Innovative SHM System on the Chulitna River Bridge

By: Leroy Hulsey, AUTC Researcher
Professor of Civil Engineering, University of Alaska Fairbanks
James Harper, AUTC Communications Specialist

This fall, AUTC and Alaska DOT&PF installed a first-of-its-kind structural health monitoring (SHM) system on Alaska’s Chulitna River Bridge. With concerns about the 42-year-old bridge’s service life, state engineers will use the SHM system to assess the bridge’s longevity and determine whether to post weight restrictions on permit and other heavy-load vehicles.

The SHM system developed from a research project titled “Structural Health Monitoring and Condition Assessment of Chulitna River Bridge”— a partnership between AUTC, Alaska DOT&PF, and Chandler Monitoring Systems, a leading fiber optic and structural health monitoring company. Led by AUTC researcher and UAF Civil Engineering Professor Leroy Hulsey, the team is saving significant costs and enhancing transportation safety with an SHM system that remotely transmits bridge conditions without requiring constant in-person checkups.

constructed in 1970, the Chulitna River Bridge is located at Historic Mile Post 132.7 on the Alaska Parks Highway. A continuous bridge with two exterior steel plate girders and three sub-strings, the original structure was 790 feet long with five spans and a 34-foot-wide, cast-in-place concrete deck. Heavy overload vehicles carrying up to 410,000 pounds frequent this route—the most direct surface link between Anchorage, Fairbanks, and Prudhoe Bay oil fields.

Concerns about this bridge are not new, as Alaska DOT&PF has completed several structural enhancements. In 1993, the bridge deck was increased to 42 feet 2 inches by replacing the original cast-in-place deck with precast concrete deck panels. To accommodate increased loads, Alaska DOT&PF also strengthened two original exterior plate girders, added steel bracing to the piers, and installed three new longitudinal steel trusses utilizing the original stringers as top chords.

To assess the bridge’s current structural performance under extreme conditions, the project team installed a real-time fiber optic structural monitoring system that provides dynamic off-site bridge monitoring. By measuring structural monitoring instruments at the bridge and relaying the data 1.7 miles to a transmission station, this system lets researchers remotely determine if bridge girders are overstressed for standard highway loads and permit vehicles.

The SHM system can operate indefinitely in extreme conditions (to -55°F). To survive, it has received many custom modifications. A power backup system was programmed to shut down in case of a power outage, and restart by automatically launching all programs. The power backup system was perfected through a series of 10 tests, and relies upon a redundant Internet connection to automatically switch to wireless communications in case of connection failure.

The 42-year-old Chulitna Bridge.
Photo credit: Mike Fisher.

Innovative SHM System on the Chulitna River Bridge continues on page 7
Evolving Partnerships and Stakeholder Service

The past year has brought quite a change in the landscape of University Transportation Centers (UTCs) with a re-competition and the new direction it created. The process has caused us at AUTC to reevaluate our position and strategic direction. We sat down with our partners and stakeholders to discuss our current and future relationships. It is what we have learned from these discussions that I wish to share.

The first thing I learned is that if we focus solely on funding, then we will likely fail. If we focus instead on our relationships with those we serve, and provide for their needs, we will likely succeed. There is nothing new here. This is simply good business.

The second thing I learned is that many of us feel that our stature as a university makes us the undeniable experts in our fields. The truth is, we are not. There are numerous transportation practitioners in the public and private sectors who—on a daily basis—solve the problems that make our transportation system work. They may use theory taught at universities as the basis of their decisions, but ultimately, they rely on their experience. In reality, once they have worked in the field awhile, they can get the job done without us.

This brings me to my third observation. If we are to truly help those we wish to serve, we need to fully understand and appreciate the issues they face. While theories and mathematical models form the basis of our design processes, it is experience that validates them. If there is a conflict between our models, it is the responsibility of the researcher to resolve those differences. We must remind ourselves that if a difference exists between the model and the physical world, it isn’t the world that is in error.

The final observation I would like to share is that we will likely be judged not by how scholarly our work is, but by how useful it is for our stakeholders. Einstein's Theory of Relativity wasn't made famous because of its mathematical eloquence. Rather, it was made famous by its ability to explain many of the observations that had perplexed the scientific community. In the end, it’s the applicability of our work that will determine our long-term professional and financial success. In short, we must work closely with our partners to help them do their work better.

So where do we go from here? We must create a forum in which practitioners work with researchers on equal footing. This isn’t very easy.

First, there is often a lack of defined common goals. I’ve sometimes said “If you know where you are going, the path will reveal itself.” Without well-defined goals, we don’t know where we are going. In coming months, AUTC will be consulting with its Governing Board as well as leadership and partners at Alaska DOT&PF and other organizations to help refine these goals.

Secondly, practitioners and researchers are from different cultures with different values. Too often we allow these differences to be a barrier to working together, but they can be a benefit if managed correctly. We have found success in funding projects that bridge significant culture gaps—between various countries, organizations, and professions. After all, customer service is the key to continued success.

Finally, researchers too often feel as though they must be in the lead of a project. I would argue that in a true partnership, the lead role must be shared. We must not view those we serve as partners of convenience. If we do, it may not be convenient for the relationship to continue.

Billy Connor
Director
bgconnor@alaska.edu

AUTC Newsletter
Published semi-annually by the Alaska University Transportation Research Center, Institute of Northern Engineering, University of Alaska Fairbanks, to inform readers about our research and outreach activities.

AUTC addresses issues related to research and technology themes as identified in the Highway Research and Technology Report (April, 2002), including 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.

For more information about our research, please contact:

AUTC
P.O. Box 755900
Room 245 Duckering Building
Fairbanks, AK 99775-5900

Or visit our web site: ine.uaf.edu/AUTC

Director
Billy Connor
bgconnor@alaska.edu

Program Assistant
Diane Wallace
autc@uaf.edu

Communication Specialist
Rob Harper
jharper11@alaska.edu

This publication is a result of funding from US DOT award DTRT06-G-0011.

The AUTC Newsletter is produced by the INE Proposals & Publications Office.

The AUTC Newsletter is produced by the INE Proposals & Publications Office.
Meeting the Needs of Alaska’s Engineering Workforce

By: Billy Connor, AUTC Director

AUTC and the University of Alaska system are dedicated to developing future leaders, especially in the field of transportation engineering. While our partners at Alaska DOT&PF move forward with a robust workforce-excellence initiative, we in the university system are working to meet the growing demand for Alaska engineers while expanding training for current engineers with a new career development program.

A recent study projected that Alaska will have 240 additional engineering job openings per year through 2018. This data also indicated a 10.3% growth rate in engineering careers in Alaska, with more than 700 new jobs and over 1,700 replacement jobs emerging by 2018.

The University of Alaska is responding to this workforce demand. In 2007, the Board of Regents approved an initiative to graduate 200 engineering students per year by 2014. In 2011, the Board also set a priority to more than double the annual number of baccalaureate graduates—a pace we have maintained for the last five years on both UAA and UAF campuses. And in 2012, the legislature authorized funding to build new facilities to address the growing challenges of cramped and out-of-date facilities at University of Alaska engineering schools. Plans for these facilities are already moving forward.

However, we at AUTC realize that simply graduating more new engineers isn’t enough. We must also help the practicing engineer continue to improve professionally. With this aim in mind, we are creating a three-phase career development Leadership Academy with our partners at Alaska DOT&PF. Hoping to educate for a career—rather than a single job—our goal is to provide the technical, management, and leadership skills that cultivate an employee’s upward mobility as career progress continues.

Engineers not only need to understand the engineering principles required to design a project, but also must grasp a project’s financial, environmental, public involvement, and scheduling requirements and have the communication skills to coordinate and complete the job.

AUTC is working with Alaska DOT&PF to develop a Level I Leadership Academy to ensure that employees have the skills to enter management. As the employee continues to advance, the curriculum includes more leadership skills delivered through a Level II Leadership Academy. Managers at this level learn about planning, employee retention and education, how to deal with external pressures, and how to set objectives and performance measures. Other topics include organizational theory, managing expectations, and program development. At the Level III Leadership Academy, department leaders are taught how to set organizational goals, develop positive relationships with external groups including the legislature, and get organizational results. Leaders are also provided tips on becoming proactive when addressing needed change or when faced with new challenges.

We are varying the way courses are delivered by including a mix of mentoring, traditional training, college-type classrooms with homework and testing, online coursework, and hybrid courses that use multiple delivery methods.

Our overall goal is to ensure that employees have the skills needed for their current job and are well prepared for their next job. We feel that this program complements the current scope of workforce-development goals within Alaska DOT&PF and fits the emerging needs of Alaska’s engineering workforce.

Milestones for Alaska DOT&PF’s Workforce Excellence Program

By: Amanda Holland, Division Operations Manager, Alaska DOT&PF
Chair, Subcommittee on Personnel and Human Resources, American Association of State Highway and Transportation Officials (AASHTO)

Alaska DOT&PF is committed to the creation and implementation of a strategic workforce-development plan that provides for the recruitment, retention, and professional growth of its workforce through a multipronged approach. Workforce planning is a systematic process for identifying and addressing the gaps between the workforce of today and the human capital needs of tomorrow.

The department began the Workforce Excellence Program in 2009 with comprehensive workforce data gathering and analysis that identified an initial need for education and raised awareness of workforce planning. The years 2009 and 2010 focused exclusively on establishing data gathering and analysis processes and preparing the department for implementation of a workforce planning program. Follow-up workforce surveys in 2010 and 2011 demonstrated a higher overall awareness and understanding of workforce planning and assisted the department’s leadership team in honing the department’s developmental needs.

Workforce Excellence, as the program is known, began department-wide activities in 2011. Tied directly to the department’s strategic plan and with complete executive sponsorship, the program focuses on leadership, professional and personal employee growth, employee retention, and effective workforce planning processes.

continues on page 7
How Will Energy Prices Impact Alaska’s Transportation System?

By: Ginny Fay, AUTC Researcher; Assistant Professor of Economics
Institute of Social and Economic Research
University of Alaska Anchorage

Introduction

Alaska’s economy was built around fossil fuel use at a time when it was inexpensive. Since then, key Alaska industries such as fishing, mining, tourism, transportation, and subsistence have grown to depend directly on liquid fossil fuels. In addition, Alaska’s urban service economy depends heavily on the low cost of living and doing business that has historically been assisted by cheap transportation fuels.

These conditions are changing rapidly and perhaps permanently. In 2005, Alaska consumed 40% more fossil fuel than any other state, according to the Energy Information Administration (EIA, 2012). By 2010, Alaskans consumed almost three times more energy than the national per capita average.

Alaska’s higher per capita energy consumption results from a variety of factors. Alaska’s remoteness and dispersed populations combined with a limited road system results in a dependence on air travel. In addition, our role as a major world air cargo and transportation hub, oil producer, and marginal refiner also contributes. This acute energy dependence creates a higher vulnerability to energy price volatilities and shocks. For state policy makers and industry, this vulnerability necessitates a better understanding of how energy prices and legislation impact transportation patterns and efficiency.

Since 2009, the Institute of Social and Economic Research (ISER) at the University of Alaska Anchorage has worked with AUTC to develop a model of Alaska’s transportation sectors to assess what might happen if fuel prices suddenly change. Titled, “Model of Alaska Transportation Sector to Assess Energy Use and Impacts of Price Shocks and Climate Change Legislation,” the project is helping illustrate and quantify the interactions between energy use, energy prices, and economic activity in Alaska.

Background

Given its geography, Alaska has long relied on aviation and marine transportation to move people and goods. Although Alaska is the largest state in the U.S., it has the fifth-lowest road mileage in the nation, leaving 82% of its communities unconnected to a state road system (Schultz, 2012). Residents of these areas primarily use expensive air passenger and consumer goods transportation. Their needs also drive demand for liquid fuels and construction materials that have both high initial and storage costs.

The reasons for Alaska’s limited road system are many, and its unusual dependence upon efficient inter-modal transportation will no doubt continue. Extreme weather, rugged terrain, vast distances, low population density, and scattered islands make future construction initiatives difficult and extremely costly when compared with the number of end users (ADOT&PF, 2008). Consequently, the major changes in Alaska’s transportation system have been primarily technological improvements within each transportation mode rather than major system changes.

In Alaska’s more populated areas, inter-modal reliance looks quite different. More than half of Alaska’s population resides within the Railbelt region, served by the Alaska Railroad and the state highway system, and a few other small urban areas in Southeast Alaska. This region, as a result, has competing transportation modes, services, and economies of scale for freight and passengers.

From an economist’s perspective, understanding Alaska’s highly inter-modal transportation system requires a focus on inputs and outputs that are specific to that system, especially energy resources.

The journey of freight goods to Alaska consumers is a good illustration. Most of Alaska’s food, household, and consumer goods that are shipped from the continental U.S. begin their journey from the manufacturing plant or distribution facility. Loaded onto trucks destined for ports in either Tacoma or Seattle, Washington, the goods travel to these locations where they are loaded onto a container ship, barge, or roll-on, roll-off vessel which sails to Alaska ports. If bound for a community connected to the highway system, the freight often completes its journey in trucks.
It may also transport north or south from or to the Port of Anchorage via the Alaska Railroad. Freight destined for towns off the road system is flown from either Anchorage or Fairbanks to a remote community. Then it is either driven by pickup truck if there is a regional road system or loaded onto smaller aircraft or boats for shipment to outlying villages. Quite often in remote areas, freight makes the final leg of the journey in sleds pulled by snow machines or on four-wheelers (ADOT&PF, 2008) (see photo right). Each leg of this journey involves a specific mode and energy resource, like liquid fuel.

Quantifying the energy needs of this intricate network requires a methodology informed by diverse data sources.

**Methods**

Understanding trends of an inter-modal transportation system requires multi-modal data. Marine shipping, barge, and trucking firms provided figures on their operations between 2006 and 2010. We also added information on Aviation modes provided by the U.S. Department of Transportation, Research and Innovative Technology Administration (RITA), Bureau of Transportation Statistics (BTS). This aviation data helped us model fuel consumption and costs per passenger mile and ton mile by aviation fleet type (U.S. DOT, RITA, BTS, 2010). Enhancing our data on maritime and rail modes, the Alaska Marine Highway System (AMHS), Interisland Ferry Authority (IIFA), and Alaska Railroad Corporation all offered statistics on their respective operations as well. Augmenting this data set, we also received information from individual companies, which we used in conjunction with secondary data to model the barge and trucking subsectors—both major Alaska industries.

**Analysis**

Three primary types of analysis are being conducted as part of this research. We are developing broad energy use statistics for each transportation subsector such as estimated total annual energy and fuel use, carbon emissions, fuel use per ton mile and passenger mile, and cost of fuel per ton mile and passenger mile. We are conducting economic input-output analysis, which estimates the employment and output of each transportation subsector in the Alaska economy. Input-output modeling assumptions will be adjusted to reflect fuel price shocks/changes and/or emissions taxes to estimate the potential impact of these changes on industry output and employment in the Alaska economy. In addition, we will conduct statistical analyses of the data to estimate changes in use patterns, efficiency and potential mode shifts across the industry during the studied time interval, including extensive fuel price volatility.

These results will give Alaska decision makers a better understanding of the state’s energy use, vulnerability to price shocks, and the kinds of transportation patterns, efficiency, and mode shifts that may accompany them.

**References**


As summer came to an end, AUTC and NASA gathered more than 100 business, research, and government counterparts from around the world for the second annual Cargo Airships for Northern Operations Workshop in Anchorage.

Sponsored by AUTC, the Institute of Northern Engineering at UAF, the NASA Ames Research Center, and ISO Polar, the workshop ran Aug. 22–24 at the ConocoPhillips Integrated Science Building at the University of Alaska Anchorage. There, a gathering of state and industry leaders as well as counterparts with many federal agencies examined how airships could transform Alaska’s commercial transportation system.

Lt. Gov. Mead Treadwell attended and gave the event’s keynote address. He outlined how airship technologies could move fuel, construction equipment, and supplies to villages and projects in rural Alaska in situations where ice roads, river ships, or barges prove unfeasible. He also highlighted the economic effects that could come from this technology, specifically how it might improve the feasibility of energy and natural resource projects across the state.

Commercial freight and shipping trends were also a key topic of discussion, as financial sector representatives outlined funding options that could make the technology feasible in Alaska.

Among the presenters was AUTC director Billy Connor, who discussed the workshop’s objective of addressing the feasibility questions about airship deployment in Alaska. He raised several major questions being discussed throughout the conference such as airship economic viability in Alaska, the potential performance of airships in the Arctic, infrastructure needs, and the kind of public-private partnership models that could make airships an option for the state.

The conference was part of a NASA-State of Alaska partnership originating from a 2010 agreement that positioned the state as an airship proving ground.

Pete Worden, director of the NASA Ames Research Center in Silicon Valley, was a main event speaker. He discussed the role airships play in NASA’s science research, opportunities with partners in the NASA Research Park, Airship Ventures, and the agency’s role in assisting the Department of Defense’s heavy-lift project with Aeros Corporation. Other speakers included former Lt. Gov. Craig Campbell, president and CEO of Alaska Aerospace Corporation; Alaska Sen. Lesil McGuire; and Tom Barrett, president of Alyeska Pipeline Services Company.

If the event’s goal was to stimulate conversations about the feasibility of airships in Alaska, it made a wide splash both in and out of state. From the Anchorage Daily News to the Seattle Times and Washington Post, extensive media coverage of the event included 11 print and online news outlets, 7 television stations, and multiple local radio stations.

Having received much positive feedback from attendees, event organizers are already in the planning stages for a 2013 workshop.

For more information about this or future workshops, visit the event’s web page online at http://event.arc.nasa.gov/airships/welcome.
The SHM system has been deployed with many custom modifications to ensure indefinite operation in extreme cold conditions (to -55°F). An on-site data collection system saves the data locally before transmitting it to a secondary data collection system maintained by INE IT at UAF. If all real-time communications with the on-site system are lost then the system will continue to store data locally until communications are re-established and the data can be transmitted to the secondary system at UAF. A backup power system is in place to shut down, and restart, the SHM data collection system in case of a power failure.

To date, the research team has conducted load testing and added an additional accelerometer sensor connection. The team spent the fall and early winter monitoring the equipment and analyzing data. Results from loading tests will be used to identify changes in load distribution for the girders and trusses. This data will identify structural changes and provide alerts when sensing systems approach or exceed established limits, and will be used to develop a SHM program for other bridges in Alaska. The next step in this research is to assemble the results and translate them into specific guidance for Alaska DOT&PF in helping it to determine whether to post weight restrictions on the Chulitna River Bridge.

Milestones for Alaska DOT&PF's Workforce Excellence Program

To maximize its effectiveness, the program has been designed to accommodate industry shifts and changing workforce demands. Training is administered via a website and is accessible at duty stations throughout the department. Workforce Excellence strives to identify and implement workforce development best practices in the transportation industry.

To date, milestone accomplishments include:

- Construction Management Graduate Certificate, available through the University of Alaska and the Alaska University Transportation Center – remote-learning option;
- Standards of Training Certification and Watch-keeping for Seafarers training;
- Generations in the Workplace training;
- A report entitled “Serving Future Transportation Needs: Succession Planning for a State Department of Transportation Organization, Its People & Mission,” conducted by the University of Alaska, Department of Civil and Environmental Engineering, prepared for the Alaska University Transportation Center and Alaska DOT&PF;
- Change Management training, delivered to leadership;
- Establishment of a Workforce Excellence website;
- Workforce Planning Communication Plan;
- American Association of Airport Executives Certified Member Program;
- Custom new employee orientation, including an employee entrance survey;
- Supervisor Toolkit, a department-specific resource for supervisors;
- Core Value Online Resource Toolkit, provides supervisor resources related to the department’s three core values; and
- Peer-to-Supervisor training, delivered twice to a total of 58 participants.

Alaska DOT&PF is launching a Mentorship Program - a voluntary program open to all department employees. Mentors and learners will be carefully matched for maximum success. The guidelines have been developed, volunteers have been identified, and a launch is underway.

Recent upcoming projects include a week-long Maintenance Leadership Academy for leads, foremen, and superintendents in the maintenance field and creation of a Leadership Development Program (tiered program primarily designed to develop leaders as they move into increasingly responsible management and executive roles). In addition, Workforce Excellence is refining an employee survey process to gather information for guiding future efforts to strengthen employee recruitment, development, and retention.

To date, Alaska DOT&PF is pleased with the success of the Workforce Excellence Program and is confident in its future.
Contents

Innovative SHM System on the Chulitna River Bridge 1
AUTC and Alaska DOT&PF installed structural health monitoring system on Alaska’s Chulitna River Bridge to determine the need for vehicle weight restrictions.

Director’s Notes 2
Stories in this newsletter highlight efforts to develop the knowledge and processes that will best serve Alaska’s transportation systems.

Meeting the Needs of Alaska’s Engineering Workforce 3

Milestones for Alaska DOT&PF’s Workforce Excellence Program 3

How Will Energy Prices Impact Alaska’s Transportation System? 4
Developing a model of Alaska’s transportation sectors to assess what might happen if fuel prices suddenly change.

AUTC Co-Sponsors 2nd Annual Airships Workshop 6
State, Federal and industry leaders examined how airships could transform Alaska’s commercial transportation system.