Investigation of Drone Applications to Improve Traffic Safety in RITI Communities

FINAL PROJECT REPORT

by

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In cooperation with U.S. Department of Transportation,
Research and Innovative Technology Administration (RITA)

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TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.

4. Title and Subtitle	5. Report Date
Investigation of Drone Applications To Improve Traffic Safety in RITI Communities	3/31/2021
	6. Performing Organization Code

7. Author(s) and Affiliations	8. Performing Organization Report No.
Xuegang (Jeff) Ban, Daniel Abramson, Yiran Zhang, Cristina Cano-Calhoun University of Washington	

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Center for Safety Equity in Transportation ELIF Building Room 240, 1760 Tanana Drive Fairbanks, AK 99775-5910	11. Contract or Grant No.

12. Sponsoring Organization Name and Address	13. Type of Report and Period Covered
United States Department of Transportation Research and Innovative Technology Administration 1200 New Jersey Avenue, SE Washington, DC 20590	14. Sponsoring Agency Code

15. Supplementary Notes

Report uploaded to:

16. Abstract

Transportation and traffic safety is a primary concern among the Rural, Isolated, Tribal, or Indigenous (RITI) communities in the U.S. Although emerging technologies (e.g., connected and autonomous vehicles, drones) have been developed and tested in addressing traffic safety issues, they are often not widely shared in RITI communities for various reasons. This research aims to explore, understand, and synthesize the opportunities and challenges of applying drone technologies to alleviate or resolve traffic safety and emergency related issues within RITI communities. The project team first sent out online surveys to communities on the outer Pacific coast of Washington State and selected the City of Westport as the study area based on the feedback. A pilot study using drones for mapping and sensing in Westport was then conducted, followed by two community meetings to explore potential drone applications. With the three outreach activities, it was found that the current need in the communities was education on drones, including training for remote pilot certification (drone license) and drone operations. Findings of this research will help guide the project team to set up specific drone-related programs in the Westport area in future research.

17. Key Words	18. Distribution Statement
Transportation; Drones; Surveys; Pilot study; Outreach Activities	

19. Security Classification (of this report)	20. Security Classification (of this page)	21. No. of Pages	22. Price
Unclassified.	Unclassified.	53	N/A

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized.**

S.I.* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
	NOTE: volumes greater than 1000 L shall be shown in m^3			
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	$candela/m^2$	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
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L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	$candela/m^2$	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

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EXECUTIVE SUMMARY

Transportation and traffic safety of Rural, Isolated, Tribal, or Indigenous (RITI) communities in the U.S. have been facing challenges. The CDC (Center for Disease Control and Prevention) in 2020 revealed that American Indians and Alaska Natives are injured or killed in motor vehicle crashes at much higher rates than other Americans (*1*). National Highway Traffic Safety Administration (NHTSA) reported that 45% of the traffic fatalities occurred in rural areas in 2020. Parallel to this, public agencies have launched multiple programs in recent years to explore the causes and solutions for transportation and traffic safety issues in RITIs, such as Tribal Transportation Safety (*2*) and Local and Rural Safety Program (*3*) from the Federal Highway Administration (FHWA), and Target Zero from Washington State (*4*), among others.

On the other hand, although emerging technologies such as UAVs (unmanned aerial vehicles, also known as drones) and CAVs (connected and autonomous vehicles) are extensively researched and heatedly discussed to improve traffic safety, few of them have been widely shared with the RITI communities due to limited funding resources, tech/equipment hysteresis, etc. Although drones have been widely applied in both urban and rural areas for several purposes (e.g., photography, agriculture), usage of drones in the RITI communities has not been fully explored. As a promising advanced technology with various applications, drones are believed to provide an economical and effective way to solve the traffic safety challenges of RITI communities. Therefore, this research aims to explore, understand, and synthesize the opportunities and challenges of applying drone technologies to alleviate or to resolve traffic safety and emergency management and response issues in RITI communities.

To achieve this, the CSET team conducted three types of activities with Pacific coastal communities in Washington State, an online survey, a pilot study, and community meetings to explore the unique needs, challenges, and issues of transportation and traffic safety and emergency management, as well as feasible solutions using drones. Through the outreach activities in the first phase of this project (*5*), the primary concern of the coastal communities focused not only on transportation but also on emergency management. Thus, the project team designed the online survey to further understand the issues in both fields and surveyed the communities through the snowball sampling process. Based on the feedback, 80% of the survey participants confirmed they would consider using drones for public works and the City of Westport was selected as an initial pilot study area. Next, the project team combined with the NSF CoPe EAGER “Coastal Hazard Planning in Time” project and cooperated with the UW NHERI RAPID Facility to deploy drones and gather data for purposes of building a 3D digital point cloud model of the Westport peninsula (supplemented with street view image data). The pilot study helped the project team learn various drone capabilities (flight duration, power capacity) and possible issues encountered during drone operations. Two community meetings were then conducted to identify drone applications in Westport. The first meeting with City of Westport Police and Public Works staff, the South Beach Regional Fire Authority, and Ocosta School District revealed that the initial barriers for drone usage in the community are the lack of drone operation skills and the lack of training for FAA-required remote pilot certification (drone license). High school students, who can learn drone technology and use the knowledge/skills to train with public agencies and use the skills for their future career, were selected for drone-related training. The second meeting was held specifically with the Ocosta school staff for detailed discussions of the training program. Findings from these data collection and outreach activities will help guide the project to establish the drone-related training program in future research.

CHAPTER 1. INTRODUCTION AND BACKGROUND

1.1. General Background

Rural, Isolated, Tribal, and Indigenous (RITI) communities in the U.S. face many challenges, including but not limited to health care, education, employment, and economics (*6*). Among them, improving RITI communities' traffic safety and emergency planning are two imperative goals. According to the Traffic Safety Facts (*7*), the latest report released by the National Highway Traffic Safety Administration (NHTSA) in 2020 showed that 45 percent of the traffic fatalities occurred in rural areas. As shown in Figure 1.1, considering that only 19 percent of the U.S. population lived in rural areas in 2019 and 30 percent of vehicle miles traveled (VMT) was estimated along rural roadways, the fatality rate per 100 million miles traveled is twice as high in rural areas than in urban (*8*). In addition, traffic crashes are a significant concern in tribal communities. The Center for Disease Control and Prevention (CDC) also identified that motor vehicle traffic crashes are a critical cause of death for American Indian and Alaska Native people aged 1 to 44 (*1*). The high rate of fatality and traffic crashes of RITI communities underlines the necessity to investigate their current needs and challenges as well as to find context-sensitive solutions.

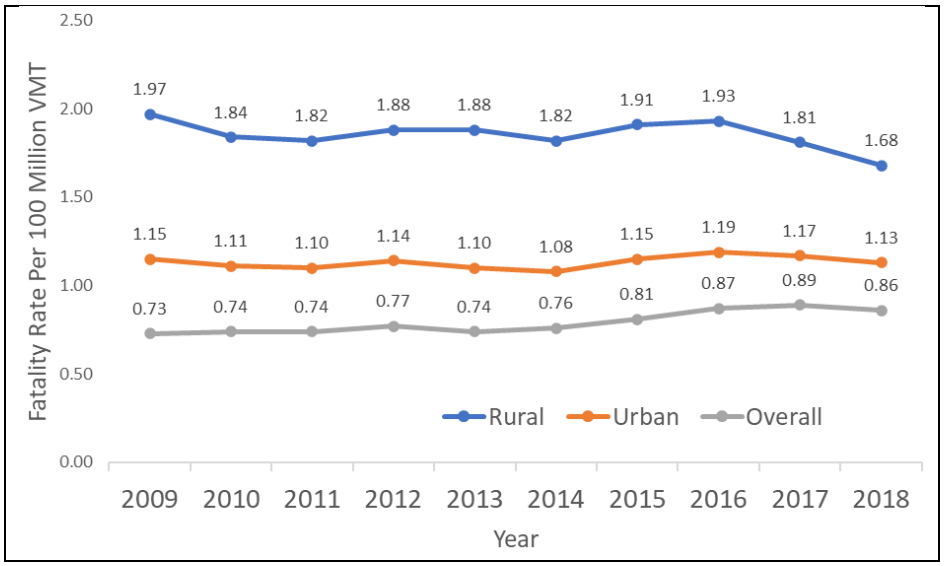

Figure 1.1. Fatality rates per 100 million VMT, by year and land use, 2009-2018 (*7*)

Traffic and transportation safety in RITI communities in Washington State (WA) also encountered many challenges. As shown in **Error! Reference source not found.**, 89 American Indians and Alaskan Natives (AIAN) died due to traffic crashes in WA State for 2016-2017. The AIAN traffic fatality rate is 28.5 deaths per 100,000 people, approximately four times that of the next highest race/ethnicity (*12*). Additionally, there are eight rural counties in WA with unrestrained fatal and/or serious injury rates in excess of 20 percent of all their fatalities (*13*). On the other hand, 21 of Washington's rural roads are rated in poor condition (the 12th highest rate in the nation) and 31 percent are in mediocre condition (*14*).

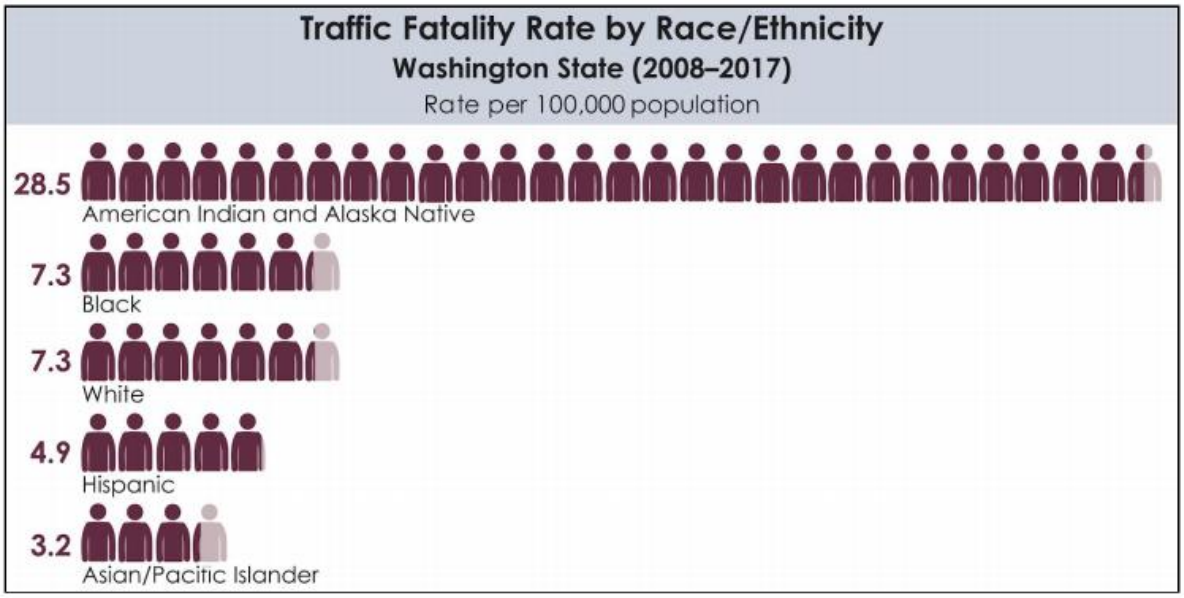

Figure 1.2 Traffic fatality rate by race/ethnicity in Washington State (*12*)

Researchers and public agencies have conducted studies to explore the current challenges to improving transportation and traffic safety in RITI communities, most of them indicate overall traffic safety inequity compared to urban areas, such as inadequate funding, insufficient infrastructure, poor road conditions, impaired driving habits (*9*), lack of communication with state and federal agencies, and incomplete and inaccurate transportation-related databases (*6*, *10*). Additionally, although emerging technologies (e.g., connected and autonomous vehicles, unmanned aerial vehicles) have been developed and tested to address traffic safety issues, few of them are shared widely in RITI communities (*5*, *11*). Moreover, RITI communities are vastly different in culture, language, location, and regulations, compounding these challenges and implying a need to identify unique traffic safety needs for a given community and develop place-specific and context-sensitive solutions.

Given the wide array of challenges RITI communities face, this project focuses on a set of recent initiatives to improve coastal disaster resilience in Washington, to explore how these initiatives may be leveraged to address traffic safety. This focus on the intersection of disaster planning, emergency management, and hazards mitigation with traffic management brings its own set of challenges, however. RITI communities have limited resources to address emergency planning, considering the diversity in ethnicity, language, political belief, and socioeconomic status, among others (*15*). The planning tools and processes that govern transportation investments and traffic management of rural areas do not often align closely with emergency planning, especially when facing multiple natural hazard threats (e.g., earthquake, flood, landslide, wildfire, and tsunamis) and most RITI communities are located in/close to hazardous areas (**Error! Reference source not found.**). Resilient and sustainable emergency management and planning not only enhances effective preparation, reliable prevention, and instant response for disaster, but also promises a safe, reliable, and sustainable mobility system. However, hazard mitigation and emergency planning, typically carried out by Federal Emergency Management Agency (FEMA)-regulated agencies, rarely integrates with the Comprehensive Plan (for land use, transportation, and public facilities) under non-urbanizing communities. The deficiency of coordination between the daily plan (Comprehensive Plan) and emergency planning can result from multiple causes. A critical factor is that communities identified as

non-growth areas under the Washington State Growth Management Act (*16*) are often not fully required to provide their Comprehensive Plans and only subject to critical areas and natural resource lands planning. Grays Harbor County (the studied county in this project where Westport is located) is one of the eleven counties in WA which is categorized as a non-growth area. How to better align planning for both emergency and everyday conditions to solve traffic safety and transportation-related issues and challenges became the critical problem in this study.

Another challenge comes from the emerging technologies (e.g., connected/autonomous vehicles, drones, among others). Most of the technologies have been developed and tested to address traffic safety issues. Nevertheless, they are often focused on urban areas considering the dominance of major metropolitan centers, which results in the lack of attention to RITI communities. Compared with other technologies such as connected and autonomous vehicles, which are still under research and testing for both operation and regulation, drone technologies are both mature and flexible in application. Therefore, the project team plans to explore practical drone usage cases in RITI communities to resolve the traffic and transportation-related safety issues and integrate them with emergency planning.

1.2. Problem Statement

This study aims to explore and synthesize the opportunities, challenges, and scenarios that drone technologies may aid in developing context-sensitive solutions to resolve traffic safety-related and emergency challenges in RITI communities. Although drones have been extensively tested in both urban and rural areas for multiple purposes (e.g., agriculture, photography), their applications in RITI communities have not been fully explored. As a promising emerging technology, drones can help provide economical and effective solutions to address traffic safety and emergency planning challenges, especially for low-density communities with dispersed activities and interspersed population which have difficult to monitor large areas given limited personnel and limited access. The project team selected the outer Pacific coast of Washington State (specifically the City of Westport) as the study area to raise awareness of their current challenges and needs in traffic safety and emergency planning.

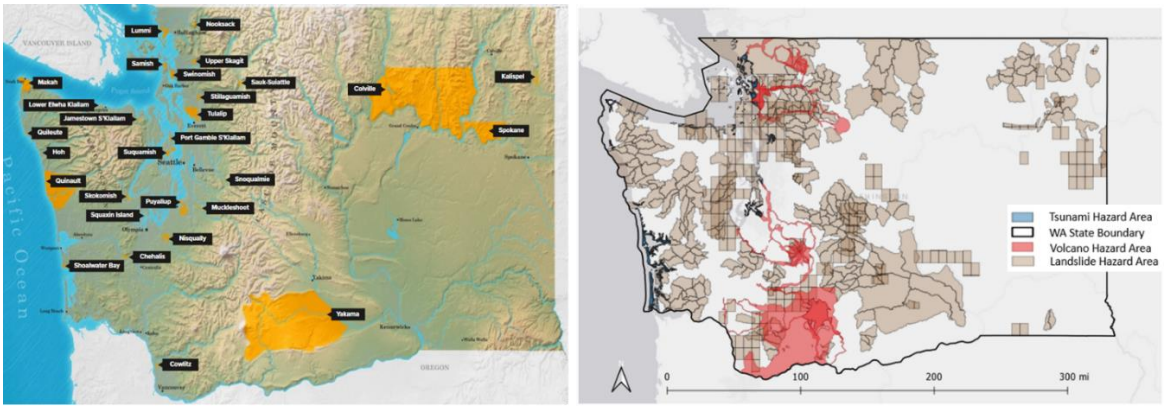

Figure 1.3 Tribes in WA (left, *12*), examples of hazard (tsunami, landslide, volcano) in WA (right)

The project team has conducted research to learn the current state of the drone-related technology and participated in several community meetings during the first year of the project (*5*) to engage with the RITI communities, drafted online surveys to learn about their current challenges and issues so as to explore a

viable solution synthesizing drone technologies, considering their unique cultural characteristics of the communities, as well as their specific social/economic/education resource limitations. This current Y3 project continued the first-year project (*5*) and conducted online surveys and a pilot study as well as community meetings with the targeted RITI communities in WA to understand their current emergency planning and traffic safety-related challenges as well as needs/views regarding drone applications.

1.3. Research Approach

The research approach contains three major steps. First, the project team conducted the online survey for both state and communities (City of Westport and the Quinault Indian Nation) located at the outer Pacific coast of WA, covering their primary concerns regarding transportation and traffic safety and emergency planning, potential drone applications, and current issues of drone usage, among others. Second, with the survey results, the team selected the City of Westport as the study area and collaborated with the NSF CoPe EAGER "Coastal Hazard Planning in Time" project to conduct a pilot study using drones for data collection to build a 3D digital model of the City of Westport. Third, after the pilot study, the project team members conducted a meeting with Westport and South Beach communities to discuss possible drone application scenarios and current challenges. The meeting highlighted the necessity of drone-related education, especially the Part 107 test (remote pilot certificate required from FAA) for Westport high school students to help city agencies apply drones for future usage. Then, an online zoom meeting was conducted with the Ocosta High School to discuss detailed education program plans.

The rest of this report is organized as follows: CHAPTER 2 introduces and summarizes the online survey findings, and CHAPTER 3 introduces the pilot study applying drones in the City of Westport. Then, CHAPTER 4 describes the outreach activities with Westport communities, including the two meetings mentioned above. Then, CHAPTER 5 summarizes the findings of the outreach activities. Finally, the conclusion and future research directions are presented in 0.

CHAPTER 2. ONLINE SURVEY

2.1. Online Survey Process

The aim of the online survey (*19*) is to understand the existing challenges, issues and needs surrounding traffic safety and emergency preparedness related scenarios in WA RITI communities and explore context-sensitive solutions using drones for both normal conditions and emergency conditions, as well as to identify local partners who are willing to undertake a pilot project with the project team. The survey also provided a 10-min slide for a brief review of drone-related technology and application scenarios as well as a proposed pilot study using drones to help community representatives better understand the drone technology.

The survey was designed to have three parts with 35 questions, covering the current challenges regarding hazard mitigation and emergency planning in the communities (related but not limited to transportation), current challenges and opportunities for daily usage (normal conditions) of the drone technology, and the participants' information. The first part was designed based on the previous outreach activities (*5*). It was found that the major challenge within most coastal RITI communities is the lack of complete hazard mitigation planning and related strategies after discussion with the community members. Thus, questions in the first part focused on the issues and challenges underlined from the Seabrook Meeting (*5*), covering transportation inspection during the disaster, tourist and vulnerable population evacuation, telecommunication recovery, and possible assistance applying drones. The second part of the questions attempted to know communities' viewpoints and understanding of the drone technology so as to identify potential applications and corresponding challenged using drones. Detailed survey questionnaire is provided in Appendix A: Online Survey.

The project team applied the snowball sampling process to the online survey. The online questionnaire was first sent out to the RITI communities and their county and State agencies, including the City of Westport, Quinault Indian Nation, Shoalwater Bay Tribe, South Beach Region, Grays Harbor County, Washington Emergency Management Division, Washington State Parks, and National Guard. In the email, the project team invited the participants to share the survey with their colleagues and other staff they thought would be necessary. Nevertheless, remote communications became less effective due to the Covid-19 pandemic: only a small number of responses were received, including those from the Westport/South Beach, the Washington Emergency Management, and the Quinault Indian Nation.

2.2. Online survey results

This section summarizes the major findings related to transportation and drone-related applications. Notice that answers may vary in communities based on their cultural, geographic, natural, and economic conditions. Detailed survey responses can be found in Appendix B: Survey Results. To protect data privacy, the project team has removed the personal information of survey participants. The survey results are summarized under emergency conditions and normal conditions based on the survey design.

The emergency planning portion of the survey focused on the natural hazards, covering tsunamis, earthquakes and landslides, liquefaction, and flooding, which are the primary concerns for Pacific Coast communities. Questions about emergency planning and challenges can be categorized into seven fields, including warning message spread, transportation infrastructure inspection, tourist evacuation, telecommunication failure and recovery, vulnerable and disabled population evacuation, search and rescue, and supply delivery. Survey questions covered the existing plans, current challenges/obstacles, and

possible drone applications under each condition. Results from the participants are then summarized in Table 2.1.

Table 2.1 Online survey results

Emergency concern	Plans & Challenges	State	Quinault Indian Nation	Westport/South Beach
warning message spread	Plans	Receive tsunami alerts from the NTWC and disseminate these alerts to local jurisdictions.	All Hazard Alert Broadcast (AHAB) Siren.	All Hazard Alert Broadcast (AHAB) Siren.
	Challenges	1. Communication networks (especially state/local conference calls and other human-dependent means of passing words can cause errors). 2. public preparedness/ education (many people don't know if they live in the tsunami zone, aren't signed up for alerts, aren't prepared to evacuate quickly, won't want to evacuate, etc.).	Hard to reach out to the elders and disabilities.	1. Lack of education and participation among the resident and employers. 2. Reaching out to elders and disabilities 3. Getting people to sign up and register for the text and email of warning notifications.
transportation infrastructure inspection	Plans	Plans are required for the county level.	1. Preliminary evaluations by FD, PD, Roads, and Construction. 2. Drones application for some inaccessible places by Environmental Protection Department.	None
	Challenges	1. Severe damage to transportation infrastructure, which blocks the evacuation route. 2. It is difficult to evaluate the number of people passing by if roads/bridges were damaged but passable.	Transportation infrastructure damage is too severe, which blocks the evacuation route.	1. Lack of available personnel. 2. Limited evacuation time, bad weather conditions, limited skill sets, lack of experience

Emergency concern	Plans & Challenges	State	Quinault Indian Nation	Westport/South Beach
tourist evacuation	Plans	1. Support local jurisdictions in tourist evacuation by providing updated tsunami modeling and maps (physical and digital) with clear pedestrian evacuation routes. 2. assist with route identification and analysis to see if more signage is needed, if a path has become unusable, etc.	1. Block the Hwy at the Moclips Hwy junction and direct tourists up towards Lake Quinault. 2. Direct tourists up the hill with everyone else. 3. Use tsunami route signs along the way.	1. Distribution of pamphlets. 2. Share evacuation route maps, signage information at lodging and hospitality sites
	Challenges	None	None	None
telecommunication failure and recovery	Plans	Apply experimental technology (such as ham radio, wireless mesh network, drones) for recovery.	Radios and drones.	1. Personnel on shift 2. volunteers 3. tsunami siren messaging Radio, cellular if available. 4. Possible technologies: Ham Radio and VHF Radio.
	Challenges	NA	Limited technology for after-disaster.	NA
vulnerable and disable population evacuation	Plans	None	1. Help from neighbors and friends. 2. Help from PD/FD/EMS	None
	Challenges	None of the local jurisdictions have specific plans in place for vulnerable populations.	1. Some seniors refuse to leave. 2. Vulnerable population is interspersed throughout the villages.	1. Manpower and rolling resources. 2. Unknown location of their residence. 3. Lack of personnel or volunteers to go from residence to residence.
search and rescue	Plans	None	1. Use the drone for inaccessible areas. 2. Start the CERT team for SAR, the clinic will be triage, and the DNR office will become the EOC.	Launch drones for damage assessment and rescue of stranded citizens.

Emergency concern	Plans & Challenges	State	Quinault Indian Nation	Westport/South Beach
	Challenges	1. No easy or quick access to 'bigger things' (helicopters, construction equipment, ATVs) for big events.	Geo-threat (about half of the town is located on an old marsh right at the mouth of the Quinault River on the shoreline, even a small disaster becomes a much bigger one here as we sit so low in elevation and the ground is not solid, liquefaction will be a big issue).	NA
supply delivery	Plans	Different jurisdictions have different plans in place. It depends on the size of the event and the amount of transportation infrastructure still usable.	Store emergency supplies (e.g., food, medical) at the evacuation area.	None
	Challenges	Lack of communication with populations that need the supplies, storage issues, potential lack of fuel, loss of airport landing strips, complete devastation of most ports/harbors/ships, simply trying to decide where limited supplies are needed most.	Road freight for supplies becomes less accessible. Flight transportation can be a way but unreliable.	Inundated, failed, and unstable roadways and bridges

Notes: NTWC: National Tribal Water Council, ATV: all-terrain vehicle, PD: Police Department, FD: Fire Department, Hwy: Highway, EMS: Emergency Medical Services, CERT: Computer Emergency Readiness Team, SAR: Search & Rescue, DNR: Department of Natural Resources, EOC: Emergency Operations Center, VHF: very high frequency.

As the table illustrates, communities from different regions encounter multiple challenges. A common but crucial challenge is the evacuation problem related to vulnerable populations (e.g., the elderly, the disabled), especially when it comes to warning messages spreading, search and rescue, and supply delivery after the disaster. The survey also underlines the crucial role of transportation and telecommunication, which determines the effectiveness and reliability of the evacuations and supports the supply delivery and communication after the events. Damaged roads or disrupted telecommunication infrastructure would cut off the connection to the outside world. Nevertheless, conducting the transportation inspection and telecommunication recovery becomes more challenging due to multiple factors, such as lack of labor, limited equipment, inexperience in applying technologies, etc. On the other hand, communities show positive attitudes towards the drone technology. It is found that both the Quinault Indian Nation and the

City of Westport have drones and plan to use them during and after the disaster for transportation infrastructure inspection, and search and rescue, among others.

For the normal condition part of the survey, most participants agreed that drones could be applied in transportation (traffic monitoring), search and rescue, photography, infrastructure monitoring, telecommunication, and supply/goods delivery. However, there are also obstacles when applying drones, as shown in the survey results (Figure 2.1), considering privacy concerns from the public, storage issues, lack of knowledge, deficiency of training for operation, lack of resources, and difficulty of developing policies and procedures for drone usage. Sixty percent of the participants identified the cost of drone technology as the primary barrier. Additionally, only one participant confirmed they have regulations for drones. Although participants from the Quinault Indian Nation and the Westport/South Beach both took drones into account for future application, drones were not considered in disaster response/daily life from the state perspective considering its cost, the possibility of pushback from senior management or anti-tech types, as well as privacy concerns from the public.

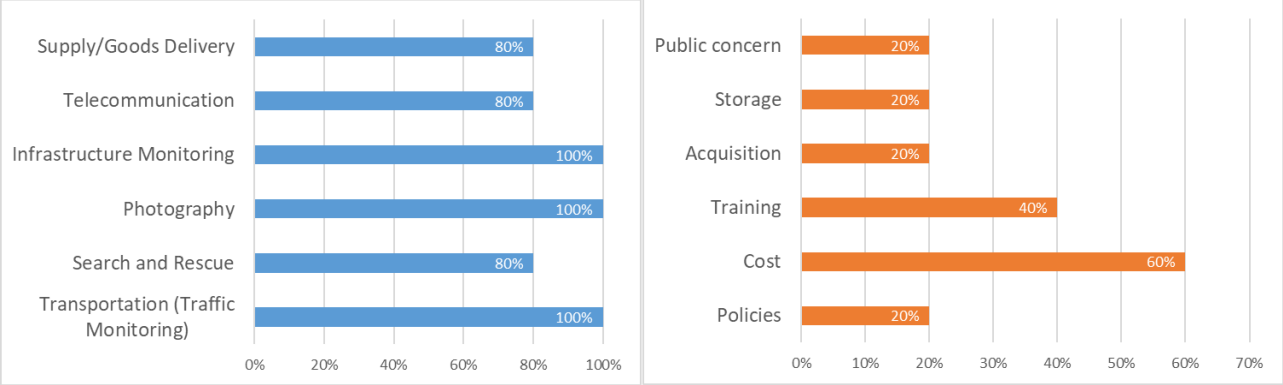

Figure 2.1 Possible drone applications for normal conditions (left) and identified obstacles (right) from the survey feedbacks.

Based on the online survey results, it is believed that drones can help assist both normal and emergency conditions. To discuss further opportunities working with RITI communities, the project team sent out follow-up invitations to the survey participants. With the received responses, the City of Westport was then selected as the pilot study area. To explore possible drone applications, the project team assisted the NSF CoPe EAGER ''Coastal Hazard Planning in Time" project team to deploy UW RAPID Facility drones to collect data in Westport peninsula and conducted two meetings with the city staff to understand their needs and future plans for using drones.

CHAPTER 3. PILOT STUDY FOR REMOTE SENSING AND MAPPING

3.1. Introduction of Westport

The project team conducted the pilot study at Westport by assisting the UW RAPID Facility staff collect remoting sensing and mapping data of the area. Westport is a small rural town located at the mouth of Grays Harbor County on the southernmost peninsula near the Pacific Ocean (Figure 3.1) (*20*). With a population of 1817 (16), local residents in Westport rely on fishing, shellfish harvesting, Oyster breeding, seafood processing, and tourism for their livelihood. The public Westport Marina is the largest marina along the outer coast of the U.S.'s Pacific Northwest (*21*).

There are multiple reasons that we chose Westport as the pilot study area. First, Westport faces similar threats in comparison to other coastal communities, including "gradual" sea-level rise (SLR), coastal erosion, and tsunamis generated by distant earthquakes (e.g., from Alaska, Japan) or nearer-ones (such as the Cascadia Subduction zone). Understanding the coastal resilience-related issues in Westport also enables us to identify challenges that all coastal communities are facing. Second, some of Westport's transportation infrastructures were reported as facing challenges from a wide range of climate hazards, specifically from extreme precipitation events and flood and storm surges from higher sea levels. Highway 30 from Astoria to Westport was identified as one of the most vulnerable corridors as there exists a high possibility that the SLR will put the roadway in Westport underwater(*22*). Third, to deal with the threat of tsunamis, the city of Westport has worked with its southern Ocosta School District to build a vertical evacuation facility, the roof of the new Ocosta Elementary School Gym, known as the first vertical structure serving as a haven for tsunami events in the US (*23*). The evacuation facility not only shows that the Westport community is open to new and innovative ideas but also provides opportunities for researchers to study traffic safety, evacuation planning, and post-disaster management. Lastly, drones are currently available in Westport. The fire department mentioned that they have drones and are now looking for possible application scenarios and drone-related training opportunities. Westport's special geo-location and the open mind for emerging technologies (like drones) from Westport communities also provide many opportunities for the drone-related pilot study, such as search and rescues for Police and Fire Department, Infrastructure inspection, SLR inspection, and transportation monitoring.

Figure 3.1 Geo-location of Grays Harbor County (left) and the City of Westport (right) (*5*)

3.2. Pilot Study: Drones for remote sensing/mapping of Westport (Aug 23 – Aug 28, 2020)

The project team assisted UW RAPID Facility staff in gathering data to build a 3D digital model for the City of Westport and the unincorporated parts of the Westport peninsula. The model will be used for

subsequent university research on local hazard impact modeling and visualization, for university design and studio courses to envision mitigation and adaptation strategies, and for community engagement.

Coordinating with the City of Westport's Public Works and Police departments, the South Beach Regional Fire Authority, and the Ocosta School District, the project team was responsible for both the remote pilot and visual observer of the drones as well as the ground-based laser scanners for data collection. The goal of the pilot study is to use drones to collect less than 3-cm GSD (ground sample distance) aerial imagery of the Westport Peninsula to create a 3D point cloud model using structure-from-motion techniques (eBee and Phantom 4), and to collect near-cm resolution aerial imagery of critical infrastructure identified by the City of Westport using Matrice 210. eBee is the fixed-wing drone specifically for mapping with a maximum flight time of 90 min (the longest flight time in comparison to the other two drones). Both Phantom 4 and Matrice 210 are quadcopters, while the camera in Matrice 210 has a higher resolution. These three drones are displayed in Figure 3.2.

a) eBee (*24*) b) Phantom 4 (*25*) c) Matrice 210 (*26*)

Figure 3.2 Drones applied in the pilot study

The project team mainly applied Matrice 210 for near-cm resolution aerial imagery of the ten critical infrastructures in Westport, including the Wastewater treatment facility, Westport Airport, North Wellfield/Standpipe, Westport Police Department, Westport City Hall, Westport Street Maintenance Department, South Beach Regional Fire Authority, South Wellfield/Standpipe/Water Maintenance, and Ocosta School. Figure 3.3 below shows that the project team cooperated with the RAPID staff operating Matrice 210 to take aerial imagery across the Ocosta School, also known as the vertical evacuation site for tsunamis. Detailed findings from the pilot study are summarized below in CHAPTER 5.

Figure 3.3 Drone operation in Westport, from the roof of the Ocosta School, North America's first tsunami vertical evacuation structure

CHAPTER 4. OUTREACH MEETINGS WITH WESTPORT COMMUNITIES

4.1. CSET outreach meeting with the City of Westport (Aug 26, 2020)

To better understand current needs, challenges, and opportunities for using drones in the City of Westport, an outreach meeting was conducted with Westport communities, including the South Beach Regional Fire Authority, Westport Police, Westport Public Works, and Ocosta School District. Before the meeting started, the project team first met the community members at Ocosta School to display how Matrice 210 and eBee can be deployed to take photos of the school buildings automatically. Figure 4.1 shows the discussion between the project team and Westport communities after launching the Matrice 210. Such outdoor activity enhanced the communities' understanding of drone technologies and provided some scenarios that Westport communities can apply drones to in the future.

The outreach meeting was held at the South Beach Regional Fire Authority Training Center. The meeting included two parts: current challenges and emergency management issues (specifically tsunamis, the major concern in Westport) and possible drone applications for both normal and emergency conditions. One of the significant challenges pointed by the participants considering emergency management is the lack of public education about tsunami preparation and evacuation, leading to chaos when the disaster happens. Such challenges can be due to various reasons: no practical drill; no post-tsunami plan for the public; multiple levels of tsunami warning (distant-source tsunami with longer evacuation time vs. near-source tsunami with limited evacuation time); lack of communication with business people and tourists; and the Covid-19 impact that increased the temporal cost for communications and hinders outreach activities. To resolve this, the project team suggested some technical solutions, for instance, applying drones with loudspeakers that can guide people along evacuation routes based on real-time information. However, current community members do not have remote pilot licenses required to operate drones under emergency conditions.

Figure 4.1 Drone display and discussion with Westport community

In addition, during the meeting, the Fire department mentioned they currently own Phantom 4 and Matrice 210 and were seeking opportunities to explore possible drone applications as well as training for the 107 test (remote pilot certification test of FAA). In addition, the Police department has also taken

drones into consideration for future usage. It was found that the more the community members consider using the drone technology, the higher the need for training of both the remote pilot license and operation skills.

To resolve this, the project team and Westport communities discussed possible education opportunities, not only for drone-related knowledge but also covering tsunami-related preparation and evacuation, including 107 test training, aerial imagery data processing method, tsunami evacuation and preparation, and radio (low power FM radio) training. As indicated in FAA, candidates who would like to take the 107 tests should be older than 16 and are able to read, speak and understand English (*27*). Considering the staff mobility in Westport's local agency, Ocosta High School students were selected as the education target, who can use the training skill for their future careers and assist local agencies' daily and emergency operations.

4.2. CSET outreach meeting with the Ocosta School staff (Mar 12, 2021)

To discuss specific plans for the drone-related education program in Ocosta High School, the project team had a zoom meeting with the School staff (Figure 4.2). The goal of the meeting is to discuss the possible programs for high students to take drone classes as well as possible projects that students can apply drones for practical applications. The meeting started with an introduction of the CSET project to the Ocosta School representatives. The project plans to share drone-related knowledge not only to high school students but also to their family members and teachers to have a better understanding of drones and apply them to help the normal and emergency conditions in the City of Westport. Besides, such drone-related skills can also help students better pursue future careers and educations. The goal of the drone-related program in the Ocosta School is to help educate high school students so that they can pass the 107 test and operate drones currently available at the Ocosta School.

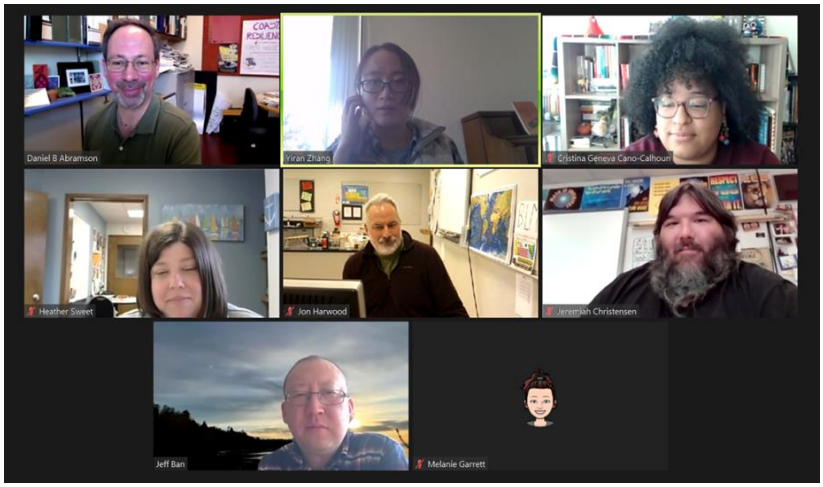

Figure 4.2 Online zoom meeting with Ocosta School representatives

Meeting participants discussed two possible programs for the drone-related courses, including the after-school program and the summer program. Students who take the drone program can earn CTE (Career and Technical Education) or science credits. To provide an effective and interesting course for high school students, especially for drone operations, the project team and Ocosta School District staff came up with various project ideas. For instance, applying drones to explore the tide along Jhon's River, dispatching

drones for mapping and data collection to study the washaway beach located in the Shoalwater Bay Tribe, and deploying drones to monitor oyster breedings, among others. Apart from drones, the project team also suggested sharing other knowledge that can be applied to drone-related data processing, such as GIS (Geographic Information System) skills and 3D modelings. The School staff also plans to explore their current drones to help the project team better determine the drone practice plans.

CHAPTER 5. RESULTS

With the experience of applying drones for mapping and sensing in the City of Westport and meetings with Westport communities and the Ocosta School District, the project team has further learned the current needs, challenges, and issues in Westport, considering the traffic transportation safety, emergency management, and possible drone applications. Moreover, the pilot study enabled the team to better identify potential challenges and feasible solutions for actual drone operations.

Table 5.1 summarizes the lessons learned for operating drones during the pilot study. It is found that aside from following the guidance from FAA, the environmental factors, such as nearby medal structures and birds, also determine each flight's success. Seagull attack, for instance, is one of the major concerns when operating drones in Westport. To avoid the birds' attacks, the research team coordinated with RAPID Facility staff to conduct data collection in the early morning and prepared to take manual control when a bird was identified approaching the drones. In addition, power capacity plays a vital role in each flight. The flight duration suggested by each drone relies on the current temperature, wind speed, and flight direction. Cold temperature and stronger wind can cause excessive power consumption, thus substantially reducing the flight time. Such environmental conditions need to be highlighted when considering drone applications under disaster scenarios. Ignoring the weather factors can cause the loss of control of drones. Additionally, it is also essential to identify available power capacity, such as how many electricity sets are available in the control center and how long one set can be fully charged. Such detailed information should be collected and analyzed before each drone flight plan to ensure a successful drone operation.

Table 5.1 Lessons learned from the pilot study in Westport

Drone operation	**items**	**Possible challenges**	**Solutions**
Before the flight	Airspace check	Restricted airspace	Request authorizations/permit
	Installation	Equipment loss/broke	• Prepare backup equipment. • Prepare other UAVs for backup.
	Compass validation	Magnetic interference	• Restart the UAV. • Find another launching spot.
During the flight	Operation	Fly away	Have visual observers to blind spots of the remote pilot.
		Bird attack	• Consider flying in the early morning to avoid birds. • Immediately decrease the flying height. • Flying vertically. • Recolor the drones in red/orange
		Out of power	• Calculate the possible flight time and manually control the drone back to the control center when the power became lower. • Prepare backup power and chargers.
		Bad weather	Reassess the flight time considering the current wind speed, temperature
		Public concern	• Wear/attach research symbols. • Bring permit docs from the local agency.
After the flight	Data collection	Data missing	Have a backup copy.

The two outreach meetings and the online survey for Westport communities provided an opportunity for the project team to further understand the challenges, issues and needs, and current conditions and views

of drone technology in Westport. It was found that transportation and traffic safety not only affect daily lives in Westport but also play an essential role in evacuation under emergency conditions. Besides, Westport communities are open to drone technology. The current limitation is not the deficiency of drones but the drone-related knowledge and operation skills. To explore drone applications that can be meaningful and feasible for training and daily operations, the project team also proposed scenarios for drones that can assist the everyday life in Westport communities Table 5.2.

Table 5.2 Drone application scenarios (potential application under normal conditions)

City	**Fire Department**	**Police Department**
• Traffic monitoring (for specific road/intersection) • Construction inspection & surveillance • Mapping and sensing • Data collection • Photography for tourism	• Fire condition inspection & firefighting • Search & rescue • Emergency equipment delivery	• Search & rescue • Traffic collision inspection • Active suspects investigation • Crime scene analysis • Surveillance • Crowd monitoring

CHAPTER 6. CONCLUSION AND FUTURE STUDY

RITI communities in Washington State face multiple challenges regarding transportation and traffic safety, and emergency preparedness. Through the online survey, pilot study, and outreach meetings with coastal communities, this project identified that drone technology, regarded as one of the advanced technologies in recent years, is able to improve the communities' safety, resilience, and emergency preparedness. Apart from the physical drones, the essential needs for communities nowadays are drone-related knowledge and skills, including how to obtain the remote pilot certification by FAA, how to operate various types of drones, how to dispatch drones considering their power capacity, among others. Therefore, the next phase of the project will focus on drone-related education programs by collaborating with the Ocosta High School.

The education program for high school students can raise community awareness of the VES (vertical evacuation structure) function and capacity at Ocosta school and help the community better prepare to make use of it for emergency conditions (e.g., tsunami evacuation), and augment it with other needed precautions. Drone-flying by students and their families on the school campus will raise situational awareness and familiarity with a technology that may be essential during disaster occurrences and other emergency situations. The education plans aim to conduct training and help students obtain their drone licenses and identify synergies among multiple objectives, such as a) priority needs in traffic and transportation infrastructure management, emergency preparedness, evacuation planning, and public safety; b) other ongoing and potentially useful STEM research and education in the community; c) drone-flying skills and drone-gathered data and data processing and analysis technology. Students can use the knowledge/skills learned to train (e.g., via internship opportunities) with fire, police, EMT, and public works, and to develop skills needed to participate in university research, including mapping and GIS, digital modeling, virtual immersive evacuation drilling, environmental science, infrastructure monitoring, and robust telecommunications systems for disaster resilience. The intern/volunteer experience with local transportation and related authorities can also help students’ long-term careers, such as job opportunities and pursuing higher educations.

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APPENDIX A: ONLINE SURVEY

'UW CSET Survey on Potential for Drone Applications in Rural Emergency Evacuation and Management'

I. Background

This online survey is part of a project funded by CSET (Center for Safety Equity in Transportation). CSET works directly with RITI communities (Rural, Isolated, Tribal and Indigenous) as a catalyst for assessing their needs and identifying possible resources. The initiative focuses on transportation safety, education, training and workforce development programs.

The aim of this online survey is to understand the current challenges, issues and needs surrounding hazard scenarios in Washington State RITI communities. With this information, we will explore a context-sensitive solution using drones as a new technology. Based on our previous outreach work with RITI communities and agency stakeholders, including the City of Westport, the South Beach Regional Fire District, Grays Harbor County Emergency Management, Quinault Indian Nation, Shoalwater Bay Tribe, and the Washington State National Guard among many others, we divided the study into two scenarios: emergency and normal situations. We hope to identify possible drone applications for each type of situation, as well as a local partner willing to undertake a pilot project with us.

The survey is of course completely voluntary on your part; you are not obligated to answer any question, though we hope you will answer as many as you can. We'd like to ask you a total of 35 questions that cover three general areas.

First, we'd like to know about your emergency plans for major hazards including tsunamis, earthquakes, severe storms, or landslides. What are the challenges, especially related to transportation, that you see in these hazards? What are the current challenges during emergency situations (e.g., tsunami, earthquake)? What are your views on how emerging technological applications such as UAV (Unmanned Aerial Vehicle), or drones, could play a role in the emergency?

Second, we'd like to learn about the current challenges and opportunities for daily use of the proposed new technology.

Last, we would like to ask three questions about which community you work in, in what capacity, and for how long. Finally, we ask if you would be willing to have us call you for a follow-up interview, and/or to discuss the possibility of partnering on a pilot project, and if so, to provide us with your contact information.

And if at any point you have questions for us, please feel free to email Yiran Zhang at yiranz94@uw.edu, Prof. Jeff Ban at banx@uw.edu, or Prof. Dan Abramson at abramson@uw.edu.

Before we start, to help you better understand drone technology, we'd like to share with you a 12-slide brief introduction to drone tech and our project. The slides includes a two-minute video and link to a brief news item, and may take in total about ten minutes to read.

I. Emergency

The following questions are mainly related to tsunami evacuation. We would like to learn about the current challenges and barriers you face to managing such an emergency.

Question 1.

34 questions left ahead.

Imagine that you are facing a distant earthquake (originating in Alaska) that may generate a tsunami in your location. You have three hours to evacuate. What challenges, if any, do you anticipate to sending out the warning message?

Question 2.

33 questions left ahead.

Can you elaborate on the challenges of spreading the warning message?

Question 3.

32 questions left ahead.

During the evacuation, some transportation infrastructures, such as highways or bridges, may be vulnerable to damage from ground shaking, landslides, liquefaction, or flooding. Have you considered any plans to inspect bridges and other infrastructure during the evacuation?

- ○ Yes
- ○ No
- ○ Other:

Question 4.

31 questions left ahead.

Briefly, how would you conduct this evaluation?

Question 5.

30 questions left ahead.

What are the challenges to conducting this assessment? What new technologies (e.g., drones, Lidar) have you considered, if any, to overcome these challenges?

Question 6.

29 questions left ahead.

If you encountered an unexpected situation (for instance, liquefaction blocked roads or damaged bridges), do you have a plan to inform the residents and evacuees in your region?

- ○ Yes
- ○ No

Question 7.

28 questions left ahead.

How you plan to spread the warning and guide them to alternative evacuation routes?

Question 8.

27 questions left ahead.

Do you plan to employ any emerging technologies to send the warning message?

(If you find questions tough to answer/confusing, you can check the slide for more information)

Smartphone apps / notifications

Drones
Social media
Radio / television broadcasting
Other:

Question 9.

26 questions left ahead.

Do you have a plan for guiding tourists—most of whom will be unfamiliar with the evacuation route—to refuge sites?

○Yes

○No

Question 10.

25 questions left ahead.

Please describe your plan for tourist evacuation.

(If you find questions tough to answer/confusing, you can check the slide for more information)

Question 11.

24 questions left ahead.

If your current telecommunication infrastructure fails, what back-up technologies do you have available to guide evacuees?

(If you find questions tough to answer/confusing, you can check the slide for more information)

Question 12.

23 questions left ahead.

Do you have evacuation plans for vulnerable populations? These could include, for example, people with disabilities, the elderly, or people who are homeless.

(If you find questions tough to answer/confusing, you can check the slide for more information)

- ○ Yes
- ○ No

Question 13.

22 questions left ahead.

What are the barriers to reaching vulnerable evacuees?

Question 14.

21 questions left ahead.

What technology do you plan to use for searching and rescuing? Can you explain your *plans?*

(If you find questions tough to answer/confusing, you can check the slide for more information)

Question 15.

20 questions left ahead.

Do you have a search and rescue plan for people with disabilities?

- ○ Yes
- ○ No

Question 16.

19 questions left ahead.

Can you explain the plans, if any, to use emerging technologies for searching and rescuing people with disabilities?

(If you find questions tough to answer/confusing, you can check the slide for more information)

Question 17.

18 questions left ahead.

During a tsunami, earthquake, or other disaster, what places do you expect will pose a danger to rescuers? What about after the disaster?

Question 18.

17 questions left ahead.

What is the plan for ensuring the safety of rescuers in these areas? What technologies (e.g., telecommunications, drones, helicopters) do you plan to use?

(If you find questions tough to answer/confusing, you can check the slide for more information)

Question 19.

16 questions left ahead.

Are there any plans to supply essential goods (medicine or food, for example) after the disaster?

- ○ Yes
- ○ No
- ○ Other:

Question 20.

15 questions left ahead.

How do you plan to transport these goods to evacuees?

(If you find questions tough to answer/confusing, you can check the slide for more information)

Question 21.

14 questions left ahead.

Are there any places where you anticipate that normal delivery (by truck) will not be available during the disaster?

- ○ Yes
- ○ No

Question 22.

13 questions left ahead.

What are your plans for getting to these hard-to-reach places?

(If you find questions tough to answer/confusing, you can check the slide for more information)

Question 23.

12 questions left ahead.

What are the other obstacles to delivering goods?

Question 24.

11 questions left ahead.

If the disaster destroys the current communication system, do you have backups?

- ○ Yes
- ○ No

Question 25.

10 questions left ahead.

Have you considered using experimental technology (such as ham radio, wireless mesh network, drones) to help recover telecommunications? If yes, could you share with us the possible technologies you plan to use?

(If you find questions tough to answer/confusing, you can check the slide for more information)

- ○ Yes
- ○ No
- ○ Possible technologies:

Question 26.

9 questions left ahead.

II. Regulation and the Possibility for Daily Application of Drones

The following questions are mainly related to the opportunities and challenges for drone applications.

Have you considered using drones in disaster response situations before?

- ○ Yes
- ○ No

Question 27.

8 questions left ahead.

In which aspect do you think drones can see daily usage?

(If you find questions tough to answer/confusing, you can check the slide for more information)

- ☐ Transportation (Traffic Monitoring)
- ☐ Search and Rescue

- ☐ Photography
- ☐ Infrastructure Monitoring
- ☐ Telecommunication
- ☐ Supply/Goods Delivery
- ☐ Other:

Question 28.

7 questions left ahead.

Does your city currently place any regulations/restrictions on using drones in emergency situations?

(If you find questions tough to answer/confusing, you can check the slide for more information)

- ○ Yes
- ○ No

Question 29.

6 questions left ahead.

How about for normal situations?

- ○ Yes
- ○ No
- ○ Other:

Question 30.

5 questions left ahead.

Can you briefly explain these regulations or restrictions?

Question 31.

4 questions left ahead.

What do you see as the barriers to applying new techniques such as drones?

(If you find questions tough to answer/confusing, you can check the slide for more information)

Question 32.

You have reached our last-question page, congratulations and thanks!

III. Personal Background

Last but not least, we'd like to know your background and a bit about the context of your experience.

With which community are you working?

- ○ Westport/South Beach
- ○ Ocean Shores/North Beach
- ○ County
- ○ State
- ○ Quinault Indian Nation
- ○ Shoalwater Bay Tribe
- ○ Other:

Question 33.

In which sector do you work? (Select as many as apply.)

- ☐ Emergency Services (EMS)
- ☐ Planning
- ☐ Public Works
- ☐ Elected Official
- ☐ Law Enforcement
- ☐ Other:

Question 34.

How long have you worked in this sector?

Question 35.

Please provide your contact information (email address/phone) if you would be willing to have us contact you for a follow-up interview on your answers, and/or to discuss participation in a pilot drone project

APPENDIX B: SURVEY RESULTS

Results for UW CSET Survey on Potential for Drone Applications in Rural Emergency Evacuation and Management (By Participant)

Results for: ID# 19336441

Submission date: 12/11/2019 11:42 AM

Total time: 1 hour, 25 minutes, 8 seconds

Question	*Response*
Question: 34 questions left ahead. Imagine that you are facing a distant earthquake (originating in Alaska) that may generate a tsunami in your location. You have three hours to evacuate. What challenges, if any, do you anticipate to sending out the warning message?	We can send out the warning via AHAB siren, Social Media, and email (employee only). Our PD officers will be utilizing their PA systems in the vehicles. We do not have a way to contact everyone simultaneously other than the AHAB siren and we are not certain everyone will be able to hear that.
Question: 33 questions left ahead. Can you elaborate on the challenges of spreading the warning message?	We do not have any way of reaching everyone and most evacuations will be by word of mouth. Our elders and those with disabilities are our greatest concern at this time. The AHAB siren is by our seawall, when the wind blows inland it is great, however if there is an offshore breeze then it reduces the area of notification.
Question: 32 questions left ahead. During the evacuation, some transportation infrastructures, such as highways or bridges, may be vulnerable to damage from ground shaking, landslides, liquefaction, or flooding. Have you considered any plans to inspect bridges and other infrastructure during the evacuation?	Other: afterwards, yes
Question: 31 questions left ahead. Briefly, how would you conduct this evaluation?	Our Fire, Police, Roads, and construction dept will be doing preliminary evaluations as soon as safely possible.
Question: 30 questions left ahead. What are the challenges to conducting this assessment? What new technologies (e.g., drones, Lidar) have you considered, if any, to overcome these challenges?	Initially, as soon as it is safe, a visual inspection will be done. As soon as people can arrive, our Environmental Protection dept has a drone or 2 to get where we cannot.
Question: 29 questions left ahead. If you encountered an unexpected situation (for instance, liquefaction blocked roads or damaged bridges), do you have a plan to inform the residents and evacuees in your region?	No

Results for: ID# 19336441	Submission date: 12/11/2019 11:42 AM Total time: 1 hour, 25 minutes, 8 seconds
Question: 26 questions left ahead. Do you have a plan for guiding tourists—most of whom will be unfamiliar with the evacuation route—to refuge sites?	Yes
Question: 25 questions left ahead. Please describe your plan for tourist evacuation. (If you find questions tough to answer/confusing, you can check the slide for more information)	The Quinault Reservation is at the end of Hwy 109. We plan to block the Hwy at the Moclips Hwy junction and direct tourists up towards Lake Quinault. Should there actually be tourists here, they will be directed up the hill with everyone else. there are Tsunami route signs along the way as well.
Question: 24 questions left ahead. If your current telecommunication infrastructure fails, what back-up technologies do you have available to guide evacuees? (If you find questions tough to answer/confusing, you can check the slide for more information)	we have nothing else
Question: 23 questions left ahead. Do you have evacuation plans for vulnerable populations? These could include, for example, people with disabilities, the elderly, or people who are homeless. (If you find questions tough to answer/confusing, you can check the slide for more information)	Yes
Question: 22 questions left ahead. What are the barriers to reaching vulnerable evacuees?	Some seniors refuse to leave, our vulnerable population is interspersed throughout the villages. Neighbors and friends will be the first to help them, PD/FD/EMS will be helping as well. Other than neighbor helping neighbor, we don't have any other way to reach everyone.
Question: 21 questions left ahead. What technology do you plan to use for searching and rescuing? Can you explain your plans? (If you find questions tough to answer/confusing, you can check the slide for more information)	We have a drone to use for areas we cannot easily reach, we have started a CERT team for SAR, our clinic will be triage, and our DNR office will become the EOC.
Question: 20 questions left ahead. Do you have a search and rescue plan for people with disabilities?	Yes

Results for: ID# 19336441

Submission date: 12/11/2019 11:42 AM

Total time: 1 hour, 25 minutes, 8 seconds

Question: 19 questions left ahead. Can you explain the plans, if any, to use emerging technologies for searching and rescuing people with disabilities? (If you find questions tough to answer/confusing, you can check the slide for more information)	Our elders/senior dept has a list of names/addresses of those with disabilities or are vulnerable. Utilizing this list will help us locate and rescue them.
Question: 18 questions left ahead. During a tsunami, earthquake, or other disaster, what places do you expect will pose a danger to rescuers? What about after the disaster?	About half of our town is located on an old marsh right at the mouth of the Quinault River on the shoreline. Even a small disaster becomes a much bigger one here as we sit so low in elevation and our ground is not solid. Liquefaction will be a big issue here. We are working to put in better walkways to expedite those trying to get up the hill.
Question: 17 questions left ahead. What is the plan for ensuring the safety of rescuers in these areas? What technologies (e.g., telecommunications, drones, helicopters) do you plan to use? (If you find questions tough to answer/confusing, you can check the slide for more information)	All we have is our radios and a drone. We are limited in technology for after a disaster. We do have a couple generators to charge those as needed if we can get the fuel.
Question: 16 questions left ahead. Are there any plans to supply essential goods (medicine or food, for example) after the disaster?	Yes
Question: 15 questions left ahead. How do you plan to transport these goods to evacuees? (If you find questions tough to answer/confusing, you can check the slide for more information)	Our stock of emergency provisions is positioned at the top of the hill and between our clinic and evacuation assembly area. this is stocked and ready to go all the time. We simply open up the containers and start dispersing in an orderly manner.
Question: 14 questions left ahead. Are there any places where you anticipate that normal delivery (by truck) will not be available during the disaster?	Yes
Question: 13 questions left ahead. What are your plans for getting to these hard-to-reach places? (If you find questions tough to answer/confusing, you can check the slide for more information)	We have no plan for this. There is one road in and out or Taholah and this is along the base of a hill by the sand dunes. We will be without help until a road is reestablished. Our Queets village is along Hwy 101 and will have access to trucks. The Quinault Village housing development along the Moclips Hwy should have access via 101 as well. If Hwy 101 fails or is blocked there is no other routes in or out for a lot of people.

Results for: ID# 19336441	Submission date: 12/11/2019 11:42 AM Total time: 1 hour, 25 minutes, 8 seconds
Question: 12 questions left ahead. What are the other obstacles to delivering goods?	Goods would have to come through Aberdeen/Hoquiam via Ocean Beach Rd, down from Port Angeles from the north through Jefferson county, or up form Ocean Shores. All three places are coastal and will be needing supplies themselves. We will need supplies flown in most likely from places east of the disaster area.
Question: 11 questions left ahead. If the disaster destroys the current communication system, do you have backups?	Yes
Question: 10 questions left ahead. Have you considered using experimental technology (such as ham radio, wireless mesh network, drones) to help recover telecommunications? If yes, could you share with us the possible technologies you plan to use? (If you find questions tough to answer/confusing, you can check the slide for more information)	Possible technologies: I am a HAM operator with a radio. However, the repeater we use is hard to hit from our low elevation.
Question: 9 questions left ahead. II. Regulation and the Possibility for Daily Application of Drones The following questions are mainly related to the opportunities and challenges for drone applications. Have you considered using drones in disaster response situations before?	Yes
Question: 8 questions left ahead. In which aspect do you think drones can see daily usage? (If you find questions tough to answer/confusing, you can check the slide for more information)	Transportation (Traffic Monitoring), Search and Rescue, Photography, Infrastructure Monitoring, Telecommunication, Supply/Goods Delivery
Question: 7 questions left ahead. Does your city currently place any regulations/restrictions on using drones in emergency situations? (If you find questions tough to answer/confusing, you can check the slide for more information)	No
Question: 4 questions left ahead. What do you see as the barriers to applying new techniques such as drones? (If you find questions tough to answer/confusing, you can check the slide for more information)	developing policies and procedures to utilizing them and familiarizing our different departments with the usages of them.

Results for: ID# 19337334	Submission date: 12/11/2019 3:30 PM Total time: 12 minutes, 39 seconds
Question	*Response*

Results for: ID# 19337334

Submission date: 12/11/2019 3:30 PM

Total time: 12 minutes, 39 seconds

Question: 34 questions left ahead. Imagine that you are facing a distant earthquake (originating in Alaska) that may generate a tsunami in your location. You have three hours to evacuate. What challenges, if any, do you anticipate to sending out the warning message?	Meeting with other local jurisdictions to ensure we are delivering the same message.
Question: 33 questions left ahead. Can you elaborate on the challenges of spreading the warning message?	Spreading the message should not be problematic with the use of the AHAB system.
Question: 32 questions left ahead. During the evacuation, some transportation infrastructures, such as highways or bridges, may be vulnerable to damage from ground shaking, landslides, liquefaction, or flooding. Have you considered any plans to inspect bridges and other infrastructure during the evacuation?	No
Question: 30 questions left ahead. What are the challenges to conducting this assessment? What new technologies (e.g., drones, Lidar) have you considered, if any, to overcome these challenges?	Not Considered.
Question: 29 questions left ahead. If you encountered an unexpected situation (for instance, liquefaction blocked roads or damaged bridges), do you have a plan to inform the residents and evacuees in your region?	No
Question: 26 questions left ahead. Do you have a plan for guiding tourists—most of whom will be unfamiliar with the evacuation route—to refuge sites?	Yes
Question: 25 questions left ahead. Please describe your plan for tourist evacuation. (If you find questions tough to answer/confusing, you can check the slide for more information)	distribution of pamphlets.
Question: 24 questions left ahead. If your current telecommunication infrastructure fails, what back-up technologies do you have available to guide evacuees? (If you find questions tough to answer/confusing, you can check the slide for more information)	None

Results for: ID# 19337334

Submission date: 12/11/2019 3:30 PM

Total time: 12 minutes, 39 seconds

Question: 23 questions left ahead. Do you have evacuation plans for vulnerable populations? These could include, for example, people with disabilities, the elderly, or people who are homeless. (If you find questions tough to answer/confusing, you can check the slide for more information)	No
Question: 22 questions left ahead. What are the barriers to reaching vulnerable evacuees?	Manpower and rolling resources.
Question: 21 questions left ahead. What technology do you plan to use for searching and rescuing? Can you explain your plans? (If you find questions tough to answer/confusing, you can check the slide for more information)	No technology.
Question: 20 questions left ahead. Do you have a search and rescue plan for people with disabilities?	No
Question: 18 questions left ahead. During a tsunami, earthquake, or other disaster, what places do you expect will pose a danger to rescuers? What about after the disaster?	Low lying land and older structures.
Question: 17 questions left ahead. What is the plan for ensuring the safety of rescuers in these areas? What technologies (e.g., telecommunications, drones, helicopters) do you plan to use? (If you find questions tough to answer/confusing, you can check the slide for more information)	No plan. Self-evacuation.
Question: 16 questions left ahead. Are there any plans to supply essential goods (medicine or food, for example) after the disaster?	No
Question: 11 questions left ahead. If the disaster destroys the current communication system, do you have backups?	Yes
Question: 10 questions left ahead. Have you considered using experimental technology (such as ham radio, wireless mesh network, drones) to help recover telecommunications? If yes, could you share with us the possible technologies you plan to use? (If you find questions tough to answer/confusing, you can check the slide for more information)	Possible technologies: Ham Radio and VHF Radio.

Results for: ID# 19337334	Submission date: 12/11/2019 3:30 PM Total time: 12 minutes, 39 seconds
Question: 9 questions left ahead. II. Regulation and the Possibility for Daily Application of Drones The following questions are mainly related to the opportunities and challenges for drone applications. Have you considered using drones in disaster response situations before?	Yes
Question: 8 questions left ahead. In which aspect do you think drones can see daily usage? (If you find questions tough to answer/confusing, you can check the slide for more information)	Transportation (Traffic Monitoring), Photography, Infrastructure Monitoring
Question: 7 questions left ahead. Does your city currently place any regulations/restrictions on using drones in emergency situations? (If you find questions tough to answer/confusing, you can check the slide for more information)	Yes
Question: 5 questions left ahead. Can you briefly explain these regulations or restrictions?	*No response*
Question: 4 questions left ahead. What do you see as the barriers to applying new techniques such as drones? (If you find questions tough to answer/confusing, you can check the slide for more information)	Cost.

Results for:ID# 19341976	Submission date: 12/13/2019 4:04 PM Total time: 54 minutes, 31 seconds
Question	*Response*
Question: 34 questions left ahead. Imagine that you are facing a distant earthquake (originating Alaska) that may generate a tsunami in location. You have three hours to evacuate. What challenges, if any, do you anticipate to sending out the warning message?	The largest barriers are communication networks (specifically state/local conference in calls and other human-dependent means of your passing word which can cause errors) and public preparedness/education (many people don't know if they live in the tsunami zone, aren't signed up for alerts, aren't prepared to quickly evacuate, won't want to evacuate, etc.).

Results for:ID# 19341976 Submission date: 12/13/2019 4:04 PM Total time: 54 minutes, 31 seconds

Question: 33 questions left ahead. Can you elaborate the challenges of spreading the warning	While there are plans in place to receive on tsunami alerts from the NTWC and message? disseminate these alerts to local jurisdictions, recent tests and events have revealed holes in these plans and a lack of preparation. For example, right now NTWC cannot alert Washington's inner coast about a tsunami and therefore the WA EMD has to manually alert to the inner coast once an alert is received from the NTWC. This obviously leaves room for human error. As for the public, there's a lack of knowledge about what forms the alerts will come in (WEA, EAS, NOAA weather radio, sirens, etc.) and what to do when an alert is received.
Question: 32 questions left ahead. During the evacuation, some transportation infrastructures, such as highways or bridges, may be vulnerable to damage from ground shaking, landslides, liquefaction, or flooding. Have you considered any plans to inspect bridges and other infrastructure during the evacuation?	Other: Not applicable to my position, sorry!
Question: 31 questions left ahead. Briefly, how would you conduct this evaluation?	Honestly, I'm not knowledgeable enough about transportation and infrastructure to formulate this kind of plan. Ideally there would be no issues of this kind in the event of a distant source tsunami; but for something like Cascadia, you'd need plans in place on the county level with trained workers who would know where to report and what to do without needing any instruction in the moment.
Question: 30 questions left ahead. What are the challenges to conducting this assessment? What new technologies (e.g., drones, Lidar) have you considered, if any, to overcome these challenges?	For a local source tsunami the issues are obviously that transportation infrastructure could be so damaged that traveling to these locations would be impossible in the first place. Even if they were passable, evacuating people might make them hard to access and assess. Anything that could fly over these blockages would be immensely helpful, I'd think.
Question: 29 questions left ahead. If you encountered an unexpected situation (for instance, liquefaction blocked roads or damaged bridges), do you have a plan to inform the residents and evacuees in your region?	No
Question: 26 questions left ahead. Do you have a plan for guiding tourists—most of whom will be unfamiliar with the evacuation route—to refuge sites?	Yes

Results for: ID# 19341976	Submission date: 12/13/2019 4:04 PM Total time: 54 minutes, 31 seconds
Question: 25 questions left ahead. Please describe your plan for tourist evacuation. (If you find questions tough to answer/confusing, you can check the slide for more information)	I haven't taken part in this planning specifically since I'm on the state level, but we support local jurisdictions in doing this by providing updated tsunami modeling and maps (physical and digital) with clear pedestrian evacuation routes. We can also assist with route identification and analysis to see if more signage is needed, if a path has become unusable, etc.
Question: 24 questions left ahead. If your current telecommunication infrastructure fails, what back-up technologies do you have available to guide evacuees? (If you find questions tough to answer/confusing, you can check the slide for more information)	Not knowledgeable about this
Question: 23 questions left ahead. Do you have evacuation plans for vulnerable populations? These could include, for example, people with disabilities, the elderly, or people who are homeless. (If you find questions tough to answer/confusing, you can check the slide for more information)	No
Question: 22 questions left ahead. What are the barriers to reaching vulnerable evacuees?	As far as I know, none of the local jurisdictions have specific plans in place for vulnerable populations - this is something that is currently being addressed by many, but it takes time to plan for something so complicated. Washington's coastal communities have a lot of people who are elderly/disabled, do not speak English, or who are hard to reach by normal means of communication. We also have many communities that would have very little time to evacuate during a local source tsunami, and no quick access to high ground. A lot of these communities are also accessed by ferry or bridge, which we can assume will be down for a Cascadia event.
Question: 21 questions left ahead. What technology do you plan to use for searching and rescuing? Can you explain your plans? (If you find questions tough to answer/confusing, you can check the slide for more information)	Not my area of expertise, sorry!
Question: 20 questions left ahead. Do you have a search and rescue plan for people with disabilities?	No

Results for:ID# 19341976

Submission date: 12/13/2019 4:04 PM Total time: 54 minutes, 31 seconds

Question: 18 questions left ahead. During a tsunami, earthquake, or other disaster, what places do you expect will pose a danger to rescuers? What about after the disaster?	I can speak best to an earthquake+tsunami scenario, in which case we'll see widespread hazards during and after the events: things like landslides, collapsed buildings, buckled roadways, dangerous waves and current activity for up to 32 hours and an immense amount of tsunami debris afterward, house fires, etc.
Question: 17 questions left ahead. What is the plan for ensuring the safety of rescuers in these areas? What technologies (e.g., telecommunications, drones, helicopters) do you plan to use? (If you find questions tough to answer/confusing, you can check the slide for more information)	Again, not totally my area of expertise. It depends on the size of the event... in a Cascadia event we most likely won't have easy or quick access to bigger things like helicopters, construction equipment, ATVs, etc. that would make S&R easier. It might be up to folks on the ground to decide case by case whether a situation is too dangerous to risk the safety of rescuers.
Question: 16 questions left ahead. Are there any plans to supply essential goods (medicine or food, for example) after the disaster?	Yes
Question: 15 questions left ahead. How do you plan to transport these goods to evacuees? (If you find questions tough to answer/confusing, you can check the slide for more information)	Different jurisdictions have different plans in place. For example, Bainbridge Island has supply pods across the island which residents are aware of so if an area is cut off due to a disaster, people can congregate at the pod and survive until help arrives. The Navy is looking into coastal landing sites which they can pre-identify as locations for dropping off goods in a large Cascadia-like event. It really depends on the size of the event and the amount of transportation infrastructure still usable.
Question: 14 questions left ahead. Are there any places where you anticipate that normal delivery (by truck) will not be available during the disaster?	Yes
Question: 13 questions left ahead. What are your plans for getting to these hard-to-reach places? (If you find questions tough to answer/confusing, you can check the slide for more information)	At the state level we push for everyone to have at least 2 weeks' supply of food and water for everyone in their family - and even longer for folks in remote areas. I know local jurisdictions will distribute supplies as soon as they can, but it may be delayed as roads are made at least somewhat passable.

Results for:ID# 19341976	Submission date: 12/13/2019 4:04 PM Total time: 54 minutes, 31 seconds
Question: 12 questions left ahead. What are the other obstacles to delivering goods?	For Cascadia (as an example): aftershocks, landslides, fires, lack of communication with populations that need the supplies, storage issues, potential lack of fuel, loss of airport landing strips, complete devastation of most ports/harbors/ships, simply trying to decide where limited supplies are needed most... the list goes on.
Question: 11 questions left ahead. If the disaster destroys the current communication system, do you have backups?	Yes
Question: 10 questions left ahead. Have you considered using experimental technology (such as ham radio, wireless mesh network, drones) to help recover telecommunications? If yes, could you share with us the possible technologies you plan to use? (If you find questions tough to answer/confusing, you can check the slide for more information)	Yes
Question: 9 questions left ahead. II. Regulation and the Possibility for Daily Application of Drones The following questions are mainly related to the opportunities and challenges for drone applications. Have you considered using drones in disaster response situations before?	No
Question: 8 questions left ahead. In which aspect do you think drones can see daily usage? (If you find questions tough to answer/confusing, you can check the slide for more information)	Transportation (Traffic Monitoring), Search and Rescue, Photography, Infrastructure Monitoring, Telecommunication, Supply/Goods Delivery
Question: 7 questions left ahead. Does your city currently place any regulations/restrictions on using drones in emergency situations? (If you find questions tough to answer/confusing, you can check the slide for more information)	No
Question: 4 questions left ahead. What do you see as the barriers to applying new techniques such as drones? (If you find questions tough to answer/confusing, you can check the slide for more information)	Initial costs and costs for upkeep, pushback from senior management or anti-tech types, possible storage issues, need for training, maybe public perception (issues with privacy, etc.).

Results for: ID# 19758493	Submission date: 5/04/2020 6:08 PM Total time: 49 minutes, 9 seconds
Question	*Response*

Question: 34 questions left ahead. Imagine that you are facing a distant earthquake (originating in Alaska) that may generate a tsunami in your location. You have three hours to evacuate. What challenges, if any, do you anticipate to sending out the warning message?	Actually getting the message out to the community. Depending on the time of day. Use of the Grays Harbor Telera to those who have subscribed. Use of the tsunami warning sirens and messages. A bilingual message is needed as well. Large companies with multiple employees need the proper training and communication devices in order to evacuate their employees.
Question: 33 questions left ahead. Can you elaborate on the challenges of spreading the warning message?	Education and participation is lacking among the residents and employers.
Question: 32 questions left ahead. During the evacuation, some transportation infrastructures, such as highways or bridges, may be vulnerable to damage from ground shaking, landslides, liquefaction, or flooding. Have you considered any plans to inspect bridges and other infrastructure during the evacuation?	No
Question: 30 questions left ahead. What are the challenges to conducting this assessment? What new technologies (e.g., drones, Lidar) have you considered, if any, to overcome these challenges?	Lack of available personnel. The time of the event, weather conditions, skill sets, experience, all will dictate what is achievable.
Question: 29 questions left ahead. If you encountered an unexpected situation (for instance, liquefaction blocked roads or damaged bridges), do you have a plan to inform the residents and evacuees in your region?	No
Question: 26 questions left ahead. Do you have a plan for guiding tourists—most of whom will be unfamiliar with the evacuation route—to refuge sites?	No
Question: 24 questions left ahead. If your current telecommunication infrastructure fails, what back-up technologies do you have available to guide evacuees? (If you find questions tough to answer/confusing, you can check the slide for more information)	Personnel on shift, volunteers, tsunami siren messaging
23 questions left ahead. Do you have evacuation plans for vulnerable populations? These could include, for example, people with disabilities, the elderly, or people who are homeless. (If you find questions tough to answer/confusing, you can check the slide for more information)	No
Question: 22 questions left ahead. What are the barriers to reaching vulnerable evacuees?	Unknown location of their residence. Lack of personnel or volunteers to go residence to residence.

Question: 21 questions left ahead. What technology do you plan to use for searching and rescuing? Can you explain your plans? (If you find questions tough to answer/confusing, you can check the slide for more information)	Westport PD has two UAV's. When possible the drones would be launched with the intent of damage assessment and rescue of stranded citizen's.
Question: 20 questions left ahead. Do you have a search and rescue plan for people with disabilities?	No
Question: 18 questions left ahead. During a tsunami, earthquake, or other disaster, what places do you expect will pose a danger to rescuers? What about after the disaster?	The low elevation areas that would be overcome with the tide. Structures or business's severely damaged that may collapse.
Question: 17 questions left ahead. What is the plan for ensuring the safety of rescuers in these areas? What technologies (e.g., telecommunications, drones, helicopters) do you plan to use? (If you find questions tough to answer/confusing, you can check the slide for more information)	Volunteers or paid personnel will be sent out in teams. 2 way communication with a commander will be on-going. If available any "eyes in the sky" would be utilized to steer rescuers to the stranded, or away from dangerous areas.
Question: 16 questions left ahead. Are there any plans to supply essential goods (medicine or food, for example) after the disaster?	No
Question: 11 questions left ahead. If the disaster destroys the current communication system, do you have backups?	No
Question: 9 questions left ahead. II. Regulation and the Possibility for Daily Application of Drones The following questions are mainly related to the opportunities and challenges for drone applications. Have you considered using drones in disaster response situations before?	Yes
Question: 8 questions left ahead. In which aspect do you think drones can see daily usage? (If you find questions tough to answer/confusing, you can check the slide for more information)	Transportation (Traffic Monitoring), Search and Rescue, Photography, Infrastructure Monitoring, Supply/Goods Delivery
Question: 7 questions left ahead. Does your city currently place any regulations/restrictions on using drones in emergency situations? (If you find questions tough to answer/confusing, you can check the slide for more information)	No
Question:	Training of personnel or volunteers to

4 questions left ahead. What do you see as the barriers to applying new techniques such as drones? (If you find questions tough to answer/confusing, you can check the slide for more information)	operate the drones. Obtaining the drones and needed equipment to operate them.

Results for: ID# 19938271

Submission date: 7/13/2020 9:08 AM

Total time: 18 minutes, 59 seconds

Question	*Response*
Question: 34 questions left ahead. Imagine that you are facing a distant earthquake (originating in Alaska) that may generate a tsunami in your location. You have three hours to evacuate. What challenges, if any, do you anticipate to sending out the warning message?	Reaching people most at risk... elderly and those with disabilities. Getting people to sign up and register for the text and email warning notifications is crucial.
Question: 33 questions left ahead. Can you elaborate on the challenges of spreading the warning message?	Once the distant event has been announced there will likely be a some lag before tsunami sirens are triggered, as wave height and speed are evaluated. This may lead to an even shorter time to respond and evacuate.
Question: 32 questions left ahead. During the evacuation, some transportation infrastructures, such as highways or bridges, may be vulnerable to damage from ground shaking, landslides, liquefaction, or flooding. Have you considered any plans to inspect bridges and other infrastructure during the evacuation?	No
Question: 30 questions left ahead. What are the challenges to conducting this assessment? What new technologies (e.g., drones, Lidar) have you considered, if any, to overcome these challenges?	Drones would be very effective in conducting an assessment.
Question: 29 questions left ahead. If you encountered an unexpected situation (for instance, liquefaction blocked roads or damaged bridges), do you have a plan to inform the residents and evacuees in your region?	Yes
Question: 28 questions left ahead. How you plan to spread the warning and guide them to alternative evacuation routes?	Utilizing County Emergency Management as a resource to inform through their notification system. Also utilize social media.
Question: 27 questions left ahead. Do you plan to employ any emerging technologies to send the warning message? (If you find questions tough to answer/confusing, you can check the slide for more information)	Smartphone apps / notifications, Social media, Radio / television broadcasting, Other: AHAB Sirens

Question: 26 questions left ahead. Do you have a plan for guiding tourists—most of whom will be unfamiliar with the evacuation route—to refuge sites?	Yes
Question: 25 questions left ahead. Please describe your plan for tourist evacuation. (If you find questions tough to answer/confusing, you can check the slide for more information)	Evac route maps, signage, information available at lodging and hospitality sites
Question: 24 questions left ahead. If your current telecommunication infrastructure fails, what back-up technologies do you have available to guide evacuees? (If you find questions tough to answer/confusing, you can check the slide for more information)	Currently none
Question: 23 questions left ahead. Do you have evacuation plans for vulnerable populations? These could include, for example, people with disabilities, the elderly, or people who are homeless. (If you find questions tough to answer/confusing, you can check the slide for more information)	No
Question: 22 questions left ahead. What are the barriers to reaching vulnerable evacuees?	Depending on event barriers could include geographic/topographic issues.
Question: 21 questions left ahead. What technology do you plan to use for searching and rescuing? Can you explain your plans? (If you find questions tough to answer/confusing, you can check the slide for more information)	Currently have one drone available at the police department.
Question: 20 questions left ahead. Do you have a search and rescue plan for people with disabilities?	No
Question: 18 questions left ahead. During a tsunami, earthquake, or other disaster, what places do you expect will pose a danger to rescuers? What about after the disaster?	The entire city is in the inundation zone, so there is danger from wave and flooding, as well as the potential for structural failures. After the event there will be unstable roadways, debris and possibly contaminated areas to deal with.
Question: 17 questions left ahead. What is the plan for ensuring the safety of rescuers in these areas? What technologies (e.g., telecommunications, drones, helicopters) do you plan to use? (If you find questions tough to answer/confusing, you can check the slide for more information)	Radio, cellular if available. Short Wave. We would rely on outside assistance for safety and rescue.
Question: 16 questions left ahead. Are there any plans to supply essential goods (medicine or food, for example) after the disaster?	Other: Minimal for Essential employees only

Question: 15 questions left ahead. How do you plan to transport these goods to evacuees? (If you find questions tough to answer/confusing, you can check the slide for more information)	N/A
Question: 14 questions left ahead. Are there any places where you anticipate that normal delivery (by truck) will not be available during the disaster?	No
Question: 12 questions left ahead. What are the other obstacles to delivering goods?	Inundated, failed and/or unstable roadways and bridges
Question: 11 questions left ahead. If the disaster destroys the current communication system, do you have backups?	No
Question: 9 questions left ahead. II. Regulation and the Possibility for Daily Application of Drones The following questions are mainly related to the opportunities and challenges for drone applications. Have you considered using drones in disaster response situations before?	Yes
Question: 8 questions left ahead. In which aspect do you think drones can see daily usage? (If you find questions tough to answer/confusing, you can check the slide for more information)	Transportation (Traffic Monitoring), Search and Rescue, Photography, Infrastructure Monitoring, Telecommunication, Supply/Goods Delivery
Question: 7 questions left ahead. Does your city currently place any regulations/restrictions on using drones in emergency situations? (If you find questions tough to answer/confusing, you can check the slide for more information)	No
question: 4 questions left ahead. What do you see as the barriers to applying new techniques such as drones? (If you find questions tough to answer/confusing, you can check the slide for more information)	Acquisition of drones, cost, training

APPENDIX C: CSET OUTREACH MEETING WITH CITY OF WESTPORT

2020-08-26
South Beach Regional Fire Authority training center
Partial recording saved as "20200826-SBRFA-meeting_notes.m4a"

Participants

Westport/South Beach:

- Dennis Benn, Chief/EMT, South Beach Regional Fire Authority (SBRFA)
- Daryl Brown, Battalion Chief/EMT, SBRFA
- Katie Didion, Public Educator/Public Information Officer, part-time, SBRFA
- Kevin Goodrich, Director, Westport Public Works
- Chris Nicholson, drone program volunteer/EMT, SBRFA
- Tracy Rosenow, Chief, Westport Police
- Heather Sweet, Superintendent, Ocosta School District

UW:

- Dan Abramson, Urban Design & Planning
- Loyce Adams, Applied Math
- Randy Leveque, Applied Math
- Yiran Zhang, Civil & Environmental Engineering

Discussion of tsunami evacuation walk map and its use

("ger_tsunami_walkmap_westport_for_print_300_dpi.pdf," at http://cms5.revize.com/revize/graysharborcounty/Emergency%20Management/ger_tsunami_walkmap_westport_for_print_300_dpi.pdf) *(made by WA DNR – Department of Natural Resources)*

- After short-turnaround ground-truthing input by Kevin Goodrich, Tracy Rosenow, Daryl Brown (and Dennis Benn? Others?), DNR finalized the map for public distribution. It will need to be updated as new tsunami vertical evacuation structures (VES) are built.
- The map is a major improvement over information that had previously been available to guide people to evacuation sites. It indicates locations of high ground on the Westport peninsula that, according to the latest modeling, would remain un-inundated by a tsunami generated by the largest considered earthquake for the region (the "L1", with a 2500-year recurrence interval), whereas the previous generation of tsunami evacuation maps showed the entire peninsula inundated. The map also shows the modeled times for foot evacuation from every point on the peninsula to the nearest un-inundated high ground.
- Remaining difficulties and questions for map design:
    - Map is complex, and despite (or because of) detailed markings, there is some confusion about what the colored zones represent: wave heights or minutes to walk to nearest high ground (the latter is correct)?
    - Nature of evacuation destinations are unclear; walk routes show the shortest ways to reach "high ground," but there is potential confusion as to whether the high ground is the destination or whether it is necessary to reach Assembly Areas or Vertical Evacuation Areas (marked as A and E, respectively).
    - The meaning of "high ground" is unclear, and its color (gray) on the map is not explained in the legend nor easily distinguishable from impassable wetland and slopes. There is potential confusion for people who mistake "high ground" for simple elevation above sea level. [*Might a bright green color be better than gray?*] "High ground" is actually "high and dry ground" based on models of tsunami wave behavior. Wave heights are

not uniform across the peninsula and depend on complex factors such as the direction of the incoming tsunami, proximity to the shore, details of bathymetry and topography, and interactions of each wave with vegetation, structures, and subsequent waves that come after earlier ones; some places that are more elevated above sea level may be inundated while other, lower, places are not. Will people follow the routes marked if they think that the nearest high ground is somewhere other than indicated on the map?
    - Is further geotechnical investigation needed to confirm the safety of areas marked as high ground? How stable are sand dunes (e.g. near City Park or north wellfield water tower) to L1 shaking? How susceptible are they to scouring by L1 tsunamis?
    - Loyce: would it make sense, as in Japan, to designate multiple evacuation destinations depending on the severity of the event? I.e., if shaking is non-existent or light but a siren sounds, then go first to shelter A, but if the event seems worse based on shaking, go to shelter B, and then to shelter C. Daryl: but this may be too complicated.
- Remaining tasks and questions for map use:
    - Walk routes need to be marked on the ground or along the way where people can see and follow them without a map. Existing signage is for vehicles, not pedestrians.
    - Assembly areas are currently just sites designated on the map; no supplies, shelter, communication equipment, or other emergency tools are stored there. There is no plan for City staff or other designated people to be there to take responsibility, distribute supplies and information. Kevin is concerned that people will expect the city government to take this responsibility, but no mandate or funds exist for city staff to fill this role or store supplies. Other than snacks and bottled water, the Ocosta School VES also has no stored supplies.
    - The evacuation planning team is discussing the desirability of having residents and hospitality businesses grouped by zone/region or neighborhood to train with the map and become familiar with their particular routes and destinations. The arrows on the map currently reflect where people reside and how to get to the nearest safe areas. Would it be helpful as a part of this training to show animations of wave behavior to explain which areas are safe and which are not? Would it be useful to have neighborhood groups themselves contribute to stocking supplies at Assembly areas and prepare for their use?

Current concern for public education about tsunami preparation and evacuation

- No practical drill, basic preparation guidance for a tsunami can be dry
- No post-tsunami plan (e.g., supply and rescue) for the public, while Westport citizens think they can count on the city/county/state/country
- Trade-offs often exist between informing people what they should know vs. causing people to panic; there will always be finger-pointing, whether because the severity of the hazard was overestimated or underestimated.
- Evacuation guidance varies for different levels of tsunami warning: distant-source tsunamis (with no or little shaking, leaving roads intact) allow for evacuation by car; near-source tsunamis (preceded by noticeable and significant shaking) should be evacuated on foot.
- Lack of communication with business people and tourists who should be informed what to do and how to organize their employees and customers
- COVID-19 is an extra challenge now for outreach

Brainstorm for educating people

- Group residents into zones and make sure they know where they should go
- Shopping bags printed with tsunami & evacuation information and checklist of "go-bag" items
- Set up annual or more frequent activities for people to become familiar with their house/neighborhood-specific evacuation route and assembly point
    - Hold the event near/within the VES/higher ground
    - Provide emergency supplies that can also be stored for tsunami events
    - Group people into zones, let them know about the neighborhood idea and let them know they should self-managed supplies and storage
    - Combine preparedness with social events, e.g. a drill that ends in a barbecue or block party that uses up perishable supplies as they are being replaced. How to make Japanese (culturally adapted) practices more in line with Westport's cultural values and life?
- More people/agencies need to be involved (PUD, Grayland water, Coast Guard, South Beach region, State)
- Tech solutions
    - Drones with loudspeakers that can guide people along evacuation routes based on real-time information, e.g. how severe the event is; where people are; etc.
        - Some problems: wind more powerful than loudspeaker; equipment sits unused most of the time; trained operators might not be present when needed
        - Some solutions: have a number of trained operators in each neighborhood or sub-community who use the drones on a regular basis, perhaps as part of a school program; include them in drills so residents become familiar with them but also know what to do if for some reason they are not workable.
    - Smartphone apps that can personalize evacuation routes based on site-specific and real-time information.
        - Problem: many residents do not have smart phones or cannot be relied on to use the app
        - Solution: have designated community members with app on their smartphones who can be point-persons for others who don't
    - Organize ham radio operators and train to participate in emergency response
        - Problem: younger community members tend not to be interested in "old" technology
        - Solution: have younger community members focus instead on new technologies, or combinations of new-and-old technologies, e.g. Low Power FM that also broadcasts over the Internet; or LPFM that broadcasts alerts, news, queries based on higher-tech-gathered information, e.g. from drones, social media, etc.

CSET project (Next step)

Education

- 107 test training (drone pilot test)
- Data processing (GIS, modeling)
- Tsunami & evacuation
- Radio (Low power FM radio, ham radio)

For

- High school/college (Grays Harbor College) students

    - What are some good topics/projects/applications to generate interest and participation?
    - College/AP credit? Are there existing UW credit-earning courses that could be adapted?
    - Independent study?
    - Internships?
- Fire department employees
- Volunteer

How

- Summer class/flexible program/after school class (for students)
- Online training
- Drone flying training
    - Data collection of Westport State park/Jhon river

Before everything starts…

- Understand current constraints
- Identify the group of people who should be trained
- Understand what data they are available to gather