DRONE TECHNOLOGY EDUCATION IN RURAL, ISOLATED, TRIBAL AND INDIGENOUS (RITI) COMMUNITIES

FINAL PROJECT REPORT

by

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16. Abstract

Transportation and traffic safety is a primary concern within Rural, Isolated, Tribal and Indigenous (RITI) communities in Washington State. Emerging technologies such as connected and autonomous vehicles, sensors and drones have been tested and developed to improve traffic safety, but these advances have largely been limited to urban areas. This project identified opportunities and challenges of adopting drone technologies in RITI communities, and explored context-sensitive applications to traffic safety and related goals. In three phases, the team conducted community workshops, online surveys and other outreach activities with state and county agencies responsible for emergency management and crisis response in coastal Tribal and non-tribal communities; a planning studio and Comprehensive Plan Update for the City of Westport and its surrounding South Beach community straddling two rural counties and including the Shoalwater Bay Indian Tribe; and a pilot educational program with the School District that serves it. To be effective in rural contexts, adoption of drone technology depends on a broadening of local skill development and needs to target diverse community goals. In short, it needs to be broadly embedded in the community. Taking this sociotechnical approach, we focused on long-term workforce development and designed and implemented an after-school program (October 2021 – June 2022) for Ocosta Junior High School students. The course taught students how to assemble and pilot drones and apply them to a variety of practical needs including public works inspection, search and rescue, and environmental monitoring of coastal flooding.

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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
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
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

Rural, Isolated, Tribal, or Indigenous (RITI) communities in the U.S. face multiple challenges. Among them, improving traffic and transportation safety and emergency planning and response capacity are imperative goals. It is believed that drone technology provides an economical and effective way to solve the traffic safety and emergency challenges of RITI communities. However, although emerging technologies such as drones are extensively researched and applied in urban areas, they are less widely applied in RITI communities due to limited funding resources, thinly stretched human capital, and lagging acquisition of tech/equipment, among other reasons. The CSET team conducted a three-phase project to identify, understand, and synthesize the opportunities and challenges of adopting drone technologies in RITI communities, and to explore context-sensitive applications. During the project's initial two phases, we conducted community workshops, online surveys, and other outreach activities with state and county agencies responsible for emergency management and crisis response in Tribal and non-tribal communities on the Washington Pacific coast; a planning studio and Comprehensive Plan Update for the City of Westport and its surrounding South Beach community straddling Grays Harbor and Pacific Counties and including the Shoalwater Bay Indian Tribe. We found that more than simply the physical acquisition of drones, the critical needs of RITI communities for consistent and sustainable use of drone technology currently are the acquisition of drone-related knowledge and skills and an understanding of their relevance more broadly within the community. Therefore in the third phase, the project focused on drone-related education and the creative exploration of their applicability to a wide range of community goals beyond the narrow mandates of a particular agency.

Starting in October 2021, the project team partnered with the City of Westport and Ocosta School District to conduct an after-school program (ASP) for Ocosta Junior-Senior High School students. Inspired by the drone-related pedagogy outlined in "Drones for Good: How to Bring Sociotechnical Thinking into the Classroom" (1), the course design included not only the teaching of drone-related technology and regulations but also integrated community-based learning, including emergency preparedness and response, environmental resilience, and traffic safety, in order to enhance students' view of drone applications that are beneficial and meaningful considering the special characteristics of their own community. The course content covers drone-related technology learning, drone regulation-based learning and drone operations with multiple application scenarios, including critical infrastructure inspection (e.g., the school's tsunami vertical evacuation structure (VES), municipal water storage tanks, state highway bridges, and flood-prone streets, parks, and drains), king tide event monitoring, search-and-rescue operations, and recreational space asset inventorying. The project team partnered with five teachers from Ocosta school and two community volunteer pilots to coach the students. Based on the nine-month ASP, this report summarizes the drone-related education opportunities, limitations and constraints as well as possible drone application recommendations for Westport and Ocosta School District.

Conclusions include: 1) volunteer and non-specialist local participants are critical factors for drone-related application in RITI communities; 2) drone education should not only focus on drone technology but also combine with community-based learning so as to develop drone applications that are locally meaningful and beneficial for a diverse range of community goals; 3) drone video and photography conducted by students during the ASP has already been useful to the local Public Works department's maintenance operations. The goal of this project is to provide guidance and recommendations for future studies regarding drone-related education in RITI communities.

CHAPTER 1. INTRODUCTION

1.1. General Background

Rural, Isolated, Tribal and Indigenous (RITI) communities in the Washington State (and the U.S.) face many challenges covering health care and education, economic development, and public safety. Among them, two imperative goals are enhancing RITI communities' traffic safety and improving emergency management. The Rural Transportation Statistics from United States Department of Transportation (USDOT) showed that although only 19% of the U.S. population live in rural areas, 43% of all roadway fatalities occur on rural roads, which is almost two times higher than the fatalities on urban roads (*2*). Transportation Safety in Tribal Areas from FHWA (Federal Highway Administration) also indicated that transportation-related injuries and fatalities have greater rates among Native American and Alaska Native populations than in other demographic groups (*3*). In Washington (WA) State, the traffic fatality rate of American Indians and Alaskan Natives (AIANs) is 28.5 deaths per 100,000 people in the population. This rate is about four times higher than other demographic groups' next highest death rate (*4*, *5*). Meanwhile, the planning tools and processes that typically govern transportation investments and traffic management in RITI communities rarely integrate with planning for hazard mitigation/emergency planning (*6*).

On the other hand, emerging technologies such as connected autonomous vehicles and unmanned aerial vehicles (drones) developed for traffic safety improvement are often not widely shared in RITI communities for various reasons. Therefore, the project team conducted a three-phase project to identify and synthesize the opportunities, challenges, and scenarios that relate to the adoption of drone technologies in RITI communities, and to develop context-sensitive applications to traffic safety-related improvements. The research approach and progress for each phase is displayed in Figure 1.1. In the first two phases (completed), the project team organized and participated in several community meetings to engage with RITI communities on the outer Pacific coast of WA State and conducted an online survey and pilot study to learn about the communities' distinctive characteristics and identify the opportunities and limitations relevant to drone technology applications.

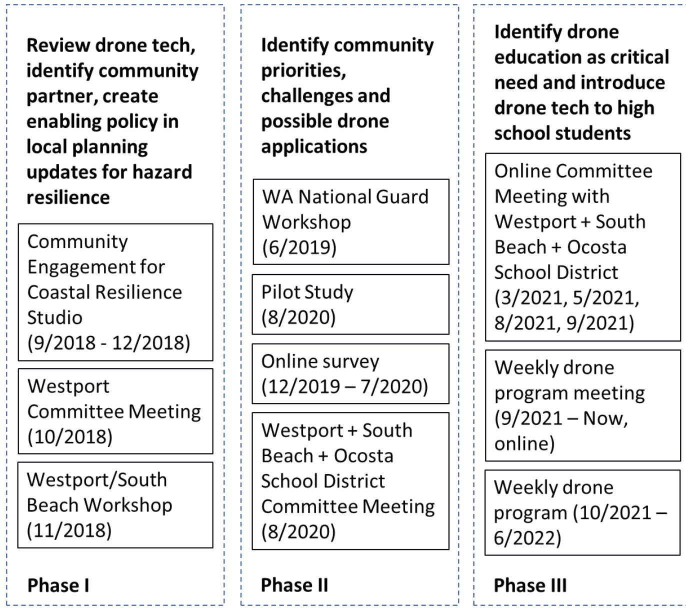

Figure 1-1. Summary of approach and progress

Phase I (the first-year project) focused on drone-related knowledge learning and community partner identification (*6*). The team reviewed drone-related literature and regulations to understand and identify the limitations and opportunities of drone technology in RITI communities, specifically on the Pacific Coast of Washington State. Working iteratively, the team began by engaging local governments in the South Beach area of Grays Harbor and Pacific Counties, including the City of Westport (Public Works Department and Police Department), Shoalwater Bay Indian Tribe, Ocosta School District, South Beach Regional Fire Authority, Grays Harbor County Emergency Management, and Washington State Emergency Management Division. Phase II then scaled up its focus by participating in a state National Guard workshop with emergency managers along the entire WA Pacific coast and distributing a survey to them. The research team also participated in a parallel project funded by the National Science Foundation with the City of Westport to collect remote sensing and mapping data using drones and other scanning technologies for purposes of documenting the environment and its hazard vulnerabilities, and developing community geonarratives about its past and future changes and adaptive potential. The main activities are summarized below (more details of these activities can be found in the previous reports (*6*, *7*)):

- Community Engagement for Coastal Resilience Planning Studio (Sep-Dec 2018): The studio engaged RITI communities (City of Westport, Shoalwater Bay Tribe and Grays Harbor County) on the Pacific coast to learn their current challenges and concerns with respect to pre-disaster recovery planning, proactive adaptive planning, and emergency evacuation and disaster preparedness planning. Additionally, the project team helped communities recognize current transportation and traffic safety challenges as well as possible drone applications. The team also helped the City of Westport draft an update to the transportation and circulation (traffic) element of its Comprehensive Plan. As part of the Update, the research team proposed the inclusion of a telecommunications sub-element that explicitly supports the exploration of drone applications for traffic and emergency management purposes. The Westport City Council adopted the Comprehensive Plan Update on July 12, 2021 (*8*).

- WA National Guard Workshop (Jun 2019): The workshop invited coastal communities from WA State to learn their current needs and challenges of emergency management under a distant-source tsunami scenario. The project team presented findings from drone-related literature and proposed possible applications relevant for RITI community emergency management conditions.
- Online Survey (Dec 2019-Jul 2020): Following up the June 2019 National Guard workshop, the team designed an online survey to further identify the current challenges, issues and needs surrounding hazard scenarios in RITI communities and find context-sensitive solutions using drones. The team used snowball sampling to conduct the survey with workshop participants from the City of Westport, Quinault Indian Nation, South Beach Region, and Washington Emergency Management Division. The survey results helped determine the focus of this project, by identifying the challenge RITI communities face in adopting drone technologies specifically for emergencies when more daily needs tend to exhaust local resources (staff time as well as funds); our proposed solution was to explore how drone technology might be made more regularly relevant to a broader segment of the population by introducing it to students in a local school district and applying it to a broader range of tasks, including emergency response as well as more general environmental awareness, infrastructure maintenance, and long-term community improvements.
- Pilot study (Drones for remote sensing/mapping of the community, Aug 2020): The project team cooperated with the NSF CoPe EAGER "Coastal Hazard Planning in Time" project (Award #1940024) to deploy UW NHERI Natural Hazards Reconnaissance (RAPID) Facility drones (with the help of NHERI staff) to gather data for purposes of building a 3D digital model of the City of Westport and 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 engaging community members in workshops to discuss strategies. 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 members piloted drones and operated ground-based laser scanners for data collection. The team also met with community members to discuss future plans for drone applications. Through these outreach activities, the school district decided to assemble a group of STEAM teachers and student families who are interested in setting up an after-school program (ASP) dedicated for drone training and education.

1.2. Study Motivation and Area

Through the previous outreach activities, online survey and pilot study with the WA coastal communities, it was found that drone-related applications have limitations peculiar to RITI communities. In comparison to urban areas with better research and better resources, RITI communities often struggle with the following problems with respect to traffic safety needs and challenges, as well as emergency planning:

- Minimal budgets for specialized equipment and few opportunities for levering economies of scale. Technologies often need to be able to perform different kinds of tasks on a frequent basis in order to justify their expenses.
- Minimal budgets (and often at a short notice) for hiring and training personnel responsible and available for the deployment of specialized technologies. Complex and specialized technologies

are often left "in the box" or "on the shelf" due to the lack of time, training, and personnel to operate them. Most official personnel and community leaders "wear many hats"; they perform multiple duties and functions, including both paid and volunteer public and community services as well as participation of economic activities.

- RITI communities rely heavily on volunteer and part-time personnel for emergency and public safety services such as firefighting, ambulance, and EMT (Emergency Medical Technicians). Training volunteer personnel in advanced technology is rarely worth the expense of time and funds unless volunteers can find a number of uses for the technology, or enjoy using it out of personal interest. Technologies that align with community members' enthusiasms are most likely to be used.
- RITI communities suffer from "brain drain" and lack of opportunity for youths to remain gainfully employed in the community as they mature.
- Given the spatial dispersedness of RITI communities and their remoteness from major service centers, there is a low likelihood in an emergency (e.g., traffic accident, tsunami) that a given piece of complex equipment will be accessible to the people who can use it and the places that need it, especially if the emergency involves widespread damage to roads and other infrastructure (e.g. storms, flooding, power-outages, wildfires, earthquakes, etc.), or occurs in isolated locations. The more people in the community who are familiar with the equipment, the more likely someone who can use it will be near it when needed.
- RITI communities and their members typically depend on a combination of local mutual assistance and individual self-reliance, initiative, and creativity to cope with emergencies, rather than rely on specialized authorities in a bureaucratic system. To be useful, technologies need to be broadly familiar and available to community members in diverse circumstances.

Given these limitations and concerns, we noticed that apart from the physical drones, the essential needs for RITI communities regarding consistent and sustainable use of drones are drone-related knowledge and skills in community members. This includes, for instance, how to operate drones of different types, how to efficiently dispatch drones considering their power capacity, how to acquire the remote pilot certification by FAA (Federal Aviation Administration) for commercial drone operation, among others. Therefore, the Phase III project focused on drone-related education programs. The project team recruited high school students for drone-related education since i) drone education programs for high school students can raise community awareness of drones, traffic safety and emergency planning, not only for the students but also for their family members and teachers; ii) drone operation on/off the campus can raise situational awareness and familiarity of technologies that may be essential under disaster/emergency conditions; iii) students can use the learned knowledge/skills to help (e.g., via internship opportunities) fire, police, EMT, and public works, and to develop skills needed to participate in university research, such as mapping and GIS, digital modeling, virtual immersive evacuation drilling, environmental science, infrastructure monitoring, and robust telecommunications systems for disaster resilience and traffic safety. Such intern/volunteer experience with local transportation and related authorities can also help students' long-term education and career goals (e.g., job opportunities, higher education applications, etc.).

The project team collaborated with the City of Westport and Ocosta School District (Figure 1.2) and participated in the after-school program (ASP) for drone education. Westport is a small rural incorporated City located on a peninsula at the south side of Grays Harbor mouth (*9*). The Westport

Marina was ranked 11th in the nation for seafood landings in 2017 with more than 250 commercial fishing vessels and landing over $64 million in seafood, equal to approximately 150 million pounds of salmon, crab, hake and other species (*10*). In 2020, Westport had a population of 2,200 people with a median age of 49.4, a median household annual income of about $45,357, a poverty rate of 17.2% (*11*), qualifying the City as a federally designated impoverished community. The Ocosta School District, based near the south of Westport, serves a diverse rural community including the City of Westport, as well as approximately 5,200 people in unincorporated areas of Grays Harbor and Pacific Counties, and the Shoalwater Bay Indian Tribe. The total minority enrollment of Ocosta Junior-Senior High School is 43%, and 78% of students are economically disadvantaged (*12*). In addition, the elementary school in Ocosta includes the first tsunami vertical evacuation structure (VES) in North America (*13*). The VES is funded entirely by a local property tax levy, demonstrating a strong local commitment to safety and multi-generational survival.

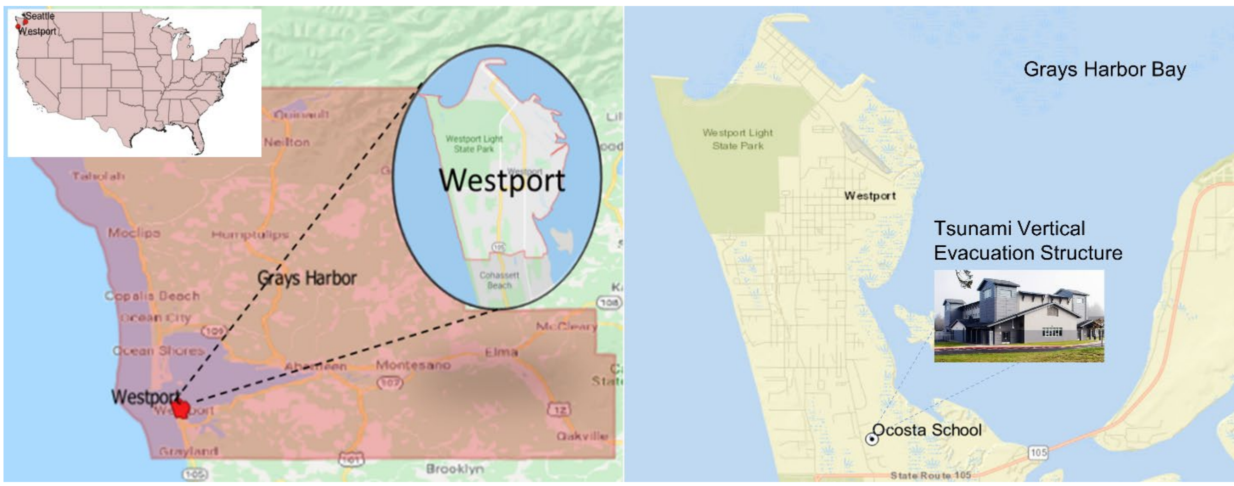

Figure 1-2. Study area in this project: City of Westport(left) & Ocosta Schools (right)

The rest of this report is organized as follows: CHAPTER 2 introduces the main framework that guides the project design; CHAPTER 3 presents the design and implementation of the after-school program (ASP), including the course design and the roles of staff; CHAPTER 4 displays the conducted activities under the ASP; CHAPTER 5 summarizes the findings and recommendations and CHAPTER 6 outlines the concluding remarks and discusses the future study.

CHAPTER 2. FRAMEWORK GUIDING THE PROJECT DESIGN

This project applies a sociotechnical approach to introducing local youth to drone technology and its applications through an after-school program (ASP) at Ocosta Junior-Senior High School. the course aimed not only to teach students drone technology itself but also to train them to conduct drone applications that are locally meaningful and beneficial for their communities. Inspired by the book "Drones for Good: How to Bring Sociotechnical Thinking into the Classroom" (*1*), the course adapted the book's college-level pedagogy to the middle and high school level by: 1) modeling sociotechnical thinking, by considering how drone applications would better help the community, and what limitations and barriers to such applications exist; 2) teaching drone assembly, drone-related regulation, and drone operation skills; 3) introducing students to the broader goals of emergency planning and response, environmental resilience and adaptation, and traffic safety, with the participation of local community leaders in municipal planning and public works, police, fire and medical response, and environmental management and design, and encouraging them to think about possible applications that could be meaningful for their communities. Through these elements, the course framework in this project integrated drone technology and community-based learning and capacity, as further discussed in this chapter. Appropriate to junior high school students, the course emphasized hands-on experience and minimized text-based learning.

2.1. Drone Technology Learning

The technical element of the ASP training focused on preparing students to identify drones' essential components and assembly, learn the FAA's basic regulations, acquire basic drone operation skills, and obtain the drone license for those who are of age (sixteen years).

Drone technology learning used existing drone kits (Rubiq) provided by Ocosta School. The Rubiq kits contain all parts and tools needed for drone assembly and drone configuration and calibration guidance. Through the drone assembly process, students were able to learn the critical components of drones, such as the power distribution board, FPV (First-person View) camera, video transmitter, and propellers (*14*). The drone configuration and calibration guidance (*15*), on the other hand, helped students learn the pre-flight check (e.g., GPS calibration) and the connection between physical drones and their remote controllers. The assembled Rubiq drone is displayed in Figure 2.1 a).

a) Rubiq (*16*) b) DJI mini 2 (*17*) c) DJI Air 2 (*18*)

Figure 2-1 Drone used in the ASP

Drone-related regulation learning followed FAA regulations. Since most of the students who participated in the Ocosta School program were under 16 years old, they were too young to take the pilot license

(107) test (*19*), but all the students took the TRUST (The Recreational UAS Safety Test) course and passed the aeronautical knowledge and safety test required by FAA for recreational drone operation (*20*). The TRUST test ensures students learn how to plan flights and fly safely in the NAS (National Airspace System) (*21*). Detailed learning contents are summarized below.

Table 2.1 Drone-related regulation learning (TRUST test content) (*20*)

Regulation Learning	Description
Airspace	• Flying operation varies under controlled/uncontrolled airspace • Possible resources for airspace check (e.g., B4UFLY)
Pre-flight Check	• Weather condition and area check (to ensure not flying drones under extreme weather, high turbulence, or signal interference areas, etc.) • Pilot situations check (pilot should be both physically and mentally ready for safe drone operation) • No alcohol and drugs before/during the drone operation • Drone check (propellers/rotor blades, landing gear, and structure or signs of damage or wear, battery condition, GPS calibration) • Control station check • Drone-related hazard learning (e.g., damaged batteries can cause fires) • Drone manufacturer's safety information check (e.g., maximum altitude, weight, and flight distance)
Operation-related Regulation	• Limit flying height (400 ft) • Keep the drone within the visual line of sight (VLOS) • Other aircraft checks • Follow the safety guidelines developed by a Community Based Organization • Drone registration requirement

Drone operation training aimed to help students build basic skills for safely flying the drones so that they could use drones for photography, infrastructure inspection, and search and rescue, among other activities. The project team provided DJI drones (DJI mini 2 and DJI Air 2, shown in Figure 2.1 b), c)) for drone operations; compared with the Rubiq drones, DJI drones’ more automatic control system makes them friendlier to operate and they are more resistant to weather conditions in Westport such as strong winds and rain. In addition to launching, landing, moving and turning, photographing and video-taking using drones were included in the drone operation training.

2.2. Community-based Learning and Capacity Building

Apart from the drone technology, community-based learning and capacity building were also embedded in the course design to ensure that the application of drone technology is locally and immediately relevant. In other words, the course design also aimed to encourage students to come up with solutions on how drone-related applications can be beneficially, efficiently, and meaningfully applied to their communities. The project team designed various scenarios for drone operations, including search and rescue, king tides documentation, and critical infrastructure inspection, among others. Not only do the various drone activities enhance students' skills in drone operations, they also help students better learn about their community, emergency preparedness and response, environmental resilience, and traffic safety.

2.2.1. Emergency Preparedness and Response

Located on a low-lying peninsula, the special geographic location exposes Westport and much of the Ocosta School District to multiple natural hazards, including storm flooding, waves and winds, coastal erosion, sea level rise, and tsunamis. More specifically, Westport faces two types of tsunami hazard: tsunamis from distant earthquakes around the Pacific rim with low likelihood to cause loss of life but the possibility of damage from waves and inundation; and local tsunamis caused by a M8.0 (or larger) earthquake on the Cascadia subduction zone which can generate catastrophic waves that cause loss of lives and widespread damage to properties. From the variation in tsunami exposure assessment of U.S. Geological Survey and the Washington Military Department Emergency Division in 2008 (*22*), it was found that most people in the tsunami hazard zone are vulnerable, including children under 5-years of age, adults over 65years of age, renters (mostly of precarious or temporary housing), among others (Table 2.2). Although Cascadia megaquakes are rare, there is an estimated 17% probability of an M9 earthquake occurring along the entire Cascadia fault within the next 50 years (*23*). Flooding caused by sea level rise, by contrast, is less damaging for Westport but is more frequent and its severity and impacts increase over time (*24*); there is an estimated 39% risk of at least one flood over 6ft taking place between 2016 and 2050 in the Westport area (*25*).

Table 2.2 Estimation of Westport's population and assets within the tsunami inundation zone (*26*)

Westport's Vulnerability to Tsunamis			
People/Assets	Number in Tsunami Zone	% of Community Total in tsunami Zone	% of Those in Tsunami zone
All residents	1,864	89%	--
Residents under age 5	85	78%	5%
Residents over age 65	416	93%	22%
Renters	318	86%	35%
Employees	107	100%	--
Businesses	32	100%	--
Sales volume	$13,183,000	100%	--

Economic data is derived from the year 2011; population numbers are based on the 2010 census.

Emergency preparedness and response learning are of relatively high priority in the community, so helping students learn about the possible natural hazards and risk in their community and the ways to prepare and respond to emergency conditions are an obvious way to develop drone applications that are both locally meaningful and helpful. Students are also the communication bridge between the school and their family members; youth-focused emergency-related drone training may also raise community awareness of emergency preparedness and response. Finally, in this community, the presence of an existing tsunami vertical evacuation structure (VES) at the school – the first such structure in North America – makes the school a natural focus of attention for emergency preparedness applications of new technology.

2.2.2. Environmental Resilience

With the knowledge of emergency preparedness in hand, the environmental resilience learning aims to help students think over the long term about how the environment is changing regardless of such rare events as a tsunami, and to envision pro-active adaptation in ways that enhance everyday life. To embed the environmental resilience thinking into the drone ASP, the project team together with the school, designed activities in which students could apply drones to identify historic disaster events, such as evidence of early tsunamis on the shore; and study the dynamism of the shoreline itself, whether due to tidal or storm flooding or to sea level rise, as can be seen in inundated areas before and during king tides in Westport. Additionally, the project team also invited specialists and researchers from Washington Sea Grant and the University of Washington to deliver lectures to help students better understand the evidence, theory and history of the events (e.g., king tides, sea level rise, and tsunamis). The data that students collected and the understanding they gained from these activities were also levered to involve them in the design of a coastal flood-prone area of City-owned shoreline site for bioremediation of former landfill pollution and construction of a public recreational park. Students in the drone program contributed to the design by inventorying recreational assets in the community's existing parks, and using Minecraft to envision facilities and spaces that would complement them. A Masters student in Urban Planning and Landscape Architecture at the University of Washington incorporated their ideas in her thesis on the design process (*27*).

2.2.3. Traffic Safety

The traffic safety-related learning design focuses on the transportation infrastructure inspection, including the damage inspection (using drones) and basic structure-related knowledge based on the investigated infrastructure. These included flying drones to inspect drain alignments for some of the most flood-prone sections of local roads and to inspect the State Route 105 Elk River Bridge, which is the peninsula's only link to the rest of Grays Harbor County. To help students better understand the bridge inspection, the Westport Director Public Works prepared learning documents regarding bridge-related terms and basic structure (shown in Appendix C), including the introduction of the bridge superstructure and substructure. Students are also introduced to search and rescue drone applications, which are relevant to evacuation operations and to crash victim rescue. Traffic safety learning aims to expand students' traffic and transportation-related knowledge and enhance their sociotechnical thinking of daily drone applications in their communities, such as traffic condition investigation and transportation infrastructure inspection, as well as emergency response.

CHAPTER 3. DESIGN AND IMPLEMENTATION OF THE DRONE AFTER-SCHOOL PROGRAM (ASP)

3.1. Course Content

The drone ASP (which we informally called “Drone Club”) was held on most Fridays at 3:00 pm starting in October (2021). The on-going COVID-19 pandemic occasionally forced postponements and presented other disruptions, which stretched the length of the program beyond the number of active weeks outlined in Table 3.1 below. The ASP often lasted 45 minutes except for the king tide and Minecraft events. To ensure a smooth and efficient activity, the project team conducted weekly meetings via Zoom on Wednesday (since October 2021) with the Ocosta High School ASP staff and volunteers, the Westport Director of Public Works, and occasional invited specialists and researchers for specific topics. During each meeting, the team discussed the activity contents, designed the activity documents (such as the course description and checklist for drone inspection) and the needed logistics. Each activity started at the Ocosta Junior-Senior High School library to introduce the planned drone activity for the students and ascertain which students would participate in the day’s activity.

Considering that the number of the participating students in drone ASP was dynamic, the first three drone flying courses were held on the high school campus to gain attention for the program and capture the curiosity of the students and maximize their engagement. The program gradually increased the number of off-campus activities. Following the guiding framework outlined above in chapter 2, detailed course contents are displayed in Table 3.1. Generally speaking, the initial five weekly units focus on becoming familiar with drone technology and regulations, and the remaining units focus on applications to emergency preparedness and response, environmental monitoring and design, and transportation and other infrastructure safety and maintenance. The detailed course syllabus and course flyer can be found in Appendix A and Appendix B. The next chapter will discuss some of the completed units in more detail.

Table 3.1 Course outline

Time	Courses	Description	Purpose	Status
Week 1	Introduction and project presentation	• Introduction of the project team to the students. • Presentation on drone-related projects and applications for the City of Westport • Drone flying display	• Ice breaker • Basic learning of drone	Completed
Week 2	Drone assembly	• Learn the drone components • Acquire drone calibration skill • Understand the connection between a	Drone technology learning	Completed

		drone and its remote controller		
Week 3	Drone regulation	Complete the TRUST test provided by FAA	Drone regulation learning	Completed
Week 4	Drone operation display	• Launching & landing • Turning & moving	Drone operation	Completed
Week 5	Drone flying	Basic skill practice of drone operation at school	Drone operation	Completed
Week 6	Drone flying	Vertical Evacuation Structure (VES) inspection	• Drone operation • Emergency preparedness and response • Infrastructure maintenance	Completed
Week 7	King tide events	• Drone operation for king tides photography • Orientation on tides, sea level rise, and coastal flooding	• Drone operation • Environmental monitoring	Completed
Week 8	Drone flying	Flying in square practice	Drone operation	Completed
Week 9	Drone flying	South water tower inspection	• Drone operation • Infrastructure maintenance	Completed
Week 10	Drone flying	Search and rescue training	• Drone operation • Emergency preparedness and response	Completed
Week 11	Drone flying	North water tower inspection	• Drone operation • Infrastructure maintenance	Completed
Week 12	Drone flying	• City Park photography and inspection • Integration of drone footage with Minecraft envisioning	• Drone operation • Environmental monitoring and design	Completed
Week 13	Drone flying	Flood-prone road inspection	• Drone operation • Transportation safety and infrastructure maintenance	Completed
Week 14	Drone flying	Elk River bridge inspection	• Drone operation • Transportation safety and infrastructure maintenance	Upcoming
Week 15	Drone flying	Historic tsunami inundation evidence mapping	• Drone operation	Upcoming

			• Environmental monitoring	
Week 16	Drone flying	Tsunami evacuation simulation and route mapping	• Drone operation • Emergency preparedness and response	Upcoming
Week 17	Pilot test training	Coaching for FAA 107 drone pilot license test	• Drone operation	Upcoming

3.2. Staff Roles

To conduct the ASP, the project team partnered with five teachers and ASP staff from Ocosta Junior-Senior High School and two volunteer community coaches with 107 licenses (a retired community member with long-term drone pilot experience and the Shoalwater Bay Tribe's police department drone operator). The drone ASP targeted students over 9th grade. Teachers and volunteers as a group were eager to mentor students in the ASP and were supportive of the students and familiar with their needs and family situations. One of the ASP staff members obtained the FAA pilot 107 license (drone license) specifically for this program. On any one day of activity, an average of two licensed drone pilots were present to coach the students in drone operation, and often three licensed pilots were present, including one ASP staff member, one community volunteer, and one UW graduate student. The other teachers and staff helped design the course contents and organize and manage the ASP, including arranging transportation and communicating with families and school officials.

CHAPTER 4. ACTIVITY DETAILS

4.1. Drone Knowledge Learning

As described above, drone technical knowledge consists of three components: drone technology itself, including functions, parts and assembly; drone-related regulation, especially FAA rules; and drone operations. To help students learn the drones and improve their technical proficiency in drone operation before conducting any outdoor and off-campus activities, the project team designed one After School Program (ASP) course for drone-related technology learning, including drone assembly and calibration; one course for drone-related regulation learning through preparation for the TRUST test; and three courses for drone operations. Approximately 10 students in the junior high school participated in the ASP courses and activities.

Figure 4-1 Drone assembly (left) and calibration (right). *Photos by Daniel Abramson.*

Drone-related technology learning and drone-related regulation learning was held in the school library. As shown in Figure 4.1, the drone assembly and calibration used the school drones (Rubiq). Through the drone assembly courses, students were separated into groups and explored the drones together. Through the drone installation, students were able to learn the power distribution board, the propeller motors, and the video transmitter of the FPV camera. Following the drone calibration guidance, students could understand the connection between drones and remote controllers step by step, covering the switch configuration, accelerometer calibration, and GPS calibration, among others.

The first drone operation course began with the explanation of safety rules for pre-flight, in-flight and post-flight checks. All students were required to pass the TRUST test (drone-related regulation learning) before they started the drone flying training. As shown in Figure 4.2, volunteers introduced the drones used for operation and emphasized the flying rules: i) pre-flight check: before each flight, the pilot should check the drone condition to ensure there is no damage to the drones, especially the propeller, battery, and the remote controller connection; ii) in-flight check: during each flight, the pilot should always keep the drone in their VLOS, and pay attention to the battery level and any possible conflicts, including the higher infrastructure, trees, other aircraft, and birds; iii) post-flight check: after each flight, the pilot should recheck the drone condition, including the battery level and damage check. Basic drone operation skills are trained for future inspection and photography training, covering the automatic and manual launching and landing, turning, straight and left/right moving, and gambling adjusting for the FPV camera.

Figure 4-2 Chris Boggs, Drone Pilot for Shoalwater Bay Indian Tribe Police Department, coaching Ocosta Junior High School students in drone operations for After-School Program. *Photos by Yiran Zhang.*

4.2. Coastal Flood Monitoring

The coastal flood monitoring activity integrates the drone operation with disaster preparedness and response and environmental resilience, including the king tide events and a Minecraft-based flood-resilient park design activity. The king tide events help students learn the possible natural hazard their community faces as well as the reasons behind the hazard. The park design using a student-built world in Minecraft improved the design's responsiveness to local conditions and values, and raised awareness among the students of opportunities to enhance community resilience (*27*).

4.2.1. King Tide Events

King tides are significant tidal events usually occurring in the City of Westport from November to January. The term "king tide" is "colloquially used to describe an extremely high tide. Ordinary tides are caused by the gravitational pull between the Earth and the moon; king tides happen when astronomical events amplify that pull" (*28*). King tides may start with a spring tide (when the moon is either new or full) or when the sun is closest to Earth in orbit. King tides bring unusually high water levels, which can cause local coastal flooding when they coincide with heavy precipitation and strong winds common during Pacific coast winters. These events provide a "preview" of the effects of sea level rise, which over time will exacerbate them and may cause shoreline erosion and land loss (*29*).

The project team designed a two-day event to help students learn the basic science of king tides and their related natural hazards (Appendix D). On the first day, the project team invited Jackson Blalock, a Community Engagement Specialist from Washington Sea Grant, to introduce this science, using paper maps and a slide show (Figure 4.3).

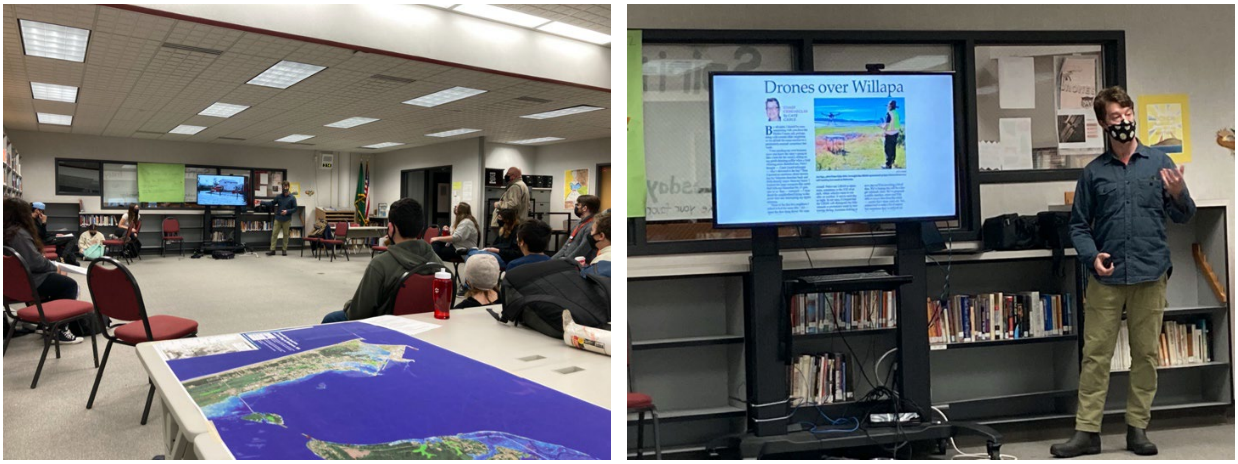

Figure 4-3 Jackson Blalock presenting king tides and coastal environmental monitoring orientation. *Photos by Daniel Abramson.*

Then students went out to view the low-lying tidal wetlands on the bay side of the peninsula at the city landfill and historic ferry pier site to better understand and record conditions at low tide using drones. On the second day, during a king tide (and very stormy weather), students viewed and recorded the tide effects both on the ocean beach side of the peninsula, and on the bay side where they had been the day before (Figure 4-4).

Figure 4-4. Ocosta after-school program students, staff and volunteers flying drones on the ocean side Half-moon Bay (left) and bay side historic ferry pier sites (right) of Westport. *Photos by Ziyang Liu.*

Figure 4-5 shows the difference between low and king tide conditions at the historic ferry pier site, with the encroachment of coastal flooding near to the landfill.

Figure 4-5. Low elevation bay side of Westport peninsula, at low tide (left) and during a king tide (right). *Photos by Daniel Abramson.*

After the king tides viewing, students and teachers gathered indoors to discuss their in-person observations and videos and photos taken by drones, to compare the inundated conditions before/during the king tide events with National Oceanic and Atmospheric Administration-projected future sea level rise impacts, and pinpoint their homes on the map to explore the likelihood of flooding around their houses (Figure 4-6).

Figure 4-6. Ocosta students and After-School Program staff with University of Washington staff and students studying future projected impacts of sea level rise on Westport as shown on NOAA/Washington Sea Grant maps and materials, for comparison with in-person and drone-video observations of king tide effects. *Photos by Ziyang Liu.*

4.2.2. Minecraft Flood-resilient Park Design

Students in the drone program also participated in a design project organized by Sarah Lukins, a Master's student in Landscape Architecture and Urban Planning at the University of Washington. The project was to design a bioremediative and flood-resilient park to replace the city’s landfill and other acquired properties likely to be the earliest sea-level-rise-affected land. Since the students had visited these sites during the king tide and flown drones there, they had become familiar with area and its projected changes. Using the popular computer game Minecraft, they were then asked to design possible facilities and equipment they would like to add/relocate to help enhance the flood-resilience of the park and complement the community’s existing recreational assets (Figure 4-7).

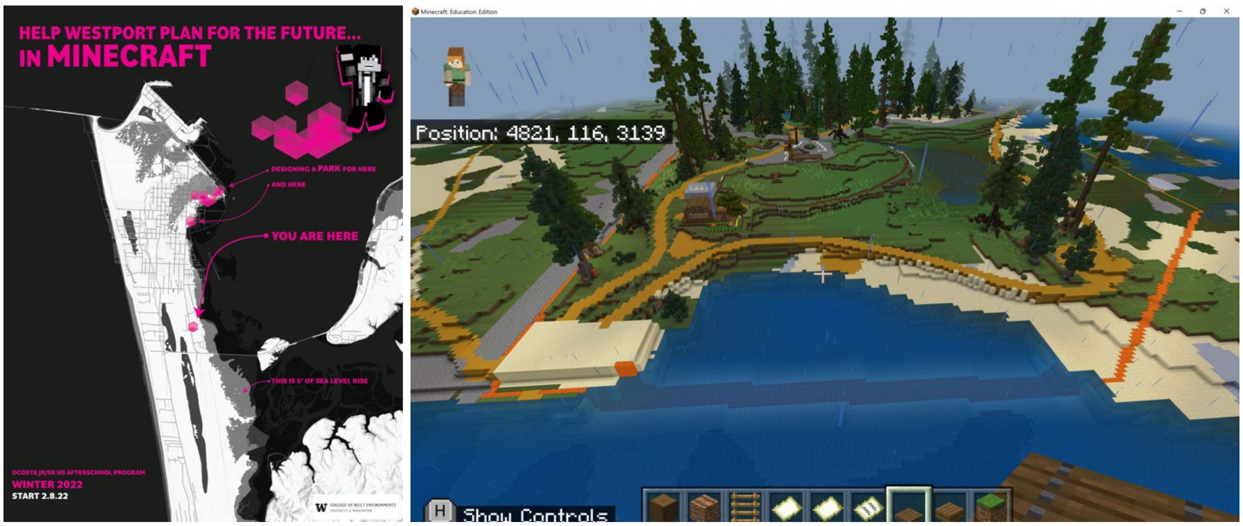

Figure 4-7. Minecraft-enabled participatory design recruitment poster (left) and student ideas for bioremediative flood-resilient landfill and historic ferry pier site, Westport. *Poster and design guidance by Sarah Lukins.*

The students visited the Master of Landscape Architecture thesis studio at the University of Washington to see Lukins’s work in progress, and presented their ideas to the Westport Director of Public Works and City Council. Details of the design process are described in one of the students’ master thesis: Minecraft as a Tool for Investing Adolescents in Climate Adaptation: A Case Study in Westport, Washington (*27*).

4.3. Critical Infrastructure Inspection

The community has concerns with several infrastructure systems that may be inspected using drones, including the north and south water storage tank inspection, school tsunami VES roof inspection, and flood-prone road inspection. Most infrastructure inspection activities were designed with a checklist covering the detailed equipment that requires to be checked and investigated. The checklists are available in Appendix E. The infrastructure inspection activity enables students to practice the hovering skills of drone operation and enhances their photography and filming skills using drones. Figure 4-8 displays the drone aerial image taken from two activities conducted for infrastructure inspection, the south water storage tank inspection and school tsunami vertical evacuation structure (VES) inspection. Both activities required students to inspect and investigate conditions and possible maintenance action for features such as the access ladder, 911 radio antenna (for water storage tank), and roof and gutters (for VES). Students were separated into groups to conduct drone operation and filming/photographing training, each of them was assigned with different tasks.

Figure 4-8 Critical infrastructure inspection drone aerial image: water tower (left) and School campus with tsunami VES (right; VES is building with flat roof and covered stairwells in each corner).

4.4. ASCE Presentation

On June 2nd, 2022, the project team together with the Ocosta teachers and students, presented a poster at the ASCE (American Society of Civil Engineers) ICTD (International Conferences on Transportation & Development) conference (the poster is available in Appendix F). Students not only observed the current research in transportation (including traffic safety) but also conducted a tour of the University of Washington College of Built Environments and the College of Civil and Environmental Engineering's NHERI RAPID facility and Smart Transportation Applications and Research (STAR) Lab. The RAPID facility is a National Natural Hazards Engineering Research Infrastructure-funded facility that deploys multiple types of drones and other data-gathering and processing technology to study environments pre- and post-hazard events. The UW RAPID facility deployed drones in Westport in 2020-2021 prior to the beginning of the Ocosta after school drone program to create a 3D "digital twin" of the peninsula for use in advanced hazard modeling and planning. The STAR Lab is a transportation research lab that investigates, evaluates, simulates, prototypes and develops intelligent transportation systems. The students' visit exposed them to some of the possibilities for drone-related research for transportation and environmental applications and sociotechnical approaches to problem-solving in their communities.

Figure 4-9. Ocosta students visit Seattle to present ASCE ICTD poster (left) with UW Prof. Yinhai Wang, organizing committee chair, Rachel Lambert and Andrea Mirante, Ocosta ASP staff, Prof. Daniel Abramson and PhD student Yiran Zhang; visiting Sarah Lukins in the UW MLArch thesis studio; and learning about advanced drones with Michael Grilliot in the UW NHERI RAPID Facility. *Photos by Yifan Lin and Daniel Abramson.*

CHAPTER 5. FINDINGS AND RECOMMENDATIONS

5.1. Major Findings

The nine-month ASP (Oct 2021 - June 2022) helped the project team train junior high school students for drone operation skills and related regulations, explore possible drone applications for daily and emergency conditions, learn the needs and challenges of the community, and better understand and identify the potential limitations and barriers to drone-related education at the junior high school level and in rural and isolation-prone communities in general. Table 5.1 summarizes the major findings of the conducted drone ASP from various perspectives, including drone operation, education, and course logistics. A smooth and successful ASP requires not only comprehensive planning and appropriate learning facility/equipment but also the ability to handle sudden/emergency situations.

Table 5.1 Major findings from the ASP

Category	Major Findings	Description

Drone Operation	Special equipment requirement may be necessary	• For safety concerns
		    ○ Some safety gears, such as propeller guard is suggested to prevent injuries from the propeller and propeller damage after accidental falling
		• For better operation
		    ○ Camera filters for better filming and photographing under strong sunlight
		    ○ Rain cover to ensure waterproof drone operation during the rainy/storm weather condition

	Pay attention to environmental interference	• Magnetic interference
		    ○ Magnetic interference often happens when flying drones near metal infrastructure (e.g., water storage tanks or structures with extensive steel reinforcing) which may interrupt the connection between the drones and their remote controller
		• Turbulence changes in a specific location
		    ○ Select drones with higher wind resistance for locations with uncertain turbulence, such as on the beach side, and/or during rainy/storm weather

Commuity Involvement	Recruit and rely on volunteer coaches	Community members with 107 drone pilot licenses who volunteered to share their personal drone equipment, expertise and time were essential as role models, supplements to school staff, and overseers for students too young to have a license.
	Use local media to recruit volunteers	Local newspapers, radio stations, and social media can spread awareness of the program and help recruit volunteer coaches from across wide region.
	Rely on local agencies for both coaching and applications	• Local public works, police, fire and emergency medical staff (many of them volunteers in that capacity) volunteered time to coach students in drone operations and provide them opportunities to use drones for real practical tasks of value to the community.

		• Engagement with these agencies exposed students to potential future employers and job opportunities.
Education	Use drones to expose students to higher education	• Involvement of university faculty, scientists and graduate students who share research that uses drones and provide students with opportunities to participate in research encourages students to consider applying to higher educational programs and more competitive schools. ○ (Still to be tested with senior high school students)
	Group study can be more efficient	Given time and equipment limitations, separating students into groups and having each of them complete a task using drones enhances the learning efficiency and ensures equal participation of each student.
	Maintain good behavior	Students may inappropriately fly drones when they become more familiar with their operation, such as hovering drones around other students for fun and flying drones without following the teachers' guidance. Teachers and mentors are responsible for reminding students of proper operation rules and saying no to misbehavior.
Course Logistics	Transportation management is crucial	Transportation management is essential for off-campus activities. School bus shortage sometimes happens for the ASP; scheduling earlier and having backup transportation plans before each ASP is important.
	Pay attention to time-consuming factors	Time-consuming factors, such as Covid-19 impact and extreme weather conditions, can cause temporary cancellation of the ASP. Backup plans or related extension requests regarding project or research are necessary. Besides, some of the activities may reach airspace that requires State/City permissions, which must be pre-scheduled.
	Dedicated school staff is critical	While the project team and community volunteers are all important to the ASP, school staff who are dedicated to the program is critical for the success and smooth operation of the ASP program.
	The weekly meeting is indispensable	The weekly meeting helps the ASP organizer handle the last-minute changes ("brain drain" or sudden leave of the teachers) and make timely plan changes.

5.2. Students' Feedback

At the end of the Spring quarter, Ocosta school helped the project team collect the course feedback from the students who participated in the ASP. As shown in Table 5.2, most students' favorite activities are field trips where they could fly drones outside and explore the surroundings (i.e., drone operation courses outside the school). For possible improvements, students would like to have more time in drone operations, receive rewards, and explore more outside areas. Feedback from the students helps the project team better understand students' interests and concerns, and enhance the course content for future ASP/Summer programs.

Table 5.2 Students' feedback

Question	Student A	Student B	Student C	Student D
What did you like the most?	Field trips and flying outside.	Getting to see the big drones like on our trip!	Getting to go places.	The Seattle Trip.
What are you looking forward to?	More field trips.	Finding things in the woods (search and rescue scenarios).	The trips!	Seeing cool things on our field trips.
Ideas for improvement?	I don't know	More time to learn how to fly well.	Some sort of reward.	More trips to interesting areas!

5.3. Recommendations

The ASP, together with the previous outreach activities, online surveys, and pilot study from Phase I and II (*7*, *30*), helped the project team identify more feasible drone applications for Westport communities. As shown in Table 5.3, the project team proposed several future drone applications for daily usage and emergency conditions. Some of the proposed applications, such as disaster simulation using drones, are based on the weekly discussion with coastal hazards specialists from Washington Sea Grant, who attempt to simulate the tsunami wave using drones and explore possible inundated areas in the City of Westport.

Table 5.3 Drone application recommendation for rural coastal communities

Scenario	Suggested drone application	Example	Possible Limitations
Daily usage	Critical infrastructure inspection	• Transportation infrastructure (bridge, highway) • Public supply infrastructure (water storage tank)	• Magnetic inference • Extreme weather condition • FAA airspace regulation • GPS signal loss
	Photography	• Whale watching • Environmental change monitoring (tides, habitat and species change, erosion, etc.)	
	Disaster simulation	Tsunami wave simulation	
Emergency Condition	Search and rescue (S&R)	• Finding people in distress offshore or in dangerous onshore situations ○ Delivering emergency supplies to them	• Magnetic inference • Extreme weather condition • FAA airspace regulation • GPS signal loss • Flying range limitation

	Disaster condition inspection	Flooding inundation investigation	• Battery limitation • Specific accessories requirements (e.g., infrared sensor for S&R, a megaphone for spreading warning message)
	Tsunami warning message spread	Spreading warning messages for 'inaccessible' areas where people are more likely to miss the warning message	
	Evacuation route testing and drilling	Documenting and disseminating routes and conditions for evacuation from sudden hazards (tsunamis, floods, landslides, etc.)	
	Accident investigation	• Fire condition inspection • Traffic accident inspection	

CHAPTER 6. CONCLUSION AND FUTURE STUDY

RITI communities in Washington State face multiple transportation/traffic safety and emergency preparedness challenges. Through the drone ASP with the Westport community and Ocosta school district, several remarks are worth mentioning. First, RITI communities' adoption of drone technology depends on not only the ASP and the school teachers/staff, but also the involvement of volunteers and non-specialist local participants. This ASP would not even start or continue without the active involvements of local volunteers or the support of local agencies (such as Public Works). Second, besides the physical drones, drone application-related locally meaningful knowledge and skills play a critical role when introducing the drone technology into RITI communities. The ASP vividly exemplifies the necessity of developing "context-sensitive" solutions in RITI communities. Third, student-flown drone footage has already proven useful to the local Department of Public Works for maintenance of infrastructure, such as water towers; to environmental monitoring and awareness of sea-level rises, such as through king tide watching; and in the participatory design of community spaces, such as sea level rise-adaptive shoreline parks. Future ASP or similar programs may be extended to more applications that can help the community in both normal and emergency conditions.

The project and the ASP are not the end of introducing drone technology in RITI communities, but a start for more promising drone-related applications and education opportunities within these communities. As shown in Table 3.1, more drone operation activities are upcoming in the Ocosta Summer School and the ASP in the next academic quarter (supported through separate funding). The project team believes that drone-related education prompts students' interests in drones and new technologies, and brings more opportunities and possibilities to the students for their future education and career.

For future study, the next goal of the drone ASP is to help students obtain their FAA drone licenses and identify synergies among multiple objectives, such as i) priority needs in traffic safety management, emergency preparedness, and evacuation planning; ii) potentially inspiration/assistance with other on-going STEM research and education in the community; iii) construction and enhancement of the drone-related skill including drone flying, drone photography and related data processing and analysis technology. With available resources (both facilities and the availability of teachers/volunteers) and proper planning/design, other emerging technologies (such as connected/automated vehicles and big data methods) should also be introduced to the students and the RITI communities to help enhance traffic safety in the communities.

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APPENDIX A. DRONE CURRICULUM DRAFT

DRONE CURRICULUM:

OCOSTA HIGH SCHOOL 2021

https://miro.com/welcomeonboard/b0Fhd1l2WFhYZmNma1F5TkNaVGtGclpjYVlQdjJHS3ZNcWxEUnpjU3pYTnZZZ3dIVjMybG9jQWpqRlZiaHdLRXwzMDc0NDU3MzYxNjQ4MTYyMDgz

CLASS 1: GETTING ACQUAINTED AND DRONE BASICS INCLUDING APPLICATIONS

COMMON TRAJECTORY:

Activity 1: Group Introductions

Activity 2: Drone applications

Show drone applications video https://www.youtube.com/watch?v=tsjVQprGZEk Class reflections:

What were some of the applications for drones in the video? Which ones do you think are the most interesting? Why?

Class brainstorm on drone applications for Westport

Small group discussion – "there are many drone applications that aren't shown in the video – spend a couple of minutes as a group, brainstorming ways that we could use drones in Westport."

We talked about things that people are fascinated by – do you think that we could study any of those things using drones? How?

Report back and create list on the board. Share some of the potential applications we have discussed with Kevin Goodrich, i.e. infrastructure monitoring for wastewater treatment and water facilities and coastal erosion over time.

TEAM 1: LOOKING AT HARD-TO-GET-TO PLACES:

No independent activities

TEAM 2: SEARCH AND RESCUE

No independent activities

TEAM 3: KNOWING YOUR COMMUNITY

No independent activities

CLASS 2: WESTPORT CONTEXT AND GUEST SPEAKERS

COMMON TRAJECTORY:

Activity 1: Ice breaker

Activity 2: Presentation on Drone Applications for Westport

GUEST SPEAKERS: Kevin Goodrich, Chief Brown (or someone else from South Beach Search and Rescue)

Have Kevin Goodrich and Chief Brown give brief presentations on ways they think students could help them in Westport with wastewater infrastructure monitoring and search and rescue. Sarah will give a brief presentation for "know your community".

Brief Q and A

Write projects on big stickies and place them around the classroom (ask Kevin and Chief Brown to go to constituent spaces). Ask students to migrate to the project team that they're most interested in (vote with their feet).

TEAM 1: LOOKING AT HARD-TO-GET-TO PLACES:

Activity 1: Check in with Kevin Goodrich and team – have them do a brief brainstorm/check in

TEAM 2: SEARCH AND RESCUE

Activity 1: Check in with S&R rep and team – have them do a brief brainstorm/check in

TEAM 3: KNOWING YOUR COMMUNITY

Activity 1: Check in with Sarah and team – have them do a brief brainstorm/check in

CLASS 3: DRONE ASSEMBLY

COMMON TRAJECTORY:

Activity 1: Ice breaker Activity 2: Drone Assembly

- Divide into groups of 3(ish) students – contingent on # of drones.
- Reference the drone assembly instructions and lesson plans provided by the drone manufacturer (using RubiQ, the discover drones from Ocosta school).
    - Introduction of drones
        - Drone history
        - Components of drones
        - Flight dynamics and data
        - Essential terminology
        - Drones and the future

TEAM 1: LOOKING AT HARD-TO-GET-TO PLACES:

No independent activities

TEAM 2: SEARCH AND RESCUE

No independent activities

TEAM 3: KNOWING YOUR COMMUNITY

No independent activities

CLASS 4: DRONE OPERATIONS AND KNOWLEDGE

COMMON TRAJECTORY:

Activity 1: Ice breaker (Zip C(odes))

Activity 2: Drone operations and knowledge (in preparation for flying and FAA test) Understanding the operation safety, regulations and laws of drones.

- Flight safety ○ Intro of flight safety ○ Protective gear ○ Battery safety ○ Pre-flight check
- Laws, Regulations & Groups
  - Regulations & Laws
  - Coordinating groups
  - Airports
  - Commercial use restrictions
  - Trespassing ○ Liability
  - State & International laws ○ Authorization
- Ethical operation ○ Privacy
  - Publication & Release of data
  - Public outreach

Test introduction and preparation guidelines – go through the FAA official website with students – have them enroll in course. https://www.faasafety.gov/gslac/ALC/CourseLanding.aspx?cID=677 If students do not finish the course at school, it will become homework for the week.

TEAM 1: LOOKING AT HARD-TO-GET-TO PLACES:

No independent activities

TEAM 2: SEARCH AND RESCUE

No independent activities

TEAM 3: KNOWING YOUR COMMUNITY

No independent activities

CLASS 5: FLY THE DRONES!

COMMON TRAJECTORY:

Activity 1: Ice breaker Activity 2: Fly the drones

Take students out to the field to fly the drones! Split them into their drone assembly/Westport project teams and have them take turns taking on different roles.

TEAM 1: LOOKING AT HARD-TO-GET-TO PLACES:

No independent activities

TEAM 2: SEARCH AND RESCUE

No independent activities

TEAM 3: KNOWING YOUR COMMUNITY

No independent activities

CLASS 5: DRONE APPLICATIONS ACTIVITY DAY

COMMON TRAJECTORY:

Activity 1: Ice breaker

TEAM 1: LOOKING AT HARD-TO-GET-TO PLACES:

Activity 1: Kevin Goodrich takes students to tour Westport wastewater facilities, and they fly some tests to take aerial footage of "hard to get to places"

TEAM 2: SEARCH AND RESCUE

Activity 1: Students are taken out to the dunes to simulate a search and rescue mission. In teams, students will use drones to locate their missing classmates and initiate a rescue. Hopefully can coordinate with South Beach search and rescue.

TEAM 3: KNOWING YOUR COMMUNITY

Activity 1:

Background: one of the things that drones help us to do is to visualize systems. When we're at street level taking pictures, we can't capture an entire road network or show where all of the water in Grey's Harbor is coming from. One of the biggest applications for using drones is mapping because a drone can get a bird's eye view of what's going on at ground level. For today's class we're going to think about mapping and connect mapping to our everyday lives.

What are the parts of a map? You can pull out Google maps on your phone... What are some of the elements that the map shows? (road networks, water bodies, commercial institutions...)

Put a bunch of maps out on a table and give students sticky notes to go around and label elements on the map – choose a diversity of maps. Examples might include Topography maps, the classic Mississippi map of river migration/time (as reference point for coastal migration/slr applications later), some of Paula Scher's more subjective hand drawn maps.

Big question: when the author made this map, what do you think they wanted to show? What was their primary intent in making this map?

Activity 2:

- Make a mind map of Westport and include places that respond to one or more of the following prompts - as you make this map think about what you want to show - for instance how could you show the emotions that you have when you visit a particular place? How might you indicate how you move through Westport? How could you show places you like to be in different seasons?
    - Guiding questions:
        - "If you've had a tough day at school, where in the Westport community would you most like to go?"
        - "When you hang out with friends in Westport, what are your favorite spots?"
        - "Where do you like to spend time in different seasons? When it's rainy out?"
        - "If you want to have an adventure, where might you go?" "What types of activities would you do there?"
- After students are done, put the maps up on the board – gallery walk and give students stickies to complement each other's maps – what do they like about each other's maps – what did people show really clearly? Are there places that they have in common? After reaching some consensus, on a big plotted map of Westport indicate these important community assets.

APPENDIX B. DRONE ASP FLYER

APPENDIX C. BASIC BRIDGE TERMS

Although bridges vary widely in material and design, there are many components that are common to all bridges. In general, these components may be classified either as parts of a bridge superstructure or as parts of a bridge substructure.

SUPERSTRUCTURE

The superstructure consists of the components that span the obstacle the bridge is intended to cross and includes the following

1. Bridge deck
2. Structural members
3. Bridge railings (Parapets), handrails, sidewalk, lighting and some drainage features

The deck is the roadway portion of a bridge, including shoulders. Most bridge decks are constructed as reinforced concrete slabs, but timber decks are occasionally used in rural areas and open-grid steel decks are used in some movable bridge designs (bascule bridge). Bridge decks are required to conform to the grade of the approach roadway so that there is no bump or dip as a vehicle crosses onto or off of the bridge.

A bridge deck is usually supported by structural members. The most common types are steel I-beams and girders, and precast, prestressed, reinforced concrete components

Secondary members called diaphragms are used as cross-braces between the main structural members and are also part of the superstructure. Parapets (bridge railings), handrails, sidewalks, lighting, and drainage features have little to do with the structural strength of a bridge but are important aesthetic and safety items. The materials and workmanship that go into the construction of these features require the same inspection effort as any other phase of the work.

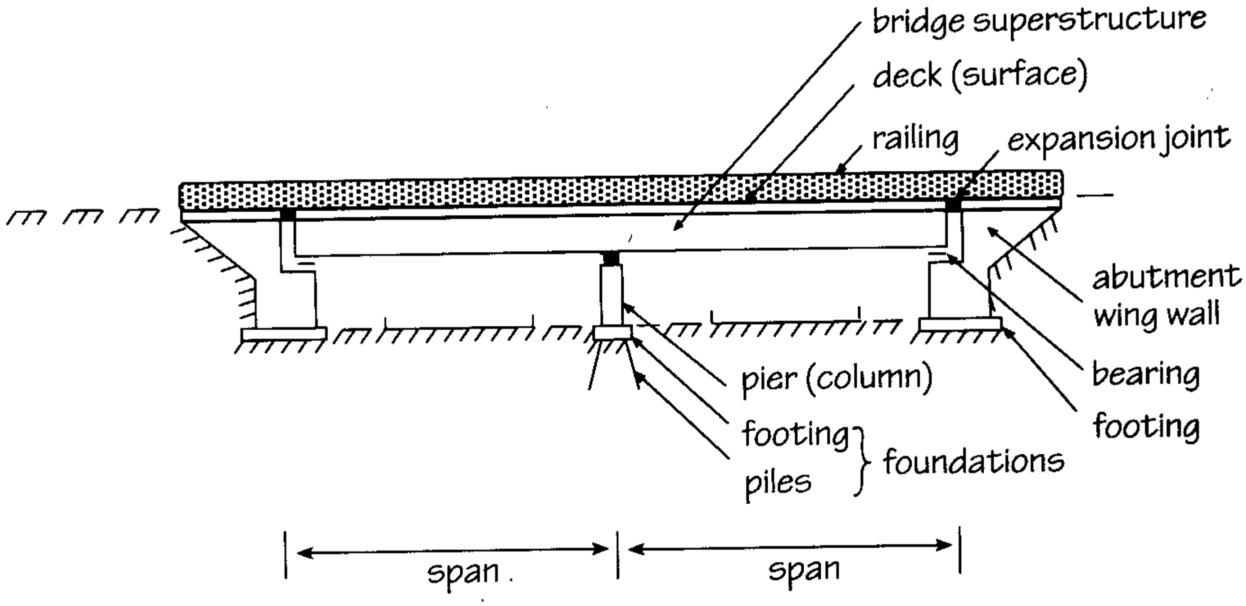
SUBSTRUCTURE

The substructure consists of all the parts that support the superstructure. The main components are abutments, piers, footings, and pilings. Abutments support the extreme ends of the bridge and confine the approach embankment, allowing the embankment to be built up to grade with the planned bridge deck.

When a bridge is too long to be supported by abutments alone, piers or interior bents are built to provide intermediate support. Although the terms may be used interchangeably, a pier generally is built as a solid wall, while bents are usually built with columns.

The top part of abutments, piers, and bents is called the cap. The structural members rest on raised, pedestal-like areas on top of the cap called the bridge seats. The devices that are used to connect the structural members to the bridge seats are called shoes or bearings. Abutments, bents, and piers are typically built on spread footings. Spread footings are large blocks of reinforced concrete that provide a solid base for the substructure and anchor the substructure against lateral movements.

Footings are built on foundation piling. These load-bearing members are driven deep into the ground at footing locations to stabilize the footing foundation. Piling transmits loads from the substructure units down to underlying layers of soil or rock.



TYPICAL BRIDGE ELEMENTS

APPENDIX D. KING TIDES EVENTS PLAN

King Tides Event Plan

Dates: Dec 3 – Dec 4, 2021

Locations: Westport, WA.

Participates:

UW Team: Dan Abramson, Sarah Lukins, Jeff Ban, Yiran Zhang

Ocosta School: Joseph Madding, Andrea Mirante, Rachel Lambert

Public Agency: Kevin Goodrich, Jackson Blalock

Ocosta School Students and their parents

Proposed Field Plan:

Friday, Dec 3, 2021

2:45 pm: Arrive Ocosta High School Library

3:00 pm: Presentation by Jackson Blalock

3:00 - 3:30 pm presentation about king tides, sea level rise and their relationship

3:30 - 3:45 pm Q & A

3:45 - 4:45 pm: Take students out by bus to site view

Show how low-lying tidal wetlands get flooded at the bay side of the peninsula (city landfill and historic ferry pier site)

View the tide effects on the more steeply sloping beach side (viewing tower or Half-moon Bay parking lot)

Saturday, Dec 4, 2021

11:30 am: Meet at the Westport Maritime Museum and walk to Half Moon Bay

12:00 am - 1:00 pm: King Tide Viewing

Drone operation for king tides

1:00 pm: Pizza Lunch & Friday Presentation Recap

Field MAp and Notes

APPENDIX E. INSPECTION CHECKLIST

South Water Tower Inspection

Description of Activity: Water Storage Tank Inspection

Use Drones for inspection of Water Storage Tank (Water Tower). Collection of video and or still photos, and report of inspection.

Task	Task Description
1	**Inspect condition of access ladder to the top of tower including handholds, rungs and connection to tower.**
	Findings: (What did you see? Did you see any damage? How would you describe the condition?)
2	**Inspect condition of top of tower, looking for and damage or potential issues.**
	Findings: (What did you see? Did you see any damage? How would you describe the condition?)
3	**Investigate Line of Sight to Sewer Pump Stations #11 (School) and #12 (S. Ocosta St.) Capture Video or stills showing view to each location.**
	Findings: (What did you see? Did you see any damage? How would you describe the condition?)
4	**Inspect 911 radio antenna on top of tower for any signs of damage and condition of anchoring system.**
	Findings: (What did you see? Did you see any damage? How would you describe the condition?)

Description of Activity: Maintenance Shop Facility Inspection

Use Drones for inspection of Maintenance Shop Building. Collection of video and or still photos, and report of inspection.

Task	Task Description
1	**Inspect Condition of Roof and Gutters** *Findings: (What did you see? Did you see any damage? How would you describe the condition?)*
2	**Inspect exterior lighting and security cameras** *Findings: (What did you see? Did you see any damage? How would you describe the condition?)*

Description of Activity: Locate Two New South Well Drilling Sites

Use Drones to locate two new well sites being developed in the South Wellfield. Collection of video and or still photos, and report of inspection.

Task	Task Description
1	**Locate wellheads for two new production wells** *Findings: (What did you see? Did you see any damage? How would you describe the condition?)*

North Water Tower Inspection

Description of Activity: Water Storage Tank Inspection

Use Drones for inspection of Water Storage Tank (Water Tower). Collection of video and or still photos, and report of inspection.

Task	Task Description
1	**Inspect condition of top of tower, looking for and damage or potential issues.** *Findings: (What did you see? Did you see any damage? How would you describe the condition?)*
2	**Inspect the outer rim of the top of tower, including all antennas attached to the rim.** *Findings: (What did you see? Did you see any damage? How would you describe the condition?)*

Description of Activity: North Wellfield – North Well #1 and #2 Investigation

Use Drones for inspection of the North Well #1 and North Well #2 Sites including structures, fencing and any other site features. Collection of video and or still photos, and report of inspection.

Task	Task Description
1	**Inspect Condition of N. Well 1 Facility** *Findings: (What did you see? Did you see any damage? How would you describe the condition?)*
2	**Inspect Condition of N. Well 2 Facility** *Findings: (What did you see? Did you see any damage? How would you describe the condition?)*

Flood-prone Road Inspection

Description of Activity: Mapping and Inspection of Flood-prone Roadways

Use Drones for inspection of Roadways in Westport that have been flooded during severe storms and King Tide. Collection of video and or still photos, and report of inspection.

Task	Task Description
1	**Locate Road Sections Identified on Map.**
	Findings: (What did you see? Did you see any damage? How would you describe the condition?)
2	**Review Stormwater Drainage System to understand flow and how the ditches and culverts tie together to drain stormwater,**
	Findings: (What did you see? Did you see any damage? How would you describe the condition?)
3	**Fly Drones along identified route and collect video and photos of ditch, culverts and catch basins.**
	Findings: (What did you see? Did you see any damage? How would you describe the condition?)

Search & Resue Training

Description of Activity: Search & Rescue Training

Use Drones to search several items from the check list. Collection of photos and report your findings.

Task	Task Description
1	**Inspect condition of plastic bats.** *Findings: (Where are they located? How many?)*
2	**Inspect condition of buckets.** *Findings: (Where are they located? How many?)*
3	**Inspect condition of cones.** *Findings: (Where are they located? How many?)*
4	**Inspect condition of hoops (extra point).** *Findings: (Where are they located? How many?)*

APPENDIX F. PROJECT POSTER FOR ASCE

Drone Technologies for RITI Communities

Yiran Zhang, Daniel Abramson, Xuegang (Jeff) Ban, Kevin Goodrich, Andrea Mirante, Sarah Lukins, Rachel Lambert, Frances Kinsley, Dezahnae Fansler, Joslynn Larson, Salvador Medrano-Aguayo, Giovany Lopez-Feria, Koa Johnson, Quinn Leonard, Jonathon Lewis, Treyten Tillerson

BACKGROUND & INTRODUCTION

Rural, Isolated, Tribal and Indigenous (RITI) communities face many challenges in Washington (WA) state

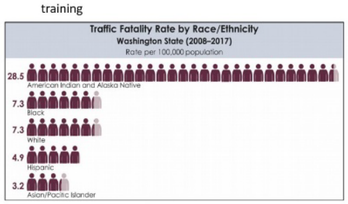
- High traffic fatalities
- Poor road condition (20%)
- Less requirement of comprehensive planning (11 counties in WA identified as non-urban-growth areas)

RITI communities often lack capacity to use transportation-related UAV (unmanned aerial vehicle) technology, including

- Knowledge of the technology and related regulation
- Local enabling regulations
- Personnel skills and time
- Motivation for sustained use given other pressing needs

Therefore, this study aims to

- Understand RITI communities' opportunities and challenges to use drones for (not exclusively) traffic safety
- Identify possible RITI context-appropriate drone applications
- Develop community-based drone literacy through youth training



Partners and Supporters

PROJECT APPROACH & PROGRESS

Phase I	Phase II	Phase III (Now)
Review drone tech, identify community partner, create enabling policy in local planning updates for hazard resilience	Identify community priorities, challenges and possible drone applications	Identify drone education as critical need and introduce drone tech to high school students
Community Engagement for Coastal Resilience Studio (9/2018 - 12/2018)	WA National Guard Workshop (6/2019)	Online Committee Meeting with Westport + South Beach + Ocosta School District (3/2021, 5/2021, 8/2021, 9/2021)
Westport Committee Meeting (10/2018)	Pilot Study (8/2020)	Weekly drone program meeting (9/2021 – Now, online)
Westport/South Beach Workshop (11/2018)	Online survey (12/2019 – 7/2020)	Weekly drone program (10/2021 - Now)
	Westport + South Beach + Ocosta School District Committee Meeting (8/2020)	

COMMUNITY PARTNER

This study team partnered with **City of Westport** and **Ocosta Junior-Senior High School.** Westport is a small rural incorporated City on the Pacific Ocean coast in Grays Harbor County, WA, with

- Small population (higher in median age)
- Low income (poverty rate is almost double that of Seattle)
- Most productive marina in WA for commercial fishing vessels (100+ million pounds of seafood per year)

Ocosta School District serves a diverse rural community including the City of Westport, unincorporated areas of Grays Harbor and Pacific Counties, and the Shoalwater Bay Indian Tribe. The total minority enrollment is 43%, and 78% of students are economically disadvantaged. Its elementary school includes North America's first tsunami vertical evacuation structure, funded entirely by a local property tax levy, demonstrating strong local commitment to safety and multi-generational survival.

AFTER SCHOOL PROGRAM

Course outline

1. • Introduction and project presentation
   • presentation on drone applications for Westport
2. • Drone assembly
3. • Drone regulation (complete FAA TRUST test)
4. • Drone operation display
   • Launching & Landing
   • Turning & Moving
5. • Drone operation
   • Flying the drones at school
6. • Drone operation
   • Vertical evacuation structure inspection
7. • King tides events
   • Drone operation for king tides photography
   • Costal erosion presentation
8. • Drone operation
   • Flying in square practice
9. • Drone operation
   • South water tower inspection
10. • Drone operation
    • Search and rescue training
11. • Drone operation
    • North water tower inspection
12. • Drone operation
    • City park photography and inspection
    • Integration drone footage with Minecraft
13. • Drone operation
    • Flood-prone road inspection

upcoming

14. • Drone operation
    • Elk bridge inspection
15. • Historic tsunami inundation evidence mapping
16. • Drone operation
    • Tsunami evacuation simulation and route mapping
17. • Coaching for 107 drone pilot license test

ASP Activity

Drone photography

CONCLUDING REMARKS

- RITI communities' adoption of drone technology depends on involvement of volunteer and non-specialist local participants
- Not only physical drones, but also drone application-related locally meaningful knowledge and skills play a critical role when introducing drone technology into RITI communities
- Student-flown drone footage has already proven useful to the local Department of Public Works for maintenance of infrastructure, such as water towers; to environmental monitoring and awareness of sea level rise, such as through king tide watching; and in the participatory design of community spaces, such as sea level rise-adaptive shoreline parks.