Overwhelmed by Brute Force of Nature: First Response Management in the Wake of a Catastrophic Incident

Hans J. J. Scholl

Overwhelmed by Brute Force of Nature: First Response Management in the Wake of a Catastrophic Incident

Hans J. Scholl

University of Washington, Seattle, United States
jscholl@uw.edu

Abstract. The four-day Cascadia Rising exercise of 2016, which simulated a magnitude 9+ rupture of the almost 700 miles long Cascadian subduction zone with up to 5 minutes of violent shaking followed by a 20 to 30 feet-high tsunami in the Northwestern United States, was one of the largest response exercises of a catastrophic incident ever conducted in the United States. It involved 23,000 professional responders in three states in the Pacific Northwest. In reality, the simulated catastrophe would likely carry a five-digit number of fatalities and send the entire region on a decades-long course of recovery to a "new" normal, in which nothing would be close to what it once had been. The study investigated the numerous managerial challenges that responders faced. Communication and coordination challenges were found the most prevalent among other challenges. The research also uncovered the lack of standardization of response structures, processes, and procedures as major inhibitors of a more effective response besides other inhibiting factors. While the "containment" and "effective mitigation" of a truly catastrophic incident is illusory, the study provides recommendations regarding preparation and problem mitigation in the management of the response.

Keywords: Emergency response management, catastrophic incident, National Response Framework (NRF), National Incident Management System (NIMS), Incident Command System (ICS), coordination failure, communication failure, process standardization, procedure standardization, structure standardization, infrastructure damage, staffing problems, humanitarian crisis.

1 Introduction

1.1 Overview

The study of the now famous Cascadia Rising exercise of 2016 has produced a total of three reports, of which the one at hand is the third. The previous two reports covered the problems of situational awareness (SA) and the development of a common operating picture (COP) [40] as well as the assessment of the technology tools, which were used and needed [39] in order to arrive at an actionable SA/COP. As expounded in the first two reports, the potential gravity of impact and extraordinary peril from a megathrust in the Cascadian Subduction Zone (CSZ) to human lives and properties in the coastal zones of the Pacific Northwest of the United States was greatly unknown until the late 1980s [39, 40]. Only since then it gradually became better understood what extent of impacts had to be expected, and what challenges first responders might have to face. For addressing the latter, all levels

of government in the three states of Idaho, Oregon, and Washington as well as FEMA region X jointly planned and conducted a four-day exercise, which simulated the response to a magnitude 9+ (M9+) earthquake and the resulting tsunami. This third report focuses on the particular managerial challenges, with which first responders were confronted. It complements and expands the findings of the other two reports.

1.2 Cascadia Rising 2016 Exercise Brief

The March 2011 megathrust and tsunami that ravaged the coastal areas of the Tōhoku region in Japan was the final push needed for policy makers and emergency managers to understand the gruesome reality of a pending catastrophic incident of this type and the high probability that something similar could happen in the Pacific Northwest at any point in time. Like the impacted Japanese region, the Northwestern coastline of the United States rises along a subduction zone. However, unlike all other subduction zones along the so-called Pacific Ring of Fire, the CSZ has not experienced a rupture in more than three centuries. As geological studies found out, M9+ CSZ ruptures recur with some regularity every 500 years [4, 49]; however, more recent studies suggest that the intervals between two consecutive megathrusts may be as short as 300 years on average [23]. The 2011 catastrophe in Japan suggested to emergency managers that response preparations for a M9+ CSZ rupture and tsunami had to be drastically revved up quickly, which led to the immediate launch of several projects culminating in the comprehensive Cascadia Rising 2016 exercise, which involved a total of 23,000 responders across three states in the Pacific Northwest during four days of exercise (June 7 to 11).

The exercise assumed violent shaking occurring for some five to six minutes, while the subduction zone ruptured from one end to the other in a zipper-like fashion. The initial shaking would be followed by an up to 40-feet high tsunami wrecking the coastal areas in the Pacific Northwest. The initial shaking would be followed by several heavy aftershocks, which would further damage already compromised structures. Total power outages along the West coast would ensue with numerous downed power feeder lines and destroyed substations, and power would not be fully restored in the impact areas for up to 18 months. Water mains would break stopping water supplies to households within a day. Sewage and wastewater lines would also break as well as gas and oil supply lines. Around 1,000 road and railroad bridges would collapse. The latter has the grim consequence that “islands” with no ingress nor egress would trap and almost hermetically insulate populations in the hundreds, or, even more so, in the several thousands with no power, no water, no sewage disposal capabilities, no fuel supplies, and no food supplies. Up to four hundred such “islands” could be forged by infrastructure destruction, which within a few days would result in a humanitarian crisis of much larger dimension than the initial impact of the megathrust and tsunami that might have already caused several ten thousand fatalities and an even higher number of injured victims. With power gone for extended periods of time, information and communication networks would become unavailable. Cell towers, which initially had remained operational after the various waves of shaking, would go silent after some 28 hours, when the back-up batteries run down. The exercise was built on the basis of the results of the Homeland Infrastructure Threat and Risk Analysis Center (HITRAC) simulation study commissioned in 2011, which was compiled by Western Washington University’s Resilience Institute into a detailed exercise scenario document [33].

1.3 Context and Paper Organization

As mentioned above, this paper is part of a study covering aspects of situational awareness, the common operating picture, the information and communication technologies used in the response, as well as the specific managerial challenges in response management after a catastrophic incident, the latter of which are the focus of this third paper. The study used to a large extent the theoretical frame and methodological instruments developed in an earlier study dedicated to a real-world disaster, which had occurred only a few years earlier [36, 37]. Interestingly, quite a number of responders that had been interviewed in the context of the real-world disaster were also involved in the CR16 exercise. Quite a few agreed to be interviewed again after the exercise. This circumstance gives the collected data a certain nuance and weight since these interviewees compared their real-world experiences from two years earlier to those from the exercise.

The paper organization is as follows: The next section presents the extant related literature succeeded by the methodology section and the research questions. Thereafter, the findings are presented for each research question, which then are discussed. Finally, future research avenues and concluding remarks are presented, which also detail the particular contributions of this research.

2 Literature Review

Managerial challenges in disaster response management have been studied, at least in part, for decades. Foci in these studies were the coordination challenges among and between organizational response units as well as between communities and professional responders [15, 34]

Central and indispensable for coordination of professional response activities and resource management as well as for collaboration with other internal and external response units is *actionable information*, which has been vetted, verified, and can be, and actually, is shared [5, 12, 36, 39, 40]. Besides actionable information, response units draw on pre-disaster planning (including interagency coordination) and rely on organizational structures and predefined practices, processes and procedures, for example, such as those defined by the US National Incident Management System (NIMS) and its core, the Incident Command System (ICS), as well as the National Response Framework (NRF), which together encompass "doctrines, concepts, principles, terminology, and organizational processes" for effective, scalable, and effective emergency response management [1, p.3, 2]. While the emergency response system in the United States has been praised as one of the most comprehensive and probably most tested in the world of its kind [44], it has also drawn heavy criticism inside the United States from academic circles [14, 32, 48] at least during its early stages as an all-hazard response framework, while more recent assessments arrive at far more favorable conclusions regarding the system's effectiveness [6, 29, 47]. The latter is also supported by positive accounts, which practitioners provide [9, 13, 25], although other reports still point at incomplete implementations [27, 28] and inconsistent applications of the frameworks [16].

However, while NIMS/ICS and NRF have provided a common frame of reference and understanding, various managerial challenges remain, which engulf any response, and in particular, once scope, scale, and duration of on incident increase. What might work still passably well in emergency responses to smaller incidents such as those of up to DC-3 to DC-4 categories on the Fischer scale [18], however, once catastrophic incidents of DC-8 to DC-10 categories happen, the challenges of such a magnitude of incidents are much harder to meet in anticipation thereof, let alone when responders from multiple jurisdictions and levels of government have

to coordinate among each other for effectively coping with the real thing. Besides the well-known (though unresolved) problem of breakdown of information sharing among responders [11] leading to incomplete situational awareness and a lack of a shared common operating picture, serious managerial challenges, for example, regarding coordination, collaboration, and resource management have been widely documented in recent literature [7, 8, 10, 21, 22, 24, 30, 31, 37, 42, 46].

As an example, in response to the DC-4/DC-5 2014 Oso/SR530 incident, serious and continued coordination and collaboration problems ensued for days and weeks between incident management teams (IMTs), the urban search and rescue teams (USARs), the County EOC and County leadership as well as the other 110+ agencies involved in the response [31, 36, 37]. In this particular incident a whole hillside had collapsed, and within a minute and a half debris of up to 21 feet high had completely covered a one-square mile area, killing 43 people, demolishing about fifty structures, and burying State Route 530 for a length of 1.5 miles [26, 31] When taking the Oso/SR530 incident response, which was rather limited in terms of scale and scope as a benchmark, then a catastrophic incident would present itself as a far graver and more complex challenge to responders from multiple jurisdictions and levels of government [3].

3 Methodology and Research Questions

3.1 Research Questions

Based on the review of the literature on the general subject as well as on the author's previous research on the particular subject matter of "managerial challenges" in response management, it is evident that coordination and communication challenges are prevalent along with a number of "other" managerial challenges not directly related to coordination/communication, which leads to the following two research questions:

Research Question #1 (RQ #1): How do coordination and collaboration challenges change or stay the same when responding to a catastrophic incident (as opposed to a non-catastrophic emergency response)?
Research Question #2 (RQ #2): How do other managerial challenges change or stay the same when responding to a catastrophic incident (as opposed to a non-catastrophic emergency response)?

3.2 Conceptual Framework, Instrument and Coding Scheme

This study has been conducted by employing the so-called "information perspective," which is a human actor and human action-centric approach to investigating managerial challenges of coordination procedures, processes, and structures as facilitators of human information needs, information behaviors, and information flows, which then lead to decision and actions. In disaster management, when looking at managerial challenges in terms of coordination and collaboration, the information perspective allows a detailed investigation of actions and interactions of responders as they are mediated via the existing and emerging information infrastructures and their various aforementioned elements [38, 41].
Based on the conceptual framework of resilient information infrastructures (RIIs) [41], a semi-structured interview protocol was devised upfront, which covered six topical areas of (1) management and organization, (2) technology, (3) governance, (4) information, (5) information infrastructure, and (6) resiliency /RIIs.

3.3 Data Selection and Analysis

Data Selection. The sample was purposive [35] and included seventeen responders from eight different groups: the (1) City Emergency Operations Centers, (2) County Emergency Operations Centers, (3) Washington State Emergency Management Division, (4) WA State Agencies, (5) Health Districts, (6) Regional Aviation, (7) Washington State National Guard, and (8) Federal Emergency Management Agency (FEMA), region X. Furthermore, twenty-three after-action reports (AARs) from all eight responder groups were collected and analyzed.

Data Extraction and Preparation. The interviews, which lasted between 33 to 107 minutes, were conducted between September 2016 and March 2017. Except for one interview, which was conducted via Skype video conferencing, all other interviews were performed in person. Notes were taken, and participant interaction was observed and recorded during the interviews. At minimum of two researchers transcribed and coded the audiotaped interviews. Also, response units' after-action reports and press interviews were collected, reviewed, and coded as appropriate.

Data Analysis. The conceptual RII framework mentioned above guided the design of the initial codebook, which contained six category codes (one for each topical area) and 141 sub-category codes. During data collection, in individual coding sessions, and in inter-coder sessions additional codes were introduced in a bottom-up fashion [19, 20, 43, 45] making the resulting codebook a hybrid of deductive and inductive analyses [17], which finally consisted of 176 sub-category codes in the six main categories.

Using a Web-based tool for qualitative and mixed-method data analyses (Dedoose main versions 7 and 8, dedoose.com), at least two researchers coded each transcript and document. Coded excerpts were compared showing high inter-coder reliability.

Code applications in the areas of "management and organization" (2,763), "information" (1,705), and "technology" (1,111) were the highest across the six main categories. For the purpose of the specific analysis on managerial challenges the code intersection represented by the sub-codes of "managerial structure," "address challenges of organizing," and "address challenges of improvising" was selected, which produced a total of 1,146 excerpts for all eight distinct responder groups. These excerpts, which could carry multiple codes, varied in length between one sentence/one paragraph and up to three paragraphs.

Separately per each responder team, the excerpts were conceptually analyzed in the subsequent phase of analysis. Recurring themes and main concepts were identified and named by means of short key phrases and keywords. These concepts/context clusters were transferred to the "canvas" of another Web-based tool (CMAP, version 6.03), a concept mapping tool. The concepts/context clusters were inspected and sorted into topical "bins" or "baskets," in which chronological, logical, and other relationships were identified. Relationship links between concepts/context clusters were established whenever evidence from the data supported that link.

Research Team and Processes. The research team consisted of the principal investigator (PI) and thirty-two research assistants (RAs). The PI and RAs worked individually and in small teams to transcribe, code, and conceptually/contextually analyze, and map the concepts. For the most part of the project, the research team met weekly in person or online and communicated via the research project site and the project listserv as well as via individual face-to-face and group meetings. Weekly meetings were streamed and recorded, which kept the whole research team in sync over extended periods of time.

4 Findings

Below the findings are presented in the order of the research questions.

4.1 Ad RQ #1 (*How do coordination and collaboration challenges change or stay the same when responding to a catastrophic incident (as opposed to a non-catastrophic emergency response)?)*

Physical Obstacles. As described in the exercise overview above, shortly after the megathrust electrical power would be immediately lost in wide geographical areas and not return for months and in some cases even for more than a year. In isolated areas here and there, and for some hours, or, for a couple of days at most, generator and backup battery-based communications and operations could be maintained on greatly degraded levels. However, the almost total loss of power would gravely impact all communication infrastructures. It would massively slow down all kinds of communications and significantly curtail information sharing capabilities, which would make coordination of response efforts and collaboration between response units exceedingly difficult. All responder groups emphasized that widespread loss of electrical power, and, with it, loss of most vital communication capabilities, would be the premier challenge in this particular response, which would require to be addressed in more realistic ways than in the initial CR16 exercise not only in future exercises but rather also in response plan development. Some responders remarked that in such situations the overall response would greatly slow down. Pre-established personal acquaintance and mutual trust between responders would become even more critical, since mainly trusted sources and recipients would be regarded premier channels of communication. Paper-based messages and T cards along with other non-electronic media would be the vehicles and primary means for organizing the response. Beyond the almost wiped-out communication infrastructure the transportation infrastructure would also be immensely degraded and bestrewn by barriers and impediments of all kinds (collapsed overpasses and bridges, blockages by landslides, fallen trees, tumbled-over buildings, downed powerlines, cracked-up road surfaces, fires, flooded areas, and spills of hazardous materials and fuels among others), so that even on-foot messengers or runners would find it difficult to deliver messages quickly. Physical obstacles would be met not only for message distribution and command coordination but also for movement coordination, for example, for moving people and resources in and out from the impact area. As one responder stated,

> "The whole issue of movement coordination in and out of the impacted area: So, you are on the one hand trying to bring in resources, be it personnel, be it equipment, be it commodities and at the same time you're wanting to evacuate parts of the population, etc., and you are having to do all of this with a tremendously impacted transportation infrastructure. So, the coordination of all this movement is a complex issue that has to be coordinated between the Federal and the State level. The complexity actually grows exponentially with a catastrophic incident." (quote #01)

While this particular responder focused on the State and Federal levels, movement coordination has also to be accomplished on local and County levels at the same time, all of which increases the order of complexity in response and responder coordination.

Interjurisdictional Coordination Challenges. As a recent study on a 2014 real, however, scale, scope, and duration-limited incident response had uncovered, when a relatively small part of the same impact area projected in CR16 was affected, challenges of coordination, communication, and collaboration abounded in this particular and far smaller response. Among those challenges jurisdictional bicker-

ing over who was in charge of what were prominent. As a reaction to these challenges, a Unified Command Structure was slowly formed, which could yet not completely overcome all effects of a certain unwillingness to collaborate on part of some responder groups. Also, besides those more subjective and interpersonal factors, the lack of standards, for example, in resource request procedures, and the difficulty of scaling up the response from daily routine to something more challenging gave responders considerable headaches. While the real response had to cope with an incident of DC-4 to DC-5 order of magnitude on the Fischer scale [18], the CR16 exercise addressed a simulated incident of DC-9 magnitude with a huge geographical scope (three states—Idaho, Oregon, Washington State, and the Canadian province of British Columbia), enormous scope (in terms of the disruption of critical infrastructures, overall damage, and loss of lives), and extended duration of disruption [18, p. 98] of several years before returning to a new normal.

Besides the physical obstacles presented before the response to this simulated DC-9 incident quickly proved much more complex than the response to the real incident two years earlier. While in some EOCs and ECCs at all levels the internal coordination worked reasonably well, the cross-jurisdictional coordination met numerous challenges. According to several interviewees and numerous after-action reports (AARs), the lack of pre-disaster plan integration across jurisdictions was experienced as painfully missing, when response actions and resource deployment needed instant vertical and horizontal coordination the most. The lack of plan integration between vertical and horizontal levels of government was immediately experienced, for example, in mass fatality management, transportation management, damage assessment, shelter management, and overall resource management. As the National Guard's CR16 AAR laconically concludes,

> "Planning partners must expend the capital and energy to pre-plan and synchronize their actions for this catastrophic event. State agencies, as organized by ESF, should develop linked plans under the Washington Emergency Management Catastrophic Incident Annex (CIA) and the Washington State CSZ Playbook, for the CSZ response." (quote #02)

However, such plan integration has to encompass also local and regional planning not only horizontally but also vertically, for example, between municipalities and counties as well as counties and State agencies, since the data also showed the lack of and need for this kind of integration. Furthermore, planning cycles across jurisdictions are not synchronized. Since jurisdictions of fairly diverse sizes and resources have to coordinate vertically and horizontally, this complex cross-jurisdictional plan coordination could become fairly challenging at least for smaller and less resourceful jurisdictions.

Lack of Standardized Operations, Processes, and Functions. While national frameworks such as NIMS/ICS and NRF provide an overall doctrine, a set of guiding principles, along with structural elements and their interplay, under the particular scenario of a M9+ CSZ rupture, the absence of more detailed standards on operational and other levels was experienced quickly. The adoption of NIMS/ICS by response units is voluntary, and its implementation leaves room for modifications and adjustments to local needs. As a consequence, responders from all groups reported about wide-spread confusion about roles (of positions) and tasks within the response framework, which led to a lot of friction in the collaboration between response units. Despite the usage of ICS forms, for example, ICS 213 (general message), ICS 201 (incident briefing), ICS 214 (activity log), or ICS 215 (operational planning worksheet) in many jurisdictions, the forms were modified or incompletely filled, and no standards existed for processes and procedures (such as message flows and distribution, message elements and composition, message and

report frequency, situation report formats, orders for temporary flight restrictions, or resource tracking among others), or functions (such as incident-specific training, emergency support functions, and search and rescue), tactics, techniques, and accountability. As a result, responses were delayed and resources were allocated late. The lack of a regional standardized command and coordination structure, in which EOCs and ECCs at local and County levels, some of which had never fully activated before the exercise, had widely diverse organizational structures ranging from adherence to NIMS/ICS and NRF to other setups including some along the lines of the framework of Emergency Support Functions (ESFs), or a hybrid of NIMS/ICS and ESFs. This organizational variety and its resulting lack of detailed and specific standards for this particular type of incident led to a whole host of coordination issues such as confusion about roles, task assignments, lines of communication, interjurisdictional agreements, and relatively simple procedures such as shift turnovers, some of which occurred without a briefing and detailed handover to the next incident commander. In the latter case, a tremendous amount of rework and loss of operational and situational awareness was the result leading to further confusion and delays. As one AAR points out,

> "There was inadequate coordination between 1st and 2nd EOC shifts (with some notable exceptions). Several members from the first shift left without sufficiently briefing their successor, leading to significant confusion. This also meant that many of the processes and tools that had been developed in the first shift had to be 'relearned.'" (quote #03)

Liaisons. Under NIMS/ICS the deployment of liaison officers (LNOs) across and between governmental levels has become an important formal element to help with inter-organizational and inter-jurisdictional coordination. Required qualifications of LNOs increase with type (I to III) of response to the incident. For example, the State of Washington appointed an official LNO with FEMA Region X. Conversely, during CR16, FEMA deployed numerous support staff at local jurisdictions who essentially performed the roles of LNOs. Also, the Washington National Guard (WANG) had LNOs placed at numerous County and City EOCs. But, also inside jurisdictions liaisons would be used, for example, the Planning Section in a City EOC would have onsite support from the City IT department or other Emergency Support Functions (ESFs). State and counties deploy LNOs also to the various tribal organizations and the Native communities.

The role of a LNO is multifaceted and can be described as a combination of a representative and point-of-contact, an interpreter, a communicator, facilitator, matchmaker, and a subject matter expert who needs very good interpersonal and inter-cultural skills, excellent knowledge of both the home and the deployment jurisdictions, their structures, their important players as well as their processes, procedures, and plans. In many cases, LNOs in order to be effective need expert knowledge of technical resources, their tactical capabilities, and their availability. Ideally, LNOs would be cross-deployed so that practical coordination between any given response units would be smooth.

In many cases, LNOs played the role of observers only reporting back to their home unit in detail about the situation at hand at the hosting jurisdiction, which then gave that home unit a clearer picture of the overall situation, However, LNOs also played a major role in resource identification, requesting, and allocation. In many cases, it was the LNOs that made things happen when the official channels of communication or resource management were unavailable or not functional otherwise. In some cases, jurisdictions asked LNOs to help with operations and planning when their own staffing levels had gone low. In these cases, the original purpose of LNOs was compromised to some extent. Furthermore, several respond-

er units were unable to fill LNO positions at the next-higher or neighboring governmental levels, for example, several counties had no LNOs at the State EOC, which considerably added to the communication and coordination challenges described above. However, in a real response to a DC-9 incident the latter two situations of repurposing a LNO or not even having a LNO deployed might well become a practical reality, which curtails coordination and communication. Said one County responder,

> "The one thing that we did learn was that we had some new people in the EOC from agencies that normally would show up, but that it was their first time to be in the EOC. So, they didn't really know where to be or what to do or what their role was, so one of the lessons learned is that we need to do a better job providing EOC liaison training establishing a base line of here are our expectations, here are the roles you perform." (quote #04)

Policy Coordination. While incident commanders at various levels of a response supervise and manage the execution of a given mission as detailed in an incident action plan, the overall policies, priorities, and objectives of a response are formulated by policy groups, that is, elected officials and other decision makers of a given jurisdiction who closely work with the incident commander(s) and the EOC/ECC in that jurisdiction. The coordination of policies of different jurisdictions is performed at the respective levels. If, for example, one municipality prefers transportation arterial clearance in mainly East-to-West direction, while the County and neighboring municipalities prefer arterial clearances in a predominantly North-to-South direction, then response teams in the various jurisdictions would likely pursue incompatible or mutually non-supportive objectives. Policy groups in these jurisdictions would be in need of a negotiated common objective, since those decisions would not be made at tactical and operational incident command level. Also, if an incident commander requests resources or actions, which involve long-term strategic capital investments or major structural changes for the jurisdiction, then the policy group would typically first authorize such requests and actions before execution. As one AAR confirms,

> "In some cases, an incident manager may possess the appropriate delegated authority for many or most decisions; however, given the long-term implications of certain decisions, they may either seek informal guidance, or in some cases a more formal policy decision from their agency administrator (e.g. elected official or governing body) prior to pursuing or implementing certain actions." (quote #05)

As the data show, internal and external policy coordination was missing in many cases leaving the incident management teams and their commanders in a state of inaction or undesired, since unauthorized, commitment. In part this was due to policy group members not participating in the exercise, which presented a missed opportunity for testing response procedures at a very critical junction. At State level, though, a Unified Command Group (UCG) was formed, which consisted of State, Federal, and military members, as well as a policy group of State Executives, which provided overall response directions and objectives. However, one needs to remember that the West Coast states are so-called home-rule jurisdictions, in which local authorities have the final say and cannot be overruled in their decision making by higher levels of government. Policy coordination, hence, requires some negotiation, although State and Federal agencies exert certain leverage over lower-level jurisdictions via resource allocation. Furthermore, the communication between the State EOC and the State Disaster Manager, on the one hand, and counties and major municipalities, on the other hand was seriously degraded, which led to an overall lack of policy coordination between the various levels of

government. As a result, various missions were found in direct conflict with each other, and significant tensions and interpersonal communication problems were observed between responder units and individuals at and between different levels of government.

Comparison of the two Responses. When taken findings from the aforementioned reports on the 2014 real landslide incident [31, 37, 39], it is obvious that the inner- and inter-jurisdictional coordination challenges, the LNO-related challenges, and the challenges regarding missing guidance from policy groups were similar in both cases, although they were far more serious during the simulation. With regard to physical obstacles, they were of significantly lesser degree in the real incident than in the simulated one. Although communication lines and cell towers were impacted by the landslide and were down for some days, electrical power was widely available, communications were reestablished quickly, and the site of impact was accessible on the ground from the East and the West as well as from the air. One of the characteristics of the early response to the 2014 incident was that the extent of the incident was initially greatly underestimated. After all, the Pacific Northwest is "landslide" country, and landslides abound every year. It took responders familiar with the "landslide" metaphor a significant amount of time to detect their own misconception and realize that the landslide at hand was an extraordinary one in terms of magnitude and extent of devastation. However, while electrical power and communications were available, the coordination of response efforts was relatively slow until the real extent of the incident was understood after some four to five days. In contrast, the CR16 exercise provided physical obstacles, which participants in terms of the assumable complete blackout were either outright ignored or greatly downplayed. Except for a couple of hours in some jurisdictions, electrical power and connectivity was assumed abundantly available, and operations continued as usual with no disruption as in daily routines, which made the exercise unrealistic from a fundamental perspective. However, both the real incident and the simulated one underscored the vulnerability and almost total dependency of response operations on modern energy and communication infrastructures. In terms of access to the site of impact and the respective multi-jurisdictional coordination problems the 2014 incident gave a sobering handsel of what to expect in a M9+ CSZ rupture incident. As one response unit leader put it,

> "I have heard in the exercise demands and witnessed this being said, 'Well, the major road arterials in the impacted area have to be open within three days.' Then I'm going, 'How long did it take us to open just one lane on the State Route 530 slide? Let alone two lanes?' That was one slide. That was only a mile and a half. One slide. It took months. And in a catastrophic incident, we are talking that times a thousand. So, we have to get real with our planning assumptions. Otherwise we are just kidding ourselves." (quote #06)

Summary of Findings (ad RQ#1). It appears that in terms of inner- and interjurisdictional coordination challenges the 2014 landslide incident provided a micromodel of what would be experienced on a far larger scope, scale, and longer duration in a M9+ CSZ rupture incident. What did not coordinate well in the 2014 incident response, would not coordinate well in the catastrophic incident response. Moreover, what worked reasonably well after some time in terms of coordination in the real incident response might take far longer to work as well in the response to a catastrophe.

4.2 Ad RQ #2 (*How do other managerial challenges change or stay the same when responding to a catastrophic incident (as opposed to a non-catastrophic emergency response)?)*

Staffing. Without exception all responder groups reported of serious actual or anticipated staffing problems after the real incident had occurred. During the exercise, quite a number of responders did not report to duty, and some carried out their task assignments in a daily-routine type of mode, or they were still occupied by their regular daily tasks during the exercise. However, in the real incident response, understaffing has to be expected as the norm, be it for reasons of victimization of staffers themselves, or physical obstacles in the path to the respective deployment site, or conflicts of interest between family care and reporting to duty, or, a combination of the aforementioned along with other contingencies. As a unit leader projected,

> "At best, we can assume that we are going to have a recall rate of 50% of our staff. At best. I'm saying, we're still optimistic if we get 50%. Because people want, the survival instinct come first and caring for your family and loved ones, and then reporting to duty. So that's going to be a big challenge on top of everything." (quote #07)

With understaffing experienced during the exercise and to be expected in the real response, essential expertise was and will be missing. Also, work hours were and would be extended, and the workload increased drastically leading to fatigue, wear-down, and mistakes, all of which limited the reasonable time of deployment or assignment. In some jurisdictions the loss of staff expertise was addressed by rotating staff through various positions so that backups became available, and expertise was hoped to be spread. However, the obvious and experienced downside of this approach was that expert knowledge was missing in a number of cases, when it was most needed, but unfortunately the expert had been deployed elsewhere. Among other staffing-related challenges were the reliance on volunteers who could disengage at any moment, trauma and stress handling for responders at shift end, as well as sheltering responders whose return to their own homes was impossible due to physical obstacles.

Planning. Many response units simply did not know about pre-existing plans, which could have been used in the response at least in part, and so they rather developed new and redundant plans from scratch under the duress of the simulated incident. However, while existing plans provide a starting point, they were generally not developed for coping with an incident of the M9+ CSZ order, nor were many of these plans up to date. In general, mass fatality plans, mass care and sheltering plans, and mass evacuation plans as well as fuel and fuel distribution plans were missing. Also, many continuity-of-operations plans (COOPs) were found out of date or unsupported.

As mentioned before, plans were frequently not shared outside their own unit, and consequently they were not integrated with those of other response units inside their own jurisdiction nor with outside jurisdictions, nor were planning cycles synchronized among and between jurisdictions. Planning in some jurisdictions lacked even basic elements such as maintaining updated organizational charts, up-to-date contact information, current vendor lists, and lists of information access points.

Planning for paper-based response efforts was absent in most, if not all, jurisdictions. This deficit could have been found particularly disruptive during the exercise; however, as mentioned before, the total loss of power and of connectivity was greatly ignored for most portions of the exercise, which illustrates the need for way more realistic planning assumptions, also with regard to future exercises regarding a M9+ CSZ incident.

The CR16 exercise also revealed the lack of planning for currently mostly unprepared families and non-resilient communities, which would be badly affected by the thousands in the real incident. Due to this lack of preparedness a humanitarian crisis of proportions has to be anticipated, in which life-saving activities have to be given priority over fatality management.

In smaller incidents, before resources are committed and action is taken, a thorough assessment of the situation is performed. However, the tumultuous situation resulting from a M9+ CSZ incident may not allow for upholding this resource commitment paradigm calling for due and diligent upfront scrutiny and assessment of the situation. Yet, for reasons outlined above, local responders may simply not be in a position to perform the necessary assessments quickly enough. Responders from upper-level governmental agencies would therefore need to know about priorities, needs, and expectations of local jurisdictions, which could be communicated via sharing of local comprehensive emergency management plans, which could then be better reflected in higher-level response planning. While these plan synchronization and integration efforts are not only necessary, but rather indispensable, since they will provide a far better starting point in the real response, one State planner's sobering remark regarding the readiness for coping with an M9+ CSZ incident provides a chilling, but rather realistic perspective,

> "In the context of a catastrophic incident--I am removing 'ready' out of my vocabulary. It doesn't exist. We continue to prepare but all we're doing is we are mitigating the impact. We are lessening the impact. And we're hoping to be in a more advantageous position to respond and recover. That's all. So that we have to admit. Then we have to admit that the greatest good for the greatest number does not include everybody. And that is a bitter pill to swallow, but we have to admit that as well." (quote #08)

Resource Management. While resource management, and, in particular, resource request management, based on ICS structures and procedures appeared to have worked reasonably well between the State and FEMA, the same cannot be claimed for County and local jurisdictions. Despite the State's efforts to standardize the resource request forms and procedures after the 2014 landslide incident, for many jurisdictions the resource request and routing procedures were still unclear, and the same resources were requested multiple times for the lack of effective resource request tracking capabilities or for the lack of request acknowledgement and timely feedback from the target agency. Many resource requests were filled incompletely or incorrectly. Frequently, requests were not prioritized. Before requesting resources from elsewhere, jurisdictions were chartered with tracking their own resources first. However, many jurisdictions lacked tracking systems for their own resources. As in the 2014 landslide incident, some jurisdictions were also still unfamiliar with the FEMA resource reimbursement requirements. In many cases, it was also unclear who had the authority to approve resource requests. Bureaucratic hurdles slowed down speedy resource allocations, and verbal approvals by responders with the authority to approve such requests were not recognized by resource administrators. Lots of confusion and double work were the result.

During the CR16 exercise, Federal, military, and State responders implemented a push mechanism for the fast allocation of resources expected to be requested. As the Washington National Guard's AAR points out,

> "This 'push' concept does not comply with the principles of the NRF or NIMS and is foreign to most Emergency Managers and Incident Commanders. The traditional and universally accepted 'pull' methodology will cost lives in this scenario. A mindset shift is required in order to achieve the least time lost for life saving capabilities." (quote #09)

However, this led to further confusion about who at County and local levels had the authority to manage the staging, the assignment, and the re-directing of those pushed-down and unassigned resources, all of which took away part of the forward staging advantage and the potential shortening of resource allocation times. The push mechanism surfaced another problem, which was also observed in the 2014 landslide response, when responders at local and regional levels simply had no idea what to request in the absence of detail knowledge about advanced capabilities, in particular, maintained by the military and Federal agencies.

Comparison of the two Responses. In the 2014 landslide response, due to the limited area of impact and the mutual-aid agreements, staffing levels were high, although some responders had not worked in the assigned positions before. Furthermore, fatigue and wear-down was contained, and post-deployment trauma and stress was addressed via targeted treatment. Moreover, no responders were among the victims. However, in both cases, responders had to improvise and plan from scratch, since the extent of the respective incident in either case overwhelmed the responders initially. While in the landslide response except for the suboptimal fatality management the planning deficiencies were addressed quickly, in a M9+ CSZ incident the lack of integrated plans would be much more severely felt immediately and for some time thereafter. Resource management and resource request management was problematic, at least initially in the landslide response. In the catastrophic incident, resource management and resource request management would become a major issue. The practiced resource push mechanism designed for catastrophic incidents appears to require substantially more planning and pre-incident coordination between potentially involved jurisdictions in order to work effectively.

Summary of Findings (ad RQ#2). Like in the findings to RQ#01 (coordination and collaboration), so in staffing, planning, and resource management quite many observations made during the real landslide response were observed again during the CR16 exercise. However, in the real M9+ CSZ incident response, the shortcomings in staffing, planning, and resource management would immediately have far more negative and far graver consequences than in the landslide incident response of 2014.

5 Discussion, Recommendations, and Concluding Remarks

Manifold Obstacles to Coordination and Collaboration. In the above mentioned previous investigations on situational awareness and the common operating picture (SA/COP) during the CR16 exercise [40], or rather the lack thereof in the early stages of the response, as well as on the uses of information and communication technologies (ICTs) in support of SA/COP [39], it became evident that the coordination of response activities and the collaboration between and among response units was critically dependent on both. SA/COP, it was found, heavily relied on the availability of ICTs; however, ICTs, equally heavily depended on the availability of electrical power and high-bandwidth network connectivity in order to arrive at full SA/COP as early as possible, which would still be days, if not weeks, in the best case. However, as this study uncovers, beyond SA/COP and ICTs as backbones of coordination and collaboration, other important issues exist, which would make effective coordination and collaboration between and among response units difficult to achieve. The devastation of other critical infrastructures, first and foremost, transportation, would severely stifle coordinated responses. A major obstacle was also found in the lack of integrated plans and synchronized planning for this particular type of incident. Neighboring jurisdictions and next higher-level jurisdictions need to establish and update such plans and maintain in sync their planning efforts. Another major obstacle was identified in the absence of standardiza-

tion of structures, processes, procedures, and forms. Further, the policy decisions of hundreds of elected officials and appointed administrators in the affected region were identified in need of alignment, for which despite the NIMS/ICS concepts of Unified Command and Area Command currently no practical mechanisms exist.

Addressing Coordination Collaboration Obstacles. For this specific type of catastrophic incident and based on NIMS/ICS and NRF, it appears necessary for the likely M9+ CSZ incident impact areas in Alaska, Oregon, and Washington to develop and negotiate among governments of all levels a "*Regional Disaster Response Coordination Framework*." In the home-rule States of the Pacific Northwest such a framework cannot be imposed on jurisdictions, but rather it can only be jointly developed by all levels of government. It would need to define mechanisms for policy decision alignment between and among jurisdictions of the impact areas, plan integration, planning synchronization, and standardization of structures, processes, procedures, and forms, and the systematic and cross-jurisdictional use of liaisons. This undertaking would be in great need of a shared vision among jurisdictional partners, productive multiyear negotiations, and significant amounts of funding to successfully complete.

Need to Plan for and Practice Paper-based Operations. While the CR16 exercise did not focus on practicing paper-based operations, it made clear that in the real M9+ CSZ incident operations and response management would be paper-based and messenger-based for extended periods of time. The pace of response would be dependent on the pace of communications. A mainly paper-based and messenger-based response would inevitably be slow. In order to speed up the response, equipping responders with much faster and more effective means of communications than paper and messengers would be paramount. Since power and connectivity would be only gradually restored, but sometimes even lost again, or, would remain available in a very degraded way, a mechanism for scaling up and scaling down such constrained operations would be needed. Planning for, providing for, and testing such scalable paper/ICT-based operations might present some unique challenges.

Planning for Backup Trained and Expert Staff. The lack of required staffing and staff qualification levels was already felt during the exercise, albeit in part for other reasons. However, in the real M9+ CSZ incident, staff levels were predicted to go below the 50 percent threshold in response units for all kinds of reasons. Planning for staffing backups is therefore an absolute necessity. The need for backup staffing might be even greater when considering the effects of fatigue and wear-down.

Resource Management Paradigm Shift. As described, Federal, military, and State responders concluded that a M9+ CSZ incident would require a paradigm shift in response resource management from "pull" to "push," which would allocate unrequested resources in presumed areas of need based on models and other assumptions. State and Federal planners have to make assumptions, use simulation models, and incorporate damage forecasts for planning so that resources can be committed to affected areas as quickly as possible.

The resource "push" method, however, would be in conflict with both the NIMS/ICS response doctrine as well as with the principle of home rule in the Pacific Northwest as the State and FEMA AARs remark. NIMS/ICS and NRF sanction a resource "pull" mechanism, which preserves the authority of resource requesting to the local authorities. As observed during the exercise, the implementation of a resource "push" regime is not without very practical problems. At the receiving end the pushing of resources led to confusion about responsibilities and accountability, and to questions about allocation authorities, along with quite a number of other problems. In practice, alignments in the command and decision structures would be required to make the resource "push" paradigm effective and

legal from a governance standpoint. While the potential advantages of a "push" regime are undeniable, at least for the early phases of the response, the proposed "*Regional Disaster Response Coordination Framework*" appears to be the context, in which such temporary changes of command and decision structure and incident-specific changes of doctrine principle would have to find their negotiated place.

Extended Training/Re-training and Funding Needs. From this investigation it follows that improved levels of preparedness for the response to a M9+ CSZ incident can only be expected if the frequency of exercises is increased. Also, the types of exercises need adjustments, for example, functional exercises in scaling between paper-based and ICT-based operations. This needs to be accompanied by increased and intensified training efforts with regard to NIMS/ICS as well as the integrated plans in a to-be-developed incident-specific regional framework. It remains to be seen whether or not the tremendous amounts of funding, which these proposed efforts require for planning and ongoing training, can be made available. In any case, since responder units in the area are undergoing a massive staff turnover through retirement, additional training and exercises will be needed.

Exercise Specifics. Every response exercise has certain artificialities, which underrepresent certain aspects of the real incident response. However, despite those artificialities, a fundamental and sobering insight from the CR16 exercise for responders was, for example, in the State of Washington, that current Statewide planning and preparedness levels were appropriate only for responding to non-catastrophic incidents and not for a M9+ CSZ incident response. Consequently, another large exercise is under planning to be conducted in 2022, this time also involving the State of Alaska.

Based on this research it is strongly recommended to integrate plans, synchronize planning, and test non-ICT-based operations prior to this exercise. It might also be desirable to have an impact area-wide schedule of smaller functional exercises after the 2022 exercise as part of a larger framework. In the 2022 exercise, it would be critical to have policy and decision makers more actively and practically involved than during CR16.

Conclusion and Outlook. It has been the object of this study to identify obstacles to coordination and collaboration of efforts in the response to a catastrophic incident and to provide recommendations for mitigating these obstacles. In so doing, the study contributes to both the academic understanding of the complexities of managing a catastrophic incident response and to the practical understanding of measures and choices available to response planners. Future investigations will follow up with assessing and evaluating the practical measures taken and the choices made by responders.

5.1 Acknowledgement

The following research assistants participated in the transcribing, coding, concept analyzing and mapping of the interviews: Ammi Bui, Hyung Jin Byoun, Sarah L. Carnes, Nuo Chen, Tiffany Chiu, Sukhman Dhillon, Sumedha Dubey, Ryan Dzakovic, Andy Herman, Yun Hsiao, Karyn Hubbell, Harsh Keswani, Manjiri Khakar, Priyanka Kshirsagar, Janani Kumar, Kung Jin Lee, Jeff Leonard, Chang Jay Liu, Christy (Hsin-yu) Lu, Ying Lu, Rachel Mahre, Grace Morris, Veslava Ovendale, Xiaoyu Qu, Jason Repko, Ed Slininger, Emily K. Smalligan, Sonal Srivastava, Rebecca Ta, Huong Thanh Thai, Xiaobin Tuo, Fan Yang, Qiaosi Wang, and several graduate assistants from Graduate Assistant Team. Special thanks to Sue Morgan who organized and orchestrated the online streaming and video recording of the weekly project sessions.

6 References

1. National Incident Management System. In: Security, H. (ed.), pp. x/156. FEMA, Washington, DC (2008)
2. National Response Framework. In: Security, H. (ed.), pp. iv/48. FEMA, Washington, DC (2013)
3. Abbasi, A., Kapucu, N.: Structural dynamics of organizations during the evolution of interorganizational networks in disaster response. Journal of Homeland Security and Emergency Management 9, 1-19 (2012)
4. Atwater, B.F., Nelson, A.R., Clague, J.J., Carver, G.A., Yamaguchi, D.K., Bobrowsky, P.T., Bourgeois, J., Darienzo, M.E., Grant, W.C., Hemphill-Haley, E.: Summary of coastal geologic evidence for past great earthquakes at the Cascadia subduction zone. Earthquake spectra 11, 1-18 (1995)
5. Bharosa, N., Lee, J., Janssen, M.: Challenges and obstacles in sharing and coordinating information during multi-agency disaster response: Propositions from field exercises. Information Systems Frontiers 12, 49-65 (2010)
6. Buck, D.A., Trainor, J.E., Aguirre, B.E.: A critical evaluation of the incident command system and NIMS. Journal of Homeland Security and Emergency Management 3, 1-27 (2006)
7. Chen, R., Sharman, R., Rao, H.R., Upadhyaya, S.J., Cook-Cottone, C.P.: Coordination of emergency response: An examination of the roles of people, process, and information technology. In: Van De Walle, B., Turoff, M., Hiltz, S.R. (eds.) Information Systems for Emergency Management, vol. 16, pp. 150-174. Routledge, New York, NY (2014)
8. Clarke, P.K., Campbell, L.: Coordination in theory, coordination in practice: the case of the Clusters. Disasters 42, 655-673 (2018)
9. Cole, D.: The incident command system: A 25-year evaluation by California practitioners. National Fire Academy (2000)
10. Comfort, L.K.: Crisis management in hindsight: Cognition, communication, coordination, and control. Public Administration Review 67, 189-197 (2007)
11. Davis, G.L., Robbin, A.: Network disaster response effectiveness: the case of ICTs and Hurricane Katrina. Journal of Homeland Security and Emergency Management 12, 437-467 (2015)
12. Dawes, S.S., Birkland, T., Tayi, G.K., Schneider, C.A.: Information,Technology, and Coordination: Lessons from the World Trade Center Response. Center for Technology in Government (CTG), SUNY Albany (2004)
13. DeCapua, M.: Letter to the Editor Regarding Incident Command System (ICS). Journal of Homeland Security and Emergency Management 4, 1 (2007)
14. Drabek, T.E., McEntire, D.A.: Emergent phenomena and multiorganizational coordination in disasters: Lessons from the research literature. International Journal of Mass Emergencies and Disasters 20, 197-224 (2002)
15. Dynes, R.R., Aguirre, B.E.: Organizational adaptation to crises: Mechanisms of coordination and structural change. Disasters 3, 71-74 (1979)
16. Earle, C.R.: C2 Agility for Emergency Management: Examining the Katrina and Sandy Responses. Journal of Homeland Security and Emergency Management 15, (2018)
17. Fereday, J., Muir-Cochrane, E.: Demonstrating Rigor Using Thematic Analysis: A Hybrid Approach of Inductive and Deductive Coding and Theme Development. International journal of qualitative methods 5, (2006)

18. Fischer, H.W.: The Sociology of Disaster: Definitions, Research Questions, & Measurements Continuation of the Discussion in a Post-September 11 Environment. International Journal of Mass Emergencies and Disasters 21, 91-107 (2003)
19. Glaser, B.G.: The Future of Grounded Theory. Qualitative Health Research 9, 836-845 (1999)
20. Glaser, B.G., Strauss, A.L.: The discovery of grounded theory; strategies for qualitative research. Aldine Pub. Co., Chicago, (1967)
21. Groenendaal, J., Helsloot, I., Scholtens, A.: A critical examination of the assumptions regarding centralized coordination in large-scale emergency situations. Journal of Homeland Security and Emergency Management 10, 113-135 (2013)
22. Guo, X., Kapucu, N.: Examining coordination in disaster response using simulation methods. Journal of Homeland Security and Emergency Management 12, 891-914 (2015)
23. Seismological Society of America, https://www.seismosoc.org/annual-meeting/how-often-do-cascadias-megaquakes-occur/
24. Hambridge, N.B., Howitt, A.M., Giles, D.W.: Coordination in Crises: Implementation of the National Incident Management System by Surface Transportation Agencies. Homeland Security Affairs 13, 1-30 (2017)
25. Hansen, R.R.: Letter to the editor regarding Incident Command System (ICS). Journal of Homeland Security and Emergency Management 3, 1-3 (2007)
26. Iverson, R.M., George, D.L., Allstadt, K., Reid, M.E., Collins, B.D., Vallance, J.W., Schilling, S.P., Godt, J.W., Cannon, C.M., Magirl, C.S., Baum, R.L., Coe, J.A., Schulz, W.H., Bower, J.B.: Landslide mobility and hazards: implications of the 2014 Oso disaster. Earth and Planetary Science Letters 412, 197-208 (2015)
27. Jensen, J.: The current NIMS implementation behavior of United States counties. Journal of homeland security and emergency management 8, 1-25 (2011)
28. Jensen, J., Waugh, W.L.: The United States' Experience with the Incident Command System: What We Think We Know and What We Need to Know More About. Journal of Contingencies and Crisis Management 22, 5-17 (2014)
29. Jensen, J., Youngs, G.: Explaining implementation behaviour of the national incident management system (NIMS). Disasters 39, 362-388 (2015)
30. Kapucu, N.: Interorganizational coordination in complex environments of disasters: The evolution of intergovernmental disaster response systems. Journal of Homeland Security and Emergency Management 6, (2009)
31. Lombardo, K., Boggs, J., Boudreau, J., Chiles, P., Erickson, J., Gerstel, W., Montgomery, D., Shipman, L., Radcliff-Sinclair, R., Strachan, S., Sugimura, D., Trimm, B.: SR 530 Landslide Commission Final Report. In: Commission, S.L. (ed.), pp. v/49. SR 530 Landslide Commission, Olympia, WA (2014)
32. Neal, D.M., Phillips, B.D.: Effective emergency management: Reconsidering the bureaucratic approach. Disasters 19, 327-337 (1995)
33. Paci-Green, R., Boles, N., Black, T., Smith, K., Munkh-Erdene, E.: Cascadia Rising: Cascadia Subduction Zone (CSZ) Catastrophic Earthquake and Tsunami (Exercise Scenario Document). (2015)
34. Quarantelli, E.L.: Disaster crisis management - a summary of research findings. Journal of Management Studies 25, 373-385 (1988)
35. Ritchie, J., Lewis, J., Gillian, E.: Designing and selecting samples. In: Ritchie, J., Lewis, J. (eds.) Qualitative research practice : a guide for social

science students and researchers, pp. 77-108. Sage Publications, London ; Thousand Oaks, Calif. (2003)

36. Scholl, H.J., Ballard, S., Carnes, S., Herman, A., Parker, N.: Informational Challenges in Early Disaster Response: The Massive Oso/SR530 Landslide 2014 as Case in Point. In: Sprague, R., Bui, T. (eds.) 50th Hawaii International Conference on System Sciences (HICSS-50), pp. 2498-2508. ScholarSpace, Waikoloa, Hawaii (2017)
37. Scholl, H.J., Carnes, S.L.: Managerial challenges in early disaster response: The case of the 2014 Oso/SR530 landslide disaster. ISCRAM, pp. 961-972. Proceedings of the 14th ISCRAM conference, Albi, France (2017)
38. Scholl, H.J., Chatfield, A.T.: The Role of Resilient Information Infrastructures: The Case of Radio Fukushima during and after the 2011 Eastern Japan Catastrophe. International Journal of Public Administration in the Digital Age (IJPADA) 1, 1-24 (2014)
39. Scholl, H.J., Hubbel, K., Leonard, J.: Communications and Technology Challenges to Situational Awareness: Insights from the CR16 Exercise. Proceedings of the 1st ISCRAM Asia-Pacific Conference, pp. 1-15. ISCRAM, Wellington, NZ (2018)
40. Scholl, H.J., Hubbell, K., Leonard, J.G.: Information Sharing and Situational Awareness: Insights from the Cascadia Rising Exercise of June 2016. Proceedings of the 52nd Hawaii International Conference on System Sciences (HICSS-52), pp. 1-11, Maui, HI (2019)
41. Scholl, H.J., Patin, B.J.: Resilient Information Infrastructures: Criticality and Role in Responding to Catastrophic Incidents. Transforming Government: People, Process and Policy 8, 28-48 (2014)
42. Stambler, K.S., Barbera, J.A.: Engineering the incident command and multiagency coordination systems. Journal of Homeland Security and Emergency Management 8, 1-27 (2011)
43. Strauss, A.L., Corbin, J.M.: Basics of qualitative research : techniques and procedures for developing grounded theory. Sage Publications, Thousand Oaks (1998)
44. Tsai, J.-S., Chi, C.S.F.: Cultural influence on the implementation of incident command system for emergency management of natural disasters. Journal of Homeland Security and Emergency Management 9, 1-22 (2012)
45. Urquhart, C., Lehmann, H., Myers, M.D.: Putting the 'theory' back into grounded theory: guidelines for grounded theory studies in information systems. Information Systems 20, 357–381 (2010)
46. Van De Walle, B., Turoff, M., Hiltz, S.R.: Coordination of Emergency Response: An Examination of the Roles of People, Process, and Information Technology. Information Systems for Emergency Management, pp. 162-186. Routledge (2014)
47. Waugh, W.L.: Mechanisms for collaboration in emergency management: ICS, NIMS, and the problem with command and control. In: O'Leary, R., Bingham, L.B. (eds.) The collaborative public manager: new ideas for the twenty-first century, pp. 157-175. Georgetown University Press (2009)
48. Wenger, D., Quarantelli, E.L., Dynes, R.R.: Is the Incident Command System a Plan for all Seasons and Emergency Situations? Hazard Monthly 10, 8-12 (1990)
49. West, D.O., McCrumb, D.R.: Coastline uplift in Oregon and Washington and the nature of Cascadia subduction-zone tectonics. Geology 16, 169-172 (1988)