COMMUNICATIONS AND TECHNOLOGY CHALLENGES TO SITUATIONAL AWARENESS:

INSIGHTS FROM THE CR16 EXERCISE

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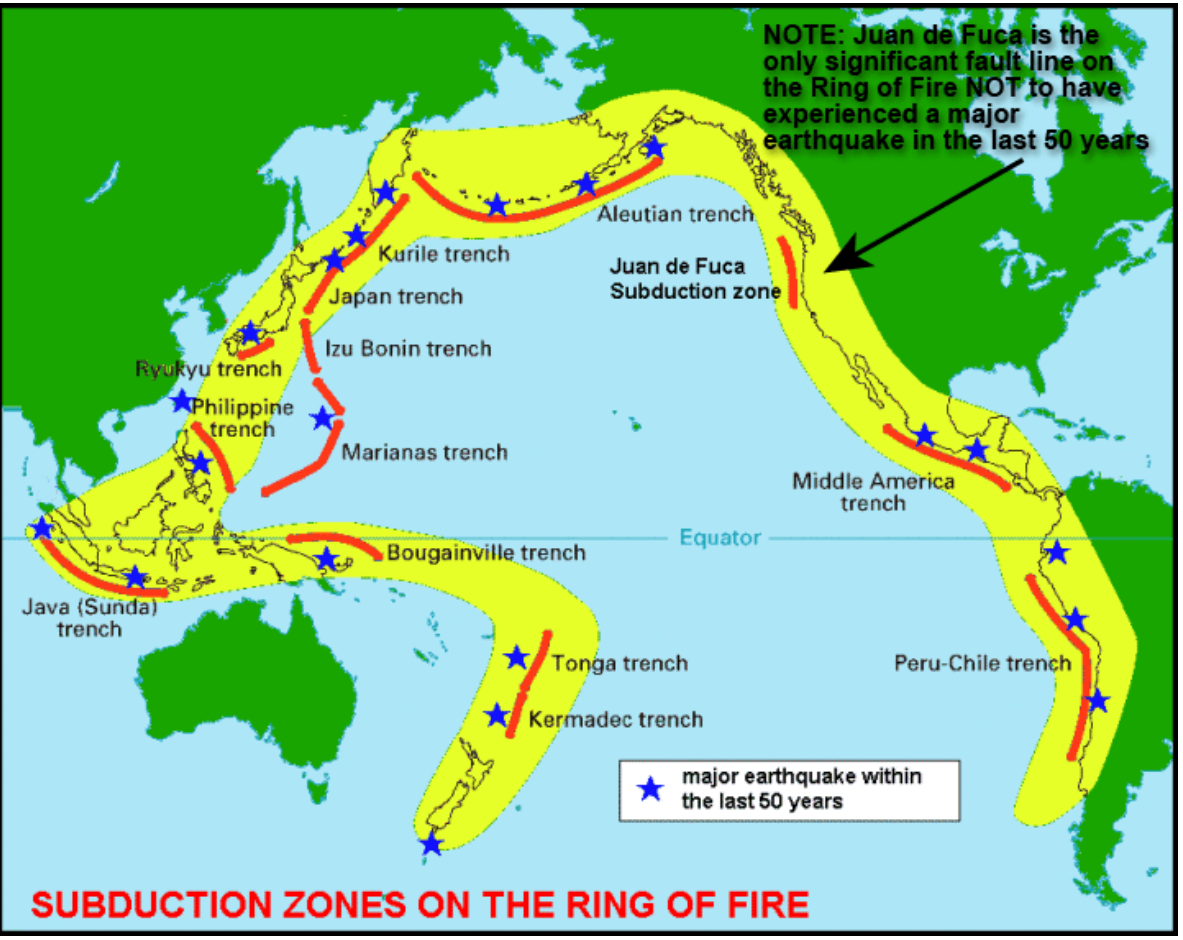
WHAT I AM GOING TO TALK ABOUT

- The Cascadia Rising 2016 Exercise
- Research Interest
- Literature
- Research Questions
- Methodology
- Findings
- Discussion
- Conclusions and Future Research
- Questions and Comments

THE CASCADIA RISING 2016 EXERCISE (1)

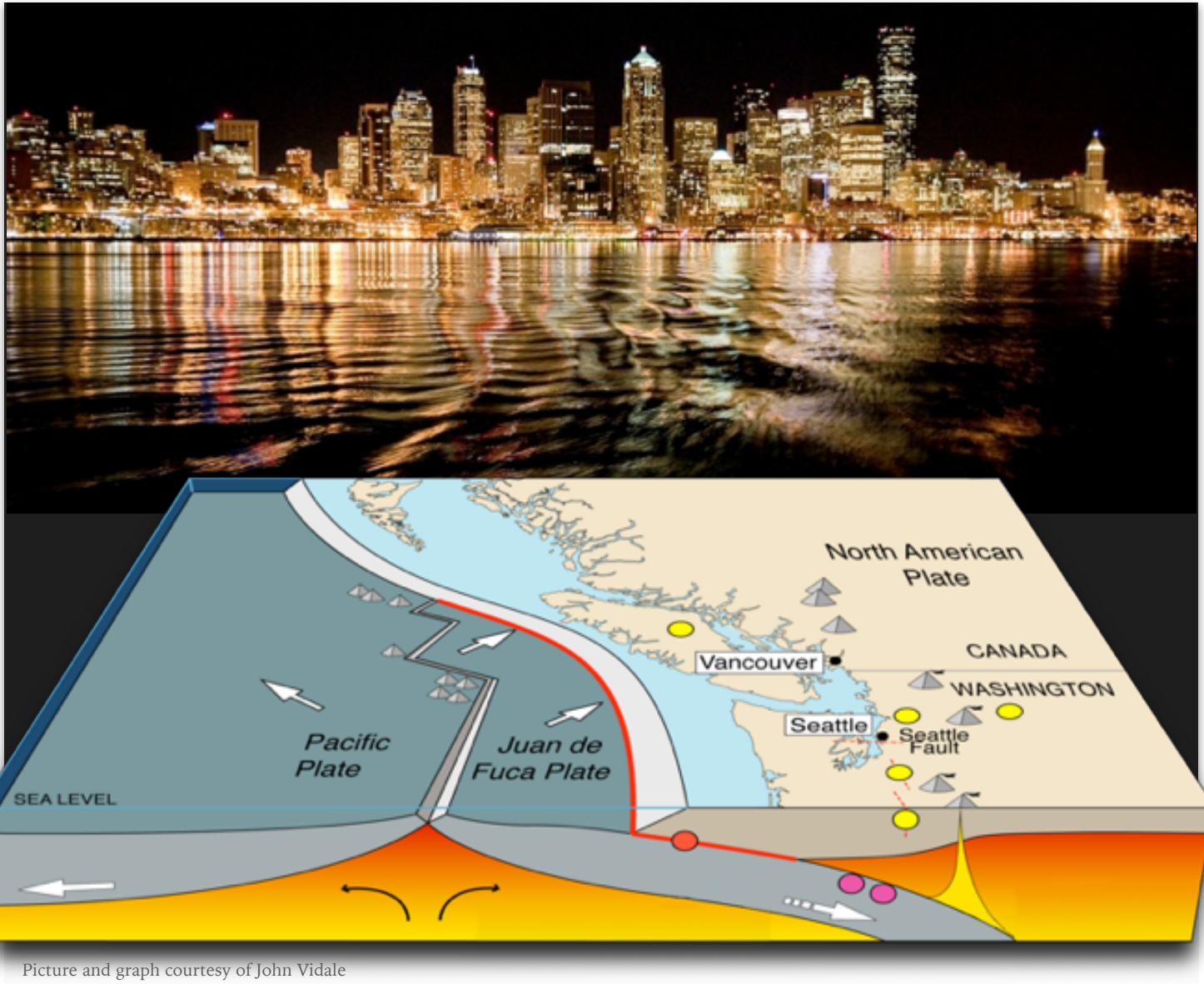
The Threat



Slide content courtesy of Lt.Col. Braun, WA National Guard and Wikipedia

- Ring of Fire
  - Accounts for 90% of all earthquakes, and 81% of the world's largest earthquakes
  - All but three of the world's 25 largest volcanic eruptions of the last 11,700 years occurred at volcanoes in the Ring of Fire.
  - Subduction zones are shown in red
  - The CSZ fault line is part of the Ring of Fire
- The CSZ is the only significant fault line on the Ring of Fire without a major quake in the last 50 years (see blue stars)

THE CASCADIA RISING 2016 EXERCISE (2)



Picture and graph courtesy of John Vidale

Exercise Details

- Conducted between June 7 and 10, 2016 (military: between June 7 and14, 2016) after two years of preparation
- Involved 23,000 participants across local, state, federal, tribal, Department of Defense, and non-governmental entities in Oregon, Washington, and Idaho with British Columbia associated
- One of the largest exercises ever conducted in the US; the largest multi-state exercise in the Pacific Northwest so far
- ***Objective***: Through disaster simulation, the purpose of this exercise was to test and validate catastrophic CSZ plans; the ability of Emergency Operations Centers (EOCs), throughout the whole community, to coordinate and communicate priorities and objectives; to share situational information; and to request, order, and transport life-saving resources to the areas most heavily impacted
- Scenario similar to the devastating March 2011 Tōhoku earthquake and tsunami in Japan

THE CASCADIA RISING 2016 EXERCISE (3)

***Figure 1** Cascadia Rising 2016 Exercise – M9.0+ Megathrust Impact Assumptions (Paci-Green et. al, 2015, p. 14)*

Impact Area

- West of and including the Interstate-5 corridor
- Zipper-like rupture from one end of the subduction line to the other is expected to occur along the 800-mile-long subduction line
- Thirty to forty-foot high tsunami would reach the coastline about 20 to 30 minutes after the rupture
- Several aftershocks of significant magnitude would be expected to follow the initial rupture inflicting more damage
- Impact on human lives and infrastructure would be the greater the closer the location to the coastline
- Impacted areas West of the Cascadian Mountain range would be inaccessible by ground transport or sea transport for extended periods of time
- Relief would first come predominantly by air transport
- Responders would find themselves stripped from using most modern information and communication technologies for the lack of power and intact communication infrastructures

RESEARCH INTEREST

- First responders' biggest challenges in early response are
  - the lack of ***situational awareness (SA)*** and/or ***shared situational awareness (SSA)***, which leads to an incomplete and distorted ***common operating picture (COP)***
  - Information and communication technologies (ICTs) are not always ***part of the solution*** but rather ***part of the problem***
- In this study we focus on the latter, that is, communication challenges, information technology challenges, information sharing challenges, for example, with systems such as WebEOC and radio technologies

LITERATURE (ON SITUATIONAL AWARENESS)

- Situational Awareness (SA) and Shared SA (SSA)
  - Endsley presented a comprehensive SA framework, in which she distinguished
    - (1) perception
    - (2) comprehension, and
    - (3) projection

    as three intertwined levels of SA (Endsley, 1995)
  - The notion of and discussion about SA/SSA was informed and influenced by advances in other disciplines and not developed in Disaster Sciences
  - Research needs to address in more detail, which level of SSA is investigated, and how the three levels of SSA transition from one another (including feedback)

LITERATURE (ON ICTS IN DISASTER MANAGEMENT)

- Information Systems in Disaster Response
  - ICTs have been playing increasingly important roles in disaster response management
  - New vulnerabilities, complications, and dependencies were also introduced (Quarantelli, 1997)
  - Turoff, et al., 2004 analyzed requirements and design principles for so-called crisis information management systems (CMIS), or what they called "dynamic emergency response management information system," or short, ***DERMIS***
  - Requirements include extreme ease of learning, usability by trained responders, conciseness, customizability to responders' specific needs, support for all EOC/IMT functions, independence from a particular physical location, and support for structured communication processes

RESEARCH QUESTIONS

- Research Question #1 (RQ#1):
  - What are specific SA/SSA-related ***communications challenges*** to professional disaster responders on all levels in the early stages of response to a (simulated) catastrophe?
- Research Question #2 (RQ#2):
  - What are specific SA/SSA-related ***information and communication technology (ICT) challenges*** to professional disaster responders on all levels in the early stages of response to a (simulated) catastrophe?

METHODOLOGY

- ***Overall Design***: An exploratory study design was chosen based on the theoretical framework of "Resilient Information Infrastructures (RIIs)" in disaster response (Scholl & Palin, 2014)
- ***Instrument* and *Coding Scheme***: Six topical areas were covered, (1) management and organization, (2) technology, (3) information, (4) information infrastructure, (5) Resilient information Infrastructures (RIIs)/resiliency. A total of twenty-five interview questions and probes were incorporated
- ***Sample***: The purposive sample included responders from eight different groups: (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. A total of 17 individuals were interviewed. Furthermore, after-action reports (AARs) from twenty-three agencies from all eight responder groups were collected and analyzed
- ***Data Collection***: Interviews were conducted in person between September 2016 and March 2017 and lasted between 33 to 107 minutes
- ***Data Analysis and Coding***: The initial codebook, which was based on the aforementioned conceptual RII framework, contained five category codes (one for each topical area) and 111 sub-category codes. Additional codes were inductively introduced during data collection, in individual coding sessions, and inter-coder sessions

TOP-30 CODES AND SUB-CODES

Table 1

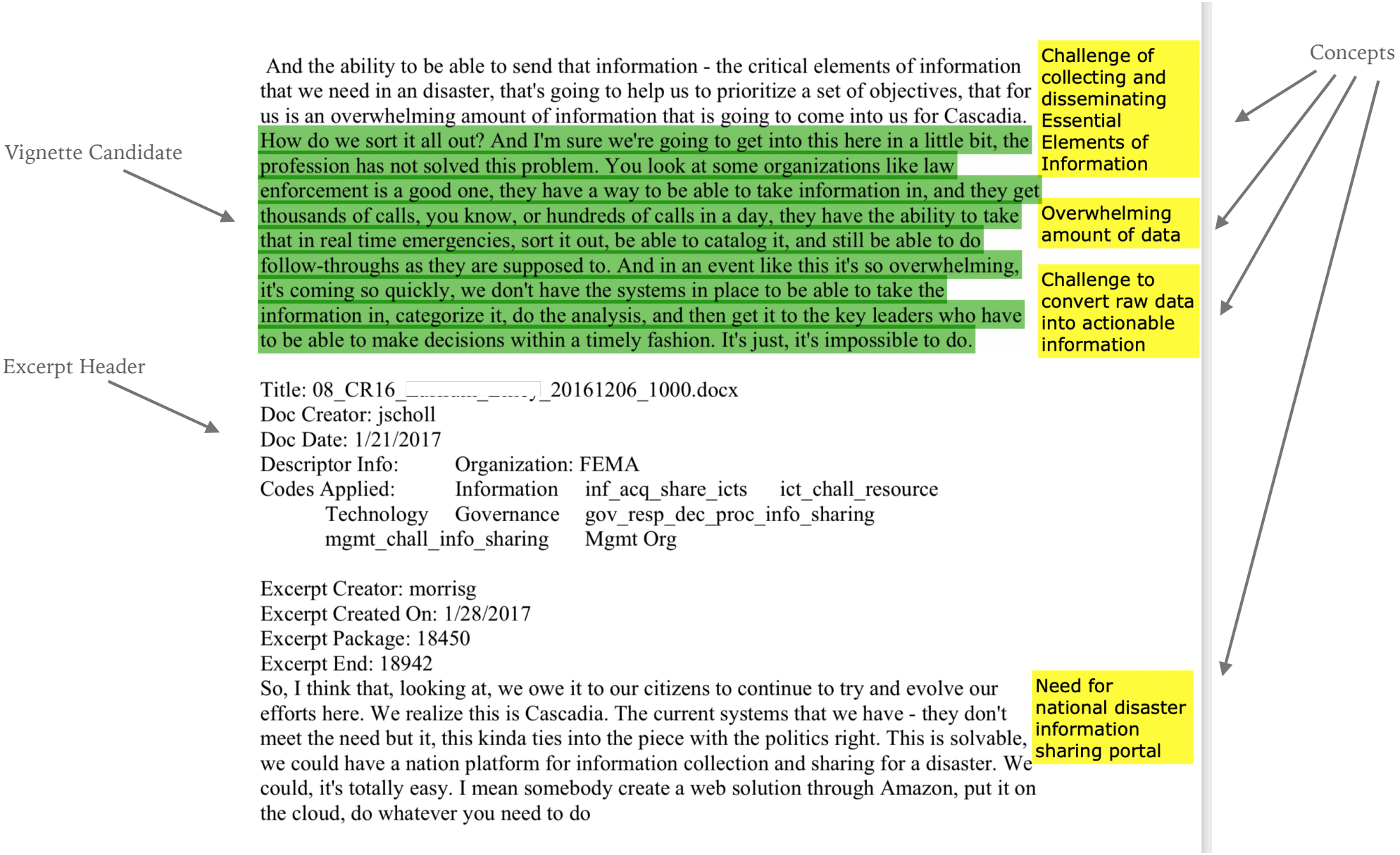
#	Code (grey) / Sub-code	Totals
1	Mgmt Org	9973
2	Information	8074
3	inf_situational_awareness	5311
4	Technology	5216
5	mgmt_chall_info_sharing	4449
6	Information Infrastructure	4088
7	mgmt_chall_resource	3827
8	Resilient IIs	3738
9	ict_use_info_sharing	3325
10	Governance	3156
11	mgmt_chall_org	2972
12	inf_common_operat_pic	2943
13	mgmt_external_partnerships	2773
14	mgmt_structure	2576
15	mgmt_chall_partnerships	2548
16	mgmt_preparedness_incl_lack_thereof	2485
17	ict_chall_using_icts	2278
18	mgmt_operational_rules	2190
19	mgmt_chall_coordination	2014
20	mgmt_resources	1988
21	gov_resp_roles	1716
22	ict_use_in/for_sit_awareness	1662
23	inf_lack_access	1583
24	ict_use_support_collab	1563
25	ii_vulnerabilties	1561
26	mgmt_training_incl_lack_of_training	1548
27	inf_need_resources	1420
28	inf_quality	1392
29	mgmt_assign_roles	1358
30	ii_means_info_handling	1335

Two Papers on "Situational Awareness"

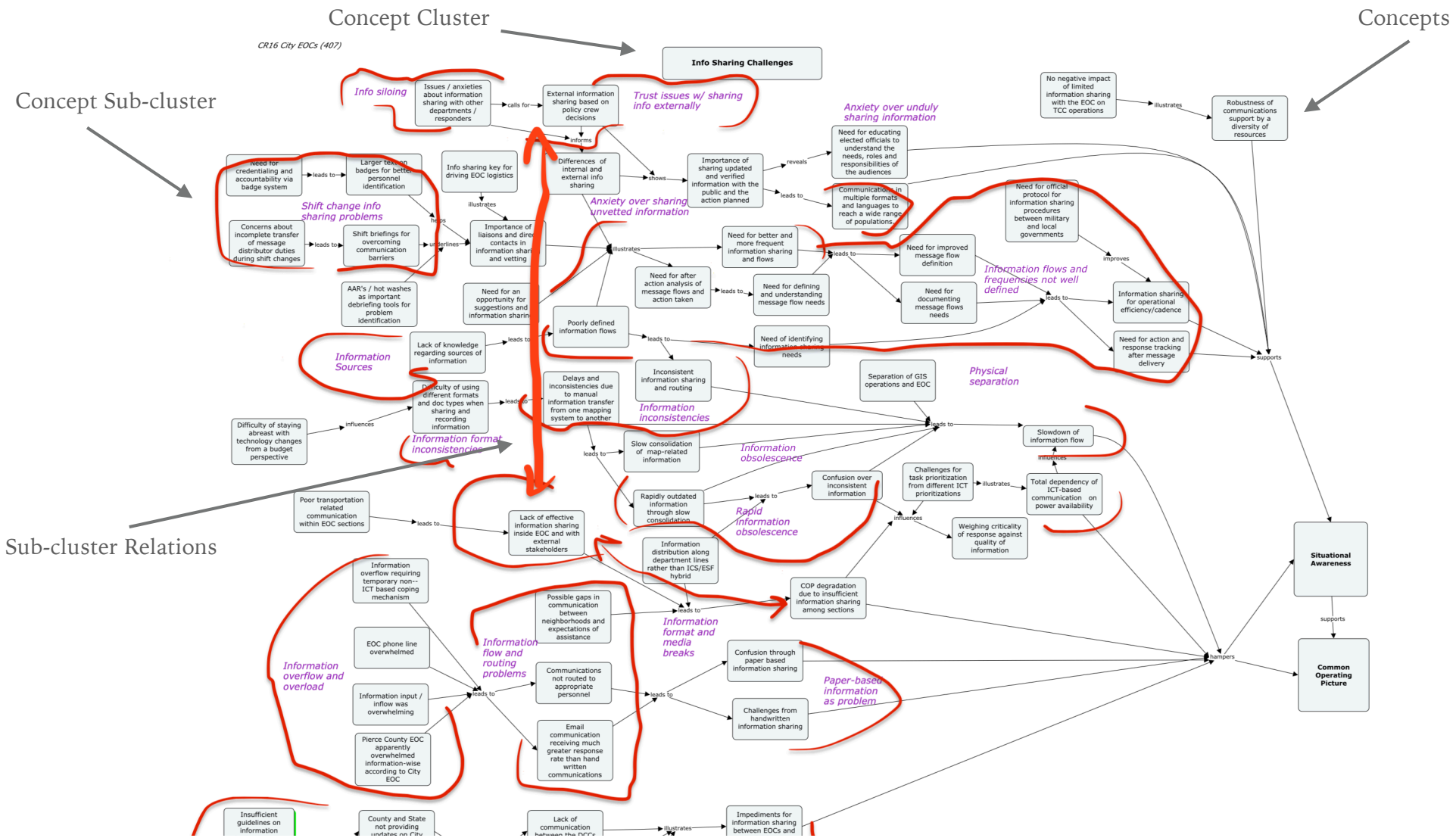
Forthcoming Paper on "Managerial Challenges"

CODE FREQUENCY DESCRIPTOR BUBBLE PLOT (DEDOOSE)

CONCEPT ANALYSIS



LOGICAL AND CHRONOLOGICAL MAPS OF CONCEPTS



FINDINGS (1)

Ad **RQ#1** *(What are specific SA/SSA-related communications challenges to professional disaster responders on all levels in the early stages of response to a (simulated) catastrophe?)*

- More than 50 percent of electric facilities are expected to undergo serious and irreparable damage, resulting in power outages for the entire Cascadia region for up to 12 months, or even longer.
- Even intact structures will most likely shut down due to capacity imbalances and overloads.
- One-to-many bottlenecks

FINDINGS (2)

Ad **RQ#1** *(What are specific SA/SSA-related communications challenges to professional disaster responders on all levels in the early stages of response to a (simulated) catastrophe?)*

- Deploying and embedding so-called liaison officers (LNOs) in each other's organizations as remedy for bottlenecks and barriers
- Need for pre-generated procedures, plans, forms, messages and ***paper redundancy***
- Initial in-area response management at all levels has to assume mainly paper-based and (slow) face-to-face and messenger-based communication mechanisms, which will last for a duration of days, if not, more likely, weeks
- As a result, situational awareness will initially be spotty, and a common operating picture will only emerge slowly leading to a harshly constrained response environment

FINDINGS (3)

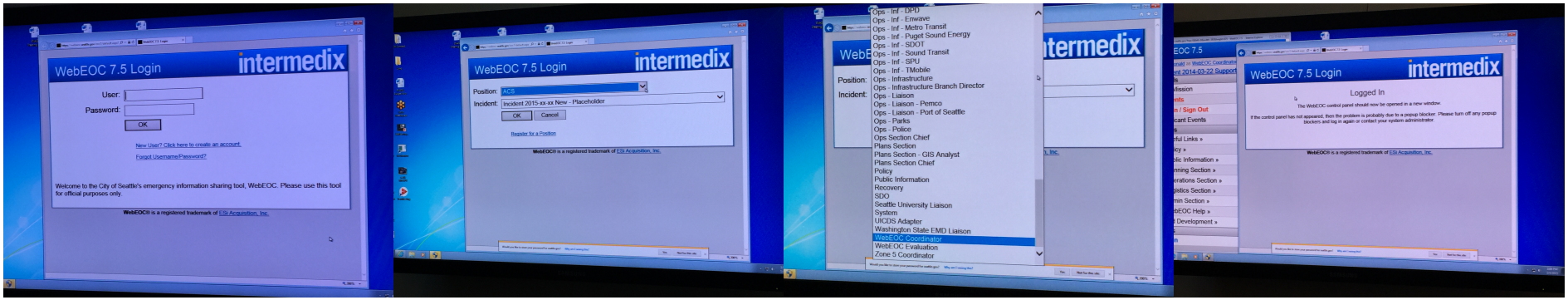
Ad **RQ#2** *(What are specific SA/SSA-related information and communication technology (ICT) challenges to professional disaster responders on all levels in the early stages of response to a (simulated) catastrophe?)*

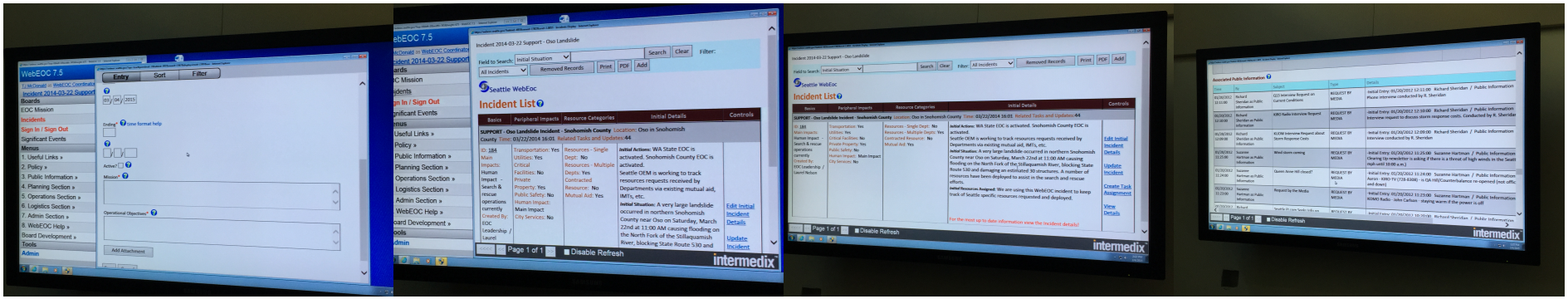
- Lack of standardization, information integration, compatibility, and interoperability
  - Various COTS (commercial-off-the shelf) systems
  - Various versions of WebEOC
  - Geographic Information Systems (such as ArcGIS) not or not well integrated
- Insufficient scalability of ICTs and insufficient bandwidth
- Lack of system functionality and difficult-to-navigate user interface or cumbersome logic of operation

FINDINGS (4)

Ad **RQ#2** *(What are specific SA/SSA-related information and communication technology (ICT) challenges to professional disaster responders on all levels in the early stages of response to a (simulated) catastrophe?)*

- WebEOC Screenshots (version 7.5)





FINDINGS (5)

Ad **RQ#2** *(What are specific SA/SSA-related information and communication technology (ICT) challenges to professional disaster responders on all levels in the early stages of response to a (simulated) catastrophe?)*

- WebEOC™ (Customizable COTS System of *Juvare* of Atlanta, GA)
  - Javascript-based browser operated; runs from local servers and/or in the Cloud; versions 7.3, 7.6, and 8.1 with an enhanced graphical user interface were in use; basically a logistics and event logging systems
  - Severe functional rigidities and limitations
    - Not self-explicatory nor intuitive to use in any way
    - Lack of integration of GIS metadata from the popular ArcGIS software
    - No sophisticated tracking or data manipulation methods like sorting certain data
    - Multiple boards such as “status update,” “significant events,” “task manager” among others along with user-generated ones
  - Interoperability Issues, Performance Issues, and Workarounds
    - State WebEOC system crashed under the load and appeared to have been unavailable for an extended period of time
    - Lack of readiness for large incidents
    - Workaround in providing each other direct access to their respective WebEOC systems

FINDINGS (5)

Ad **RQ#2** *(What are specific SA/SSA-related information and communication technology (ICT) challenges to professional disaster responders on all levels in the early stages of response to a (simulated) catastrophe?)*

- Radio Technologies
  - Lack of HF Radio Interoperability
    - Radio interoperability requires both frequency or equipment compatibility. Even when operating on the same frequencies, different agencies used incompatible radios, so that interoperability remained a major problem until both frequency/channel allocation and equipment compatibility via standardization have been secured
  - Limitations of Alternate and Auxiliary Communications
    - Bandwidth problems and equipment incompatibilities also hampered backup infrastructure of stationary HF backup stations and satellite phones
    - Amateur (or, HAM) radio used at municipal, county, State, and Federal levels as an auxiliary communication infrastructure
    - Lack of training on part of amateur HAM operators

DISCUSSION (1)

- Gaining/Maintaining SA/SSA Under Circumstances of Massively Degraded Radio and ICT Infrastructures
  - Expectable aftershocks will substantially add to the damage of these structures, which have already been compromised
  - Incident will rather dynamic in nature, while response capabilities, and, particularly, reconnaissance and intelligence capabilities will be massively degraded
  - Inaccessible "islands" for extended period time due to the collapse of hundreds of bridges and overpasses
  - Ingress and egress other than on foot or by airlift will be virtually impossible
  - Reaching the level of basic "perception" in SA/SSA would need weeks rather than days, and "comprehension," as the second level of SA/SSA, will take weeks, if not months
- No power, no or slow networks, limited local ICT-supported operations, if any,
  - Substantial efforts need to undertaken ex ante to prepare for this particular scenario in terms of still accessible hardcopy-based tools such as checklists, essential elements of information questionnaires, contact information, pre-scripted public messages, and the like
  - Information sharing will be slow
- ICT mirror infrastructures outside impact area as alternative
- Airlifting in and out batteries/generators/fuel but also ICT equipment and paper-based records

DISCUSSION (2)

- State of Currently Used Emergency ICTs in Light of the 2004 DERMIS Recommendations
  - ***Extreme ease of learning*** was seen as a foremost requirement: Unmet by any of the systems in use
  - ***Usability by trained responders***: Met in part by all investigated systems
  - ***Conciseness*** (relating to a user interface): None of the systems comes even close to matching up with this requirement
  - ***Customizability to responders' specific needs***: In part met by WebEOC; however, becoming very cumbersome when system is increasingly populated
  - ***Support for all EOC/IMT functions***: Mainly lacking––for example, major GIS-related information could not easily be integrated into a system like WebEOC
  - ***Independence from a particular physical location***: Met by WebEOC; however severe limitations in terms of scalability
  - ***Support for structured communication processes***: Can be met by a number of the systems studied———lack of standardization in forms and processes

CONCLUSION AND FUTURE RESEARCH

- The Cascadia Rising 2016 (CR16) Exercise has produced multiple inconvenient insights
  - Communication infrastructures and dedicated emergency management information systems (EMIS) will be very vulnerable to and badly damaged by the impact of a catastrophic mega-thrust of magnitude 9 plus and the following tsunami
  - Current ICTs and radio technologies are not ready for the prime time of a large-scale integrated response effort
  - Exercise artificialities may have made the real-world incident appear more manageable than it would be in reality
  - Nevertheless the simulation helped uncover numerous areas for improvement
  - Emergency management needs to engage in serious considerations and planning of necessary paper-based alternatives and the transition from paper-based to ICT-supported response management
  - It is recommended that the exercise be repeated and conducted under the assumption of an even more severe scenario with stingier injects
  - Currently, the US Pacific Northwest would be caught absolutely flat-footed by a mega-thrust

THANK YOU!

QUESTIONS OR COMMENTS?