CASCADIA SUBDUCTION ZONE EARTHQUAKE BASING AND SUPPLY DELIVERY STRATEGY BASED ON CURRENT PLANNING AND HISTORICAL EVENT ANALYSIS

Graduate Research Paper

Michael E. Ridley, Major, USAF

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Michael E. Ridley, BS

Major, USAF

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Committee Membership:

Dr. Paul Hartman
Chair

Abstract

The Cascadia Subduction Zone (CSZ) presents us with a catastrophe of proportions never before seen in the United States. While nestled in the ring of fire, the Juan de Fuca subduction plate is unique in that it spans two countries, three states, lies along a coast (promotes tsunamis), rests along an entire mountain range formed by thousands of small volcanoes, and is expected to produce one of the largest earthquakes in US history thanks to its subduction properties. To compound the problem, this fault wasn't known to be active until 25 years ago which has resulted in much of the infrastructure in the quake zones not having been built to withstand such a large magnitude earthquake. Shuttling supplies to quake victims after a CSZ earthquake presents significant challenges in coordination between all three state governments to include the multitude of local and federal agencies which in itself is unprecedented for a humanitarian response within the United States. Communication between all support entities will be the largest challenge which is why new new technologies need to be leverage. Also, a tsunami will make the delivery of supplies and communication among first responders that much more challenging along the coastal region. More importantly, there needs to be a clear understanding of what our capabilities are for the airlift of those lifesaving supplies and how a plan can be executed to use them when the time comes. While current planning efforts within USNORTHCOM and FEMA is extensive, additional research based on historical evidence can be exceedingly useful. This paper ties that historical perspective into those planning efforts to better understand what is required to respond to a Cascadia Subduction Zone event.

To all those quiet heroes who gave it their "all" in times of humanitarian crisis.

Acknowledgements

Many people contributed to the formulation of this paper. First and foremost, Dr. Paul Hartman, through many phone conversations, emails, extensive knowledge and perspective, and great patience helped me structure and hone this paper to something comprehensive and readable. While this research tended to veer off in many wild and confusing paths, you helped me keep its vector on target. Thank you for that. Big thanks to Michael Jackson and his companions on the USNORTHCOM J4 staff. They kept an extremely friendly and helpful demeanor though all my continual pestering and I would never have been able to put this paper together without them. To Mr. Stephen White, my Sponsor, for allowing me to contribute something (albeit infinitesimally small) to the great mission that FEMA supports. What an honor it is. My thanks to Pamela Bennett-Bardot, the Expeditionary Center Librarian, who always keeps the most positive attitude and is endlessly helpful in finding research data and articles for us. Lastly, another big thanks to my classmates who supported my research and helped in so many ways to finally accomplish this goal.

Michael E. Ridley

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CASCADIA SUBDUCTION ZONE EARTHQUAKE BASING AND SUPPLY DELIVERY STRATEGY BASED ON CURRENT PLANNING AND HISTORICAL EVENT ANALYSIS

I. Introduction

When deciding how to respond to an enormous earthquake such as what the Cascadia Subduction Zone will produce, the Department of Defense (DOD) has very limited historical data for planning purposes. The reason is because there has never been such a massive earthquake within the borders of the United States since this country was founded. The last earthquake of such a magnitude took place in 1700. The United States is still considered a relatively new country compared to other countries around the world, and in geological terms, 300 years is not considered significant, so it's no surprise really that there are many geological events that we haven't witnessed within our borders yet.

THE CASCADIA SUBDUCTION ZONE IN CROSS SECTION:

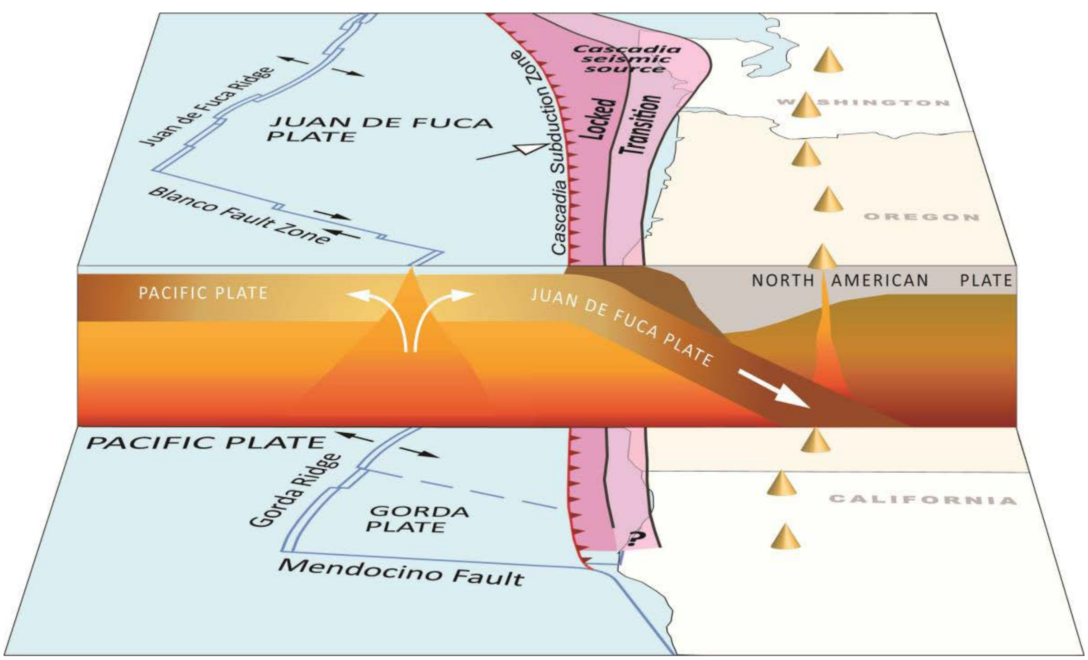


Figure 1 Image source: Oregon Department of Geology and Mineral Industries (Cascadia Region Earthquake Workgroup, 2013).

New crust forms at spreading ridges between the Pacific Plate and the Juan de Fuca, Gorda, and Explorer plates. As these three plates are pushed east-ward, they are forced to subduct beneath the North American Plate. Strain builds up where they have become stuck (locked) and will be released one day in a great earthquake (Cascadia Region Earthquake Workgroup, 2013)

We can, however, use subduction earthquakes such as the Sumatra and Haiti earthquake outside of the United States as a general guide to what we can expect. “The Sumatra earthquake of 2004 was the first large subduction earthquake in the world for more than 40 years. As such, this tragic event served as a clear reminder of the very large-scale impacts of an earthquake and tsunami of this magnitude” (Cassidy, 2015). We can also use our responses to massive hurricanes as a pseudo base for what we can expect regarding airframe capabilities and delivery timelines. For this, we look at our responses to Hurricane Katrina and Hurricane Sandy, both very different response efforts but both also on massive scales similar to what we would see after a CSZ event.

When such an event happens, such as that expected along the CSZ, the DOD, FEMA, USNORTHCOM, USTRANSCOM, and AMC will play a significant role in assigning airlift to missions to deliver needed supplies to those affected which means communication between them will be critical. Also, understanding which supplies are needed in which areas will be one of the most challenging efforts to overcome and requires communications technology that the DOD can plug into so that decisions on what supplies are needed where between FEMA and the DOD are clearly articulated and executed. This communication technology is the First Responder Network Authority which will be discussed in detail later in this paper. Since a large portion of the emergency transportation capability needed by DOD is in civil sector resources, close coordination among a wide variety of military and United States Government departments and agencies will be required to meet contingency transportation requirements (JP 4-01, 2013). The process for which we can expect to take place that will require lifesaving airlift missions to deliver supplies needs to be fully understood by all parties so there is no delay in the execution of that plan. This paper will also outline that process in a way that’s easily understood.

Because so little historical evidence for responding to such an event is essentially non-existent, there are many assumptions this paper must make. Those assumptions are outlined in the sections below. Many of those assumptions revolve around the suitability of airfields around the subduction zone, which is not much dissimilar to what USNORTHCOM did when they developed their Cascadia Subduction Zone playbook. While shake models have been helpful in better understanding which airports we can count on, historical evidence from other massive earthquakes and hurricanes is also critical to understanding the damage we can expect to see not just from the earthquake itself, but also from the resulting tsunami.

General Issue

While much of the planning efforts for a coordinated response in articulated in a great deal within the USNORTHCOM playbook, little reference is given to historical occurrences and the resulting response efforts. It's important to relate current and future planning to what we've witnessed in the past. If we do this, the mistakes we make won't be attributed to the lack of hindsight which we've seen in many recent humanitarian response efforts. Due to the complexities and dynamics involved in assigning aircraft within the DOD, it's even harder to understand how that process will work and what can be expected from the perspective of outside agencies. Further, the issue deepens without knowing for sure what airstrips can be counted on after a massive CSZ earthquake. FEMA will inevitably be called upon within the first day to assist the State governments. They have a preplanned, tailorable list of commodities called the FEMA Resource Phasing Plan that contains detailed data including personnel numbers, quantities of vehicles and equipment, volume and weight data for load planning, and sub-configurations to accommodate transportation flexibility (USNORTHCOM Playbook, 2016). It's used in conjunction with USTRANSCOMs transportation feasibility analysis which uses the

Joint Flow and Analysis System for Transportation (JFAST), and Air Mobility Commands Mobility Planners Calculator (AMPCALC) to simulate the flow of all the commodities and people through different scenarios. Those scenarios are built to simulate various airports, roads, and seaports that are destroyed or limited in their availability due to earthquake and tsunami damage. What is not entirely clear, however, is what has and has not worked well from previous disasters. Also, the entire process that is put into place to request those air assets and what can be expected to be available to use to transport goods into the affected areas is not easily understood when you have so many moving parts such as a massive earthquake relief effort. Fixed wing C-130's can be considered for use instead of rotary wing aircraft in certain circumstances, and certain airfields should not be expected for use due to soil liquefaction from the earthquake. Lastly, the communication effort required for such a massive response will need to be precise, clear, and standardized across the board to be effective. This communication is the key area that has proven time and time again to be a major hindrance in every humanitarian response effort we've conducted. Most notably are the communication issues that developed in the early stages of our response to Hurricane Katrina which will be discussed later in this paper. These are some of the variables that muddy the waters and prevent expectation management when the machine is set into motion in response to a real world event. In order to alleviate some of that confusion, this paper attempts to clearly draw the picture of how this process will work, what assets should be utilized for delivering needed supplies, what we have learned about this process from previous catastrophic events and the benefits of having a robust public communications system to tie all these variables together.

Problem Statement

Despite the DOD finding the majority of its Humanitarian Assistance/Disaster Relief (HA/DR) mission overseas, what the American people remember most is how that response effort was administered within the borders of their country. In order to provide an effective and efficient response to a Cascadian Subduction Zone earthquake, precise, clear, and standardized communication between multiple agencies is required, deciding what aircraft (rotary or fixed) and routes would best be suited to deliver supplies from a forward supply location to the quake victims and what process could be expected for tasking those aircraft.

It is the policy of the United States to strengthen the security and resilience of the Nation against earthquakes, to promote public safety, economic strength, and national security.

Research Hypotheses

My hypothesis is that it would be best to use a half hub and spoke system for the delivering of supplies to victims after a Cascadia Subduction Zone earthquake. The hubs would be located as close to the quake zone as possible and would primarily be serviced by C-130's. The spokes would be rotary wing delivering supplies from the hubs which would require rotary wing landing zones and monitored supply drop off locations. HH-60's and Chinooks would best be used in a limited capacity for delivering supplies to austere locations due to their payload capacity. Anything smaller would not be beneficial for supply delivery. Communication would be best executed through the use of handheld radios transmitting through local repeater stations and should utilize channel frequencies based on geographic areas.

Research Focus

My focus will be on bases available after a CSZ event and resulting tsunami, the type of aircraft utilized in delivering supplies and the communication process for the entire effort. This analysis will be based on historical lessons learned, current planning efforts by USNORTHCOM, FEMA, and other agencies, and my limited knowledge garnered from the School of Advanced Study of Air Mobility.

Investigative Questions

1: What did similar historical disaster relief efforts look like?

2: Based on that, what are probable airstrips and staging areas that we can count on?

3: Should we use fixed or rotary wing to shuttle supplies and how will they be used?

4: What is the process for FEMA to request airlift?

5: What is the best method of communication amongst all agencies involved?

Methodology

For this paper, I'll be using a Qualitative method based on literature reviews from scholarly reviewed journals and current planning efforts from USNORTHCOM, FEMA, and other agencies. I'll develop a map of affected area and overlay a grid to separate out quadrants and focus on available runways and infrastructure within each quadrant. To answer the questions on rotary versus fixed or a mix of the two, I'll associate each quadrant with airfield availability and its support capacity to each of the two airframes which will flush out the suitability of using one or the other or both within that specific area. Next, I'll outline a governance strategy for how FEMA would request airlift through USTRANSCOM. Lastly, the qualitative method will include research on the current efforts for developing a better communications strategy during humanitarian response efforts and if it is suitable or not based on historical incidents.

Assumptions/Limitations

Planning for Worst Case Scenario

As with most Operations and Contingency Plans, we assume the worst case scenario and then tailor down from there. To eliminate confusion about NORTHCOMs planning factors that themselves have also assumed worst case scenario, this paper assumes the same. Such an event would look like an 8 to 9.0 seismic event and would create a full rupture along the entire 800 miles of the Juan de Fuca subduction zone. USNORTHCOMs planning factors identify the necessity for states to formally request FEMA assistance who will in turn promptly request airlift from USNORTHCOM. The nature of these assumptions is what led to USNORTHCOMs rigorous efforts at preparing a formalized playbook which outlines in moderate detail the missions to be executed in the event of such an earthquake.

Access to data is limited

The majority of the data for this research has been acquired through briefings, after action reports from other humanitarian assistance/disaster response (HA/DR) to include Haiti, and the USNORTHCOM playbook itself. Unfortunately, there have not been an abundancy disasters' responses by the DOD within the borders of the United States. Certainly, there has not been a response proceeding an earthquake of significant size which has made it difficult not only for this research paper but also for USNORTHCOM to build a foundation on. Most planning factors are speculative and are the best guess variable. While Haiti does provide valuable insight into the response effects, it is a much different critical path of events that led up to that response which took place in a third world country, located over 1000 miles from a major Air Force base capable of sustaining regular airlift.

Assumptions/Limitations

- While state and local agencies will play a huge role, this paper focuses on federal forces (primarily title 10) who will be pivotal during this disaster response
- We will not be waging a significant war which would soap up many of our critical assets
- Levels of damage and boundaries of damage are based of the Mercalli Scale (see fig 3) but could differ in many aspects dependent on location of epicenter and quake intensity which cannot confidently be predicted
- Airports/bases directly in quake and tsunami zone (east of I5) will be inoperable for the first few days

Implications

Airlift will be pivotal in the early stages of response to save lives and ensure our fellow countrymen and woman are safe and secure. Identifying suitable staging areas and airlift assets in advance could potentially speed up the response effort. We can do this by looking at data from past humanitarian response both inside and outside our borders. The most relevant data will come from responses we've conducted inside our boarders since data points such as infrastructure integrity, response times, and lines of communication are more accurate and relevant to a Cascadia Subduction Zone response. Catastrophic events usually occur at unknown times and locations which make it nearly impossible to predict all the variables that will come into play. However, the more we plan in advance, the more we can manage expectations and streamline communication when a catastrophic event happens. Historical data plays the most pivotal role is this planning effort.

II. Literature Review

A Tale of Three Disasters

To better define the roles of fixed and rotary wing assets after a CSZ event, it's critical to first review past events and understand how they were utilized under different scenarios. Even more important is to understand the effectiveness of them in their given role. One thing is certain which is every natural disaster will bring with it new and unique circumstances that no single plan could possibly encompass all of it. The unpredictability and complications they bring are compounded when we introduce our own variables with regard to our response. "Natural disasters bring to the fore the astounding independence and facility of the complex mobility systems and infrastructure moorings that make up contemporary transitional geographies" (Sheller, 2012). Flexibility in posturing and execution will ultimately bring the necessary success after such a catastrophic situation. It's no secret that no matter how much we plan, our true strengths and weaknesses will always bear forward in time of crisis for everyone to criticize and praise. The best we can do is learn from those critics, humbly accept the praises, and plan for the worst.

For the purpose of this paper's literature review, I'll cover in detail three specific natural disasters, and the follow-on relief efforts attempted in the aftermath. Those include the Sumatra earthquake and tsunami of 2004, Hurricane Katrina, and Hurricane Sandy. The Haiti earthquake relief effort will be referenced as well but not in as much detail as the other three incidents. The 2011 Japan Tohoku earthquake will also be discussed but solely for the purposes of the data analysis used to identify available bases after a CSZ event. While these disasters are all very different, having occurred in diverse geographies with their own unique set of challenges, the one thing they do have in common is that they've occurred in the relatively recent history with airlift assets that are still available today and would be called upon when the next disaster hits. The Sumatra earthquake and tsunami are especially important because they occurred along the “ring of fire”, the outline of subduction plates in the Pacific basin where all the most powerful earthquakes and the largest concentration of volcanoes occur. Because of the subduction properties along the Indo-Australia plate which caused the Sumatra earthquake and subsequent tsunami, we can garner valuable insight into what would be expected along the subduction zone from the Juan de Fuca plate in the Cascadia region.

Expected Damage

There are no detailed records of a natural disaster within the borders of the United States that can give us even a close depiction of what we can expect after a CSZ event. The Aleutian-Alaska Subduction Zone had a 9.2 earthquake in 1964, and while this does help us better understand what kind of geological movements to expect, it didn’t occur in a populated area, nor was it recorded with detailed measurement tools like what we use today. The fact is, plate tectonics was just being developed as a theory at the time of the Alaskan earthquake and was not yet widely accepted. “Even with months of careful observation and field work, the cause of the earthquake remained a mystery until USGS scientist George Plafker set out to investigate the event and interpreted what he saw in the field. This new insight helped confirm the concept of plate tectonics and changed earthquake science forever. No unifying theory existed on what caused these types of great earthquakes” (Robertson, 2014). Still, it did provide us insight into some potential damaging effects to infrastructure as was seen in the city of Anchorage over 500 miles away.

Figure 2 Image source: United States Geological Survey website. Photo of Anchorage after the 1964 earthquake (Survey, 1995). Additional pictures from the USGS of the devastation can be found in Annex A.

There are subduction zone events that we can learn from outside the Unites States. We have details from the 2004 Sumatra earthquake which “share many similarities to the Cascadia Subduction Zone” (Cassidy, 2015). As Cassidy states, studying the Sumatra Earthquake is exceptionally important, not only because it also occurred along a Subduction Zone similar to the CSZ, but it was the first event of this size recorded on modern instruments, collected in near-real time, and provided an opportunity to illustrate what other similar subduction zones around the world could expect in terms of ground shaking, coastal uplift, aftershocks, and tsunamis. While it is probably not a good indication of how well our more advanced and modern infrastructure will stand up to such tectonic movement, it does paint an accurate picture of the severity of the event itself which we can then model against.

The Sumatra and Cascadia have many similarities to include both having similar convergent rates (the force of the plates against each other), similar lengths of fault, and similar sediment thickness and sea floor smoothness. The data from the Sumatra quake shows us that intensity IX occurred less than 75 km from the rupture zone, VIII and greater occurred less than

150 km from the rupture zone, VI-VII extended to distances of 300-400 km, and IV-V (caused cracks in buildings and people ran outdoors in panic) extended to a distance of 1,000 km. (Martin, 2005). See Fig 3 below for descriptions of each intensity value. If we translated this to the distances around the CSZ, the quake would be felt all across western Canada and the USA, Alaska to Mexico, with the zone of significant damage extending along the west coast inland approximately 100-150 km (Cassidy, 2015).

If there is any particular comfort that can be had from the data with regard to the Sumatra earthquake, it's the noticeable lack of volcanic activity. According to Cassidy (2015), no major

Category	Effects	Richter Scale (approximate)
I. Instrumental	Not felt	1-2
II. Just perceptible	Felt by only a few people, especially on upper floors of tall buildings	3
III. Slight	Felt by people lying down, seated on a hard surface, or in the upper stories of tall buildings	3.5
IV. Perceptible	Felt indoors by many, by few outside; dishes and windows rattle	4
V. Rather strong	Generally felt by everyone; sleeping people may be awakened	4.5
VI. Strong	Trees sway, chandeliers swing, bells ring, some damage from falling objects	5
VII. Very strong	General alarm; walls and plaster crack	5.5
VIII. Destructive	Felt in moving vehicles; chimneys collapse; poorly constructed buildings seriously damaged	6
IX. Ruinous	Some houses collapse; pipes break	6.5
X. Disastrous	Obvious ground cracks; railroad tracks bent; some landslides on steep hillsides	7
XI. Very disastrous	Few buildings survive; bridges damaged or destroyed; all services interrupted (electrical, water, sewage, railroad); severe landslides	7.5
XII. Catastrophic	Total destruction; objects thrown into the air; river courses and topography altered	8

Figure 3 Image source: sms-tsunami-warning.com. Modified Mercalli Scale VS Richter scale (Warning, 2017).

eruptions have occurred in the decade following the 2004 event. Given that the Cascadia Mountain Range is essentially made up of thousands of volcanoes, this is definitely good news, although not a predictably definite outcome. Regardless, volcanic activity after a CSZ event is outside the scope of this article and will be recommended for future research.

While USNORTHCOM does not reference the Mercalli scale in its planning efforts, they did use modeling and simulations with assistance from FEMA to better understand the expected damage from a CSZ event. According to the USNORTHCOM playbook (2016), "the severe prolonged shaking is assessed to cause: near total coastal devastation (453 miles of impacted coastline) from the tsunami, landslides and up to 1,100 bridge failures making roadways largely impassable leaving tens of thousands of persons stranded and in need of support, severe structural damage including collapse of up to 10,000 unreinforced masonry buildings, and varying levels of damage to tens of thousands of wood frame structures, earthquakes related injuries and hospitals damaged and in need of decompression, and cause widespread power outages severely hindering operation". It's not hard to see from these assessments the significant complexities that will result from the devastation and the looming challenge ahead once this event unfolds.

Initial Response

Sumatra

Earthquakes are much like the market, one can never truly predict their activity which makes them that much more difficult to prepare for. If we knew exactly when and where they would hit, we could plan years ahead with staged resources and react immediately. Unfortunately, the strength, exact location, destruction of infrastructure, and breadth of effect are all unknown. What we do have are the lessons learned in the immediate aftermath of the Sumatra earthquake, Hurricane Katrina, and Hurricane Sandy.

As mentioned earlier in this paper, the Sumatra earthquake of 2004 was the first recent earthquake of significant magnitude along a subduction zone that was recorded with modern instruments. What we learned from that event was that tsunamis are incredibly hard to track but since then, significant efforts have been undertaken to fix that. Now in the Cascadia, a prototype

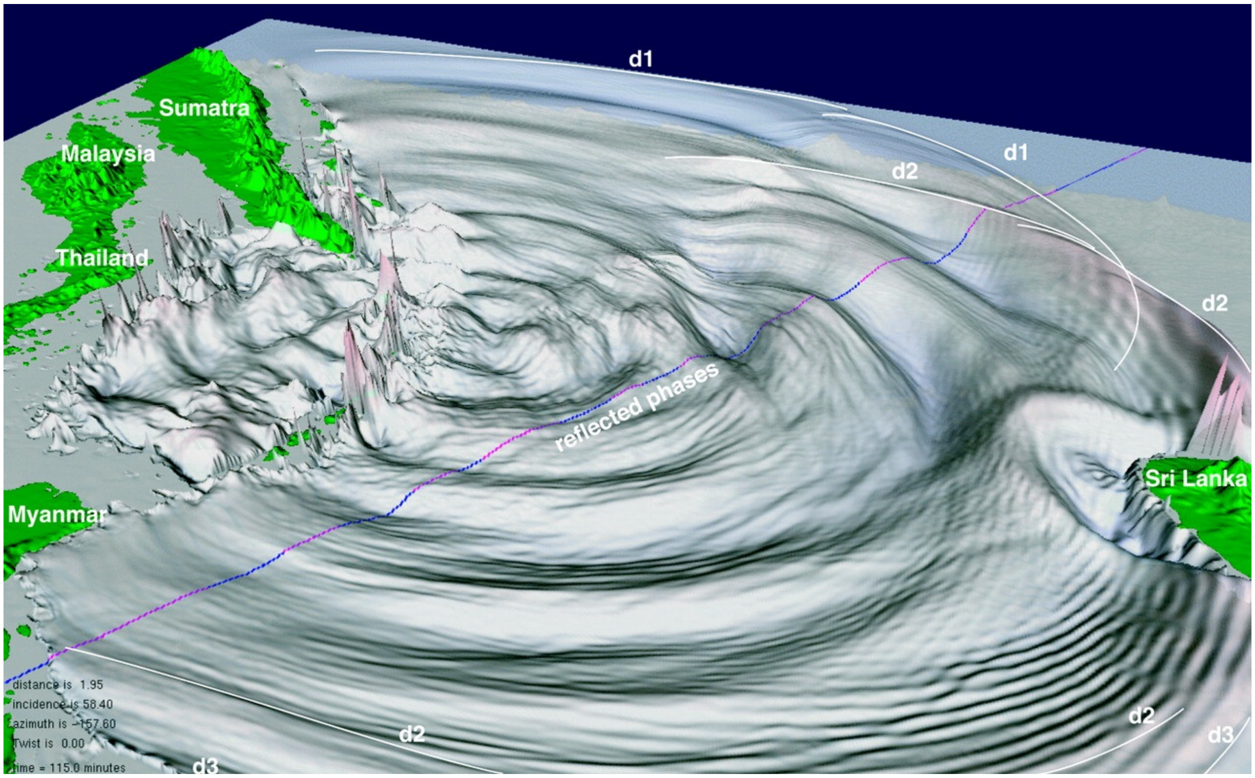


Figure 4 Image source: Bulletin of the Seismological Society of America (America, 2017). 2004 Sumatra Tsunami tracking.

early warning system integrating seismic and GPS data (with Cascadia subduction earthquakes as a key target) is now being developed (Given et al. 2014).

This system will utilize the GPS and seismic data to get incredibly accurate and real-time data on the tsunami which will be used to warn residents and first responders. Also, much like hurricane tracking, it'll allow us to more quickly stage assets in preparation for a response effort immediately after the earthquake. It must be mentioned that a tsunami is not a guarantee. For example, while the 2004 Sumatra earthquake which had a magnitude of 9.2 produced a massive tsunami 115 feet high in several places and reached the coast in just over 30 minutes while the following year in 2005 another 8.4 earthquake on the same fault created almost no tsunami. This is attributed to the breakage of the sea floor. If the sea floor breaks along the fault from the geological forces, a tsunami will be created from the vertical displacement of the water. There are many instances, however, where the plates slipping will not break the sea floor, and an insignificant amount of water gets displaced from this kind of earthquake.

Hurricane Sandy

Right after Hurricane Sandy hit the east coast, USNORTHCOM and FEMA were already in a position to start the disaster relief engine due to many factors which would most likely not be present after a CSZ event. First, USNORTHCOM was in the middle of a hurricane relief exercise when Hurricane Sandy showed up on the radar. Second, the hurricane path could be projected which gave all the agencies and civilian support units ample time to prepare and evacuate before the Hurricane hit their locations. After landfall, the primary focus for recovery was “people, power, and plumbing”. Despite getting a significant amount of power restored by the seventh day, a large Nor’easter pushing into New Jersey and New York which further complicated the relief operation and took power out to another million people. According to USACE (2012), while the Nor’easter had minimal impact on post-Sandy operations, it did increase the complexity of the missions with additional pumping and drainage required as well as power generation and technical assistance. During a CSZ earthquake, USNORTHCOM and FEMA should be prepared for unexpected storms or events such as aftershocks that will continue to hamper recovery efforts. Incredibly, 15 days after Hurricane Sandy hit the East Coast, only 15,000 were still without power (4.5 million residences got power back), and 5,000 were in temporary shelters (Blyth, 2012). The majority of those in temporary shelters were due to their homes no longer physically existing.

Hurricane Katrina

Many people remember the response for Hurricane Katrina as not going very smoothly. Many disaster relief policies changed after Hurricane Katrina due to the many issues that were encountered. The relief effort was one of the first major real natural disasters for the active duty and Guard to respond to within our borders. The fact is that Hurricane Katrina didn't take us by surprise. We had hurricane hunters in the air with WC-130's from the 53rd Weather Reconnaissance Squadron several days before Katrina even made landfall.

Once it did make landfall, it was devastating. "East of there [Louisiana-Mississippi boarder] the counterclockwise winds (128 mph) pushed a 28-foot storm surge from the Gulf of Mexico into the town of coastal Mississippi and southwestern Alabama. Failures of floodwalls along the New Orleans canals and overtopping of the levees in the East left 80% of the city flooded for weeks" (Haulman, 2006). President Bush didn't break away from his vacation in Texas until two days after Katrina had made landfall. The first week in September proved the most challenging and the one most people remember about Katrina. Law and order broke down which lead to violence, stealing, vandalism, and looting. According to Haulman, 2006), "thousands of refugees, lacking adequate food, drink, plumbing, air conditioning, and space, crowded at the Superdome and the convention center, where violence threatened to erupt". What happened in Katrina was not too dissimilar to Haiti. Many islands started to form with people separated from food, water, and medical due to the flooding throughout the area. It's possible we'll see islands of communities in the aftermath of a CSZ event as well due to the infrastructure such as roads and bridges being destroyed and how that gets dealt with will be vitally important.

Historic Utilization of Fixed Wing

Hurricane Sandy

The day after Sandy made landfall, USNORTHCOM received and approved [its first] mission assignment from FEMA for strategic airlift to move power restoration (utility) vehicles, support personnel, and cargo from multiple location to Stewart International Airport in NY to support what became Task Force Power Restoration. According to Blyth (2012), as of 2 November (3 days after hurricane landfall), it was assessed that only 30% of the Guard was being utilized. One day later, TRANSCOM had completed the execution of sixteen C-17 flights and six C-5 flights. The following day that number would rise to 44. Their response seemed to be working, showing that fixed wing, specifically C-17's and C-5's were the required asset for strategic supply delivery. They allowed the shuffling of supplies from all over the country to

Figure 5 President Obama and Governor Christy, left (Downing, 2015), first responders utilizing a small boat for rescuing people, right (Hunger, 2012).

descend on this one location that needed them most. But this is to be expected in the aftermath of a natural disaster like this. Delivering supplies over that last tactical mile is what presents such a significant challenge. Very little was utilized in the way of tactical fixed wing after

Hurricane Sandy. Since McGuire AFB and Hanscom were used as Base Support Installations (BSI's), we were able to get the majority of the required strategic cargo in close enough to where the "last mile" could be transported via trucks. That which could not go by truck was usually brought in with a helicopter pending allowable weight restrictions. Small boats from various emergency organizations also played a pivotal role in rescuing people and delivering supplies. While a CSZ might not provide such a prolonged dumping of water on land, the tsunami expected after the CSZ might create significant flood areas which could only be accessed by boat. This is an important factor when considering how to deliver supplies to some of the populations that will be affected by the Tsunami along the coast. These assets could be prepositioned by local first responders when the need arises.

Hurricane Katrina

Hurricane Katrina was a different story, however. The second day after Katrina, USNORTHCOM set up Joint Task Force Katrina, led by Lt. Gen. Russell L Honore' from the United States Army while Maj. Gen. Scott Mayes from the United States Air Force served as the Joint Forces Air Component Commander (JFACC). While the storm had been tracked with WC-130's (hurricane hunters) from the 53d Weather Reconnaissance Squadron, our response to the disaster was ultimately much slower than it was to Sandy. According to Haulman (2006), the Eighteenth Air Force Tanker Airlift Control Center (Air Mobility Command) managed the US Air Force's fixed-wing airlift which consisted of C-130s, C-17s, and the mighty C-5s. What the fixed wing aircraft were most remembered for was their use in evacuating people from the strategic locations such as the New Orleans International Airport to hospitals in San Antonio, Kansas City, and Lackland AFB. That evacuation was done on the reverse leg of their missions while their flights into the hurricane-stricken areas brought necessary food, equipment, emergency personnel, troops, and supplies. "C-17s that had delivered emergency personnel and equipment to New Orleans, instead of returning to their home bases empty, carried refugees from New Orleans to Dobbins Air Force Base, Georgia, as well as San Antonio, Texas" (Haulman, 2006). These bare bases included tent cities for housing personnel and support equipment. This was a notable achievement during the Katrina relief effort which was not originally planned for and can easily be incorporated into the airlift plans for a CSZ event. One factor that was unexpected was the requirement for a significant amount of troops to help with security due to the breakdown of law and order within the affected areas that were essentially cut off from outside help. Thirty-three C-17s and "hosts" of C-130's, KC-135's, and C-5s were also used to shuttle in armed troops. It's unknown if this kind of reaction will be seen within the rural or urban areas along the coasts of Oregon and Washington which are expected to become quite secluded after both the earthquake and tsunami hit.

While most airfields in and around the affected area were either too small or too incapacitated to support strategic airlift, the New Orleans International Airport served as the strategic hub. Despite having robust command and control before the hurricane, the Air Force had to deploy a "Contingency Response Group from McGuire AFB, NJ to the airport with combat controllers and medical teams to establish a bare base operations there" (Haulman, 2006). The Contingency Response Group capability of the Air Force coupled with the Army's land version to create the Joint Task Force Port Opening capability will be pivotal in creating tactical hubs for the reception and onward movement of supplies and emergency responders after a CSZ event. Ground transportation is critical in delivering supplies that last tactical mile. While ground transportation is outside the scope of this paper, it's recommended for a future research topic.

The Utilization of Rotary Wing

Hurricane Sandy

Three days after Hurricane Sandy made landfall, the Navy deployed a three-ship Amphibious Ready Group to the New York harbor. This provided marines and helicopters which would be used for intra-theater operations. Before Sandy even hit the coast, fragmentary orders were issued to include Hanscom AFB on the ready to provide eight helicopters for Search and Recovery (SAR) and medium intra theater airlift. While rotary wing was important for delivering supplies, this was primarily a ground operation with the Joint Forces Land Component Command in conjunction with the Joint Logistics Operation Cell working to clear the roads of debris and truck supplies to the required locations.

Hurricane Katrina

"USAF helicopters took part early in the disaster relief effort. Their role was most important in the New Orleans area, where only helicopters were allowed to fly below 20,000 feet." (Haulman, 2006). The helicopters used were HH-60s from the Air Force Reserve Commands 920th Rescue Wing from Patrick AFB and the 943d Rescue Group from Davis-Monthan AFB. They were critical for FEMA to provide damage assessments from the skies and to deliver damage assessment teams to various locations in the affected zones. HC-130's were used early on as well but only as refueling aircraft for the HH-60's. This refueling capability is a critical piece of information since any rotary wing asset used will be severely constrained by its fuel supply. Simultaneously, additional HH-60's and HC-130's from Air Force Special Operations Commands 347th Rescue Wing at Moody AFB conducted search and rescue operations in the area. According to Haulman, MH-53 helicopters refueled by MC-130 tankers from the 16th Special Operations Wing at Hurlburt Field also took part in the search and rescue operations. All of these assets served under the Joint Task Force Katrina. The 106th Rescue Wing provided search and rescue HH-60s as well. Most notably, however, were the UH-1's that were utilized. Haulman continues that eight UH-1's from Air Force Space Command (Minot AFB, F.E. Warren AFB, Malmstrom AFB, and Vandenberg AFB) were critical to the relief efforts. These helicopters were small and more nimble than the larger HH-60's and MH-53's and were utilized to deliver "food, water, medicine, and other supplies to hurricane victims along the Mississippi Gulf Coast" (Haulman, 2006). UH-1's are most famous for their role in the Vietnam war. They are indeed smaller helicopters but can still pocket a range of 200 miles depending on the load it's carrying which can be as diverse as a communications package to medical litters to combat soldiers to desperately needed food, water, and medical supplies. Undoubtedly, these assets will be critical to the days and weeks after a CSZ event. It's unknown as to what platform exactly will take the place of the UH-1 once it formally retires in the future but it can't be argued that whatever airframe does take its place will be just as crucial to the planning for humanitarian response efforts.

Figure 6 UH-1 at Minot AFB on the left (Morris, 2015) and HH-60 refueled from a HC-130 on the right (Pierce, 2009).

The UH-1's were a key thread in the humanitarian relief blanket and should be incorporated in the planning factors for delivering support in the days after a CSZ event. Helicopters rescued a total of 4322 people (Haulman, 2006) in the aftermath of Hurricane Katrina. Initially, the helicopters rescued people from rooftops but were later used to shuttle people from shelters to locations where they could receive proper medical attention. One must understand the difficult situation people were in after Katrina. Homes, hospitals, neighborhoods were all cut off from rescuers which created an "islanding effect" as Sheller (2012) put it. Because of this, the only available help came from boats and helicopters. It's clear that these rotary wing aircraft were incredibly instrumental in the day's following this natural disaster.

Governance Strategy

There is a series of events that will need to take place to get the required airlift to the right places with the right supplies, at the right time. A smooth line of communication and having all parties understand this process is critical since it's not just a matter of taking planes from other operations and tossing them into the relief effort. If no stringent vetting process of checks and balances exist, airlift would be utilized inefficiently and end up causing more problems in the end. The good news is that the request process, when executed correctly, can work extremely fast and efficiently. States have the capability to use their state-owned assets first through their National Guard or state agencies. In an event along the CSZ however, federal support will be required. "Notification of USNORTHCOM will occur through three primary means; (1) U.S Geological Survey (USGS) Notifications, (2) traditional and Social Media Reports, and (3) DOD Installation Reporting" (USNORTHCOM Playbook, 7). This will all happen before FEMA even submits the request to USNORTHCOM for airlift assistance. Once Washington, Oregon, and California request federal support from FEMA, DOD aircraft from anywhere in the world can be looked at for potential tasking. FEMA will assess the situation to include what supplies they have and where they need to go, then put an airlift request in through USNORTHCOM. Much like the DOD's Operation Plans, FEMA uses a Resource Phasing Plan that will help guide their decisions into what supplies will be needed where. USNORTHCOM will, in turn, validate that request and input it into the Joint Operations Planning and Execution System (JOPES) which is the primary method for airlift requests to USTRANSCOM. Requests for airlift come to USTRANSCOM through JOPES from the supported combatant command (CCMD)--in this case NORAD-USNORTHCOM" (Breedlove, 2016). USTRANSCOM planners validate the request and send to 618 AOC for scheduling. Requests also can come via the SAAM Request System (SRS).

For Assets available to be tasked (any service)….DSCA warrants a 1A3 priority which is the highest priority except for Presidential-directed missions and forces in combat so there should be plenty of airlift available assuming no major wars break out at the exact timeframe of a CSZ event (Breedlove, 2016). Breedlove also mentions that Military Sealift Command ships can be activated to support as well. Most are in a Reduced Operational Status (ROS) 5 meaning they have five days to attain Full Operational Status (FOS). These ships can bring relief supplies/equipment to the impacted area. The limiting factor would be an operational port due in part not only to the coasts proximity to the fault line but also to the resulting tsunami which as we saw after Japan's Tohoku earthquake where the coastal region was devastated, making seaports inaccessible for a significant amount of time in the aftermath of the quake. In the event the seaports are compromised, we can still use Joint Logistics Over the Shore (JLOTS) which is a Service capability to provide loading/unloading of ships without fixed port facilities. Commercial companies have a similar capability like the one Crowley used in Haiti in 2010.

Navy aircraft carriers off the coast could potentially contribute airlift if a carrier is in the area which would prove extremely valuable since as discussed below, the majority of the airfields that we can rely on after a CSZ event will be to the east of the Cascadia Mountains. Having an aircraft carrier just off the coast would provide the capability of immediately delivering supplies and search and rescue operations to the coastal regions which are expected to be the hardest hit. Breedlove points out that of the airlift available, the best suited for delivering forward supplies to the victims (from a forward supply base to the victims) are rotary wing. The goal would be to use fixed wing capable airfields to more efficiently move supplies, but helicopters will be necessary to get to the remote, otherwise inaccessible areas.

The Need for FirstNet

The first responder communication plan allows airfield assessments to be conducted in a reasonable amount of time, and promotes supply requirements from rural locations to get communicated up to the proper levels, required locations for medical logistics identified in time for airlift missions, and communication flow all the wat to the lowest levels. In essence, without this efficient line of communication, all efforts of an organized recovery after a Cascadia event will halt with every minute ticking away lives that could have been saved. It’s a trap we fell into during 9/11 and even during Katrina. The 9/11 commission report identified deficiencies in first-responder systems and concluded that “Congress should support pending legislation which provides for the expedited and increased assignment of radio spectrum for public-safety purposes…” (Ryckman, 2015). “It is scandalous that police and firefighters in large cities still cannot communicate reliably in a major crisis,” Thomas Kean former chair of the 9/11 Commission, said at the December 5, 2005, launch of the report card. After Katrina hit, a common topic in the media was the failure of adequate communication taking place between all levels of response. According to the First Response Coalition paper (2005), "media reports showcased how local, state, and federal public safety departments could not coordinate their hurricane and emergency responses because their communications networks were outdated and incompatible, the same problems that were first brought to prominence after 9/11".

The fix for this communication problem is now a reality with the creation of FirstNet. Congress established First Responder Network Authority (FirstNet) with the passage of the Middle-Class Tax Relief and Job Creation Act of 2012. This act "authorizes FirstNet to hold the 700 MHz spectrum license for the network, which will be based on commercial standards for the Long Term Evolution (LTE) service and which will evolve with technological advancements" (FEMA, 2012). FirstNet will manage the building, deployment, and operation of this critical network for First Responders. According to Ryckman, Prime spectrum for the network has already allocated along with $7 Billion dollars. A board of directors has been set up with representatives from the President's cabinet, telecommunications industry professionals, and public-safety representatives. FirstNet has now finally been set up, and as of March 2017, AT&T has been selected to build FirstNet Network, "a nationwide wireless broadband network dedicated to America's first responders. The effort is a significant investment in the communications infrastructure that public safety desperately needs for day-to-day operations, disaster response and recovery, and securing large events" (Ward, FirstNet Memo, 2017). AT&T is expected to invest about $40 billion over the life of the 25-year contract to build, deploy, operate, and maintain the network.

The good news is that 26 states have already made significant progress with FirstNet to include Washington, Oregon, and California. Currently, Washington has set up a program called Washington OneNet or WON which has been busy working with FirstNet on a comprehensive state plan that meets the needs of the State. Once this plan is given to the Governor of Washington, he or she will have 90 days to accept it or opt out of it. If a state governor opts out of FirstNet's plan, they will incur a great deal of risk and costs building their own infrastructure that still needs to be compatible with FirstNet. There are many reasons why a state would opt out to include the fact that when FirstNet is built and implemented, states will have to pay a usage fee for the network, much like the average consumer does for their cell phone. This cost, however, is what will pay for the operating and sustainment of the network. Regardless, the important issue is that Washington, Oregon, and California move out on whatever decision they make and ensure they implement their network in a way that seamlessly integrates with the entire system.

III. Methodology

This paper's research is primarily base on qualitative methods, using case studies from various Disaster Relief missions and the planning assumptions brought forth by the rigorous efforts of USNORTHCOM and FEMA. According to Yin (1984), "the case study is preferred in examining contemporary events, but when the relevant behaviors cannot be manipulated…. you would use a case study method because you deliberately wanted to cover contextual conditions-believing that they might be highly pertinent to your phenomenon of study." (Yin, 1984). This is the case when discussing disaster relief operations. Anyone who has ever read any after action report on any disaster relief effort knows that unexpected variables seem to occur with such surprising irregularity that preparing for a disaster seems almost impossible. More times than naught we've had to disregard any plan in place and rely on our doctrine to rebuild a new plan, seemingly on the fly. One could argue that at no point in time have we ever wielded as much technology and potential to close the gap between disaster and relief than we do know. When Katrina hit, or Haiti occurred, it took days, even weeks to get aid to people. In the case of Haiti, some never got it at all.

According to Sheller (2012), "…one of the perversities of post-disaster recovery is that outsiders' network capital and access to mobility further marginalizes those whom they seek to help. One of the most wrenching examples of this was plain to see for almost any aid working who went to Haiti after the earthquake; along one of the major thoroughfares leading out of the city towards Carrefour Feuilles went a parade of the SUV's of the 'blancs' (white/foreigners), the belching heavy goods vehicles, the UN armored personnel carriers, the overloaded Tap-Taps (buses), and the usual traffic of creatively modified pick-up trucks. The traffic all passed close to a median strip on which had sprouted a temporary settlement, stretching for close to a mile.

Along this narrow median strip there was a long line of tiny shelters cobbled together with tarps and scraps of metal or wood. And in those tiny shelters people were struggling to live – bathing, cooking, feeding babies, sleeping – within feet of the fearful phalanx of huge vehicles full of alleged rescuers, who passed them by with nothing but shocked faces".

It's important that we don't overload our efforts to the point that we spend all our resources supporting the rescuers themselves and deny those that were meant to get the help to begin with. This calls for a truly expeditionary approach to the problem. It also requires a look back on what did and didn't work and how we've incorporated those lessons into our current planning constructs. "Also fitting is that case studies are generalizable to theoretical propositions and not populations or universes. This, I think, aligns very well with the point of doctrine and how we position ourselves within the DOD to achieve various ends" (Kostrubala, 2016). According to Kostrubala, those ends are how we respond to a disaster. Seemingly, we are finding ourselves within the DOD participation in disaster relief efforts.

Within weeks of Hurricane Sandy's landfall, General Charles Jacoby, then commander of USNORTHCOM stated, "this [support to disaster relief operations] is going to happen again, and there is an expectation now that the DOD will play a key role. The day of 'this is not our job' is over. It is now part of the fabric of how we operate in the homeland, this is a legitimate DOD mission, and we need to get organized for it and not treat it as a pickup game. The final measure is saving lives and reducing human suffering, but in addition to that, we have key terrain in the United States where this not only impacts the nation but on the world" (Blyth, 2013).

Once the data has been gathered, I utilize a method of separating the Cascadia region out into quadrants. I find it easier to break down the geography this way so as to better describe certain regions without the reader having to triangulate on a map the locations discussed in this paper. Also, I found this method very useful given the generalities I've had to apply. By using this method, I'm able to rule out potential locations that were previously planned for and make recommendations for new ones. I'm also better able to give a general recommendation for how rotary and fixed wing can be used within the region to deliver supplies and cargo. Attached to this quantitative look at the problem, I've included a brief governance strategy to give FEMA a better idea of what to expect from the inner workings of the DOD airlift system. The time to understand these details is not when the disaster hits, but before it with deliberate planning.

IV. Analysis

Overview

In this chapter, I'll compare lessons learned from events such as Hurricane Katrina, Hurricane Sandy, The Sumatra Earthquake, the Alaska-Aleutian earthquake, 2011 Tohoku earthquake, and conclude a general idea of where the most impacted areas would be in the Cascadia Region after a significant earthquake and Tsunami. From that, we can theorize what airstrips could be utilized and then what airframes might be best suited to deliver supplies to victims. Finally, I'll compare information from USNORTHCOMs playbook planning variables and provide a conclusion on which airframes should be utilized. It should be noted that USNORTHCOM has done extensive research with FEMA on earthquake simulations to bring about their planning factors. Much of that research has been put into a detailed plan known as the USNORTHCOM Playbook Cascadia Subduction Zone (CSZ) Catastrophic Earthquake & Tsunami Response which is an exceptional effort at laying the foundation for further detailed planning on a comprehensive response. I have the deepest respect for all the individuals that must have and still are pouring long hours into this incredible planning effort. It is by far the most detailed, in-depth, and more importantly, cross service planning effort we have undertaken for a natural disaster response. For the purposes of this paper however, I don't intend to contradict any of their planning efforts, rather use them as a tool to further my points. In addition, detailed simulations and research of Tsunami and earthquake predictions is outside the scope of this paper. What I'm trying to do here is use some of that data that's already been researched, compare it to historical events to get a rough idea of damage expectation and then draw some generalized conclusions on what airfields could reasonably be expected to survive the devastation from a CSZ event. This will help in identifying the best means of transport for supplies to earthquake and Tsunami victims.

For the purposes of this paper, I'll only be concerned with runways that exceed 3,500 feet in length and 80 feet in width due to regulations (AFI 11-2C-130V3) that stipulate minimum peacetime runway lengths of 3,000 feet plus 500 feet for max efforts and a minimum runway width of 80 feet. These are the minimum requirements for a runway to support a C-130 and

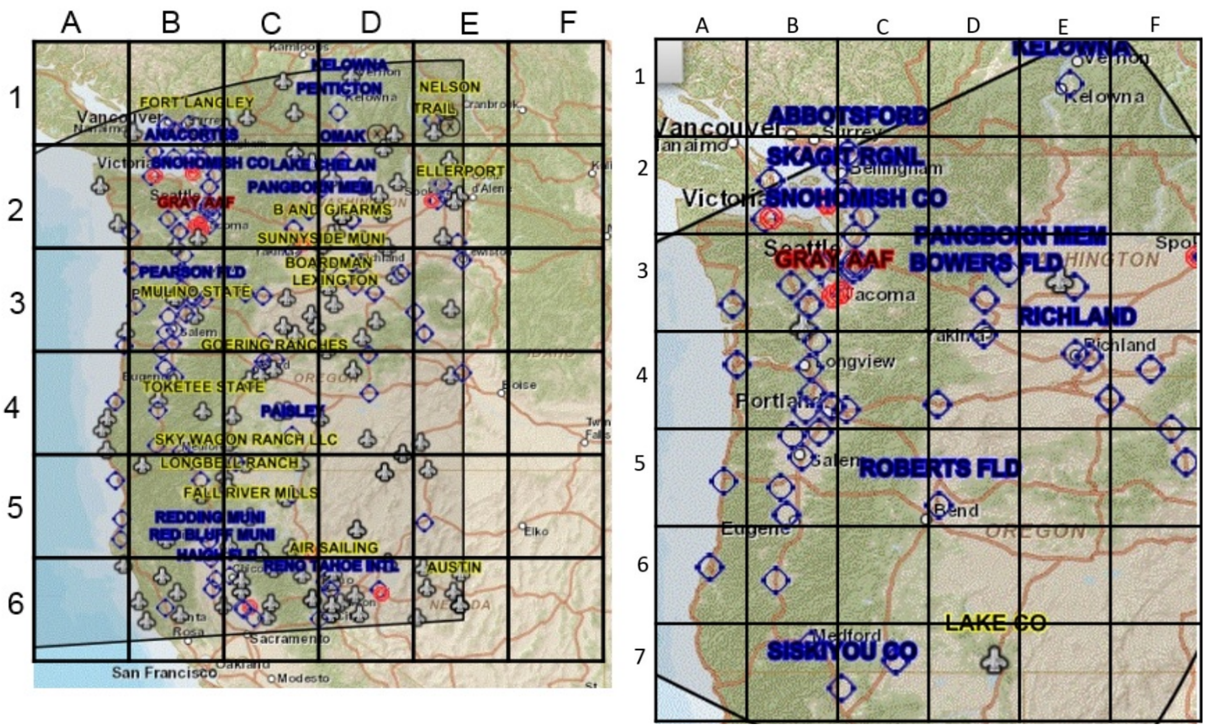


Figure 7 shows all the airfields without runway length and width limitations on the left and only those runways meeting the criteria for a C-130 on the right. I produced these charts with data from the National Geospatial Intelligence Agency.

without tactical C-130 support, it will be extremely difficult to open, operate, and sustain a secluded runway for both search and recovery operations as well as supply delivery. For those locations with minimum infrastructure that cannot support C-130's, only supplies received via ground or airdrop will be viable operations as rotary wing will not be able to operate out of an austere airfield that cannot be sustained by C-130. Most likely, many airfields, while perhaps not sustainable for C-130's, can be sustained via ground operations but that it outside the scope of this paper. The National Geospatial Intelligence Agency provides airfield information for the Cascadia Region which I overlaid onto a quadrant map of that area. By breaking up the Cascadia region in quadrants, we can better visualize and break down what areas would be most impacted by both a 9.0+ earthquake and the follow-on tsunami. Again, for the purposes of this paper, I only utilized airports that included the following parameters: active civilian, active joint, active military, active airfields with few facilities, abandoned but usable, minimum 3500 feet in length, 80 feet in width, and the runway being of permanent material. The left panel in figure 7 above shows all available airstrips in the area. The right panel in figure 7 above shows only those that meet my parameters. One can see that the latter becomes a much more manageable and realistic list of airstrips that can be utilized.

Expected Damage Area

First, we know that after Hurricane Katrina hit, areas were flooded with standing water after the storm surge inland at an approximate 6-mile range at its worst locations (C&C Technologies, 2005). Similarly, the Tsunami from the 2011 Tohoku Earthquake and subsequent tsunami reached as far inland as six miles as well, all the way to the city of Sedai.(Baron, 2011). Hurricane Sandy proved to be more complex. While flooding was experienced as far inland as 8 miles, this was primarily due to the inner waterways branching off from Raritan Bay. Much of the East coast is made up of small islands, inlets, bays, deltas, and intercostal which make these area's much more susceptible to flooding when major hurricanes hit. Regardless, using this data, we can assume that tsunami flooding at the Cascadia region would likely be similar to

Japan and New Orleans with flood waters breaching six miles inland. It's very evident that while six miles will primarily be secluded to the coastal towns in Washington and Oregon, the inter waterways around Seattle and Tacoma are very susceptible, assuming the tidal surge from the Tsunami makes its way in and around those bays and inlets. It's noted however that Joint Base Lewis-McChord (JLM) actually sits right at 6 miles inland from its bay inlet, and even if the Tsunami surge were able to somehow wind its way around all the inlets to the city of Tacoma, JBLM would not be flooded for long, especially given its elevation of 365 feet above sea level. Note the fact that the tsunami reached maximum heights of 115 feet after the 2004 Sumatra earthquake. In fact, other than Seattle-Tacoma International Airport (Sea-Tac), it can be reasonably assumed that most major airstrips in the state of Oregon and Washington would be relatively unscathed from the Tsunami. While Sea-Tac does reside slightly higher than JBLM in elevation at 433 feet, it's located only two miles inland and sits higher up on the inlet towards the bay than JBLM. Because of these variables, it's hard pressed to assume it won't be hindered from the Tsunami. However, its elevation gives it a significant advantage, and it should be one of the first airfields to be assessed for damage in the aftermath of the earthquake and Tsunami. With regard to strategic and tactical locations for resupply and delivery of aid and workers, the water ports will be the most devastated by a Tsunami. Understanding this destruction is critical due to the geography of the Cascadia region and becomes significant when you realize that all airports along the coast would be devastated from the Tsunami so even if a water port were to survive the incredible waves, there would be no airport to shuttle the supplies from those locations. In essence, supplies would sit at those water ports and go no further. This is why airstrips (to include JBLM) is so critical to the response effort. They lie many miles down a twisting water inlet which could shield them from the main force of the tsunami and provide a critical multi-modal hub for strategic offload for boats and a tactical onward movement for helicopters and fixed wing. Also, having an aircraft carrier off the coast will provide an enormous advantage. However, that is outside the scope of this paper.

The earthquake will create more significant problems than the resulting Tsunami with regard to airfield damage and denial. The USNORTHCOM plan states that “much of the damage will be limited to those airfields between the coast and the I5 corridor, thereby allowing response forces to use airfields east of the Cascade Mountains to reach the affected area”. However, it should be a top priority to find a usable airfield west of the Mountains or repair one immediately since most of the aid required after an earthquake will be needed in that area. I don’t think it can be overstated to say that trucking supplies through the mountain range simply isn’t responsive enough.

Available Airstrips

Tsunami

USAFNORTH has determined with regard to R-11 utilization, Port Angeles (WA), Shelton (WA), Vancouver/Pearson Field (WA), and Troutdale (OR) will not be available to use (Glenn, 2016). This capability is primarily centered on its fuel capability and not necessarily its infrastructure integrity. This is an important factor because if we cannot maintain fuel at a certain location, it does little to no good to stage airlift assets there. However, their planning factors have included JBLM (WA), Newport Airfield (OR), Hillsboro Field (OR), Redmond Airfield (OR), Kingsley Field (OR), Cape Blanco Airfield (OR), Yakima (WA), and Travis AFB (CA) as airfield locations that can support refueling and defueling operations. It’s important to note several factors with these planning assumptions. First, FEMA and the DOD have identified through the USNORTHCOM Playbook, JBLM, Travis AFB, and Kingsley Field as DOD Base Support Installations (BSI’s). “BSIs/Type I Federal Staging Areas (FSAs) 464 in the I5 corridor and coastal areas will be overwhelmed for the initial response, but are geographically positioned to best support the response, so their available capacity will be leveraged. As a result, this operation will require the use of multiple installations and the logistics/force flow will need to be carefully prioritized" (USNORTHCOM, 2016). These installations are critical nodes for the staging of supplies and will need to have fuel for incoming fixed wing and outgoing rotary wing assets. In addition, Hillsboro Field (OR), Yakima Field (WA), Newport Airfield (OR), and Cape Blanco Airfield (OR) have been identified by AFNORTH as locations for R-11 support which means the R-11's would have to be flown in but once they are, they will have fuel for helicopter missions, both search and recovery and those delivering water and supplies. Not mentioned in the planning factors, however, is that both Newport and Cape Blanco sit about half a mile from the coast which means they will be impacted by the Tsunami, if not the earthquake itself.

Figure 8 Google map photo of Newport Municipal Airport (note its proximity to the coast).

If the planning factor is to assume Newport and Cape Blanco will be available, additional planning will be needed for the bedding down of forces with regard to life support. At the very least, the surrounding area will be slow to drain from the flood waters, if not the airfield itself and space might be limited for sustaining any significant number of people and operations.

For alternative airfields to Newport and Cape Blanco, I turn to my quadrant map of airfields in the area but at least six miles inland as to avoid repercussions from the tsunami. Newport is located in quadrant A6 and Cape Blanco would normally be located within quadrant A7 but it's not listed on my map due to not meeting my parameters for a suitable airfield for C-130's. Most likely it's due to the runway condition which is different from that of Newport. In fact, all airfields located in quadrants within the A column are considered susceptible to significant impact from Tsunami and for the purposes of this paper, will not be considered viable options for staging areas. They should, however, be considered as primary candidates for initial assessments after the Tsunami as they could prove vital to linking up multimodal logistical support. Also, according to the USNORTHCOM/USTRANSCOM Interagency Transportation Feasibility Analysis conducted in 2016, it was determined that during a "RED" scenario which is assumedly a worst-case planning concept, both Bowerman and Astoria airfields are taken as a loss due to proximity to the coast and will "significantly challenge simultaneous deployment concepts. Notice that these are the two airfields located in quadrant A2 and A3 respectively and will be incapacitated due to a tsunami. Astoria would be the largest loss due to it having three runways and significant infrastructure capable of housing support personnel and victims.

Earthquake

Based on earthquake modeling, USNORTHCOM has planned for all airbases within the I5 corridor (west of the Cascadia mountains) to essentially be unable to support any fixed wing airframes. In addition, all airfields east of the Cascadia Mountains should be able to withstand any shaking from the earthquake and can be counted on for immediate use. According to

Cassidy (2016), the coastal airbases will also be subjected to coastal subsidence and uplift. Essentially, the earth along the coast will both fall and rise creating areas dramatically higher or lower than before the earthquake. This is important because it can cause additional flooding along the coast and tear huge rifts into the earth in the same area where those critical airstrips lie. According to the Modified Mercalli Scale and as recorded during the Sumatra subduction earthquake, intensity levels VII and VIII are the lowest areas that will create damage that could render airstrips unusable. These intensities occurred under 100 miles for levels VIII and up and

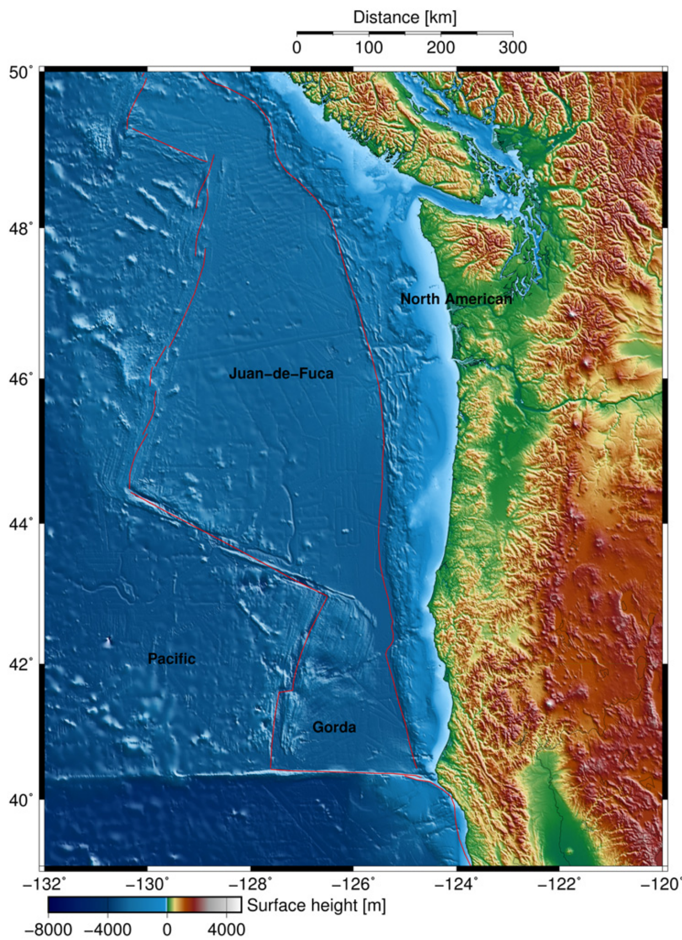


Figure 9 Image source: Outline of Juan de Fuca plate (Sanders, 2015).

up to 250 miles for level VII and below. When measuring these distances, it's important to take into consideration where the epicenter will be. In this case, it'll be along the Juan de Fuca plate subduction zone which can be seen approximately 30 to 50 miles off the coast, depending where on the coast you are. In figure 9 below, the outline of the Juan de Fuca plate can clearly be seen. This data was captured by the largest seismologist project ever undertaken at the cost of $20 million dollars. It required the placement of 120 seismic instruments along the plate's subduction areas and mapped how the mantel was flowing under the Juan de Fuca plate (Sanders, 2015). With these key distances in mind, one can see that the intensity zone VIII as recorded during the Sumatra quake where "poorly constructed buildings were destroyed" (Modified Mercalli Scale further above), extends all the way to the Cascadia Mountain range. This is not good news for airfields that fall anywhere within the I5 corridor. This includes all airfields from B1 to B7 and even C1 to C7 on the grid. This data does not necessarily deviate from USNORTHCOM planning, however, it does impede on some of USAFNORTH's planning concepts with regard to where they'll station refueling bases in the I5 corridor region. Initially, any base in the I5 corridor region will have to be ruled out for immediate use, however, it probably won't take long to survey the bases closest to the western edge of the mountain range utilizing remotely piloted aircraft or U2's to see that some airfields are either still operational or would only require minimal construction to get them worthy of accepting C-130's. According to Haulman (2006), the 99th Reconnaissance Squadron from Beale Air Force Base in California flew U-2's over the disaster area for aerial photography and imagery, while the 45th Reconnaissance Squadron from Offutt Air Force Base in Nebraska flew OC-135's for the same purpose. In addition, USNORTHCOM has identified Light Airfield Repair Packages (LARP) that can be put onto a C-130 and airdropped to various bases. The capability of the LARPs include repairing airstrips within a 12 hour period for C-130 operations. Due to the extreme nature of a Cascadia Earthquake and the potential damage it could cause to many of the airstrips on the west side of the Cascadia Range, USNORTHCOM has pushed the 12 hour planning timeline for airfield repair (once a LARP package arrives) out to 24 hours.

The LARP packages will be necessary, as even the airport on the west side of the Cascadia Range furthest from the subduction zone (Portland Troutdale Airport) lies within 130 miles of the epicenter and will be subjected to intensity VIII damage. This includes every airport in the I5 corridor to include Seattle-Tacoma International and Joint Base Lewis-McChord. Where does this leave us with the closest airfields that are capable of supporting C-130's and lie outside intensity zone VIII? Utilizing the National Geospatial Intelligence Agency website, one can see that Pangborn Memorial Airfield (7,000 foot runway), Bowers Airfield (5,590 foot runway), Yakima Air Terminal/McAllister Airfield (7,604 foot runway), Columbia George Regional Airport (5,097 foot runway), Crater Lake Klamath Regional Airport (10,300 foot runway), and Bend-Redmond Airport (5,097 foot runway) all lie immediately to the east side of the Cascadia, closest to the coast but outside the intensity VIII zone. These are the locations of the tactical C-130 bases that will be the first line of supply staging. From here we will be able to operate rotary wing assets for delivering supplies to victims on the other side of the Cascadia Mountains, for pushing out LARP packages, for onward movement refueling operations, for airdropping supplies to designated drop zones, for immediate forward staging of medical and logistical equipment, and to act as the half-moon hub pushing out the spokes to the other side of the Cascadia Range. From these locations we can fly supplies out to airbases on the other side of the range once identified from reconnaissance as being suitable for forward staging. Without hesitation, the DOD should be preparing to utilize these airfields immediately after a Cascadia Zone event. This is where some of USNORTHCOMs planning begins to slightly deviate. They are planning to use Fairchild, Travis, and Beale AFB as strategic DOD staging hubs, or Base

Support Installations (BSI's). In addition, Installation Support Bases for FEMA will be established at Grant International Airport (Moses Lake), Bend-Redmond Airport, and FSA's at Marion Sweet Field, Everett Pain Field, Bellingham Airport, McNary Field, and JBLM. For starters, Grant International is labeled as one with "few facilities" according to the Geospatial data. In addition, Bellingham, Everett, McNary, Marion Sweet, and JBLM all fall in the intensity VIII zone which make them very susceptible to damage. Despite this, they should be put on the priority list for airfield assessments. According to the USNORTHCOM playbook, "the priority assessment will be SEATAC Airfield in Seattle, WA and Portland International Airfield in Portland, OR due to their capacity and then coastal airfields Bowerman Airfield (Aberdeen, WA), Newport Municipal Airport (Newport, OR), Willapa Airport (South Bend, WA), and Tillamook Airport (Tillamock, OR). Additional airfields are Fairchild Airfield (Port Angeles, WA), and Southwest Oregon Regional Airport (Coos Bay, OR)".

"Key planning factors include FEMA's request for the DOD to simultaneously push capabilities to the three geographic regions (Coastal, I5 corridor and East of the Cascades) as part of FEMA's comprehensive and coordinated movement plan" (USNORTHCOM, 2016). For this, the DOD has determined its initial priorities as:

- Assessment and opening of airfields in the Coastal and I5 Corridor
- Aerial Search and Rescue (SAR)
- Lifesaving urban search and rescue and medical capabilities to the Coastal area of operations
- Incident awareness and assessment
- Additional key transportation, life sustaining, and logistical enablers to facilitate opening of the transportation pipeline

Figure 10 below outlines the DOD overarching concept of operations as taken from the USNORTHCOM playbook.

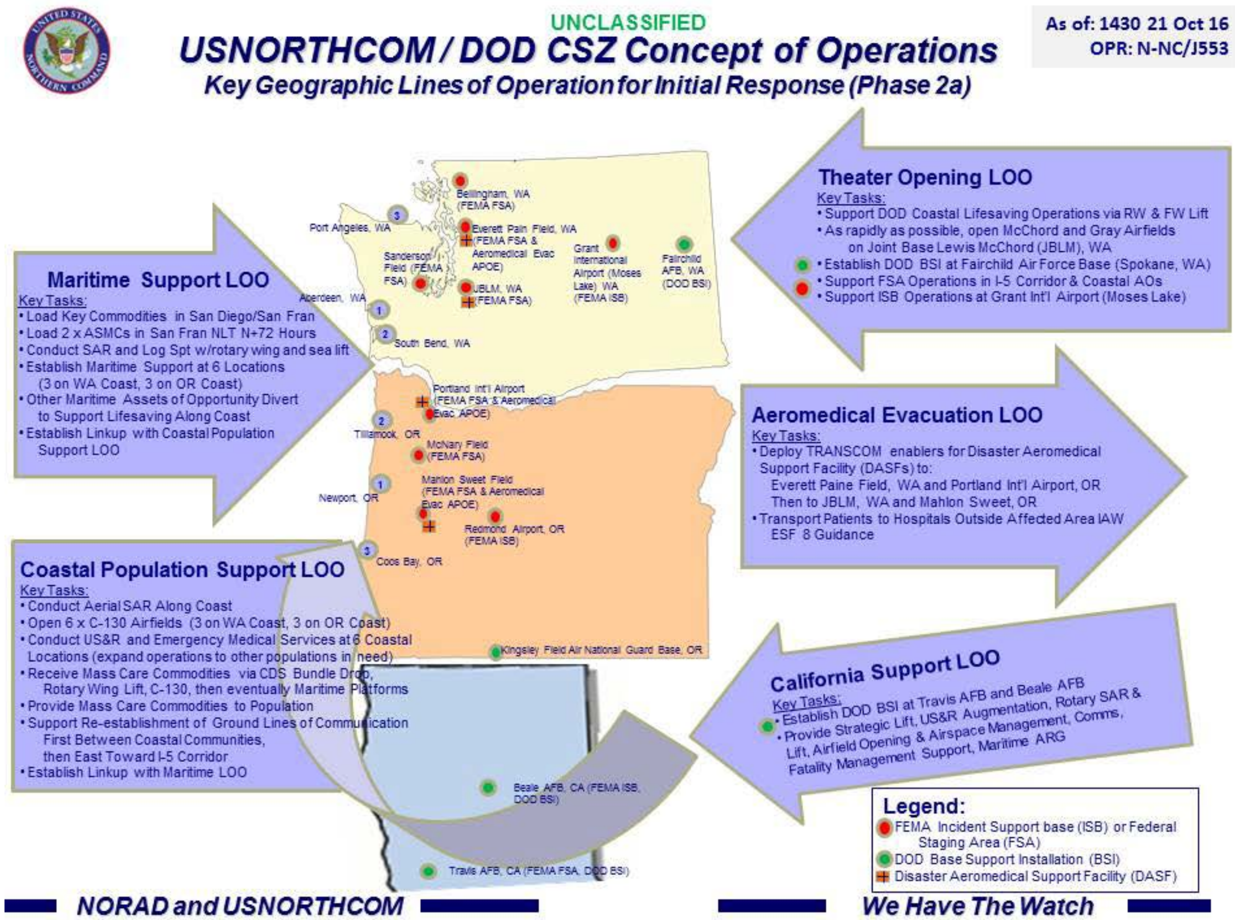


Figure 10 Image source: USNORTHCOM/DOD CSZ Concept of Operations (USNORTHCOM, 2016).

Accordingly, pending initial airfield assessments, the life-saving, life-sustaining, and medical and logistical capabilities for the coastal region right after the earthquake will have to be carried out by rotary wing and vertical takeoff and landing (VTOL) aircraft. This holds true per my analysis based on the tsunami data and after action reports from the other major natural disasters. Note that USNORTHCOM is also planning on utilizing Port Angeles, and South Bend

(Willapa Harbor Airport) which will both be extremely susceptible to tsunami devastation due to their proximity to the ocean.

The rotary wing aircraft have a limited range however, so their operations will be limited to a relatively short radius (couple hundred miles at most) around 504 nautical miles according to the US Air Force fact sheet on the HH-60G Pave Hawk. This means 250 miles one way and even less with the added weight of food, supplies, and/or rescued victims.

V. Conclusion

General Conclusions and Recommendations

The USNORTHCOM playbook does an exceptional job at producing a foundation for our response to a CSZ event. Despite this, however, there are still many lessons learned that can be incorporated into the plan but will take time to properly integrate. Included in the plan should be a lessons learned section which will help set the stage for why various decisions were made for the planning factors used. An effort this massive will undoubtedly make it difficult to not only incorporate every contributing organizations planning assumptions and needs but to ensure they are integrated using the same assumptions and modeling data.

There are many lessons learned from previous HA/DR efforts. In addition, subduction zone earthquakes similar to what will be expected from a Cascadia event have occurred in the recent past. The Sumatra event is a perfect learning experience since modern instruments were used to record the effects of that earthquake. These events should be studied more in depth, and their responses further analyzed and compared to what we are planning after a Cascadia earthquake. This will ensure we are not doomed to make the same mistakes over and over again.

It's recommended that USNORTHCOM also think about planning efforts with state and local agencies in the use of FirstNet. While the DOD tends to focus solely on their own operational stove pipe, it's essential that we also, if not integrate our communication systems with FirstNet, adapt to FirstNet so that we can plug into that critical infrastructure and gain the efficiencies from communication without hindrance across all agencies and borders. After action reports show time and time again that communication is one of our primary shortfalls during HA/DR events. Having access to the network is only the first step. It's also imperative we have listings of emergency management offices we know we'll want to communicate with immediately after a CSZ event such as emergency airfield response teams. We know during these events there are multitudes of organizations working together to accomplish the same goal, which is to relieve pain and suffering. It's something that we've gotten better at but we now have this opportunity to continue improving our process with FirstNet and create a standardized method of communicating with first responders in the DOD and other governmental organizations.

The results from USNORTHCOM and FEMA's modeling simulations hold true for the most part. While they ultimately have more realistic data than I have access too, I can only come to my conclusion based on my own analysis. To that extent, I conclude that the general assumptions about the airfields along the coast being disrupted from the tsunami and earthquake which are centered along my A1 and B1 quadrants are accurate. This extends to the airfields throughout the I5 corridor. Where my conclusions slightly deviate is with the initial base utilization. In addition, it appears planning efforts put an extensive amount of resources at the strategic hubs (Travis, Beale, Fairchild) but spreading those resources out among multiple bases closer to the eastern foot of the Cascadia (my C1 and D1 quadrants) and creating a more half-moon hub and spoke system could create efficiencies for delivering supplies and make coordinating the recovery operation more manageable. The below information outlines other areas of interest that are findings based on my research which potentially could use a second look at while planning for a CSZ event.

In the aftermath of Katrina, it was found that incorporating the movement of people out of the affected areas by the hurricane was extremely efficient. Since the strategic lift had delivered their supplies and were heading back to other primary staging areas, it was a perfect opportunity to transport victims outside of the affected area so they could receive proper medical attention. It's possible USNORTHCOM is already planning to use this method but it's not mentioned in their Playbook and thus requires mentioning here.

DOD could find significant benefits by utilizing the Tsunami tracking systems to better prepare JBLM and other locations holding response assets. If they are to play a pivotal role in the initial response effort, they will need as many of their assets and people ready to deploy immediately. However, it's not only the earthquake that will prove detrimental to their efforts but also the tsunami. Knowing if and when it will hit, the DOD can move their aircraft, personnel, and equipment in areas on the base that would potentially be least affected by the tsunami. The DOD would also be able to immediately tailor their response plan in real time depending on where the tsunami hit.

Placing boats in reserve status and locations would be extremely beneficial to accessing those areas flooded by the resulting tsunami. This proved essential after Hurricane Sandy and will undoubtedly be beneficial within that 6-mile range from the coast. Utilizing UH-1s for the response effort proved enormously beneficial (if not unexpected) during the Katrina relief effort. These assets came from the northern tier bases which are even closer to the Cascadia region then they were to Katrina. There is no reason why they shouldn't be incorporated into USNORTHCOM's planning efforts.

During the Hurricane Sandy response, the Navy deployed three boats from the Amphibious Ready Group which contributed Marines and rotary wing. These assets, along with the Air Force Special Ops MC-130's and HH-60's provided incredible response effort for intra-theater ops. The amphibious group was not identified in USNORTHCOMS planning, but if it worked so well in the past, it could be something to look into for future planning efforts.

The First Responder Network is something the DOD might want to participate in for many reasons. The USNORTHCOM Playbook states, “After a Tsunami, in Washington, the majority of coastal communications infrastructure will likely be severely damaged and inaccessible to repair crews. Those facilities along the immediate coastline will likely be destroyed by the predicted tsunami wave. Communications in these areas may be limited to radio frequency and satellite telephones. Oregon. Like Washington, the coastal communications infrastructure will be severely impacted by the earthquake and resultant tsunami.” For this reason alone, it’s imperative that we have capable communication with local and federal response agencies, especially since the DOD will be participating in a supporting role.

Dual status commander was used effectively during Hurricane Sandy relief efforts. According to the USNORTHCOM Playbook, “In the event capabilities of the State and 179 AKNG are exceeded and the Lead Federal Agency determines that DOD has the 180 required capability, a Dual Status Commander (DSC) may be considered”. I don’t think this is hard lined enough and given the significant amount of guard and reserve forces that will be deployed in support of a CSZ effort, a dual status commander should not be a “consideration”, rather it should be an expectation.

Newport Airfield (OR), and Cape Blanco Airfield (OR) will be destroyed by a tsunami but, AFNORTH is planning on utilizing both for R-11 support. Cape Blanco does not meet C-130 requirements, so its capabilities are extremely limited. This is something USNORTHCOM might want to take a closer look at. FEMA is planning on establishing operations at Grant International Airport (Moses Lake), Bend-Redmond Airport, and FSA’s at Marion Sweet Field, Everett Pain Field, Bellingham Airport, McNary Field, and JBLM. According to the Geospatial data and discussing with several pilots within my class that have experience with Grant, it’s not a suitable airfield for staging a relief effort. More consideration might want to be given for this location. In addition, Bellingham, Everett, McNary, Marion Sweet, and JBLM all fall in the intensity VIII zone which make them very susceptible to damage and should not be immediately relied upon without a proper survey. Utilizing the National Geospatial Intelligence Agency website, one can see that Pangborn Memorial Airfield (7,000 foot runway), Bowers Airfield (5,590 foot runway), Yakima Air Terminal/McAllister Airfield (7,604 foot runway), Columbia George Regional Airport (5,097 foot runway), Crater Lake Klamath Regional Airport (10,300 foot runway), and Bend-Redmond Airport (5,097 foot runway) all lie immediately to the east side of the Cascadia, closest to the coast but outside the intensity VIII zone which makes them perfect candidates for forward staging locations. Most of these, however, are no mentioned in USNORTHCOM's Playbook. Note that USNORTHCOM is also planning on utilizing Port Angeles, and South Bend (Willapa Harbor Airport) which will both be extremely susceptible to tsunami devastation due to their proximity to the ocean.

After Katrina, Unmanned Aerial Vehicles and USAF U2s were used for surveillance and provided critical coverage of assessing the damaged zones. In the case of a CSZ event, the USNORTHCOM Playbooks states "However, the employment of UAVs can be a challenging due to the OSD(P) policies and Federal 3552 Aviation Administration restrictions." This should not be a roadblock, especially during a humanitarian crisis. Also, the U2's are stationed out of Beale AFB with the 99th Reconnaissance Squadron. All effort to clear the path for using these invaluable reconnaissance assets should be made in advance, so when the time comes after a CSZ event to use them, there will be no delay in their deployment.

Lastly, the use of a Joint Task Force Port Opening (JTF-PO) element could prove valuable in bridging the oceanic, ground, and air lines of transportation. Not much is mentioned about the use of JTF-PO but if used in the right locations, could prove instrumental in a multimodal delivery of supplies to victims.

Recommendations for Future Research

There are many different subjects that could easily be expanded on for the benefit of this topic. Some of those include the capabilities of port operations after a Cascadia Earthquake and how those operations could be incorporated into a multimodal system for logistics support. This will be a key ingredient to the recovery plan if maritime resources should play a significant role, which they should. Another important area of future research would be an analysis of the best locations for air dropping supplies and equipment. It's no secret to anyone involved in the planning process for a CSZ event that some supplies will simply have to be air dropped into some areas due to their remote location or their crumbled infrastructure. Helicopters simply can't push out the bulk supplies of food, water, and medical needs that some populated areas need so we'll have to rely on C-130's and C-17's to air drop those supplies in the absence of any useable runway or ground lines of transportation. Further research should be done on the staging of fuel for rotary wing and fixed wing assets. Some work has been accomplished in this area but it doesn't appear that any earthquake modeling or shake data has been incorporated to that planning.

Future technologies such as the use of drones to deliver supplies are increasingly becoming a reality, but we need to have a comprehensive plan for how they will be operated and in what capacity. Drones can contribute a capability that we've never had in past relief efforts to include immediate aerial scouting, reconnaissance of damaged locations, delivery of supplies (albeit limited quantities), and even as a means of delivery communication equipment to victims in order to communicate quicker and easier with those in need. Most of these tasks can even be done via automated or autonomous drones.

Appendix

Appendix A

Photographs of the Aleutian-Alaska Subduction Zone had a 9.2 earthquake in 1964 pulled from the Unites States Geological Survey website

Air traffic control tower at Anchorage Airport (Survey, 1995)

Alaska railroad rails torn from its ties (Survey, 1995)

Raised Shoreline from the thrust of the Aleutian-Alaska plate (Survey, 1995)

Fissures opened on highway near Portage, AK (Survey, 1995)

Appendix B.

FEMA Emergency Support Function Outline

EMERGENCY SUPPORT FUNCTION ANNEXES: INTRODUCTION

Purpose

This section provides an overview of the Emergency Support Function (ESF) structure, common elements of each of the ESFs, and the basic content contained in each of the ESF Annexes. The following section includes a series of annexes describing the roles and responsibilities of Federal departments and agencies as ESF coordinators, primary agencies, or support agencies.

Background

The ESFs provide the structure for coordinating Federal interagency support for a Federal response to an incident. They are mechanisms for grouping functions most frequently used to provide Federal support to States and Federal-to-Federal support, both for declared disasters and emergencies under the Stafford Act and for non-Stafford Act incidents (see Table 1).

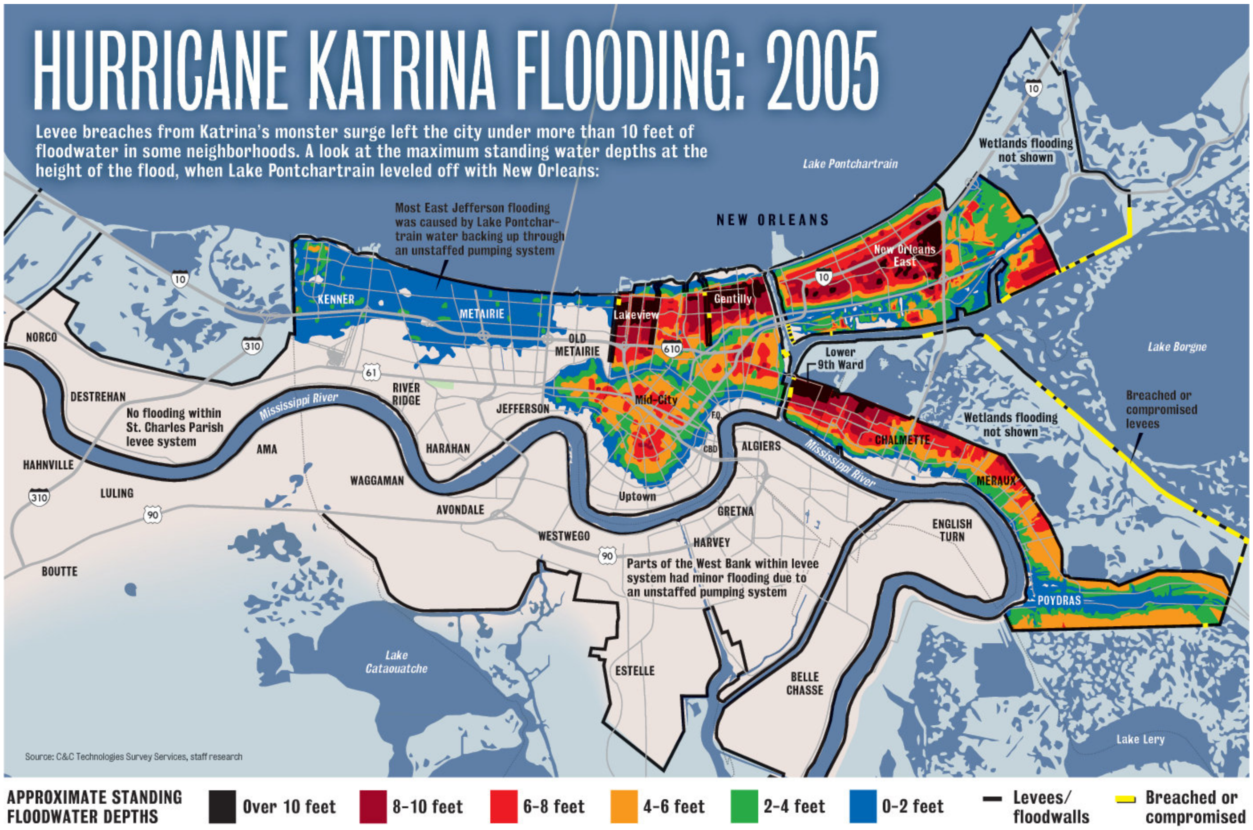
The Incident Command System provides for the flexibility to assign ESF and other stakeholder resources according to their capabilities, taskings, and requirements to augment and support the other sections of the Joint Field Office (JFO)/Regional Response Coordination Center (RRCC) or National Response Coordination Center (NRCC) in order to respond to incidents in a more collaborative and cross-cutting manner.

While ESFs are typically assigned to a specific section at the NRCC or in the JFO/RRCC for management purposes, resources may be assigned anywhere within the Unified Coordination structure. Regardless of the section in which an ESF may reside, that entity works in conjunction with other JFO sections to ensure that appropriate planning and execution of missions occur.

Table 1. Roles and Responsibilities of the ESFs **ESF**	**Scope**
ESF #1 – Transportation	Aviation/airspace management and control Transportation safety Restoration/recovery of transportation infrastructure Movement restrictions image and impact assessment
ESF #2 – Communications	rdination with telecommunications and information technology industries Restoration and repair of telecommunications infrastructure Protection, restoration, and sustainment of national cyber and information technology resources Oversight of communications within the Federal incident management and response structures
ESF #3 – Public Works and Engineering	rastructure protection and emergency repair Infrastructure restoration Engineering services and construction management ergency contracting support for life-saving and life-sustaining services
ESF #4 – Firefighting	rdination of Federal firefighting activities Support to wildland, rural, and urban firefighting operations

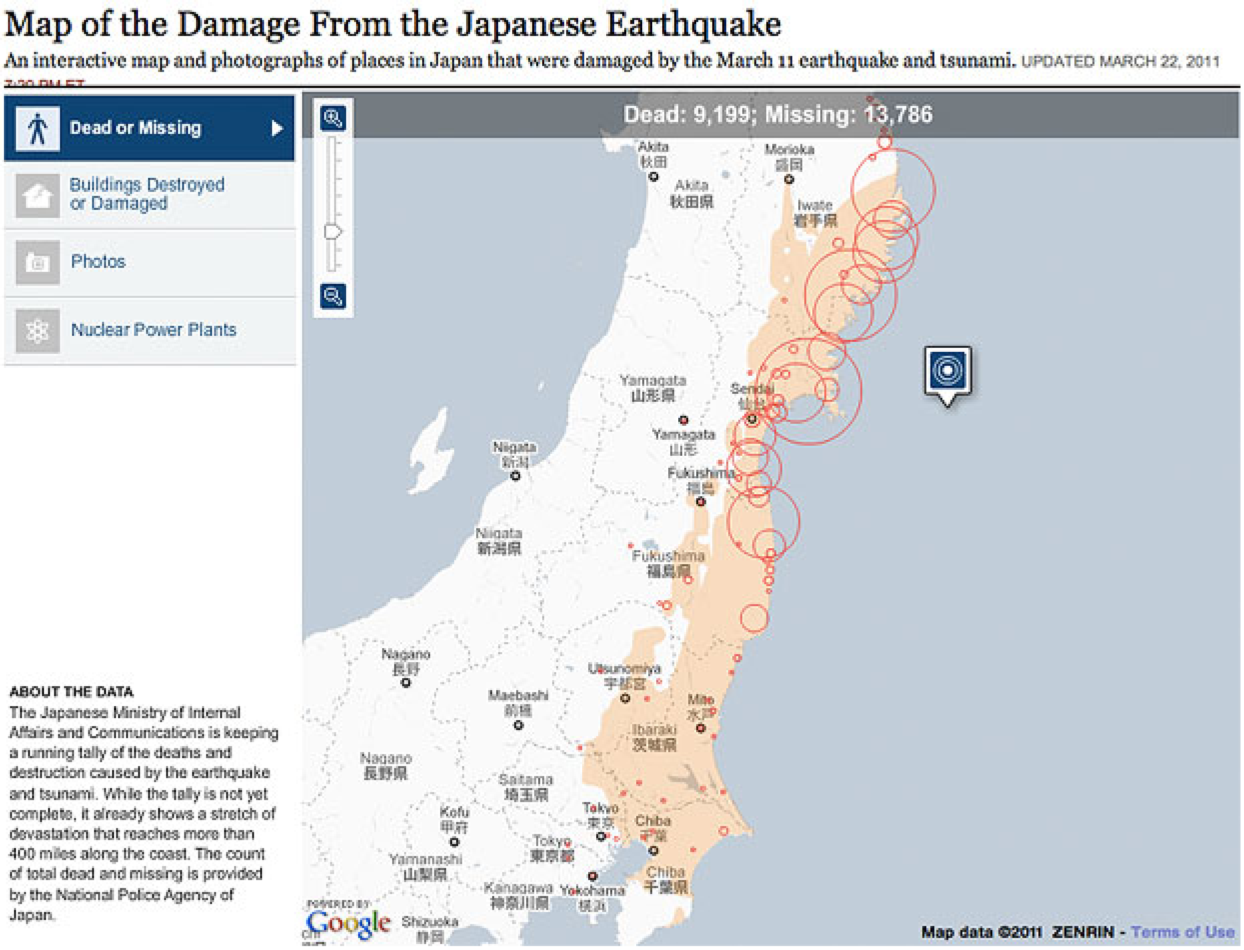
Appendix C.

Hurricane Katrina Flood Map from C&C Technologies Survey Services



Appendix D.

Map of the 2001 Japanese Tsunami Damage Area



Appendix E.

Quad Chart

Cascadia Subduction Zone Earthquake Basing and Supply Delivery Strategy Based on Current Planning and Historical Event Analysis

Maj Michael E. Ridley
Advisor: Dr. Paul Hartman, Ph.D.
Advanced Study of Air Mobility (ASAM)
Air Force Institute of Technology

Introduction

The Cascadia Subduction Zone (CSZ) spans two countries, three states, and is expected to produce one of the largest earthquakes in US history. To compound the problem, this fault wasn't known to be active until 25 years ago which has resulted in much of the infrastructure in that area not having been built to withstand such a large magnitude earthquake.

Shuttling supplies to quake victims after a CSZ earthquake presents significant challenges in coordination between all three state governments to include the multitude of local and federal agencies which in itself is unprecedented for a humanitarian response within the United States. Communication between all support entities will be the largest challenge which is why new new technologies need to be leverage. Also, a tsunami will make the delivery of supplies and communication among first responders that much more challenging along the coastal region. While current planning efforts within USNORTHCOM and FEMA is extensive, additional research based on historical evidence can be exceedingly useful. This paper ties that historical perspective into those planning efforts to better understand what is required to respond to a Cascadia Subduction Zone event.

Research Questions

1: What did similar historical disaster relief efforts look like?

2: Based on that, what are probable airstrips and staging areas that we can count on?

3: Should we use fixed or rotary wing to shuttle supplies and how will they be used?

4: What is the process for FEMA to request airlift?

5: What is the best method of communication amongst all agencies involved?

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Analysis

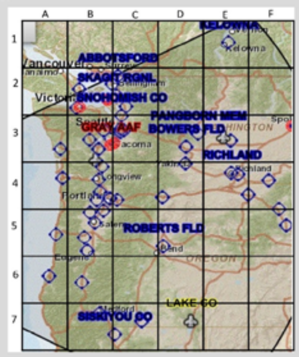
By analyzing historical relief efforts, I added additional planning variables to what USNORTHCOM has already accomplished. In addition, I've outlined the governance strategy for FEMA to request airlift through USNORTHCOM and highlighted the need and importance for the DOD to plug into the First Responder Network which will be utilized by all other government agencies in the very near future.

Historical Data

By utilizing data from past tsunamis and hurricanes, we can identify probably distances that a tsunami would travel inland.

Japan 2011 tsunami, Indonesia 2004 tsunami and both hurricane Sandy and Katrina all point to an approximate 6 mile inland distance that a tsunami will travel which will affect some of the planning assumptions used by USNORTHCOM.

In addition, there are several strategies that worked well in the past but were not included on the planning efforts for a CSZ event such as the use of shuttling personnel out of the effected zones via supply transports on their reverse leg, the use of the UH-1 helicopters, and the prepositioning of amphibious assets.



Category	Effects	Richter Scale (approximate)
I. Instrumental	Not felt	1-2
II. Just perceptible	Felt by only a few people, especially on upper floors of tall buildings	3
III. Slight	Felt by people lying down, seated on a hard surface, or in the upper stories of tall buildings	3.5
IV. Perceptible	Felt indoors by many, by few outside; dishes and windows rattle	4
V. Rather strong	Generally felt by everyone; sleeping people may be awakened	4.5
VI. Strong	Trees sway, chandeliers swing, bells ring, some damage from falling objects	5
VII. Very strong	General alarm; walls and plaster crack	5.5
VIII. Destructive	Felt in moving vehicles; chimneys collapse; poorly constructed buildings seriously damaged	6
IX. Ruinous	Some houses collapse; pipes break	6.5
X. Disastrous	Obvious ground cracks; railroad tracks bent; some landslides on steep hillsides	7
XI. Very disastrous	Few buildings survive; bridges damaged or destroyed; all services interrupted (electrical, water, sewage, railroad); severe landslides	7.5
XII. Catastrophic	Total destruction; objects thrown into the air; river courses and topography altered	8

First Net & Governance Strategy

All historical disaster response efforts highlight the need for better communication which is exactly what First Net does. However, it's not currently being adopted by the DOD.

There are many variables in the governance strategy that will be tailored by FEMA/USNORTHCOM based on the actual event details.

Methodology

Qualitative method based on literature reviews from scholarly reviewed journals and current planning efforts from USNORTHCOM, FEMA, and other agencies.

Recommendations

1. Strategically place amphibious assets so a quicker response effort can be implemented around those areas most affected by the tsunami
2. Develop a process for the DOD to integrate into the First Responder network
3. Dual commander status needs to be identified in the planning stages since a significant amount of reserve and guard forces will be utilized for the response effort
4. Have an immediate plan for how the DOD will plug into the tsunami tracking system so only those assets hit by the tsunami will be immediately assessed for tsunami damage
5. Reassess the use of Newport Airfield and Cape Blanco Airfield for R-11 support after the CSZ event (possible tsunami damage)
6. Reassess the use of Grant International Airfield for C-17 support
7. Utilized a JTF-PO to bridge the ground and air movements

Collaboration

USNORTHCOM, FEMA, USTRANSCOM

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14. ABSTRACT
If the historical occurrence of earthquakes are any indication of predictable date range and magnitude, then the Cascadia Subduction Zone (CSZ) presents us with a catastrophe of proportions never before seen in the United States. While nestled in the ring of fire, the Juan de Fuca subduction plate is unique in that is spans two countries, three states, lies along a coast (promotes tsunamis), rests along an entire mountain range formed by thousands of small volcanoes, and is expected to produce one of the largest earthquakes in US history thanks to its subduction properties. To compound the problem, we didn't know this was an active fault until 25 years ago which has resulted in much of the infrastructure in the quake zones not having been built to withstand such a large magnitude earthquake. Shuttling supplies to quake victims after a CSZ earthquake presents significant challenges in coordination between all three state governments to include the multitude of local and federal agencies which in itself is unprecedented for a humanitarian response within the United States. Communication between all support entities will be our largest challenge which is why we need leverage new technologies. In addition, a tsunami will make the delivery of supplies and communication among first responders that much more challenging along the coastal region. More importantly, we need to make clear what our capabilities are for the airlift of those lifesaving supplies and how we can most efficiently execute a plan to use them when the time comes. While current planning efforts within NORTHCOM and FEMA is extensive, additional research based on historical evidence can be exceedingly useful. This paper ties that historical perspective into those planning efforts in order to better understand what we're up against with a Cascadia Subduction Zone event.

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