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Practitioners' Perceptions of Fitness to Task of a Leading Disaster Response Management Tool

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Abstract. Crisis Information Management Systems (CIMS) have been used in Emergency and Disaster Response Management for decades. However, while these systems have emerged and improved over time, they still appear to provide lower efficacy when incidents become more complex, and, in particular, when used in the context of multijurisdictional responses to large and growing incidents and extreme events. Most CIMS like E Team, Veoci, or WebEOC are commercial off-the-shelf systems (COTS), which allow for and also require from emergency response units the customization of the application to their own specific needs. This survey-informed study took a look at practitioners' experiences with one of the most widely used CIMS, that is, WebEOC. The results were mixed at best and confirm other studies, which pointed at WebEOC's lack of scalability, interoperability, network security, and ease of use. The study concludes that in the face of ever more frequent incidents of greater magnitude the case for developing and deploying securely interoperable and scalable CIMS is compelling and has to be addressed.

Keywords: Disaster Response Management; coordination of emergency responses; information and communication technologies; ICTs; Crisis Information Management Systems; CIMS; WebEOC; National Incident Management System; NIMS; Incident Command System; ICS; Commercial Off-the-Shelf Systems; COTS.

1 Introduction

Contemporary commercial Crisis Information Management Systems (CIMS), it has been suggested [1, 2], support emergency managers and responders relatively well when used in response to smaller, every-day, and geographically isolated incidents. When, however, multiple jurisdictions and different levels of government agencies need to coordinate their responses, they appear to exhibit limitations and rigidities in terms of interoperability, scalability, reliability, network security, and ease of use. Unfortunately, not only when different vendors' systems have to interact, but rather also when the same system such as WebEOC has to scale up to meet the needs of a more demanding multi-level and multi-jurisdictional context [3], this experience of constraints and lack of scalability seems to be commonplace [4, 5].

As discussed elsewhere, given the wide range of incidents in terms of scale, scope, and duration [6] spanning from local emergencies such as leaks of hazardous materials or a building afire to large-scale, large-scope, and long-duration catastrophes such as the Indian Ocean Earthquake and Tsunami of 2004, the Galveston Hurricane of 1900, or the East Japan Earthquake and Tsunami of 2011, the coordination, integration, and scalability of operations is essential to the effectiveness of the response [7, 8]. In the United States, the National Response Framework (NRF) and the National Incident Management System (NIMS) with its Incident Command Structure (ICS) were designed exactly for the purpose of providing a common terminology and a framework of principles, practices, processes, which would be scalable, flexible, and comprehensive enough to guide responders of any discipline along the whole spectrum of possible disasters (ibid.). While these response frameworks entail a certain degree of organizational standardization, the information management portion of the framework and its supporting information and communication technologies (ICTs), that is, the CIMS would have to carry the burden, as the NIMS/ICS planners anticipated,

“Communications and information systems should be designed to be flexible, reliable, and scalable in order to function in any type of incident, regardless of cause, size, location, or complexity. They should be suitable for operations within a single jurisdiction or agency, a single jurisdiction with multiagency involvement, or multiple jurisdictions with multiagency involvement. Communications systems should be applicable and acceptable to users, readily adaptable to new technology, and reliable in the context of any incident to which emergency management/response personnel would be expected to respond” [7, p. 24].

By the time, these guidelines were formulated, CIMS such as WebEOC were already in use at all levels of government across the United States, and although WebEOC was still far from having become a kind of de-facto standard, a rather wide variety of non-interoperable CIMS was already in use around the Country. This, however, began to slowly change when in 2012 the US Federal Emergency Management Agency (FEMA) also adopted WebEOC for their internal use [9]. Yet, only a few years into FEMA’s use of this particular CIMS, it became evident that for security and performance reasons the WebEOC implementation at FEMA would not interoperate with State, Territory, or Tribal WebEOC sites forcing both FEMA and the respective agencies into tedious, error-prone, and time-consuming double work for necessary data exchanges [10]. It immediately follows that during responses to larger incidents, when the coordination and collaboration between and among agencies, both vertically and horizontally, are badly needed such bottlenecks would be counterproductive and costly. This study’s intent was to find out, document, and analyze how practitioners experience their work with WebEOC during a response with the aim of better understanding the efficacy and usefulness of this commercial CIMS along the entire spectrum of emergencies and disasters.

The publication is organized as follows: First, related work on WebEOC in the academic literature is reviewed. Next, research questions and the methodology are

detailed. Then, the findings for each research question are presented followed by a discussion of the findings. Finally, concluding remarks and directions for future research are presented.

2 Related Work

While professional response organizations in the United States have chosen from and implemented a wide range of COTS CIMS for the purpose of supporting their respective response operations, WebEOC appears to have become the most proliferated CIMS [4, 11]. Interestingly, in academic research, although CIMS are at the core of modern information management in emergency response, they have not yet systematically been assessed and evaluated in terms of their efficacy over the entire spectrum of incident responses. As a recent study suggested, “the role of information management tools used in <emergency management>... needs further investigation,” which according to the authors required to include “studying differences between centralized control and distributed participation; incorporating multiple incident data into a visually informative form for decision makers (e.g., hazardous conditions); and improving designs suitable for updating information in a timely manner” [12, p. 10]. Nevertheless, some research, even with regard to WebEOC, has been conducted while the overall picture has remained spotty. The first well-known quasi-academic comparison of contemporary CIMS was conducted as early as 2002 by the Hart study, which was sponsored by the Department of Justice’s National Institute of Justice (NIJ). The study performed a 106 “features” comparison of then contemporary CIMS, among which WebEOC scored highest with 102 desirable “features” identified [13].

A number of WebEOC-related studies went down a similar pathway, when investigating features (such as “boards”) and their relative usefulness in incident responses [11, 14-17]. Some studies took a high-level descriptive approach without concerning themselves with any technology or feature details [16, 18]. WebEOC was also found as a unifying connecting link in private-public partnerships between business communities and government agencies [2, 19].

While studies like the former portrayed WebEOC’s versatility, others emphasized more critical findings. Around the time that the NIMS/ICS designers detailed their recommendations regarding necessary interoperability, interconnectivity, and scalability requirements for CIMS (as quoted in the introduction), academic research also came to similar conclusions [5, 20]. Along these lines, WebEOC was found incomplete in terms of the availability of needed information [21] also with regard to information sharing between and among different agencies [22]. During a multi-jurisdictional response to a major landslide disaster, WebEOC implementations at Federal level (FEMA) and State levels were found unable to interoperate in most basic ways for security concerns on either side [23]. Similarly, in the simulation of a catastrophic incident, that is, under artificial exercise conditions when no damage of critical infrastructure had actually occurred or was even assumed under the simulated scenario, the interoperation and information sharing between a State-operated WebEOC site and two dozen county WebEOC sites broke completely down under the sheer load of requests [24].

Besides these serious load-related issues, other reports found a lack of automatic information summarization technologies implemented in WebEOC [15], which made it hard for responders to see the forest for the trees, once an incident response began growing, so that information had to be manually aggregated on paper to be useful [25]. The latter study also found “poor interoperability” within the network infrastructure [25, p. 9] resulting in poor information sharing exacerbated by ineffective ex-ante staff training and unaddressed communication gaps.

Other studies found that in order to make good use of WebEOC, the incident response had to accommodate to the “tool” rather than that the tool accommodated to the demands and needs of the response [26]. The same study also reported that WebEOC’s customizability, while giving the respective agency the flexibility to tailor the tool to its specific needs, by so doing it also sacrifices standardization and compatibility with other WebEOC implementations. Many agencies, particularly resource-poor ones, may even have great difficulty with setting up WebEOC in a tailored fashion [5, 26].

When analyzing the efficacy of a particular CIMS in response to an incident, scale, scope, and duration of this particular incident present the first benchmarks to consider. As mentioned in the introduction, a CIMS, which performs reasonably well in the response to incidents of small scale, small scope, and short duration may not perform as well when scale, scope, and duration of the incident increase, let alone when catastrophic proportions are reached. However, few studies such as Son et al. on CIMS efficacy have taken this consideration into account. When, for example, taking Fischer’s scale [6], which categorizes emergencies and disasters in a range from “DC (for disaster category) 1” to “DC 10” with “DC 1” standing for an everyday local and small incident and “DC 10” representing a catastrophe of extraordinary magnitude and annihilation, it appears intuitively evident that a CIMS has to be extremely scalable to cover this enormous range.

In summary, the efficacy of existing CIMS, and especially, WebEOC, in emergency and disaster response management is understudied; therefore, it has remained an open question of whether or not current CIMS, and here, WebEOC, are fit to task, in particular, when it comes to larger and dynamically growing incidents towards the upper end of the Fischer scale.

3 Research Questions and Methodology

3.1 Research Questions

As the literature review illustrated the gap of understanding with regard to the efficacy of CIMS, and specifically WebEOC, in practical disaster response management is wide. Moreover, it will be a potentially life-saving and likely disaster-mitigating contribution if this known gap in understanding could be narrowed. It also appears that the most important stakeholders, that is, disaster responders would bring first-hand practical experience to the table, when it comes to the efficacy of WebEOC, which leads to the following two research questions:

Research Question #1 (RQ #1):

How do professional emergency responders perceive the efficacy and fitness to task of WebEOC in emergency response management?

Research Question #2 (RQ #2):

What specific, if any, concerns regarding WebEOC (and its use) do professional emergency responders express in emergency response management?

3.2 Data Selection and Analysis

Instrument. Owing to the paucity of research on the subject and the concurrent absence of a guiding theoretical framework, the inquiry had to be of exploratory nature. For this purpose, an online (Google Forms) fourteen-question survey was devised. All questions except the last were either single or multiple choice questions. The first two questions established demographics (affiliation, WebEOC licensing status). The next eleven questions queried about use and performance aspects of WebEOC. The last question was free-format and open-ended, which gave participants an additional opportunity to enter their own observations in a narrative.

Sample. The intention of the researchers was to reach out and receive feedback from both the managerial and professional levels of disaster responders around the country. As a reminder, this inquiry did not seek to statistically test any hypotheses regarding the usefulness of WebEOC in disaster response. It rather intended to explore the perception of usefulness of WebEOC on part of professional disaster responders who had gained practical experience with this particular CIMS, which suggested a convenience sample was to be used [27]. As a long-term practitioner and a leader in the field, the second author has run a regular and well-respected blog for several years, which is read by a large audience of response professionals. In order to attract responses, the survey was attached to an opinion editorial that the second author posted on his blog site [28]. The tone of the blog was critical towards WebEOC, which was hoped to prompt professional responders into reacting and taking the survey, either for reasons of strong disagreement, or for the opposite.

Data Collection. The vast majority of the data were received and collected within two and a half weeks after the publication of the opinion piece. Very few responses were entered weeks after the publication. A total of 83 responses were received, and 48 respondents also took the time to enter a narrative, some of which was extensive and rich. Half of the respondents were County-level responders, 26.3% State-level responders, 13.1% Municipal Government-level responders, just under 5% Federal-level responders, 2.4% other governmental institution-level responders, and 3.6% were non-governmental-organization-based responders. The vast majority of responders (72.6%) represented organizations that had active WebEOC licenses, and 17.9% of responders represented organizations that previously held a WebEOC license.

Data Analysis and Coding. Data were analyzed in an open coding approach [29, 30], in which tentative concept labels were attributed to chunks of texts and their particular attributes. The concept labels were connected with regard to their relationships to each other in an axial-coding exercise [31] and compared to the

results of the eleven single and multiple-choice survey questions for plausibility, consistency, and further explanation.

Neutrality/Impartiality. This research has not been funded nor otherwise supported by any commercial or other vested interest.

4 Findings

In the following the findings are presented in the order of the research questions. The findings from both the single/multiple-choice questions and the free-format narratives are integrated in each findings subsection.

Ad Research Question 1 (RQ #1) — (How do professional emergency responders perceive the efficacy and fitness to task of WebEOC in emergency response management?)

The first survey question attempted to establish the overall satisfaction or dissatisfaction of survey respondents with WebEOC. Without undue speculation it was assumed that responders' satisfaction or dissatisfaction with WebEOC would largely correspond to the system's perceived efficacy and fitness to task. It was found that 33.7% of respondents were either very satisfied or at least somewhat satisfied whereas a majority of respondents (53%) across all groups were either very dissatisfied or somewhat dissatisfied, while 18.1 percent of respondents fell into neither camp. In other words, with only about one third of respondents expressing satisfaction of some kind with the system, WebEOC's efficacy and fitness to task in emergency and disaster response management appears to be called into question for the most part. However, based on the demographic and other data derived from the survey, it was possible to provide sharper contours and more granular detail for painting this mostly unfavorable overall picture of WebEOC performance in US emergency and disaster response management.

As Figure 1 shows when breaking down the distribution of satisfaction and dissatisfaction along government levels, WebEOC-related satisfaction is strongest at Federal and State levels, whereas on County and municipal levels dissatisfaction prevails. It is noteworthy, though, that while the survey produced only four responses from the Federal level, the four responses were widely spread with regard to the degree of satisfaction, and no Federal-level response indicated the highest level of satisfaction with WebEOC.

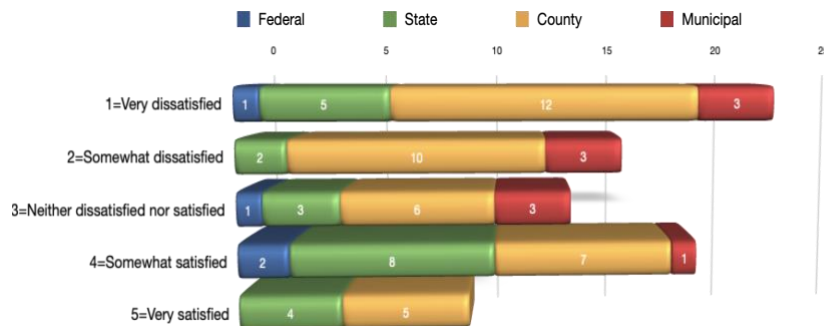


Figure 1. WebEOC User Satisfaction/Dissatisfaction per Government Level

Table 1. WebEOC User Satisfaction/Dissatisfaction Relative to Other Factors

Variable Values (Variables: Frequency, Ease of Use, Functionality, & Customization)	Very or somewhat dissatisfied (%)	Very or somewhat satisfied (%)
Daily Use	17.9%	60.7%
Weekly Use	28.2%	14.3%
Monthly Use	15.4%	14.3%
Infrequent Use	38.5%	10.7%
Very complicated	37.5%	0.0%
Somewhat complicated	32.5%	37.0%
Neither complicated nor easy	20.0%	22.2%
Somewhat easy	10.0%	29.6%
Very easy	0.0%	11.1%
Basic Functions	26.3%	17.9%
Advanced Functions	73.7%	82.1%
No/Little Customization	28.2%	11.1%
Some Customization	25.6%	25.9%
Substantial Customization	25.6%	33.3%
Extensive Customization + Add-ons	20.5%	29.6%

Taking County and municipal levels together, overall dissatisfaction with WebEOC was more than twice as frequent as was overall satisfaction with the tool. Among the variables, which might influence the degree of satisfaction or dissatisfaction, the authors suspected “frequency of use,” “ease of use,” “functionality,” and “degree of customization” (see Figure 1). Upon inspecting the percent values, one might tend at first sight to associate, for example, far more frequent, that is, “daily use” with higher degrees of satisfaction; as Figure 1 shows, only 17.9% of “somewhat or very dissatisfied” respondents indicated that they used WebEOC on a daily basis, while,

in contrast, outright 60.7% of “somewhat or very satisfied” respondents suggested they used the system on a daily basis. One might argue that more frequent use leads to, or, at least, illustrates higher degrees of satisfaction. However, regression analyses on all independent variables specified above and their combinations did not produce any statistically significant prediction of the dependent variable (satisfaction/dissatisfaction).

Despite this particular finding, it is noteworthy that WebEOC customization is the greater the higher the level of government (see Table 1). For the Federal level, substantial WebEOC customization was reported in all cases, on State level, customization is over 82% with half of this attributed to “extensive customization with add-ons.” On County and municipal levels, customization of WebEOC is also found in or slightly above 70% the responses; however, on the municipal level no “extensive customization with add-ons” is reported.

Table 2. WebEOC Customization per Government Level (%)

Degree of Customization	Federal	State	County	Municipal
Little or no customization	0.0%	13.6%	25.6%	30.0%
Some customization	0.0%	18.2%	23.1%	50.0%
Substantial customization	100.0%	22.7%	30.8%	20.0%
Extensive customization/add-ons	0.0%	40.9%	20.5%	0.0%
Not sure	0.0%	4.5%	0.0%	0.0%
Totals	100.0%	100.0%	100.0%	100.0%

Table 3. WebEOC Functionality Usage per Government Level (%)

Functionality	Federal	State	County	Municipal
1=Basic Functions	0.0%	0.0%	30.8%	70.0%
2=Advanced Functions	100.0%	100.0%	66.7%	30.0%
3=Not sure	0.0%	0.0%	2.6%	0.0%
Totals	100.0%	100.0%	100.0%	100.0%

With regard to functionality, again the higher the government level the more the advanced functionality of WebEOC is employed. At municipal level, overwhelmingly basic functionality of WebEOC is adopted, which illustrates an enormous gap of sophistication and experience between the local level and even the next higher level (County), let alone the State and Federal levels (see Table 2).

One of the most important, if not *the* most important task in emergency management is gaining and maintaining *Situational Awareness (SA)*, which is the prerequisite for developing and also maintaining a *Common Operating Picture (COP)*. Fully developed and vetted SA/COP are at the core of any effective and successfully targeted response to any incident [7, 32]. In this particular context, the

detailed geographic location of incident-related information is essential. Many response units employ highly specialized Geographic Information Systems (GIS) such as the Environmental System Research Institute’s ArcGIS. However, WebEOC also comprises a mapping component of its own and affords some GIS record integration with ArcGIS, although the WebEOC mapping component lacks the sophistication of ArcGIS.

Table 4. Usage of WebEOC Mapping per Government Level (%)

Usage of WebEOC Mapping	Federal	State	County	Municipal
Mapping never used	75.0%	22.7%	48.7%	60.0%
Mapping rarely used	0.0%	27.3%	20.5%	40.0%
Not sure	0.0%	9.1%	2.6%	0.0%
Mapping regularly used	25.0%	22.7%	17.9%	0.0%
Mapping key functionality	0.0%	18.2%	10.3%	0.0%
Totals	100.0%	100.0%	100.0%	100.0%

As Table 3 demonstrates, WebEOC-based mapping is rarely if ever used at municipal level, and also at Federal level its usage is relatively low, which in this latter case is most likely attributable to the use of more powerful GIS at Federal level. But on County and State levels, this particular mapping functionality is never or rarely used in almost 70%, or almost 50%, of the cases, respectively. Similar to the Federal level, it is likely that both County and State responders utilize more powerful and more specialized tools like ArcGIS instead. As before, a major gap in functionality utilization, and consequently, sophistication with regard to WebEOC-based generation and preservation of SA/COP appears to exist between municipal levels of government and higher levels.

Table 5. Intra-/extra-jurisdictional Connectivity per Government Level (%)

Connectivity	Federal	State	County	Municipal
Not connected (intra-jurisdictional)	75.0%	15.0%	23.7%	22.2%
Some connected (intra-jurisdictional)	25.0%	65.0%	57.9%	66.7%
All connected (intra-jurisdictional)	0.0%	20.0%	18.4%	11.1%
Totals (intra-jurisdictional connectivity)	100.0%	100.0%	100.0%	100.0%
Not connected (extra-jurisdictional)	75.0%	10.5%	30.8%	0.0%
Some connected (extra-jurisdictional)	25.0%	36.8%	43.6%	88.9%
All connected (extra-jurisdictional)	0.0%	52.6%	25.6%	11.1%
Totals (extra-jurisdictional connectivity)	100.0%	100.0%	100.0%	100.0%
Upstream log in	n/a	40.9%	27.8%	33.3%
No upstream log in	n/a	59.1%	72.2%	66.7%
Totals (upstream log-in connectivity)	n/a	100.0%	100.0%	100.0%

Problems with connectivity have been a known WebEOC characteristic, which encompass network load issues, connection security issues, slow or no responses, connection failures, among others [22-24, 26, 33]. The survey instrument distinguished between same-jurisdiction connections (including resource requesting

and tracking) and cross-jurisdictional connections (also, including resource requesting and tracking). Since most respondents were believed to be non-experts on ICT network-related matters a control question was included that prompted for the type of establishing connections to WebEOC systems in other jurisdictions (upstream log-in for access). For example, FEMA does not allow for their WebEOC implementation to directly interoperate with States' WebEOC implementations. Rather State responders have to remotely log on to the FEMA system via a secure connection, where an account for them is maintained. Many States act likewise with their lower-ranking jurisdictions. If upstream log-in is provided as a connectivity mechanism, then in all likelihood there is no other connectivity mechanism established in that particular direction. It is obvious that this type of interoperation is anything but seamless and has to be seen as an inelegant workaround. As Table 4 shows, Federal-level respondents confirmed that most of their WebEOC implementations do not connect to other systems. In contrast, a majority of State, County, and municipal respondents corroborate that most of their WebEOC implementations interoperate in some fashion with other WebEOC systems, both intra-jurisdictionally and extra-jurisdictionally. The highest numbers of upstream log-in access were found at State level (40.9%) followed by municipalities (33.3%) and Counties (27.8%). However, that means that in most cases no upstream log-in appears to exist or to be used.

When looking at the narratives in survey responses, only a single highly positive comment stood out from a State-level responder who reported on a decade-long experience also praising the cost-benefit ratio of WebEOC. Unfortunately, the responder did not give more details, for example, regarding the use of the system across emergencies of different magnitudes, or regarding the coordination with other agencies. Another State responder stated that all lower-level jurisdictions log on to their State WebEOC system during an incident response, so that the incident is dealt with from a unified SA/COP perspective. Another State responder referring to an identical log-in-from-remote setup between the State and lower-level jurisdictions, however, remarked that the system was "clunky" and not easy to use, and unlike the other two respondents who were very satisfied with WebEOC, this respondent was somewhat dissatisfied. Some County respondents noted that their upstream log-in setup was a one-way street only for sharing State information downstream. Interestingly, WebEOC's mapping functionality was mentioned in the narrative responses only twice: Despite one County respondent's overall dissatisfaction with WebEOC, this individual was highly appreciative of the integration of ArcGIS and WebEOC, which allowed for importing some data from WebEOC into ArcGIS (sic!). Another respondent who was neither satisfied nor dissatisfied with WebEOC had not come across this integration functionality and rather urged for GIS integration. Although mildly satisfied with WebEOC, but implicitly acknowledging the system's problems, one Federal responder stated,

"Big Tech could solve this easily; look at the interoperability within Apple or Google apps - maps, sharing, email, messaging, browsing are instinctively linked. Imagine what they could do if given the task to package existing apps into an EM layer" (quote #1—from survey responses).

In summary, dissatisfaction with WebEOC among survey respondents was found much stronger and more outspoken than satisfaction thereof, and, in particular, the “very dissatisfied” outnumbered the “very satisfied” by a margin of more than two to one in the responses. When analyzing, which (independent) variables might have influenced these particular outcomes, neither “frequency of use,” nor the “functionality used” (basic or advanced), nor the “degree of customization”, nor “ease of use” were found predictors for satisfaction or dissatisfaction on part of the respondents. Furthermore, WebEOC mapping was relatively sparsely used, and certainly not as a core function, but rather as an add-in, which was connected to a more powerful GIS. Finally, overall WebEOC connectivity was only moderately implemented with States most highly engaged. Given the relatively high levels of dissatisfaction in the perception of responding practitioners WebEOC’s fitness to task appears to be debatable, and it appears that the reasons for this dissatisfaction are multifold.

Ad Research Question 2 (RQ #2) — (What specific, if any, concerns regarding WebEOC (and its use) do professional emergency responders express in emergency response management?)

Respondents expressed most of their concerns in the open-ended narrative at the end of the survey. However, one multiple-choice survey question was geared at eliciting potential concerns regarding moving away from WebEOC. Nine choices were given including one “other” as shown in Table 6 below. The respondents marked a total of 222 choices, or on average 2.7 per respondent. It appears that no single concern stood out above all others with the exception of “budgetary concerns” with 33.3%, which was most pronounced on Federal level than on any other government level followed equally with 16.7% each by concerns regarding “going outside the norm” (sic!), “difficulty of adopting a new system,” and both the institution and its internal stakeholders too “deeply invested” into the status quo with WebEOC.

Table 6. Concerns and Obstacles Perceived (When Switching from WebEOC -- in %)

Concerns/Obstacles	Federal	State	County	Municipal
State standard	0.0%	20.6%	18.8%	18.2%
No known alternative	0.0%	16.2%	15.8%	21.2%
Budgetary concerns	33.3%	11.8%	10.9%	6.1%
New system might not be working	0.0%	4.4%	6.9%	9.1%
Changing means going outside the norm	16.7%	7.4%	9.9%	18.2%
Difficult adoption of a new system	16.7%	16.2%	6.9%	12.1%
Institution deeply invested	16.7%	13.2%	10.9%	9.1%
Internal stakeholders deeply invested	16.7%	8.8%	9.9%	6.1%
Other	0.0%	1.5%	9.9%	0.0%
Totals	100.0%	100.0%	100.0%	100.0%

In lower-ranking jurisdictions the implicit or explicit de-facto standardization on WebEOC as the emergency and disaster management system represented the most

highly cited concern with 20.6% at State, 18.8% at County, and again 18.8% at municipal levels. Furthermore, at municipal level a higher-ranking concern with 21.6% was the absence of a “known alternative” to WebEOC. Since only very few “other” concerns were specified, the first eight choices in this multiple-choice question on the subject must have covered the prevailing concerns and perceived obstacles fairly comprehensively.

On the municipal level, respondents’ concerns revolved around the perceived high cost of changes in system versions, system administrators, and when adding functionality by coding and recoding. Some municipal responders felt that WebEOC was oversized for their respective needs, while others bemoaned the absence of mobile versions. Quite a number of municipal responders decried the perceived lack of ease of use and straightforward task-relevant functionality. Said one respondent,

“Having used both <another system> and WebEOC, I have found WebEOC is clunkier and less user friendly. <The other system> is easier to build what is needed by the user.” (quote #2—from survey responses).

And another municipal respondent explained,

“WebEOC is designed for large agencies not the majority of EM offices with one or two staff” (quote #3—from survey responses).

County respondents also criticized that WebEOC’s lack of intuitiveness and ease of use, which they felt did not take into account the relatively modest ICT savviness of average emergency responders, in particular, in the more typical case that responders would not use the system frequently enough to maintain familiarity. Like respondents on municipal level, the county respondents also expressed dissatisfaction with WebEOC’s lack of functionality and unintuitive user interface. In this context some respondents used explicit language to illustrate their personal frustration with WebEOC (“It sucks.” “Terrible old system that has become a failure.” “Outdated and obtuse system that wastes an agency’s limited resources.” “Lots of money spent. Still doesn’t work.” “After using WebEOC for numerous large and small emergencies and disasters over the past years, I give WebEOC functionality and “usability” a grade of C/C-.”). Respondents on this government level also pointed at compatibility and interoperability problems, which emanated in part from a lack of standards set and followed in WebEOC implementations resulting in a wide variety of organizationally incompatible implementations. Some of these incompatibilities could be attributed to different needs at different levels of government. As one County respondent shared,

“Local EOCs who have adopted WebEOC as their software of choice in this State are buying and operating their WebEOC systems independently (State and local WebEOC systems do not interface with each other). If the locals buy their own WebEOC system, they tailor boards also to their respective EOC needs and unfortunately all the boards do not match each other at all the respective EOC levels” (quote #4—from survey responses).

On State level, the concerns of lower-ranking jurisdictions were echoed regarding the lack of “ease of use” and “functionality” as well as the high cost of maintenance including extensive training needs for coping with WebEOC’s complexity.

Frustration with WebEOC was also expressed on this level in no uncertain terms (“WebEOC is very clunky.” “<WebEOC> has outlived its usefulness and should be trashed.”). As mentioned while for States “interconnectivity” exists via secure upstream single-user log-in onto FEMA’s WebEOC implementation (and not, as manifest, via a bidirectional State-WebEOC-to-FEMA-WebEOC interoperation protocol), this type of interconnection is limited in capacity and bi-directionality, which creates unpleasant bottlenecks and redundancies, in particular, in the resource request process, which employs so-called resource request forms (RRFs). As a State respondent explains,

“Throughout our response in various disasters, missions could easily get lost as hundreds of mission requests flowed into WebEOC in a short period of time. This was problematic and challenging. We created alerts if missions were time sensitive or not updated in a timely fashion. Having no interface between our State and FEMA’s WebEOC platform is problematic and time consuming as we submit RRF’s, we have to submit paper RRFs to FEMA which defeats the purpose of WebEOC” (quote #5—from survey responses).

Another respondent summed up the experience with WebEOC this way,

“The biggest problem with WebEOC is that emergency managers all too often have to manage WebEOC instead of using it as a tool (quote #6—from survey responses).

On Federal, respondents did not leave comments except for one (see quote #1 above). However, this respondent also highlighted the high licensing cost and the limitations (“single channel”) of WebEOC.

In summary, respondents from all levels of government were critical with the relatively high cost of licenses for using and maintaining WebEOC. In particular, a dearth of functionality, a deficit in true interoperability, and a lack of ease of use were criticized on all levels of government. The terms “clunky” and “outdated” were used repeatedly.

5 Discussion, Future Research, and Concluding Remarks

5.1 General Observations

Crisis Information Management Systems (CIMS) differ from other and, particularly, non-mission critical information management systems in at least two ways: (1) With regard to their specific purpose, and even more so, with respect to their centrality in the overall critical information infrastructure, CIMS must be resilient, that is, robust, resourceful, redundant, and rapid (in operational usability and response time) [7, 34]. The findings of this study along with those of earlier academic reports, however, suggest that WebEOC would not qualify as a resilient CIMS along these lines, at least not in terms of robustness nor rapidity. It rather appears to slow down in response time and even to break down under only moderate loads, which apart from security and network safety concerns also explains the lack of true multiway interconnectivity (with FEMA presenting the most prominent example).

Interconnectivity is at the core of any system's scalability. If interconnectivity is limited, then scalability is limited. With limits in scalability the respective CIMS can only be reasonably and safely used in responses to relatively small-scale incidents. (2) CIMS are supposed to be extremely easy to understand and use [7, 35], since under the typically increasingly stressful circumstances of an incident response, professional responders have no time nor do they have the stomach for struggling with idiosyncrasies and peculiarities of any given CIMS. The respective CIMS has to support the response seamlessly and without putting additional burdens on its users. However, WebEOC reportedly appears not to be in this category of seamless CIMS. Paraphrasing one respondent's words, when using WebEOC in more complex incident responses, rather frequently the tail appears to be wagging the dog.

In a nutshell, in terms of flexibility, reliability, scalability, and ease of use, WebEOC does not appear to meet the CIMS standard requirements formulated in the basic NIMS document of 2008 [7, p. 24] according to this study's findings.

5.2 The Need for a Widely Accepted, Resilient, and Scalable CIMS

In a recent study on the subject, Son and colleagues performed a meta-analysis of the literature [12] and confirmed earlier insights regarding resiliency in emergency management that highlighted factors including "collective sensemaking," "team decision making," and "interaction and coordination" (p. 10), all of which heavily rely on the availability and proper functioning of a capable and robust CIMS as a prerequisite. As has been shown elsewhere, it does not suffice that a system can actually perform certain operations under certain circumstances. It rather also matters what the respective system's overall performance expectancy is, which is colored by past and present experiences from a human agent's (and here professional responder's) perspective [5]. If human agents who have to perform together as a coordinated group grow increasingly frustrated with a system's expected performance, then the acceptance of using such a system plummets, which seems to be the case with WebEOC among numerous responders on all level of government. In other words, if WebEOC's reputation among a large group of responders is turning unfavorable through lived and repeated negative experience, then the impact on the adoption and use of the system in the larger community of responders becomes problematic through the social influence of the disenchanted group. Conversely, if a CIMS, satisfies the performance expectations of a group of human agents, then the system's adoption and use is strongly and more widely supported also through the group's social influence. As seen in the findings, some responders suggested alternative COTS CIMS, while still others preferred a national initiative and a system standardized and centrally supported for all levels of government at affordable cost. The idea of using cloud-based services and existing standard tools for such undertaking might also be a viable path, which deserves study and evaluation.

It has been argued elsewhere that scalability is not only an upward affair, but rather also includes downward capabilities in case that power and networking capabilities are completely lost for an extended period of time and low-tech solutions have to be employed temporarily. While these incident scenarios might still be rare,

incidents of larger magnitude will undoubtedly encompass situations, in which, on the one hand, multijurisdictional collaboration and coordination of the response is badly needed, while, on the other hand, major portions of the critical (information) infrastructure are destroyed or degraded to an extent, which makes such coordination and collaboration extremely difficult. CIMS redundancy then means that critical functions in such scenarios need to be performable elsewhere, and logistical support for equipping responders on the ground who have limited or no direct connectivity with updated stand-alone CIMS from remote sites via appropriate means of physical transportation.

5.3 Limitations of the Study

WebEOC is a CIMS predominantly used in the United States. The results reported here may be different for other CIMS in other countries. Also, software systems undergo relatively frequent revisions. This study did not discriminate between respondents reporting on the most recent version as opposed to older versions of this particular COTS. As a result, experiences with newer versions of WebEOC might have produced more favorable results. However, the convenience sample still reports on “what is currently out there;” yet, a large random or systematic sample might have produced more accurate results. While the number of respondents (83) who fully took the survey cannot be called small, it nevertheless was not large enough to produce highly robust results, which would lend themselves subject to elaborate statistical analyses. The study attracted participation by attaching the Web survey to a subject matter blog widely read by practitioners in emergency management. This particular blog entry on WebEOC was highly critical of the system, which might have primed and incentivized more respondents with negative than positive views to also share their own mainly negative views on WebEOC. Therefore, besides the sampling situation also from this latter perspective of potential bias, no claim of results-based generalizability can be made. Furthermore, when testing for predictors for the dependent variable (satisfaction/dissatisfaction) via regression analysis, none of the independent variables was found as outcome predictors. This might change in case of a larger and systematic sample. While these limitations are acknowledged, the study nevertheless was able to document in detail considerable dissatisfaction with WebEOC on part of practitioners on all levels of government who gave ample comments in support of their views. The study, hence, represents a broader exploratory step than previous studies also geared at better understanding the current problem space involving WebEOC.

5.4 Concluding Remarks and Future Research

It has been the object of this exploration to identify and document practitioners and system users’ perceptions of fitness to task of WebEOC, the leading crisis information management system (CIMS) in the United States. This study contributes to the understanding of challenges and potential pitfalls when using commercial-off-the-shelf systems (COTS) in the context of emergency and disaster response management. While WebEOC appears to have some support among practitioners (mainly on Federal and State levels), a far larger number of practitioners on all levels

of government was found to be highly critical of the system with respect to its perceived high cost, difficult maintenance, low performance, insufficient functionality, limited interoperability, and weak scalability. Since CIMS are the backbone of effective all-hazard and all-magnitude incident responses, these findings, which are supported by other studies, have to prompt further research, since they suggest a serious vulnerability in the Nation's capacity to effectively cope with emergencies and disasters, which can have adverse consequences for lives and assets.

Future research therefore needs to focus on how CIMS can be devised that meet the long established criteria and performance benchmarks [7, 36] and what obstacles must be cleared in order to implement them.

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