The Alaska University Transportation Center (AUTC) theme, "Transportation Safety, Security, and Innovation in Cold Regions," was selected to complement the mission and direction of the University of Alaska. This theme also takes into account the needs of such agencies as the Alaska Department of Transportation & Public Facilities, the Alaska Railroad Commission, the Alaska oil and gas industry, and the broader Alaska transportation community. Research at the university’s three main campuses (University of Alaska Fairbanks, University of Alaska Anchorage, and University of Alaska Southeast) fills a national need; AUTC is the only center with a specific, primary focus on transportation in cold regions.

AUTC’s theme and efforts apply to all modes of transportation. Alaska depends on multi-modal transportation as part of its economic growth. For example, the state depends on a mix of highway, air, marine, rail, and pipeline to meet its transportation needs. Alaska faces unique challenges, including population density that varies widely across the state; long distances between communities (often with no interconnecting roads) and high dependence on aviation and marine transportation; a diversity of geographic features, along with complicating factors such as permafrost and extremely cold temperatures; and high transportation costs. Pipelines for oil (and, in the future, other fuel sources) dramatically impact the economy of Alaska and the economic well-being and security of the nation. However, because the pipelines traverse arctic and subarctic terrain, the challenges of planning, designing, constructing, and maintaining pipelines are unique.

Alaska’s Congressman Don Young recently stated, “Living in a climate where the weather has such a large impact on the condition of our roadways and infrastructure, it is especially important for us to study how we can improve on what is already being done. A focus of this should be better ways to pave our roadways and keep them intact.” Young and AUTC are in agreement that improvements in cold regions transportation engineering must be a key aspect of the AUTC.

The center also addresses issues related to those identified in the Highway Research and Technology report (a joint publication released by the Federal Highway Administration, the American Association of State Highway and Transportation Officials, and the Transportation Research Board) as key research and technology themes, including but certainly not limited to the impact of climate change on permafrost, reducing construction and maintenance costs of transportation infrastructure, improving air quality during the winter months, and other measures that address multimodal issues facing Alaska and the nation’s transportation community.
Alaska University Transportation Center
Transportation safety, security, and innovation in cold regions.

Table of Contents
Message from Billy Connor, Director   2
Organization   3
Governing Board   4
AUTC Staff & Faculty   5
AUTC Research Facilities   6
Research 2008   8
Newly Funded Projects   9
Ongoing Projects   18
Completed Projects   24
Outreach and Dissemination   26
Student Participation   28
Goals, Funding, & Expenditures   30
Photo Credits   32

AN ANNUAL REPORT OF RESEARCH, EDUCATION, AND TECHNOLOGY TRANSFER ACTIVITIES FOR 2008
Who cares about innovation? The answer may surprise you. In “Challenges of Innovation” (Business Week 22 August 2008), Irving Wladawsky-Berger discusses major barriers to innovation: indifference, hostility, and isolation.

Indifference is often a result of spending too much time “tending the machine.” Every CEO, he points out, knows it is politically expedient to at least appear to embrace innovation, but many do little beyond that. Most executives gain top positions by being good operational managers – that is, they spend most of their time making sure their organization operates efficiently and successfully. However, as Wladawsky-Berger states, “management is about business results and processes,” while leadership – key to implementing change – is about people. Executives must surround themselves with highly talented people who share their vision; the successful encourage long-sightedness and innovation in this inner circle, rather than a strict focus on operations. In some cases, managers, who are notoriously short on time and resources, are even hostile to new ideas, especially if these come not from those closest to them, but from the “outside.”

Isolation often comes from organizational structure. According to the 2005 National Innovation Initiative report, Wladawsky-Berger notes, innovation “is multidisciplinary and technologically complex. It arises from the intersections of different fields or spheres of activities.” Communication and collaboration across – not within – specialties is the way to innovation. In contrast, most companies are organized along product lines or activity lines, and these sub-organizations are rarely encouraged to work together.

Is it possible for UTCs to foster innovation? The UTC mission is to “advance the state-of-the-art in transportation research and develop the next generation of transportation professionals.” How can we share our innovations with busy, indifferent, isolated organizations? As university-based, federally funded organizations, we’re generally outside all those powerful inner circles.

Partnerships with industry and other agencies can be catalysts for change. Perhaps if we understand the management culture, we can find opportunities to sell innovation. Let’s go back to the statement that executives surround themselves with those who share their visions. If we can approach one of those talented people in a position of trust, perhaps we can sell a UTC-developed idea. We must be willing to “share the glory” with those who can implement our new ideas.

Be tenacious. I’ve seen a number of ideas rejected one year that became the number one highly supported project a year or two later. The idea wasn’t any different, but the environment was. These opportunities may result from changes in leadership, in the market, or in public perception. No matter the cause, we must recognize and take advantage of those opportunities.

Ask yourself how much you value innovation. I’ve been surprised at how many researchers resist change especially if they perceive that it will cause change in their own lives. If you’re going to sell innovation, you must fully embrace it in all its forms. Perhaps we should evaluate ourselves first.
AUTC is fortunate to have an active and engaged governing board providing direction.

Their understanding of the overarching issues facing cold-regions transportation is essential to Alaska’s future. Our board members represent both transportation technology users and those who must manage infrastructure at national, state, and local levels. All transportation modes are represented in this dynamic group.

**Sherri Y. Alston**
Director, Transportation Policy Studies, Office of Policy & Governmental Affairs
Federal Highway Administration (FHWA), Washington DC

**Bruce Carr**
Director, Strategic Planning
Executive Office
Alaska Railroad

**Michael Downing**
Senior Project Manager
HDR Alaska, Inc.

**Gary Gustafson**
Manager, Environmental, Regulatory & Land
Alaska Gas Resources
BP Exploration (Alaska) Inc.

**Rick Kessler**
President & CEO
Horizon Services Group, VP & CIO, Horizon Lines

**Robert Lewis**
Regional Executive Manager
Federal Aviation Administration, Alaskan Region

**Mike McKinnon**
Transportation Program Manager
Denali Commission of Alaska

**Jeff Ottesen**
Director, Statewide Planning
Alaska Department of Transportation & Public Facilities (AKDOT&PF)

**Lance Wilber**
Director, Traffic Department
Municipality of Anchorage, Alaska

To learn more about our board members, visit: www.alaska.edu/uaf/cem/ine/autc/about/board.xml
AUTC staff grew in 2008, extending across three participating campuses and bringing new skills, engineering management, and technical abilities to the program.
AUTC RESEARCH FACILITIES: ONE CENTER, THREE CAMPUSES

AUTC has ready access to facilities for performing air and water quality tests, geotechnical investigations, and common and specialized materials testing. Various controlled-environment chambers are available, as are extensive opportunities for field testing. All our labs and equipment meet the needs of AUTC’s cold-regions theme.

Each campus offers unique resources, creating a research network across the state that supports both research and teaching activities.

UAF facilities are particularly well-suited to studies of soil and ice behavior under various loading scenarios. Sophisticated materials-testing equipment is available, including both 55 kip and 220 kip MTS servohydraulic test systems for static and dynamic tests, FlexTest SE and TestStar IIs controllers, and a unique GCTS dynamic triaxial shear testing system with a SCON 2000 Digital Controller.

AUTC offers the most extensive and varied cold-weather testing landscape in the USA. One good example is a series of basin lysimeters installed on the grounds of the UAF Experimental Farm. An AUTC research team built an instrument trench and installed twelve lysimeters. Researchers placed thermistors and soil-water monitors in two lysimeters. This facility will be used to measure how herbicides move through soil and how quickly they become inert in our subarctic environment.

One Anchorage bridge serves as a test bed customized for monitoring soil conditions and their effects on bridge supports throughout the seasons. The Campbell Creek Bridge at the North Fork is a 360-foot-
long, three-span, prestressed concrete girder bridge supported by steel pipe piles. This test site will yield data on bridge behavior under both earthquake events and ambient vibrations, including traffic-induced shaking, as well as frozen ground depth and temperature data.

**Engineering facilities at the University of Alaska Anchorage** include a Geomatics laboratory and a sediments research facility. The latter is home to a tilting flume, 55 feet long. The channel bed (18 inches wide and a foot deep) can be tilted at precise angles to mitigate scale effects due to the use of natural sand as a model sediment. This equipment is the culmination of a partnership between the US Army Cold Regions Research & Engineering Laboratory, the National Science Foundation Experimental Program to Stimulate Competitive Research, and the university.

**Growing resources at the University of Alaska Southeast** are directed toward preparing students to enter engineering programs. In 2008 UAS offered its first engineering classes as part of the newly approved Pre-engineering Certificate. Lori Sowa introduces students to the engineering profession, to analysis methods for solving engineering problems, and to data analysis through graphing and spreadsheets. Students begin wrestling with fundamental concepts in the areas of statics and mechanics, electrical circuits, and thermodynamics; and they practice their new analytical problem-solving skills in teaching labs. Environmental Engineer Sowa spent part of her career in the Alaska Department of Environmental Conservation’s Division of Water, working in environmental assessment and remediation, water quality, and wastewater treatment and disposal. She brings to the classroom a strong sense of what engineers can contribute to their communities.
The issues surrounding transportation have become so complex that no one discipline or organization can address them successfully.

In 2008 AUTC received 61 proposals totaling $16.2 million; we funded 16 of these, for a total of about $1.5 million in AUTC support. Ongoing projects accounted for around $536,000 of these funds.

In choosing new projects, the AUTC selection committee took careful note of the Statement of Needs published by the Alaska Department of Transportation & Public Facilities. Six projects draw on expertise at UAF and UAA to address such topics as stable soils for constructing foundations, increased flooding frequency, and transportation construction design. Other new projects address a wide range of issues, from water quality to analyzing how well electric cars perform in an arctic environment.

Partners in this year’s projects include AKDOT&PF, the Alaska Railroad, Washington State University, Iowa State University, Oregon State University, the Yukon Territory government, and several private corporations. Information on all funded projects, as well as reports and other published results, are available at our research web site: www.uaf.edu/ine/AUTC/.
Converting the Fairbanks Metropolitan Area Transportation System (FMATS) Travel Demand Forecasting Model from QRS II to TransCAD

In the last two decades, Fairbanks, Alaska, has seen significant population growth. Based on the 2000 U.S. Census, it was designated an official urbanized area. The Federal Highway Administration requires urbanized areas to form a Metropolitan Planning Organization to oversee transportation planning and management of federal highway funds. Governor Murkowski officially designated the Fairbanks Metropolitan Area Transportation System as the MPO for the Fairbanks urban area.

An MPO developing a region’s transportation plans and programs to accommodate mobility needs uses a travel demand model that provides information on current and future transportation system operations. Since 2003, FMATS has used the Quick Response System II. The QRS II system uses simple methods for travel demand forecasting and is intended for smaller urbanized areas where traffic congestion and vehicle emissions are not significant concerns. However, as traffic in the FMATS area grows, and more importantly, as the air quality in the region frequently falls below EPA standards, the QRS II model can no longer meet the requirements set by various federal agencies.

This project, conducted by Ming Lee of the UAF Civil & Environmental Engineering Department, will convert the old QRS II model to a state-of-the-practice TransCAD model. TransCAD, a software program many MPOs in the US use, provides up-to-date modeling and forecasting methods consistent with federal requirements. This conversion will incorporate current population and employment data for the Fairbanks area, and it will be calibrated to the most recent traffic counts in the area. This new model will give FMATS the capability to produce traffic forecasts for their long-range (up to 2030) transportation update.

Attenuation of Herbicides in Subarctic Environments

The Alaska Railroad Corporation needs effective and low-cost ways to manage vegetation growth along railroad lines. This project, in partnership with the USDA Agricultural Research Service, will investigate the environmental fate, attenuation, and effectiveness of herbicides currently being evaluated for use along Alaska’s transportation corridors. This project will address such questions as, “Once these herbicides are applied, how long does it take for them to enter the soil? Where do they go, and how long does it take for them to dissipate?”

The herbicides will be applied near the southern end of the AKRR rail line. Researchers David Barnes, of UAF CEE, and William E. Schnable, of the Water & Environmental Research Center, will track these applications over two years through a series of soil and ground-water samples to obtain site-specific attenuation data. They will also perform mass balance studies on the herbicides using lysimeters installed at the UAF Fairbanks Experiment Farm. These studies will result in a better understanding of the environmental fate of these herbicides applied in Alaska’s maritime subarctic zone.

Finally, a block plot study will be conducted at the Fairbanks Experiment Farm to confirm a cold-related reconcentration phenomenon observed in previous studies on one of the herbicides, triclopyr.

This project will build on results from previous studies to create the knowledge base necessary to minimize environmental risks associated with herbicide application in Alaska’s sensitive, cold region ecosystems.
Using Geotextiles to Mitigate Frost-heaving in Alaska Pavements

Frost heave and thaw weakening cause extensive damage to roads and airfields in Alaska. One way builders battle these problems is by using geotextiles, essentially materials or fabrics that underlie a pavement system. Geotextiles can be expensive and labor-intensive to install, and some are more effective at wicking moisture away from the pavement foundation than others.

AUTC researcher and materials specialist Xiong Zhang leads a project designed to evaluate a new fabric developed by a private corporation. This fabric shows great promise as a more cost-effective way to reduce moisture migration, frost heaving, and thaw weakening in pavement systems installed in remote cold regions areas. However, no one knows how this material will stand up to seasonal freeze-and-thaw cycles, whether it can keep pavements high and dry, or how to best place the fabric in a pavement structure (under the base, or in the middle of it? In the silty soil below?).

This project will use laboratory testing and numerical simulations to explore the fabric’s strengths in wettability and capillary action (that is, its ability to quickly absorb water from the soil and drain it away from the pavement). Project results will help pavement designers in Alaska, as well as reducing the costs of building roads in remote areas with poor soils.

Evaluating the Overheight Detection System

at the Eklutna River/Glenn Highway Bridge

The Eklutna River/Glenn Highway bridge has, in the past, sustained repeated impacts from overheight trucks. In 2006, AKDOT&PF installed an overheight vehicle detection and warning system at the overpass. The system includes laser detectors, alarms, and message boards. Since installation, personnel have seen no new damage to the bridge, and no sign that the alarm system has been triggered. Although this is good news, the particulars are a mystery: Is the system functioning? Is the mere presence of the equipment enough to deter drivers from gambling with a vehicle that might be over the height limit? Is it worth installing similar systems at other overpasses? Is the state getting its money’s worth, or not?

This project, led by AUTC’s Ming Lee, will examine the bridge for any evidence of damage, then fit the system with a datalogger that will record and video any events that trigger the warning system. Finally, just to be sure, researchers will test the system with (officially) overheight vehicles. Project results will help AKDOT&PF determine if this system is functioning, and if a similar system will (cost) effectively serve other areas.

Updated Precipitation Frequency Analysis for the State of Alaska

All transportation construction must include a hydrologic component, an analysis that deals with rainfall amount and intensity for a defined time period. To function well, these components must be designed based on accurate rainfall estimates — how much, how long, and how often. Such information is usually supplied by the National Oceanic and Atmospheric Administration National Weather Service. But this organization last collected data in Alaska in the early 1960s, when our record of data collection was quite short, and only a minimal network of rain gauges was available. Together, AKDOT&PF, AUTC, and NOAA plan to update this important data set.
Collecting precipitation in a place like Alaska is still difficult. Our weather station network is still sparse. For example, the area north of the Brooks Range, known as the Arctic Slope of Alaska, is one of the least-understood climatic regions of the United States. This region, with an area over 230,000 km², has only 6 long-term precipitation gauges. Another obstacle is that many of the existing gauges are unattended. In remote environments, with harsh weather conditions and wildlife, precipitation records are sometimes difficult to interpret. Along with a sparse weather monitoring network, the greatest elevation range in the US is found in Alaska (from sea level to 6,194 meters at Mt. McKinley). Together the rough, complex topography and limited gauging make spatially distributed precipitation analysis a major challenge. Finally, many different organizations operate different stations and use different instrument packages for observing precipitation, so the data available isn’t immediately compatible.

This project, lead by Douglas L. Kane and Amy Tidwell, both of the UAF Water & Environmental Research Center, will use new methodology and new modeling techniques to analyze both the original data and data collected in the nearly 50 years since the last effort was published, in 1963.

The research team will partner with NOAA’s National Weather Service to update precipitation frequency estimates for the state, collecting rainfall records from meteorological stations and private rain gauges throughout Alaska, correcting the data for bias and other inaccuracies, and using new models for spatial distribution and frequency. This new information will ultimately be published as Volume 14 of the NOAA Atlas, Precipitation-Frequency Atlas of the United States.

**Impacts of Climate Variability and Change on Flood Frequency Analysis for Transportation Design**

Designing infrastructure for roads and bridges requires accurate estimates of flood frequency and magnitude so that designers can adequately manage risk and balance resources available for construction, maintenance, and flood damage costs. Alarming trends in temperature changes and increasing potential for flooding have understandably led to concerns about long-term changes in hydrology and how infrastructure might be affected by flooding. Existing engineering design criteria still rely heavily on historical estimates. Recent climate change documentation suggests that designers might be better served by design criteria that take into account climate variations. This study addresses whether or not current flood frequency estimates for southcentral Alaska adequately characterize actual flood occurrences given the limited data available, the influence of natural climate variability on extreme events, and potential climate change.

This project, led by Amy Tidwell of the UAF Water & Environmental Research Center, will provide better understanding of the level of uncertainty associated with statistics currently used as design criteria, quantify the implied uncertainty in flood damage losses, and attempt to identify factors, such as climate variability and change, which possibly affect the accuracy and validity of estimated flood statistics. Researchers will collect and analyze historical and new data from the USGS, the Alaska Climate Research Center, and other published sources relating to modes of climate variability affecting Alaska. Project results will better inform AKDOT&PF about the range of potential water-related risk that may be realized over the design life of a structure.
Bridge Deck Runoff: Water Quality Analysis and Best Management Practice Effectiveness

In building and maintaining bridges across Alaska, AKDOT&PF must consider safety, environmental issues, and cost effectiveness. Most bridges cross water bodies, and all have methods of draining storm water (rain) from the bridge deck. This study examines whether or not this runoff significantly contributes roadway contaminants to nearby water bodies. AUTC researchers Robert Perkins and Ming Lee will explore what state or federal criteria govern such situations, and whether or not the discharge significantly degrades water quality. What storm water management practices should the AKDOT&PF incorporate into designs for new bridges or bridge replacement and retrofit projects? Other states have addressed these issues, and their experiences may be helpful. But our evaluation must take into account Alaska regulations and our cold environment with its long winters and, in some regions of the state, heavy snowfall. Springtime melting of plowed snow often results in a quickly draining, highly contaminated runoff.

This project will produce a database of information on all state bridges regarding bridge deck runoff. It will also report on Best Management Practices developed in other states and how these might be adapted to meet Alaska’s needs.

Stabilizing Marginal Soils with Geofibers and Synthetic Fluid

Constructing airfields and roadways in western and northwestern Alaska is expensive. These areas are remote, requiring high transportation costs for materials and construction crews, and the gravel sources typically used for a good, stable foundation are scarce. Any required gravel is often brought in by barge at costs in excess of $300 per cubic meter. Consequently, builders would rather use local, available silts and sands as much as possible, but soils in northwestern Alaska are often silty, soggy, and prone to erosion and collapse. Engineers continually look for methods that allow them to improve and use local materials. One such method is to use a new combination of geofibers and synthetic fluid. Earlier AUTC research has shown that these materials can improve poor, silty soils, making them suitable for use in construction projects.

This project, led by AUTC’s Kenan Hazirbaba, will evaluate the effectiveness and feasibility of this new technology for typical Alaskan soils. The research team will work with AKDOT&PF personnel, using laboratory and field tests to gain an in-depth understanding of exactly how these new geo-materials improve soils.

This project will ultimately provide design guidelines that will address using these materials with soils encountered particularly in western and northwestern Alaska. Providing such guidelines will eliminate the need for performing project- and site-specific testing, and thus reduce overall construction costs.

Life Cycle Cost Analysis for Alaskan Bridge Components

Decaying infrastructure, and limited funds to renew it, is moving our national transportation system toward crisis. Which bridges are past their service life? Which ones could function for another decade or so? How much will it cost to replace each? The US Department of Transportation has asked every state to develop a long-range plan (through 2030) for bridge replacement. To meet this goal, Alaska must create a priority list and a plan for replacing its own aging transportation infrastructure.

The accepted design life for a bridge is set at 75 years, but this rather arbitrary number does not take into account new building techniques, or seasonal stresses, or variations in frequency and size of vehicles supported, to say nothing of environmental stresses like scouring, ice damage, and earthquakes. Bridges deteriorate in different ways, at different rates. A more accurate way of determining an existing bridge’s service life is essential to the state’s plan.

This study, led by AUTC’s Leroy Hulsey and Andrew Metzger, of UAF’s Civil & Environmental Engineering Department, will collect data on environment, material...
aging processes, repair records, and current costs, to create a process for conducting a life-cycle cost analysis for a highway bridge in Alaska. This project will provide state planners and bridge engineers with the tools to estimate an average cost per bridge, as well as upper and lower bounds of maintenance and/or damage costs.

**Geological Investigations for the Dalton Highway Innovation Project as a Case Study of Ice-rich Syngenetic Permafrost**

AKDOT&PF plans to construct a new section of the James W. Dalton Highway, which runs from just north of Fairbanks to Deadhorse, Alaska. Although the new section is only three miles long (from Milepost 8.5 to Milepost 11.5), it will avoid a steep climb, making the road safer to drive. Preliminary work shows that this new section will cross an area of extremely complex permafrost conditions. The area is characterized by ice-rich, syngenetic Pleistocene permafrost, which can be up to 100 feet thick and contains huge ice wedges (“syngenetic” describes frozen ground that slowly “grows” upward as sediments are deposited on the surface). Imagine giant walls of ice, 30 to 100 feet tall, and 6 to 15 feet wide, networked together inside ice-rich silt formed 40,000–10,000 years ago. These ice wedges can make up 30 to 50 percent of the ground structure. To top it off, the area is located in the discontinuous permafrost zone, and the soil temperatures are relatively high; any human activity in this sensitive area can trigger thaw settlement of soils and permafrost degradation.

The durability of roads crossing such complex conditions depends on a design based on the best geotechnical information available, continuous monitoring, and timely maintenance. The better the design, the less maintenance work required. AUTC permafrost experts Yuri Shur and Mikhail Kanevskiy will help prepare for this construction project, performing a geotechnical investigation of the area, training AKDOT&PF engineers in the secrets of permafrost behavior, and providing guidance in developing a methodology for describing, sampling, and testing the ice-rich syngenetic Pleistocene permafrost. In May 2008, Kanevskiy and UAF students Matthew Dillon and Jonathan O’Donnell performed field work at the study site together with an AKDOT&PF drilling crew; they delivered frozen cores from eight boreholes to AUTC labs for further study. Drilling results confirm Shur and Kanevskiy’s preliminary estimations of the permafrost conditions.

In addition to supporting the best design possible for the Dalton Highway, project results will be useful to construction projects throughout the Circumpolar North, and they will contribute to educating a new generation of engineers at the University of Alaska.
Measuring Temperature and Soil Properties for Finite Element Model Verification

Many stretches of Alaska’s highways show signs of damage caused by the thawing of ice-rich permafrost located under the road’s embankment. Additionally, many older road projects were designed with slopes cut into ice-rich soils. These slopes were designed to thaw, slump, and flow until a new thermal equilibrium and a new slope angle stabilized. But this practice has yielded more thawing ground than necessary, and more roadside erosion than current federal environmental regulations approve. AKDOT&PF currently uses a two-dimensional finite element program to analyze heat flow through a typical roadway embankment and its underlying foundation soils, which gives designers more accurate information for stable slope design and for preserving frozen soils. But such a program is only as good as the data that goes into it.

Over the next two years, this project, lead by Margaret Darrow, a UAF geological engineer, will monitor ground temperature data from two existing embankments, their underlying foundation soils, and in a back slope cut into frozen ground. Researchers will also collect and preserve soil samples in their original state (that is, thawed or frozen) from each location for lab testing, including thermal conductivity measurements, water content, and unit weight. These data will be used to ground-truth AKDOT&PF’s modeling program, confirming the model’s ability to predict an embankment design’s impact on frozen ground.

Using Shallow Anchors and an Anchored Mesh System for Cut Slope Protection in Ice-rich Soils

Permafrost soils present special problems to builders of roads and other transportation lines in Alaska. When a sloped bank in a permafrost area is cut to make way for a road, the soil may thaw and slump or collapse. Six years may pass before vegetation re-stabilizes the slope, and in this time, erosion increases and extends the damage, often making roadways hazardous with mud and landslides. Builders have tried many strategies for slope stabilization, some more effective (and more expensive) than others. One strategy is to use wire netting held in place by soil anchors, but there is little information on how this approach performs in Alaska’s frozen, shallow, silty soils.

This project, led by AUTC researcher Xiong Zhang, and in partnership with AKDOT&PF, will investigate how shallow anchors perform in frozen soils. This project will also design an anchored wire mesh system for protecting and stabilizing ice-rich cut slopes. Zhang’s findings will be useful to other types of mitigation projects, including rock slide areas and highway retaining walls.
**Economical Analysis of Using Light-emitting Diode (LED) Technology for Alaskan Street Lights**

Street lights use a lot of energy, especially when nights are more than 12 hours long. Communities are exploring how light-emitting diode technology, already popular in many devices, from flashlights to electronic billboards, might be applied to city-wide lighting systems.

Some researchers suggest that under ideal conditions, an LED system might use 50 to 75% less energy than a traditional street light system. Under the right conditions, LEDs can have a longer performance life. In general, the devices tend to be less fragile, and they switch on and off quickly, with no “flickering”. Many believe LED technology is the next step, after fluorescents, in efficient indoor lighting for the United States. LED lighting technology is also moving into the street lighting market, as a possible alternative to high pressure sodium lamps.

Converting an existing street lighting system to LED’s isn’t as simple as switching out a bulb; LED’s require entirely different circuitry and power supply designs. Just installing the new equipment can cost a city several million dollars in immediate capital costs. LED systems are more sensitive to changes in power supply. In temperate climates, LED light systems can overheat, burning out circuitry and requiring frequent, expensive repairs. Alaska may have an advantage here; our lower environmental temperatures may be ideal for LED use. Some companies suggest that LED systems can last five to ten times longer than fluorescents in colder climates.

Another concern is how much light LED’s actually shed on a city street. In some places where the new street lights have been installed, people perceive that LED’s produce less light than the old lamps, and that the light available does not improve visibility as well. The electroluminescence emitted by an LED fixture produces a much smaller “circle” of light than old-style lamps; some argue that this will require more lights placed closer together, increasing capital and energy costs.

This joint effort between UAA and UAF will explore replacing traditional HPS street lights in urban areas of Alaska with LED’s. The UAA team, lead by Hsueh-Ming Wang, will develop an economic model to help the municipality of Anchorage and AKDOT&PF form a replacement plan for urban lighting systems. They will also explore the possibility of equipping each LED street lamp with an individual power source, driven by solar or wind energy. Ultimately, they plan to design, install, and monitor the performance of a prototype street light powered by a solar cell on the University of Alaska Anchorage campus. The UAF team, lead by Richard Wies, will address LED power utilization in a large-scale system, as well as whether an LED system can meet the national highway visibility standards set by American Association of State Highway Transportation Officials.

Above: UAF’s Richard Wies with a string of LED lights suitable for indoor lighting. Wies will explore LED power utilization for municipal street lighting applications and how well LED systems meet AASHTO standards for light visibility and range.
Warm Mix Asphalt

Hot Mix Asphalt (that is, a mixture of asphalt cement and aggregates that makes up the bulk of pavement) is typically spread at temperatures between 280˚ and 320˚F, and compacted quickly. In cold regions, hot mixes can be difficult to compact, particularly if the layers are thin and the weather is cool. Contractors often struggle to compact rapidly cooling asphalt to the necessary densities. Pavements with too little compaction are weaker and have a shorter service life.

Warm Mix Asphalt, which includes additives that keep it workable and compactible at a lower temperature (250˚ to around 270˚F) make it possible to pave roads at lower temperatures, which can extend the construction season, particularly in Alaska.

WMA is also better for the environment; it gives off less fumes than HMA and results in less radiated heat. Manufacturers and materials suppliers suggest that producing WMA saves 30% in energy costs, and reduces CO₂ emissions by 30%. WMA can be hauled for longer distances without becoming unworkable. All these factors make WMA ideal for use in cold regions.

Although WMA is already popular in Europe, and is rapidly gaining in use in the US, very little is known about how such pavements perform in extremely cold weather, or about the best practices for applying WMA in cold regions.

This project, led by AUTC’s Juanyu Liu, will evaluate the performance of several different Warm Asphalt Mixes, investigating material properties as well as low temperature performance, rutting potential, and moisture sensitivity. Liu will assess engineering properties of WMA binders and mixes in the laboratory, evaluate WMA mixes in the field, and monitor emissions during WMA production and application. Project results will give contractors and AKDOT&PF the information necessary to decide how suitable WMA technology is for Alaska.

Liu has already tested three binders containing Sasobit, a commercial wax additive (mixtures of 0.8%, 1.5%, and 3%), based on previous research and a field trial in the Petersburg-Mitkof Highway Upgrade Project, Phase II.

In general, Sasobit improved rutting resistance but deteriorated both fatigue and low temperature cracking resistance.

Liu’s findings will be presented across the state in professional seminars and in pavement design classes for both practicing engineers and traditional college students.
Alaska Marine Highway System Analysis

The Alaska Marine Highway System safely and reliably transports people, goods, and vehicles among Alaska communities, Canada, and the contiguous 48 states. AMHS has been operating year-round since 1963, with regularly scheduled passenger and vehicle service to 30 communities in Alaska, plus Bellingham, Washington, and Prince Rupert, British Columbia.

During the past ten years AMHS has carried an average of 400,000 passengers and 100,000 vehicles per year. Currently, AMHS generates almost $50 million in annual revenue. However, like much of the nation’s transportation infrastructure, AMHS facilities are aging, and the system will soon need new vessels and upgraded docking facilities. The State of Alaska already contributes to AMHS operating expenses, which approach $100 million a year. The next big question is how to keep the ferries running safely, reliably, and efficiently.

This project, lead by Paul Metz, a UAF expert in Alaska’s multi-modal transportation system, seeks to develop a detailed picture of the Alaska Marine Highway’s mission and performance, as well as operating and financial scenarios for the next five to twenty years. This analysis takes into account the transportation needs of Alaska’s coastline communities and the resources the state has available to meet those needs. AKDOT&PF will use the results of this study to plan for long term operation of the state’s extensive ferry system.

Feasibility of Electric Cars in Cold Regions

Electric vehicles — cars that run on electricity stored in batteries — have drawn increasing interest from federal agencies, the auto industry, and academia as a promising path to reduced reliance on fossil energy and elimination of pollutants.

This project, under the direction of UAF Mechanical Engineer Jing Zhang and UAF student Michael Golub, will study the feasibility of using electric vehicles as reliable transportation in cold regions. Researchers will evaluate conditions where the electric car is appropriate; for instance, for short trips around town or for longer trips. They will also address the issue of using electric cars as a mode of transportation; the optimal distance between origin and destination; and potential environmental impacts on transportation operations. This study will be conducted in Fairbanks, an urban area in Interior Alaska, as a case study. Project results will include data and analysis of electric car performance for urbanized areas in cold regions.

The knowledge gained from this research can assist departments of transportation in cold regions when considering adopting electric cars as an alternative transportation method.
Developing Ambient PM$_{2.5}$ Management Strategies
Most people think Alaska has plenty of clean air, but sometimes geography and temperature conspire to violate the air quality standards, especially those for fine particulate matter (PM$_{2.5}$) set by U.S. Environmental Protection Agency regulations.

An extreme inversion occurs when air temperature increases (rather than decreases) with altitude, and Interior Alaska inversions are some of the most extreme in the country. A Fairbanks inversion acts like a lid on a pot, trapping wood smoke, car and smoke stack exhaust, and other pollutants, allowing them to build to dangerous levels in the air.

This project collects and analyzes field data relating to air quality and meteorology, with an eye toward identifying the major contributors of PM$_{2.5}$ and how we might better manage these sources. Researcher Tom Marsik is updating an improved experimental model with new data collected from downtown Fairbanks. The team has performed a year-by-year analysis of their data to examine potential trends in automotive emissions relative to other sources. They have also experimented with the EPA’s Chemical Mass Balance software in an effort to quantify pollution sources.

Developing Snow and Ice Control Plans for Urbanized Areas in Cold Regions
Alaska averages about 70 inches of snowfall a year across the state, from around 600 inches in Thompson Pass, near Valdez, to a measly 30 inches in Barrow. Managing snow and ice on the state’s streets and walkways is a hefty annual budget item. Regular maintenance operations often include plowing and salt distribution, usually sodium chloride (NaCl), which is available, inexpensive, and capable of lowering the freezing point of water, usually melting ice at moderately low temperatures.

One problem with using sodium chloride as a de-icer is that it is only minimally effective at pavement temperatures of less than 20˚F. For Interior Alaska, where temperatures can sometimes hover around -30˚F for weeks, 20˚F can seem like a balmy dream. At the same time, environmental concerns about additives that land in the roadside soil and find their way into the water table are increasing, and some traditional practices for snow and ice control are becoming unacceptable.

Researchers for this project, headed by Ming Lee and David Barnes of the UAF Civil & Environmental Engineering Department, have analyzed the results of conductivity and chloride concentration tests performed on soil and water samples collected in the study area (Fairbanks) in April, after snow and ice begin to melt. Their findings suggest that AKDOT&PF’s salting practices in the northern region do not cause conductivity and chloride levels to exceed limits set for waste water and agricultural regulation. Also, the road salt used showed no heavy metal content exceeding existing federal guideline limits.

Alaska Bridge Bent Pushover Software, Including Concrete Confinement Effects
The American Association of State Highway and Transportation Officials is developing new recommendations for bridge designs that can better withstand earthquakes. These new guidelines use pushover analysis, a technique in which a computer model of a structure is subjected to increasing lateral loading until its components fail. Pushover analysis is an effective way to highlight any weakness in a bridge’s performance under earthquake conditions.

However, there is no one easy-to-use program available to design engineers; no programs focus on the bridge bent design (sometimes called a pier design) most commonly used in Alaska, where steel shells encase reinforced concrete columns to improve seismic performance. This project, headed by Michael Scott of Oregon State
University is developing software customized for pushover analysis of Alaska-style bridge bents. Currently, Scott is working with AKDOT&PF engineers to user test the new program.

**Effects of Permafrost and Seasonally Frozen Ground on the Seismic Responses of Transportation Infrastructure Sites**

Alaska is one of the most seismically active areas in the world, and past earthquakes have caused considerable damage to its highway infrastructure. How the ground under a bridge behaves during an earthquake is influenced by the type of soil present and whether it is frozen or not. Although some studies suggest that a frozen surface layer can reduce surface ground motion during an earthquake, no one has systematically studied how permafrost or seasonally frozen ground affects site response characteristics, and current seismic design codes do not address specifically how to take these effects into account.

This interdisciplinary project, headed by Zhaohui Yang in the UAA Civil Engineering Department, combines seismic data recorded at bridge sites with computer models to identify how highway bridges built on permanently and seasonally frozen ground behave during an earthquake.

This year Yang instrumented an Anchorage area pier-design bridge with an array of seismic and other sensors that feed data to a recorder mounted on the bridge. Zhang’s team of graduate students also drilled a 6-foot-deep borehole on the site and added a digital temperature acquisition cable to collect ground temperature profiles periodically. The team will collect, process, and analyze data through the summer of 2009. Once complete, project results will contribute to new guidelines to help engineers design better highway bridges and embankments in Alaska.

**Evaluating Liquefaction Resistance in Degrading Permafrost and Seasonally Frozen Ground**

About 85% of Alaska is underlain by permafrost (that is, ground that remains frozen year-round for at least three years) or discontinuous permafrost (areas where air temperatures hover near 32°F). When ice-rich soils thaw, they can change in a variety of ways — they may compact, slump, or grow soggy — and most of these are bad news for structures built in or on changing frozen ground. Alaska is also by far the most seismically active state in the U.S.; the Alaska Earthquake Information Center locates and reports about 22,000 earthquakes each year. Permafrost degradation in regions with high seismic activity increases the potential for soil liquefaction, which can be a serious threat to transportation and utility infrastructure, as many professionals observed during the November 2002 Denali earthquake (magnitude Mw 7.9).

This project, headed by UAF Civil & Environmental Engineering Professor Kenan Hazirbaba, is conducting laboratory studies to investigate the liquefaction resistance of frozen and seasonally frozen ground. Two sets of tests are underway: One focuses on evaluating how soil liquefaction is influenced by freeze-thaw cycles throughout the year. The second evaluates how liquefaction is influenced by temperature distribution in degrading permafrost.

So far the research team has conducted several series of cyclic strain-controlled triaxial tests on local silts at various shear strains (ranging from 0.005% to 0.3%) and temperatures (-0.2°C, 0.5°C, 1°C, 5°C, and 24°C) to explore how temperature influences liquefaction behavior. They have also analyzed data on how temperature affects liquefaction potential and the dynamic properties of partially frozen or thawed local silts. These test results will help establish criteria for liquefaction susceptibility in both melting permafrost and soils that regularly undergo freeze-thaw cycles.
Investigating Methods for Maturing Concrete in Very Cold Weather
This research, lead by AUTC’s Yongtao Dong, is developing and testing protocols for determining concrete curing strength during the construction process, so that building under very cold conditions can be performed safely and quickly.

So far researchers have determined the laboratory strength-maturity correlations for concrete mix designs that AKDOT&PF construction teams commonly use. Field tests are scheduled for spring and summer of 2009. Ultimately, this study will produce a guide to procedures and computations designed to help AKDOT&PF personnel use the maturity method to better estimate the strength of concrete poured on site.

Forecasting Railroad Freight
Based on Mineral Resource Development
One element of extending transportation infrastructure is having a clear sense of who will use a system and what and how much that system will transport. A community considering something on the scale of a railroad running from Alaska, across British Columbia, to the U.S. Midwest has a great deal of planning to do. Paul Metz, UAF geological engineer and expert in getting minerals out of the ground and into industry, is the man to help. Metz’s team, a mix of state, industry, and university researchers, is examining information collected from multinational sources, then using it to improve computer models for estimating the contributions that mineral products could make to railway development (both as freight and as a way to diversify the area’s economic base).

Metz’s team is analyzing the world market for mineral resources, with a focus on new processing technologies suitable for cold climates; reviewing and refining methodologies for estimating mineral potential in Alaska and northwest Canada; and reviewing databases of mineral sites in Alaska, Yukon, and British Columbia to create a tentative map for where and how these minerals might ride the rails. This partnership involves both the State of Alaska and several provinces in western Canada.

Measuring the Effectiveness of Rural Dust Control Strategies
Dusty, unpaved roads affect the quality of life for many villages in cold regions; in Alaska alone, roughly 60% of the roads are unpaved. Dust reduces visibility on the road for drivers and pedestrians. Dust can cause respiratory ailments, and it can affect food harvests (such as berries and other plants) for people who live off the land. In addition, loss of fine material reduces road surface quality, increasing maintenance costs as well as wear and tear on vehicles.

Everybody acknowledges the problem, but finding a solution is a contentious matter. Simple paving is often unworkable; costs are high, local materials may be unsuitable, and long-term maintenance may be unavailable. Possibilities for dust control abound, but which will fit best with a subsistence lifestyle, and what can the state’s thinly stretched budget afford?
This project, headed by AUTC’s David Barnes, is developing a dust control research map that identifies and prioritizes critical areas and designing instrumentation and methodology to accurately monitor dust production on roads. These tools will be used to support AKDOT&PF in field testing various dust control measures in several locations.

So far, researchers for this project have qualitatively assessed palliative performance on a number of unpaved runways, tested newly designed instrumentation, and measured palliative performance with these prototype instruments at one rural road site.
Seasonally Frozen Ground Effects on the Seismic Response of Highway Bridges

Seasonally frozen ground is less flexible (or stiffer) than unfrozen. Although we think of bridges as solid and unbending, every bridge will — and should — flex a little, under the right conditions (including earthquakes). Like the ground that supports them, bridges built on deep pier foundations seem to become less flexible in winter. Currently there are no guidelines for predicting to what extent seasonal changes affect a bridge’s ductile performance; that is, how much effect does frozen ground have on whether a bridge’s materials will flex (or not) under seismic loads without fracturing? This project studies these changes across several years, measuring how bridge structures respond to seasonal changes, and exploring how bridge stiffness changes over time.

This study is a joint effort between civil engineers at the University of Alaska Fairbanks, University of Alaska Anchorage, and Iowa State University. This team, led by AUTC’s Leroy Hulsey, combines seasonal field monitoring of an existing bridge, field monitoring of piers sunk in ice-rich soils, and analytical modeling of bridge structures under seismic loading.

The team is currently monitoring ground temperatures at the test piles and in the near vicinity of the test site. Findings so far indicate that frost depths at the piles are deeper than depths farther from the test area. The data collected in this project will contribute to further frozen ground and seismic studies.

Preservation of the Alaska Highway

The Alaska Highway, the only road connecting Alaska to the contiguous United States, crosses large areas of permafrost-rich soils. Highway reconstruction in the mid-1990s damaged the organic layer that insulated and protected the surrounding permafrost. Since then, heat transfer through the road has been melting the ground ice. The thawing and settling ground has created dips, bumps, potholes, and cracks. Throughout the past 10 years, the climate has been relatively stable, but in the near future, climate warming will undoubtedly increase permafrost degradation and damage to the road. AUTC, working with the Yukon Department of Highways and Public Works, has been exploring ways to slow this permafrost degradation. This project selected a test site, characterized surrounding soil conditions, and installed instrumentation for long-term data collection. Team members also worked with engineers at YHPW and Laval University to finalize designs for mitigating damage to the highway.

Impact of Fines Content on Resilient Modulus Reduction of Base Courses During Thawing

When spring comes to many cold regions, the active layer (the top few feet of soil that freezes and thaws seasonally) can thaw very quickly, while deeper soil remains frozen. The active layer can become saturated with water from snow melt that collects on top of the frozen layer. In these circumstances, roads across Alaska are almost “floating” on a soft foundation. Too often, poorly supported pavement can buckle and sag under the weight of heavy tractor trailers and other vehicles, and it can remain deformed once the soils drain and become stable again. One way to reduce this damage is to control the amount of fines (essentially rock dust) in a pavement mixture.

This project, headed by UAF’s Juanyu Liu, investigates base course materials commonly used in Alaska’s roads, observing changes in their stiffness, as well as how their soil-water characteristics change under freeze-thaw cycles, and how different percentages of fines and moisture influence their properties. Data from this study will be used to produce better pavement designs, particularly in some rural areas, where project engineers might be forced to use locally available material with high fines content.
Characterization of Asphalt-treated Base Course Material

Asphalt-treated bases are often used in new pavements in Alaska; the materials are available and low-cost, but there is little data on how these base materials perform in cold regions. This study, headed by Juanyu Liu, UAF Civil & Environmental Engineering, is investigating four ATB types (hot asphalt, emulsion, foamed asphalt, and reclaimed asphalt pavement) popular for treating Alaska base course materials. The research team will collect data on stiffness, fatigue, and permanent deformation characteristics under different temperatures.

Liu and Ph.D student Peng Li completed a detailed literature review, including information from ongoing research projects, to compile the latest information concerning ATB characterization. Using a resilient modulus testing system set up according to AASHTO T307 requirements, they found that ATB material tested at 0°C and -10°C showed such low levels of deformation that they had to redesign their testing procedures and instrumentation.

To date, using the new design, they have completed resilient modulus tests of ATB material commonly used for northern and central regions, as well as rutting tests using a Georgia Loaded Wheel Test apparatus. Specimens of foamed asphalt-treated material, fabricated in AKDOT&PF labs, will soon be tested.

Seismic Design of Deep Bridge Pier Foundations in Frozen Ground

More and more Alaskan bridges rest on drilled shaft foundations, where a shaft of reinforced concrete is constructed deep in the soil, sometimes with a steel casing. Bridge columns are built atop these foundation shafts. A bridge designer planning this relatively cost-effective and simple foundation takes into account many variables, including soil type and bridge behavior, given a moderate-to-large earthquake. The foundation shafts are designed to respond to earthquake events by yielding and forming a “plastic region” in particular areas; these areas “absorb” and control the forces that actually impact the rest of the bridge. Designing for the location of these plastic regions, as well as their length, depends largely on the properties of the surrounding soil.

Frozen soil behaves differently than unfrozen, and this drastically changes where and how these plastic “hinges” form. The result is that a bridge built to withstand a large magnitude earthquake in warm weather may fail in cold.

This project, led by Sri Sritharan, Department of Civil, Construction, & Environmental Engineering at Iowa State University, is developing design methods for drilled shaft foundations that are customized for Alaskan bridges, soils, and temperatures.

Currently, researchers are testing how steel, concrete, and soil behave under cold conditions. Their findings will be used to establish the new design methodology.
Performance Analysis of the Dowling Multi-lane Roundabouts

Alaska, like much of the U.S., is a late convert to roundabouts. The first multi-lane roundabouts in Alaska were constructed in 2004 at the ramp terminals of the Dowling Road/Seward Highway interchange in Anchorage. These serve as junctions for commuters accessing the Seward Highway. The roundabouts were intended to ease traffic pressure on this important commuter route.

Since their completion, the roundabouts have performed as intended with minimal maintenance. As vehicle traffic in Anchorage continues to grow, however, use of the Dowling roundabouts also increases. The roundabouts are currently operating at or near capacity with long vehicle queues at their entrances during peak traffic hours.

This research project, led by AUTC’s Ming Lee, is examining the performance of multi-lane roundabouts and how drivers use them. The roundabouts are being videotaped, including the vehicle queues at entrances, between 4:45 and 6:15 p.m. on three weekdays in winter as well as summer. Researchers are reviewing the video records and counting individual turning movements made by motorists; they are also measuring the length of vehicle queues. Winter data, recorded in December 2008, have been collected.

In future work, researchers will analyze these data using RODEL and SIDRA software, programs designed for roundabout analysis. Field-measured speed and queue length will be compared with numbers predicted by the two software programs and other available roundabout design guides. The safety performance of these roundabouts will also be examined and compared with that of intersections equipped with traditional traffic lights. Analysis results can assist the AKDOT&PF in determining whether and where to construct additional multi-lane roundabouts; it will also add to the database of information available to U.S. traffic planners.

Smart FRP Composite Sandwich Bridge Decks in Cold Regions

What if every time a bridge on a lonely road grew icy, it could automatically notify the local DOT to begin ice control safety measures? What if a bridge could notify someone every time an overloaded truck hit the decking, or when the trusses under it began to weaken?

This project, headed by Pizhong Qiao, Civil Engineering, Washington State University, takes the first steps toward developing, manufacturing, testing, and implementing Smart Honeycomb Fiber-Reinforced Polymer (S-FRP) sandwich materials for transportation projects. This material integrates advanced composite materials with sensors and actuators. This study is a partnership of Washington State University, University of Alaska Fairbanks, and Kansas Structural Composites, Inc.

So far, researchers have designed and fabricated an S-FRP sandwich deck panel and several S-FRP sandwich beams and developed structural health monitoring strategies. Cold temperature testing of these prototypes is in progress. Researchers have also conducted analytical studies and numerical finite element simulations for the S-FRP sandwich deck panels.
Evaluating Wearing Surfaces for the Yukon River Bridge (J.L. Hulsey, $122,112 funded through RITA & AKDOT&PF). This study considered seven different systems for durable, lightweight decking alternatives for the E.L. Patton Bridge, which carries the Dalton Highway and the Trans-Alaska oil pipeline across the Yukon River: wood on wood, wood on UHMW (ultra high molecular weight polyethylene; this same material is used for applications ranging from snow boards to boat bottoms), UHMW on wood, UHMW alone, FRP (fiber reinforced polymer) sandwich panels, FRP cellular panels, and COBRA-X (a brand of high-density polyethylene material, often used for railroad crossings).

Experimental results indicated that a composite system of polyethylene and wood, or two layers of polyethylene, performs better than the bridge’s original wood/wood system in all testing areas.

Solving Plastic Deformation Problems for Anchorage Flexible Pavements (J.L. Hulsey, $192,200, AKDOT&PF). Anchorage, Alaska streets are generally paved with hot-mix asphalt, and pavement rutting is a long-standing problem, both in terms of safety and on-going maintenance costs. In northern climates, pavement rutting is generally considered to be caused by studded tire wear, plastic deformation, or a combination of the two.

This study addressed plastic deformation. Study results are based on a four part approach: laboratory evaluation of HMA cores extracted from nine rutted pavements, literature review, review of mix designs in relation to results obtained from field cores, and development of alternative rut-resistant mixes.

The report provides suggested mix designs to minimize the plastic deformation component of rutting in the Anchorage area. Notable results include two new Hot Mix Asphalt designs. UAF developed one mix, based on using the Bailey method to obtain an optimum aggregate blend in accordance with Superpave protocol, that shows promise in mitigating rutting in Anchorage streets. Another Hot Mix Asphalt, developed by AKDOT&PF and tested in UAF’s labs as part of this project, also shows promise.

Using Geofibers and Synthetic Fluids as Stabilizers for Marginal Soils (Kenan Hazirbaba, $11,194, RITA & Peak Civil Technologies). This project explored using two soil stabilizers developed by Peak Civil Technologies (PCT), an Alaskan company, to improve silty soils. PCT developed a combination of two stabilizers, a plastic fiber to increase soil strength (Geofiber 3627BT) and a synthetic fluid that “replaces” water in the soil (Severely Hydrotreated Paraffinic Liquid). Early results suggest that the right mix of geofiber, synthetic fluid, and water, combined with some aging, can improve soil CBR values by at least 300%.

Integrated Vegetation Management Along Alaska’s Highways (David Barnes, $164,487, RITA & AKDOT&PF). This project worked with AKDOT&PF, the USDA Agricultural Research Service (Subarctic Agricultural Research Unit), and the Salcha-Delta Soil & Water Conservation District to develop an integrated plan for roadside vegetation control.

The most salient study results concern the half-lives determined for each herbicide sample collected from the Delta Junction test site. Samples obtained up to 27 days (prior to an increase in herbicide concentration found in the soil following a relatively large rain event) after application indicate that the attenuation rates are similar to rates reported in the literature for more temperate soils. Further, both 2,4-D and triclopyr are found in the soil at some concentration one year after application, indicating that herbicide persistence is longer compared to reported results from more temperate regions.

Researchers also found that the percentage of herbicide mass measured at each sampling event compared to the mass applied was small and relatively consistent for each site through the course of the study. Our conclusion is that plant uptake and metabolism play a key role in the attenuation of herbicides applied to subarctic soils.

Screening Tests for Gilsonite Application (Juanyu Liu, $7,903, Sealmaster). This project investigated the properties of an asphalt commonly used in Alaska (PG52-28), and how it behaved over a wide range of temperatures as increasing percentages of gilsonite (0%, 3%, 6%, 10%, and 12%) were added. Liu found that adding up to 3%...
gilsonite improved the asphalt’s ability to resist rutting, thermal cracking, and fatigue, but at higher percentages the asphalt’s performance in thermal cracking and fatigue tests began to suffer. To learn more about this project, visit www.uaf.edu/ine/AUTC/ProjectPages/GilsoniteApplication.html.

Guidelines for Risk Analysis in Construction Contract Changes (Robert Perkins, $20,000, RITA & AKDOT&PF). Work changes are common in construction contracts, especially for large projects. The stakes can be higher in Alaska, where a short building season and remote locations can push a project into an additional year, with extra staging costs, staffing, and scheduling nightmares.

This project produced a guide for AKDOT&PF managers and engineers that better prepares them for judging project risk and estimating costs; a draft of this guide is currently under review at AKDOT&PF.

TRACX: Large Truck Crashes, (Ming Lee, $7,500, Chenega Advanced Solutions & Engineering). This project used integrated qualitative and quantitative research methods to investigate behavioral factors that may increase the risk of large truck crashes. The study drew on data collected from the Federal Motor Carrier Safety Administration’s Large Truck Crash Causation Study.

Factors examined included fatigue, stress, use of alcohol or illegal drugs, driver recognition errors (such as inattention, distraction, inadequate surveillance), and aggressive driving decisions (such as driving too fast, following too closely, and so on).

Study results indicated that, among drivers involved in accidents, for those who had more than 6 hours of sleep before the crash, about 45% of them crashed due to various driver behavioral factors. For those drivers involved in accidents who had less than or equal to 6 hours of sleep, 80% of the accidents were due to critical driver performance errors. The results can be interpreted as supporting that sleeping for more than 6 hours at the last sleep interval before driving can reduce the crash risk due to driver performance errors by 35%.

AUTC makes project profiles, research publications, videos, annual reports, and newsletters available on its web site. Visit www.alaska.edu/uaf/cem/ine/autc/ to find these and other publications.


Project Update: Impact of Fines Content on Resilient Modulus Reduction of Base Courses during Thawing (2008) by Lin Li, Juanyu Liu, and Xiong Zhang.


NEWLY AVAILABLE RESEARCH PUBLICATIONS

Right: A single vehicle, large truck crash on the Dalton Highway, Alaska. The Dalton is an important corridor for shipping goods to and from the North Slope of Alaska.
In 2008 our researchers and staff presented the latest in transportation research in professional meetings and conferences, as well as publishing newsletters (available online at www.uaf.edu/ine/AUTC/) featuring current research, education, and technology transfer activities.

AUTC worked as part of Transportation Northwest, partnering to support joint research and education projects benefitting the Northwest region.

AUTC is a member of the Region 10 Northwest Transportation Consortium, a consortium of University Transportation Centers and related State Departments of Transportation that provides a venue for collaborating on projects and issues important to the Northwest. This year AUTC hosted the NW Consortium conference here at UAF, May 19-20.

AUTC supported activities at the Ninth International Conference on Permafrost, hosted on the UAF campus June 29 through July 3, 2008.

NICOP hosted over 800 researchers from all over the world as they came together to develop a comprehensive view of the thermal, ecological, and engineering state of permafrost globally.

AUTC participated in sharing expertise and resources with the international community. AUTC also contributed to an extensive set of research proceedings that detail the work of this historic conference. Conference videos are available from the AUTC web site. To purchase the conference proceedings, visit http://www.nicop.org/
Local Technical Assistance Program
AUTC partnered with the AKDOT&PF Research & Technology Transfer to support several joint projects with LTAP, the Local Technical Assistance Program.

LTAP, funded by the Federal Highway Administration, is part of a nationwide network with an organization in every state. LTAP seeks to improve the quality and safety of the surface transportation system through interactive relationships and information exchange.

Alaska R&T² (Alaska’s LTAP) assists local governments through research, training, and technical assistance, to keep the state and other transportation agencies informed on new technologies and best management practices.

This year AUTC contributed funds and expertise to several Alaska R&T² projects, from engaging the next generation of engineers to giving local builders the latest information on soils and foundations.

AUTC and Alaska R&T² are pooling their resources to support a transportation lending library on the UAF campus. The Alaska R&T² library, located in the Keith B. Mather Library, currently contains over 40,000 transportation related documents.

Developing an Online Course in Highway Geometric Design
Alaska, like other states, foresees a shortage of well-trained transportation professionals who have the capabilities to develop innovative solutions to transportation problems. Low numbers of transportation faculty and students, and uneven distribution of expertise are part of this trend. Students graduating with civil engineering degrees often begin their professional careers with little background in fundamental transportation engineering design, such as highway geometric design.

This project, a collaboration between AUTC and Washington State University, will develop a course module that will serve as a prototype for a broadly adaptable online learning program based on known theory and best practices in engineering education and online learning. This course will integrate a variety of learning tools, including video lectures by practicing engineers and university faculty, graphic representations and video of actual highway designs, exercises in problem-solving and analysis, and printable reference documents.

The courses will meet the needs of both university students and practicing professionals in Alaska and Washington.

Developing an International Partnership for Research
AUTC is exploring new relationships with research organizations outside the United States. Director Billy Connor joined Dan White, Director of the Institute of Northern Engineering, and Larry Hinzman, Director of the International Arctic Research Center (both at UAF), in participating in the Workshop for Academic Exchange between the University of Alaska Fairbanks and the Kitami Institute of Technology (KIT). This workshop, which focused on Cold Regions Engineering in the Arctic Area, provided an opportunity to meet with students and staff at the Kitami Institute.

Attendees worked to develop a partnership for research and technology transfer. Participants found common ground in the areas of transportation, climate change, seismic design, and the study of sea ice.

Plans are underway for the Japanese delegation to visit the UAF campus in March of 2009, to further develop joint opportunities for research and education.

Below: Billy Connor, AUTC Director, tries the driving simulation unit, used for simulating driving on snow and ice, part of the research facilities available at the Kitami Institute of Technology.
Student participation in research is a given for AUTC projects. This year AUTC projects provided research experience to 24 graduate and undergraduate students in areas from air quality to rural health quality issues.

Students participate in project planning, field work, lab testing, report preparation, and meetings with end users and other stakeholders. AUTC students often contribute to national-level publications and present their research to a wide professional audience. This year AUTC creates opportunities for post doctoral researchers as well, creating mid-level positions on research projects that give top-notch young researchers opportunities to practice project management and to mentor other staff and students.

AUTC support at the University of Alaska Southeast is contributing to a new engineering-focused learning environment.

This fall UAS will launch a new program, a pre-engineering certificate with emphasis areas in Computer Systems, Electrical, and Mechanical Engineering. These pre-engineering courses will be taught on-site. “We are very pleased to offer this new option for students to begin a degree program in Engineering by taking their first year of classes at UAS,” said Patrick Brown, AUTC Associate Director for UAS.

After the first year, students will transfer to larger programs, such as those available at UAA or UAF, to continue an engineering degree. According to Brown, this program was designed to help address an expected shortage of engineers in Alaska.
The 2008 Alaska University Transportation Center Student of the Year Award recipient is Will Rhodes, a University of Alaska Fairbanks Master’s candidate in Environmental Engineering. Rhodes earned his Bachelor of Science degree at UAF in Geology in 2005.

Rhodes’ research has centered on “Herbicide Attenuation in Alaskan Soils,” a joint project among the AUTC, the Alaska’s AKDOT&PF, the USDA Subarctic Agricultural Research Unit, and Salcha-Delta Soil and Water Conservation District. As part of this project, he participated in controlled field testing in Delta Junction and Valdez, Alaska to determine how effective a combination of mechanical brush cutting and herbicide application might be in controlling vegetation.

Rhodes examined soil samples collected over the course of a year from field sites treated with a combination of mechanical mowing and herbicide. He analyzed these samples in the lab to track how quickly the herbicide chemicals diminished under varying climactic conditions, and what simpler compounds they formed as they broke down. Rhodes spent the winter analyzing his data and writing his thesis.

Study results will aid the AKDOT&PF and the Alaska Railroad Corporation in making decisions on herbicide use in Alaska and on best practices for application.

The most challenging part of this project, Rhodes says, was mastering the logistics and organization involved in working with two remote field sites and multiple research partners to develop a strong, reliable experimental methodology.

Rhodes was chosen for this award based on his research achievements and his high GPA.

Will Rhodes, AUTC student of the year for 2008, collected soil samples in Delta Junction, Alaska for herbicide dissipation studies.
AUTC continues to address Alaska’s needs with an eye toward national priorities. Over the last year, we have found that many of our parochial issues indeed have national implications. Dust control is an excellent example. While we would like to think Alaska has cornered the market on dusty byways, the US alone has over 1.4 million miles of gravel roads. The knowledge we gain is no doubt directly applicable nationally and internationally. Fugitive dust from roadways is both a health concern for those adjacent to gravel-surfaced roads and a safety issue due to reduced sight distances. AUTC has set in motion an aggressive program to eliminate dust emanating from transportation facilities. We have partnered with the Alaska Department of Transportation & Public Facilities, the Denali Commission, local communities, and industry in this effort. To date, AKDOT&PF and local communities have treated many airports and community roads with dust palliatives and soil stabilizers. AUTC has developed a portable prototype device capable of measuring real-time dust raised by vehicle tires. Through this effort, we have determined that several products developed by dust palliative producers reduce dust by as much as 91%. Over the coming year, we will extend this project to determine the working life of the palliatives. One side benefit to minimizing dust is reduced road-maintenance costs, with less need for grading and surface replacement. Most communities find that a two to three year life makes these palliatives affordable. We are providing industry with our data so that they can improve their products. Climate change continues to be a focus. AUTC is heavily involved in the Governor’s Climate Change Adaptation Advisory Group, which is preparing recommended policy for the State of Alaska. As most scientific literature notes, Alaska’s climate is changing more rapidly than anywhere else in the nation. We have an opportunity to disseminate our experiences to the nation. For example, many of our coastal communities are threatened by beach erosion due to storms that occur during periods when the coast was historically protected by sea ice. Warming has kept the ocean free of ice later, well into the stormy early-winter period. As a consequence, we must evaluate our transportation infrastructure to ensure that affected communities have an access to services and that the infrastructure can withstand whatever storms occur.

Research and research-related administrative costs in 2008 accounted for 66% of our funds. Funding for outreach and education activities was approximately 18%, with 2% additional funds committed to technology transfer. General administrative costs were 14%.
evacuation route. We must also define future transportation corridors to minimize the impact of these changes.

**We look for projects that fundamentally change the way we manage our system.** Challenges such as climate change, rising energy costs, increasing construction costs, and increasing demands on our transportation system strain our dwindling funding resources. We challenge our researchers to stretch their creativity to ideas like finding a replacement for asphalt, designing a flexible concrete, or perhaps developing bridge-monitoring systems that provide engineers with information about the long-term health of any given bridge. Why not use Intelligent Transportation Systems to provide a driver with the information necessary to adjust to current highway conditions? After all, the greatest advantage of a university is that it creates a space where researchers are encouraged to challenge codes and standard practices. Many of the projects in this report do exactly that.

**AUTC is taking a leadership role in educating our transportation engineers of the future.** This is done by working in partnership with the UAF College of Engineering & Mines, the UAA School of Engineering, and the new pre-engineering certificate program at UAS.

In addition we are working with industry to accelerate the education of engineers already in the workforce. We hope that 2009 will see the beginning of a Construction Management graduate certificate, which will represent the skills needed to effectively manage construction projects. We are also working with industry to provide other transportation skills such as geometric design, traffic management, inspection, and materials testing training, and others.

**AUTC is focusing on our future through innovation, education, and partnerships.** Our goal is to challenge our researchers and students alike to stretch their imaginations to solve cold regions transportation issues, to look beyond standard practice, and to challenge conventional wisdom. Clint Adler, Chief of Research at the AKDOT&PF has issued AUTC a challenge to step out in front and become a leader in research, education workforce development, and workforce retention. AUTC eagerly accepts this challenge.

The chart above represents total expensed funds for 2008 by source. Federal dollars accounted for 39% of our funding; various state agencies supplied 34% of funding dedicated to specific research projects; UAF supplied 11%, and 1% was provided by private sources. The State of Alaska supplied another 15% as continuing infrastructure support for the UTC program.
PHOTO CREDITS

Front cover: From left: (1) Photo courtesy of L. Hinzman, International Arctic Research Center. (2) Photo courtesy of AUTC staff. (3) Photo courtesy of AUTC staff. (4) Photo courtesy of University of Alaska Southeast. (5) Photo courtesy of Water & Environmental Research Center staff. (6) Photo by K. Hansen, INE Publications & Proposals Office.

Page 2: Photo by S. Boatwright, INE P&P.

Page 4: Photo of Sherri Alston courtesy of S. Alston. Photo of Mike McKinnon courtesy of M. McKinnon. Photo of Rick Kessler courtesy of R. Kessler. All other board member photos by K. Hansen.


Page 7: Middle: Photo courtesy of O. Smith, UAA. Right, top: UAA graduate students Ruel Binonwangan and Gang Xu; Photo by Z. Yang, UAA. Right, bottom: Photo of Lori Sowa courtesy by A. Bogolepov, UAS Marketing and Public Relations.

Page 8: Left: Photo of Z. Yang and graduate student G. Yu courtesy of UAA staff. Right photos by K. Hansen, INE P&P.

Page 9: Bottom right: Photo by AUTC staff.

Page 10: Photos by S. Boatwright, INE P&P.


Page 12: Photo of K. Hazirbaba courtesy of AUTC staff.

Page 13: Photo of Y. Shur in syngenetic Pleistocene permafrost by M. Kanevskiy, INE.


Page 15: Photo of R. Weis by K. Hansen, INE P&P.

Page 16: Photos by B. Brunette, AKDOT&PF.

Page 17: Left, bottom: Photo of Alaska ferry by M. Kanevskiy. Right: Photo by S. Boatwright, INE P&P.
PHOTO CREDITS

Page 18: Photo of R. Johnson and T. Marsik, by K. Hansen, INE P&P.

Page 19: Photos courtesy of Z. Yang, UAA.

Page 20: Photo by D. Filler, UAF.

Page 21: Photo of J.L. Hulsey and M. Kanevskiy by Photo by student Jacob Horazdovksy.


Page 23: Photos of smart bridge decking and graduate student Wei Fan courtesy of P. Qiao, Washington State University.

Page 25: Photo of wrecked truck courtesy of W. Schnabel.

Page 26: Photo of NICOP (June 29-July 3, 2008) poster session, held in UAF’s Wood Center; photo courtesy of D. Kane, NICOP US National Committee.

Page 27: Photo of Billy Connor, in KIT’s state-of-the-art driving simulator, part of the Workshop for Academic Exchange between University of Alaska Fairbanks (UAF) and Kitami Institute of Technology (KIT), courtesy of B. Connor.


Page 29: Left: Photo of W. Rhodes by K. Hansen, INE P&P. Right: Photo of Rhodes collecting soil samples courtesy of AUTC staff.
TRANSPORTATION SAFETY, SECURITY, AND INNOVATION IN COLD REGIONS.