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## “Collective C2 in Multinational Civil-Military Operations”

**Title of Paper**
Information Access Challenges: Data Fission Needs of the Field Expert

**Topic(s)**
Information and Knowledge Exploitation; Concepts, Theory, and Policy; and Experimentation, Metrics, and Analysis

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# ABSTRACT

Field experts, otherwise known as super users have complex data retrieval needs that extend beyond internal systems. For example, field experts who interface with a command and control structure rely on both “decision” and “raw” data. These complex data needs are further complicated when field experts need to assemble rich data to make critical and timely decisions in situ from an affected area, in adverse conditions. Our research details instances where “raw data” is compromised to best suit the broader population of users, bypassing the critical needs of field experts. Recognizing fused decision data is usually groomed by a designated field expert, the intervention alone dilutes the purity of raw data. This ongoing research addresses the following research question: What are the information access challenges of the field expert in an operational context when tasked with critical and timely decision making requests? This paper focuses on one aspect of the aforementioned question: How do field experts adapt their environment to retrieve raw data? Using rapid ethnographic assessment we highlight one raw data contingency essential for field expert decision making. Our assessment takes a bottom-up approach demonstrating the need for timely low-level data for critical decision making that is not readily available. The contribution of this research is directed towards sustainable best practices that are agile and light-weight and can support the field expert needs for critical fused data and the need for raw data as part of accurate decision making. We propose an approach for data consolidation which benefits decision makers, especially those who need vital and accurate information at the lowest level of detail. A data fusion scheme, which provides decision makers the ability to derive knowledge sets independent of pre-fused data, is included

**Keywords:** Data fusion, decision making, command and control.

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## 1. Introduction

Incident command systems (ICS) are gradually migrating to multi-team systems that are populated by collectives of individuals (Hof, de Koning, and Essens, 2010) who contribute situation details (data) towards a common operational picture (COP). The situation details stored within an ICS are usually groomed by a designated expert at the strategic command level. While a COP is essential for overall incident response, the data needs of field experts responding from an affected area differ and include environmental contingencies (terrain, weather, culture, resources). These field experts (lower echelon) deployed to an affected area must work with constrained resources unlike the upper echelon who reside outside of the affected area. In situ decision making from the field is therefore coupled with constraints (Gomez, 2008; Gomez, 2010), such as limited communication capabilities, making access to data (real-time and archived) more challenging. In addition, field experts experience information overload. Recognizing the ongoing challenges of information overload, we posit that use of "raw" data bypasses information overload because the field expert is not receiving "information" and instead receiving/handling "raw" data. As such, a framework is needed for field experts who rely on a local operational picture (LOP) and archived raw data for decision making.

In this paper we focus on the "raw" data needs of field experts from an affected area, at the operational level, during crisis response. We utilize the definition of response as provided by FEMA which "includes immediate actions to save lives, protect property and the environment, and meet basic human needs. Response also includes the execution of emergency plans and actions to support short-term recovery (FEMA, 2011)." On June 15, 2010 Department of Homeland Security (DHS) Secretary Janet Napolitano announced new standards for private sector preparedness including the need for monitoring and measuring of data collectives for preventative measures and metrics (AIS, 2009). At present scant research exists on this topic for the private sector. Coupling this need with civil military operations (CMO), Ackerman (2011) explains "The armed forces are overwhelmed by all the data its various sensors are sniffing out. They want a single data stream that combines drone video feeds, cell phone intercepts, and targeting radar."

Using a bottom-up approach, our ongoing empirical research focuses on the actor (field expert) who interfaces with the aforementioned data (Gomez, 2008; Gomez 2010; Gomez and Bartolacci, 2011). The context of our discussion will highlight the actor in a CMO and the recipient of raw data needs, such as "sensor output products from imagery and video, communications intercepts and the tracking of a moving target" a need identified by Darpa (Ackerman, 2011). We extend the aforementioned empirical research which measures the performance of field experts in a simulated training environment, such as those in civil-military situations. Through training and simulation, we capture constrained communication protocols (raw data in the form of an SMS text-message) that pertain to a LOP. We hypothesize that decision data must be coupled with raw data at the atomic level for field experts who are making critical decisions that are timely and made in real-time. The need for atomic level (raw) data differs from data mining techniques and what we term "data fission".

This paper reports on a single instance from our rapid ethnographic assessment. Our findings support the need for a Data Fission Framework aimed to improve the assembly of raw data for use by field experts. A Data Fission Framework is needed to accommodate field experts who bring their own interpretations to the situation (incident) in an affected area rather than interpretations based on a decision maker's data set. We argue that the need exists for raw data that falls under the decision fusion process depending on the application domain. Due to the complexities of the crisis (emergency) management domain and the intricacies in assembling data, we leverage a rigorous grounded theory approach for the overarching research at hand. For this phase of our research, we focus on rapid ethnography assessment.

To inform the research at hand and our framework, we assess data sources to extend our training application, allowing us to measure field expert behavior in a controlled setting. We demonstrate a single instance where "raw" data is needed and the information challenges of the field expert. We use environmental data (climate, weather) as the starting point for our analysis for two reasons: 1) data is relevant and critical to both civil and military field experts in an affected area; 2) data is credible and unclassified. Section one of this paper presents the research objective. Section two introduces field expert information challenges, an overview of CMO and information overload. We transition to information fusion and then step through instances were decision data compromises the decision making of the field expert and explain information fusion. Our discussion transitions to a proposed data fission framework and the foundation for field expert observations. We conclude with the contribution and next steps of this ongoing research.

## 2. Background – Field Expert Information Challenges

The three primary levels of CMO are: 1) strategic; 2) operational; and 3) tactical. In this paper, we focus on the operational level and the role of the field expert (Gomez et al., 2006; Gomez and Passerini, 2007). The field of crisis response is continuously challenged by the uncertainty and unique dimensions (Gomez et al. 2007) that accompany each incident. The complex data needs and constrained resources further complicate the role of the field expert responding from an affected area. To-date experts are challenged by information overload and constrained resources when responding from the field. Information overload originates from complex systems that house "information" at the strategic command level. The transmission of information lacks purity and often is not sufficient for the field expert in an affected area. On the one hand real-time data can be messy, yet on the other hand decision data often dilutes the purity of raw data. Moreover, complex systems data are difficult to visually represent (Green et al. 2010; Yoo, 2010) with multimedia facts. Transmission of multimedia data to a field expert in an affected area is also an issue and where raw data transfer would benefit the field experts in an affected area.

We differentiate between data and information using the definition of "raw as facts that have not been processed to reveal their meaning (Rob and Coronel, 2009)". For instance, field experts responding to crisis management incidents rely on ICS for event details (FEMA, 2011; McKenna, 2010).

### 2.1 Data for Decision Making

Real-time details of an incident can include unique dimensions and be digitally represented as text, graphics, audio or video. Aside from raw data needs relating to the COP, the field expert in an affected area needs raw data in line with the environmental contingencies and LOP for critical and timely decision making. The contingencies of CMO at the operational level are further complicated by the distinct nature of the crisis response units (NGO, civilians) for an incident. Alike, the contributions from these responding units and the crowds are invaluable (CNN, 2010) to the field expert. The unique needs of the field experts who handle complex problems rely on a combination of complex systems (decision) data and incident specific (raw) data.

The nature of CMO falls between two distinct populations: the military (trained) and civilians (untrained or cross-sector). The experts are assigned to the affected area to fill a gap (need). Focusing on the field experts of civil-military operations, we note “recent policy initiatives, national security, military strategies, and military doctrine demonstrate a growing appreciation of the need to leverage more nonmilitary instruments of national power, reposed in the interagency process and the private sector, entailing a more holistic, and balanced strategy (CMO, 2008).” Incident details aligned with CMOs— are holistic, cumulative, integrative, and synergistic, working in the seams of power and gaps in organizations, phases, and processes— include dimensions of the population, the interagency and multinational options for collaboration and relationship building (CMO, 2008). The field experts who are working in the seams of power and gaps in organizations need access to multiple courses of data (decision and raw) to fill those gaps. For instance a rapid rate of change in temperature in an affected area may be a trigger for response at the local level and differs from having only the minimum and maximum temperature predictions in a 24 timeframe.

### 2.2 Information Fusion

Information fusion as defined for our research rests upon Rhetorical Structure Theory (RST). Mann and Thompson’s (1988) research on RST provides a seminal contribution to the first research of information fusion and discourse. Information fusion is defined as an “information process that associates, correlates and combines data and information from single or multiple sensors or sources to achieve refined estimates of parameters, characteristics, incidents and behaviors” (Llinas et al. 2004; Kludas et al. 2008). Fusion processes are normally represented as low, intermediate and high and become structured metadata. Information fusion is best represented in three levels named as follows: 1) data fusion; 2) intermediate fusion, and 3) decision fusion.

### 2.2.1 Data Level Fusion

Data level fusion is generally defined as the use of techniques that combine data from multiple sources (dimension #1 & #2) and gather that information in order to achieve inferences (see scatter plot), which will be more efficient and potentially more accurate than if they were achieved by means of any single source (one or the other histogram). Otherwise known as "low level fusion", where several sources of raw data are combined to produce new raw data that is expected to be more informative and synthetic than the inputs. Typically, in image processing, images presenting several spectral bands of the same scene are fused to produce a new image that ideally contains in a single channel all (most) of the information available in the various spectral bands. An operator (or an image processing algorithm) could then use this single image instead of the original images. This is particularly important when the number of available spectral bands becomes so large that it is impossible to look at the images separately. In sum, data fusion can be considered "raw data" once removed or level 1 of structured data.

### 2.2.2 Intermediate Level Fusion

Intermediate level fusion also called feature level fusion, combines various features. Those features may come from several raw data sources (several sensors, different moments, etc.) or from the same raw data. In the latter case, the objective is to find relevant features amongst available features that might come from several feature extraction methods. Typically, in image processing, feature maps are computed as pre-processing for segmentation or detection. In sum, intermediate fusion can be considered "raw data" twice removed or level 2 of structured data.

### 2.2.3 Decision Level Fusion

Decision level fusion, also referred to as high level fusion combines decisions coming from several experts. Decision fusion is that data known to be stored in a data warehouse and what now is the input to data mining activities and most accessible to the general user (actor/field expert). "By extension, one speaks of decision fusion even if the experts return a confidence (score) and not a decision. To distinguish both cases, one speaks of hard and soft fusion. Methods of decision fusion include voting methods, statistical methods, fuzzy logic based methods, etc. (Dasarthy, 1994)." In sum, decision fusion can be considered "raw data" three+ times removed or level 3 of structured data.

## 3. Field Expert Data Needs – A Discussion

Information fusion has seen exponential growth due to connectivity, cost and information technology capabilities. The notion of "sharing" can be seen from emails to social media and web applications. The sheer volume of data used to fuse information not to mention the processing time and resources needed to fuse information is large. While a COP is necessary for all levels (strategic, operational, tactic) of crisis response, the reliance on a common operating picture and the ability to harness that information is challenged for field experts who are deployed to an affected area and detached from the incident command systems providing a COP.

### 3.1 Balancing Decision Data and Raw Data

The field of crisis (emergency) management relies on field experts who are confronted with critical real-time decisions that contain a high degree of uncertainty. The multitudes of dimensions that surface from a single incident produce massive data archives, such as the incident type and level of severity (Gomez et al. 2007). The coupling of information with the precise needs of each field expert (actor) is often compromised when data has already been handled by a decision maker before archiving for actor (field expert) access. Information repositories (data warehouses), regardless of level, have already been once removed from "pure" raw data. For example, on the NOAA site, historical temperature data is publically available which displays historical data points per day of the temperature minimum, maximum, average, heating index and cooling index. What we do not see is how often the "minimum" temperature was reached in a single day, nor the "maximum" temperature per day leaving us with a missing piece of vital “raw” data. Extending the need for temperature change throughout the day, we narrow the focus of our example to seasonal heat wave data

A crisis management incident, much like a corporate project, requires field experts have access to common information and then specifics that are at a much lower level (data) than the roles combined. In many cases, the data management associated with the lower level data has already been structured and is no longer raw data. The proper data management of end-user (actor/field expert) data should afford retrieval in its raw, unstructured form. Once the structuring of data begins, the information process begins. We note that implementing the National Information Sharing Guidelines to share intelligence and information should improve the ability of systems to exchange data that can enable data sharing activities and allow for emphasis at the atomic level (DHS, 2008).

Field experts need the ability to assemble data based on their unique needs from complex systems, which contain valuable data. Moreover, in times of crisis, the need for raw data assembled for use from multiple perspectives (roles) needs to be rapidly disseminated. To-date this process often falls to decision makers who elect which information should be shared and made available. As a result, the decision making quality falls to the acquisition of needs based on data collected. The decision making process should afford information richness beyond the view of a single data source and the purpose of this research. At present, the greatest value of combined data rests within an application domain (i.e. specialty area) when data has already been handled by decision makers in lieu of assembled raw data.

### 3.2 Examples of Data Needs

The fusion of information from multiple data sources has increased exponentially with technology advances, namely GIS systems and data mining efforts. Another challenge that affects the information fusion balance is proper data management of end-user (actor/field expert) raw data and a method for structuring information so that you can get back to the unstructured (raw) data (Rob and Coronel, 2009). The power of super computers coupled with push/pull functionality of mobile devices enables the contributions of unstructured data but limit the retrieval of raw data from storage.

To-date multiple approaches have been taken to aggregate, fuse and mine data. One data aggregation study notes that “summary statistics of cancer data are either provided only by geographic unit (county, state, etc.), or by population demographic unit (age, ethnicity, etc.) (Maciejewski et al. 2010). Relative groupings of cancer statistics for analysis and summary reporting is an important task for public health officials. In this example, we highlight the disparity between data collected in rural and urban counties is often detrimental in the appropriate analysis of cancer care statistics. One common method of handling this situation is to summarize cancer data by population within a state, ignoring the spatial data components (Maciejewski et al. 2010). The spatial components are invaluable to a field expert who specializes in this area.

Semantic graph analysis is another issue (Yoo, 2010). From a data processing (availability) perspective, data fusion related activities remain in the scientific community. Balancing fusion and fission is complex. The complexities make this situation a viable candidate for grounded theory. Moreover, little information systems (IS) research has been conducted following the rigors of grounded theory (Matavire et al. 2009; Van Niekerk et al. 2009). Moreover, using grounded theory for information fusion has not been accomplished at the time of this research and where we place emphasis.

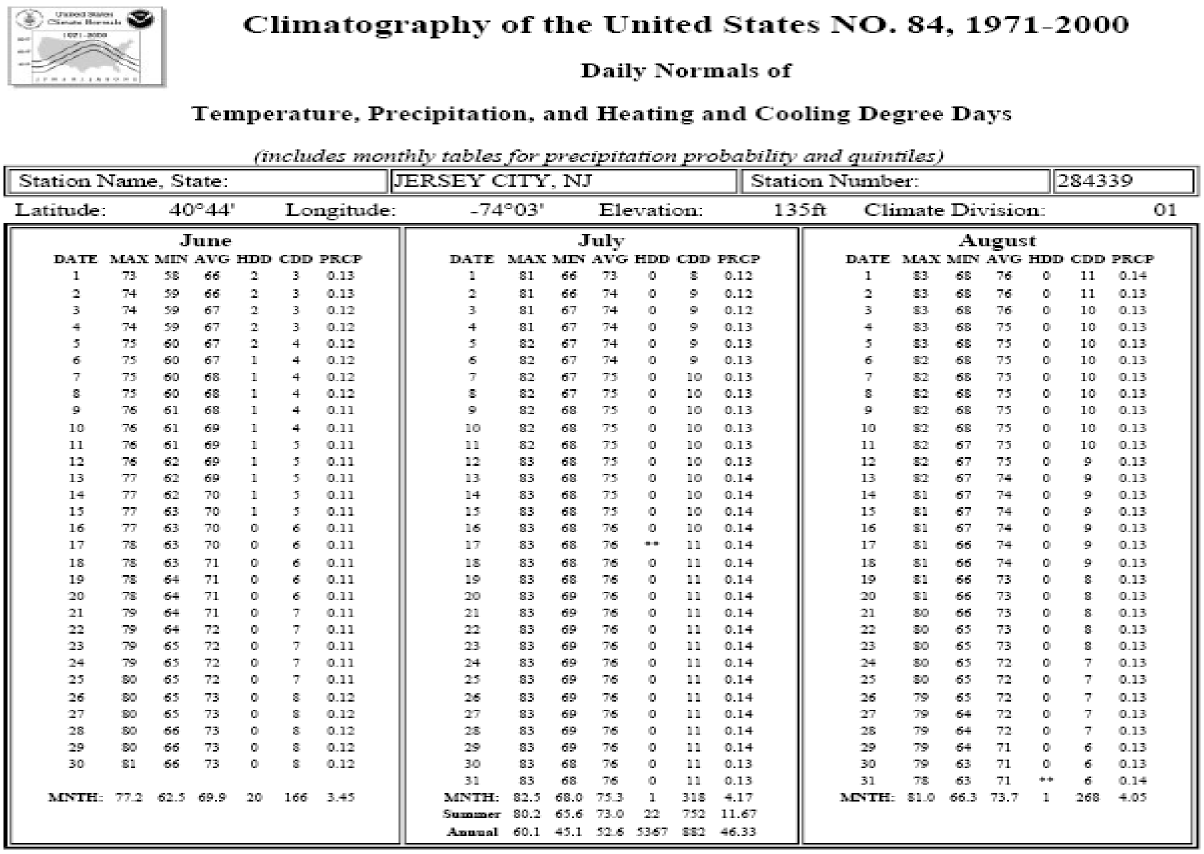
The 2010 snowstorm on the East coast which paralyzed several states presents a recent incident that involved information retrieval from the Regional Integrated Transportation Information System (RITIS). Both status information and GIS mapping information in real-time (McKenna, 2010) were made available. RITIS fuses collected information together and then resends it to those who have access. The data collected varies in that field experts are frequently forced to a common view of data through the data owner's lens. We argue that this approach can cause a myopic view of the situational awareness and force a predetermined decision outcome. By allowing field experts the ability to form their own views, we provide an environment where multiple outcomes are possible.

Historical data can expedite and improve the decision making process. In most instances, data captured by a system, such as RITIS, becomes historical data over time, and is housed within a data warehouse architecture. The information made available to the actor (field expert) has already been handled by a decision maker and is no longer "raw data". While the information that is shared can be invaluable, the need for "role specific" raw data that is timely and relevant still remains**.**

## 4.0 Rapid Ethnographic Assessment – Environmental Data Needs of Field Experts

Theoretical grounding for wicked problems, as seen in crisis management becomes a challenge leading to a mixed-methods approach for this ongoing research. Following Millen's (2000) rapid ethnographic assessment method with three key ideas: 1) narrow the focus; 2) use interactive observation techniques; 3) use collaborative data analysis methods. This paper focuses on key idea number 1 "narrow the focus" and is presented below. Our conclusion will discuss next steps for key ideas 2 and 3.To begin our rapid ethnographic assessment we narrowed "the focus of the field researcher before entering the field". We observe field expert needs by using a dimension (weather) of crisis response that is present in most CMO crises.

We use environmental conditions (weather) to "zoom in on the important activities (Millen, 2000)" of our field experts. Our rational for a rapid ethnographic assessment is to identify credible, public data sources that can be used when observing field experts in a controlled (simulated) environment. To accomplish key idea 2 "use interactive observation techniques" we are expanding our web-based training application (*New Jersey Institute of Technology IRB Protocol Number E80-07*) that measures usage behavior of field responders. Data sources from our key idea 1 will be used for key idea 2.



Climatography of the United States NO. 84, 1971-2000

Daily Normals of

Temperature, Precipitation, and Heating and Cooling Degree Days

*(includes monthly tables for precipitation probability and quintiles)*

| | | | |
|---|---|---|---|
| Station Name, State: | JERSEY CITY, NJ | Station Number: | 284339 |

Latitude: 40°44' Longitude: -74°03' Elevation: 135ft Climate Division: 01

June

| DATE | MAX | MIN | AVG | HDD | CDD | PRCP |
|---|---|---|---|---|---|---|
| 1 | 73 | 58 | 66 | 2 | 3 | 0.13 |
| 2 | 74 | 59 | 66 | 2 | 3 | 0.13 |
| 3 | 74 | 59 | 67 | 2 | 3 | 0.12 |
| 4 | 74 | 59 | 67 | 2 | 3 | 0.12 |
| 5 | 75 | 60 | 67 | 2 | 4 | 0.12 |
| 6 | 75 | 60 | 67 | 1 | 4 | 0.12 |
| 7 | 75 | 60 | 68 | 1 | 4 | 0.12 |
| 8 | 75 | 60 | 68 | 1 | 4 | 0.12 |
| 9 | 76 | 61 | 68 | 1 | 4 | 0.11 |
| 10 | 76 | 61 | 69 | 1 | 4 | 0.11 |
| 11 | 76 | 61 | 69 | 1 | 5 | 0.11 |
| 12 | 76 | 62 | 69 | 1 | 5 | 0.11 |
| 13 | 77 | 62 | 69 | 1 | 5 | 0.11 |
| 14 | 77 | 62 | 70 | 1 | 5 | 0.11 |
| 15 | 77 | 63 | 70 | 1 | 5 | 0.11 |
| 16 | 77 | 63 | 70 | 0 | 6 | 0.11 |
| 17 | 78 | 63 | 70 | 0 | 6 | 0.11 |
| 18 | 78 | 63 | 71 | 0 | 6 | 0.11 |
| 19 | 78 | 64 | 71 | 0 | 6 | 0.11 |
| 20 | 78 | 64 | 71 | 0 | 6 | 0.11 |
| 21 | 79 | 64 | 71 | 0 | 7 | 0.11 |
| 22 | 79 | 64 | 72 | 0 | 7 | 0.11 |
| 23 | 79 | 65 | 72 | 0 | 7 | 0.11 |
| 24 | 79 | 65 | 72 | 0 | 7 | 0.11 |
| 25 | 80 | 65 | 72 | 0 | 7 | 0.11 |
| 26 | 80 | 65 | 73 | 0 | 8 | 0.12 |
| 27 | 80 | 65 | 73 | 0 | 8 | 0.12 |
| 28 | 80 | 66 | 73 | 0 | 8 | 0.12 |
| 29 | 80 | 66 | 73 | 0 | 8 | 0.12 |
| 30 | 81 | 66 | 73 | 0 | 8 | 0.12 |
| MNTH: | 77.2 | 62.5 | 69.9 | 20 | 166 | 3.45 |

July

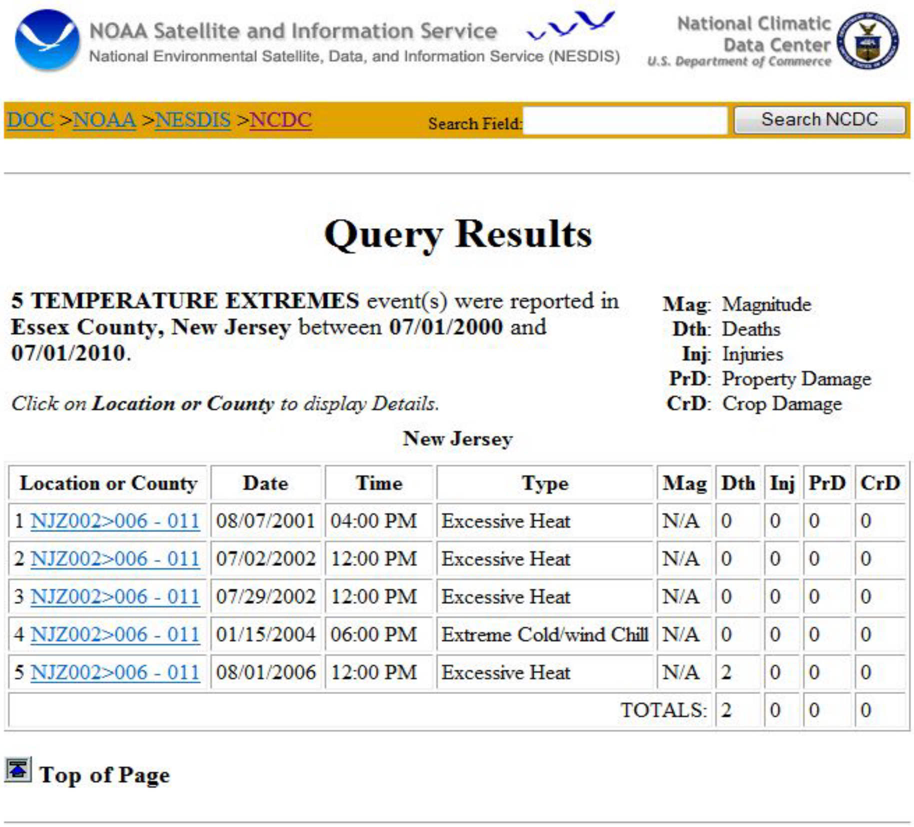
| DATE | MAX | MIN | AVG | HDD | CDD | PRCP |
|---|---|---|---|---|---|---|
| 1 | 81 | 66 | 73 | 0 | 8 | 0.12 |
| 2 | 81 | 66 | 74 | 0 | 9 | 0.12 |
| 3 | 81 | 67 | 74 | 0 | 9 | 0.12 |
| 4 | 81 | 67 | 74 | 0 | 9 | 0.13 |
| 5 | 82 | 67 | 74 | 0 | 9 | 0.13 |
| 6 | 82 | 67 | 74 | 0 | 9 | 0.13 |
| 7 | 82 | 67 | 75 | 0 | 10 | 0.13 |
| 8 | 82 | 67 | 75 | 0 | 10 | 0.13 |
| 9 | 82 | 68 | 75 | 0 | 10 | 0.13 |
| 10 | 82 | 68 | 75 | 0 | 10 | 0.13 |
| 11 | 82 | 68 | 75 | 0 | 10 | 0.13 |
| 12 | 83 | 68 | 75 | 0 | 10 | 0.13 |
| 13 | 83 | 68 | 75 | 0 | 10 | 0.14 |
| 14 | 83 | 68 | 75 | 0 | 10 | 0.14 |
| 15 | 83 | 68 | 75 | 0 | 10 | 0.14 |
| 16 | 83 | 68 | 76 | 0 | 10 | 0.14 |
| 17 | 83 | 68 | 76 | ** | 11 | 0.14 |
| 18 | 83 | 68 | 76 | 0 | 11 | 0.14 |
| 19 | 83 | 68 | 76 | 0 | 11 | 0.14 |
| 20 | 83 | 69 | 76 | 0 | 11 | 0.14 |
| 21 | 83 | 69 | 76 | 0 | 11 | 0.14 |
| 22 | 83 | 69 | 76 | 0 | 11 | 0.14 |
| 23 | 83 | 69 | 76 | 0 | 11 | 0.14 |
| 24 | 83 | 69 | 76 | 0 | 11 | 0.14 |
| 25 | 83 | 69 | 76 | 0 | 11 | 0.14 |
| 26 | 83 | 69 | 76 | 0 | 11 | 0.14 |
| 27 | 83 | 69 | 76 | 0 | 11 | 0.14 |
| 28 | 83 | 69 | 76 | 0 | 11 | 0.14 |
| 29 | 83 | 69 | 76 | 0 | 11 | 0.14 |
| 30 | 83 | 68 | 76 | 0 | 11 | 0.13 |
| 31 | 83 | 68 | 76 | 0 | 11 | 0.13 |
| MNTH: | 82.5 | 68.0 | 75.3 | 1 | 318 | 4.17 |
| Summer | 80.2 | 65.6 | 73.0 | 22 | 752 | 11.67 |
| Annual | 60.1 | 45.1 | 52.6 | 5367 | 882 | 46.33 |

August

| DATE | MAX | MIN | AVG | HDD | CDD | PRCP |
|---|---|---|---|---|---|---|
| 1 | 83 | 68 | 76 | 0 | 11 | 0.14 |
| 2 | 83 | 68 | 76 | 0 | 11 | 0.13 |
| 3 | 83 | 68 | 76 | 0 | 10 | 0.13 |
| 4 | 83 | 68 | 75 | 0 | 10 | 0.13 |
| 5 | 83 | 68 | 75 | 0 | 10 | 0.13 |
| 6 | 82 | 68 | 75 | 0 | 10 | 0.13 |
| 7 | 82 | 68 | 75 | 0 | 10 | 0.13 |
| 8 | 82 | 68 | 75 | 0 | 10 | 0.13 |
| 9 | 82 | 68 | 75 | 0 | 10 | 0.13 |
| 10 | 82 | 68 | 75 | 0 | 10 | 0.13 |
| 11 | 82 | 67 | 75 | 0 | 10 | 0.13 |
| 12 | 82 | 67 | 75 | 0 | 9 | 0.13 |
| 13 | 82 | 67 | 74 | 0 | 9 | 0.13 |
| 14 | 81 | 67 | 74 | 0 | 9 | 0.13 |
| 15 | 81 | 67 | 74 | 0 | 9 | 0.13 |
| 16 | 81 | 67 | 74 | 0 | 9 | 0.13 |
| 17 | 81 | 66 | 74 | 0 | 9 | 0.13 |
| 18 | 81 | 66 | 74 | 0 | 9 | 0.13 |
| 19 | 81 | 66 | 73 | 0 | 8 | 0.13 |
| 20 | 81 | 66 | 73 | 0 | 8 | 0.13 |
| 21 | 80 | 66 | 73 | 0 | 8 | 0.13 |
| 22 | 80 | 65 | 73 | 0 | 8 | 0.13 |
| 23 | 80 | 65 | 73 | 0 | 8 | 0.13 |
| 24 | 80 | 65 | 72 | 0 | 7 | 0.13 |
| 25 | 80 | 65 | 72 | 0 | 7 | 0.13 |
| 26 | 79 | 65 | 72 | 0 | 7 | 0.13 |
| 27 | 79 | 64 | 72 | 0 | 7 | 0.13 |
| 28 | 79 | 64 | 72 | 0 | 7 | 0.13 |
| 29 | 79 | 64 | 71 | 0 | 6 | 0.13 |
| 30 | 79 | 63 | 71 | 0 | 6 | 0.13 |
| 31 | 78 | 63 | 71 | ** | 6 | 0.14 |
| MNTH: | 81.0 | 66.3 | 73.7 | 1 | 268 | 4.05 |

**Figure 1. Climatology Summaries – June-August, Jersey City, New Jersey**
Source: http://www.ncdc.noaa.gov/DLYNRMS/dnrm?coopid=284339

We posit that studying the behavior of field experts, in a context that removes complexities and has a lowest-common denominator will allow for performance assessment (Gomez, 2010). Our approach is based on previous empirical research which measures individual usage behavior of field experts when confronted with changing weather conditions and validated by field experts (DHS and military backgrounds). Key idea 3 “use collaborative data analysis methods” will be triangulated with our assessment findings and previously developed instruments from our training application. Our framework extends next steps (Gomez, 2008; Gomez and Bartolacci, 2011) to mirror a recognizable instance (environmental condition) that applies to CMO. As such, we utilize—environmental data, namely climate metrics—a critical and recognizable dimension for CMO crisis response. We focus on a predictable situation within CMO as a visualization of context that is simplistic and can be studied in an unclassified manner. This bottom up approach ensures we can create a framework and test a model for precision and for replication effectiveness (resources, etc.).



Query Results

**5 TEMPERATURE EXTREMES** event(s) were reported in **Essex County, New Jersey** between **07/01/2000** and **07/01/2010**.

*Click on **Location or County** to display Details.*

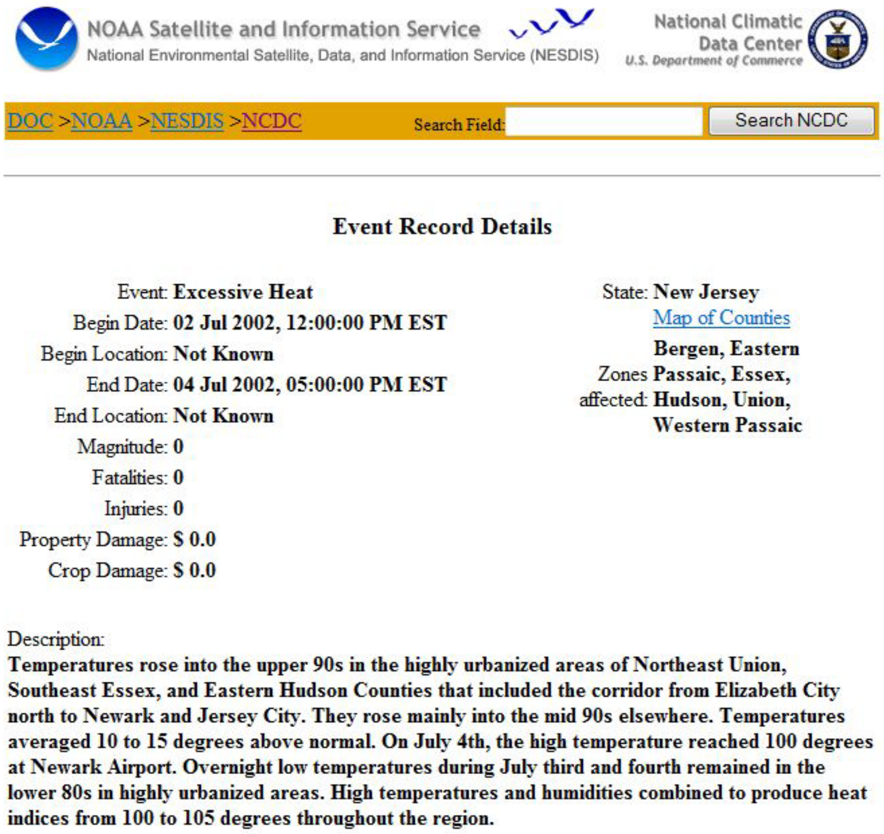
**Mag**: Magnitude
**Dth**: Deaths
**Inj**: Injuries
**PrD**: Property Damage
**CrD**: Crop Damage

**New Jersey**

| Location or County | Date | Time | Type | Mag | Dth | Inj | PrD | CrD |
|---|---|---|---|---|---|---|---|---|
| 1 NJZ002>006 - 011 | 08/07/2001 | 04:00 PM | Excessive Heat | N/A | 0 | 0 | 0 | 0 |
| 2 NJZ002>006 - 011 | 07/02/2002 | 12:00 PM | Excessive Heat | N/A | 0 | 0 | 0 | 0 |
| 3 NJZ002>006 - 011 | 07/29/2002 | 12:00 PM | Excessive Heat | N/A | 0 | 0 | 0 | 0 |
| 4 NJZ002>006 - 011 | 01/15/2004 | 06:00 PM | Extreme Cold/wind Chill | N/A | 0 | 0 | 0 | 0 |
| 5 NJZ002>006 - 011 | 08/01/2006 | 12:00 PM | Excessive Heat | N/A | 2 | 0 | 0 | 0 |
| | | | | TOTALS: | 2 | 0 | 0 | 0 |

**Figure 2: Temperature Extremes in New Jersey (2000-2010).**
Source: http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms

To narrow the focus we selected environmental contingencies (weather) as our crisis management data, specifically dangerously high temperatures excursions, which "is the number one weather-related killer in the United States. NOAA National Weather Service statistical data shows that heat causes more fatalities per year than floods, lightning, tornadoes, and hurricanes combined (NOAA, 2010)." The implications of "heat" extend beyond human health. Field experts from within specialty domains access heat wave data. Extending to the preparedness phase of crisis management and the continuity of business, the need for precise data details continues. At present minimal to no theory has been introduced for the use of data fusion and sustainable information (best practices), especially as it relates to the emergency (crisis) management domain and unstructured (raw) data needs. An invaluable resource of data archives comes from the National Oceanographic and Atmospheric Administration (NOAA), whose data policy provides open access to physical climate data in near real-time mode (as possible) (NOAA, 2009). To a field expert who leverages climate information (metrics) as only one dimension of their responsibilities, the volume of raw data can be overwhelming, while decision data (consolidated) may compromise their interpretation for a task at hand.



**Event Record Details**

Event: **Excessive Heat**
Begin Date: **02 Jul 2002, 12:00:00 PM EST**
Begin Location: **Not Known**
End Date: **04 Jul 2002, 05:00:00 PM EST**
End Location: **Not Known**
Magnitude: **0**
Fatalities: **0**
Injuries: **0**
Property Damage: **$ 0.0**
Crop Damage: **$ 0.0**

State: **New Jersey**
Map of Counties
Zones affected: **Bergen, Eastern Passaic, Essex, Hudson, Union, Western Passaic**

Description:
**Temperatures rose into the upper 90s in the highly urbanized areas of Northeast Union, Southeast Essex, and Eastern Hudson Counties that included the corridor from Elizabeth City north to Newark and Jersey City. They rose mainly into the mid 90s elsewhere. Temperatures averaged 10 to 15 degrees above normal. On July 4th, the high temperature reached 100 degrees at Newark Airport. Overnight low temperatures during July third and fourth remained in the lower 80s in highly urbanized areas. High temperatures and humidities combined to produce heat indices from 100 to 105 degrees throughout the region.**

**Figure 3: Temperature Extremes in NJ: Event Record Details (2002).**
Source: http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms

Information that is shared among multiple populations for a COP includes predictive patterns and is typically found within decision fusion architecture (data warehouse), introducing our research question: What are the information access challenges of the field expert in an operational context when tasked with critical and timely decision making requests? Beginning with a bottom-up approach we focus on a lowest-common denominator at the operational level when a field expert is deployed to an affected area. We focus on environmental data (local conditions) for this paper for several reasons: 1) it is politically neutral; 2) datasets for discussion purposes are unclassified and publically available; 3) is a dimension that plays an important role in most crisis; 4) environmental sentinels and sensor are producers of "raw" data. We step through a simplified example of a field expert to remove barriers allowing us to focus on the purity of raw data and an algorithm that can be developed and tested before aggregating contingencies between strategic alliances (partnerships). Our rapid ethnographic assessment utilizes data analysis as the first point of collection and to clearly identify a situation and field expert instance for qualitative analysis. We posit that "data fission" must be invoked by the actor (field expert), who has "role specific" needs. As such, a phased approach (key ideas 1-3) is designed to elicit rich and dense descriptions on information access needs of the field expert. The objective is to extend research beyond the complex system data (decision fusion) to "individual and critical" decision making needed by field experts making decisions in real-time mode on complex problems with a high degree of uncertainty.

Expanding our extreme weather training scenario which was designed for local field responders and field tested with over 50 participants (EM practitioners and volunteers), we have reviewed the NOAA site to assist in narrowing our focus and entering the field to observe field experts. Assuming our field expert is monitoring the upcoming heat wave and benefits from the accuracy and historical metrics of NOAA in addition to energy grid metrics of the local area. (NOAA, 2009), metrics are stored in several formats. Figures 1 might be applicable for a COP and ongoing monitoring whereas figures 2 and 3 provide details specific to extreme temperatures. From a "decision" data perspective (Figure 1) we note differences in the information presented. Figure 1 provides a consolidated view of the year by month and day. The maximum temperature per day is displayed. Let's assume our field need the rate of change in temperature throughout the day but only when the temperature is projected to exceed 100 degrees F. The baseline for action and supporting procedures may differ from the "extreme" temperature criteria of NOAA (Figures 2-3) moreover the result set did not provide metrics throughout the day. As an example, heat shelters are made available (evacuation plan, people centric) at the local level based on procedures that note "extreme heat" which may not correlate with NOAA's result set and in our result set (figure 3) does not correlate given there are only 5 days of extreme heat in the past 10 years and in the local NYC area, shelters were open intermittently throughout the 2010 summer due to energy grid implications. Lower grid voltages or "brown out" conditions may trigger load shedding of non critical services to reduce power consumption.  Buildings may be shut down or processes halted which could further reduce the demand on the power grid.

## 5. Data Fission Proposed Framework

Our focus towards a Data Fission Framework is based on real-world scenarios that benefit from ongoing "data fusion" initiatives, but leave the field expert with a data set that is less than optimal for the decision making process from their affected area. Figure 3 below provides a visual representation of how we are formulating the relationships between concepts for an integrated framework to predict phenomena. The criticality of extreme temperature data is but one example representing the importance of raw data combined with real-time event data and decision fused data.

The Data Fission Framework proposed (Figure 4) is represented from a high level based on our ongoing research. We leverage the availability of decision data to guide our "who, what, where, when, why, and how" questions for qualitative interviews that are a next step of this research. Because our research question centers on the need for "raw data retrieval", we posit that the decision data and raw data needs should drive this process.

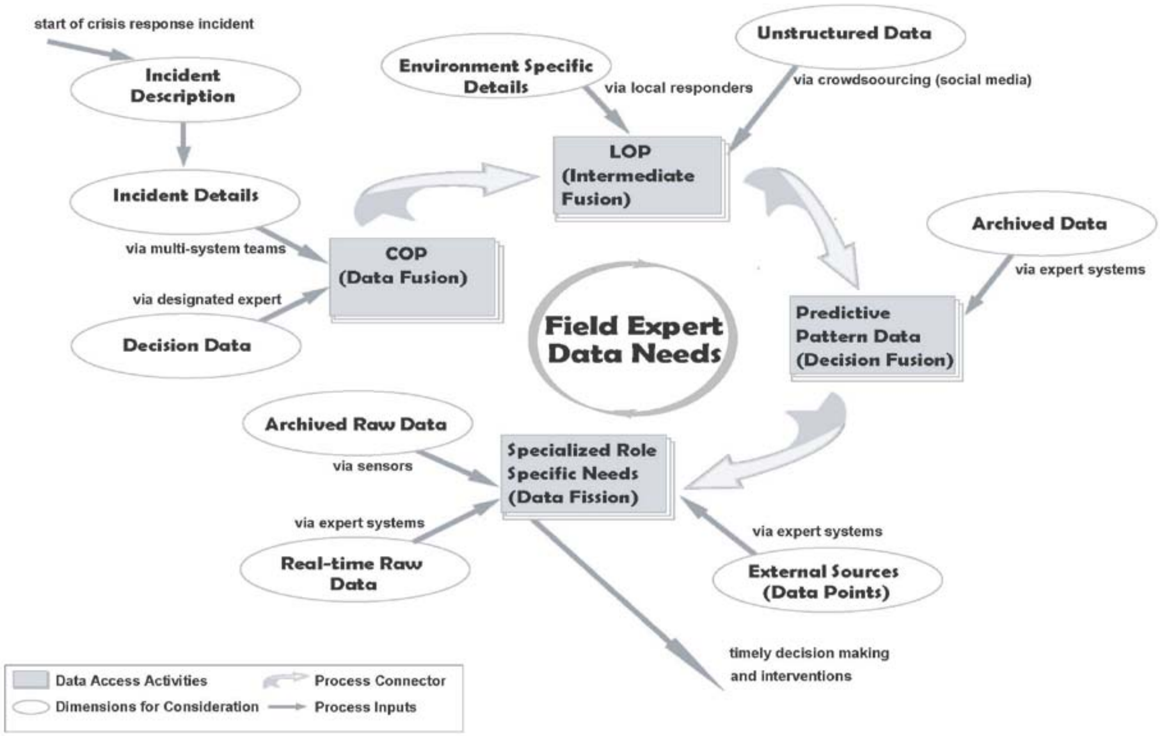


**Figure 4. Proposed Data Fission Framework.**

Our personal and professional experiences afford us the opportunity to recognize other weather conditions will exist. Moreover, not all heat related raw data is made available for use (i.e. additional properties). Data dimensions are sometimes lost in the data fusion cycle when data owners attempt to provide reduced, yet useful data to the majority of field experts. Because of this data reduction, the needs of some field experts may not be met. An example of this can be found in figure 1 above. In this example, NOAA lists average daily maximum temperatures for an entire year. Field experts attempting to infer a first responder minimum reaction time to an event horizon would find this data set to be inadequate for their needs. In this case, data fission would be required to expose the larger raw data set comprised of individual data measurements over each day to determine a maximum rate of change in a 24 hour period. This data dimension would be invaluable for first responders to calculate the resources needed in an affected region for specific event horizons

In contrast, the classification of “expert system” plays a critical role where the raw data (dimensions) will need very careful analysis and would benefit from the “use of questioning”. For our heat wave event, NOAA is an expert system of decision fusion data by region for rate of temperature change monitoring. On the other hand, sensor networks could provide real-time metrics of extreme temperature changes. While both instances are sources of data, the dimensions (attributes) associated with the expert systems and relationships between the dimensions and the field expert would be the basis for our “use of questioning.”

## 6. Conclusions and future research

The task at hand and research to-date presents a complex need for field experts who are responding from an affected area. While it would seem simplistic to store raw data and have field experts access that data directly, the importance of a common view, snapshot and visual across field experts as a way to expedite and establish a common ground is essential. Exactly where the data fission component best fits within the information fusion process requires ongoing research. As a next step, we will prepare for field expert observations. Of primary interest are the raw needs of the field expert and how we can "locate the needle in the haystack" to expedite and improve real-time decision making when human lives and organizational materials are a risk.

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