, and provides training to enable it (FEMA, 2014).

**ICS**

The Incident Command System (ICS) is a management system developed under the umbrella of NIMS, to enable integrative incident management under a common organizational structure (FEMA, 2014).
TERMS AND LAYOUT

The terms and a first draft of the ontology elements were derived from interviews with:

- Captain McGonagle of the Amherst Police Department
- Dr. Joshua Lynch: Medical Director of Mercy Air, Director of Emergency Medical Services at Millard Fillmore Subarban Hospital, Medical Director for 7 Fire Departments in the WNY area
- Bryan Brauner: CEO of Twin City Ambulance
- James Reger: Emergency Manager for the University of Buffalo
- Mark Kreyer: DHS Protective Security Advisor for the Buffalo District

The initial conceptual model was translated into an OWL file, using protege and following the Basic Formal Ontology (BFO 2.0). The .owl file will have some of the elements of the existing bodies of data mentioned in a previous section, mostly in the form of properties of the classes created for this ontology.
AXIOMS AND RELATIONSHIPS

The ontology has a set of axioms and reflects a set of relationships between elements.

Axioms

Each person can only have one role at any given point in time.
Each responder is a member of a responding agency
Each vehicle belongs to an organization
Any victim who are is breathing after the airway is cleared, has an Expectant triage Status
All Medevac helicopters have an Emergency Medicine Physician and a Paramedic
All Advanced Life Support Ambulances have a Paramedic
All Victims with a triage status of Immediate are transported under the care of at least a Paramedic

Relationships

<table>
<thead>
<tr>
<th>Relationship</th>
<th>Source</th>
<th>Target</th>
<th>Inverse Relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triages the</td>
<td>EMT</td>
<td>Victim</td>
<td>Is triaged by</td>
</tr>
<tr>
<td>Transports the</td>
<td>Ambulance</td>
<td>Victim</td>
<td>Is transported by</td>
</tr>
<tr>
<td>Operates the</td>
<td>EMR</td>
<td>Ambulance</td>
<td>Is operated by</td>
</tr>
<tr>
<td>Secures the</td>
<td>Police Officer</td>
<td>Focal Building</td>
<td>Is secured by</td>
</tr>
<tr>
<td>Occupies</td>
<td>Building Occupant</td>
<td>Building</td>
<td>Is occupied by</td>
</tr>
<tr>
<td>Occurs at</td>
<td>Process ASE Gross Triage Victim Triage</td>
<td>Site Focal Building Focal Building Triage Staging Area</td>
<td></td>
</tr>
<tr>
<td>Send Information</td>
<td>Dispatcher</td>
<td>Responders</td>
<td>Receive information</td>
</tr>
</tbody>
</table>

Table 2 - Ontology relationships
THE .OWL FILE

The .owl file is based on a BFO 2.0 reasoning and falls under its domain neutrality. This will allow further integration with existing ontologies. The BFO was downloaded from the BFO webpage of the IFOMIS website, and imported with Protege to integrate this ontology.

Continuants

The majority of the classes specified in this ontology are generically independent continuants. The material entities are mostly object that are in some way related to immaterial entities, for example:

"a first responder person is a member of a responding agency organization"

Worth mentioning are:

- The site classification is used to refer to physical geographical locations of person, vehicle or organizations.
- The object aggregates that represents a population of objects, like a police force that is a collection of police officers. This representation of aggregates can be useful when considering that a police force can behave differently than a group of individual police officers acting independently.

Figure 3 - Independent Continuants
The Specifically Dependent Continuants are used to characterize some of the properties of the objects. For example: Victim Status or Age are relational qualities of victims, and 1st Officer on the scene or Incident Commander are roles that a person can have.

![Figure 4 - Relational Qualities](image)

Figure 4 - Relational Qualities

The Active Shooter role does not exist because there is no direct participation of the shooter in the response efforts. This person is just outside of the scope of this project.

![Figure 5 - Roles](image)

Figure 5 - Roles

**Occurents**

The occurents define the processes that occur during the response to an ASE. These occurent reflect the processes identified in the timeline of events, and include: the triage process, the securing the building process, the transport patient process, among others.

The actual Active Shooter Event is also a process, and is therefore also defined as an occurent in the .owl file.

![Figure 6 - Processes](image)

Figure 6 - Processes

**FUTURE WORK**

The current .owl file has plenty of room for improvement. The most immediate way to improve it is going to through be increased integration with BFO 2.0 to import the XML standards from the existing bodies of data for emergency response. This could potentially identify more classes and deeper hierarchies, leading to a more accurate understanding of the response efforts as a whole, along with more efficient coordination in these efforts.
This ontology will also benefit from an extension to include a classification of the decision making process, for the decisions regarding victim management. Integrated in this ontology will be a building ontology to allow the system prototype to incorporate building blueprint features in a way that allows the highest level of re-usability possible.

Notes of future work...

### Class: Participation Point

**Definition:** (...)

**Properties:** consists of at least one of the following: task, decision, communication

### Class: Decision

**Definition:**

**Properties:** type (operational, organizational, strategic) input; output (task, notification, alert, request, assignment, postponement); decider (command, collaborative, consensus)

### Class: Task

**Definition:**

**Properties:** start time; end time; objective; description; status; ownership

*Check Task Ontology (TMO) and TOVE*

### Class: Communication

**Definition:**

**Properties:** sender; receiver; message;

*Check speech acts (SEARLE); Kishore, Sharman, Ramesh – DSS*
REFERENCES

Aurora Fire Department, Century Theater Shooting: preliminary incident analysis,


