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Good morning Chair Murkowski, Ranking Member Cantwell and members of the committee. I'm Michael West, State Seismologist with the Alaska Earthquake Center and current chair of Governor Walker's Alaska Seismic Hazards Safety Commission. In my roles, I am privileged to work closely with the USGS, NOAA, the National Science Foundation and private entities to improve Alaska and the nation's resilience to earthquake, tsunami, volcano, and landslide hazards.

My objective today is to share with you the importance of the various natural hazards legislation bills you are considering. My examples are drawn largely from the state I represent. These are just a tiny sample of the broad impacts of these programs across the country. As a late-breaking addition, I will also touch on the magnitude 7.9 earthquake which impacted my state just last week. This earthquake provides a sobering example of the importance of strong earthquake and tsunami programs, as well as an example of why we still have a long way to go in preparing the nation to weather such events.

Why authorizing legislation matters

This committee has been instrumental in bringing an impressive suite of natural hazards bills. On behalf of the organizations I represent and our peer organizations around the country, I thank you. These bills matter. Whether it is the National Earthquake Hazards Reduction Program (NEHRP), the National Volcano Early Warning System (NVEWS), or the Landslide Preparedness Act, these bills provide a national framework for coordinating across federal agencies, between states, and with community and private stakeholders.

Many of these activities exist at the state and regional level whether or not there are congressional authorizing bills. However, it is these bills that provide the national umbrella to coordinate and support these activities. Each of the following programs is different, but the theme cutting across them is the same. By ensuring that our efforts are coordinated—across agencies, across states, across the public-private entities—we can achieve the greatest reductions in natural hazards risks in the most efficient and cost-effective ways.

National Earthquake Hazards Reduction Program

The reauthorization of the National Earthquake Hazards Reduction Act is deeply important for Alaska and the nation. This act was visionary in 1977 by spanning four agencies and countless activities to create a unified national strategy for earthquakes. It was developed and has been maintained with huge grassroots efforts crossing disparate advocacy groups, professional societies, and academic organizations. That breadth is a testament to the 40-year impact of NEHRP.

Alaska has benefited from NEHRP by inclusion in national programs and standards. Without a national vision, it is likely that federal agencies would often overlook Alaska's needs with the all-too-common "Alaska is an outlier" excuse. I have been told of proposal calls a few decades ago that included a latitude cutoff intended specifically to exclude Alaska. Though Alaska's population remains relatively small, the extreme nature of our infrastructure, combined with the fact that we are home to three-quarters of all domestic earthquakes, gives Alaska citizens an outsized vulnerability. Having a national vision, set by NEHRP, has helped keep Alaska from being completely written off in the earthquake discussion.

A lot has changed in 40 years however. Updating NEHRP to reflect past progress and new needs is an important part of reauthorization. I encourage you to continue listening to each of your states' priorities and to ensure they are being met by the next iteration of this landmark legislation.

Advanced National Seismic System

One of the most vital components of NEHRP is the Advanced National Seismic System (section 7707). The ANSS was intended to provide a collaborative framework for ensuring strong earthquake reporting and analysis across all regions of the country. Developed on an explicitly collaborative model between states and the USGS, the ANSS was a visionary program when introduced. The 2000 congressional authorization for the Advanced National Seismic System stated it would:

> *Establish and maintain an advanced infrastructure for seismic monitoring throughout the United States that operates with high performance standards, gathers critical technical data, and effectively provides information products and services to meet the Nation's needs.*[1]

The ANSS remains a vibrant, diverse collaboration with huge potential. It blends national consistency under the powerful leadership of the USGS with strong state and regional earthquake centers tailored to state-level needs and stakeholders. It is a model of healthy collaboration between state and federal entities.

However, after 18 years, many of the most basic goals set for the ANSS have yet to be met. Across the country, earthquake centers have struggled to maintain basic monitoring infrastructure. They have not been able to conduct basic research on how to

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[1] *Assessment of Seismic Monitoring in the United States: Requirement for an Advanced National Seismic System, http://pubs.usgs.gov/circ/1999/c1188/circular.pdf, (p. 20) last retrieved Jan. 22, 2018*

operate more effectively and efficiently. And, with just a few exceptions, they have not been able to implement breakthrough technologies such as integrated geodetic monitoring and earthquake early warning.

For example, in Alaska, the most basic ANSS performance standards for earthquake reporting accuracy[2] have never been achieved for more than half of the mainland. The National Science Foundation operates an impressive geodetic network through its Plate Boundary Observatory program. However, unlike much of the rest of the country, the Alaska data are largely unavailable in real-time or in processed forms usable by existing earthquake monitoring systems. While earthquake early warning is being aggressively pursued in CA, OR and WA, Alaska does not even have the backbone seismic network and hardened communications systems to begin experimenting with early warning. Each of these are examples of ways in which the ANSS needs to continue striving, and needs to evolve, to meet modern stakeholder demands.

The Alaska component of the ANSS is operated by the Alaska Earthquake Center at the University of Alaska Fairbanks. The success or failures of the center's monitoring network has ripples across many agencies. This network is the primary long-term source of Alaska seismic data for NOAA's tsunami warning centers. It is also a critical component of Alaska's volcano monitoring, providing broad regional coverage for volcanoes that do not have dedicated instrumentation. Over the past dozen years, at least three volcanic eruptions were detected or principally monitored under the auspices of the ANSS using the assets of the Alaska Earthquake Center. Despite this track record, the collaborative funding model used to support the ANSS has withered in the past half dozen years. Responding to long-term declines in federal support, as well as more recent declines in state support, the Alaska Earthquake Center has had to slash staffing and reduce services for stakeholders including the USGS, NOAA's tsunami warning centers, and partner state agencies. In response to these funding reductions, in August of 2016 the center suspended most maintenance and repairs of the Alaska seismic network. The impacts were immediate, and within a few months the percentage of data returned from the network dropped to its lowest level in several years. One-time stopgap funding in mid-2017 provided a reprieve and allowed the center to begin addressing some of the long-standing deferred maintenance needs. But a long-term sustainable model is not yet in site. The precise issues vary from state to state, but the earthquake centers that operate in most other regions are facing their own version of these issues.

The ANSS remains a strong foundation with huge potential to improve earthquake and tsunami hazard efforts in all states. But with funding that has languished for years, many of these basic objectives have simply not been achieved. It is my great hope that we will recognize this before the next catastrophic earthquake makes it abundantly clear.

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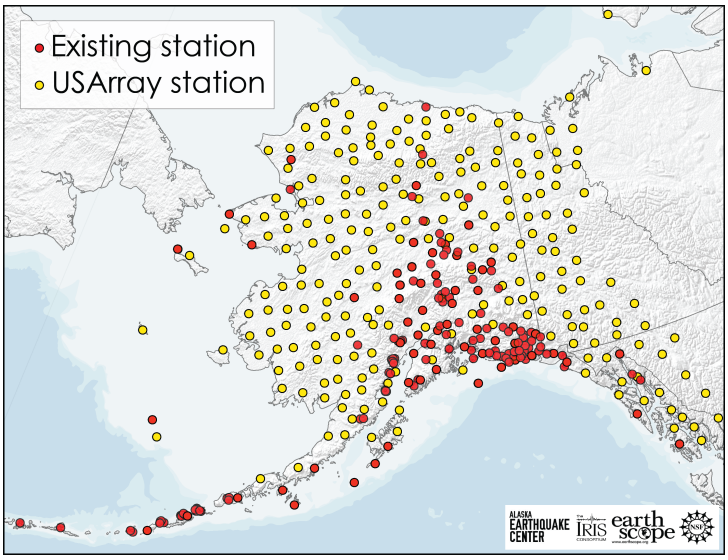
[2] *Advanced National Seismic System Performance Standards*
http://earthquake.usgs.gov/monitoring/anss/docs/ANSS_Perf_Standards.pdf (p. 2) last retrieved Jan. 22, 2018

The USArray Opportunity

The National Science Foundation's USArray project is now fully installed in Alaska, with a total of 192 new monitoring stations arranged in a grid across mainland Alaska. Agencies including USGS, NOAA, NASA, BLM, NPS, and NSF are benefiting USArray network capabilities ranging from seismic to meteorological monitoring. These agencies have drafted multiple reports and white papers extolling the contributions, and potential for expanded capabilities, of USArray for their missions in Alaska. Data from the network are in full operational use for: earthquake and volcano monitoring; tsunami warning; weather and fire forecasting; and Arctic domain awareness. In-state, the Alaska Earthquake Center, the Tsunami Warning Center, the Alaska Volcano Observatory, the National Weather Service, and the Interagency Coordination Center for forest fires are using the data in their respective 24/7 missions.

Recognizing this opportunity to strengthen Alaska's monitoring systems, in the spring of 2016 Governor Bill Walker requested a study on the benefits of enhanced earthquake monitoring and potential earthquake early warning in Alaska. The Alaska Seismic Hazards Safety Commission addressed this request by conducting a survey of a diverse set of stakeholders. The report was delivered to the governor in June, 2016. Among other recommendations, the commission concluded that there are significant regional disparities in monitoring that should be remedied, and that there should be a baseline capability for characterizing earthquakes across all regions of Alaska. The commission highlighted the specific opportunity afforded by the USArray project:



Map of Alaska's seismic monitoring network with and without the National Science Foundation's USArray stations.

> *It is in Alaska's best interests to improve monitoring wherever practicable through the adoption of seismic stations. The USArray Transportable Array offers a proven and unparalleled opportunity to enhance earthquake monitoring and provide more consistent earthquake information*[3].

Planning for the 2019 decommissioning of USArray is already underway. In November 2016, congressional staff and staff from the Office of Science and Technology Policy participated in a workshop[4] with representatives of several federal and state agencies to brainstorm the long-term sustainability of this state-of-the-art monitoring network. The

[3] *http://seismic.alaska.gov/download/ashsc_meetings_minutes/ASHSC_Benefits_EQ_Monitoring_6_27_16.pdf (p. viii)*
[4] *https://www.arcus.org/meetings/2016/usarray*

network is integrated by design with Alaska's existing seismic network. The Alaska Earthquake Center is uniquely positioned to assume long-term operation on behalf of state and federal stakeholders. But despite years of discussion, including last November's workshop, no unified plan has emerged to secure the facility's ongoing operation.

The first of the November 2016 USArray Sustainability Workshop's recommendations addressed the need for a joint solution:

> ***USArray sustainability should be guided by a multi-agency state and federal partnership.*** *The USArray facility has stakeholders across many agencies and programs. A governance model that represents this breadth will ensure a diversified and cost-effective long-term facility.*

The USGS has developed an implementation plan focused on the specific federal needs of the USGS Earthquake Hazards Program emphasizing the populated southern tier of Alaska[5]. This is an excellent step forward. The National Weather Service has been a great champion in coordinating partner agencies around the USArray opportunity including NASA, BLM, NPS, BOEM, and the Air Force. These agencies have met in person and coordinated on a white paper under the leadership of NWS. This, too, is excellent progress. To date, however, there is still no adoption plan that accounts for the needs of NOAA's tsunami program or NOAA's weather forecasting mission. Several things will need to happen rapidly in order to create a sustainable partnership in time to head off NSF's scheduled removal of the network in 2019. A thorough implementation plan and budget, integration with the complementary USGS efforts, and coordination with state-level stakeholders would help bring this effort to fruition in time. Without these, however, the USArray assets could end up fragmented between a variety of unrelated programs.

The second recommendation from the November 2016 workshop spoke to this danger by presenting a vision for how the facility could be sustained to the benefit of all stakeholders:

> ***The sustained portions of USArray should be supported as a unified facility.*** *Shifting multiple subsets of the array into the sponsorship of different agencies would splinter the uniformity that is a hallmark of the facility. Several models exist to pool resources across organizations.*

Preserving the array as a unified state-operated facility ensures that its real value—which derives from its geographic scale and flexible station design—remains focused on serving as many Alaska stakeholders as possible, rising above the winds of budgets, politics, and competing missions.

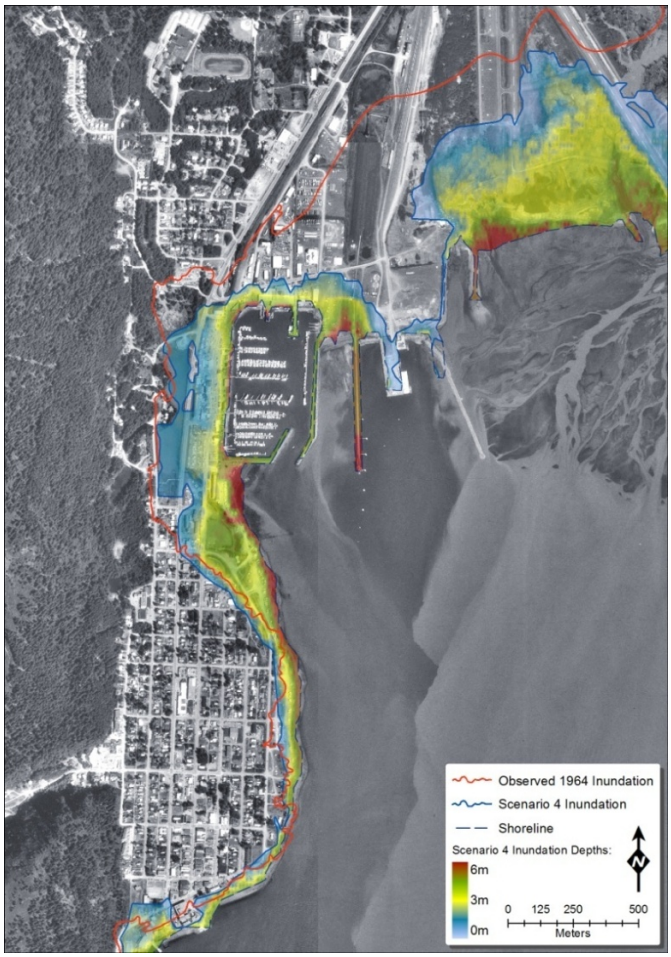
[5] This plan was requested in the FY17 budget language to the Department of the Interior but has not been released at the time of writing.

Tsunami Warning Education Research Act

This legislation, passed in spring 2017, is worth revisiting today because it is a shining example of a successful state-federal natural hazards collaboration. Administered by NOAA's National Weather Service, TWERA provides tsunami warning and tsunami preparation capabilities for the entirety of the coastal U.S. This collaboration of scientists and emergency managers collectively addresses issues ranging from tsunami monitoring instrumentation to tsunami warning coordination to community education and preparedness.

The program's reach is particularly deep in Alaska. Under TWERA, NOAA supports a considerable amount of the seismic monitoring instrumentation in Alaska operated both by the National Tsunami Warning Center and the Alaska Earthquake Center. This collective capability is the foundation for the rapid tsunami warnings issued by NOAA. Individual communities plan and drill for tsunamis using detailed maps of anticipated tsunami inundation and pedestrian evacuation. The evacuation routes that mark Alaska's coastal communities are based on these same maps, also produced under the auspices of TWERA.

Though TWERA will not be on the congressional docket again for a few years, it is a model program, offering proven examples for how other hazards programs might organize to provide the maximum benefit to communities while enlisting the broadest set of collaborators and stakeholders.



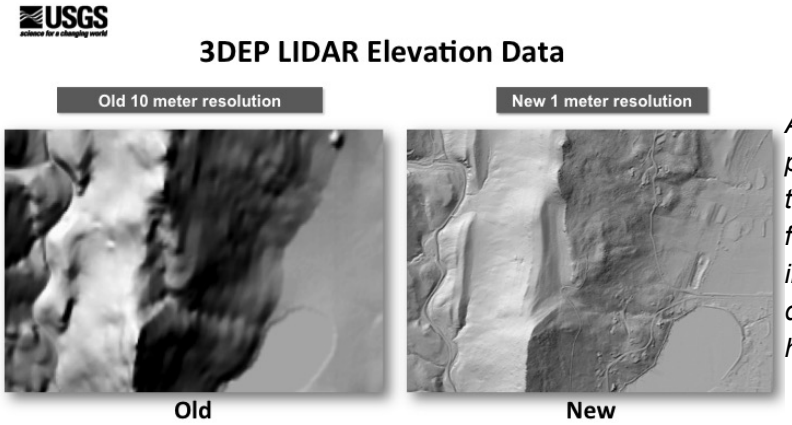
Tsunami inundation scenario for Seward. Such maps are the foundation for tsunami evacuation planning and for the siting of emergency facilities. This work is performed at UAF and supported largely under the authorization of TWERA.

Geologic Mapping for Hazards

The National Cooperative Geologic Mapping Program (NCGMP) is a hallmark program within the USGS. Since 1992, the program has contributed $129 million to geologic mapping through grants to state geologic surveys. The states have matched this through one-to-one matching funds. The program has generated over 7,000 new geologic maps, produced in

large part at the state level in accordance with state priorities. State monies are left on the table each year, however, because of limits in the federal contribution.

These mapping programs support a wide variety of end uses, with natural hazards being a particularly critical end-use. High resolution mapping is the foundation for landslide evaluation, as it is practically impossible to assess landslide hazards without good topography. Our understanding of earthquake hazards is also limited by incomplete mapping. Geologic and topographic maps provide a mechanism for identifying and assessing fault lines that might otherwise remain hidden until the next big earthquake. Mapping provides one of the more cost-effective ways to scan large regions for hidden faults.



An example of the added resolution provided by modern mapping technologies. Many features, such as fault lines, that may have been invisible in older data, can be discovered and assessed in modern high resolution topography images.

Many people will assume that mapping the nation was completed decades ago. But while the program has been very productive, only 17% of the nation is mapped at the scale needed for land use planning and resource development (1:24,000). At the current rate of progress, some parts of the country will not be adequately mapped for centuries—an unacceptable timeframe given the life-health-safety, commercial, and national mineral and energy security benefits realized from geologic mapping.

The proposed 3DEEP program within the USGS would address these issues, and more, through a combination of topographic, geologic and geophysical mapping. Improved natural hazards preparedness would be just one of the many ancillary benefits.

NVEWS and Volcano Hazards

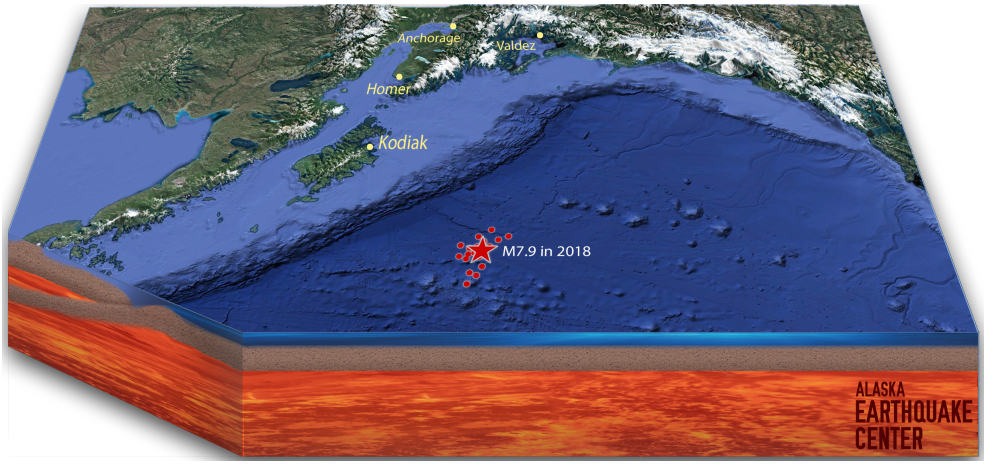
Alaska is the most volcanically prodigious state in the nation. In the past decade, Alaska has experienced more than two dozen eruptions, some of which posed significant threats to air-traffic over the North Pacific. The National Volcano Early Warning and Monitoring System Act proposes a national plan to monitor the nation's most hazardous volcanoes at levels commensurate with their threat. There are 54 active volcanoes in Alaska and another 16 in the Pacific Northwest, as well as active volcanoes in the Pacific and Caribbean Islands, which threaten large population, commercial and agricultural centers, and domestic and international air traffic. On an average day, 50,000 people and 90% of the nation's air cargo to Asia follows routes that pass over Alaska's volcanoes. NVEWS would create a national system to improve on existing eruption forecasting and research. Together these would improve the overall level of volcano monitoring across the country.

Alaska has an additional volcano instrumentation issue related to the phase-out of analog communications equipment as stipulated by the National Telecommunications and Information Administration. The need for so-called spectrum compliance runs the risk of rapidly making obsolete the Alaska Volcano Observatory's chosen equipment at many volcanoes. If this were to happen, a significant portion of the observatory's proximal monitoring would go offline and the ability to forecast eruptions using seismic data would be severely compromised.

The upgrades of analog equipment are related to NVEWS in that they would help achieve the overall goal of modern instrumentation at volcanoes with substantial threat levels. However, the issue is also independent of NVEWS in that the requirements to comply with appropriate spectrum use exist regardless of whether the NVEWS program is passed into legislation.

January 22 Magnitude 7.9 Offshore Kodiak Earthquake

This earthquake occurred just a few days before this testimony was submitted. Full analyses of this earthquake and tsunami are just beginning to come together at the time this testimony was submitted, but some early observations are pertinent to this hearing. Fortunately, the earthquake occurred a couple of hundred miles offshore in the Gulf of Alaska. This greatly limited the impact of the shaking, though it was felt very strongly by the vast majority of the Alaskans. Tsunami warnings were sounded for this earthquake based on input from the National Tsunami Warning Center and based on the vigor and duration of shaking in local communities. Based on the information available, this was the correct thing to do.



Location of the January 22 earthquake. Star marks the epicenter. Small circles mark preliminary aftershocks. The offshore setting limited the shaking impact of the earthquake but raised legitimate concerns about a potential tsunami.

This particular earthquake was scientifically unusual (and unexpected) and ruptured in a way that minimized the formation of a tsunami. However, the vast majority of earthquakes of this size in similar locations are likely to generate significantly larger tsunami waves than were observed last week.

Parts of Alaska's intertwined earthquake and tsunami monitoring systems worked well. Initial warnings were issued in under five minutes. There were significant failures during this earthquake as well however. An unrelated power outage at Golden Valley Electric Association caused much of the state's seismic data to be unavailable at the time of the earthquake. Though some systems had backup power, the failure caused internet outages that essentially shut down parts of the seismic network for more than an hour. As a result, much of Alaska's monitoring data was not immediately available to the Alaska Earthquake Center, the National Earthquake Information Center, or the National Tsunami Warning Center. The systems designed to warn and evaluate the safety of the Trans-Alaska Pipeline System were similarly affected. The performance of all of these agencies were negatively impacted by the power outage.

While it is fortunate that this earthquake turned out to be non-lethal, the lack of capacity for continuity of operations led to an abject failure of the state's monitoring system. This failure can be traced directly to the long-term declines in support for earthquake monitoring at both the federal and state level. Without robust funding for adequate maintenance of field instrumentation, sufficient staffing, and explicit continuity of operations, it should be no surprise to anyone when systems fail catastrophically. This has been clearly identified for several years as the single biggest vulnerability in Alaska earthquake monitoring. However, to date, agencies and stakeholders have not found this to be a high enough priority to support.

The authorization bills in discussion today are a great first start at tackling these problems. It is important to follow them up, however, with adequate funding and congressional oversight to ensure that the stated goals are being met.

Conclusions

New legislation is something we should always approach with caution, but the value of these bills and the programs they support are beyond dispute. They do cost money. But their combined cost, about one dollar per American per year is absolutely trivial compared to a single major disaster. The fact that NEHRP and other programs have languished for years without reauthorization has directly hurt us. The agency individuals I rely on, some in this room, are doing an admirable job of holding together the coordination and relationships that these laws enable. But the uncertainty that comes from not having an authorized program ripples across these agencies, it ripples out of Washington, into the states, to people like me, and ultimately impacts our municipal stakeholders who are simply trying to build safe, resilient communities.

These bills under consideration have real world consequences. Authorizing NEHRP and the related natural hazards programs would send a very strong message. It would send a message that, as a nation, we are proactive about disasters. It would send a message that we value safe construction, safe public buildings, responsible resource development, resilient infrastructure, informed emergency management, and educated citizens. These are not partisan or even controversial topics. They are programs and goals that we should all be able to get behind.

I sincerely appreciate the opportunity to testify. I hope I have provided solid on-the-ground perspective, and I would welcome whatever questions you have today or at a later time.