S. HRG. 109–521

VOLCANIC HAZARDS—IMPACTS ON AVIATION

HEARING

BEFORE THE

SUBCOMMITTEE ON DISASTER PREVENTION AND PREDICTION

OF THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION
UNITED STATES SENATE

ONE HUNDRED NINTH CONGRESS

SECOND SESSION

MARCH 16, 2006

Printed for the use of the Committee on Commerce, Science, and Transportation

U.S. GOVERNMENT PRINTING OFFICE

29–351 PDF WASHINGTON : 2006

For sale by the Superintendent of Documents, U.S. Government Printing Office
Internet: bookstore.gpo.gov Phone: toll free (866) 512–1800; DC area (202) 512–1800
Fax: (202) 512–2250 Mail: Stop SSOP, Washington, DC 20402–0001

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ONE HUNDRED NINTH CONGRESS

SECOND SESSION

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VOLCANIC HAZARDS—IMPACTS ON AVIATION

THURSDAY, MARCH 16, 2006

U.S. SENATE,
SUBCOMMITTEE ON DISASTER PREVENTION AND PREDICTION,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Washington, DC.

The Committee met, pursuant to notice, at 10:07 a.m. in room SD–562, Dirksen Senate Office Building, Hon. Ted Stevens, Chairman of the Committee, presiding.

OPENING STATEMENT OF HON. TED STEVENS, U.S. SENATOR FROM ALASKA

The CHAIRMAN. Thank you all for coming here today. It's a very confused day, probably about 40 votes on the floor today. We all know the threat that volcanic ash poses for Alaska. The staff just gave me a little bit of ash, Dr. Eichelberger, from Augustine. I've got an opening statement which I'll put in the record. But very clearly over half the population of Alaska lies within 200 miles of Augustine. And 2 months ago it spewed ash throughout south central Alaska shutting down several airports throughout the area.

We're going to have testimony today, from Captain Terry McVenes, Air Safety Chairman for the Airline Pilots Association, Mr. James Quick, Program Coordinator for the Volcano Hazardous Program at USGS and Dr. John Eichelberger, Coordinating Scientist at Alaska Volcano Observatory at the University of Fairbanks, and Dr. Eichelberger, I do thank you for flying all this way to appear before us to make the record on this issue, and I'm sure you want to go back in case Augustine decides to erupt again, right.

[The prepared statement of Senator Stevens follows:]

PREPARED STATEMENT OF HON. TED STEVENS, U.S. SENATOR FROM ALASKA

Thank you all for coming today, I am happy to be chairing this hearing, since volcanic ash poses such a grave threat to Alaska. I expect Senator DeMint to join us a bit later.

As we speak, Augustine Volcano located in Cook Inlet, is at code orange, which means an explosive eruption is possible within a few days and may occur with little or no warning. The United States Geological Survey folks in Alaska sent me this picture last night. This was right before sunset yesterday over Augustine, you can see the steam spewing from the top.

Over half the population of Alaska lies within 200 miles of that volcano. Two months ago, it spewed ash throughout south-central Alaska, shutting down several airports throughout the area.

Alaska averages four days of volcanic ash activity a year, and since more than one third of Alaskans do not have road access, flying is the preferred method of transportation. Anchorage, our biggest city, is within potential striking distance of ash from over 9 active volcanoes. Anchorage International Airport is also the largest cargo hub in the United States, and all passenger flights from Asia to the United States, fly over Alaska and its 41 active volcanoes.

Dr. EICHELBERGER. Exciting times.

The CHAIRMAN. Thank you. Senator, do you have any opening statement?

STATEMENT OF HON. E. BENJAMIN NELSON, U.S. SENATOR FROM NEBRASKA

Senator BEN NELSON. I would ask that my more complete opening statement be included in the record. Let me say first I appreciate very much, Mr. Chairman, you having this hearing today. Coming from the State of Nebraska we don't have to worry much about our volcanoes. We're not too concerned in the state about experiencing a loss due to a tsunami or a hurricane either, but we recognize that the number one mission of our government is to protect our citizens.

While we may have other natural hazards we have to deal with, we're certainly mindful, and sensitive, to hazards that others experience. I'm very pleased to be able to be here today. We recognize that the hazards of volcanoes are not limited to those on the ground, but also to those who fly in the air as well. We all have an abiding interest in making sure that we're doing everything that we can in this Committee to protect the public.

I thank you very much, and I thank the witnesses as well.

[The prepared statement of Senator Nelson follows:]

PREPARED STATEMENT OF HON. E. BENJAMIN NELSON, U.S. SENATOR FROM NEBRASKA

Coming from the State of Nebraska, we don't have to worry about volcanoes, tsunami, or hurricanes. But we do know that the number one mission of the government is to protect its citizens, whether through military strength, homeland security, or ordinary warnings about environmental hazards. It is this duty to protect through warnings that is at the heart of today's hearing on volcano hazards to aviation.

Our witnesses today will tell us about the Nation's 169 geologically active volcanoes, and the dangers they pose. Frankly, when we think of volcano hazards, we assume they pose a danger to people on the ground, those who live and work near these sleeping giants. But each year, up to 50,000 aircraft pass near potentially active volcanoes. Should one of those volcanoes erupt, the consequences are dangerous, as Captain Terry McVenes will tell us.

In April 2005, the U.S. Geological Survey issued "An Assessment of Volcanic Threat and Monitoring Capabilities in the United States: Framework for A National Volcano Early Warning System (NVEWS)." The NVEWS report states that many hazardous and potentially hazardous volcanoes are left largely under- or un-monitored, including 18 very high threat volcanoes and 37 high threat volcanoes. The report concludes that full monitoring of these volcanoes and more basic monitoring of moderate and low threat volcanoes through a National Volcano Early Warning System (NVEWS) will allow the U.S. to protect both people and property proactively.

I hope that we will learn that significant progress has been made since last April, and that there is a plan for systematically addressing the priority monitoring challenges. However, I fear that this is basically a question of money, money that the Geological Survey doesn't have. The FY 2006 budget for the USGS Volcano Hazards Program is $21.5 million. The FY request is $21.7 million, an increase of $206,000. According to your budget documents, the agency hopes to rebuild and improve monitoring at four sites. However, there will be no wide scale implementation of the NVEWS framework. The plan for FY 2006–2007 supports no new monitoring in

2006 and new monitoring at only one volcano, Pagan volcano in the Marianas, in FY 2007.

I look forward to our witnesses' candid assessment of what is truly needed to protect our citizens on the ground and in the air.

The CHAIRMAN. They just sent this to me. That picture was taken just before sunset yesterday, so the volcano is semi-active again, Doctor. Let's proceed in the order that's on the schedule. Captain McVenes, may we have your testimony. All of your statements, by the way, will appear in full as though read and our statements likewise will appear as though read. But we're under a time constraint unfortunately because the votes start at 10:30. But, Captain, will you proceed, please.

STATEMENT OF CAPTAIN TERRY McVENES, EXECUTIVE AIR SAFETY CHAIRMAN, AIRLINE PILOTS ASSOCIATION, INTERNATIONAL

Captain MCVENES. Thank you, Mr. Chairman and Members of the Subcommittee. I am Captain Terry McVenes, Executive Air Safety Chairman of the Air Line Pilots Association (ALPA), which represents more than 60,000 professional pilots who fly for 39 airlines here in the United States and Canada. ALPA appreciates the opportunity to discuss volcanic hazards and the impacts on aviation.

Of the more than 1,330 volcanoes worldwide that have demonstrated activity over many thousands of years, approximately 500 of them have recent histories of events and action. However constant seismic monitoring is only available on 174 volcanoes and yet, worldwide, there are 55 to 60 eruptions per year. From 1980 to 2005, more than 100 turbojet aircraft have sustained volcanic ash damage, with repair costs in excess of $250 million dollars. Seven of these encounters caused temporary engine failure, and 3 of the aircraft involved temporarily lost all engine power. These engine failures took place as far away as 600 miles from the erupting volcano and more than 1,500 passengers were in jeopardy.

Volcanoes around the Pacific form what's referred to as the Pacific Ring of Fire. Most of the ring volcanoes are unmonitored for seismic activity yet some of the world's busiest air navigation routes crisscross these areas. Consequently turbojet aircraft encountering volcanic ash could be in grave danger.

I have brought with me at your request an actual recording of a KLM Flight. A Boeing 747 with more than 240 passengers onboard, that encountered volcanic ash, during the 1989 eruption of Mt. Redoubt near Anchorage, Alaska. Listen closely to the radio transmissions between Anchorage Center, which is the air traffic control facility for that region, and KLM 867.

So what happened here? All four engines and many electrical systems failed in only 59 seconds. The cockpit displays became an electronic nightmare. Ash was shorting electronic circuit boards. This four-engine jumbo jet was a glider for several minutes. Although all engines eventually were able to be restarted, they all delivered reduced performance. In fact the last engine only restarted just before landing in Anchorage. They did finally land safely, but there was $80 million dollars in damage to the airplane. Had the crew's emergency procedures failed, more than 200 fatalities and a total hull loss could have been the result.

In a 1982 encounter near Jakarta, Indonesia, a British Airways Boeing 747 had a similar experience at night when Mt. Galungung erupted and propelled ash to flight altitudes without warning. That British Airways crew was surrounded in ash. They lost communications because of the electronic interference, all four engines flamed out, and was left without assistance until just before an emergency landing. With communications lost, most aircraft systems failed, and the crew was only able to navigate to safety visually. They successfully avoided what could have been another fatal consequence.

There has been progress. Today both geostationary and polar orbiting satellites can detect eruption gases and cloud movement. However, industrial priorities must be constantly justified and Federal budgets annually adjusted to assure that these capabilities continue on future replacement satellites. Shifting priorities and shrinking Federal budgets have repeatedly lessened these satellite capabilities in recent years.

There remain some problems to be addressed. In spite of the satellite umbrella, seismic monitors are needed around the world, especially in sparsely populated areas where communications are not fully developed. The Mariana Islands, for example, have volcanoes throughout their territory. Mt. Anatahan, the most active, has only minimal seismic monitoring plus a backup instrument on nearby Pagan. It has had eruptions for the last 3 years, including a stretch of five straight months of activity propelling ash clouds to cruise flight altitudes. Flights to these islands have been disrupted, and there have been deviations of commercial traffic flying air routes over the islands. Though Guam and Saipan are usually excellent en route alternates for over flights, volcanic activity introduces special emergency fuel and weight limiting procedures for long-range twin-engine commercial aircraft. These special procedures and diversions have cost carriers in the millions of extra operating dollars. In addition, U.S. military operations around Guam have been frequently postponed or canceled, driving DOD expenditures there higher. A wider array of monitoring in the Marianas could improve predictability, allow earlier warnings for the air traffic system, and reduce unnecessary reroutes and/or cancellations in this important area of the world.

So to summarize, we continue to have multiple ash encounters by airliners every year. Potentially active volcanoes, especially in remote locations need to be seismically monitored 24 hours a day, 7 days a week. Geologic observatories must coordinate closely with regional air traffic authorities to ensure that warnings are disseminated as soon as possible. Commercial operators should ensure that flight crew training curricula address the normal and emergency procedures for hazard avoidance and inadvertent encounters. The Congress and U.S. Government agencies should be cognizant of the volcanic hazard and its impacts on aviation, in order to understand the technical and financial support required to maintain the necessary detection that is required and to provide those resources. Aspects of this program are shared by the U.S. Geological Survey, the Smithsonian Institution, the National Oceanic and Atmospheric Administration (NOAA) and its National Weather Service (NWS), and the Federal Aviation Administration (FAA). All of their administrative budgets must be annotated in support of shares of that responsibility.

In conclusion, commercial turbojet aircraft are certified with multiple redundant systems to prevent total system failures. Yet even they can be rendered helpless by volcanic ash. Therefore, detection, prediction and dissemination strategies are essential to avoid the hazard. Either we will identify a turning point in our understanding of the volcanic hazards and the impacts on aviation, or we will continue on our present course and accept the hazards of the encounters that we have reviewed. Unfortunately, continuing on our present course may produce fatal results.

Mr. Chairman, I appreciate the opportunity to share ALPA's views on this important matter, and I will be happy to answer any questions you and the other Members of the Subcommittee may have. Thank you.

[The prepared statement of Captain McVenes follows:]

PREPARED STATEMENT OF CAPTAIN TERRY MCVENES, EXECUTIVE AIR SAFETY CHAIRMAN, AIR LINE PILOTS ASSOCIATION, INTERNATIONAL

Mr. Chairman and Members of the Subcommittee, I am Captain Terry McVenes, Executive Air Safety Chairman of the Air Line Pilots Association (ALPA), which represents more than 60,000 professional pilots who fly for 40 commercial airlines in the United States and Canada. ALPA appreciates this opportunity for me to appear before you today to join with members of government and the aviation community to discuss volcanic hazards and the impacts on aviation.

Discussion

Historically, 1,330 volcanoes worldwide have demonstrated indications of activity over many thousands of years. More than 500 of them have shown some activity in recent history, but constant monitoring is currently only available on 174 volcanoes and yet, worldwide, there are 50 to 60 eruptions per year. From 1980 to 2005, more than 100 turbojet aircraft have sustained at least some damage after flying through volcanic ash clouds, resulting in cumulative damages of over $250 million dollars. At least 7 of these encounters have resulted in temporary engine failure, with 3 aircraft temporarily losing power from all engines. Engine failures have occurred at distances from 150 to 600 miles from the erupting volcanoes. Ash related aircraft damages have been reported as far as 1,800 miles from a volcano eruption.

The eruption of a volcano located in a densely populated area of the world can produce catastrophic consequences for those in its vicinity. Because the ferocity of volcanic eruptions bring potential danger to life and property, the most active of them usually have seismic monitors near them, and networks of observatories and scientists with reactive plans to transmit warnings, evacuate population and protect life. Volcanic activity is usually obvious to those in close range and public reports may be as plentiful as those from the scientific community. As a necessary adjunct to those plans, aviation authorities must be notified so that air traffic may be rerouted to avoid potential danger.

Volcanoes located in sparsely populated regions present a vastly different problem because most are unmonitored, and reports of activity may be either extremely random or nonexistent. Warnings to the aviation community may never be given, and the first indication for an aircraft in the area may be an inadvertent encounter with the ash cloud. Many of the volcanoes around the rim of the Pacific Ocean fall into that category. Volcanoes along the western coasts of North and South America, the Alaskan Aleutians, the Kamchatkan Peninsula, and the Asian coastal regions South to Australia, form what geologists refer to as the Pacific Ring of Fire. The majority of the Ring's volcanoes are unmonitored, yet some of the world's busiest air navigation routes crisscross these areas. Turbojet aircraft exposed to heavy concentrations of volcanic ash are in grave danger. Multi-engine commercial aircraft encountering ash clouds have suffered severe consequences as a result. As an example, KLM Flight 867, a Boeing 747 with more than 240 passengers aboard, encountered the 1989 eruption of Mt. Redoubt near Anchorage, Alaska. Review these transmissions between Anchorage Center, the air traffic control facility for that region, and KLM 867 . . .

Video/Voice/Recording plays for 57 seconds for Members and audience at hearing . . .

Pilot KLM B–747—"KLM 867 heavy is reaching {flight} level 250 heading 140"

Anchorage Center—"Okay, Do you have good sight on the ash plume at this time?"

Pilot KLM B–747—"Yea, it's just cloudy it could be ashes. It's just a little browner than the normal cloud."

Pilot KLM B–747—"We have to go left now . . . it's smoky in the cockpit at the moment sir."

Anchorage Center—"KLM 867 heavy, roger, left at your discretion."

Pilot KLM B–747—"Climbing to {flight} level 390, we're in a black cloud, heading 130."

Pilot KLM B–747—"KLM 867 we have flame out all engines and we are descending now!"

Anchorage Center—"KLM 867 heavy anchorage?

Pilot KLM B747—"KLM 867 heavy we are descending now . . . we are in a fall!"

Pilot KLM B–747—"KLM 867 we need all the assistance you have sir. Give us radar vectors please!"

To classify this encounter as one presenting grave danger for those 240 passengers and that crew is an understatement! All four engines of this aircraft failed within 59 seconds! A false cargo compartment fire warning indication required special attention by the crew. All normal airspeed indications failed! The avionics compartments containing all of the radio, radar, electronic systems monitoring, and communications systems, all overheated and individual systems failed. The sophisticated electronic cockpit displays became an electronic nightmare. While ash was contaminating the engines and causing them to flame out, it was also contaminating electrical compartments and shorting electronic circuit boards. This four engine jumbo jet was essentially a glider for several minutes until the crew was able to individually restart engines. Three of the engines eventually restarted but delivered reduced performance. The fourth engine eventually came on line when the aircraft was on final approach to Anchorage. Although the crew landed safely, the encounter caused $80 million dollars damage to the airplane. Under only slightly different circumstances, 240 plus fatalities and a total hull loss could have been the result.

KLM 867 was only one of several commercial aircraft exposed to varying amounts of damage during several days of volcanic activity from Mt. Redoubt. Anchorage is one of the world's busiest airports for both passengers and cargo. The eventual economic impact of aircraft damages, cargo delays, passenger flight delays and cancellations, and general disruption to the Alaskan economy was staggering. Every commercial aviation operation in or through that territory suffered economic consequences.

Mt. Redoubt was monitored, and the system of warnings was activated, but the capability to detect and predict the ash movement, and to track the cloud, was not as sophisticated in 1989 as it has become today. Nor were the commercial flight crews as aware of the hazard, or as specifically trained to deal with avoidance or escape, as many have been trained to do today.

In an earlier encounter near Jakarta, Indonesia, a British Airways Boeing 747 had a similar experience at night when Mt. Galungung erupted and propelled ash to flight altitudes without warning. That BA crew was enveloped in ash, lost communications because of the electronic interference, flamed out all four engines, and was left without assistance until just before an emergency landing. With communications lost, most aircraft systems failed, and pure visual pilotage to navigate to safety, they also successfully avoided what could have been fatal consequences.

Progress

The capability for today has improved. Both geostationary and polar orbiting satellites employ sensors to detect eruption gases and to depict cloud movement. However, industrial priorities must constantly be justified and funding made available to ensure that those capabilities continue on future replacement satellites. Shifting priorities and shrinking Federal budgets have lessened the satellite capabilities in recent years. Operational plans are employed throughout the world to maintain communications priorities to transmit volcanic ash hazard warnings and notices within the aviation community. Since 1989, two international volcanic ash and aviation safety conferences have been held to bring the scientific and aviation communities together to refine and improve prediction, detection, and monitoring of the hazard; and to improve training, operational procedures, and communications and warning strategies within the aviation community.

Remaining Problems to Be Addressed

In spite of the satellite umbrella, seismic monitors are needed around the world, especially in sparsely populated areas where communications are not fully developed. The Mariana Islands, for example, have volcanoes throughout their territory. Mt. Anatahan, the most active, has only minimal seismic monitoring plus a backup instrument on nearby Pagan. It has had eruptions for the last three years, including a stretch of five straight months of activity propelling ash clouds to cruise flight altitudes. Flights to the islands have been disrupted, and there have been deviations of commercial traffic flying air routes over the islands. Though Guam and Saipan are usually excellent en route alternates for over flights, volcanic activity introduces special emergency fuel and weight limiting procedures for long-range twin-engine commercial aircraft. These special procedures and diversions have cost carriers in the millions of extra operating dollars. In addition, U.S. military operations around Guam have been frequently postponed or cancelled, driving DOD expenditures there higher. A wider array of monitoring in the Marianas could improve predictability, allow earlier warnings for the air traffic system, and reduce unnecessary reroutes and/or cancellations in this important area of the world.

Lesson Summary

- Potentially active volcanoes, especially in remote locations, should be seismically monitored 24/7.
- Geologic observatories must coordinate closely with regional air traffic authorities to ensure that warnings are disseminated as soon as possible.
- Commercial operators should ensure that flight crew training curricula address the normal and emergency procedures for hazard avoidance and inadvertent encounters.
- The Congress and U.S. Government agencies should be cognizant of the volcanic hazard and its impacts on aviation, in order to understand the technical and financial support required to maintain the necessary detection and prediction resources. Aspects of this program are shared by the U.S. Geological Survey (USGS), the Smithsonian Institution, the National Oceanic and Atmospheric Administration (NOAA) and its National Weather Service (NWS), and The Federal Aviation Administration (FAA). All of their administrative budgets must be annotated in support of shares of that responsibility.

Conclusion

Commercial turbojet aircraft are certified with multiple redundant systems to prevent total system failures. Yet even they can be rendered helpless by volcanic ash. Therefore, detection, prediction and dissemination strategies are essential to avoid the hazard. Either we will identify a turning point in our understanding of the volcanic hazards and the impacts on aviation, or we will continue on our present course and accept the hazards of the encounters that we have reviewed. Continuing on our present course may produce fatal results.

Mr. Chairman, I appreciate the opportunity to share ALPA's views on this important matter, and I will be happy to answer any questions you and the other Members of the Subcommittee may have.

The CHAIRMAN. Thank you very much, Captain. Dr. Eichelberger.

STATEMENT OF DR. JOHN C. EICHELBERGER, PROFESSOR OF VOLCANOLOGY, UNIVERSITY OF ALASKA FAIRBANKS; COORDINATING SCIENTIST, ALASKA VOLCANO OBSERVATORY

Dr. EICHELBERGER. Thank you, Mr. Chairman, and Members of the Subcommittee for this opportunity to discuss prediction and prevention of volcanic hazards. I would like to focus on the Alaska region and for obvious reasons that's where most of the U.S. volcanoes are and the Alaska Volcano Observatory which has an unusual aspect of direct involvement of the academic research community. I am Coordinating Scientist of AVO, and so I lead the University portion of the AVO effort. And as Senator Stevens pointed out, we're now dealing with a major eruption of Augustine volcano.

It's rapidly extruding lava. It had an explosive phase early on and could go back to major explosions really at any time.

Americans tend to think of their 49th state as remote, although remoteness is in the eye of the beholder. Most people don't think of their homes as remote. It surprises people to discover that flights between eastern Asia and North America pass over Alaska, not Hawaii. Thus, some 25,000 people traverse Alaska's skies every day and Anchorage ties Tokyo in air freight. Along this route are about 100 volcanoes capable of blasting ash to flight levels, with the potentially fatal results that Captain McVenes described. Some of these volcanoes are in Japan, many in the Russian Far East, and about half in Alaska.

It is not enough to justify a program by pointing out a danger. The more important question is whether something can be done about it. And for volcanoes, this means getting people out of the way. Happily, prediction of eruptions is possible through geophysical monitoring, so volcanology is a case where a modest investment produces a large benefit in reducing the impact of catastrophic natural events.

For the airlines, adequate monitoring means knowing when and where it is safe to fly. For communities, it means knowing when to protect facilities, how to advise people on health risks and when to evacuate. By making information on the condition of Augustine volcano, instantly available to everyone, AVO, I believe, has vastly reduced the disruption caused by the current activity.

Our observatory is unique in the world in that it is a thoroughly collaborative undertaking of Federal and State government scientists, and, key from my standpoint, faculty and students of the university. The strengths of this approach are diversity of expertise, the connectedness of the university to local communities, government agencies, and the U.S. scientific community, and—most of all from the university's perspective—the involvement of students in exciting science for immediate public benefit and the education of the next generation of geoscientists.

The challenges of Alaska which our Chairman is well aware of, have kind of defined our areas of leadership. We have developed the means to geophysically monitor volcanoes in remote harsh environments. We've been the first to use satellite remote sensing operationally for volcano monitoring.

We have educated a diverse group of talented geoscientists who serve in public, private and academic sectors, not just in natural hazard mitigation but also in areas of mineral and energy resources.

We now have 30 volcanoes geophysically monitored and no other observatory in the world comes close to that.

Finally, and here again our academic face helps us, we're the most international of observatories, linking with our Russian colleagues to cover the entire North Pacific. For the university, having a strong core program in volcano monitoring leads to success in related areas. Spin-offs from this work include a new model for particulate plumes; new satellite remote sensing techniques; international volcano research drilling in Japan (we actually drilled through the conduit of an active volcano); geothermal energy research in Alaska (which I think is a bright hope for the future);

and collaborative volcanological education and research in the Russian Far East and Alaska—the latter is supported by the National Science Foundation and the Russian Academy of Sciences involving students from all over Russia and the U.S. These NSF programs have opened a new bright window in our common border with Russia, which I think is very important.

The immediate challenge for the Alaska Volcano Observatory, illuminated by the current eruption, is stability of Federal support. We hope that through improved coordination among the Departments of Interior, Transportation and Commerce and the National Volcano Early Warning System that Dr. Quick is going to discuss that will become possible.

The need for a combination of instrumented vigilance, advances in technology and science of volcano monitoring, and geoscience education will continue as long as humankind exists on this dynamic planet. The benefits are not only property and lives saved, but in knowledge gained and in students inspired. Thank you.

[The prepared statement of Dr. Eichelberger follows:]

PREPARED STATEMENT OF DR. JOHN C. EICHELBERGER, PROFESSOR OF VOLCANOLOGY, UNIVERSITY OF ALASKA FAIRBANKS; COORDINATING SCIENTIST, ALASKA VOLCANO OBSERVATORY

Mr. Chairman and Members of the Subcommittee, thank you for this opportunity to discuss the natural hazard threat that volcanoes pose to international aviation over Alaska, to Alaska's communities, and to the role that the Alaska Volcano Observatory plays in mitigating this hazard. James Quick of the U.S. Geological Survey, on behalf of Acting Director Patrick Leahy, is reporting at this hearing on the national program of volcano hazard mitigation. I would like to focus on some of the special and unusual aspects of this work in the Alaska region by the Alaska Volcano Observatory (AVO), an observatory which itself has some unusual aspects. I am Coordinating Scientist of AVO, and as such lead the University of Alaska portion of the AVO effort. This is an important time for such a report, as we are now dealing with an explosive eruption in Alaska's most populous region, as well as with unrest at other volcanoes. I believe that AVO's successful prediction of and response to the eruption of Augustine Volcano makes the case for continued support of this effort all the more compelling.

Americans tend to think of their 49th state as remote, although remoteness is in the eye of the beholder. A remote place is far from home and usually at the corner of a map. But Earth does not have corners. It surprises people to discover that flights between eastern Asia and North America pass over Alaska, not Hawaii. Thus, some 25,000 people traverse Alaska's skies every day and Anchorage ties Tokyo (Narita) in landed airfreight. Along this route are about 100 volcanoes capable of blasting ash to flight levels, some in Japan, many in Russia, and about half in Alaska. However, Alaska's volcanoes are remote in the sense of getting geophysical equipment installed and getting data out. They provide unforgiving environments for hi-tech instrumentation. These facts, combined with Alaska's small population, define the mission of AVO and explain its areas of international leadership in volcanology.

Of course, it is not enough to justify a program by pointing out a danger. The more important question is whether something can be done to reduce the impact of a natural event in terms of damage to property and loss of life. For volcanoes, this often means getting people out of harm's way, which in turn requires either immediate or preferably advance warning of eruptions. Happily, prediction of eruptions in a useful timeframe is often possible for volcanoes through observation of increased seismicity, subtle inflation, and increased heat and gas output. These changes are detected through surface seismic and GPS networks, through surveillance flights, and through sophisticated satellite remote sensing techniques. In addition to when, it is vital to know how a volcano will erupt, and for this we rely on the lessons of history that geology of the volcano provides.

Ash clouds do not respect immigration procedures, and so comprehensive monitoring requires close coordination with international counterparts. Finally, hazard information must be disseminated widely, freely, and instantly, as is now possible through the Internet and World Wide Web. These activities, then, comprise the Alaska Volcano Observatory. Except for very large eruptions—infrequent but they do happen, and Alaska did have the world's largest eruption of the 20th century in 1912—potential losses are less than for large earthquakes or hurricanes. But volcanology is a case where a modest investment produces a large benefit in reducing the impact of catastrophic events.

For the airlines, the result of AVO's vigilance is knowing when to cancel flights during an eruption, knowing when it is safe to fly, or knowing when to take on extra fuel and less cargo if diversion may be necessary. Indeed, the availability and reliability of volcano eruption warnings is a factor in cargo airlines choosing to use Anchorage as a refueling stop. For communities, it means when to shut down or protect facilities from ash and how to advise people on health risks.

How does one carry out a sophisticated and diverse monitoring program in a state with a small population? The way Alaskans persevere through other challenges: cooperation. The Alaska Volcano Observatory is unique in the U.S. and probably the world in that it is a thoroughly collaborative undertaking of Federal scientists, state scientists, and university faculty and students. There are many rewards to this approach, despite its seeming administrative complexity. As the USGS Acting Director cites, the USGS has a Congressional mandate to mitigate geologic hazards, of which volcanism is an important component. The USGS manages AVO and supports it within its national pool of volcanological talent. The Alaska Division of Geological and Geophysical Surveys (ADGGS) has a similar mandate at the state level, and is naturally more attuned to state priorities. In addition, ADGGS maintains extensive knowledge and databases of state geology, and is a logical choice for disseminating this information to the public. The University of Alaska has the unique role within the partnership of education, both in terms of introducing students to societally engaged science and in producing the next generation of geoscientists. It also provides a fertile intellectual environment that is more difficult to maintain in government agencies. All three partners have their specialties, though they also all participate in the monitoring and scientific aspects of the operation.

Strengths of this unique approach are the diversity of expertise it makes available, the connectedness of the observatory to local communities, government agencies, and the U.S. scientific community, and—most of all from the university's perspective—the involvement of students in exciting science for immediate public benefit. It is worth noting that volcanology programs funded by other agencies such as the National Science Foundation (NSF) and NASA cannot provide this experience because geophysical monitoring, the task of turning geoscience data quickly into information for safety decisions, is solely the mission of the USGS Volcano Hazards Program.

The challenges of Alaska have defined AVO's areas of leadership. We have pioneered the installation of stand-alone geophysical stations that can operate without attention for two to three years in a harsh environment, telemetering real-time seismic and GPS data via radio, satellite, and telephone links to Anchorage and Fairbanks. We have initiated the first operational satellite monitoring of active volcanoes, sometimes catching the very earliest precursory activity because infrared-imaging satellites (for example, weather satellites) can peer down into deep craters. We have contributed much to the scientific community's understanding of how volcanoes work. And we have educated a diverse cadre of talented geoscientists who serve in public, private and academic sectors, not just in natural hazard mitigation and research, but also in acquisition of mineral and energy resources. We have also developed volcanology's most acclaimed website, which serves the dual purposes of dissemination of hazard information and, for the Nation as a whole, science education. We are the most international of observatories, having worked with our Russian colleagues to develop monitoring capabilities first in Kamchatka and now in the Kurile Islands. Russian volcanoes frequently put ash into areas where the U.S. has aviation safety responsibilities. The most amazing fact about AVO is the number of volcanoes geophysically monitored: 30. No other observatory in the world comes close.

For the university, having a strong core program in volcano monitoring leads to success in related areas of endeavor. Spin-offs from this work include a new model for particulate dispersal in the atmosphere; new satellite remote sensing techniques; volcano research drilling in Japan funded by the international scientific community; geothermal energy research in Alaska; and collaborative volcanological education and research in the Russian Far East and Alaska, supported by NSF and the Russian Academy of Sciences and involving students from all over Russia and the U.S. These NSF programs have opened a new bright window in our common border with Russia.

The immediate challenge for the Alaska Volcano Observatory is adequate funding, not so much in terms of dollars though a modest increase is essential, but in increased stability. The USGS Volcano Hazards Program has not received sufficient funds to cover the expanded role of monitoring volcanoes that threaten only aircraft. Hence, Congress has annually assigned about half of AVO's budget, representing mitigation of the ash hazard to aircraft, to the FAA, which then transfers the funds through the Department of Commerce to USGS. This cumbersome process precludes long-term planning. This year we have a serious funding shortfall just as Augustine Volcano emerged from two-decade slumbers and volcanoes Spurr, Veniaminof, Cleveland, and Korovin became "hot."

Alaska Volcano Observatory is the most obvious example of the evolving role in natural hazard mitigation of the USGS Volcano Hazards Program. Before AVO, no "remote" volcanoes were monitored. Changing perceptions of remoteness are a natural consequence of increasing human population and changing patterns of human travel, specifically, reliance on long-distance, great-circle-route air travel. Fortunately, evolving technology has kept pace and gives us the tools to mitigate newly recognized hazards. The need for a combination of instrumented vigilance, advances in technology and science of volcano monitoring, and geoscience education will continue as long as humankind exists on this dynamic planet. The benefits are in knowledge gained as well as in property and lives saved.

The CHAIRMAN. Our next witness is Mr. James Quick, Program Coordinator for the Volcano Hazards Program at USGS. Dr. Quick.

STATEMENT OF DR. JAMES E. QUICK, PROGRAM COORDINATOR, VOLCANO HAZARDS PROGRAM, U.S. GEOLOGICAL SURVEY, DEPARTMENT OF THE INTERIOR

Dr. QUICK. Mr. Chairman and Members of the Subcommittee, thank you for this opportunity to discuss the threat that volcanoes pose to aviation and our vision for a national volcano early warning system to monitor the Nation's volcanoes at levels commensurate with the threat that each poses.

The message that I hope to convey is that volcanic eruptions even at seemingly remote volcanoes pose a serious threat to aviation. But this threat can be effectively mitigated by strategic improvement of volcano monitoring capability coupled with continued improvement in interagency communication and response plans.

Currently Mount St. Helens in Washington, Kilauea in Hawaii, and Augustine in Alaska are erupting. And several other volcanoes are being closely watched for possible renewed eruptive activity.

Most people are aware of the hazards that erupting volcanoes create on the ground, including mudflows, fiery avalanches, and lava flows such as those that could reach in less than 2 hours the highly developed Kona Coast on the flanks of Mauna Loa in Hawaii.

Less well known by the public is the threat posed to aviation by erupting volcanoes. Volcanoes threaten aviation safety when magma erupts explosively and plumes of small pieces of volcanic rocks, minerals, and glass, what we term ash, are ejected high into the atmosphere and drift for long distances across air routes.

For example, the 1992 eruption of Mt. Spurr in Alaska was tracked on satellite images for more than 3,000 miles downwind of the volcano over Canada and the Great Lakes region, disrupting air traffic as far east as Cleveland, Ohio.

Many major air routes traverse the world's most volcanically active regions, and numerous instances of aircraft flying into volcanic ash clouds have demonstrated the life-threatening and costly damages that can be sustained.

The practical mitigation strategy is for aircraft to avoid airspace containing volcanic ash. Ash avoidance is not a simple matter. It involves elements of: ground-based volcano monitoring, satellite-based detection of ash clouds, modeling cloud movements in the atmosphere, and coordinated communication protocols among volcanologists, meteorologists, air traffic controllers, dispatchers and pilots.

As the USGS has increasingly recognized that volcano monitoring is needed to protect against aviation hazards, we have adjusted our monitoring program accordingly. For example, although the ground population is sparse in the volcanically active Aleutian Islands of Alaska, the risk to aviation is high. More than 200 flights carry roughly 25,000 people over Northern Pacific air routes on a daily basis. With the support of Senator Stevens, the Alaskan Volcano Observatory, which is a partnership between USGS, the University of Alaska Fairbanks, Geophysical Institute, and the State of Alaska has systematically expanded its monitoring into the Aleutian chain, from four instrumented volcanoes in 1996, to 30 at the end of this past summer's field work.

Impending volcanic eruptions can be forecast, and warnings issued before the hazardous event occurs. This capability was recently demonstrated at Augustine volcano near Alaska's most populated area, the Cook Inlet, when the Alaska Volcano Observatory issued a successful forecast on January 10, 2006.

Such forecasts and warnings depend on telemetered, real-time data from adequate arrays of different types of monitoring instruments located on and near volcanoes. No single geophysical monitoring technique or system can confidently provide timely alerts of eruptions.

In order to meet the needs of the aviation community, our goal is to notify the appropriate FAA center of an ash-producing eruption within 5 minutes of its onset. This level of notification requires 24/7 operation at U.S. Volcano Observatories, and sufficient ground-based monitoring networks. Once an eruption is in progress the USGS, NOAA, FAA and the Air Force Weather Agency share data and coordinate their warning messages, so that necessary information reaches the cockpit quickly.

There are 169 active volcanoes in the United States. In order to focus resources among these volcanoes, the USGS recently published an evaluation of the Nation's volcanoes monitoring needs based on a systematic assessment of the societal threats they pose. This publication is the scientific foundation for a national volcano early warning system and identifies as high priorities for improved monitoring 19 volcanoes in Alaska, and the Northern Mariana Islands, that pose substantial threats to aviation but that have no real-time ground-based monitoring, and 9 Cascade volcanoes that pose threats to both aviation and ground communities, but have inadequate, or antiquated networks.

In conclusion, please allow me to reiterate that there are no remote volcanoes when we consider aviation hazards. Mitigation of this risk requires appropriate volcano monitoring, timely analysis and efficient teamwork by multiple agencies.

The USGS will continue to do its part by providing scientific information based on reliable monitoring data.

Thank you, Mr. Chairman, for providing the opportunity to present this testimony and I'll be pleased to answer any questions that you may have.

[The prepared statement of Dr. Quick follows:]

PREPARED STATEMENT OF DR. JAMES E. QUICK, PROGRAM COORDINATOR, VOLCANO HAZARDS PROGRAM, U.S. GEOLOGICAL SURVEY, DEPARTMENT OF THE INTERIOR

Mr. Chairman and Members of the Subcommittee, thank you for this opportunity to discuss the natural hazard threat that volcanoes pose to aviation, the U.S. Geological Survey role in volcano research, monitoring, and eruption warnings, and our national strategy for a proactive, fully-integrated volcano hazard mitigation effort.

Overview of Volcanic Hazards Program

For more than 125 years, USGS has provided the Department of the Interior, the Nation, and the world with relevant science to guide policy and safeguard society. This legacy of scientific excellence is reinforced by the authority afforded USGS under the Disaster Relief Act (Pub. L. 93–288, popularly known as the Stafford Act) as the lead Federal agency with responsibility to provide notification for earthquakes, volcanic eruptions, and landslides, to enhance public safety, and to reduce losses through effective forecasts and warnings based on the best possible scientific information.

The United States is home to 169 volcanoes considered to be active, more than any other country in the world. The USGS has recently completed a systematic assessment of the relative societal threat posed by each of the Nation's 169 geologically active volcanoes. For each volcano, the study determined a level of societal threat based on an evaluation of the hazards that could be anticipated and the societal exposure to those hazards. This study, *An Assessment of Volcanic Threat and Monitoring Capabilities in the United States: Framework for a National Volcano Early Warning System (NVEWS)*, the recommendations of which are discussed later in my testimony, is being used to guide long-term improvements to the national volcano-monitoring infrastructure operated by USGS and its partners. The USGS and its Federal, State, and university partners operate five volcano observatories to monitor eruptive activity and unrest at 50 volcanoes in the Cascade Range, Hawaii, Alaska, California, and Yellowstone National Park. Currently, three U.S. volcanoes are erupting (Mount St. Helens in Washington, Kilauea in Hawaii, and Augustine in Alaska), and two are being closely watched for unrest or renewed eruptive activity, Mauna Loa in Hawaii and Anatahan in the Northern Mariana Islands.

The threats that volcanoes pose to populations on the ground are generally understood in the United States. Most people are aware of the hazards that erupting volcanoes create, such as lava flows, hot, gaseous flows of volcanic blocks and ash, and mudflows. The potential harm of these phenomena, in terms of loss of life and societal and economic disruption, are very serious considerations for communities near or downwind and downstream of many of the Nation's volcanoes. For example, lava flows from Mauna Loa Volcano, which has been exhibiting signs of increased unrest for two years and may be advancing toward eruption, can reach the highly developed Kona Coast of Hawaii in as little as two hours. Within the Cascade Range, 13 volcanoes pose significant threats to people and infrastructure on the ground. At Mount Shasta in California, searing avalanches of volcanic rock and gas could reach more than 6,000 people in the vicinity of the town of Weed and Mount Shasta City in less than 10 minutes. Large mudflows formed by melting of thick ice and snow on Mount Rainier, Mount Baker, or Glacier Peak in Washington could race down populated valleys at speeds of up to 60 miles per hour, devastating communities lying in the path of the potentially deadly mudflows.

With appropriate monitoring, impending volcanic eruptions can be forecast and warnings issued *before* the hazardous events occur. This capability was demonstrated in advance of the June 1991 eruption of Mount Pinatubo, Philippines—the largest volcanic eruption of the 20th century to affect a heavily populated area. Because the eruption was forecast by scientists from the Philippine Institute of Volcanology and Seismology (PHIVOLCS) and USGS, civil and military leaders were able to order massive evacuations and take measures to protect property before the eruption. The USGS and PHIVOLCS estimate that their eruption forecasts saved at least 5,000 and as many as 20,000 lives. At least $200 million to $275 million in losses of military aircraft and equipment were averted by having those assets flown to safe areas or covered in advance of the eruption. A more recent example of this successful forecasting ability was demonstrated at Augustine Volcano near Alaska's most populated area, the Cook Inlet. Utilizing monitoring networks already in place, the Alaska Volcano Observatory detected the onset of unrest and raised the alert level on November 29, 2005, and began monitoring the unrest closely to determine if activity was likely to escalate, plateau, or die down. Unrest continued to escalate, and the USGS issued an information bulletin on January 10, 2006, that indicated a heightened possibility of an explosive eruption within the "next few weeks or months." The following day, an eruption at Augustine Volcano was underway. Timely forecasts and warnings such as these examples depend on telemetered, real-time data from adequate arrays of different types of monitoring instruments located on and near volcanoes and on remotely sensed data transmitted by other agencies (e.g. GOES satellite data from National Oceanic and Atmospheric Administration (NOAA)).

Volcanic Threats to Aviation Safety

Less well known by the public is the threat posed to aviation by erupting volcanoes. Volcanic eruptions pose a serious threat to aviation, but one that can be mitigated through the combined efforts of earth and atmospheric scientists, the aviation industry, and air-traffic control centers. Volcanoes threaten aviation safety when magma erupts explosively to form clouds of small jagged pieces of rocks, minerals, and volcanic glass the size of sand and silt that rises miles above the earth's surface and is spread by winds aloft over long distances across flight paths of jet aircraft. Unlike the soft fluffy material created by burning wood, leaves, or paper, "volcanic ash" particles are angular, abrasive fragments having the hardness of a pocket-knife blade. Upon impact with an aircraft traveling several miles per minute, ash particles abrade the windscreen, fuselage, and fan blades in the turbine engines. In addition to the problem of abrasion, the melting temperature of the glassy rock material that comprises ash is lower than the operating temperatures of jet engines. Consequently, ingested ash particles can melt in hot sections of aircraft engines and then fuse onto critical components in cooler parts of the engine. An aircraft encounter with ash can result in loss of visibility, and failure of critical navigational and flight systems, and can immediately and severely degrade engine performance, resulting in engine flame out and total loss of thrust power.

The volcanic-ash hazard to aviation extends the volcanic threat far beyond the local area or region where a volcano is located. For example, the 1992 eruption of Mount Spurr in Alaska produced an ash cloud that was tracked on satellite images for three days and more than 3,000 miles downwind of the volcano over Canada and the Great Lakes region.

Many major air routes traverse the world's most volcanically active regions, and numerous instances of aircraft flying into volcanic ash clouds have demonstrated the life-threatening and costly damages that can be sustained. From 1973 through 2003, 105 encounters of aircraft with airborne volcanic ash have been documented. This is a minimum number of encounters because incidents have not been consistently reported.

The potential for a disastrous outcome of an ash/aircraft encounter has been illustrated by three dramatic encounters. The first occurred in 1982 when a Boeing 747—at night over water with 240 passengers—flew into an ash cloud about 100 miles downwind from Galunggung volcano in Indonesia. The aircraft lost power in all 4 engines and descended 25,000 ft. from an altitude of 37,000 ft. above sea level. After 16 minutes of powerless descent, the crew was able to restart three engines and make a safe landing in Jakarta. A few weeks later, a second Boeing 747 with 230 passengers encountered an ash cloud from another eruption of the same volcano. The aircraft lost power to 3 engines and descended nearly 8,000 ft. before restarting one engine and making a nighttime emergency landing on two engines. In both cases, the aircraft suffered extensive damage. Fortunately, a greater human tragedy was averted.

A third incident occurred in 1989 and was related to an eruptive event at Redoubt Volcano in Alaska. A Boeing 747 with 231 passengers onboard was nearing Anchorage International Airport and flew into what appeared to be a thin layer of weather clouds. It was actually an ash cloud erupted by Redoubt Volcano, approximately 150 miles distant. The aircraft lost power from all four engines and descended for four minutes over mountainous terrain. With only one to two minutes remaining before impact, the engines were restarted and the aircraft safely landed in Anchorage. Damage was estimated at more than $80 million (in 1989 dollars).

A decade of these harrowing events prompted action by airlines, dispatchers, air-traffic control, aviation meteorologists, and volcanologists. It had become clear to all that damaging, even life-threatening, aircraft encounters with volcanic ash are not flukes but rather a persistent hazard that requires a coordinated, multi-pronged, operational response for the purpose of ash avoidance. Responding to this newly recognized hazard, the International Civil Aviation Organization (ICAO)—with strong participation from USGS scientists—established procedures on a global scale for the rapid dissemination of information related to ash-producing eruptions and the movement of ash clouds to the aviation sector. One of these procedures is the use of a color-coded alert system for volcanic ash warnings to the air carrier industry. This alert system, originally developed in 1990 by USGS scientists at the Alaska Volcano Observatory (AVO), is now recommended for worldwide use by ICAO.

Areas Targeted for Increased Monitoring

As the USGS has increasingly recognized that volcano monitoring is needed to protect against aviation hazards as well as the more well-known ground hazards, we have adjusted our monitoring program accordingly. For example, although the ground population is sparse in the volcanically active Aleutian Islands of Alaska, the risk to aviation is high. More than 200 flights carry roughly 25,000 people over Northern Pacific air routes on a daily basis. Since 1996, with funding support from FAA, AVO has undertaken to expand its monitoring beyond the few volcanoes that threaten communities around Cook Inlet in the south central portion of the state. Over the past decade, AVO has systematically expanded its seismic monitoring into the Aleutian chain, from 4 instrumented volcanoes in 1996 to 28 at the end of this past summer's field work. This increase in real-time monitoring capability is an amazing accomplishment of both planning and execution on the part of AVO, a partnership between USGS, the University of Alaska Fairbanks, and the State of Alaska.

AVO also developed a capability for frequent, systematic satellite monitoring of active volcanoes throughout the North Pacific, to recognize pre-eruptive thermal signals at volcanoes and to detect eruptive plumes. This pioneering effort at regional satellite monitoring complements traditional seismic monitoring and serves as a model to other volcano observatories worldwide. AVO is also contributing to National Weather Service (NWS) efforts to develop the Volcanic Ash Collaboration Tool, a system that uses networked workstations for real-time collaboration among agencies by providing common views of data sources and the ability to rapidly delineate and discuss areas of ash hazard.

Another area where USGS recently began volcano monitoring due to volcanic hazards to aviation is the Commonwealth of the Northern Mariana Islands. Like the Aleutians, ground population is sparse on most of these islands, but the aviation risk is significant, including the threat to stealth B–2's and other military aircraft housed at Andersen Air Force Base on Guam. The initial eruption in May 2003 of Anatahan—a long dormant volcano with no real-time ground-based monitoring in place—was a surprise. Since then, USGS has installed a rudimentary seismic system with real-time data transmission and is working closely with local emergency management officials, the U.S. Air Force, NOAA, and FAA to provide eruption notifications.

The activity at Anatahan has demanded sustained vigilance. In 2005, the volcano erupted to over 40,000 feet numerous times and expelled several million cubic yards of ash during a nearly continuous eruptive episode that lasted eight months. After the largest ash eruption, USGS provided forecasts of ash deposition on Saipan to the local government there. USGS also supports AFWA's mission of providing volcanic-ash advisories and situational awareness to DOD aviation. For example, USGS volcanologists furnished short-term forecasts of potential ash-plume heights to AFWA for use in planning and completing a critical training exercise in the Marianas region by the USS Nimitz Carrier Strike Group.

Interagency and International Coordination

Ash avoidance is not a simple matter—it requires the coordinated efforts of volcanologists, meteorologists, air-traffic control centers, dispatchers, and pilots. It involves elements of: ground-based volcano monitoring, satellite-based detection of ash clouds, modeling cloud movements in the atmosphere, and specific communication protocols among the diverse parties responding to the hazard.

In the United States, the USGS, NOAA, Federal Aviation Administration (FAA), and Air Force Weather Agency (AFWA) at Offutt Air Force Base in Nebraska collaborate according to International Civil Aviation Organization (ICAO) guidelines, sharing data and refining communication protocols so that necessary information reaches commercial and military pilots, dispatchers, and air-traffic controllers quickly. The USGS has responsibility for providing notifications of significant pre-eruption volcanic activity, volcanic eruptions, and volcanic ash in the atmosphere. The USGS capability to provide such notifications is based on data and observations collected from monitoring networks operated by the five U.S. volcano observatories supported by the USGS Volcano Hazards Program.

USGS volcano monitoring activities do not stand alone. For both aviation and ground hazards, no single geophysical monitoring technique or system can confidently provide timely alerts of eruptions; neither seismic networks, GPS arrays, nor remote sensing techniques on their own are adequate for reliable forecasting or alerting purposes. Recognizing this, we have developed very close working relationships with groups that track ash clouds using civilian meteorological satellites, in particular the AFWA and NOAA's Volcanic Ash Advisory Centers (VAACs) located in Washington D.C. and Anchorage. During precursory unrest and eruptive episodes, we share observational data and maintain frequent telephone contact to ensure consistent interpretations of volcanic activity and potential hazards. No one organization has a monopoly on critical monitoring information. Effective communication among the various groups is crucial to successful mitigation of the hazard.

In addition to USGS monitoring efforts, we also are working to improve the communication procedures that are critical for eruption and ash-cloud information to reach the cockpit. In call-down lists at U.S. volcano observatories, FAA, VAACs, and aviation weather offices of the National Weather Service (NWS) are among the first agencies to be notified. Since the mid-1990s, USGS scientists have worked with Russian scientists to disseminate information about eruptions from the Kamchatka Peninsula that could affect U.S. controlled airspace. Recently, USGS scientists played a key role in the establishment of the first-ever monitoring and reporting group for the Kurile Island chain of volcanoes. The USGS has organized the formulation of inter-agency operating plans for dealing with ash episodes in the North Pacific and Marianas regions. These plans provide operational guidance by documenting the required procedures of the government agencies responsible for ensuring safety of flight operations. The USGS is working with FAA, NOAA, and AFWA to complete a national operational plan for volcanic ash hazards to aviation.

Another important role for USGS is hazard education—building awareness among volcanologists, meteorologists, pilots, dispatchers, and air-traffic controllers of the nature of the hazard and how to respond to it. The USGS has assisted in the development of training videos for pilots and air-traffic controllers, provided technical briefings for airlines and industry groups, organized technical symposia, and published articles in aviation journals.

Research Priorities

Research is also a critical component of mitigation. To improve our forecasting abilities, we need to gain a much better fundamental understanding of eruption processes. Research and experience in the 25 years since the 1980 eruption of Mount St. Helens has brought volcanology to a point where, with adequate monitoring systems in place, the timing of volcanic eruptions can be forecast with some confidence hours to days in advance. The next major scientific goal for volcanology is to accurately forecast the size and duration of eruptions, which bears directly on hazards issues confronted by enroute aircraft and people on the ground. For instance, being able to forecast that an eruption will be small and unlikely to erupt ash to altitudes above 15,000 feet versus one that sends ash to 50,000 feet will have amajor impact on response by the aviation community. Another aspect is the ability to identify when an eruption is over, not just temporarily paused. This is quite a complex problem. Such information is valuable to airports, for example, because it tells them when they can start cleaning up from ashfall and hasten the return to normal operation.

Air routes over active volcanic regions will continue to be heavily used, and volcanic ash will persist as a serious aviation hazard. Much has been done to mitigate the volcanic threat to aviation. More volcanoes are being monitored now than 10 years ago, and eruption reporting targeted to the aviation sector is in place. Satellite detection of ash clouds and forecast models of ash-cloud dispersion have greatly improved. As a result of increased awareness and improved information in support of ash avoidance, no multiple-engine airplane failures have occurred since 1991. Despite these successes, much work remains. Many hazardous U.S. volcanoes are not monitored at a level that provides for adequate tracking of volcanic unrest that precedes eruption. It is still possible for there to be significant periods of time when ash clouds drift undetected in or near air-traffic routes, as was the case with the surprise eruption in 2003 of Anatahan volcano in the Mariana Islands. Hours elapsed from the eruption's onset to the issuance of the first warning to aviation of ash in the atmosphere.

Results of the Volcanic Threat and Monitoring Capabilities Assessment

In order to better focus resources on improved monitoring of volcanoes that present the greatest threat, USGS recently published the results of the first overall evaluation of the Nation's volcano-monitoring needs based on a systematic assessment of the societal threats posed by all of the 169 geologically active U.S. volcanic centers. The publication is entitled *An Assessment of Volcanic Threat and Monitoring Capabilities in the United States: Framework for a National Volcano Early Warning System (NVEWS)*. The report scores various hazard and exposure factors for each volcano and identifies volcanoes where monitoring capabilities are inadequate—and in some cases nonexistent—for the threats posed. The results of the NVEWS assessment are being used to guide long-term improvements to the national volcano-monitoring infrastructure operated by USGS and affiliated partners.

Aviation hazards carried substantial weight in the NVEWS assessment. The USGS developed a methodology for assessing aviation threat on a regional and local basis at each volcano and determined that about half of U.S. volcanoes represent a significant threat to aviation. Of this group, 19 volcanoes in Alaska and the Northern Mariana Islands that pose substantial threats to aviation have no real-time ground-based monitoring. These 19 volcanoes are identified as high-priority NVEWS targets where better monitoring is needed.

Surprise eruptions occur at volcanoes that lack real-time ground-based sensor networks. Depending on the remoteness of the volcano, even eruption reports may be delayed without proper monitoring. Recent experience shows that while eruptions can be confirmed in a matter of minutes at volcanoes with ground-based monitoring, it may require several hours for eruption confirmation at un-instrumented volcanoes by remote sensing or pilot reports. Because of the speed with which an aircraft can travel toward a potential volcanic-ash encounter (about 8 miles per minute), real-time 24/7 eruption reporting is necessary. Our goal is that an observatory shall notify the appropriate regional air traffic center of an ash-producing eruption within five minutes of the start of the event. This level of notification requires 24/7 operations at U.S. volcano observatories, adequate networks of seismic and other instruments and, in some cases, portable ground-based RADAR to detect ash clouds at night and in bad weather.

In the NVEWS assessment, other very-high-threat volcanoes, including nine in the Cascade Range in California, Washington, and Oregon and four in Alaska, were identified as having inadequate or antiquated networks and are considered under-monitored for the threats posed to both aviation and ground communities and infrastructure. Eruptions at Mount St. Helens, Kilauea, Augustine, and Anatahan and unrest at Mauna Loa in Hawaii and Spurr in Alaska also require a robust monitoring capability.

Conclusion

Volcanic ash will continue to be a dangerous and costly threat to aviation into the foreseeable future. The USGS will continue its efforts to enhance monitoring capabilities at those sites where the greatest risk exists.

Hazard mitigation for U.S. volcanoes requires:

- *Continued improvement of monitoring capabilities and instrumentation of U.S. volcanoes with high aviation risk*. Concerns should focus not only on reporting where and when an eruption has occurred and how high its plume went, but also with reliably diagnosing volcanic unrest and forecasting likely eruptive activity, including how long eruptive activity might continue and the potential for recurring explosive events.
- *Continued refinement of protocols for communicating eruption and ash hazard information to other agencies and clientele*. The aviation community must be familiar with and confident in monitoring and notification abilities through the use of conferences, publications, drills, and demonstrations.
- *Continued USGS leadership in building awareness of the ash hazard to aviation*. Without broad-based hazard awareness, the commitment to carry out a mitigation strategy is severely weakened. The USGS will continue to foster hazard education through a variety of venues and methods.

There are no remote volcanoes when we consider aviation hazards. Mitigating this risk requires efficient teamwork by multiple agencies. The USGS will continue to do its part by providing timely information based on reliable monitoring data. However, as the ability to prevent ash encounters improves to the point that fewer incidents occur, we must not mistakenly conclude that no threat exists. Rather, we must call for continued vigilance and support of proven, broad-based mitigation efforts.

Thank you, Mr. Chairman, for the opportunity to present this testimony.

The CHAIRMAN. Thank you very much. We have a problem here and I don't know how we're going to deal with it this year, because of the policies on earmarks. In the past the monies that you have spoken about for the Alaska Volcano Observatory have come from three basic sources from USGS, and this year the President's budget does contain the same amount we had—as a matter of fact it's gone up by $100,000 its $4.4 million, in 2006 and 2007. However the monies that the FAA has received have been because of an earmark that the Congress approved at my request each year. NOAA also contributed the $300,000 dollars a year to maintain the ash flow computer models. Their funding was cut by 50 percent and the future of the FAA money is in serious doubt.

Now Captain, I think you've made the case for the international air routes going through the airspace of these volcanoes and we'll do our best to try and maintain that FAA earmark. As I said, I really don't know what's going to happen to it this year. But let me ask Dr. Quick—USGS, because of Augustine I understand, has had to direct a lot of your monies in both monitoring equipment and manpower to really help keep track of the Augustine eruption patterns that have developed since January of this year. Has that adversely affected USGS' capability to monitor other active volcanoes throughout our country, Alaska and the south 48?

Dr. QUICK. Mr. Chairman, the USGS responds to new eruptions of volcanoes by redirecting funds to the extent possible. The eruption of Augustine has basically impacted our operations in Alaska such that we will be performing no field work on hazard assessments in the Aleutians this year, nor will we be extending the monitoring network in the Aleutian chain this year as the eruption continues, as we project it may for another 5 months or so. Based on past histories, we project that it will be necessary to redirect funds from other activities, such as purchase and deployment of equipment to extend the monitoring network in the Mariana Islands and rebuilding of the monitoring network damaged by the eruption of Anatahan also on the Mariana Islands. Funds will be redirected that were previously identified for improvement of monitoring networks at Mount Rainier, Mount Hood, and Three Sisters.

Let me assure you that monitoring volcanoes is the last thing, however, that we will turn off. And we will continue to monitor volcanoes as long as our networks are active.

The CHAIRMAN. Well, thank you. Have you discussed this with the hierarchy of USGS in terms of any requests for supplemental money for your agency?

Dr. QUICK. We have had discussions about possible supplementals, yes.

The CHAIRMAN. We'd be happy to be included in those discussions, if that's possible, because there is a supplemental going through right now, as a matter of fact. And I would not want your agency to be without funds necessary to continue expanding this coverage. As Captain McVenes has indicated the danger goes all the way across the Pacific, not just in our area. I hope that we can continue to expand and to increase the safety factor as far as those planes are concerned. Dr. Eichelberger, again I thank you for coming all this way. Can you tell me, you're part of this observatory; it really involves information going from USGS, from NOAA, to the FAA.

Dr. EICHELBERGER. Right.

The CHAIRMAN. Each agency has to be involved. And obviously each agency has to have funds. Are you satisfied that the funding of the past was sufficient?

Dr. EICHELBERGER. Yes, I think the outcome as far as enacted funding has been sufficient. It's been very good. Although this year we're doing a million dollars or about 15 percent, just as we face this eruption. And I'm very concerned about the future for the reasons you outlined.

The CHAIRMAN. You're right, that earmark went down a million dollars. It was at a $4 million dollar level.

Dr. EICHELBERGER. That's correct.

The CHAIRMAN. And now it's down to a $3 million dollar level. And in fact it requires an earmark to even maintain that.

Dr. EICHELBERGER. That's correct, yes. So, without either an earmark or a new firm arrangement for support within the Federal budget process, we'll be starting to dismantle the team. It's easy to see why this has happened I think. For one thing originally it was seen as kind of a local problem in Alaska. But really it's an international one. And then of course the aviation hazard was a newly recognized thing. It was an expansion of the USGS mission which USGS never received an increase in funding for. It's in a sense within FAA mission but it's not within FAA expertise, so one can understand how this has happened, but it certainly needs to be addressed.

The CHAIRMAN. Well, after the—what was it, the 1989 eruption we had a meeting at the FAA office in Anchorage, USGS came to that, as well as representatives of the airline industry and the university and the observatory process was the outcome of that meeting.

Dr. EICHELBERGER. Yes.

The CHAIRMAN. And it has been looked on by Congress as just another Alaskan piece of pork.

Dr. EICHELBERGER. That's extremely unfortunate. But, you know——

The CHAIRMAN. And that's one of the unfortunate problems of being located where we are, whatever we add to the budget as one of my colleagues formally said, was Eskimo ice cream. I just don't know how to handle this one this year. We're going to have to have some greater understanding throughout the country the fact that those planes are flying in—they're not even landing in Alaska. Isn't that right, Captain?

Dr. EICHELBERGER. Many of them are not, that's right.

The CHAIRMAN. Most of them are over flying Alaska these days, cargo planes land there because of fuel, but the bulk of the planes that your pilots fly start in Chicago or New York, and fly over Alaska on the great circle route to the Orient. And that's the great advantage of the great circle route to the pilots, it just happens to come over Alaska.

Dr. EICHELBERGER. Yes.

The CHAIRMAN. But this is not an Alaska matter, this is protecting Americans and people from all over the world that are traveling on those planes. We don't seem to have the understanding here that we need.

Dr. EICHELBERGER. That's right.

The CHAIRMAN. Senator Nelson?

Senator BEN NELSON. Thank you, Mr. Chairman. Do we know what some of the other nations in the vicinity do in terms of monitoring, and what their contribution to this process may be? They're obviously the beneficiaries of the same route, and they obviously would have some of the same problems. Do we know what they're doing?

Dr. EICHELBERGER. Yes, Japan is very advanced in monitoring its volcanoes. Probably in general their volcanoes are more thoroughly monitored than ours are. Russia has a lot of very bright energetic people and not much in the way of financial resources right now. And we have worked very closely with them to help them develop their monitoring, which they are now doing more and more. In fact I'll be going there after this meeting and continue that work.

Senator BEN NELSON. Thank you, Mr. Chairman.

The CHAIRMAN. Senator DeMint?

STATEMENT OF HON. JIM DEMINT, U.S. SENATOR FROM SOUTH CAROLINA

Senator DEMINT. I apologize for missing your testimony; I appreciate all of you coming here. It's clearly a problem that a lot of us have not been that familiar with. So it's very helpful to me. This Committee is all about prediction and prevention of natural disasters and certainly volcanoes are one of those issues. Just one question, I know we need to go vote, and this has probably already been answered. But does the airline industry—and Captain, I can direct this at you, believe that they receive adequate warnings from the National Weather Service, the Federal Aviation Administration, or the U.S. Geological Survey, about potential threats of ash plumes? I mean, where are we with that?

Captain MCVENES. Well if you look at the events that have taken place, fortunately a lot of the mitigation strategies and the monitoring of volcanic eruptions have improved greatly. We haven't had any total engine failure situations since 1991, so obviously there has been some progress made.

But we're still in a position where we need to do a little bit better job. Have a little bit better monitoring, so we can do better forecasting of when these eruptions will take place so that the airlines can better plan their routes around these areas; so that we don't get ourselves in a position of inadvertently getting into them when we don't know it.

We also need to have some more research and advancements in the areas of predicting the movement of the ash clouds again so we can better plan ahead of time.

Senator DEMINT. But this can be a problem at 30–40,000 feet right?

Captain MCVENES. Yes sir.

Senator DEMINT. We've got a lot of work to do, I appreciate all the information and Mr. Chairman, unless you have some additional questions?

The CHAIRMAN. No, I do appreciate you taking the time, all of you, to come help us make a record of this, so we can do our best to try and restore this funding this year.

Dr. EICHELBERGER. Well, thank you. Thank you very much.

The CHAIRMAN. I know it's been hard on you particularly, Doctor, so thank you very much for coming.

[Whereupon at 10:43 a.m., the hearing was adjourned].

APPENDIX

PREPARED STATEMENT OF DANIEL K. INOUYE, U.S. SENATOR FROM HAWAII

I doubt that the general public is aware of the grave dangers volcanic ash clouds present to passenger jets. Given the number of volcanoes that we have in Hawaii, we are a bit more familiar with this hazard.

Ash from an erupting volcano can reach 30,000 feet, the same altitude passenger jets fly. Volcanic ash may limit visibility, damage flight control systems, and cause jet engines to fail. It is difficult for pilots and radar operators to distinguish ash clouds from ordinary clouds, but the implications of flying through an ash cloud can be disastrous.

The airlines have experienced a number of such cases, including one incident where a passenger jet lost more than 14,000 feet of altitude and resulted in $80 million worth of repairs. Also, ash clouds can drift several hundred miles away from the eruption and present risks to planes far away from volcanic activity. These are serious concerns for me and the people of my state because we rely so heavily on aviation for our transportation needs.

The best way to address this risk is for planes to avoid the volcanic ash clouds completely. However, this requires coordination between seismologists, volcanologists, air traffic control operators, and pilots. This entire system depends on the accurate monitoring of volcanic activity.

The recent report by the United States Geological Survey (USGS) is disturbing because it found that many of the most dangerous volcanoes currently are unmonitored. It correctly concludes that a greater, more complete monitoring effort is required. I encourage the USGS to commit greater attention and resources to the National Volcano Early Warning System.

PREPARED STATEMENT OF THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)

This Statement for the Record will provide a brief background on the impacts of volcanic ash on aviation, and highlight the National Oceanic and Atmospheric Administration's (NOAA's) role in mitigating the impact of volcanic hazards on aviation.

Impact on Aviation

With the advent of modern fuel-efficient commercial jet aircraft engines and the increase in flights worldwide, routine volcanic eruptions, which previously had been only a minor inconvenience to commercial aviation, have become a major hazard. When fine silica particles lofted into the atmosphere by volcanic eruptions come into contact with jet engines, the particles melt from the heat of the engine and become hard deposits on the turbine blades. These deposits can eventually result in a loss of power or emergency shut-down of the engine. Because aircraft are capable of moving at several hundred miles an hour, the ash particles also act as projectiles. These particles cause abrasion to the aircraft, damaging windshields, fuselage, and critical instrumentation on the outside of the aircraft. The ash can also enter the aircraft's cabin and ventilation systems.

The aviation industry is greatly impacted by the hazards posed from volcanic ash. More than 80 commercial aircraft worldwide have unexpectedly encountered volcanic ash in flight and at airports in the past 15 years. Seven of these encounters caused in-flight loss of jet engine power, which nearly resulted in the crash of the airplane. These incidents highlight the vulnerability of aircraft to volcanic ash clouds.

The national and international aviation communities have taken action to help aircraft avoid such dangerous environments. In the mid-1990s, the International Civil Aviation Organization (ICAO) and NOAA reached an agreement whereby NOAA monitors satellite imagery and data to detect volcanic eruptions and, in the event of an ash eruption, issues advisories and warnings for the aviation community. NOAA also runs computer simulations to forecast the dispersion of volcanic ash. NOAA, the U.S. Geological Survey (USGS), and the Federal Aviation Administration (FAA) work in a strong partnership to monitor and mitigate the effects of volcanoes on aviation.

Airspace managers, in consultation with airlines, pilots, and others in the aviation community, have developed a course of action in the event of an impending encounter with volcanic ash. The common goal is to completely avoid the ash cloud. To accomplish this, airspace managers determine new flight paths for the aircraft based on the location of the ash cloud and its projected path. There are "safety zones" near ash clouds which range from a few miles to several hundred miles based on forecast uncertainty and winds. Minor deviations can cost the airlines in the order of tens of thousands of dollars, while significant re-routes, which include landing at alternate airports, can cost airlines hundreds of thousands of dollars or more per flight.

Timely and accurate observation, forecast, and warning information is crucial to the aviation community for safety and economic reasons. The aviation industry is moving toward a minimum of five minutes lead time to be notified of an explosive volcanic eruption. Such an eruption can send its ash high into the atmosphere reaching flight level in about five minutes, potentially impacting en route jet traffic. Research continues to develop better tools for forecasters to provide faster and more accurate detection of eruptions.

NOAA Operations

Major volcanic events during the 1980s and into the early 1990s helped to bring the global community together to help mitigate the hazards of volcanic ash. By 1997, the ICAO established nine worldwide Volcanic Ash Advisory Centers (VAACs) as part of a global network. NOAA currently operates two of these nine VAACs. The Washington D.C. VAAC is jointly managed by NOAA's National Weather Service (NWS) and NOAA's National Environmental Satellite Data and Information Service (NESDIS). The Anchorage, Alaska, VAAC is managed by NWS and co-located with the NWS Alaska Aviation Weather Unit (AAWU).

The Washington VAAC area of responsibility includes the continental United States, Central America, the Caribbean, and South America to 10 degrees south latitude. It also includes U.S. controlled oceanic Flight Information Regions (FIRs). The Anchorage VAAC area of responsibility includes the Anchorage FIR and a portion of eastern Russia (north of 60° N. latitude and east of 150° E. longitude).

The role of the VAAC is to monitor all available satellite, radar, and other observational data (e.g. Pilot Reports) to determine the location, extent and movement of volcanic plumes. VAACs use this information to issue real-time text and graphical products about airborne volcanic ash to the aviation community. The centers use volcanic ash dispersion model predictions to assist in making a forecast of these ash plumes out to 18 hours. The dispersion model predicts where the volcanic ash will spread over time and this information is then relayed to the user community. Information about the volcano, including a detailed forecast of the ash plume, is included in a Volcanic Ash Advisory (VAA). VAACs provide this information to international Meteorological Watch Offices (MWOs), which in turn issue Significant Meteorological Information (SIGMETs) to the aviation community. The SIGMET is the official warning product for airborne volcanic ash.

There are dozens of MWOs around the globe, ostensibly one for each country, or one designated by a country as an MWO. These offices are established under an ICAO agreement, with three designated in the United States located at the Aviation Weather Center in Kansas City, the Weather Forecast Office in Honolulu, and the AAWU in Anchorage. MWOs are responsible for issuing SIGMETs, warning the aviation community about atmospheric hazards to aircraft, including volcanic ash, turbulence, large areas of thunderstorms, icing, and tropical cyclones.

The NWS also issues volcanic ash products for the national airspace managers in the Federal Aviation Administration's (FAA's) Air Route Traffic Control Centers (ARTCC). Center Weather Advisories are produced by NWS Center Weather Service Units (CWSU), which are collocated at 21 ARTCCs. NOAA products and information are distributed widely to the aviation community, private sector, U.S. military agencies, and Federal, state, and local governments.

As a further service to Alaska, one of the most volcano-vulnerable areas of the United States, the Alaska Aviation Weather Unit/Anchorage VAAC, Anchorage Weather Forecast Office, and CWSU also participate in an interagency group for volcanic ash. Membership in this interagency group includes the NWS, USGS, FAA, United States Air Force, United States Coast Guard, and the State of Alaska Division of Homeland Security and Emergency Management. The group meets quarterly to discuss a wide variety of issues including science, research, and operations issues concerning volcanic ash. The group is also responsible for updating an Alaska Interagency Operations Plan for Volcanic Ash Episodes every 2 years, which defines the responsibilities of each of the participating agencies. The Alaska plan has become the foundation for the development of a new National Interagency Volcanic Ash Plan.

Active Volcanoes

The Anchorage VAAC has just over 100 historically active volcanoes contained both within and in close proximity to the Anchorage FIR. In 2005, there were several active volcanoes both within and in close proximity to the Anchorage VAAC area of responsibility. These volcanoes included Veniaminof and Cleveland in the Aleutian Islands and Karymsky, Sheveluch, Bezymianny, and Klyuchevskoy in Kamchatka, Russia. In 2006, only Augustine Volcano located just 175 miles southwest of Anchorage has become active starting on January 11. A series of emissions continued throughout February. As Augustine is close to the Kenai Peninsula and Anchorage, the State of Alaska Division of Homeland Security and Emergency Management, USGS, FAA, NWS, State of Alaska Department of Environmental Conservation, Municipality of Anchorage Health and Human Services, and others have worked closely together during these events to help mitigate potential impacts from the eruptions. This collaborative partnership between numerous agencies at different levels was coordinated by the NWS National Volcanic Ash Program Manager, who is located at the NWS Alaska Region Headquarters in Anchorage, AK.

In 2005, the following volcanoes within the Washington VAAC area of responsibility were active; Mount St. Helens in Washington State; Colima and Popocatepetl in Mexico; Soufriere Hills on Montserrat Island; Anatahan volcano on the Mariana Islands chain; Santa Maria and Fuego in Guatemala; Santa Ana in El Salvador; Reventador, Tungurahua, and Sangay in Ecuador; Galeras in Colombia; and Negra, Sierra, and Fernandina on the Galapagos Islands. So far in 2006, six volcanoes have been active including Colima, Popocatepetl, Reventador, Santa Maria, Soufriere Hills and Tungurahau. Ash from volcanoes located within the Anchorage VAAC area of responsibility, such as Augustine volcano, can move into the Washington VAAC area of responsibility, requiring detailed additional coordination and requiring the Washington VAAC to issue volcanic ash advisories.

Volcanic Ash Dispersion Models

NOAA's Air Research Laboratory (ARL) continues to improve volcanic ash modeling with the HYbrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model. The HYSPLIT model is NOAA's official dispersion model and was developed by researchers at NOAA in partnership with the external community. When the Washington or Anchorage VAAC detects an eruption in their area, NOAA's National Centers for Environmental Prediction is notified and runs the HYSPLIT model. The dispersion model predicts where the volcanic ash will spread over time and this information is relayed to VAACs, as well as the user community. By tracking volcanic ash and forecasting where it will spread, NOAA is helping to reduce the risk volcanic eruptions pose to aviation.

Research and Improvements

The research community is very involved in the volcanic ash hazards program. NOAA has made many contributions during the past decade. A prime example of this effort is the development of multi-spectral volcanic ash image products using Polar Operational Environmental Satellite (POES) data, Geostationary Operational Environmental Satellite (GOES) data, and Moderate Resolution Imaging Spectroradiometer (MODIS) data from the National Aeronautics and Space Administration (NASA) Aqua and Terra spacecraft. The FAA Aviation Weather Research Program is also working on a multi-sourced automated 3-dimensional analysis of volcanic ash clouds. Here "multi-sourced" refers to the use of multiple satellites (geostationary and polar-orbiting) and multiple ash detection and height estimation methods (according to viewing wavelengths available, time of day, scene characteristics, etc.). Sensors on NOAA's GOES and POES satellites are able to detect a volcanic ash eruption within minutes of an event. In some instances, these satellites are the only means by which NOAA meteorologists know a volcanic ash hazard exists in the airspace. To build on current satellite contributions to NOAA's volcanic ash activities, NOAA's future GOES and NPOESS (National Polar-orbiting Operational Environmental Satellite System) will continue these detection capabilities. NOAA supplements its operations using data from NASA Aqua, Terra, and TOMS (Total Ozone Mapping Spectrometer) spacecraft, and foreign satellites, as needed.

New guidance and products resulting from this research is tailored to aviation needs and is focused on making the national airspace system safer and more efficient during a volcanic ash event. Efforts are focused on integrating the latest advancements in volcanic ash detection and dispersion from the research community, allowing users to overlay and manipulate this information in real-time, developing tools to generate impact statements and graphics, and disseminating the impact statements to end users in a timely fashion so hazard mitigation plans can be activated.

The Volcanic Ash Collaboration Tool (VACT) is an experimental tool designed to help locate and determine the extent and movement of volcanic ash so that more accurate, timely, consistent, and relevant ash dispersion and ash fallout watches, warnings, advisories, and forecasts can be issued. The VACT allows users at different sites and with different expertise to simultaneously view identical displays of volcanic ash and other related data sets (i.e., shared situational awareness) and collaborate in real-time. The VACT assists forecasts in preparing and issuing current products and services and will also make possible future products such as graphical tactical decision aides for airspace management. The VACT has been successfully tested in operations in Alaska during the recent eruptions of Augustine volcano.

All volcanic ash events are captured and archived to help improve detection and dispersion methodologies, train new users on VACT functionality, detect and eliminate problems with multiple agencies collaborating in real-time on volcanic ash events, and improve dissemination techniques.

Future efforts will focus on incorporating the VACT to adjacent VAAC's operations so information isn't lost as ash moves across the globe. The text chat capability will be extended to be multilingual. As new detection, fallout, and dispersion techniques are created, they will be integrated into the tool. New capabilities in dissemination technology are also planned to be incorporated into the VACT. Such a tool also shows great promise to allow interagency coordination for other hazards such as tsunamis and hurricanes, and also represents a capability to allow NOAA scientists to brief other decision-makers, the media, etc.

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