

June 5th

2009




COLLEGE OF SCIENCE AND ENGINEERING

PROJECTS DAY



SEATTLE UNIVERSITY



Cover shot features senior design team, ECE 09.3. From l-r:
Erik Moroles, James Okullo (Sparling associate and Seattle University c/o '07 alumni),
Henry Louie (Seattle University Electrical Engineering assistant professor), Steve Szablya
(Seattle University director of facilities), Theodora Rupp, and Anthony Robbins



2008-2009

LIST OF PROJECTS

Results Delivered.

CIVIL & ENVIRONMENTAL

Seattle City Light	Pedestrian Bridge Replacement
Snohomish County Public Works	Green Street Project
Tinnea & Associates LLC /	High Early Strength, Resistivity Concrete Mix
Seattle Public Utilities	
University of Washington	Steel-Plate Shear Wall Design
Willapa Hills Farmstead Cheese	Willapa Hills Cheese Wastewater

COMPUTER SCIENCE

Nordstrom Inc.	Automate Cosmetics Line Assignment
AREVA T&D	PMU Simulation

ELECTRICAL & COMPUTER

Artisan Instruments	Sound Engine
PACCAR	Airspeed Probe Team 1
Seattle University	Small Human-Powered Generator Design

INTERDISCIPLINARY

(Electrical & Computer and Mechanical)

The Other Roadside Attraction	Angst Warriors Art Installation
The Boeing Company	Multi-Motion Test Machine and Compliant Coupling Testing
Seattle University	Community Fountain Design

MECHANICAL

National Park Service /	Mt. Rainier Solar PV System
University National Park Energy Partnership Program (UNPEPP)	
PACCAR	Airspeed Probe Team 2

BUSINESS

Historic Flight Foundation	Market Research and Strategy Development
Twisted Pair Solutions	Land Mobile Radio

WELCOME FROM THE DEAN



Welcome to Projects Day 2009! For more than twenty years, the Project Center has provided our seniors the opportunity to work in teams, engage with external organizations, and apply the engineering skills they've learned at Seattle University. I want to acknowledge the project mentors and the faculty advisors who have worked with the teams throughout the academic year, helping them come to a deeper understanding of what

it's like to solve "real-world" problems.

We are proud of our students and what they have accomplished. I encourage you to look through this program, identify some projects of interest, and attend the team presentations. If you have a question, fire away! I'm confident you'll be impressed with the quality of our graduates.

The Project Center is one of the jewels in the crown of the College of Science and Engineering. We are grateful to the corporate sponsors who make it possible for us to provide our students with this terrific educational experience. Thank you for your generous support!

Michael J. Quinn, Dean
College of Science and Engineering



On behalf of our faculty and students, I wish you a warm welcome to Projects Day 2009, our annual presentation of design team results to sponsoring organizations, visitors, and friends. I am grateful for the encouragement and assistance provided by our Science and Engineering Advisory Board and the Project Center Advisory Committee in promoting the external sponsorship of our projects. I also want to thank our sponsoring companies and organizations. Without the participation of these companies, our students would not be able to experience the growth that comes from working on real industry projects under the guidance of company liaisons. Thank you for your gift of time, wisdom, encouragement and guidance.

I would also like to acknowledge the coordination efforts of professors Nirmala Gnanapragasam and Katherine Kuder in Civil and Environmental Engineering; Alvin Moser in Electrical and Computer Engineering; Greg Mason and Christopher Stipe in Mechanical Engineering; Richard LeBlanc in Computer Science and Software Engineering; Amy Haedt, Corporate Relations Manager; and Diannie Ran and Michael Smith, Administrative Assistants. I also would like to thank Dean Kellye Testy and Associate Dean Richard Bird of the School of Law for allowing us to use Sullivan Hall for our function. Finally, I'd like to thank Rebecca Parker of the School of Law for excellent event support.

This is truly a day that can only happen when Seattle University and the larger community work together to support the scientists and engineers of tomorrow.

Jeff Gilles, Director
College of Science and Engineering Project Center

PROJECTS DAY

SEATTLE UNIVERSITY

SULLIVAN HALL

JUNE 5TH, 2009



12:00 - 12:30 PM

Registration

12:30 - 1:30 PM

Poster session

1:30 PM

Welcome, Provost Dr. Isiaah Crawford & Dean Michael Quinn

National Council of Examiners for Engineering and Surveying Awards Presentation

1:45 PM

First presentation session

»ROOM C5: GREEN PROJECTS

The Boeing Company

National Park Services / UNPEPP

Snohomish County Public Works

Mechanical Algae Lipid Extractor

Solar PV System

Green Street Project

»ROOM C6: ART PROJECTS

Artisan Instruments

The Other Roadside Attraction

Nordstrom Inc.

Sound Engine

Angst Warriors Art Installation

Automated Cosmetics Line

Assignment

»ROOM 109*: TRUCKS & TROLLEY PROJECTS

PACCAR

PACCAR

Tinnea & Associates LLC /

Seattle Public Utilities

Airspeed Probe Team 1

Airspeed Probe Team 2

High Early Strength, High

Resistivity Concrete Mix

»ROOM 110*: BUSINESS PROJECT

Historic Flight Foundation

Market Research &

Strategy Development

2:45 PM

Break

* Please enter Room 109 and 110 from the rear of the classroom, down corridor between rooms.

SCHEDULE

3:00 PM

Second presentation session

»ROOM C5: COMMUNITY BENEFIT PROJECTS

Seattle University

Community Fountain Design

Seattle University

Small Human-Powered Generator Design

»ROOM C6: HVAC CONDENSATION, WASTEWATER,
BRIDGE PROJECTS

Costco

HVAC Study

Seattle City Light

Pedestrian Bridge Replacement

Willapa Hills Farmstead
Cheese

Willapa Hills Cheese Wastewater

»ROOM 109*: DEVELOPMENT AND TESTING PROJECTS

AREVA T&D

PMU Simulation

The Boeing Company

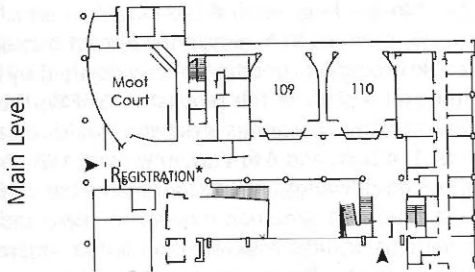
Multi-Motion Test Machine &
Compliant Coupling Testing

University of Washington

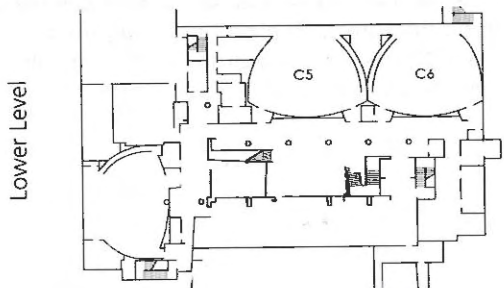
Steel-Plate Shear Walls Design

4:00 PM

Reception



SULLIVAN
HALL



Newhalem Creek Pedestrian Bridge Replacement

NUMBER: CEE 09.1
SPONSOR: Seattle City Light
SPONSOR LIAISONS: David Anderson, Dan O'Sullivan
FACULTY ADVISOR: Tom Rines
STUDENTS: Kevin Kay, Dylan Martin, Paul Massart, Sam Sideras

Seattle City Light (SCL), a power company that provides electricity for the greater Seattle area, requested that the CEE 09.1 team design a new pedestrian bridge spanning 75 feet over Newhalem Creek. The bridge will provide SCL employees access to an intake house for one of their hydroelectric dams located near the town of Newhalem, Washington. The team's goal is to provide SCL with a functional design considering both service life and economic constraints. Designed to meet the standards of the 2006 International Building Code and the American Institute of Steel Construction (AISC) Steel Construction Manual, the bridge will use a steel truss to support the decking across the creek and concrete foundations on both banks. A588 grade steel was selected as the primary material to maximize the strength as well as reduce environmental effects both on the bridge and surrounding park area.

Green Street Project

NUMBER: CEE 09.2
SPONSOR: Snohomish County Public Works
SPONSOR LIAISON: Brian Larmore
FACULTY ADVISOR: Prof. Wesley Lauer
STUDENTS: James Armitage, Huy Le, Joshua Potter, Matthew Tiedemann

Snohomish County Public Works (SCPW) is interested in promoting the use of Low Impact Development (LID) practices. LID attempts to minimize the impact human development has on the ecological and hydrological condition of a watershed by mimicking the pre-development conditions of a site. At the request of SCPW, the CEE 09.2 design team developed a LID design that integrates a pervious walkway and a series of rain gardens at the corner of 134th St. and Ash Way, in Everett, WA. Project deliverables include: four stages of design drawings and cost estimates (30%, 60%, 90% and final), construction support, a post-construction monitoring plan, and simplified design charts for sizing rain gardens on sites with less than 5,000 square feet of impervious areas within Snohomish County. The charts allow designers to easily size rain gardens without performing a costly computer analysis. Using the hydrologic software application MGSFlood, the team developed design charts presenting optimum rain garden area as a function of impervious drainage area, infiltration rate, rainfall rate, and basin depth.

High Early Strength, High Resistivity Concrete Design

NUMBER:	CEE 09.3
SPONSORS:	Tinnea and Associates LLC, Seattle Public Utilities
SPONSOR LIAISONS:	Jack Tinnea, Ryan Tinnea
FACULTY ADVISOR:	Prof. Katherine Kuder
STUDENTS:	Samuel Bellomio, Michael Fanoni, David Johnson, Jessica Swanson

Due to concern that stray current from light rail tracks would corrode underground utility pipelines, Seattle Public Utilities asked team CEE 09.3 to develop an electrically resistive concrete for use under new tracks as mass transit expands. The concrete was also expected to comply with high early strength and workability requirements. With the help of Tinnea and Associates LLC and previous research, the team mixed and tested the fresh and hardened state properties of four concrete mixes, modifying each with varying percentages of supplementary cementitious materials to achieve a high early strength, high resistivity concrete mix design. Based on this research, mix design recommendations were made.

Steel Plate Shear Wall Research and Design

NUMBER:	CEE 09.4
SPONSOR:	University of Washington
SPONSOR LIAISONS:	Jeffrey Berman, Laura Lowes
FACULTY ADVISOR:	Prof. Jeffrey Dragovich
STUDENTS:	James Grant, Jeri Shimazu, Glenn Strid, Sean Wegener

Steel Plate Shear Wall (SPSW) systems are used in structures to resist lateral load due to wind and seismic loading. The University of Washington (UW) is currently researching Smart and Resilient Steel Plate Shear Walls (SR-SPSW), which include "self-sensing" and "self-centering" concepts. As part of their research, the UW requested that team CEE 09.4 design the SPSWs for three- and nine-story prototype structures subjected to wind and seismic loading. The structures were designed using both strip and orthotropic plate finite-element modeling. The structure designs were then analyzed using elastic time history analysis and a non-linear pushover analysis to provide a correlation between elastic and inelastic behavior. These designs will serve as prototypes for future UW experiments and as a baseline for comparison with new SR-SPSWs designs. The project deliverables included a final report containing design calculations, design drawings of the nine-story structure, a construction cost estimate and life cycle analysis, and electronic copies of the computer models and design drawings.

Willapa Hills Wastewater Treatment

NUMBER: CEE 09.5
SPONSOR: La Ferme de Metras, LLC
SPONSOR LIAISON: Stephen Heuffed
FACULTY ADVISOR: Prof. Michael Marsolek
STUDENTS: Heather Baetge, Tony Sayavong, Charlie Wence, Chad Wiggins

Willapa Hills Farmstead Cheese is a sheep dairy and cheese-making facility near Chehalis, Washington. The company requested the CEE 09.5 team to design a wastewater treatment system for the whey and clean-in-place wastewaters generated during cheese making. The water was to be reused for irrigation or discharged into the Chehalis River. The final design had to allow the farm to apply for certified organic status while remaining within their budgetary constraints. The proposed design included a primary treatment stage followed by constructed wetlands. The property was surveyed to optimize site placement. Raw whey was used in several lab experiments to investigate its biodegradation, settling, and capacity for filtration. These lab results, coupled with EPA guidelines for the design of the constructed wetlands, were used to generate the final design. In addition, the design has the flexibility to accommodate future expansion of the dairy operation.

Mechanical Algae Lipid Extractor

NUMBER: ME 09.1
SPONSOR: The Boeing Company
SPONSOR LIAISONS: Dave Daggett (Boeing), Ann Mescher (UW)
FACULTY ADVISOR: Prof. Teodora Shuman
STUDENTS: Graham Bratzel, Ian Mayther, Paul Woosley

Growing concern over the environment and depleting petroleum resources is driving the development of new renewable fuel sources. Air travel relies on liquid fuels with high energy densities. The Boeing Company has become a catalyst for finding a sustainable and clean burning fuel solution. In their search for a solution, Boeing presented the ME 09.1 team with the task of designing a mechanical pre-treatment method to aid in efficiently extracting lipids from microalgae. These lipids will be used to produce Bio-Jet, a renewable biomass based jet-fuel replacement for Boeing planes. Current extraction technology makes algae an expensive and infeasible fuel source. An energy efficient extraction method that is scalable to an industrial level is needed. The design team tested two solutions to meet this need, including (1) a ball mill using glass microspheres to bludgeon the algae, and (2) electroporation to create permanent holes in the cell membrane through application of high voltage electric fields. Oil extraction was performed by the Seattle University Chemistry Department with further investigation of the solvent-decanting method used in previous research. Cell growth and lipid content curves were constructed in conjunction with the SU Biology Department to determine peak oil content in the algae's growth cycle. By efficiently extracting a high percentage of available lipids when they are of the highest concentration the cost of algae based fuels will be reduced yielding an economic and clean fuel alternative to current petroleum options.

HVAC Cost Analysis

NUMBER: ME 09.2
SPONSOR: Costco
SPONSOR LIAISON: Craig Peal
FACULTY ADVISOR: Prof. Christopher Stipe
STUDENTS: Khalifah Alghanim, Deborah Macias, Andrew Hinrichs, Nicolas LeDuc

Costco stores located in humid regions of the U.S. are encountering maintenance and safety problems from refrigeration equipment condensation. Condensation can be reduced by lowering the indoor air temperature and by removing moisture from the incoming outdoor air. Cost and environmental analyses were performed on the effect of reducing the indoor air temperature from 78 °F to 74 °F and 72 °F. The ME 09.2 team developed an energy-based computer model of a standard Costco building to determine energy consumption and associated costs of the changes in operating conditions. These analyses found that lowering the thermostat to 74 °F and 72 °F increases energy consumption 5% and 7%, respectively. The temperature changes with the addition of a desiccant wheel dehumidification system resulted in an energy increase of between 12% and 25% for the three temperatures. These changes will cost between \$22,000 - \$165,000 per year depending on the system and operating configuration. Additionally, these changes will increase annual carbon emissions by 150-930 metric tons.

Mt. Rainier National Park Solar PV System

NUMBER: ME 09.3
SPONSOR: National Park Service / UNPEPP
SPONSOR LIAISONS: Keith Boyd Fackler Jr., James Fuller
FACULTY ADVISOR: Prof. Teodora Shuman
STUDENTS: Kevan Brown, Eric Flickinger, Kristi Goebel

Mount Rainier National Park (MORA) is reducing its energy consumption and environmental impact. The ME 09.3 design team recommended improved energy practices for the Sunrise area of MORA to minimize its carbon footprint. First, the team designed a stand-alone solar photovoltaic (PV) system with a backup propane generator to replace the diesel generators currently used. The hybrid PV system will reduce harmful emissions and noise pollution. Second, the team performed an energy audit on the Sunrise Lodge. A significant amount of heat is lost through the aging structure, wasting energy. Installing double pane windows and adding insulation will decrease the energy loss by 75%. If all of these energy conservation measures are implemented, MORA can mitigate as much as 130 metric tons of carbon dioxide per year during the four months that Sunrise operates.

Airspeed Probe Team 2

NUMBER: ME 09.4
SPONSOR: PACCAR
SPONSOR LIAISONS: Mark Fredrickson, Al Kimbell, Alec Wong
FACULTY ADVISOR: Prof. Robert Cornwell
STUDENTS: Michael Barton, Brian Hensley, Trung Nguyen

As fuel prices rise, PACCAR's Kenworth truck division is studying ways to help drivers of its vehicles reduce operational costs. Roughly 50% of the fuel consumed in commercial trucking is due to aerodynamic drag, which results in decreased fuel efficiency. As a result, Kenworth is interested in providing the drivers of its vehicles with real-time information on the magnitude and direction of the headwinds in which the truck is operating. Design team ME 09.4 collaborated with design team ECE 09.2 to develop a truck mounted system to measure the wind velocity and direction, transmit the information wirelessly to the truck's on-board computer, and provide a real-time display for the driver. The wind speed and direction are determined by measuring the drag force on a rod of known geometry subjected to the same headwind as the truck. To make the system self contained, a set of solar panels power both the sensor and wireless transmission unit. A full scale prototype of the system was designed and field tested. A technical report, working prototype and engineering drawings were delivered to Kenworth at the conclusion of the project.

MIDI Sound Engine

NUMBER: ECE 09.1
SPONSOR: Artisan Instruments
SPONSOR LIAISON: Mark Anderson
FACULTY ADVISOR: Prof. Agnieszka Miguel
STUDENTS: Mark Cabiao, Okezie Eze, Tyler Gillies, Matt Ginsey

Artisan Instrument produces electric organs based on the MIDI (Musical Instrument Digital Interface) standard and using extensive sampling of a variety of instruments for synthesis. The ECE 09.1 design team has redesigned Artisan's MIDI Sound Engine, porting it to a new platform and adding features such as equalization and reverberation. In addition, security for the system has been improved. The new engine can be produced at less cost than the original.

Airspeed Probe Team 1

NUMBER: ECE 09.2
SPONSOR: PACCAR
SPONSOR LIAISON: Mark Fredrickson
FACULTY ADVISOR: Prof. Paul Neudorfer
STUDENTS: Clement Maufrais, Paul Nguyen, Kevin O'Donnell, Gerd Padilla

PACCAR Inc., a global technology leader in the design and manufacture of heavy duty trucks, requires a system for measuring windspeed and direction from a moving truck. Using the guidelines of low-power, low-cost and retrofit capability, the ECE 09.2 design team developed a Zigbee-based wireless communication system to deliver two streams of digitized data to an in-cab computer, powered from the cigarette lighter of the dashboard. This computer runs an application written to process the signals, calculate windspeed and direction and display the information as text and as graphic display on its display screen.

Small Human-Powered Generator Design

NUMBER: ECE 09.3
SPONSOR: Seattle University
SPONSOR LIAISONS: James Okullo (Sparling), Steve Szablya (SU)
FACULTY ADVISOR: Prof. Henry Louie
STUDENTS: Erik Moroles, Anthony Robbins, Theadora Rupp

Much of rural Zambia is off the national power grid. Nevertheless, many villages have TVs, radios, and cell-phones, all of which are battery powered. Rather than walk miles for the purpose of recharging batteries, the ECE 09.3 team has designed an electrical generator that can be built almost entirely of locally available materials and powered by human muscle. The design has been optimized for long-term operation and rugged operating conditions. The generator can be used to charge batteries or run efficient lighting systems and the documentation can be used to spread electrical self-sufficiency across the countryside.

Angst Warriors Art Installation

NUMBER: INT 09.1
SPONSOR: The Other Roadside Attraction
SPONSOR LIAISON: Pam Hom
FACULTY ADVISORS: Prof. Mike Larson, Prof. Al Moser
STUDENTS: Renaud Chauvin-Martin, Dean Hoaglan, Michael Lie,
Joe McMichael, Yansen Rosli, Jordan Wagner

Local artist Pam Hom has developed a group of tall metal sculptures that are roughly humanoid. The goal of the INT 09.1 design team is to help develop a system in which the sculptures can move about in a usually purposeful, yet angst-filled way. The team has provided mobility, anti-collision features and three prototypes, as well as documentation for building more sculptures. There will eventually be as many as 21 of these sculptures. The documentation is complete enough for others to construct more of these mobile platforms. The controls for these sculptures contain parameters that can be set by the artist to modify the movements in various ways to provide different artistic effects.

Boeing Multi-Motion Test Machine and Compliant Coupling Testing

NUMBER: INT 09.3
SPONSOR: The Boeing Company
SPONSOR LIAISON: John Finigan
FACULTY ADVISORS: Prof. Al Moser, Prof. Frank J. Shih
STUDENTS: Javier Castegnaro, Acer Daken, Brock Jahner,
Benjamin Juarez, Chelsea Ryberg, Tyler Sandstrom,
Derek Vetter

The Boeing Company wants to reduce the time required to set up various tests for aircraft components. Boeing requested the INT 09.3 team to design a multi-motion testing system (MMTS) capable of producing rotary rates of 3600 RPM and linear displacements up to 12 inches at 20 in/s and 10,000 lb force. The ability to quickly configure the apparatus for specific tests improves the efficiency of the test laboratory operation. The machine incorporates two belt-driven modules: a ball screw that produces the linear motion and a free-spinning module that performs torsional and rotational tests. The motor is driven by a SSD AC 890+ vector driver controller. A graphical user interface (GUI) was implemented to control the test parameters using MS Visual Studio and National Instruments' Measurement Studio.

Chirundu Community Fountain Design

NUMBER: INT 09.4
SPONSOR: Seattle University
SPONSOR LIAISONS: Rebecca Dugopolski and Heidi Machel,
Herrera Environmental Consultants
FACULTY ADVISORS: Prof. Mike Larson, Prof. Phillip Thompson
STUDENTS: Faisal Mased, Sonya Milonova, Meghan Reha,
Ian Tromble

Chirundu, Zambia is a town of approximately 7,000 people on the Zambezi River. Chirundu's water distribution system is not affordable for many residents, so these families collect water and wash their clothes in the river, which is a prominent community gathering place. The river is the native habitat for the Nile crocodile, and attacks are frequent at this site. Waterborne diseases are also a persistent problem. Using locally available materials, the INT 09.4 team designed a mechanical pumping system and fountain to provide water and a space for gathering in a location protected from crocodiles. The team also developed a water treatment system to remove pathogens from the portion of the water intended for drinking and cooking. The team will also provide the community with resources and training to produce chlorine for residual disinfection in stored water. The team plans to travel to Chirundu in June 2009 to implement the design.

PMU Simulator

NUMBER: CSSE 09.1
SPONSOR: AREVA T&D
SPONSOR LIAISONS: Kevin Cheung, Robert St. Andre
FACULTY ADVISORS: Prof. Eric Larson
STUDENTS: Joe McMichael, Tyler Pigott, Brandon Quinn,
Scott Tembreull

AREVA T&D is a provider of fully integrated electrical network management software. AREVA hopes to effectively incorporate data from increasingly popular telemetry modules called Phasor Monitoring Units (PMUs) to update and differentiate their suite of network management solutions. However, testing this software with existing PMU hardware is prohibitively expensive and resource-intensive. This project involved creating a PMU simulator that is responsible for simulating over fifty PMUs. To provide realistic data, the user can add simulations of real-world events and disturbances to the PMUs in real-time. AREVA's data acquisition software can connect to the simulated PMUs over a network through the IEEE C37.118 standard interface for synchrophasors. This simulator will greatly reduce the cost of testing and demonstrations.

Automated Cosmetic Line Assignment System

NUMBER: CSSE 09.2
SPONSOR: Nordstrom Inc.
SPONSOR LIAISON: James Hoover
FACULTY ADVISOR: Prof. Annie Dai
STUDENTS: Nicolas Filori, Devin McBride, Logan Waggoner

Nordstrom Inc., a leading fashion specialty retailer, currently uses a time consuming manual process to identify the employees in their cosmetic department for billing purposes. For each Nordstrom cosmetic department across the nation and each cosmetic product line sold in a particular cosmetic department, there must be at least one employee designated to represent that product line. This relation between an employee and cosmetic product line is known to Nordstrom as a cosmetic line assignment. Enabling Nordstrom to track line assignments both accurately and swiftly is imperative for both scheduling and billing reasons. The CSSE 09.2 design team's objective was to build a web-based cosmetic line assignment application to automate and simplify the previously manual process. This was accomplished through the use of Visual Basic .NET accompanied by an MSSQL database. The standardized solution will eliminate data errors and re-entry by providing a uniform method for line assignment entry and tracking.

Market Research and Strategy Development

SPONSOR: Historic Flight Foundation
SPONSOR LIAISON: John Sessions
FACULTY ADVISORS: Prof. Leo Simpson
STUDENTS: Craig Chartier, Brooke Novak, Jon Olmsted

Historic Flight Foundation was established in 2005 with the intention to collect, restore and share significant aircraft from the period between Charles Lindbergh's historic flight and the first test flight of the Boeing 707 (1927-57). Beginning in 2006, the primary focus became planning for a permanent facility to share the collection, maintain the aircraft for flight and restore aircraft that might be added to the collection. Construction of the Restoration Center has been completed and the client's focus is now on creating a business plan to ensure the long-term viability of the museum. The students were able to achieve their objectives by taking a four-pronged approach. First, research was conducted on possible sources of revenue, both from operations and from donations and grants. Second, a market analysis was undertaken including a survey and demographic research. Third, insights were provided into a possible organizational structure. Finally, a draft-level P&L was constructed by combining the proposed sources of revenue with potential costs.

Land Mobile Radio

SPONSOR: Twisted Pair Solutions
SPONSOR LIAISON: Bill Rebozo
FACULTY ADVISORS: Prof. Leo Simpson
STUDENTS: Vasili Arvanitidis, Danny Sullivan, Rebka Tadesse

Effective communication relies on two or more parties understanding a common language. The Land Mobile Radio (LMR) market is in desperate need of a solution that will enable unified communications. In researching the LMR market, outside sources, using a forecasted method from 2005, indicated a sales estimate of \$6.6B for 2007. Looking deeper, the supplier analysis estimated \$8.2B in sales for 2007, demonstrating that even with the projection of growth, these sources drastically underestimate the potential of the LMR market. Government and Public Safety are the leading customer segments, representing approximately 85% of the European market and 90% of the North American market. Policy makers are leading the efforts to unify communications which are crucial to emergency coordination. Twisted Pair is in a unique position with the opportunity to be a part of the next stage of technological evolution in telecommunications. The software known as Wave is currently the most effective platform to enable true interoperability. The future direction of radio, Software Defined Radio, is not well known, but has extremely exciting capabilities and the potential to be yet another step in the evolution of communication. This market research project provided Twisted Pair with information to plan their strategic market positioning.

SPONSORING ORGANIZATIONS, MANAGERS, AND LIAISONS

We want to acknowledge with special thanks the organizations that sponsored projects in 2008-2009, and especially the managers and liaisons representing the sponsors, who worked with the students throughout the year. The time these liaison representatives spent in consultation with our teams is much appreciated by the students and their faculty advisors. It is the liaisons who provide the history and background of each project, its relationship to other work in the sponsoring organization, and much of the technical direction that makes a project successful.

AREVA T&D	Kevin Cheung, Andre St. Andre
Artisan Instruments	Mark Anderson, Red Carlson
The Boeing Company	Dave Dagget, Norm Englund, John Finigan
Costco	Franz Lazarus, Craig Peal
Herrera Environmental Consultants	Christina Avoilio, Rebecca Dugopolski, Heidi Machel
Historic Flight Foundation	John Sessions
Kenworth Truck Company	Alec Wong
Mt. Rainier National Park / University National Energy Partnership Project (UNPEPP)	James Fuller
Nordstrom Inc.	James Hoover, Deb Huntting, Maureen Kamali, Bill Tucker
The Other Roadside Attraction	Pam Hom
PACCAR	Mark Fredrickson
Seattle City Light	David Anderson, Dan O'Sullivan, Dee Smiley
Seattle University	Steve Szablya
Snohomish County Public Works	Art Louie, Brian Larmore, Max Phan
Sparling	James Okullo
Tinnea & Associates LLC	Jack Tinnea, Ryan Tinnea
Twisted Pair Solutions	Bill Rebozo
University of Washington	Jeffrey Berman, Keith Boyd Fackler Jr., Laura Lowes, Ann Mesche, Geoff Mitchell, Philip Malte
Willapa Hills Farmstead Cheese	Stephen Heuffed

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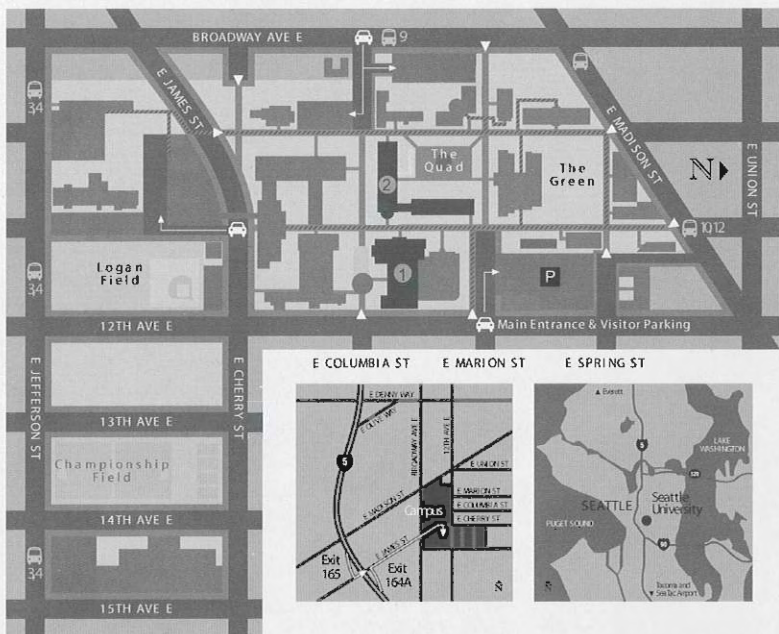
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- ▲ Campus Entry Point ♿ Accessible Route 🚌 King County Metro 🚗 Parking Entrance P Parking
 ① Sullivan Hall (School of Law) ② Bannan Center For Science & Engineering



DIRECTIONS FOR PROJECTS DAY

FROM THE NORTH:

- Head south on I-5
- Take exit 165A to James Street
- Left onto James Street
- Left onto 12th Avenue
- Left onto East Marion Street

FROM THE SOUTH:

- Head north on I-5
- Take exit 164A to James Street
- Right onto James Street
- Left onto 12th Avenue
- Left onto East Marion Street



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