Cover Photos:  

*Upper left:* Overland ice build-up, sometimes known as icing or glaciering, as a result of water trapped on top of permafrost. Photo by Misha Kanevskiy.  

*Lower left:* Institute of Northern Engineering research faculty Daniel Fortier collects ice cores for “Preservation of the Alaska Highway,” a newly funded Alaska University Transportation Center project. Photo by Eva Stephani. To learn more about this project, see page 20.  

*Upper right:* Damage to the Richardson Highway, Alaska, caused by the Denali Earthquake of 2002. Photo courtesy of Alaska Department of Transportation & Public Facilities.  

*Lower right:* A small plane at one of the many Alaskan airports located off the road system; Alaska has more private pilots per capita than any other state in the USA. Photo courtesy of AKDOT&PF.
Alaska University Transportation Center
Transportation safety, security, and innovation in cold regions.

Table of Contents

Message from the Director 2
Remarks by U.S. Representative Don Young 3
Center Theme & Mission Statement 4
Organization & Campus Directors 5
Governing Board 6
AUTC Staff & Faculty 7
AUTC Research Facilities 8
Research 10
Ongoing Research 11
Newly Funded Research 17
Outreach and Dissemination 22
Student Awards 25
Goals 2008 26
Funding & Expenditures 27
Photo Credits 28
In the past fiscal year, thanks to the hard work of its staff, support from the University of Alaska administration, and numerous others who provided support and advice, the Alaska University Transportation Center has become a reality. In particular, we thank Representative Don Young, who recognized the need to advance transportation in Alaska by involving a nationwide network of research universities.

This year, AUTC awarded — or committed to long-term research projects — just over $1.7 million; these federal funds were matched by our partners, a list that includes the Alaska Department of Transportation & Public Facilities, members of private industry, and five universities nationwide. We expect to more than double that figure in research funding in the upcoming year, and our aim is to search out and encourage larger-scale proposals.

As I reviewed the year’s funding trends, I noticed the average proposal size was less than $200,000. A preponderance of these projects focused on finding immediate solutions to nagging problems; a great deal of this year’s energy is focused on applied research. Since these problems were the concern of those who provided matching funds, this is certainly no surprise. I am concerned, however, that we are missing opportunities for innovation.

Research can be considered in three tiers: applied, exploratory, and basic. Applied research focuses on today’s problems and is usually expected to produce immediately usable results. Consequently, applied research trends toward low-risk projects with generally small incremental improvements in the way we operate.

Unfortunately, if our entire program is aimed at applied research, we cannot expect to contribute to resolving the larger, global-level transportation issues we face. Alaska — and the nation — will continue to fall behind.

Exploratory research, as its name implies, looks at new, untried ideas for potential solutions. Such projects are higher risk and require more time to make an impact, but the potential outcomes can be far more profound. Perhaps the greatest potential outcome for exploratory research is its ability to “leapfrog” existing technologies, moving toward completely new perspectives and capabilities. Exploratory research also provides the ability to develop a strategic, systemic approach to transportation research, rather than always extending and upgrading the “old model.”

Basic research develops new knowledge we can (we hope) apply in the future. The primary goal of basic research is not necessarily to solve a specific problem, but to gain a deeper understanding of how some aspect of our world works. Through this understanding, we may be able to move to exploratory, and ultimately, to applied research. Basic research does not mean studying the world without purpose, but studying in detail areas that may have the potential for large payback sometime in the future.

Just as a good investor manages a stock portfolio (a few interesting but risky investments, a few stable, slow-growing investments), so must research centers manage a research portfolio, striving to find an optimum balance of applied, exploratory, and basic research to truly move transportation practices forward. If we fail to do so, our transportation system will continue to deteriorate.

Toward this end, one major AUTC goal is to develop a balanced research portfolio over the next year. This goal requires developing alternate funding sources and longer time lines, building partnerships, and encouraging researchers to think creatively.

As you review this round-up of our inaugural year and our initial research paths, I hope you see the signs of growth and innovation I see, as well as our potential for developing new ways of meeting the research challenges we all face in the future.
My congratulations to the Alaska University Transportation Center and its first annual report.  

I’m pleased to have been asked to comment on why university transportation centers were an important effort during my time as chairman of the House Transportation and Infrastructure Committee.

Now more than ever, I believe the economic health of the United States depends on a healthy transportation network. As demands on that network increase, funding to maintain and improve it have become more critical. It’s time to build smarter — rather than larger — infrastructure. Environmental issues, including greenhouse gases and climatic warming, demand increased transportation efficiency. Deaths on our nation’s highways remain at unacceptably high levels. These and other issues must be addressed if we are to remain economically healthy and if we are to continue to enjoy the freedom of mobility Americans love.

We can’t afford to consider infrastructure for planes, trains, cars, and boats as independent systems. Moving freight and people usually requires more than one mode of transportation, and all modes share common issues and some potential for common solutions.

University transportation centers are an important venue for improving transportation in this country. UTCs increase the transportation work force through undergraduate and graduate degree programs. They help the current work force stay current by offering continuing education and information on the newest technologies, including the results of UTC research. UTC research facilitates creative solutions to transportation issues in a way that other venues cannot.

Alaska’s University Transportation Center has the unique ability to address transportation in cold regions. Alaska is both its market and its research laboratory, and I am pleased to have been instrumental in its creation.

AUTC will address permafrost issues and the unique multi-modal nature of moving people, goods and energy in Alaska. This center can address sensitive environmental issues, act as a proving ground for cold weather technologies and products, and develop a work force with specialized knowledge. One important effort is an outreach to the Alaska Native population to increase its presence in the transportation work force.

I am certain the Alaska University Transportation Center — and all UTCs — will reach beyond current technologies and ideas to find innovative and varied education delivery methods, to coordinate transportation research for maximum benefit and minimum redundancy, and to work closely with its wide and diverse team of transportation agencies, industries and users.
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 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 inter-connecting 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 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 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 to address multi-modal issues facing Alaska and the nation’s transportation community.

AUTC has chosen six focus areas that offer unique challenges in cold regions:

- Preserving the environment
- Operating transportation systems
- Planning transportation systems
- Designing transportation systems
- Constructing transportation systems
- Maintaining facilities & equipment
ORGANIZATION & CENTER LEADERS

AUTC Director

UAF Provost

INE Director

Executive Committee (UAA, UAF, UAS)

Selection Committee

Governing Board

Program Manager

Fiscal Officer

Faculties:
- Faculty (Structures) 50%
- Research Technician
- Faculty (Transportation Operations) 50%
- Other Faculty as Required (UAA, UAF, UAS)
- Faculty (Transportation Materials & Seismic) 50%
- Faculty (Geotechnical Materials & Seismic) 50%
- Faculty (Geotechnical Modeling) 50%

Faculties:
- Faculty (Transportation Materials & Seismic) 50%
AUTC is fortunate to have an active and engaged governing board. Like all university transportation center boards, ours provides direction to AUTC. In our development phase, AUTC chose members who were visionaries, leaders who could establish a path into the future. They were chosen not for their technical abilities, although all excel in their fields, but for their ability to understand the over-arching issues facing cold-regions transportation. Further, AUTC invited board members who could represent both users and those responsible for managing transportation infrastructure at the national, state, and local levels. All transportation modes are represented in this dynamic group.

The governing board has stated that one of the major contributions AUTC can make to the University Transportation Center program is to facilitate Alaska’s role as a cold regions test bed for the rest of the United States. To learn more about our board’s ideas, read the 2007 AUTC Governing Board Five Year Road Map, which can be found at: www.uaf.edu/ine/AUTC/GoverningBoard/.
The core staff is the backbone of any organization. AUTC is lucky to have staff who truly enjoy their jobs — it shows. Each person brings a unique ability to the team, ranging from management, to administration, to technical ability. Diversity of background, age and culture translate into healthy contributions to all aspects of the program. Several of the staff share appointments that include both teaching and research responsibilities. This structure ensures that students benefit from the work AUTC performs.

**UAA ASSOC. DIR. JANG RA**
“Speed wins.”

**UAF ASSOC. DIR. LEROY HULSEY**
“Bridges are living things; you can tell if one is healthy, or not.”

**UAS ASSOC. DIR. KAREN SCHMITT**
“All that is gold does not glitter, not all those who wander are lost....”
-- JRR Tolkien, in Lord of the Rings

**DIRECTOR & GOVERNING BOARD MEMBERS**
“Congestion increases as you get closer to the ant hill.”

**Ming Lee**
Research Faculty
“Some men are born out of their due place. Accident has cast them amid certain surroundings, but they have always a nostalgia for a home they know not….”
-- Somerset Maugham, in The Moon and Sixpence

**Sandra Boatwright**
Proposals & Publications Manager
“If I can’t canoe, pencil-whipping proposals will do.”

**Kathy Petersen**
Grant Manager
“It’s all about the numbers, and I clearly need a side car for the kids.”

**Jenny Liu**
Research Faculty
“We just don’t have enough pavement to get everyone home at the same time.”

**Saundra Jefko**
Program Assistant
“Ittuq, piqpaktuq, and iglaqtuq” (Inupiat for Live, love, and laugh)

**Gary Tyndall**
Lab Manager
“Adapt, improvise, overcome.”
-- adapted from Heartbreak Ridge

**Xiong Zhang**
Research Faculty
“To build a good structure, one has to build a good foundation first.”
AUTC has ready access to facilities for performing common and specialized materials testing, geotechnical investigations, air and water quality tests, and various controlled-environment chambers, as well as extensive opportunities for field testing. All our labs and equipment meet the needs of our cold regions theme.

**Structures Lab**

This facility supports both undergraduate and graduate studies, providing opportunities for students to perform basic tests on materials and structures. Lab space is well-equipped with adjustable load frames and the latest technology in sensors, acoustic emissions, and data acquisition systems.

**Geotechnical Lab**

This lab, which also serves both graduates and undergraduates, is well-equipped for sample preparation and for testing a wide range of soil properties such as triaxial compression strength, cohesiveness, water content, permeability, and shear strength. Equipment includes two digital Tri-test load frames, a Tri-Flex 2 permeability test system, and several California Bearing Ratio and soil consolidation test systems.

**Advanced Materials Testing Lab**

This lab supports research in the fields of geotechnical, pavement, materials, and structures engineering. State-of-the-art and prototype test devices are coupled with computer controllers to conduct intricate short- and long-term tests under a variety of conditions, including cold temperatures and simulated earthquakes.

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. This lab is also home to a 5k COX load frame coupled with an environmental chamber capable of maintaining temperatures ranging from -40 to 200°F. In addition, this lab has a unique CICS dynamic shear testing system for advanced soil tests.

**Asphalt Mix and Cement Testing Labs**

Systems for testing the properties of various asphalt concrete mix designs, including pavement stability, flow, percent of air voids, asphalt content, and bending beam strength are available in this facility. How different stabilizers and additives affect these mixes can be measured under various conditions so that researchers can make more reliable predictions for pavement performance in the field.

**Superpave Lab**

This lab is equipped for the full range of superpave mix design and performance-graded asphalt tests. The effects of additives can be quickly and accurately determined.

**Environmental Labs**

AUTC has access to environmental laboratories equipped to handle a wide variety of research projects and interests. These labs have facilities committed to controlled environmental experiments, wet chemistry, and bench techniques, as well as a broad range of instruments and skilled research support staff.

Both benchtop and field-scale water quality meters are available for measuring common parameters such as temperature, pH, conductivity, dissolved oxygen, and turbidity.
These facilities are also equipped to meet some organic chemistry needs. One good example is AUTC’s ongoing project on the degradation of herbicides in cold regions (see page 11 to learn more about this project). These water-soluble and non-volatile herbicides are challenging to measure. The environmental labs allow use of a boron trifluoride methanol complex to attach a methyl ester group to the herbicides. The resulting herbicide esters are semi-volatile, and can be quantified easily by gas chromatography-mass spectrometry (GC/MS) equipment in the lab.

These labs support an assortment of instrumental techniques. Both flame and graphite furnace atomic absorption are available for major metals as well as for trace metal analysis. Anion and cation analysis are both available through ion chromatography. Elemental analysis of solid samples can determine total carbon, hydrogen, nitrogen, sulfur, and oxygen. Platinum catalyst combustion and infrared detection are used to measure total and dissolved organic carbon in water samples.

The range of instruments available is valuable for characterizing water sources by detecting naturally occurring constituents, as well as identifying and quantifying anthropogenic pollutants.

**Cold Room Facilities**

AUTC can study arctic conditions inside the lab, conducting experiments at extremely low temperatures, even during warm Interior Alaska summers.

Three R. W. Smith walk-in controlled environment rooms allow research projects to be conducted at temperatures ranging from ambient down to -4°F. These rooms also have proven very useful for testing equipment prior to deployment in arctic regions. Another cold room (40 feet by 8 feet), capable of temperatures below -60°F, is available through the Cold Climate Housing Research Center. To learn more about CCHRC, visit www.cchrc.org/.

**Permafrost Tunnel**

Ground that remains frozen for at least three years (that is, through at least two summers) influences nearly every kind of infrastructure in Alaska in one way or another. North of the Brooks Range, continuous permafrost underlies most of the topography to some soil depth. Discontinuous permafrost is more common in Interior Alaska. Permafrost may contain tiny bits of ice (“pore ice” or “interstitial ice”), filling small spaces between individual grains of sand, silt, or gravel; sometimes much larger forms occur (such as the ice wedge in the picture, upper right). For permafrost soils, ice volume can range from only a few percent to nearly 100%.

The United States Army Cold Regions Research and Engineering Laboratory operates a unique research facility, the CRREL Permafrost Tunnel, located in the Goldstream Valley, about 10 miles from Fairbanks. The tunnel’s frozen walls expose a continuous cross-section of undisturbed, perennially frozen, fossil-rich silt, sand, and gravel on top of quartz-mica-schist bedrock.

Originally excavated to study geology, ice science, and mining and construction techniques specific to permafrost environments, the tunnel still offers unique opportunities for students and research scientists. For the AUTC, the tunnel serves as the perfect lab to explore such subjects as climate change impacts, permafrost deterioration mechanics, and frozen soil strength.
AUTC received 65 proposals totaling $12 million in its first Request for Proposals; we funded 16 of these. The selection panel made its choices based on the six focus areas established by the governing board:

- Preserving the environment
- Operating transportation systems
- Planning transportation systems
- Designing transportation systems
- Constructing transportation systems
- Maintaining facilities and equipment

The selected proposals centered around:

- Seismic impacts on structures in frozen ground
- Air and water quality
- Dust control and soil stabilization
- Vegetation control
- Freight forecasting
- Highway materials

While these projects focus on Alaska’s unique problems, each also relates to national and, in some cases, international problems. Many center on specific issues; for example, several projects address soil-structure interaction during seismic events. The 2002 Denali Earthquake refocused attention on understanding how seismic energy moves from the soil to a structure, especially in frozen or partially frozen soils. While each project focuses on a specific portion of this wide issue, participating agencies and overlapping peer review panels assure coordination.

Our partners in this year’s projects include five universities, the Alaska Department of Transportation and Public Facilities, the Alaska Railroad, the Denali Commission, the Canadian Government, and many members of the private sector.

To learn more about any of these projects, visit our research website at www.uaf.edu/ine/AUTC/ProjectPages/.
INTEGRATED VEGETATION MANAGEMENT ALONG ALASKA’S HIGHWAYS

AUTC researcher and civil & environmental engineering Professor David Barnes is working hand in hand with the Alaska Department of Transportation & Public Facilities, 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.

Traditional mowing methods have become too expensive to be effective in providing the sight distances necessary to avoid vehicle-animal collisions. Currently AKDOT&PF spends about $2 million annually on mowing. Roughly 1,500 “moose vs. car” accidents occur in Alaska every year; they result in lost human lives as well as wildlife, and cost the public another estimated $2 million annually. In many cases, mowing, which creates an enticing smorgasbord of young willow sprouts, only attracts more moose.

This research team is evaluating new strategies for managing tall, woody species (like willows) as well as for discouraging non-native invasive species (such as dandelions, vetch, and sweet clover). Strategies include combining mechanical and chemical control methods. Over the last two summers researchers conducted controlled field tests in Delta Junction and Valdez, Alaska, to determine how effective a combination of mechanical brush cutting (mowing) and herbicide application might be in controlling vegetation growth.

One big question is how herbicides behave once they enter our sub-arctic soils. Where do they go, and how long does it take for these chemicals to dissipate? As our research partners evaluate the overall effectiveness of each control method, we seek to quantify what happens to the herbicides used in the field test over the long term, and what effects they might have on the surrounding area.

Researchers are currently focusing on two different herbicides, triclopyr (3,5,6-trichloro-2-pyridyloxacetic acid) and 2,4-D (2,4-dichlorophenoxy acetic acid), and two different application methods, standard broadcast spraying and a relatively new technology called wetblade mowing. Wetblade mowing applies the herbicide onto the cut stem of the vegetation as the blade cuts the stem; this greatly reduces the amount of herbicide that falls to the ground.

Determining the fate of these herbicides involves applying them to two different field sites. These sites are representative of climatic conditions common in the sub-arctic, which are very different from other climatic zones where other researchers have conducted similar tests. After application, researchers collect soil samples over time to determine the fate and, ultimately, the attenuation rate (the rate at which the concentration of the chemicals diminishes in the soil).

These study results will contribute to developing an integrated vegetation management plan that is both cost-effective and environmentally safe. In addition, this project is providing hands-on research experience for two graduate students in civil & environmental engineering, Stacey Frutiger and Will Rhodes (pictured above).
Evaluating Wearing Surfaces for the Yukon River Bridge

Two UAF structural engineering graduate students are researching decking materials for what most Alaskans call “the Yukon River Bridge,” also known as the E.L. Patton Bridge. This 1976 award-winner carries the Dalton Highway and the Trans-Alaska oil pipeline across the river at a 6% grade. Thirty feet wide, with six spans, it was designed to withstand -60°F temperatures, huge ice loads from the river, trucks hauling supplies to the oil fields, and the oil pipeline; perhaps, in the future, it will also carry a gas line.

AKDOT&PF built this bridge with an eye toward the future, using a state-of-the-art orthotropic steel deck. Although far stronger than a concrete structure, and capable of spanning far longer distances (a must for the Yukon River), this design could not support the weight of a permanent wearing surface such as asphalt, and the bridge was decked with layers of strong, light, Douglas fir.

A 6% grade may not sound steep, until you imagine driving up it in a loaded tractor trailer on a slick, icy, winter day. Truckers often use tire chains to cross the bridge, and maintenance crews have found that chains and snow removal damage the wooden wearing surface and reduce traction quickly.

The timber decking was replaced in 1981, 1992, 1999, and 2007. The trees that produced the original decking were massive old-growth firs, strong and close-grained. Subsequent decking has come from younger, softer trees. As timber quality has decreased, so has the time between replacements, while material costs always increase.

Leroy Hulsey, associate director of AUTC and a structural engineering professor at UAF, is leading a search for more cost-effective, lightweight alternatives. Graduate students Zachary Jerla and Wilhelm Muench are testing state-of-the-art materials, looking for one that can stand up to the everyday abuse Alaskans dish out. The team started by reviewing literature on tire chain damage; surface traction measurements for materials with wet, dry, and icy surfaces; and material performance as it relates to the orthotropic structure. As is often the case for construction in the High North, they found no reports on similar testing. It was time to blaze a new trail.

Wilhelm Muench (photo bottom left) designed a special traction testing machine that mimics the load and friction created by a truck crossing the bridge. Muench’s machine uses two rams and two load cells to measure the influence of a truck load on a test specimen. One ram applies a vertical load, while the other pushes or pulls the wearing surface under the wheel.

Zachary Jerla developed a load frame (bottom right) to test the structural flexibility of various possible decking materials. Jerla’s equipment performs both static and dynamic loading: In one test, a concentrated load (single point) is applied while strains and deflections are measured; in the other, a load simulating dual truck tires is applied while displacements and strains are measured.

This study is considering seven different systems: 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).

The team is conducting their tests at both room temperature and at -20°F. Experimental results to date indicate 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. Product performance tests will be conducted in the coming year, and these should provide the data needed to make design decisions on which wearing-surface materials will keep people and oil crossing the bridge for the foreseeable future.
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 major challenge and a hefty annual budget item. AKDOT&PF notes that 2006-2007 costs were about $18.3 million — almost $3,200 per mile of roadway! Regular maintenance operations often include a combination of plowing and salt distribution, usually sodium chloride (NaCl), which is readily available, inexpensive, and capable of lowering the freezing point of water, usually melting ice at moderately low temperatures.

As Alaska’s population and economy grow, traffic increases, and clear roadways become more and more important; just ask anyone who slid through a mirror-slick intersection last winter. 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 gradually becoming unacceptable.

This research project, headed by Ming Lee (above, right) and David Barnes of the UAF Civil & Environmental Engineering Department, examines the environmental impact of using salt to de-ice winter streets, as well as studying new snow and ice control technologies suitable for urbanized areas (that is, an area surrounding a small, central city and serving as home to at least 50,000 people) in cold regions. The city of Fairbanks, Alaska (population 31,324 in 2005), located in the North Star Borough (pop. 87,650) will serve as field site and case study for this project.

This research team will work with AKDOT&PF to examine existing snow and ice control practices, and to understand where road salt goes, and what effect it has on the environment, after it leaves the pavement. They will also explore using new technologies such as Geographic Information Systems (GIS) and Global Positioning Systems (GPS) to better plan and monitor local salt usage and a combination of snow and ice control strategies.

This project addresses two necessary and promising research areas in AUTC’s five-year road map: preserving the environment and maintaining facilities and equipment. In addition to making Alaska’s roads safer and its roadsides and waterways more healthy, ultimately this project will help departments of transportation throughout the world’s cold regions make the best of the money they invest in snow and ice control.
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 of permafrost very near 32°F). Both types of frozen ground are prone to degradation for various reasons, including above-ground construction activities and increasing average temperatures due to climatic warming. When ice-rich soils melt, 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. Even the active layer (soil that freezes in the winter and thaws in the spring) can influence the roads and buildings it supports.

Along with vast areas of frozen soil, Alaska has a lot of earthquakes. It is 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 dramatically increases the potential for soil liquefaction, which can be a serious threat to transportation and utility infrastructure, as many professionals observed during the November 3rd, 2002 Denali earthquake (magnitude Mw 7.9).

Soil that stays frozen can be quite strong, with a high load-bearing capacity, but engineers know little about how thawing soil behaves, especially under the stress of an earthquake. Because of this lack of knowledge, current infrastructure designs for transportation systems and utilities tend to be either overly conservative, with a huge price tag, or optimistically oversimplified, and of dubious reliability. This study promises to provide in-depth understanding of liquefaction in cold regions soils (that is, how water-rich soils behave under stress), and the results will support more cost-effective and reliable designs.

This project, headed by UAF Civil & Environmental Engineering Professor Kenan Hazirbaba (bottom right), is conducting laboratory studies to investigate the liquefaction resistance of frozen and seasonally frozen ground. Two sets of tests are underway: One set focuses on evaluating how soil liquefaction is influenced by freeze-thaw cycles in the seasonally frozen (active) soil layer. The second evaluates how liquefaction is influenced by temperature distribution in degrading permafrost. The results of these tests will help establish criteria for liquefaction susceptibility in soils that regularly undergo freeze/thaw cycles and for melting permafrost.

Hazirbaba’s research team will produce a database on how cold regions soils tend to behave under seismic loading conditions, as well as design recommendations for transportation and utility transmission infrastructure in these areas. This project also supports two graduate students specializing in cold regions earthquake engineering.
**Using Geofibers and Synthetic Fluids as Stabilizers for Marginal Soils**

At the foundation of most runways, railways, roads, and utility corridors, you need at least one thing: some fairly stable dirt. Different soils compact in different ways, depending on the size and distribution of the soil grains, how much water is present, how well the soil drains, and whether the soil is cohesive or cohesionless (that is, does it tend to stick together, or not?). At least as far back as the Romans, builders have tried to improve weak and shifty soils, often by adding a soil stabilizer—a mineral, chemical, or some other material to make a stronger, more durable foundation material. Some soil stabilizers are used to control dust, often by causing tiny soil particles on a surface to clump together. Other stabilizers can improve a soil by increasing its load-bearing capacity. Still others improve soil strength by enhancing its ability to drain and to resist erosion.

Many Alaskan soils are made up of glacial silt, which is notoriously fine-grained, frost-susceptible, and susceptible to erosion and collapse if not improved or treated. Builders in Alaska have tried many strategies for improving foundations, from using concrete to giant rolls of plastic netting.

Peak Civil Technologies (PCT), an Alaskan company, may have another solution. PCT has developed a combination of two stabilizers, a plastic fiber to increase soil strength (Geo Fiber 3627BT) and a synthetic fluid that “replaces” water in the soil (Severely Hydrotreated Paraflinic Liquid). The picture above (top left) shows a mixture of silty soil and these two additives. PCT recently applied their soil stabilizer “combo” at Cape Simpson, on Alaska’s northwest coast, just below Cape Hope, on a runway site characterized by poorly graded sand (USCS class: SP; middle photo shows the application site). PCT plans to apply their combo to a new site, one characterized by silty sand (USCS class: SM), in Bethel, Alaska, on the Kuskokwim River.

But they have some questions first: How much geofiber is enough? How much synthetic fluid is enough? How much can this soil type be improved? And how poor a soil can a builder begin with?

AUTC has partnered with PCT to explore these issues. AUTC researcher Kenan Hazirbaba will lead a systematic experimental study to measure the resilient properties and compressive strength of the silty soil sample before and after addition of the new soil stabilizer combo. Tests include measuring the California Bearing Ratio (CBR) of soil samples compacted in the lab. In the photo below (bottom left), research assistant and mechanical engineering student Duane Davis performs a CBR test on a “fortified” soil sample. Hazirbaba’s team is also exploring the compressive strength of undrained, unconsolidated soils using triaxial compression tests.

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%.

This research could lead to cheaper and better railroads, roads, runways, and ultimately, mineral resource development.
Almost all paved roads are topped with a mix of hot asphalt and rocks, but not all hot mixes are the same; some don’t perform well under extreme temperature changes, and some applications wear out very quickly as the number and weight of vehicles using the roads increase.

As usual, Alaska’s varied environment means varied problems in paving infrastructure. In southeast Alaska, where temperatures are relatively warm and traffic is heavy, pavements tend to rut easily. In central and northern Alaska, where temperatures can shift from 95°F to -60°F in a single year, pavements suffer more from fatigue cracking (caused by a combination of traffic load and intermediate temperature change) and low temperature cracking (caused by extremely cold temperatures; that is, asphalt contracts, and after a certain point, other forces — the rock in the mix, the base support to which the asphalt is attached — restrain this contraction, and the asphalt essentially tears itself apart.). Every year, AKDOT&PF Maintenance and Operations workers spend roughly $10 million replacing worn-out, damaged pavement all over the state. State agencies and private companies alike are looking for ways to make our roads last longer.

“The first question to ask,” said AUTC researcher Jenny Liu, an expert in materials and pavement engineering, “is how does your asphalt hold up?” What kind of additives are being used? Polymers? Crumbed rubber (such as recycled tires)? A natural material like gilsonite?

Gilsonite (a natural, resinous hydrocarbon, mined in Utah and named for Sam Gilson, the first man to market it) is relatively cheap, easy to use, and combines well with asphalt. While it is a very popular choice in the rest of the United States, Alaska has been wary of gilsonite. Although it can improve asphalt performance in warm temperatures, in colder climates, gilsonite-modified asphalt can be very brittle. The solution is to add just enough gilsonite — but how much is that?

This project, funded by the company Sealmaster, 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 (above, right) prepared a range of samples using these gilsonite-modified asphalts, then, using UAF’s pavement testing facilities, subjected them to tests designed to simulate aging, rutting, fatigue cracking, and thermal cracking. Liu used her findings to determine the performance grade (PG) of these gilsonite-modified asphalt samples according to Superpave specifications.

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.

Liu’s next study will examine how her gilsonite-modified asphalt performs with aggregates (that is, rocks) in the lab. To learn more about this project, visit www.uaf.edu/ine/AUTC/ProjectPages/GilsoniteApplication.html.
NEWLY FUNDED PROJECTS

CHARACTERIZATION OF ASPHALT-TREATED BASE COURSE MATERIAL

Asphalt-treated bases are often used in new pavements in Alaska; the materials are available and relatively low-cost, but there is little detailed data on how these base materials perform in cold regions.

This study, headed by Jenny Liu, UAF civil & environmental engineering, will investigate 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. Study results will contribute to a pavement design manual for highway engineers, as well as benefit current Alaska pavement design systems, and encourage engineers to use more locally available materials.

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 a good way to highlight any weaknesses 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 (the bridge below is a good example).

This project, headed by Michael Scott of Oregon State University (below, left), will develop software customized for pushover analysis of Alaska-style bridge bents. Ultimately, use of this software will help reduce the cost of new bridges by minimizing the time AKDOT&PF engineers spend analyzing their designs for earthquake loads.

DEVELOPING AMBIENT PM\textsubscript{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\textsubscript{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 exhaust, smoke stack exhaust, and all the other pollutants everyday living produces, allowing them to build up to dangerous levels in the air we breathe.

The Fairbanks North Star Borough needs a strategy for improving air quality when the temperature dips down to -30°F and stays there. This project, lead by Ron Johnson of the UAF Mechanical Engineering Department (right photo shows Johnson and graduate student Tom Marsik), will collect and analyze field data relating to air quality and meteorology, with an eye toward identifying the major contributors of PM\textsubscript{2.5} and how we might better manage these sources.
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 considerably damaged 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 (above, left) in the UAA Civil Engineering Department, will combine 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. Project results will contribute to new guidelines to help engineers design better highway bridges and embankments in Alaska.

Guidelines for Risk Analysis in Construction Contract Changes

Work changes are common in construction contracts, especially for large projects. When contract changes must be made, how the owner (the organization paying for the work) and the contractor (the firm performing the work) agree on a fair and reasonable cost can be as complex as a good poker game. It is usually in the owner’s best interest to negotiate a lump sum price for changes before the new work starts (forward-pricing). Forward-pricing passes considerable risk (such as work delays, changing weather, getting new materials to remote sites, and re-scheduling other projects) to the contractor, who deserves some compensation for assuming it. The owner wants the best deal possible, and the contractor is the best judge of his (or her) own costs. 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, lead by UAF engineering science management specialist Robert Perkins (middle picture, right), will produce a guide for AKDOT&PF managers and engineers that will better prepare them for judging project risk and estimating costs.

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 becomes trapped on top of the frozen layer, and roads across Alaska are suddenly almost floating on a softer foundation. Too often, the 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 Jenny Liu, will investigate base course materials commonly used in Alaska’s roads, observing changes in 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.
Investigating Methods for Maturing Concrete in Very Cold Weather

In-place tests can be used to estimate concrete curing strength during construction so that building operations can be performed safely or curing procedures can be terminated. Compression tests performed on field cylinders do not represent the strength of the concrete as it exists in the structure. The maturity method, when properly employed, provides a good estimate of concrete strength. This research, headed by Yongtao Dong of UAF (below, left), will develop maturity protocols to facilitate in-place estimation of concrete strength for construction projects.

The maturity parameters (that is, activation energy and temperature data for concrete types commonly used in cold regions) will be determined through lab experiments designed to monitor the thermal history of concrete samples cured under a range of temperatures. This information will be compared with the results of uni-axial compression tests for these samples.

Dong will also instrument several ongoing construction projects with embedded electronic maturity meters in order to collect a thermal history at critical locations on a structure. Ultimately, this project 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.

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 can cause respiratory ailments and affect food harvests for people who live off the land, as well as reducing road visibility.

In addition, this loss of fine material also reduces road surface quality, increasing maintenance costs as well as wear and tear on vehicles.

Everybody agrees there is a 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 David Barnes (UAF CEE; below, right) will develop a dust control research map that identifies and prioritizes critical areas, design instrumentation and methodology to accurately monitor dust production on roads, and use these tools to support AKDOT&PF in field testing various dust control measures in several locations.

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 it 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, expert in getting minerals out of the ground and into industry, is the man to help. Metz’s team will examine information collected from multi-national sources, then use it to improve computer models for estimating the contribution that mineral products could make to railway development (as freight and as a way to economic diversity).

Project tasks include 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. The photo above (left) shows a sample rich with lead, zinc, and silver. A large deposit (over a billion tons) of similar ore lies along the border between Yukon and the Northwest Territory. This partnership involves both the state of Alaska and several provinces in western Canada.

**Preservation of the Alaska Highway**

The only terrestrial link connecting Alaska to the contiguous United States is the Alaska Highway; it is an important transportation line for people and goods going in and out of the state. If you drive between Tok and Haines, Alaska, you will see (and feel) the bumpy effects ice-rich permafrost can have on a road. In the Yukon, highway reconstruction in the mid-1990s damaged the organic layer that insulated and protected the permafrost. Since then, heat transfer through the road has been melting the ground ice beneath and around it. The steadily thawing and settling ground has created dips, bumps, potholes, and cracks. Throughout these 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, will test possible ways to slow permafrost degradation.

This project, lead by Daniel Fortier (above, right), expert in frozen ground research for the Institute of Northern Engineering, used aerial photographs to identify terrain characterized by ice-rich permafrost. Researchers chose a test site near Beaver Creek, Yukon Territory, that is typical of the landscape along much of the highway. Preliminary drilling indicates the permafrost is ice-rich down to 10 meters. The site contains several inactive (unmelted) ice wedge networks. UAF labs are analyzing samples collected this past summer to determine the permafrost’s geotechnical properties. Under the road embankment, the soil has thawed to depths of 1 to 4 meters, and some areas already remain unfrozen year-round. The team will complete permafrost characterization before the spring 2008 construction of the test section. Electrical resistivity and ground-probing radar will be used to image the extent of the maximum thawed zone under the road embankment and to determine the stratigraphic contacts in the undisturbed ground.

**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 will study 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, lead by AUTC’s Leroy Hulsey, will combine 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 data collected in this project will contribute to further frozen ground and seismic studies.

**Seismic Design of Deep Bridge Pier Foundations in Frozen Ground**

More and more Alaskan bridges rest on drilled shaft foundations, where a shaft is constructed deep in the soil using reinforced concrete, sometimes with a steel casing. Bridge columns are built atop these foundation shafts (an example shaft and bridge appear below). 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. When an earthquake occurs, the foundation shafts respond by yielding and forming a “plastic region” in particular areas and controlling the lateral force that actually impacts the rest of the bridge. The location of these plastic regions, as well as their length, depends, largely, on the properties of the surrounding soil. But what if these properties change after the bridge is built?

Frozen soil behaves differently than unfrozen, and this drastically changes where and how these plastic “hinges” form. A bridge built to withstand a large magnitude earthquake in warm weather may fail in cold, essentially because the lateral force demand on the bridge is 40 to 50% higher at -20°F. This project, lead by Sri Sritharan (below, left), Department of Civil, Construction, & Environmental Engineering at Iowa State University, will develop two design methods for drilled shaft foundations, both customized for Alaskan bridges, in frozen conditions, increasing the likelihood that bridges will survive both summer and winter earthquakes safely.

**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 (Chiao), Civil Engineering, Washington State University (below, right), takes the first important steps toward developing, manufacturing, testing, and implementing Smart Honeycomb Fiber-Reinforced Polymer (S-FRP) sandwich materials for various transportation construction applications, particularly highway bridge decks in cold regions. This novel material (an example appears below, second from the right) will integrate advanced composite materials with sensors and actuators to form structures capable of improving construction speed in cold climates and self-monitoring structural conditions in remote sites. Ultimately, this new decking might include a polymer wearing surface better suited to snow and ice control.

This study is a partnership of Washington State University, University of Alaska Fairbanks, and Kansas Structural Composites, Inc. In the first year, researchers will focus on analyzing the dynamic response analysis of S-FRP sandwich decks and optimizing sensor and actuator distribution, lab testing prototype decking/sensor sandwich structures, developing a self-sensing and monitoring strategy for the new materials, and fabricating samples for testing.
AUTC gears its outreach and technology transfer efforts toward building strong relationships with both local and extended professional communities, and toward introducing these communities to the latest transportation research available. In many ways, 2007 was a year of partnerships, of combining our resources with both local and national groups to further mutual goals. AUTC worked to raise awareness of our work in several different forums.

Locally, our researchers regularly attended AKDOT&PF meetings on special topics selected by staff in the traffic, materials, and construction engineering departments. Our goal was to support these engineers in understanding and addressing problems they identified. AUTC also partnered with AKDOT&PF to offer professional classes to local transportation engineers. This is the first step in developing a continuing education program customized to meet the needs of state engineers, as well as local governments and companies in the private sector.

On a national level, our researchers and staff made presentations at several professional meetings and conferences, as well as publishing a newsletter (available online at www.uaf.edu/ine/AUTC/) featuring current research, education, and technology transfer activities.

AUTC is an affiliate of Transportation Northwest, pursuing opportunities for joint research and education projects benefitting the Northwest region. AUTC is a member of the Northwest Transportation Consortium, a consortium of University Transportation Centers which provides a venue for collaboration on projects and issues important to transportation in the Northwest. As part of this group, AUTC is participating in specialized research committees and helping to develop an extensive system for distance education that will draw resources and expertise from the Pacific Northwest to benefit students throughout the area. As part of the Western Alliance for Quality Transportation Construction, a group of 12 states and federal
agencies, AUTC is working to standardize test methods (WAQTC, AASHTO, & ASTM), to seek accreditation for the Transportation Technician Qualification Program (TTQP), and to contribute to national research, training, and technology deployment programs.

The following are a few highlights of this year’s outreach activities.

**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.

Together AUTC and Alaska R&T² participated in UAF’s Alaska Summer Research Academy. This summer camp is designed to introduce young people to science and engineering. Our faculty and graduate students worked to involve campers in projects that ranged from bridge building and pavement testing to designing more effective traffic signs for the college campus.

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.

AUTC also contributed to LTAP’s sister program, the Tribal Technical Assistance Program. Among other goals, TTAP seeks to help Native American communities become aware of tribal transportation issues through education and training. Together with TTAP and the UAF Interior-Aleutians Campus, AUTC is working to provide transportation education and technical assistance to Alaskan villages.

**Pavement Design Course**

AUTC, in cooperation with the UAF College of Engineering & Mines, offered a semester-long pavement design course to 20 AKDOT&PF employees and 5 graduate students. Using the AKDOT&PF technology transfer classroom in Fairbanks, Jenny Liu taught the fundamental theories of pavement design, including how different materials, construction techniques, and environmental factors influence pavement performance. She also covered several design methods for flexible pavements suited to highway and airfield use, and how these designs can best be applied in cold regions, as well as how to apply these strategies to pavement repair and rehabilitation.

“Teaching such a wide range of students, with very different backgrounds and needs, was very challenging,” notes Liu. “I’m already planning for the next class.”

**Mat-su Borough Chip Seal Program**

AUTC provided expertise, and assistance in evaluating materials, to the Matanuska-Susitna Borough as they developed a chip-sealing program to reduce maintenance costs and improve safety by reducing dust on local roads. This project, funded by the Alaska Legislature, will ultimately develop a procedure for successfully resurfacing existing roads with minimal preparation.

**Logistical Support for NICOP**

As part of its rapid response program, AUTC is supporting the Ninth International Conference on Permafrost, which will take place on the UAF campus June 29 through July 3, 2008.

NICOP will host researchers from all over the world (over 600 abstracts have been accepted) who are focused on developing a comprehensive view of the thermal, ecological, and engineering state of permafrost.

Together these scientists are building a coherent understanding of how cold regions environments may change in the future, and this knowledge is vital to AUTC’s research activities, which include developing an understanding of Alaska’s rapidly changing climate, with its associated impacts on the design, construction, and maintenance of the state’s infrastructure.

This conference reflects AUTC’s goal of sharing knowledge and resources with the international community; with AUTC’s help, NICOP will offer reduced conference costs to assist young investigators and scientists, as well as publish an extensive set of research proceedings detailing the work of this historic conference.
**Undergraduate Participation in Research**

This year AUTC projects provided hands-on research experience to nine undergraduate students in areas from air quality to road rehabilitation. These unique experiences offer invaluable practical job experience to students before they enter the work force, and often influences students to think about a career in engineering research.

One good example is senior Eva Stephani (geological engineering; pictured below), who joined an AUTC research project this past summer. She assisted in collecting soil cores as part of the “Preservation of the Alaska Highway” project (see page 20). In November 2007 she will return to the field to collect data through ground-penetrating radar, profiling the roadbed and surrounding area to define the depth of different soil layers.

Stephani loves the “practical aspect” of fieldwork: “You learn so much when you see and touch things, as opposed to just learning the theory. In the field, you can really see the nuance of what you only study in the classroom.” She says that her mentor, Daniel Fortier, is very good at explaining every aspect of the work. “The field is really his domain,” notes Stephani. “It’s very motivating, to be involved in a research project; you see the classwork in a new way.” She hopes to continue her studies in permafrost in the UAF graduate program, and looks forward to many more field seasons.

Including undergraduates in research also creates mentoring opportunities for graduate students. “I like to assign mentoring responsibilities to my graduate students,” says Leroy Hulse, AUTC associate director. “It provides graduate students with opportunities to teach others, and enriches their educational experience. The undergraduates get to experience performing actual research, and they get to watch another researcher — the graduate student — consider the same problem; it gives them a sense of alternatives, and perspective.”

**Permafrost Tunnel Tours**

AUTC-affiliated faculty look for ways to extend their research into the public sphere, and permafrost expert Yuri Shur (UAF civil & environmental engineering) has access to one of the best learning labs available in Interior Alaska.

Shur (below), who has been studying the properties of frozen ground for over 30 years, gives tours of the CRREL Permafrost Tunnel to students such as Alex Vraa (above) and other groups; it is the perfect opportunity, Shur notes, to talk about the complex and numerous mysteries of frozen ground. Working with his postdoctoral researchers, he has entirely re-written the “history” of ice in the tunnel, and he tries to pass this new perspective along to the visitors. “Many students — the first time they enter the tunnel — what they say is ‘dirty, smelly, cold!’” says Shur. “I hope to show or tell them something so unusual, that they’ll think about studying permafrost themselves.”
Wilhelm Muench (left) won this year’s AUTC Outstanding Student Award, which allowed him to attend the Transportation Research Board 86th Annual Meeting held in Washington, D.C. on January 21–25, 2007.

“Twelve thousand engineers all in a small area makes for an interesting bunch,” said Muench, who spent four days attending presentations on structures and bridges. His favorite was “Load and Resistance Design of Concrete Bridge Superstructures.” This type of structural design appeals to Muench, he said, because it allows an engineer to sketch out so many possible creative solutions (the sketch below is one of his alternatives). Although many designs are based on simple assumptions about stress and shear, “in reality, what’s happening in a beam is very complicated.” Many structural details common to bridge abutments, for instance, require more complex designs.

According to session presenter Shrinivas Balkrishna Bhide, Muench noted, “managers will hate this design method, because you can give the same problem to 20 engineers, and they’ll all give you different, correct answers.”

Muench, who is from Ketchikan, Alaska, completed his M.S. in civil engineering this summer. In the future, he said, “what I should do is get a job in Fairbanks involving structural engineering, but I may run away and go surveying.”

Muench was chosen as AUTC’s Outstanding Student of the Year based on his grades and demonstrated innovation in research testing.

Every University Transportation Center awards an outstanding student; this group shot of the nation’s most promising engineers and their mentors was taken at the 86th TRB Annual Meeting by the Mineta Transportation Institute.
Balancing Alaska’s unique needs with national transportation priorities can be a difficult task. Unlike most of the contiguous United States, Alaska’s transportation infrastructure ranges from a well-connected road network to isolated roadways and airports, often constructed using substandard materials and intermittently maintained. Factors such as omnipresent frozen or semi-frozen ground, a high level of seismic activity, arctic and subarctic climate forces, and sparse population render useless many traditional transportation planning, design, construction, and operational tools.

Although Alaska is the most seismically active state in the nation, both in terms of earthquake frequency and magnitude, current building codes are based on California seismic codes. In addition, these codes do not take into account contributing factors such as frozen and thawing ground or substandard soils.

All current climate models show the Arctic will be the first to undergo change. Alaska has already experienced significant shifts in temperature and rainfall over the last 30 years. Unfortunately, existing climate change models do not provide enough detail for engineers designing in northern regions. Many past construction practices have focused on preserving permafrost (in northern Alaska) or on managing thaw (in the south). Southcentral Alaska is experiencing increased rainfall, while the Interior is drying. Consequently, we find ourselves trying to adapt with inadequate information.

Balancing the needs of Alaska’s fragile environment with the need to provide transportation to an increasing population is a constant tug of war. Issues such as habitat conservation, water and air quality, and control of invasive plant species require that we better understand not only how transportation systems affect these problems, but also how access to lands near transportation corridors affects the environment. Resource and transportation agencies often find themselves in conflict because neither has adequate knowledge upon which to base their decisions.

Alaska is similar to the contiguous US in at least one way: throughout the country, federal transportation funding continues to decrease, even as need increases. The result is more and more new construction, and less and less upkeep. We have two choices: increase funding or reduce the cost of building and maintaining infrastructure.

Alaska’s contrary profile provides AUTC with an opportunity to explore new ideas that may ultimately benefit cold regions across the world. For innovative solutions to these issues, we must look for technologies that radically alter the way we build and operate.

This creates three challenges. First, we must encourage a broad change in engineering culture. Generally, engineers tend to avoid risk, favoring the tried-and-true over the new idea. Although successful for individual construction projects, this strategy can work against innovation and dissemination of new designs and techniques across the discipline. We must find ways to encourage engineers and decision-makers to invest in exploring new ideas that have potential, but no guarantee for success. Second, we must explore new funding alternatives. People’s attitudes toward publicly funded projects have changed in recent years; they are less supportive of system-wide improvements. Transportation decision-makers need to better understand public perspectives and find ways to demonstrate how system-wide changes benefit the individual. Third, we must find ways to reduce transportation costs. Possible avenues include designing longer-lasting infrastructure, finding less expensive construction techniques, and improving transportation system operations as well as efficiency.

A review of the this year’s AUTC project list (see pages 10–24) reveals a focus on soil structure interaction as it relates to seismic activity, increased use of locally available marginal materials, dust and vegetation control, and air quality. We are encouraging our researchers to review existing practices, adapt those that show promise, and to be creative in developing new technologies. Success depends on convincing decision-makers that investing in more speculative research is investing in our future. In the long run, we cannot fail if we gain knowledge and put that knowledge to work.

AUTC’s primary goal over the next year is to improve integration of research across transportation modes. Our governing board continues to challenge us to make the maximum impact with our research and educational activities. The board recognizes that all transportation modes have common needs and that the solution to one mode’s problem can perhaps be adapted to other modes.

A second goal is to increase AUTC’s presence in the transportation community through outreach programs such as workshops, training, and aid to transportation agencies. To this end, we are working to provide professional certificates for construction management. In the future we hope to offer professional certificates in other transportation areas.

In order to truly influence a transportation community, we must identify ongoing transportation problems, address them with research, then disseminate our findings to this community through education and training.
The chart above illustrates funds expended and committed by category for FY2007. Research and research-related administrative costs accounted for 54% of our funds. Funding for outreach and education activities was approximately 22%, with 14% additional funds committed to technology transfer. General administrative costs were roughly 10%.

The chart below represents total expensed funds for FY2007 by source. Federal dollars accounted for 44% of our funding; various state agencies supplied 34%, the University of Alaska Fairbanks supplied 20%, and 2% was provided by private sources.
PHOTO CREDITS

Front cover photos: see front inside cover. Back cover photos: Top right photo by Billy Connor. Bottom left photo courtesy of AKDOT&PF Bridge Design.

Pg 2: Billy Connor, Director, Alaska University Transportation Center. Photo by Sandra Boatwright, INE Publications & Proposals Office.

Pg 3: Don Young, Alaska’s Representative to the US Congress. Photo courtesy of the Office of Congressman Don Young.

Pg 4: Top: Winter travel in rural Alaska often depends heavily on alternative types of transportation such as snow machines. Pictured are Institute of Northern Engineering Director Daniel M. White (foreground) and Civil & Environmental Engineering Professor David Barnes (background). Photo by Silke Schiewer. Bottom: Summer travel can include long traffic stops for road repair. Here motorists wait on the Parks Highway, which runs between Fairbanks and Anchorage. Just visible in the background is Denali (sometimes known as Mt. McKinley), the highest peak on the North American continent. Photo by S. Boatwright.

Pg 6: 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 Kala Hansen. Bottom of page: Panoramic shot of the AUTC Board and other visitors, taken at the July 2007 US DOT site visit. Pictured from left to right are Bruce Carr, Gary Gustafson, Billy Connor, Leroy Hulse, Jeff Ottesen, Jang Ra, Michael Downing, Rick Kessler, UTC Program Acting Director Thomas E. Marchessault, US DOT University Programs Specialist Robin Kline, and Lance Wilber. Panorama by Matt Nolan. To learn more about Nolan’s panoramic work and its applications in field research, visit www.uaf.edu/water/faculty/nolan.

Pg 7: Photo of Karen Schmitt courtesy of University of Alaska Southeast. Photo of Sandra Boatwright courtesy of S. Schiewer. All other photos by K. Hansen.

Pg 8: Bottom left: Duane Davis. Photo by K. Hansen. Top Right: The Trans-Alaska Pipeline System runs 800 miles from the North Slope to Valdez. In 2001, roughly 1 million barrels of oil a day traveled the pipe. About 75% of the pipeline crosses permafrost. In some areas, the pipeline is elevated above ground to keep the permafrost from melting. In the right foreground is an example of a thermosyphon system, which keeps the permafrost beneath the pipeline frozen and stable. Photo courtesy of the Institute of Northern Engineering.

Pg 9: Top right: Ice wedge photo by M. Kanevskiy, INE research faculty. Bottom right: Wetblade mower photo by Daniel Debord.

Pg 10: Photo taken on the Matanuska Glacier, Alaska, showing a moulin (a hole in the glacier caused by snow melt water flow at the glacier’s surface. Photo by M. Kanevskiy.

Pg 11: Bottom left: Herbicide application at a Delta Junction, Alaska, field site. AKDOT&PF partnered with AUTC researchers for all field applications for this project. Photo by Daniel Debord. Top right: UAF graduate students Stacey Frutiger and Will Rhodes conducted field and soil sample testing in support of the Integrated Vegetation Management project. Photo by Todd Paris, University Marketing & Publications.

Pg 12: Bottom left: Graduate student Wilhelm Muench uses the traction testing machine he developed to collect data on how a smooth tire performs on various decking samples. Photo by Zach Jerla. Bottom right: Graduate student Zach Jerla operates the load frame he developed for exploring damage caused by load and friction on possible decking surfaces for the Yukon River Bridge. Photo by Wilhelm Muench.


Pg 14: Top: Extensive sections of Alaska are underlain by permafrost. As ice-rich soils thaw (note striated areas in the exposed bank, below the vegetation), the degrading ground can “slump” or collapse, creating areas that are prone to further warming and erosion. Photo by M. Kanevskiy. Middle: road damage due to soil liquefaction during an earthquake. Photo courtesy of AKDOT&PF. Bottom: AUTC faculty Kenan Hazirbaba. Photo by K. Hansen.

Pg 15: Top: The bowl shows a mixture of silty soil and two soil stabilizers. Photo by K. Hansen. Middle: Peak Civil Technologies personnel apply soil stabilizers
to a test site in Cape Simpson, on Alaska's northwest coast. Photo courtesy of Peak Civil Technologies. Bottom: Student Duane Davis performs CBR testing of soil samples in a UAF soil testing lab. Photo by K. Hansen.

Pg 16: Left to right: AKDOT&PF personnel apply asphalt to an airfield site. Researcher measuring rutting damage in an Anchorage intersection. Pavement showing signs of fatigue cracking. All three photos courtesy of AKDOT&PF. AUTC researcher and professor Jenny Liu in her asphalt testing lab. Photo by K. Hansen.

Pg 17: Left to right: Asphalt application as part of the Matanuska-Susitna Borough Chipseal Demonstration Project. Photo courtesy of Matanuska-Susitna Borough Operations & Maintenance. Professor Michael Scott of Oregon State University sets up equipment and facilities for an AUTC-funded project, "Alaska Bridge Bent Pushover Software, Including Concrete Effects." Photo courtesy of OSU. A Fairbanks, Alaska bridge built using the Alaska-style Bridge Bent Design; these vertical piers are made of steel shells surrounding reinforced concrete. Photo by K. Hansen. UAF Mechanical Engineering Professor Ron Johnson and graduate student Tom Marsik install instrumentation for collecting data on airborne fine particulate matter near a Fairbanks home. Photo courtesy of Institute of Northern Engineering.

Pg 18: Left to right: University of Alaska Anchorage Professor of Civil Engineering Zhaohui Yang. Photo courtesy of UAA. Bridge support showing evidence of earthquake damage. Photo courtesy of AKDOT&PF. Negotiations over work changes in construction contracts can sometimes be tense, as AUTC Associate Director J. Leroy Hulsey (left) and UAF Professor of Engineering Science Management (right) demonstrate. Photo by K. Hansen. Road showing pavement damage characteristic of poorly draining foundation materials. Photo courtesy of AKDOT&PF.


Pg 20: Left to right: A sample containing lead, zinc, and silver ore. A large deposit of similar ore (over a billion tons) lies along the border between the Yukon and Northwest Territories. Photo by K. Hansen. Coal cars await unloading at the University of Alaska Fairbanks power plant. Photo by S. Boatwright. INE researcher Daniel Fortier spent the summer of 2007 using soil coring equipment and collecting data for the "Preservation of the Alaska Highway" project. Soil core collected as part of the "Preservation of the Alaska Highway" project; note the ice crystals throughout the sample, and most apparent in the upper right corner of the photo. Both photos by Eva Stephani.

Pg 21: Left to right: Professor Sri Sritharan, Iowa State University Civil, Construction, & Environmental Engineering. Photo courtesy of S. Sritharan. Construction of a steel-encased reinforced concrete deep bridge pier. Next photo shows completed bridge on the Parks Highway, Alaska. Both photos courtesy of AKDOT&PF. A sample of Smart Honeycomb Fiber-reinforced Polymer (S-FRP) sandwich material. Last photo shows Pizhong Qiao (Chiao), Professor of Civil Engineering, Washington State University. Both photos courtesy of P. Qiao.

Pg 22: Upper left: Charlie O'Brien, a student participating in the Alaska Summer Research Academy learns the basics of surveying. Lower left: AKDOT&PF surveyor Scotty Sexton teaches student Megan Hinzman how to use levels to establish the foundation height for a bridge, part of a new "walk among the treetops" center for the UAF Georgeson Botanical Gardens. Ultimately, the popular tours will include a short talk about how bridges are designed. Upper right: AKDOT&PF staff participate in a "Learn to Return" seminar, about safely exiting a downed plane. All three photos courtesy of the Alaska R&T. Lower right: Graduate student Wilhelm Muench demonstrates his traction testing machine for an ASRA class. Photo by K. Hansen.

Pg 23: Bottom left: Undergraduate Eva Stephani, research assistant for the "Preservation of the Alaska Highway" project. Photo by K. Hansen. Upper right: Alex Vraa, ASRA student, tours the CRREL Permafrost Tunnel as part of his class in civil engineering. Photo courtesy of ASRA. Lower right: UAF CEE Professor Yuri Shur. Photo by K. Hansen.

Pg 25: Upper left: Wilhelm Muench, AUTC Outstanding Student of the Year. Photo by K. Hansen. Lower right: Every University Transportation Center awards an Outstanding Student; this group shot of the nation's most promising engineers and their mentors was taken at the 86th TRB Annual Meeting by the Mineta Transportation Institute.
The old Willow Creek Bridge (right), located near milepost 35.2 of the Hatcher Pass Road, is the oldest standing through-truss highway bridge in Alaska.

Alaska Department of Transportation & Public Facilities documents suggest that it was built in the early 1920s, part of the Willow-Fishhook Road, to support the mines operating in the Hatcher Pass area. The construction was most likely part of the Alaska Road Commission upgrades begun in 1922.

The design of the bridge structure is impressive in its simplicity and its hardiness.

The bridge was last repaired in 1970 (when the photo below was taken), and has been out of service since 1975. The new bridge is located just upstream of the old; it carries thousands of Alaskans and tourists into Hatcher Pass every year.