

Semi-Annual Report

University Transportation Centers Program

July 1–December 31, 1999

Prepared for

University Transportation Centers Program, U.S. Department of Transportation

Prepared by



**National Institute for Advanced Transportation Technology
University of Idaho**

Michael Kyte, Director
Judith C. Breedlove, Management Assistant
Donald Blackketter, Director, Center for Clean Vehicle Technology
Melissa Lines, Technical Writer

March 2000

Table of Contents

INTRODUCTION.....	1
INSTITUTE THEME	1
SCOPE	1
<i>Technology Transfer Center</i>	2
<i>Center for Transportation Infrastructure</i>	2
<i>Center for Traffic Operations and Control</i>	2
<i>Center for Clean Vehicle Technology</i>	3
PART A. CONTINUING SUCCESS: A SEMI-ANNUAL REPORT ON THE RESULTS OF THE UTC INVESTMENT	4
PEER REVIEW PANEL EVALUATION OF CONTROLLER INTERFACE DEVICE (CID)	4
NIATT STUDENT OF THE YEAR—DAN GERBUS.....	7
IDAHO ENGINEERING SCIENCE CAMP—1999	9
ONGOING UTC-FUNDED RESEARCH.....	11
<i>Actuated Control—Phase I: Oversaturation</i>	11
<i>Development of Video-Based and Other Automated Traffic Data Collection Methods, Phase II</i>	12
<i>Traffic Signal Summer Camp 2000</i>	13
<i>Advanced Vehicle Concepts Team Electric Vehicle,</i>	14
<i>Vehicle Performance Simulation</i>	15
<i>Biodiesel Fuel from Yellow Mustard Oil</i>	16
<i>Spark Ignition Engine Conversion to Aquanol Fuel</i>	17
<i>Diesel Engine Conversion to Aqualytic Fuel</i>	18
<i>Aqueous Alcohol Research—Reactor Studies</i>	19
<i>Optimal Design of Hybrid Electric-Human-Powered Lightweight Transportation.</i> 20	
<i>Designing Ply Orientations of Composite Laminates with Genetic Algorithms.....</i>	21
<i>Lead Acid Battery Development</i>	22
<i>High Performance Auxiliary Power Units</i>	23
PART B. RESEARCH PROJECT STATUS.....	24
PART C. FINANCIAL STATUS.....	25

INTRODUCTION

The National Institute for Advanced Transportation Technology (NIATT) was established in 1991 as part of the Intermodal Surface Transportation Efficiency Act. Since 1991, NIATT has grown both in size and scope. NIATT was granted institute status by the University of Idaho (UI) in July 1998 in recognition of its university-wide, multidisciplinary activities. In 1998, NIATT was funded through the University Transportation Centers (UTC) Program, along with 32 other university transportation centers. This report describes the results of UTC program funding from July 1, 1999 to December 31, 1999.

Institute Theme

Our theme is transportation technology. We develop, evaluate, and market technology products. We define a technology product to be hardware or software deployed to improve our nation's transportation system. We define hardware as systems or components for traffic control devices, vehicles, and infrastructure.

Scope

Four centers operate as part of our transportation institute. Each has a unique mission related to transportation, while still supporting our overall theme and mission:

- Technology Transfer Center
- Center for Transportation Infrastructure
- Center for Traffic Operations and Control
- Center for Clean Vehicle Technology

The UTC program funds the work of two of the centers, the Center for Traffic Operations and Control and the Center for Clean Vehicle Technology.

Technology Transfer Center

The mission of the Technology Transfer (T2) Center is to provide leadership that supports and enhances the overall effectiveness of local transportation agencies through communication, consultation, technical support and training programs.

The T2 Center's activities focus on active, progressive, and cost-effective transfer of highway technology and technical assistance. Funding for the center comes from the Local Technical Assistance Program (LTAP) of the Federal Highway Administration. The center's primary customers are Idaho's small cities, counties, and highway districts.

Center for Transportation Infrastructure

The mission of the Center for Transportation Infrastructure is to develop, test, and evaluate technologies that can be used to improve the highway infrastructure in the state of Idaho, the Pacific Northwest, and the nation. The activities of this center focus on infrastructure components that include pavements, bridges, and construction materials, as well as planning methods, design practices, and software development. Funding for this center comes primarily from the State Planning and Research Program (SPR) of the Idaho Transportation Department (ITD). This center's primary customer is ITD.

Center for Traffic Operations and Control

The mission of the Center for Traffic Operations and Control is to develop, test, and evaluate technology products supporting advanced traffic control systems. The activities of this center focus on a traffic control system testbed that includes five components: traffic detection, control, surveillance, simulation, and optimization. Funding for the work of this center comes from the University Transportation Center (UTC) grant. The main customer for the work of this center is local government agencies and practicing engineers in small to medium-sized cities (up to a population of approximately 150,000).

Center for Clean Vehicle Technology

The mission of the Center for Clean Vehicle Technology is to develop, test, and evaluate technologies to reduce the impact that vehicles have on the environment. This includes technologies for the new generation of vehicles,¹ as well as for recreational vehicles to be used in environmentally sensitive areas such as national parks.

This center's activities include developing technology testbeds consisting of electric and hybrid electric vehicles, models of alternative vehicles, and software models for vehicle performance. The testbeds will be used to demonstrate innovative designs, materials, fuels, drive trains, and power sources. Funding for the activities of this center comes from the UTC grant. Center projects will also develop partnerships that contribute technologies, collaborative funding, and/or expertise. The main customers of this center include federal and state funding agencies and industrial partners. Federal agencies include the Department of Transportation (DOT) and the Department of Energy (DOE) Office of Transportation Technology. Other partners include regional transit authorities and engine manufacturers.

¹ This supports the federal government's Partnership for a New Generation Vehicle (PNGV).

PART A. CONTINUING SUCCESS: A SEMI-ANNUAL REPORT ON THE RESULTS OF THE UTC INVESTMENT

Peer Review Panel Evaluation of Controller Interface Device (CID)

Since receiving the UTC grant, NIATT researchers in the Center for Traffic Operations and Control have been developing a controller interface device (CID) that will provide a real-time link between the CORSIM traffic simulation model and a traffic signal controller.

The CID gives the traffic engineer the opportunity to test any signal timing plan that can be operated with a NEMA or 170 traffic controller, using the traffic simulation logic built into the CORSIM traffic simulation model. It also provides a means to test advanced traffic control logic. FHWA has asked NIATT to design a version of the CID that builds on the pioneering work of Darcy Bullock of Purdue University. This new version will use faster communication links, handle up to 20 individual intersections, be easily manufactured, be much smaller and more portable than the current version, and be more easily configured.

The peer review panel members for the Center for Traffic Operations and Control and other interested parties were asked to attend a meeting on November 5, 1999, to assess the CID project. At a morning session, NIATT personnel presented the results of the first two phases of work on this project. The presentation included a brief background of the CID concept, the technical development process conducted by NIATT, the status of the project (including all design details and decisions), the educational and human resource components of the project, and the potential for marketing the product.

In the afternoon session, the panel met in executive session to review the information. An evening session was conducted to discuss the results of the panel review, which was subsequently printed and is summarized on the following pages.

Summary of the Peer Review Evaluation for the Controller Interface Device (CID) (KLK201)

A. Technical Aspects

The evaluation team reports that the CID development is a much-needed technology at this time, which can address a number of traffic signal control applications including but not limited to:

- Bench testing of controllers and cabinets
- Optimization of intersection performance
- Testing new intersection applications or deployment
- Planning for the impacts of special events
- Training and education of students and practitioners
- Testing of existing and new controller features
- Research into alternative control strategies

Even if the hardware becomes obsolete, software development for use with CID will remain a viable research area. That is especially true if the device is further developed and maintained. Issues of copyright or patent considerations need to be researched.

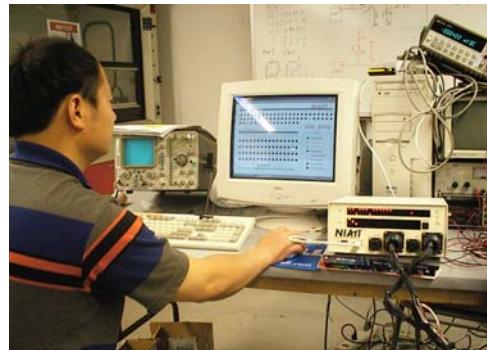
B. Process Review

The team agrees that CID meets NIATT program priorities: the product was developed on schedule, on budget and within the goals as defined, and the research involved faculty, graduate and undergraduate students. FHWA and state representatives on the evaluation panel indicated that the CID does an excellent job of meeting their expectations.

The evaluation team encourages the writing of technical papers as part of the product marketing and software application implementation. The CID provides an opportunity for short courses and training, especially in its application. Training should concentrate on the needs of the Intermountain area, which will also meet the needs of other areas.

C. Marketing

The evaluation team suggests that NIATT develop a marketing plan in which they first identify application software and then the potential users, perhaps establishing a market research/ application development team. The team suggests that there needs to be a partnership with the manufacturer to control its use, to provide technical support and advice, and to enhance the application software.



Research assistant Zhen Li demonstrates how the CID links CORSIM to a Traffic Controller.

D. Institutional and Other Issues

It is the team consensus that the project should not be abandoned if NIATT is unable to get an industry partner. Specialized manufacturing companies should be approached, or universities might be interested in the CID for training and research.

If the CID is indeed turned over to an industry partner, NIATT should remain involved and aware of problems or enhancements and continue to work on additional software applications.

A fourth phase of research should be added to the development cycle to address final product testing, enhancements, market plan, and advertising. The TRB IDEA program and SBIR funding opportunities should be investigated.

Participants serving on the evaluation panel are listed below:

Jim Pline, panel chair	Peer review panel member; Pline Engineering, Boise, ID
Jim Larsen	Peer review panel member; Ada County Highway District
Raj Gahman	Peer review panel member; FHWA, Washington, D.C.
William Kloos	Peer review panel member; City of Portland
Carlton Robinson	Peer review panel member; consultant, Washington, D.C.
Mike Boydston	Idaho Transportation Department, Boise, ID
Dale Moore	Idaho Transportation Department, Boise, ID
Tom Urbanik	Texas A&M, College Station, TX
Roelof Englebrecht	Texas A&M, College Station, TX
Larry White	Six Mile Engineering, Boise, ID

Contact: Brian Johnson, University of Idaho
208-885-6902 bjohnson@uidaho.edu

NIATT Student of the Year—Dan Gerbus

NIATT was proud to name Dan Gerbus, PhD candidate in mechanical engineering, as its Outstanding Student of the Year. Dan joined the ranks of students from university transportation centers across the nation who have been honored over the past eight years for their achievements in research and their outstanding academic performances.

Dan Gerbus received his BS in mechanical engineering at the University of Cincinnati and his MS at the University of Idaho. Dan's interests range from analytical modeling and experimental mechanics to design and CNC machining.

For the past two years, Dan has been a participant and leader in Idaho Engineering Works, an innovative model for capstone design classes that focuses on human dynamics, communication, teamwork, personal reflection, and professionalism.

“The success of the senior design program,” writes one of Dan’s nominators, “largely stems from the professionalism and stewardship of the student members of the Idaho Engineering Works. Dan has been instrumental in helping us refine and communicate these principles.”

As a teaching assistant for ME 424/426 Senior Capstone Design course, he trained and advised graduate and undergraduate students in machine shop equipment operation, project management, solid modeling, team-based product design, and design for manufacturability. These skills have helped lead to the success of several NIATT projects funded under DOT’s University Transportation Centers Program. These projects include the zero-emissions racecar, alcohol-water fuel engine conversion, two-stroke engine test stand design, electrically isolated power train design, and most recently, the FutureTruck 2000 competition. Dan worked on the development of composite structure design software and assisted fellow graduate students with other NIATT-funded research, especially those involving genetic algorithms to optimize composite materials, equation decoupling software, and alcohol-water fuel igniter design.

Dan’s dissertation topic for his research pursing a Doctorate of Philosophy involves optimized structural design and the complete fabrication of an electrically assisted



Dan Gerbus displays his Outstanding Student of the Year certificate he received at the TRB annual meeting. Pictured, (left to right: Mort Downey, Deputy Secretary; U.S. Department of Transportation Secretary Rodney E. Slater; Gerbus; and DOT's Research and Special Programs Administration (RSPA) Administrator, Kelley S. Coyner.

bicycle, research sponsored by NIATT under the UTC program. The bike utilizes fuel cells and composite materials to optimize the system.

A second of Dan's nominators notes that more important than what Dan has done is "who" Dan Gerbus is. "Simply put," the nominator writes, "Dan is committed to excellence in many areas. In fact, he has shown excellence in more areas than any other graduate student whom I have seen. . . . What's remarkable is the age at which he has achieved this expertise."

Dan attended a special ceremony held during the Transportation Research Board 79th annual meeting in Washington, DC, in January 2000. He received an Outstanding Student of the Year certificate presented by U.S. Transportation Secretary Rodney E. Slater. In addition, Dan received a check for \$1000 from NIATT.

Idaho Engineering Science Camp—1999

For over sixteen years, the University of Idaho College of Engineering has conducted science camp experiences for Idaho high school students with the goal of providing science and engineering education to younger students in Idaho and the Northwest region. For the past five years, NIATT has teamed with Boise State University to conduct a weeklong Science Camp on the BSU campus for approximately 40 students entering grades 9 and 10. GTE Foundation, Hewlett-Packard, and others have generously supported the camp. The camp has enjoyed great success in attracting minority and economically disadvantaged children, mostly from southern Idaho.

Because of the success of the program, support and funding from local southern Idaho industries and individuals was more readily available. In 1998, support was successfully sought from the GTE Foundation and the NASA Idaho Space Grant Consortium (ISCG) to help fund a second camp on the University of Idaho campus. GTE funds were used to offer camp scholarships to Hispanic, Tribal, African American, and other minority children from the Coeur d'Alene (Idaho)/Spokane/Tri-Cities (Washington) area.

The 1999 Idaho Engineering Science Camp was held June 27 through July 2 on the Moscow campus with 23 students entering 10th and 11th grade in attendance. The curriculum for the camp was organized using the same learning process methodology that has proved highly effective in past years. This methodology is based on the philosophy that learning, thinking, problem solving, communication, teamwork, and assessment are processes to be developed (and continually improved) by students as they master the content of

a discipline area. Known in the education literature as “process education,” this approach is lively, timely and systematic. It is concerned equally with content (discipline-specific knowledge) and skill development.

Each day of the camp consisted of a variety of 30-60 minute learning activities, including computer-aided design, project work, team reflection, field trips and games. The main goal of each activity was to empower students to become life-long learners, both capable



Science camp participants cheer as their electric boats race through the flume.



A key element of the science camp experience is teamwork.

and eager to learn new math and science concepts on their own. In addition to two camp coordinators (Steve Beyerlein and Donald M. Blackketter, Mechanical Kris Brown, Civil Engineering, North Idaho College; Mike Hightower, Plummer High School; three graduate and four undergraduate students assisted with the science camp. NIATT staff administered the funds, handled registrations, and arranged publicity.

Students' comments about the camp illustrate their satisfaction with the experience:

- "It was one of the funnest things I've ever done."
- "This camp encouraged me to try new things."
- "The mentors were great! They were well informed and they were good listeners."
- "I learned a lot of useful stuff that I wasn't aware of before."
- "Science Camp is really fun and interesting."

Ongoing UTC-Funded Research

Actuated Control—Phase I: Oversaturation KLK202

The role of the automobile is more important today than ever before. However, the increased use of the automobile has led to congestion in metropolitan areas—in some cases, so severe that gridlock occurs. Several methods currently exist to reduce delays and keep traffic flowing, but most of these methods are very expensive and in some instances not feasible.

The goal of this research is to generate strategies to alleviate congestion at signalized intersections by adjusting signal-timing parameters. These strategies involve using linear optimization of the maximum green intervals to account for the high volumes of traffic. The ultimate goal is to have multiple intersections that will allow the maximum amount of traffic flow, therefore reducing the amount of congestion in the arterial system. This involves increasing the maximum green intervals, optimizing the phasing pattern, managing the internal queue, and maintaining the operation for non-saturated movements.

Our plan is to design a formulation for one intersection at a time, since it is simpler to implement the constraints required. After the first intersection is optimized, we add additional intersections into the arterial system. Our first formulation optimized the signal timing parameters, but not the phasing patterns, for one intersection. The second formulation included parameters to increase the efficiency of the phasing pattern, as well. The third formulation will include multiple intersections.

To verify the linearly optimized signal timing scheme, we will simulate the intersections using CORSIM, a microscopic-based program that produces several important output results (such as delay and throughput volumes). The comparison between the pre-optimized operation of the intersections and post-optimized operation will provide a basis to support the validity of our work.

We expect to develop a final formulation that can be applied to any oversaturated system by inputting the geometry, traffic, and signalization parameters and optimizing the oversaturated movements. For this case study, data will be used from actual oversaturated intersections throughout the state of Idaho. We will then analyze the data and use it to show the effects of these strategies developed. Once these strategies are applied, we expect to show a decrease in the oversaturation, and therefore a decrease in the delay per vehicle and an increase in the amount of traffic flowing through a signalized intersection.

Geoffrey Judd, Graduate Student
Contact: Zaher Khatib, University of Idaho
208-885-2957 zkhatib@uidaho.edu

*Development of Video-Based and Other Automated Traffic Data Collection Methods,
Phase II
KLK203*

The objective of the current research is to further develop a user-friendly software package, "Traffic Tracker," for collecting and analyzing time-related traffic data. Traffic Tracker is a Windows-based version of the DOS-based program "Traffic Data Input Program (TDIP)." Traffic Tracker was developed using Visual Basic and performs a step-by-step analysis of the traffic parameters from data collection in the field to final data analysis.

This project is being conducted in two phases. The first stage of the research was to review and assess the existing Traffic Tracker software version 1.2. The software was analyzed for functionality, assessed for user-friendliness, and tested for accuracy. This was achieved by verifying that each function in the software would perform as expected. One hundred twenty test runs were done to check the accuracy of the software. The errors and their sources were identified as well as the areas for modification and corrections. This process has been completed.

The second stage of the project includes the addition of a new module for analyzing signal warrants. Signal warrants are a set of traffic specifications established by the *Manual on Uniform Traffic Control Devices* (MUTCD) for justifying traffic signals. There are eleven signal warrants, each of which justifies the minimum condition for signal controls.

Manual checking of the warrants is a tedious and lengthy process. The objective is to develop a software module that will effectively and accurately analyze traffic warrants. This work is currently underway.

Binu Abraham, Graduate Student
Contact: Michael Kyte, University of Idaho
208-885-6002 mkyte@uidaho.edu

Traffic Signal Summer Camp 2000
KLK205

The objective of this project is to provide undergraduate civil engineering students with the opportunity to learn about the latest traffic signal systems hardware and software. Traffic Signal Summer Camp 2000 will provide ten undergraduate transportation engineering students a week on the University of Idaho campus during which they will participate in hands-on laboratory exercises as well as classroom sessions conducted by engineers and technicians from government and industry and UI faculty.

A number of traffic engineering professionals have agreed to serve as camp counselors along with UI faculty Michael Kyte and Zaher Khatib:

- Mike Boydston, Idaho Transportation Department
- Darcy Bullock, School of Civil Engineering, Purdue University
- Ken Courage, Civil Engineering Department, University of Florida
- Bill Kloos, City of Portland, Bureau of Transportation System Management
- Jim Larsen, Ada County Highway District
- Joseph Marek, Clackamas County Traffic Engineer and Development Review Manager
- Dale Moore, Idaho Transportation Department
- John Ringert, Kittelson & Associates

Recruiting materials have been prepared and advertising has been arranged. A flyer will be distributed at the annual TRB meeting; emails have been sent to ITE schools; advertisements ran twice in the *ITE Journal* and once in *Women in Engineering*. Applications are due February 11, 2000.

Contact: Michael Kyte
University of Idaho
208-885-6002
mkyte@uidaho.edu

*Advanced Vehicle Concepts Team Electric Vehicle,
Phase II: FutureTruck 2000
KLK302*

The Center for Clean Vehicle Technology was notified in late August 1999 that their proposal to participate in the FutureTruck 2000 competition had been accepted by the Department of Energy. The goal of the FutureTruck program is develop a vehicle with a two-thirds reduction in greenhouse gas emissions compared to today's conventional sport utility vehicles, while achieving improved recyclability and maintaining comparable performance, utility, safety, and cost of ownership. This award from DOE meant that we would receive a year-2000 Chevrolet Suburban and \$10,000 "seed" money. Our first step was to ensure that our planning and design of vehicle would meet FutureTruck objectives and goals.

Based on our initial proposal to DOE and subsequent research, we estimated that the total cost of the next two years of the project would be approximately \$250,000. During the fall of 1999, we raised the additional funds needed for the project. We were successful in obtaining funding from private sponsors in excess of \$75,000. Among the sponsors, Edward and Mary Schweitzer contributed \$50,000 for this year, with a commitment for \$150,000 over the next two years. We are continuing our efforts to raise the additional funds we need.

Actual work on the Suburban will begin after its delivery, which is expected in late December 1999. However, we started bringing together all the components needed to convert the vehicle, including a Turbo Direct Injection Volkswagen diesel engine. We expect the Suburban to be in running condition by April 28, 2000, for display at the Idaho Engineering Expo.

Contact: Donald Blackketter, University of Idaho
208-885-6228 dblackketter@uidaho.edu

Vehicle Performance Simulation
KLK305

The ultimate objective of the vehicle simulation project is to develop a performance-driven hybrid electric vehicle software model. With this model, vehicle performance goals are input and the model determines the best possible component configuration. SmartSolve, our software tool under development, uses two unique algorithms that efficiently and accurately determine solutions to highly coupled sets of linear and non-linear equations. Several modifications to the algorithms were recently completed as part of this project. The hybrid electric vehicle model will use existing algorithms from SmartSolve as well as more advanced numerical and logic-based methods.

One of the main improvements we made to the SmartSolve code was to rewrite each function into modules. This modular structure has improved performance, troubleshooting, and expandability. The code is quicker and encounters far fewer errors than previous versions. Because the algorithms are divided into modules, they can be tested individually. Modifications to the code are also easier to implement because each module performs a specific task. Adding or deleting functions does not change other parts of the code. Another major advantage of the modular structure is that separate modules can be used to build other applications quickly and easily. The graphical user interface specific to an application is essentially the only coding that needs to be created. The modules are then used without modification. This is a tremendous advantage for building and testing new applications.

We also rewrote the SmartSolve parser, which determines the number of variables and mathematical operators in equations, and added new features. With the revisions, SmartSolve can rewrite equations that could cause computational errors during solving. Usually, in order to numerically solve a set of equations, a researcher must guess the value of a variable and then move closer and closer to its real solution. This approach can be problematic because a function may not be defined at a discrete value within the range of steps. Alternatively, by rewriting equations, SmartSolve can make a function continuous throughout the range of steps without changing its functionality.

A vehicle model that will incorporate all the equation management and numerical solving features of SmartSolve is currently being developed. The software will have a user-friendly graphical interface with the look of a typical Windows application. With these modifications and SmartSolve solving features, the performance-driven vehicle model promises to be an invaluable software tool for the design engineer.

Dave Alexander, Graduate Student
Contact: Donald Blackketter, University of Idaho
208-885-6228 dblackketter@uidaho.edu

Biodiesel Fuel from Yellow Mustard Oil
KLK310

University of Idaho plant scientists have developed yellow mustard varieties that have the potential to significantly reduce the cost of the oil used in biodiesel production. The purpose of this project is to produce quantities of biodiesel from these locally grown varieties to test in both laboratory engines and in a 1999 Dodge 2500 diesel-powered, on-road pickup truck.

This fall, emissions test data for 5 different vegetable oil esters were analyzed. The esters, representing a range of iodine numbers from 7.88 to 133, were tested both neat and in 20 percent/biodiesel/80 percent blends in comparison with low sulfur diesel fuel for the effect on regulated emissions. It was found that lower iodine numbers were correlated with reduced nitrous oxide (Nox).

A 1999 Dodge 4x4 quad cab, with 5.9 L turbocharged and intercooled Cummins Electronic ignition engine was obtained and a slip tank and pump were installed to increase the fuel capacity from 30 to 130 gallons, extending its range to 2000 miles. Initial power and fuel economy tests were obtained using the dynamometer at Spokane's Western States Caterpillar. Problems with that equipment prevented us from completing the high RPM portions of the torque curve. Cummins Northwest ran an injector cutout test; however, this turned out to be a no-load test, which is unsatisfactory. We have since obtained the software and hardware from Cummins for running this injector cutout test on our own dynamometer when it is installed.

One thousand gallons of yellow mustard biodiesel were produced from oil obtained from Montana Specialty Mills in Great Falls, Montana. We have also produced 1,000 gallons of biodiesel from canola oil.

A visiting engineer from the General Motors Milford proving grounds in Michigan is currently at the University of Idaho assisting with several activities, two of which are related to our biodiesel project. He is working on plans to install a Superflo dynamometer, previously purchased by the university but not installed. We hope to have this in place by spring 2000. He is also working on our EMA engine test facility.

Every year, senior students in Biological and Agricultural Engineering work on a capstone design project. This year, two seniors are adding a stripping column to remove and recycle alcohol as well as process controls to monitor and control the flow of inputs, thus improving the efficiency and reliability of our continuous flow biodiesel system.

Contact: Charles Peterson, University of Idaho
208-885-7906 cpeterson@uidaho.edu

*Spark Ignition Engine Conversion to Aquanol Fuel
KLK315*

Combusting ethanol-water fuels with a Catalytic Plasma Torch (CPT) promises to reduce pollutant emissions from low-compression engines in urban areas. The goal of our project is to demonstrate the feasibility of retrofitting a spark ignition engine for catalytic operation and to monitor long-term operation in a public transit application. We were able to obtain a van with a spark ignition (SI) engine from Valley Transit in Lewiston, Idaho, and we have been working with Aqalytics Technologies, Inc., to convert the vehicle to burn aquanol as well as gasoline.

Making improvements to the igniter has been an important step toward reaching our goal. Both this project and the diesel engine project (KLK316) will benefit from advances in igniter construction that were made over the past six months. Over this period of time, the development of the igniter has advanced to the point that it can be depended on for over 200 hours of operation. The design has been changed to allow more rapid and defect-free construction. The igniter cores are now constructed by outside vendors in quantities of 100. A precision resistor maker is now winding the platinum heater that had been wound onto the ceramic rod by hand. Once the heater has been precision wound, alumina powder is flame-sprayed over the coil to protect it from the combustion environment. Once the alumina has been sprayed over the outside, the igniter core “blank” is complete.

The core blanks can be sized more easily than the previous design. The cores are now mated with a modular electrical feed-through. In the prior design, the feed-through and the core were one piece. The new two-piece design can be fabricated without defects and much more rapidly than previous designs. Together these improvements have made igniters easier to fabricate and more reliable once assembled.

The van being used for this project was fitted with fuel system components that are impervious to ethanol. The fuel and spark map for the gasoline engine was optimized so that the engine will run on gasoline using the new HalTech fuel computer. This system replaced the OEM engine computer and will give the van a multi-fuel capacity.

Andron Morton, Graduate Student
Contact: Steve Beyerlein, University of Idaho
208-885-4932 sbeyerlein@uidaho.edu

Diesel Engine Conversion to Aqualytic Fuel
KLK316

Combining the use of a Catalytic Plasma Torch (CPT) with ethanol-water fuels promises to dramatically reduce nitric oxide emissions from diesel engines while maintaining rated power output. The project involves converting a direct injection diesel engine into a homogeneous charge compression ignition engine. Our goal is to demonstrate the feasibility of retrofitting a diesel engine for catalytic operation.

Because the original igniters were not durable enough to allow testing on the high compression engine, the project focus shifted temporarily to igniter development. These improvements were tested on a Yanmar engine. Once the igniter had been improved, the Yanmar was run on two separate occasions in order to gather operational data. In all, fifty hours of run-time were logged on the Yanmar engine. Data was gathered and reported on the following:

- NO_x, CO, O₂, CO₂ emissions
- Power Output
- Exhaust Temperature
- Ignition Timing
- Oil Analysis (after 35 hours)

NOx emissions were low, no more than 50ppm. CO emissions were almost identical to those of the baseline (operating on #2 diesel). Power output was slightly increased over diesel operation, 20 hp instead of 18 hp on diesel. Exhaust temperatures were lower than on diesel fuel, as expected, due to the presence of water (810°F instead of 1200°F). Ignition timing was adjusted from 20 degrees before top dead center to two to three degrees before top dead center. This timing change was accomplished by shortening the igniter core. Even with the highly advanced ignition timing, the engine managed a one percent improvement in thermal efficiency over diesel combustion. An early theory that water content can be used to adjust timing was proven false. Water, however, can be used to control detonation. The oil analysis showed high concentrations of bearing materials, but long periods of inactivity are likely responsible for this.

Andron Morton's Master's thesis focused on his work with the igniter construction. Andron will receive his MS at the university's spring 2000 graduation ceremony.

Andron Morton, Graduate Student
Contact: Steve Beyerlein, University of Idaho
208-885-4932 sbeyerlein@uidaho.edu

Aqueous Alcohol Research—Reactor Studies
KLK317

The objective of this project is to complete a reactor design that accurately predicts heterogeneous and homogeneous ignition over a range of fuel types, fuel-water mixtures, and initial thermal conditions. Presently, we are building a plug-flow reactor to help unravel the catalytic ignition mechanism. The reactor will be pressurizable to 20 atmospheres, capable of vaporizing liquid fuels, able to accept a wide range of equivalence ratios and ethanol-water mixtures, transportable for experiments in other laboratories, and flexible to allow different test sections. A literature search for other high-pressure plug flow reactors is completed. Design calculations are finished. The vaporizer section is now under construction. Assembly and testing will continue through summer 2000.

Part of this project involves performing detailed chemical kinetic calculations. Data from the reactor will give us confidence in the veracity of our calculations. A program that performs hydrodynamics, chemical kinetics and transport (HCT) was obtained gratis from Dr. Charlie Westbrook at Lawrence Livermore National Laboratory. A literature search for gas-phase elementary chemical reactions is completed. Many of these reactions are already contained in one of the HCT databases. A literature search for heterogeneous ethanol-Pt elementary reactions is underway. These reactions will be added to the HCT databases and a subroutine to perform heterogeneous reactions will be included with the HCT source code. The HCT code was successfully compiled on a Pentium PC platform.

Contact: Judith Steciak, University of Idaho—Boise
208-364-4080 jsteciak@uidaho.edu

Optimal Design of Hybrid Electric-Human-Powered Lightweight Transportation
KLK320

Bicycle riding is gaining popularity today in America. People are becoming health conscience and tighter restrictions are being placed on vehicle emissions. As a low emissions transportation alternative and an excellent source of physical exercise, people in metropolitan areas are commuting to work on bicycles.

However, there is a sector of the population who would like to commute to work on a bicycle but are unable to do so. Some elder members of the population do not have the physical stamina to travel the distance from home to work. Others do not wish to be out of breath and in a sweat as they arrive at work. The need then arises for a transportation alternative that provides a physical workout for the rider, but also provides additional power assistance to make the pedaling less of a strain. Hybrid bicycles with electrical motor assistance are currently available on the market that may be pedaled as a traditional bicycle. The electrical assistance is controlled by the rider and may be used continuously or just to negotiate hills.

The power assist has allowed people to travel greater distances and over tougher terrain than they could using bicycles without an electrical assist..

At the University of Idaho, research and development is currently underway to design such a hybrid bicycle. The scope of the University of Idaho hybrid-bicycle project is to design and test a hybrid bike that will out perform those models currently available. This design will weigh less than the competition, efficiently couple power from the electric motor and the rider, have the same aesthetic appeal as a "typical" bicycle, and be fully functional in all weather conditions.

Several features will be incorporated to minimize the maintenance involved in a bicycle. A completely enclosed chainless drive system is being considered to eliminate the periodic adjustments of the derailleurs. The motor and batteries will also be enclosed for protection from weather. The power system will be sized to power the bike up to 20 mph for one hour without pedaling from the rider.

The first hybrid prototype is scheduled to be completed by June 2000. This prototype will have a unique gear train to couple the power from the electric motor and from pedaling. Testing will be conducted on the prototype and recommendations will be made for the next design phase.

Dan Gerbus, Graduate Student
Contact: Edwin Odom, University of Idaho
208-885-7330 eodom@uidaho.edu

Designing Ply Orientations of Composite Laminates with Genetic Algorithms
KLK320

Composite materials hold great promise to meet a variety of transportation structural needs. On one end of the spectrum, composite materials are needed to repair some of the 575,000 bridges in this country, one-third of which are structurally deficient.² On the other end of the spectrum are applications such as the composite car seat used in the 1997 Mercedes-Benz C Class minivan. Other possible applications for composite materials include frame rails for truck trailers, body parts for auto-mobiles, pressure vessels to store natural gas or hydrogen, and drivelines for heavy duty trucks. In any of these applications, the composite material has to meet material property design requirements. However, at present, the designer has to guess at a formulation, fiber direction, and laminate dimensions, perform an analysis of the guess, then compare the results of the analysis to see if the guess met the design requirements. If the guess is wrong the designer guesses again. The designer will eventually find a composite material to meet the design requirements but it seldom will be the optimal solution. Designers need a way to begin with design requirements and then, by way of an analysis program, find what possible materials, fiber orientations, and laminate dimensions meet these design requirements.

The purpose of this study is to develop a process to design transportation-related structures. We expect our software to facilitate the design of lightweight structures fabricated with laminated composite materials. Currently, composite material software programs require the user to first specify the material and lamina orientation for each ply in the laminate. Then the laminate properties are calculated and used in a structural analysis. If the results of the structural analysis do not meet the design requirements, the designer must modify the material and lamina orientations to improve the laminate properties. This is a multi-valued problem and can be tedious for 50- or 100-ply laminates.

Our software program works by coupling a genetic algorithm to a standard laminate point stress analysis program. By using a genetic algorithm, the user first inputs the desired laminate properties or structural needs. The program then finds possible lamina orientations and material selections to the requirements. Comparisons to standard designs for pressure vessels, drive lines and generic flat plates have been positive. The algorithms guess possible solutions, which are then evaluated. The best solutions are merged and mutated to obtain a new set of possible solutions, which are then reevaluated. This process continues until a solution is found. No commercially available composite program currently exists that uses genetic algorithms to assist in the design of generic composite material laminates.

Robert Sachjen, Graduate Student
Contact: Edwin Odom; University of Idaho
208-885-6228 eodom@uidaho.edu

² 1997 Federal Highway Administration bridge survey.

Lead Acid Battery Development
KLK330

The objective of this project is to develop an advanced, sealed lead acid battery for a range extended, hybrid electric vehicle (REHEV), by first investigating the use of paste additives to improve the performance of the existing batteries.

Our initial work is the subject of a paper ("Evaluation of Two Paste Additives on Cell Performance," Dean B. Edwards and Troy C. Dayton, University of Idaho) that was accepted for presentation at the 15th Annual Battery Conference at Long Beach, California, in January 2000. The abstract of the paper follows:

In this paper, we investigate the effect of two different positive paste additives on cell performance. We develop models for cells having plates with paste containing these additives as well as plates without any additives. In this manner, we can make theoretical comparisons between the performance of cells with and without additives. The results of our model simulations are compared with experimental data. We find that the positive paste additives can be used to improve performance.

Contact: Dean Edwards, University of Idaho
208-885-7229 dedwards@uidaho.edu

High Performance Auxiliary Power Units

KLK331

The focus of the current research is to model a Hybrid Electric Vehicle (HEV) to predict its fuel economy and emissions. We initially developed a steady state model in spring 1999 to calculate the energy use and fuel economy for a vehicle traveling at a constant speed.

During the summer and the fall of 1999 the steady state model was extended to a quasi-steady model. Quasi-steady means that at each time interval (usually one-second intervals), the program iterates through the performance calculations using steady state data. This iterative steady state data is then summed to predict the performance of the vehicle. The program, HEV Energy Management, was written in Visual Basic. It allows the user to select a driving cycle. The driving cycle is a file containing the vehicle velocity and road grade as a function of time. The driving cycle can be chosen from a list of federal test procedures or the user can define his or her own. The user can then input parameters to define the vehicle components such as electric motor, batteries, and auxiliary power unit (APU).

In order to verify and obtain information for input into the program, vehicle and engine testing will be conducted. To support this testing, a 1.9 liter Volkswagen turbo direct injection (TDI) diesel engine and a five-gas EMS emissions analyzer were purchased. The Volkswagen TDI is now mounted on a teststand where brake specific fuel consumption as well as emissions will be obtained at steady state operating points.

The vehicle model was written in Visual Basic to take advantage of its user interface capabilities. It also allows for the program to be compiled and run as an executable file. This allows others to use HEV Energy Management without having to purchase additional software.

The 1.9 TDI engine will also be used in the FutureTruck 2000. Modeling the engine performance will enable the Advanced Vehicle Concepts Team (AVCT) predict the performance of the modified Suburban. This will help them prepare and improve their vehicle for the FutureTruck 2000 competition.

We will continue to refine the model and incorporate the SmartSolve equation solving routines. The program now allows the user to select components, run the simulation, and view the results. With these features, the program is more user-friendly. In the future, we will revise the program to select the desired vehicle performance as an input. The output will be the engine and battery-pack sizes. In this way the program can be used as a design tool.

David Reiche, Graduate Student
Contact: Dean Edwards; University of Idaho
208-885-7229 dedwards@uidaho.edu

PART B. RESEARCH PROJECT STATUS

Table 1 lists the status of NIATT research projects, grouped according to their status.

Table 1. Research Project Status

Project Status	Project Number	Project Title	Principal Investigator
New	KLK205	Traffic Signal Summer Camp	Michael Kyte
New	KLK202	Actuated Coordinated Signalized Systems: Phase I—Oversaturated Conditions	Zaher Khatib
New	KLK310	Biodiesel Fuel from Yellow Mustard Oil, Phase I	Charles Peterson
Ongoing	KLK201	Development of Controller Interface Device for Hardware-in-the-Loop Simulation, Phase III	Brian Johnson
Ongoing	KLK203	Development of Video-Based and other Automated Traffic Data Collection Methods, Phase II	Michael Kyte
Ongoing	KLK204	Development of Internet-Based Laboratory Materials: Phase II—Computer-Assisted Traffic Analysis Training	Michael Kyte
Ongoing	KLK302	Advanced Vehicle Concepts Team Electric Vehicle: Phase II: FutureTruck 2000	Don Blackketter; Steve Beyerlein
Ongoing	KLK305	Vehicle Performance Simulation, Phase II	Don Blackketter
Ongoing	KLK315	Spark Ignition Engine Conversion to Aquanol Fuel	Steve Beyerlein
Ongoing	KLK316	Diesel Engine Conversion to Aqualytic Fuel	Steve Beyerlein
Ongoing	KLK317	Reactor Studies of Water-Alcohol Mixtures, Phase II	Judi Steciak
Ongoing	KLK320 & KLK 321 (combined)	Optimal Design of Hybrid Electric-Human-Powered Lightweight Transportation	Edwin Odom Don Blackketter
Ongoing	KLK330	Lead Acid Battery Development	Dean Edwards
Ongoing	KLK331	High Performance Auxiliary Power Units, Phase II	Dean Edwards Steve Beyerlein

PART C. FINANCIAL STATUS

Name of Grantee: National Institute for Advanced Transportation Technology		Grant Year: 7/1/99-6/30/00
CATEGORIES	APPROVED BUDGET	EXPENDED
	YEAR 2	7/1/99 TO 12/31/99
Center Director Salary	\$91,333.00	\$3,249.06
Faculty Salaries	\$142,673.00	\$7,671.63
Administrative Staff Salaries	\$97,827.00	\$672.00
Other Staff Salaries	\$27,470.00	\$7,052.61
Student Salaries	\$187,285.00	\$105,357.16
Staff Benefits	\$104,309.00	\$10,835.62
Total Salaries and Benefits	\$650,897.00	\$134,838.08
Scholarships	\$81,588.00	\$13,260.00
Permanent Equipment	\$0.00	\$15,254.50
Expendable Property & Supplies	\$151,658.00	\$57,532.59
Domestic Travel	\$35,000.00	\$19,875.02
Foreign Travel	\$0.00	\$0.00
Total Direct Costs	\$268,246.00	\$105,922.11
Facilities & Administrative (Indirect Costs)	\$410,857.00	\$88,374.06
TOTAL COSTS	\$1,330,000.00	\$194,296.17
US DOT funds	\$655,500.00	\$320,614.14
University of Idaho funds	\$674,500.00	\$315,978.12