The Crisis of Designing for Disaster: How to Help Emergency Management During The Technology Crisis We Created

Nicolas LaLone*
University of Nebraska at Omaha
nlalone@unomaha.edu

Phoebe O. Toups Dugas
New Mexico State University
phoebe.toups.dugas@acm.org

Bryan Semaan
University of Colorado Boulder Affiliation
bryan.semaan@colorado.edu

ABSTRACT

Emergency Management (EM) is experiencing a crisis of technology as technologists have attempted to innovate standard operating procedures with minimal input from EM. Unsurprisingly, there has yet to be a success. Instead, technologists have focused on consumer culture and fostered a slow-moving crisis as the gap between what consumers and EM can do is deep. At present, the most ubiquitous aspect of technology in disaster is its capacity to exacerbate response, create new kinds of disaster, and create consumer expectations that EM cannot meet. In the present work, we highlight how and why technological production needs to shift its ontological premises dramatically to meet the needs of technology for first responders. From supporting practice to taking a few steps back from the bleeding edge, we offer a range of suggestions based on the technological capacities of emergency management in the present and in the future.

Keywords

Crisis Informatics, Participatory Design, Ethnography Emergency Management, Please Stop Trying to Make Fetch Happen

INTRODUCTION

Researchers in all facets of technology production have tried to make tech for first responders, emergency operations centers, and to help emergent groups and EM work better together. Nearly all of it has completely failed and those that do not completely fail, never see regular use. This is unfortunate because disasters are the result of a lack of human oversight in preparing for local natural, civil, or technological hazards (Kelman 2020; Hartman et al. 2006). If humans are the cause of disaster and technology, especially information communication technologies (ICTs), then a technological solution is needed to cope with the human-created cause of disaster. This should frighten us as this means that the earth itself no longer protects us from those elements.

And yet, we tend to seek a piece of flex tape to hold down the disaster in the form of an ICT. In this case, the past years have been devoted to making social media that piece of flex tape and as Figure 1, that tiny piece of tape might be interesting, but it is certainly not going to keep all disasters at bay. When a hazard results in a disaster, all technologies fall into two categories: no signal or congested signal.

Thus, nearly all technology loses functionality and becomes a paperweight. This is an important point because regardless of the status of their technologies, consumers will still attempt to ask for help using their devices as they

*corresponding author

Figure 1. For many years, we have seen papers that attempt to solve age-old issues like situation awareness with sophisticated tools replete with features and dependencies that could never survive in the wild. This is what we need to stop doing.

bring the mental model of plain-old telephone services from their childhood to the mobile ICT world. Help, in these cases, falls under the responsibilities of emergency management (EM) practitioners: local, state, national, federal, or tribal responders, depending on the type of hazard and its breadth. These groups will most likely not know consumers are asking for help from said devices.

There is a gap between what technologies EM has integrated and what technologies consumers will use. Despite the years of consumer training, residents in and around ground zero will turn to information communication technologies (ICTs); however, EM practice tends to focus on plain-old telephone services (POTS). This will result in needless injury, even death. This is a *technology crisis*, one that EM is not necessarily responsible for, but one issue among many that technologists have created. In previous work, we focused on EM's technical capacity and its potential fixes (Lalone et al. 2023). However, in this piece we will focus on the how ICT designers in human-computer interaction, user experience design, human-robot interaction, human factors, and all other fields focused on technology continually exacerbate EM practice by not understanding it.

If our focus was on EM, we would note a 2019 report from the US Office of the Inspector General (OIG) that outlines the various ways that EM does not use technologies (Homeland Security Office of the Inspector General 2019). But our focus is not EM, but crisis informatics and human-computer interaction more generally. To this, we highlight Palen and Anderson (2016) who note that EM is too suspicious of technologies and so designing solutions that use consumer-grade technologies will never be proven to be valid. The author's note, "What is necessary is to have sufficient permission by emergency management to support solutions as they emerge from grassroots operations and then to foster those ideas deliberately in subsequent events" or, to be more succinct, we should wait to see what emergent groups use and then support them because EM will not listen to us (Palen and Anderson 2016). We offer that there is a potential third solution and that it begins with why we make software.

There is a complex discussion in and around the philosophy technology; however, we believe that it can be a simple discussion. To wit, we offer two ways of thinking about technology. In Bensaou and Earl's "The Right Mind-set for Managing Information Technology" (1998), the authors note that there are differences in approach to inserting technology into an industry. The authors ask the question, "When we're trying to improve a business process, how does technology fit into our thinking?" to which they note 2 distinct models of thought:

- US Framing: "We assume that technology offers the smartest, cheapest way to improve performance."

- Japanese Framing: "We identify a performance goal and then select a technology that helps us achieve it in a way that supports the people doing the work."

Generalizations like these are often dangerous; however, we are not interested in the "East versus West" mindset but how this mindset reflects the insertion of the word "technology" in the English language. It was Samuel Beard's attachment of technology to cultural progress that has fostered a mindset of "tech first, consequences later" (Schatzberg 2006). This is replicated by the "Right Mind-set" piece as the US view of technology can be summarized as, "the smartest, cheapest way to improve performance." Technologists in the US have tried to enhance the performance of EM as an industry without actually knowing how that industry works.

This mindset, while a capitalist success, does not work for US-based EM. EM is unique in that it works most often in domains that do not have the infrastructure necessary to manifest the required use theater that ICT requires for day-to-day activity. This has been the central cause of the failure of crisis informatics as well as software design for EM in general. We assume that this is just another space where technological solutions can and should persist. What we offer is that there is another way to consider it; not only the Japanese way outlined by Bensaou and Earl (1998), but other ways in general.

Edgerton (2011) discusses an obsession with invention and innovation, i.e., the US mind-set outlined above:

> "by thinking about the history of technology-in-use a radically different picture of technology, and indeed of invention and innovation, becomes possible. A whole invisible world of technologies appears. It leads to a rethinking of our notion of technological time, mapped as-is on innovation-based timelines. Even more importantly it alters our picture of which have been the most important technologies. It yields a global history, whereas an innovation-centered one, for all its claims to universality, is based on a very few places. It will give us a history which does not fit the usual schemes of modernity, one which refutes some important assumptions of innovation-centric accounts."

This quote affords us a capacity to think about the ways EM uses technology; rather than seeking innovation and invention, we instead adopt a less-than-bleeding-edge mindset that looks at technologies actually being used by EM practitioners.

And so we go back to Palen and Anderson's 2016 quote about seeing where emergent groups of consumers are using technology. This is an approach that still embraces the chasing-innovation mind-set. Instead, we offer that a more compatible approach has to acknowledge the history of technology as a stand-in for cultural success (Schatzberg 2006) in concert with understanding how EM needs technology to be.

We offer the results of a survey of EM practitioners that focuses on what technologies they *can* currently use. By understanding practice, we can identify technologies that can promote technological integration with EM. Through these understandings, we can offer new ways to engage consumer technology cultures. *Specifically* we will show how those technologies being ignored weaken the resilience of any municipality to hazard events. We conclude with a featureset new software devoted to disaster should embrace.

BACKGROUND

In this section, we contextualize technology and EM. First, we note the current status of EM in the US as it does not have a well-defined bound. Second, we offer an often overlooked issue in EM, the consequences of tech in disaster. Finally, we offer and contextualize crisis informatics and computation more broadly in EM.

Emergency Management & Technology

One of the most difficult aspects of work in and around EM is that this is a field, discipline, domain, practice, profession, or area that has yet to be fully individuated. We take Simondon's concept of Individuation or essentially using procreation processes to describe how named entities like "cars", "computer scientists", "laws", and other named objects come into being (Simondon 2017). In this case, EM is what Simondon would refer to as a "pre-individual" – a zygote containing enormous potential. EM has been in this stage since time immemorial: humans have always volunteered to help others when under duress, regardless of culture. In the case of the age of growing professionalism of named professions, EM has always remained in the pre-individual stage. Crisis informatics (Palen et al. 2020) has attempted to create technologies, to fertilize the idea of EM, but this has failed to take. And so the potential of EM remains, and yet the actions taken by those of us in the ISCRAM community or more broadly, the design of software, implies that we have not recognized our collective failure.

To understand this, we must define what EM's current form is. EM is best defined as "a discipline that deals with risk and risk avoidance" (Haddow et al. 2021). Risks are a characteristic of a particular municipality and the people who belong to this discipline are sometimes called, "Disaster Experts" (Knowles 2012). The disaster experts, the EM practitioner, is often the only discipline or practice which sees the world as a series of potential disasters and tries to plan around them. Planning is where EM practice begins. One aspect of movement from pre-individual to individuated EM is the slow movement from reaction and response to planning and mitigation (Multi-Hazard Mitigation Council 2019). EM practitioners are disaster experts who identify and plan around how harm could disrupt their jurisdiction who lack recognition by those living in their jurisdiction.

EM remains in a pre-individual state as practitioners and educators attempt to define its paths to individuation through professionalization and training without any of the technologies we have been attempting to give them. The pre-individual state is due to three factors. First, the pipeline of emergency medical services, fire fighting, law enforcement, and the armed forces and as such, outside knowledge of government processes essentially truncates outsiders from entering the field without being in one of those spaces. Second, because of this pipeline, EM practitioners to have a very specific version of a lack of diversity that leads to issues in one locale being manifest everywhere else simultaneously. Finally, EM has been implicated in "technical deficiencies" relating to everything from communication to computer maintenance (Homeland Security Office of the Inspector General 2019; Chappellet-Lanier 2019). This has led to an increasingly vulnerable local, state, and federal scope of responsibility that can be directly tied to both data and ICT use and a lack of a way to discuss EM's individuation status directly.

The Consequences of Tech in Disaster

Something to understand about EM is that practice is rigid. In order to integrate something new in EM, it needs to become a part of the Incident Command System (ICS) or the National Incident Management System (NIMS). These are the workflows EM has fostered that have created the barrier crisis informatics has yet to breach. This is the source of the tech crisis in EM Lalone et al. 2023. The crisis has not occurred because EM is tech-averse. It is created and maintaned because consumer culture has been (recklessly, some would say) integrating technology and culture without including EM for decades. In the present, we must correct this issue without the creators of those consumer ICTs doing the work themselves.

ICT research focusing on use in crisis begins in 2001 with the World Trade Center attack (Blake et al. 2004). This labor became CI after the 2007 Virginia Tech school shooting when researchers examined how students used email to understand where the shooter was located (Vieweg et al. 2008; Palen, Vieweg, et al. 2009).

These events are concurrent to the creation of internet culture, the invention and adoption of mobile devices, and the rise (and fall) of social media. Internally with EM, the creation of After-Action Reports (ARRs) has the knowledge necessary to understand local issues tech could be created for. However, these ARRs are often not available or heavily redacted in the US and so the portion of EM that could help HCI or crisis informatics is often missing. What results is that each event sees different technologies being involved along with a variety of public data with little to no engagement of EM and what little engagement was done is locked away in an ARR no one can (or will) access. In this section, we will discuss a number of events that provide a landscape (Bos et al. 2007) that can help us understand the consequences of not collecting the wisdom of the past in EM or HCI or CI.

We begin with a disaster that highlights a potential space of development for pre-first responder tech, the Joplin Tornado of 2011. Next, we discuss Hurricane Sandy where misinformation highlights a growing issue that needs to be addressed. Finally, we discuss the crowdsourcing disaster and its constant detractors.

The Joplin Tornado – 2011: Highlighting How First Responder Tech Needs to Come Before First Response

The Joplin Tornado was a tragendy within which a multitude of residents died attempting to verify that a hazard event was indeed heading for their home. This began with Wide-Area Alerts (WEA), an essential tool for EM. A moment's notice will lower loss of life whether it be 10, 30, or mere moments before said hazard event descends on the people being alerted (N. J. LaLone, Hughes, et al. 2021). The key to WEA is for recipients to take immediate action. Unfortunately, mobile devices allow anyone who has one to look things up and this has enormous consequences for WEA when seconds count (Paul et al. 2015; Gelino and Reed 2019). This is sometimes referred to this as the "verification pause" (Tapia, Hughes, et al. 2018; N. J. LaLone, Hughes, et al. 2021) or "milling about" (Wood et al. 2018).

Joplin's Tornado, response, and recovery highlighted issues around alert messaging (Kuligowski 2020). One of the parameters for CI and software makers to consider is the space between a hazard event and a WEA. Diminishing the verification pause is becoming vitally important. And this is a potential space of development, tech that can detect and pre-warn individuals before a WEA is sent. And this is an example of a sudden-onset disaster. Different development potential exists for other kinds of hazard events.

Hurricane Sandy – 2012: The Continuing Issue of Mis-, Dis-, and Mal-Information

While Joplin showed us a potential space for development, Hurricane Sandy showed us an impact for EM itself. Mis-, Dis-, and Mal-information have been the subject of repeated inquiry with regard to social media (Lopatovska and Smiley 2013; Rajiv 2013; Sadri et al. 2018; Roy et al. 2020; Pourebrahim et al. 2019; Stewart and Wilson 2016; Lachlan et al. 2014; Wang et al. 2015). This slow-moving hazard event has allowed researchers to examine residents before, during, and after the event (Neppalli et al. 2017; Chauhan and Hughes 2016; Hughes et al. 2014; Canales et al. 2019). As the storm spread, misinformation on social media caused confusion and disruption (Gupta et al. 2013; Chatfield et al. 2014).

What this event did was essentially highlight how vulnerable EM was to such disruptions. A lack of ability for the homogenous, non-diverse population of EM practitioners was shown to be unable to contend with these kinds of attacks Neppalli et al. 2017; Lalone et al. 2023. And it has only gotten worse with time.

Boston Marathon – 2013: Savior then Pariah

We can see the state of misinformation in EM when we examine the events in and around the Boston Marathon bombing of 2013. Two bombs were detonated near the finish line of the marathon and in the initial response, Bostonians and marathon attendees were able to use ICTs to organize themselves before official response could (N. LaLone, Toups Dugas, et al. 2020; Williams et al. 2017; Howieson 2018).

In addition, we saw the crowd of people with ample computational power and time begin to go through petabytes of text-based tips, images, and movies in or around the areas of detonation (Tapia, N. LaLone, et al. 2014; Starbird et al. 2014; Lee et al. 2015). This was a moment of celebration for online communities, for crowdsourcing in disaster. And yet, the efficacy of the crowd forced investigators to investigate quickly resulting in the deaths of a security guard and the second suspect in the bombings. This widely reported event caused the downfall of the potential of the crowd in incidents like this (Tapia, N. J. LaLone, et al. 2014). Despite that, the crowd was helpful and beneficial in a variety of ways that go undiscussed.

Tip lines and seeking help from civilians was nothing new, in this case it resulted in a deluge of information that EM, law enforcement, and the FBI were unprepared for (N. J. LaLone, Kropczynski, et al. 2018). Crowdsourcing efforts by emergent groups has continued to grow and adjust according to criticisms and issues per event (N. J. LaLone, Kropczynski, et al. 2018). Only, this growth has been without the influence of EM practice, nor the media, nor HCI or CI. We have failed to capitalize on any of these events.

METHOD AND DATA

We use a survey to understand the technical capabilities of EM that was created with the help of the Emerging Technology Caucus in the International Association of Emergency Management. One of the researchers has been active within the the ETC[1] and was thus able to augment the instrument to best represent EM. The scales for the 38 Likert-response questions in the instrument originated in survey instrument for introductory computer science courses (Kang et al. 2015). All respondents answered around 30 questions and were recruited via posts on EM practitioner groups of Facebook and LinkedIn, word-of-mouth, and snowball sampling. In all, 126 personnel in and around EM completed the survey. The structure of the survey is as follows.

Survey Structure

First, respondents were asked demographic- and context-oriented questions relating to who they are, their gender identity and ethnic categories, their education, and if they were ever in the armed forces. Respondents then reported their relationship with EM by identifying their unit and how it was constructed. Respondents then began the technology questions. This produced seven categories:

- browser and ICTs,
- social media policies and administration,
- mapping technologies,
- cybersecurity,
- database platforms,
- programming, and
- IOT.

[1]More information about the ETC can be found at `https://www.iaem.org/groups/us-caucuses/emerging-technology`.

The scale used for these categories were:

- "I don't know what this is,"
- "I am not sure how to do this task,"
- "I have done this but might need some help,"
- "I can perform this task without any assistance,"
- "I could train staff to do this."

As categories, they are mutually exclusive but offer adequate differentiation from beginning to end.

Finally, there were 3 open-ended questions ranging from what technical capabilities will be important to EM soon, what technical capabilities are important now, and if the survey missed anything the respondent felt was important. For the present research, the questions being focused on are the blocks of questions about technology.

Method

We have noted that one of the authors of the present research is actively participating as an EM practitioner in order to understand practice well enough to find spaces to add technology. Since 2018, the researcher has participated in the Emergency Management Institute's (EMI) Advanced Academy, has completed nearly every training module that is available to interested participants, and has begun to participate in local EM efforts. The result is that this survey represents what the practitioners need combined with inside information from CI as an academic. Because of how EM functions, this level of integration is not only looked for, but required. As current chair of the ETC, we have gained immeasurable insight into what sorts of technologies EM needs.

The method we have used to understand these data is a combination of action-oriented methods. First, we approached tech integration with EM through, "Qualitative Media Analysis" (Altheide and Schneider 2012). Next, we used participant observation (Blandford et al. 2016) and action research (Hayes 2014) to discuss what we could do versus what EM needed us to do. Qualitative Media Analysis was used because much of what EM does requires researchers to gain more knowledge about how ICS works, how deployment works, and how the activity of EM congeals and persists. Participant observation has been necessary as obsessive note taking and memories must be cataloged in order to maintain a record of the actions and activities of EM itself.

RESULTS AND ANALYSIS

This section begins with a discussion of how well-represented EM work is in comparison to the field itself. This is followed by each of the different types of technology asked about: browser and internet communication technologies, social media policies and administration, mapping technologies, cyber-security, database platforms, programming, and finally new kinds of hardware.

Demographics

EM is not a diverse domain which has consequences for tech in general. About 75% of respondents fell between the ages of 25 and 55. 97% of respondents did not identify as Hispanic leaving 3% of them identifying as Cuban, Mexican or Puerto Rican. Next, 88% identified as white / Caucasian with Black / African American being the next highest category at just 3%. While unbalanced and non-diverse, these numbers fall in line with the 2004 and 2013 evaluations performed on emergency managers (Cwiak et al. 2004; Weaver et al. n.d.).

Another specific consequence to the lack of diversity in EM is how the data will be presented. Because EM is a non-diverse space and dominated by white men, the closest approximate form of diversity through which we can analyze is that of gender. Within these data, 64% of the sample identified as men, 29% identified as women and 7% did not disclose their gender identity. The 1 person identifying as non-binary in the sample has been removed due to potential inabilities to protect their anonymity (Scheuerman et al. 2020).

Regarding participants' self-assessment of their daily role:

- 70% reported EM;
- 8% reported "administrative";
- 6% reported "training / exercising"; and
- 6% reported "Other", typically identifying as "Search and Rescue", a specific aspect of EM (e.g., the Park Service), or specific roles within emergency management like intelligence, consultant, or leadership.

The difficulty of the questions, "Select the closest representation of your domain" in a field as diverse and lacking in strict bounds as EM is not abnormal. That so many respondents noted their domain within the bounds of the question without relying on the "other" category speaks to an EM that may be stabilizing in terms of its job categories, responsibilities, and assigned purview. This is an important finding for CI who may be finding stakeholders that do not actually belong to the jurisdiction or responsibilities pertinent to the thing being developed.

Browser and Internet Communication Technologies

This section shows that while EM is generally light in terms of technology usage, the technologies of communication are well-integrated within the everyday life of EM practitioners. These items include: private browser tabs, email account setup, using *Microsoft Excel*, tethering, virtual private networks (VPN), and computer security.

Over 80% of respondents could open a private browser tab and set up email accounts. Over 60% of respondents could use formulas in excel without assistance or could train staff to use them. Where things began to differ was gender-based. 70% of the men who responded and 60% of women felt that they could use their mobile devices as a tether as well as to set up a VPN. Internet security saw a wider gap with 50% of men and 60% of women saying they were either not sure how to perform that task or are unable to do it at all. As with all technology use, there is an expectation about age and that if one is younger that one will be better with technology (Kirschner and De Bruyckere 2017). And yet, the results of the survey indicate that age is not a factor in any way–this will be addressed in the discussion. These results are indicative of the absolute height of EM practitioner technological prowess. CI researchers should very much pay attention to these statistics.

Social Media Administration and Policy

Social media administration and policy is of particular interest to crisis informatics (CI) (Palen et al. 2020). The questions for this section focus on setting up a Facebook page, a Twitter account, and a TikTok account[2]; communicating with the public via social media; and writing both social media use policy and public engagement and data sharing policy. For these questions, the results are like those of the browser and information communication technology. Of our respondents, 60–70% generally understood how to set up accounts and communicate with the public. Where they disagreed was on the short-form video sharing platform called TikTok with around 50% of all respondents indicating that they had no idea how to do that, or what TikTok even is. Since this survey ran, various bills banning TikTok on government devices has led to this question being necessary to ask as while Government officials cannot use it, it can still be an active hub of discussion about disaster from consumers.

Respondents indicated that they did not know how to, "write policy for engaging online emergent groups (VOST[3], Reddit, hashtag participants[4]) on social media." Of the respondents, 60% said that they either do not know how to do this or would need help to write policy. While this leaves 40% of respondents indicating that they could write policy, 50% of respondents who are spread out across local and state jurisdictions state that they do not know how to create policy or what that policy might be. For CI, this section should be eye-opening.

Mapping Technologies and Geographic Information Systems

For EM practitioners, the map is one of the most common objects for coordination, situation awareness, and the foundation of practice itself (N. LaLone, Alharthi, et al. 2019; Toups Dugas, Lalone, et al. 2019; Toups Dugas, N. LaLone, et al. 2020; Fischer et al. 2015; Kogan et al. 2016; Alharthi et al. 2021). Surprisingly, or perhaps not given the specialty of geo-spatial analysis, the most common task that respondents had confidence with was printing a map from GIS specifically. When asked if they understood how to maintain layers, analysis data from GIS, or share those data with others, most respondents (70% or more) indicated that they would need help to perform the task at best. EM is organized around specific tasks. Through that, we can say that this category is one of the first moments where the separation between those who could know despite it not being part of their duties and need to know as part of their duties stands out. The map and mapping technologies are a potential in-road for technology integration.

[2]Each of these is a large-scale online social media platform: `https://facebook.com`, `https://twitter.com`, `https://tiktok.com`, respectively.

[3]VOST stands for Virtual Operations Support Team. These are attempts to provide volunteers distance-based opportunities to participate in response(Fathi et al. 2020)

[4]Reddit is a web aggregation community that has routinely taken part in collecting and disseminating data since the Aurora, CO theater shooting of 2012. While this is one way to participate in, or focus one's energy during a disaster (N. J. LaLone, Kropczynski, et al. 2018), additional participation has been done through Twitter's hashtag capabilities(N. LaLone, Toups Dugas, et al. 2020).

Men					
	I don't know what that is	**I am not sure how to do this task**	**I have done this before, but I might need help.**	**I can perform this task without any assistance**	**I could train staff to do this.**
Firewall Exceptions	13%	47%	20%	10%	10%
Use 2-Factor	2%	9%	19%	41%	29%
Encrypt HDD	4%	39%	26%	14%	18%
Find my IP Address	1%	9%	33%	29%	28%
Respond to Malware	5%	38%	34%	14%	9%
Respond to Ransomware	7%	48%	22%	14%	9%
Cyber-Vulnerabilities	3%	44%	31%	10%	10%

Women					
	I don't know what that is	**I am not sure how to do this task**	**I have done this before, but I might need help.**	**I can perform this task without any assistance**	**I could train staff to do this.**
Firewall Exceptions	8%	65%	13%	8%	8%
Use 2-Factor	0%	18%	15%	40%	28%
Encrypt HDD	3%	63%	15%	13%	8%
Find my IP Address	0%	21%	33%	21%	26%
Respond to Malware	0%	68%	20%	13%	0%
Respond to Ransomware	0%	75%	18%	8%	0%
Cyber-Vulnerabilities	3%	55%	25%	15%	3%

Table 1. Results from this Inventory Survey focusing on technology components of cyber-security separated by gender.

Cybersecurity

The items queried for this section focused on firewall exceptions, 2-factor authentication, data encryption, malware, ransomware, and coping with cyber-vulnerabilities. These items are perhaps the most pertinent to CI as computation has literally created these new hazards. In Table 1, please find the percentages of respondents who answered each question. Firewall exceptions were the least known. In fact, as we lean into more and more tech-focused objects, "I don't know what that is" becomes a more and more common answer. 20% of respondents felt comfortable stating that they could make firewall exceptions without any help or could train those respondents.

Knowledge of Databases and Their Applications

In this block of questions, the target moves to data itself. In specific, this block of questions could be referred to as, "the data science block" in that it involves the creation of datasets and methods of analysis. Respondents were asked about: querying unstructured and structured data, deploying Amazon Web Services (AWS), adding information to a database, using advanced search functions, and finally, two items about the growing threat of vulnerabilities related to misinformation and fake accounts. Due to the increased importance of data and data storage over the tenure of the COVID pandemic, it is disappointing to see that only 20% of men and 13% of women respondents could perform queries on unstructured data which is data gathered without an existing data model. This is in agreement with the 29% of men and 58% of women performing data on structured data which is gathered with a model in mind. See Table 2 below for a breakdown of these data.

When coordinating access to data in large-scale events, bandwidth issues often present a hindrance to that coordination. While products like Firstnet and other EM targeted bandwidth platforms promise coverage, this has often not been the case. On-the-ground services are often missing, EOC-oriented bandwidth needs is often in need of flexibility and scaling. Thus, the inclusion of a reference to AWS, which allows one to scale web access based on need. While 73% of respondents who identify as men and 95% of respondents who identified as women did not know what AWS is or how to deploy it, this points to a useful training item. It also points to a difficulty with regard to *any* CI platforms that can be used to comb social media or provide useful AI or machine learning of text-based

	Men				
	I don't know what that is	**I am not sure how to do this task**	**I have done this before but I might need help.**	**I can perform this task without any assistance**	**I could train staff to do this.**
Query Unstructured Data	22%	30%	28%	12%	8%
Query Structured Data	20%	26%	26%	20%	9%
Deploy AWS	36%	37%	17%	6%	3%
Add data to Database	4%	14%	25%	44%	14%
Use Advanced Search	4%	16%	33%	15%	32%
Identify Misinformation	0%	13%	19%	37%	31%
Identify Fake Accounts	2%	20%	23%	27%	28%
	Women				
	I don't know what that is	**I am not sure how to do this task**	**I have done this before but I might need help.**	**I can perform this task without any assistance**	**I could train staff to do this.**
Query Unstructured Data	23%	45%	20%	8%	5%
Query Structured Data	23%	8%	13%	15%	43%
Deploy AWS	50%	45%	0%	5%	0%
Add data to Database	5%	18%	15%	38%	25%
Use Advanced Search	0%	13%	20%	40%	28%
Identify Misinformation	0%	13%	18%	38%	33%
Identify Fake Accounts	0%	20%	23%	38%	20%

Table 2. Results from this Inventory Survey focusing on databases and data science separated by gender.

communication as there is currently no one, anywhere in EM that could do this. There are additional issues around BOOLEAN search strings as this question could be misinterpreted due to confirmation bias issues.

Knowledge of Coding

Writing computer code is generally indicative of knowledge of the inner workings of computation. This is important to CI-oriented tools as the complex dependencies and components of any tool EM would use requires this knowledge. Much of what the respondents answered to this question is situated with existing preconceptions of EM as a technologically deficient space.

70–90% of all respondents claimed "I don't know what that is" or "I am not sure how to do this task" for every item on this block. Only 3–10% of all respondents indicated that they could either perform the task without help or train others. The lowest values of table 3 is indicative of the earlier discussion of *Microsoft Excel*. One interesting point from these data is the JSON question. While 45% of women and 36% of men indicate that they do not know what a JSON file is. One potential step forward is to offer training about how to deal with JSON data. It could open up avenues for integration.

Interestingly, the answers to the questions focusing on "interpreted" versus "compiled" languages indicate additional potential avenues for technology integration and CI work to find allies. While there is much work to be done about programming skills, languages like Python and Lua which are interpreted languages have at least a little more representation inside of EM than that of compiled languages. This is an important discovery as Python especially may be slightly more known and therefore a vehicle through which training can be pursued.

Drones, Networking Hardware, and Internet of Things

Finally, respondents answered questions related to flying drones, setting up routers, setting up mesh networks, using HAM radio, setting up Internet of Things (IoT), and setting up networked printers. These questions are related to both old and new technologies but also practical and needed tools for bases of operation, EOCs, and various kinds of mobile command. Despite these needs, many respondents noted that they were not sure how to fly drones with just 29% stating that this was something that they knew how to do without assistance or could train others to do.

Men					
	I don't know what that is	**I am not sure how to do this task**	**I have done this before but I might need help.**	**I can perform this task without any assistance**	**I could train staff to do this.**
Interpreted Language	35%	44%	13%	3%	5%
Compiled Language	34%	48%	14%	1%	3%
Python	31%	53%	9%	1%	5%
Java	21%	65%	12%	0%	2%
Javascript	20%	63%	14%	1%	2%
Pull Data from API	27%	53%	10%	6%	3%
Analyze JSON File	36%	47%	12%	2%	3%
Analyze CSV File	16%	28%	22%	19%	15%

Women					
	I don't know what that is	**I am not sure how to do this task**	**I have done this before but I might need help.**	**I can perform this task without any assistance**	**I could train staff to do this.**
Interpreted Language	43%	45%	5%	0%	8%
Compiled Language	40%	50%	5%	3%	3%
Python	38%	50%	10%	3%	0%
Java	33%	63%	3%	3%	0%
Javascript	28%	68%	0%	5%	0%
Pull Data from API	38%	53%	5%	3%	3%
Analyze JSON File	45%	53%	0%	0%	3%
Analyze CSV File	10%	35%	33%	15%	8%

Table 3. Results from this Inventory Survey focusing on programming capabilities and data formats separated by gender.

Regarding routers and mesh networks, IoT, and printers, these are necessary items for any a BOO and while many may relate these to the "IT division's" duties, the overlap of skills and domain were called upon when answering questions earlier in the survey related to everyday job skills. As a result, these may be ICT-oriented items that get relegated to the technology officers. However, the overlap of skills relating to administration, performance, and non-tech-oriented tasks seems to stand in stark difference to that of tech-oriented ones. This also needs to be unpacked in future work.

The interesting thing about these data is that these are all aspects of CI that have been dominating research streams. Or, in the case of ARES/HAM[5], technology that has been around for decades. So we see a strange juxtaposition for these technologies. The first part of the juxtaposition is that new technologies are either unknown or EM personnel are unsure how to use them. This includes things like flying drones, setting up mesh networks, or the diverse representation of IoT devices. The second part of this juxtaposition is the old technology of ARES/HAM. These technologies came about in the late 1800s and are juxtaposed against so-called "bleeding edge" new technology. So there is a space within old technology and new technology where there has been an impact but it is not currently understood. More work is needed here.

Other Perspectives and Sources of Information About the Technology Crisis in EM

While we administered a survey, we did include three open-ended questions in this survey. Those questions are focused on 3 distinct time frames: immediate need, future need, and survey need. In asking these questions, we had hoped that respondents would reflect on what they could currently do and what they hoped to be able to do in the future. The content of these is significant enough to warrant its discussion independent of the survey.

The first question was "What are the technological skills you feel are necessary RIGHT NOW in EM?" Answers to this question were extremely diverse. Comments included things like, "be flexible" to "Data Management." Of

[5]ARES is an acronym that stands for, "Amateur Radio Emergency Service". This group of HAM radio operators have gone through training to be certified to activate during a disaster. More research is needed in HCI about this specific group as their activities are becoming more varied and regular. For more information, see http://www.arrl.org/ares.

	Men				
	I don't know what that is	**I am not sure how to do this task**	**I have done this before but I might need help.**	**I can perform this task without any assistance**	**I could train staff to do this.**
Fly Drone During Response	1%	43%	27%	16%	13%
Set up Router	1%	14%	40%	30%	15%
Set up Mesh Network	15%	49%	17%	9%	9%
Use HAM/ARES	7%	36%	21%	17%	19%
Set up IoT	13%	22%	28%	22%	15%
Set up Networked Printers	0%	9%	35%	36%	20%

	Women				
	I don't know what that is	**I am not sure how to do this task**	**I have done this before but I might need help.**	**I can perform this task without any assistance**	**I could train staff to do this.**
Fly Drone During Response	0%	68%	30%	3%	0%
Set up Router	0%	25%	43%	28%	5%
Set up Mesh Network	23%	55%	8%	13%	3%
Use HAM/ARES	13%	46%	18%	21%	3%
Set up IoT	18%	48%	18%	13%	5%
Set up Networked Printers	0%	15%	45%	28%	13%

Table 4. Results from this Inventory Survey focusing on new types of technology like Internet of Things (IoT) separated by gender.

interest here are common answers that include, GIS, Cybersecurity, Dashboard use, networking capabilities like filesharing, and "anything computer." Each of these items are technologies that are immediately applicable to their work and have been part of a push from the current Biden administration meant to help foster more digitally-aware EM personnel.

The next question was, "What are the technological skills you feel will be necessary to learn in the near-future of EM?" Answers to this question were meant to reflect the future of EM. However, many of the answers were focused on issues that have presented themselves throughout the COVID-19 pandemic. Answers ranged from, "digitizing the EOC" to "EOC software." These answers make sense from a practice-based perspective as they are essentially answers and solutions to questions and problems in EM right now that can be fixed.

When the answers focused on the distant future, they typically revolved around programming, drone usage, data mining, and crowd sourcing. These are important pieces of information related to the future of EM that CI can use. There are allies who want to use AI, machine learning, and various aspects of information retrieval, but the onus is on CI to make them usable by groups that do not have the capabilities to embrace them. Many of the answers here allowed us to focus how to interpret these data.

DISCUSSION

Here, we discuss the revelations of our analysis. Where we will concentrate is on how these results should shape the paths forward for software designers, tool makers, and the variety of professions, disciplines, and domains that make up human-computer interaction. First, we will discuss

SQL, JSON, and General Programming

The most simple way for moving forward with EM and tech integration is with simple tools created at a time when computers were not networked. In other words, we need to look backward when technology required fewer dependencies and relied less on what would become UX. One way to do this is through data warehousing and the products used to do that.

Data warehousing has enormous potential for EM technology integration for a few simple reasons. First, SQL will allow the EM practitioner, and the EOC they practice in to begin to collect all matter of data. These data, be it in blue sky or grey sky situations, will be a source of information and wisdom for that municipality.

What's more interesting is that SQL will allow EOC's to add dimensions to their existing datasets. So, while we may say that each home is on a spreadsheet, we can additionally attach census data, crime blotters, histories in terms of development, and other forms of human-based events that will have an impact on when a hazard event begins. Next, SQL can allow for data to be collected by disaster and to be warehoused in such a way as to be reflected by the ways that hazard events descend on the municipality.

After-Action Reports, those items that in the US are not available for research purposes, could also be replaced and kept hidden in favor of extant data. In doing this, institutional knowledge could be partially embodied inside of the SQL database. The only real barrier are that existing IT professionals are typically incapable of anything requiring force in EM and because of this, trainings of EOC personnel would need to supplant that policy weakness.

Second, we mentioned JSON in the results section. JSON data, much like SQL, provides a different way to house data and as such, different ways to produce insights from them. In conjunction with SQL, the recognition of JSON presents a useful way to begin designing tools for EM to use. The interesting part of these two concepts is that they require trainings first, not necessarily the creation of tools.

Finally, we noted in the results that programming languages have at least been heard of. And so these 3 items have what seems to be a 3-step process. First, we begin to train on datawarehousing. Second, we begin to train on not only gathering those data, but how to store and analyze them. Third, we then begin to offer how existing programming languages like Python can be used to harness even more potential within those data. Much of the work in and around software carpentry [6] could be useful as a foundation to build upon. Next, we discuss integration with ICS and NIMS.

The Power of ICS and NIMS

The Incident Command System (ICS) and the National Incident Management System (NIMS) are responsible not only for the lack of technology in EM, but the lack of technical skills of EM practitioners. These are extremely rigid hierarchies that require an enormous amount of socialization in order to see efficient deployment and activation that can be seen in Figure 2 These two protocols are most likely responsible for why age has no influence on tech skills in our sample. And so, we can say unequivocally that if anything can be done to shorten or fill in the gap between EM and consumer technologies, it needs to begin here.

At the moment, the "IT GUY" is often invoked as a reason that no one has to know technology. However, as is noted by the Office of the Inspector General notes with regard to the person responsible for IT in the EOC is deficient. The OIG notes that:

> "We attribute these deficiencies to the FEMA Chief Information Officer's limited authority to manage IT agency-wide, as well as to a decentralized resource allocation approach that hinders funding for the centralized IT environment. These deficiencies are not new, and were reported in prior Office of Inspector General audits throughout the last 13 years (Homeland Security Office of the Inspector General 2019).

And so, there will be no technological deployment or integration unless EM changes or shifts. What is needed is a series of discussions nationalwide (in the US) or whereever EM is struggling with IT, in an effort to ask, "how do you see your job changing if it were wired somehow?" And through this, new concepts appear. For example, one of the most insightful moments in the open-ended questions from our survey notes that:

> All of this technology requires an analog process (forms, status boards, maps) tailored to your situation and then supported by technology that may or may not work during an emergency.

And so, we see a potential use case that requires zippy quick input along with some discussions of how software could help make the process of filling out forms faster. This is timely because a recent RAND report noted that,

> "The wide variety of constructs currently in use were developed at different points in time, by various entities, and often in response to spe- cific events or needs. Although constructs were developed to address particular needs, the over- all number of constructs has grown, leading to a large group of them that requires that emergency managers have detailed familiarity with the rela- tionships between the constructs. The resulting group of constructs is poorly integrated and not optimally structured for the current operating environment confronting emergency managers" (Barnosky et al. 2022).

[6] Software Carpentry, https://software-carpentry.org/, was started by Greg Wilson in 1998 and focuses on providing essential knowledge of computation to those who have no knowledge currently. The approaches there have proven useful to at least one of the authors in presenting these concepts to EM.

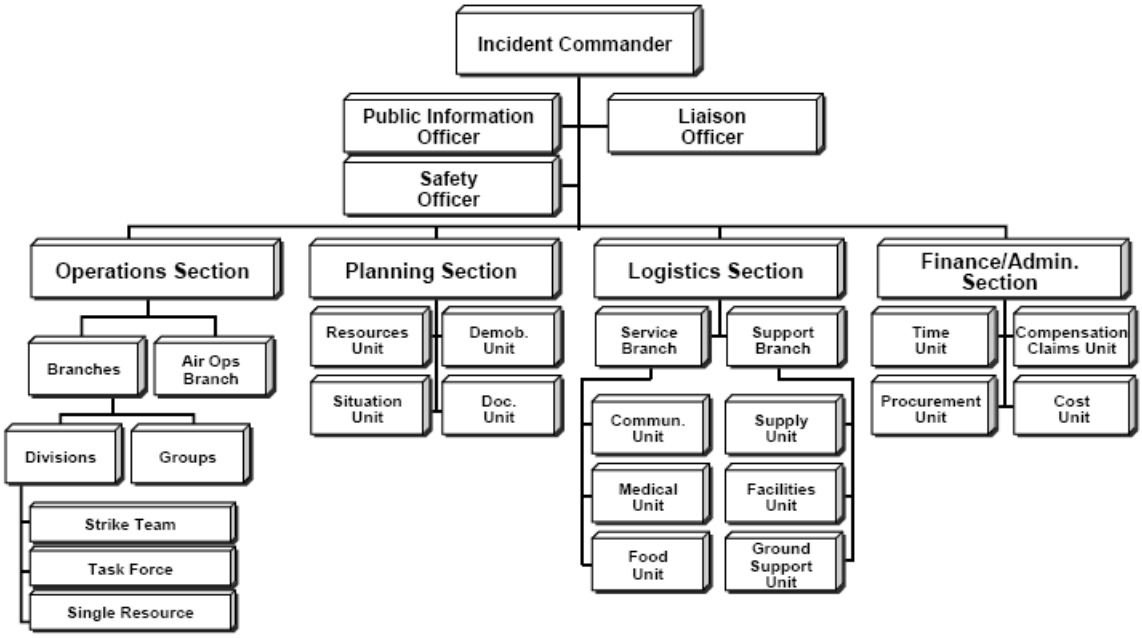

Figure 2. The Incident Command System currently has no true spot for the IT guy to exist. At times, the public information officer assumes this role and we have written about this in (Dailey et al. 2017). Other times, IT finds itself in logisitics. Where and for whate reason IT could be elevated to its own branch remains to be seen.

From the above, if the socio-technical system of EM is to lean a little heavier on the technical portion of things, then there is an opportunity for researchers to engage the variety of forms, programs, constructs, and funds that EM practitioners can actually use. In fact, this would be an excellent use of Machine Learning or Human-in-the-Loop Artificial Intelligence.

If these concepts are not followed, then expect no actual technologies to be adopted. This is because at the moment, IT-related issues, even cybersecurity, is sent to a team with little to no knowledge required by the EOC commander or the personnel on other teams. For example, one respondent noted that,

> "I have an extremely advanced IT team and Cybersecurity Incident Response Team (of which im a member) at my disposal but I am not nor do i need to be a subject matter expert, only have access to true professionals and have a user level knowledge of my own systems."

From this, we can surmise that this commander does not and will not engage the machine they are using past what they call, "a user level" which, from a UX point-of-view, is essentially using a one-off application that can do one thing. This is repeated quite a few more times in the open-eneded questions where respondents noted that,

> "The last few questions should ask "do you have staff can can do these functions?"

> "Some of the tasks in the last section are handled by dedicated IT techs."

Or if we take an extreme case, IT professionals who make it off of the team devoted to technologies,

> Persons like me who have significant IT skills tend to be lateral transfers into the EM field; we do not come up through the ranks nor are we developed in EM degree programs. When I first began attending FEMA trainings there were raised eyebrows and questions about whether I belonged there. Not only do I belong, but I lead.

And this is where ISCRAM as well as those domains and discplines that factor into this domain could actually begin. This is not bleeding edge. This is not advancement of technology. This is not moving tech forward. It is dealing with the wounds of the bleeding edge, those who are left behind by those advancing, or those who have to contend with tech moving forward with little to no thought provided in how it might function in the midst of disaster.

Training, Exercises, and the Red Line

The last discussion item is more of a "weaknesses" and "call to action" moreso than a discussion point. Training in EM uses simulation and role-playing almost exclusively. These can be done in a room, a building, a city block, several city blocks, a city, a region, or several states. At their core, these are large-scale role-playing games that folks will embody specific roles much like the tenets of Nordic LARP (immersive play) (Stenros and Montola 2011) or American LARP (rule-based play) (Stark 2012).

How these exercises are created has changed or shifted in most respects since they began being created in the 1970s. However, much like technology, LARP and role-playing have shifted and adjusted a massive amount since their creation. From dungeon master-less games to different forms of role-playing (and LARPing), EM can benefit not only from these developments but *especially* from the mixed media approaches these types of games have been developing.

If or should *anyone* want to integrate technology with EM, then a mixed media exercise platform would be extremely welcome. This is especially if that platform can allow 10 to a million EM professionals to engage simultaneously would revolutionize the field as well as decrease the barriers of tech integration. This is a weakness, ultimately, in studying EM. They call it the "red line" and it continues to thwart any potential growth.

The "red line" or, "I can't know what I don't know" is a different form of the argument from above. Whereas certain forms of it originate in and around the myth of the IT GUY, this is a symptom of a much larger problem, that of ICS or NIMS. The rigid hierarchy is not only total and absolute, it also is not changed that often.

Until these concepts change, learning new things just is not capable of being performed. However, exercises could be used to investigate new ways for hierarchies to be used. And the mixed media approach can not only show new approaches, but potentially useful technologies that could help in existing or those new approaches. While we would consider this a weakness of this study, it is also a weakness of attempting to study EM. One cannot simply study EM, one has to be EM to study it.

CONCLUSION

Perhaps the most surprising finding of this is neither surprising nor actually a finding, EM is bad with technology because technology never included their practice. However, the conclusion from this is something that needs to be said and needs to be understood far better than it has been. That thing that needs to be stated is this: there is currently no path forward for technology use in EM.

From the bureaucracies of EM to the ways EOC personnel are trained, there is currently no form of function for technology. In the instance that there is technology, there is often a mythological figure calleed, "The IT Guy" that is often pointed to as the technical person in EM; however, they have absolutely no spot on any org chart and as such, cannot advocate for tech use Homeland Security Office of the Inspector General 2019.

And so we return to our research prompt we were seeking to explore, that of the technology crisis in EM. To this, we can say that the technology crisis has appeared because of how we currently design and create technology. We make technology to work in a very tight configuration, often confined to a single task with very limited affordances. What needs to occur is that we begin to augment production processes with disaster in mind and by including disaster, we will also include EM functionality that EM would then have the onus of adoption and discussing with the makers how they need it to work.

To wit, the final aspect of this piece is to provide 3 pillars, 3 tenets for designing technology for the EOC, for the EM practitioner, and for disaster in general. These 3 tenets can best be sumarized as they need to be, analytics focused, planned on measuring and incorporating developments in the city as the SMART city planning moves forward, and they need to focus on where EM is, rather than where an advanced user of technologies might be.

To be more expansive, we believe that the EM tech tenets should be:

- EM Technology should primarily be used before a hazard event for planning and mitigation analytics (analytics).
- EM's response technology needs to work during a response when all other technology doesn't work or focus on extensible solutions for infrastructure damage (city planning).
- EM's everyday focus on technology should be primarily around the concept of the risks they create (basic tech skills).

Or to be more direct, we need to focus technologies on before an event occurs, we need to focus on how technologies could be integrated with the cities users live in, and how EM can interface with those technologies. In doing so, Crisis Informatics can embrace a future of more frequent hazard events by fostering an accessibility wave that has been needed since before the computer existed.

That said, there are opportunities to take steps that can help EM become more competent with tech and make technology more amenable to the kinds of theaters EM operates in. First, CSed has an opportunity to engage this space by engaging adult learners in ways that are unlike any other adult learner in higher ed. A practitioner who has no need for computation at all is a unique challenge for CSed. In fact, much of the lessons of this piece are indicative of an industry so unlike consumers as to be an entirely new domain to explore.

Next, software design in EM cannot use the same mindset as that of software or hardware design for consumer technologies. CI has an opportunity to not only find new kinds of design, but also has the potential to extend existing designs in a sort of extensible design philosophy. An example of this can be found in N. LaLone, Toups, et al. 2022 wherein locative media could be used post-hazard if a municipality placed a batter-powered mesh network that activates when the grid itself fails.

CI has spent so much time trying to force ICTs into EM without acknowledging how unlike consumer culture EM actually is. By acknowledging this failure, we gain a new space for design, new avenues for exploring how computation could work in a resource light environment, and even potential areas for civic software design. And so, to ISCRAM we say that the slow decline of interest in ICT4D, Humanitarian Software, EM, CI, and every aspect of design that focuses on disaster is a result of an incompatibility with the target of those designs. These incompatibilities range from practitioner knowledge to infrastructure availability to focusing on sole stakeholders and a light engagement with whatever branch of EM they can contact.

Each of these incompatibilities has contributed to CI's decline resulting in the publication of Palen and Anderson 2016's essential reading declaring any lack of success at all. And yet, each of the failures outlined are simply a lack of basic ethnography, a lack of getting to know the space being designed for. This is not entirely the faulty of CI as we see a difficulty with regard to how technology is viewed both as a product and from designers. And so, getting to know this area shows us that a new kind of design is possible, a paradigm shift that can help influence software to be in a place that does not see accessibility (resilience, safety, reinforcing) as an afterthought, but as an origin point.

We will close this piece by offering 3 rules to creating technologies that we would offer as a way to not only shorten the gap between consumer technologies and EM integration. They are:

1. We need to begin with the assumption that any ICT will not function in a hazard.
2. We need to understand how technologies consumers use can be used by disruptive groups to make any response effort worse.
3. We need to design technologies for EM using the old mindset of the Cold War wherein technology could survive and be used post-nuclear winter.

The last rule is perhaps the biggest stretch of logic; however, we believe this is an extension of the mindset issue. Beginning with this mindset will result in robust, unbreakable information pipelines that CI can embrace and provide all manner of training for, uses for. So get started.

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