FINAL REPORT FOR BENTLY CENTER AWARD (2015-2016)

Awardee

Stephen M. Klisch, Professor, Mechanical Engineering, sklisch@calpoly.edu

Award

25.5 units (7.5 in 2015 Summer quarter, 8 in 2015 Fall quarter, 6 in 2016 Winter quarter, 4 in 2016 Spring quarter)

Summary of Accomplishments

As stated in the original proposal, the **primary objectives** of the assigned time were: *"to maintain momentum in establishing Cal Poly's Human Motion Biomechanics (HMB) Lab and ... to serve as an effective and conscientious steward of the Bently endowment*" Most of my supported time was spent in four areas: 1) preparing proposal materials for external funding, 2) working with 25 HMB Lab students to develop the HMB Lab and conduct research on funded proposals, and 3) serving as Director of the Bently Center. In this report, I focus on items 1 and 2.

During the period of support, my activities included 1) attending the 2015 SB3C Conference (June 17-20, 2015) with five students where we delivered 5 poster presentations with 1 student receiving the 2nd Place award in the M.S. Research Poster Competition, 2) working with my student team to further develop our experimental and analysis protocols for motion analysis experiments, 3) working with my student team on research projects funded by STRIDE, CSUPERB, W.M. Keck Foundation, and Army Medical Research and Materiel Command, 4) preparing IRB protocols for several research projects, 5) submitting and revising a peer-reviewed journal paper based on M.S. thesis research, and 6) performing administrative tasks related to my positions as HMB Lab and Bently Center Directors.

Publications and other Deliverables (students in bold)

Peer-reviewed conference papers: poster presentations

1. **Sylvia MK**, **Czapla NA**, Lerner ZF, Tuttle DJ, Schueckler OJ, Hazelwood SJ, Klisch SM. Development of a human knee joint finite element model to investigate cartilage stress during walking in obese and normal weight adults. *SB3C Conference*, Jun 2015. 2nd Place Award, M.S. Research Poster Competition.
2. **Czapla NA**, **Sylvia MK**, Lerner ZF, Tuttle DJ, Schueckler OJ, Hazelwood SJ, Klisch SM. Human knee joint finite element model using a two bundle anterior cruciate ligament: validation and gait analysis. *SB3C Conference*, Jun 2015.
3. **Deschamps JE**, Hazelwood SJ, Klisch SM. Pseudo-rigid body method for reducing soft tissue artifact: validation and application to gait. *SB3C Conference*, Jun 2015.
4. **Kraemer LI**, **Gutierrez-Franco JD**, **Deschamps JE**, **Dudum KC**, **Dandekar EM**, Hazelwood SJ, Porumamilla H, Klisch SM. Design and implementation of an instrumented pedal for cycling biomechanics research. *SB3C Conference*, Jun 2015.
5. **Dudum KC**, **Deschamps JE**, **Gutierrez-Franco JD**, **Kraemer LI**, **Gonzalez-Smith A**, **Dandekar EM**, Hazelwood SJ, Klisch SM. Using OpenSim to predict knee joint moments during cycling. *SB3C Conference*, Jun 2015.

Peer-reviewed journal papers

1. **Deschamps JE**, Klisch SM. Pseudo-rigid body method for reducing soft tissue artifact: validation and application to gait. Submitted (original May 2016, in revision) to the *Journal of Biomechanics*.

Miscellaneous presentations / activities

1. Klisch SM. Motion analysis of knee biomechanics. *Orthopaedic Surgery Research Conference*, Dept. of Orthopaedic Surgery, UC San Diego, Jun 2015.
2. Klisch SM. Knee Joint biomechanics and obesity. *Cal Poly STRIDE – UC Berkeley School of Public Health Joint Obesity Symposium*, Oct 2015.
3. Certification: Biomedical research course for human subjects research. *Collaborative Institutional Training Initiative* (www.citiprogram.org), Nov 2015.
4. Klisch SM, **Dudum KC**, **Darke J**. Human Motion Biomechanics Lab: Student Projects, *Meeting of the CENG Dean's Advisory Council*, Nov 2015.
5. Klisch SM, Hazelwood SJ, **Darke J**, **Orekhov G**, **Montoya D**. Eight IRB protocols submitted to, and approved by, *Cal Poly's Human Subjects Committee* and the *Army Human Research Protections Office*, Oct 2015-May 2016.

Student Impact

Supervision of Cal Poly M.S. research projects

1. Jake Deschamps (ME, MS thesis project, in progress, PI Klisch), *Pseudo-rigid body method for reducing soft tissue artifact: validation and application to gait.*
2. Juan David Gutierrez-Franco (ME, MS thesis project, Jun 2016, co-PI Porumamilla), *The effects of obesity on resultant knee joint loads for gait and upright cycling.*
3. Eshan Dandekar (KINE, MS research, Spring 2014-present).
4. Haley Terndrup (KINE, MS research, Summer 2015).
5. Grace Privett (KINE, MS research, Winter 2016-present).
6. Michael Rumery (ME, MS thesis project, Winter 2016-present, co-PI Hazelwood).
7. Gabriel Del Castillo (BMED, MS thesis project, Spring 2016-present, co-PI Hazelwood).

Supervision of Cal Poly B.S. research projects

1. Karim Dudum (BME, BS research, Spring 2014-Spring 2016).
2. Luke Kraemer (ME, BS research, Spring 2014-Spring 2016).
3. Alejandro Gonzalez-Smith (ME, BS research, Summer 2014-present).
4. Jim Darke (BME, BS research, Summer 2015-present).
5. Daniel Montoya (ME, BS research, Fall 2015-present).
6. Greg Orekhov (ME, BS research, Fall 2015-present).
7. Nina Yadlowsky (ME, BS research, Winter 2016-present).
8. Isaac Gomez (KINE, BS research, Winter 2016-present).
9. Greg Lane (ME, BS research, Winter 2016-present).
10. Jordan Skaro (ME, BS research, Spring 2016-present).
11. Katherine Mavrommati (BMED, BS research, Spring 2016-present).
12. Megan Pottinger (BMED, BS research, Spring 2016-present).
13. Sam Tucker (ME, BS research, Spring 2016-present).
14. Kathleen Balfour (BMED, BS research, Spring 2016-present).

Supervision of non-Cal Poly student projects

1. Claudio Ghisleni (ME, MS, University of Bergamo, Italy, Summer 2015, co-advisor Birdsong).
2. Jared Gardner (Atascadero High School, Summer 2015).
3. Quint de Kleijn (ME, MS, University of Eindhoven, Netherlands, Fall 2015, co-advisor Mackin).
4. Harsh Goel (BME, UC Berkeley, Winter-Summer 2016).

Other student impacts

1. Developed Learning Modules (ME 212, ME 402) for the funded Keck Undergraduate Education Program grant (please see below for more details).

Proposals and other Leverage

Active awards during the period of support (external awards only: other grants funded by STRIDE and CENG R-IDC)

1. **W.M. Keck Foundation** – Undergraduate Education Program, Phase II Application. (PI Klisch, co-PIs Self, Hazelwood, Clark, Taylor)
1/1/16-6/30/19; $350,000 (direct costs only)
Title*:** Human Motion Biomechanics lab: Integrating research and education in an interdisciplinary setting. ***Aims: To 1) engage an interdisciplinary team of students in targeted biomechanics research, 2) develop an interdisciplinary undergraduate course to engage students in biomechanics research, and 3) develop inductive learning modules in several existing courses. ***Status:*** submitted Aug 2015 with conference call presentation in Sep 2015; awarded Jan 2016.

2. **US Army Medical Research and Materiel Command (AMRMC)**. (PI Klisch, co-PIs Hazelwood, Self)
3/15/16-3/14/19; $513,645 (total costs)
Title*:** Joint loads and cartilage stresses in intact joints of military transtibial amputees. ***Aims: To investigate the effects of select exercises, for both short-term rehabilitation and long-term fitness sustainment, on joint loads and cartilage stresses for transtibial amputees. ***Status:*** awarded Jan 2016.

3. **CSU Program for Education and Research in Biotechnology (CSUPERB)**. (PI Klisch, co-PI Hazelwood)
6/1/15-11/30/16; $15,000 (total costs)
Title*:** Experimental and computational analyses of joint and tissue loading in ACL reconstructed and contralateral knees. ***Aims: To 1) conduct EMG-driven inverse dynamic analyses of motion analysis experiments to estimate joint loading in ACL reconstructed and contralateral knees during exercise and 2) use whole joint finite element models to estimate cartilage tissue loading in ACL reconstructed and contralateral knees during exercise. ***Status:*** awarded May 2015.

FINAL REPORT FOR BENTLY CENTER AWARD (2015-2016)

Awardee

Russell V. Westphal, PhD, Donald E. Bently Professor; also, Constant J. & Dorothy F. Chrones Professor; Mechanical Engineering, rvwestph@calpoly.edu

Award

15 WTU Summer 2015 through Summer 2016 (originally proposed as 3 units for each of Summer 2015 through Summer 2016 = 3/3/3/3/3, modified at Chair's request to 3/3/4/0/5)

Summary of Accomplishments

Two main tasks were proposed: (1) **author a publication** concerning recent non-proprietary work on the Boundary Layer Data System (BLDS) project, and (2) **propose new sponsored** work that employs recent non-proprietary development of the BLDS. The support of the Donald E. Bently Center provided the proposer with 15 units total of summer and academic year release time which allowed completion of both of the specific proposed tasks, as well as supporting the continuation and expansion of a broad range of BLDS-related and other student project activities. This support is gratefully acknowledged.

Publications. A paper was submitted, accepted, presented, and appears in the proceedings of the June 2016 AIAA AVIATION meeting. A second extended abstract was submitted and accepted, with full manuscript in preparation, for the 2017 AIAA SCITECH meeting in January 2017. Former students Brittany Kinkade and Rachael Schelley were co-authors of these publications whose preparation resulted directly from the Bently Center support. Students Kris Lawrence and Htet Htet Oo are named as co-inventors on a patent disclosure arising from one of the sponsored projects. The proposer advised students Kris Lawrence and Alex Powers who completed their MS thesis work during the award period and submitted final thesis documents to the Cal Poly archive. The proposer is presently adviser for two additional MS thesis students, Htet Htet Oo and Andrew Elliott, whose work is in progress.

Proposals. Two formal proposals were prepared and awarded during the award period; one to the Boeing Commercial Airplane Company, and one to Northrop Grumman Corporation. The total value of these awards is $70 K; work on both of these projects is in progress. A third formal proposal ($30.5 K) was submitted with Northrop Grumman to the US Air Force; this proposal remains under consideration. An informal, "rough order-of-magnitude" budget was provided to Boeing for work that would follow-on from the current award; this $96 K proposal is under consideration. In addition, two informal proposals for no-cost demonstrations were submitted—to NASA Armstrong Research Center and to Tesla—these offers are currently under consideration. Finally, there were two separate, additional sponsored projects with awards totaling $150 K that were in progress during the period of this award.

Other Work. The proposer supported four senior projects as sponsor/client during the period of the Bently award. These projects involved 13 students and were funded from the awardee's professional development discretionary funds.

Publications and other Deliverables (students in bold)

Peer-reviewed conference papers

1. **Kinkade, B.**, Sullivan, A., Westphal, R. V., Gerhardt, J. "A New Skin Friction Gauge," AIAA-2016-4031, AIAA AVIATION, June 13-17, 2016, Washington D.C.
2. Westphal, R. V., and **Schelley, R.** "Instrument for In-Flight Boundary Layer Rake Measurements," extended abstract submitted June 2016 and accepted August 2016 for AIAA SCITECH Jan. 9-13, 2017, full manuscript in preparation (final manuscript due December 2016).

Patent Disclosure

1. "Directional Dynamic Absolute Pressure Sensor Shroud and Arrangement", Docket Number NGC-00215 (00869-0030), co-inventors Chris Harris, Yuan Li, **Htet Htet Oo**, Dan Cuppoletti, Russ Westphal, **Kris Lawrence**, Jim Gerhardt (patent owner: Northrop Grumman)

Other Presentations

1. "The Boundary Layer Data System," invited presentation for "Lunch & Learn" at Scaled Composites, Mojave, CA, July 8, 2015 (co-presenter: Anne Sullivan)
2. "Recent Adventures in Thermal & Pressure Anemometry," invited presentation at Thermal Design Center, Santa Clara, CA, Sept. 8, 2015
3. "The Cal Poly Boundary Layer Data System Project and Graduate Education", presented to ME Industrial Advisory Board, Oct 16 2015
4. "The Boundary Layer Data System," invited presentation at Stanford Univeristy, Jan 28, 2016
5. "The Boundary Layer Data System", presented to ME Graduate Seminar, Feb 3, 2016

Student Impact

Supervision of student M. S. thesis projects

1. **Kris Lawrence** (M. S. thesis advisor, Mechanical Engineering, June 2015 – July 2016; completed thesis, employed by Lockheed Martin; committee: Hans Mayer, Glen Thorncroft).
2. **Alex Powers** (M. S. thesis advisor, Mechanical Engineering, June 2015 – June 2016; completed thesis, employed by BobSweep; committee: Chris Pascual, William Murray).
3. **Andrew Elliott** (M. S. thesis advisor, Mechanical Engineering, Jan. 2016 – present; anticipated completion 2017; committee: TBD)
4. **Htet Htet Oo** (M. S. thesis advisor, Mechanical Engineering, Jan. 2016 – present; anticipated completion 2017; committee: TBD)

Senior Projects Sponsored

1. "High-Speed Air Jet Turbine Test Apparatus" Students: Kenneth Enstrom, Cody Lee, Cameron Naugle, Isaac Thomas (Dec 2015)
2. "Rotor Test Rig" Students: Derek Nelson, Ethan Pautz, Htet Htet Oo (Dec 2015)
3. "ESC Efficiency Test Rig" Students: Matthew Hudson, Grace Cowell, Marcus Pereira (June 2016)
4. "Flow Meter Test Rig" Students: Michael Swartz, Emily Guss, Cory Davis (June 2016)

Proposals and other Leverage

Active awards during the period of support

1. **Boeing Commercial Airplane Company** (R. V. Westphal, PI)
June-Dec. 2016; $45. K
Title*:** Flight Test of Boundary Layer Data System (BLDS). ***Aims*:** Demonstrate BLDS for Boeing Commercial Airplane applications. ***Status: submitted January 2016, funded June 2016.

2. **Northrop Grumman Corporation** (R. V. Westphal, PI)
June-Dec. 2016; $25. K
Title*:** Cal Poly Flow Measurement Technology Development Program IRAD 2016. ***Aims*:** Develop measurement technology of aircraft engine inlet testing. ***Status: submitted April 2016, funded June 2016.

3. **Northrop Grumman Corporation** (R. V. Westphal, PI)
June-Dec. 2016; $25. K
Title*:** Cal Poly Flow Measurement Technology Development Program IRAD 2015. ***Aims*:** Develop measurement technology for aircraft engine inlet testing. ***Status: completed Dec. 2015.

4. **US Air Force Wright Aeronautical Labs**; subcontract through **Northrop Grumman Corporation** (R. V. Westphal, PI)
Oct. 2014-Oct. 2016; $124. K
Title*:** Cal Poly Support for Swept BEES/SWEETER. ***Aims*:** Develop and apply specialized instrumentation for wind tunnel test of laminar flow technology. ***Status: in progress.

Proposals submitted during the period of support and not yet awarded

1. **US Air Force Wright Aeronautical Labs**; subcontract through **Northrop Grumman Corporation** (R. V. Westphal, PI)
Dates TBD, formal, $30.5 K
Title*:** Excrescence Flight Demonstration. ***Aims*:** Support application of BLDS for flight test to validate new manufacturing tolerance criteria for laminar flow/low drag aircraft design and manufacture. ***Status: formal proposal submitted July 2015; USAF indicated desire to fund but have not yet awarded.

2. **Boeing Commercial Airplane Company** (R. V. Westphal, PI)
Nov 2016-June 2018; $96.1 K
Title*:** Boundary Layer Data System (BLDS) for Boeing EcoD 2018. ***Aims*:** Apply BLDS for Boeing Commercial Airplane on their planned 2018 EcoDemonstrator flight test program. ***Status: informal ROM budget submitted July 2016, under consideration.

3. **NASA Armstrong Research Center** (R. V. Westphal, PI)
Dates TBD; informal, no-cost demonstration
Title*:** No-Cost Demonstration of the Boundary Layer Data System for NASA. ***Aims*:** Demonstrate application of BLDS on NASA's Gulfstream III "SCRAT" research aircraft. ***Status: informal "white paper" submitted January 2016; NASA has not replied to the offer.

4. **Tesla** (Graham Doig, PI; R. V. Westphal, co-PI)
Dates TBD; informal, no-cost demonstration
Title*:** Demonstration of BLDS for Tesla Vehicle Aerodynamic Testing. ***Aims*:** Provide Tesla with a demonstration of BLDS in operation during an on-the-road test of their choosing. Use the experience to guide preparation of a formal proposal. ***Status: informal offer submitted spring 2016; approved by Tesla engineers and awaiting test date.

FINAL REPORT FOR BENTLY CENTER AWARD (2015-2016)

Awardee

Thomas J. Mackin, Professor of Mechanical Engineering, tmackin@calpoly.edu

Award

12 units (4 in Fall 2015, 4 in Winter quarter 2016, 4 in Spring 2016)

Summary of Accomplishments

The release time awarded through this proposal was used in two key ways: Frist, the time enabled me to secure research funding from a major athletic equipment corporation; Second, the release allowed me to more actively participate in Homeland Security Research and education at The Center for Homeland Defense and Security at the Naval Postgraduate School. In the Fall of 2016 I hosted Quint DeKlein, a student from Eindhoven. This student developed a testing protocol for extracting joint forces during walking and jogging. Quint worked exclusively in the HMB lab with guidance by Prof. Klisch. This work was used to support a proposal on athletic shoe design that helped me obtain funding to support research on athletic shoe design. Once funding was obtained, my research shifted to materials development with the aim of establishing design criteria linked directly to joint forces. We have successfully developed characterization methods and models to related materials response to processing and microstructure. We are currently developing the FEA models that will guide future cushioning system design. This work has support 2 graduate students, two faculty and 5 undergraduate students.

On the Homeland Security side, I used my release time to present seminars on infrastructure case studies in October 2015, January 2016 and March 2016. I also advise 4 graduate students at NPS, whose thesis work covers a broad range of homeland security issues (see list below).

Release time was also used to finish writing a paper on battery pack performance and design and to wrap up another project on batteries using the multi-physics simulation capabilities of ComSol. It is important to note that much of my research is covered by confidentiality agreements which currently preclude broad public dissemination of results.

Publications and other Deliverables (students in bold)

Peer-reviewed journal papers

1. **Kevin Parsons**, and T. J. Mackin, "Design and Simulation of a Passive Thermal Management System for Lithium-Ion Battery Packs on an Unmanned Ground Vehicle," accepted for publication in The Journal of Thermal Science and Engineering Applications, Summer 2016.

Peer-reviewed Conference Publications

1. **Joel Stoudman**, John Dunning and Thomas Mackin, "Heat Generation Modeling of two Lithium Batteries: from the cell to the pack on Comsol Multiphysics", Comsol Conference 2015, Grenoble, France, October 15, 2015.

Technical Presentations

1. **Joel Stoudman**, John Dunning and Thomas Mackin, "Heat Generation Modeling of two Lithium Batteries: from the cell to the pack on Comsol Multiphysics", Comsol Conference 2015, Grenoble, France, October 15, 2015.

Student Impact

Supervision of funded student projects at Cal Poly

1. **Patrick Hutchinson**. Graduate Student in the ME Dept. Funded through project on athletic shoes. Thesis: Microstructure/properties relations in foamed viscoelastic polymers. Advisor: Tom Mackin. 3/2016- present. Expected graduation in June 2017.
2. **Michael George**. Undergraduate in ME. Funded through project on athletic shoes. Advisor: Tom Mackin. Project title: Design and production of a Fatigue testing machine for athletic shoes. 3/2016-present.
3. **Andrew Acosta**. Undergraduate in ME. Funded through project on athletic shoes. Advisor: Tom Mackin. Project title: Design and Development of a Fatigue testing machine for athletic shoes. 3/2016-present.
4. **Daniel Montoya**. Undergraduate in ME. Funded through project on athletic shoes. Advisor: Tom Mackin. Project title: Experiments to characterize the microstructure and the mechanical properties of foamed polymers 3/2016-present.
5. **Samuel Tucker**. Undergraduate in ME. Funded through project on athletic shoes. Advisor: Tom Mackin. Project title: Design and Development of a non-contacting strain mapping system using MatLab. 3/2016-present.
6. **Eshan Dandekar**. Graduate Student in Kinesiology. Funded through project on athletic shoes. Advisor: Tom Mackin. Project title: Experiments to characterize the microstructure and the mechanical properties of foamed polymers 3/2016-present
7. **Rachel Kangas**. Undergraduate in ME. Funded through project on athletic shoes. Advisor: Tom Mackin. Project title: Experiments to characterize the microstructure and the mechanical properties of foamed polymers 3/2016-6/2016.
8. **Jim Darke**. Undergraduate in BMED. Funded through project on athletic shoes. Advisor: Tom Mackin. Project title: Experiments to characterize the microstructure and the mechanical properties of foamed polymers 3/2016-present.

Supervision of funded student projects at The Center for Homeland Defense and Security, NPS

1. **Mathew Jonkey**. Commander, 92nd Civil Support Team, Nevada National Guard. Graduate Student in the Center for Homeland Defense and Security (CHDS). Thesis: Civil Support Teams and CBRNE-sensing sUAS. Advisor: Tom Mackin. 1/2016- present. Expected graduation in December 2016.
2. **Chad Stangeland**. Assistant Chief, Moorhead Fire Department. Graduate Student in the Center for Homeland Defense and Security (CHDS). Thesis: Fracking: Unintended consequences for local communities. Advisor: Tom Mackin. 1/2016- present. Expected graduation in December 2016.
3. **Don Simko**. Emergency Management Program Specialist-Public Assistance, FEMA HQ. Graduate Student in the Center for Homeland Defense and Security (CHDS). Thesis: Increasing road infrastructure capacity through the use autonomous vehicles. Advisor: Tom Mackin. 1/2016- present. Expected graduation in December 2016.

4. **Larry King**. Supervisory Transportation Security Inspector, DHS/TSA. Graduate Student in the Center for Homeland Defense and Security (CHDS). Thesis: Security Resource Decision Making For Passenger Rail Systems. Advisor: Tom Mackin. 1/2016- present. Expected graduation in December 2016.

Proposals and other Leverage

Active awards during the period of support

1. **Athletic Shoe Corporation (name withheld by contract restrictions** (Thomas J. Mackin and Steve Klisch), $121,000.

FINAL REPORT FOR BENTLY CENTER AWARD (2015-2016)

Awardee

Andrew Kean, Professor, Mechanical Engineering, akean@calpoly.edu

Award

12 WTU (5 WTU in Winter 2016 and 7 WTU in Spring 2016)

Summary of Accomplishments

Neurofibromatosis 2 (NF2) is a devastating genetic disease characterized by bilateral vestibular schwannomas. A vestibular schwannoma is a tumor of the sheath around the nerve which transmits sound and balance information from the ear to the brain. These tumors are benign, in the sense that they are not cancerous. But they are not benign in their effect on patients of this disease. Typical consequences of this disease include loss of hearing, balance dysfunction, facial palsy, loss of eyesight, hand/foot drop, other brain tumors, and death.

In order to do whatever I can to help improve the quality of life of pediatric NF2 patients, my proposed plan for 2015-2016 focused on the following three tasks:

Task 1) Continue my literature search on NF2 in order to identify areas where a mechanical engineer can positively impact the treatment of this genetic disease.

Current status: I have completed the work and the outcomes of which are discussed below.

Task 2) Develop a survey (email or phone) for medical researchers focusing on NF2 to try to identify areas of need. I plan to develop one survey for those doing genetic research on the causes of NF2 and a second survey for those caring for NF2 patients. From this survey, I will identify further research to be performed.

Current status: I developed an email survey for medical researchers focusing on NF2. The number of these physicians is small, so in the end it was sent to only about 10 people. Response rate was initially very low, but by following up via phone and/or at an NF2 meeting, I increased the number of responses somewhat. The treatment of NF2 tumors is somewhat split between proponents of surgery and proponents of some form of radiation treatment. Recommendations to me from researchers (not surprisingly) roughly tracked their own chosen approach to treatment. There was no clear consensus as to the best approach for a mechanical engineer from these discussions.

A third area of treatment involves clinical drug trials. At present, there are no approved drugs for treatment of NF2, but infrequent trials/testing does occur. Based on discussions with researchers and Cal Poly's lack of a medical center, I decided that I had little to contribute in this area.

Due to medical privacy issues, I was unable to distribute my second survey for those caring for NF2 patients. Instead, I attended a NF2-focused meeting at Children's Hospital Los Angeles to address this area of inquiry.

Based on these discussions/surveys, I identified that the best place for me to impact pediatric NF2 patients was technology development/integration to improve their quality of life, as outlined below.

Task 3) Given that I am not a genetics expert, my future focus will clearly be on areas where a mechanical engineer can have a direct impact and where I can get ME students involved in my research.

Current status: In order to have the greatest impact in the shortest amount of time, I chose to pursue integration of existing technologies for the expressed purpose of improving quality of life of pediatric NF2 patients. Because the most common consequence of the disease is loss of hearing, I chose to address this first.

A hardware platform was chosen which would allow to integrate speech recognition software to convert conversation to printed words in real-time. This will enable a hearing-impaired user of the device to read the words of others as they are spoken, without having to continually look down at a computer or phone. It will reduce the necessity to lip-read for those patients with limited hearing, and also reduce the requirements for sign-language knowledge by those caring for NF2 patients.

Specifically, a new product called the Vuzix M300 Smart Glass was identified as the most appropriate platform. This product can run either Android or iOS, but Android was chosen for my efforts because of my greater familiarity with this operating system. The Vuzix M300 was originally expected to ship by summer 2016, but they offered a Migration Package where they shipped an existing M100 Smart Glass when I first ordered the product, and will swap it out for free with a M300 when they are released. The shipping date of the newer product has been postponed, so all research performed so far has focused on the less capable M100 product. At present, the replacement M300 is expected to ship this fall.

While the M100 has built-in voice navigation controls, this software proved too limited to understand regular conversation. An Android application was needed improve this capability of the device. Specifically, the Dragon Anywhere speech recognition application by Nuance Communications was purchased for this purpose. While use of this product is not perfect, it has enabled the M100 to recognize most spoken words in real-time and convert them to text.

An unexpected challenge has arisen regarding the noise-cancelling microphone of the M100 smart glasses. It has clearly been designed in a way to focus on the spoken words of the wearer of the glasses and filter out other noises/voices. For the application described here, it would be better if it ignored the spoken words of the wearer and instead focused on the voices of those in conversation with the wearer. There may be a software solution to this, but at present, I am researching the addition of a compact “shotgun” microphone to the M100 or M300 smart glasses to enhance the directional focus of the microphone.

Testing of the M100 smart glasses with Dragon Anywhere has taken place by myself and by a NF2 patient. She has been successfully able to read conversations as they happened. The device has proven successful in quiet environments, but has had limited success in environments with high levels of ambient noise (e.g., restaurants). The additional microphone mentioned previously may help in these more challenging situations. This is part of the research planned for the current academic year.

Publications and other Deliverables (students in bold)

Due to the early nature of these efforts, no peer-reviewed publications have been submitted.

Student Impact

After identifying my research focus here, I felt that software engineering students would be most interested in my efforts. I have tried to get students involved in my efforts by posting inquiries in various buildings on campus, but, due to a lack of budget for student salary, no such participation has taken place.

Proposals and other Leverage

None.

FINAL REPORT FOR BENTLY CENTER AWARD (2015-2016)

Awardee

Xi Wu, Professor, Mechanical Engineering, xwu@calpoly.edu

Award

7 units in 2016 Winter quarter

Summary of Accomplishments

During 2015-2016 academic year, my research focused on rotor dynamics, designing and manufacturing Active Magnetic Bearing (AMB) for Bently rotor kit. Most of my supported time was spent in the following areas and activities: (1). I sponsored a senior project of designing and manufacturing Active Magnetic Bearing for the rotor kit in vibration lab. AMBs provide a new way of increasing the shaft speed in rotor dynamics by suspending a rotational rotor in magnetic field with extremely low friction and wear. Controllers are incorporated into AMB to adjust the electromagnetic forces and effectively control the dynamical behavior of the rotor position. (2). designing of AMB is very challenging because there are few references. The first step in designing the AMB was to determine the magnetic force that the bearing had to produce to levitate the rotor. This involved theoretically analysis of a two-plane mass rotor system suspended between two bushings. Based on the comprehensive theoretical calculations, components of AMB were designed. (3). CAD model of the whole rotor kit with AMB was created. This model is imported into ADAMS to do comprehensive dynamic analysis. This step is iterative and critical to improve the designing of AMB. To the best of my knowledge, our ADAMS rotor kit model with AMB is the first one to realistically simulate the interactive dynamic behavior of rotor dynamics and magnetic bearing. The bearing system were analyzed in MSC ADAMS to determine the vibrational response of suspended masses on a flexible rotor that each have an eccentricity at different phase angles. In addition, generated magnetic forces and magnetic flux densities were analyzed utilizing the FEA method in Abaqus. Magnetic forces by each of the 8 poles were induced by an applied current to each actuator that acted perpendicular to an applied current density field inside solid copper windings. (4). lastly, AMB components were properly designed, manufactured and assembled together. In addition to laminated stator, stator case and magnetic coils, the AMB assembly consists of actuating and sensing electronic hardware which typically includes: (a) a digital control board that receives and analyzes data, then implements C code converted from MATLAB or LabVIEW, (b) power amplifiers that convert controller signals into desired magnetic actuator currents, and (c). sensors that convert physical displacements into voltages. This rotor kit with AMB successfully passed the physical test. (5). I was invited to teach "Smart Vehicles" class at Munich University of Applied Science during summer. I introduced students the concepts and background of "smart vehicles". Then they are required to finish two feedback-control system projects using MATLAB\Simulink: *Project 1,* design automatic cruise control system to maintain a constant vehicle speed despite external disturbances. Project 2, apply the anti-lock braking system or ABS to detect slip, then momentarily reduce the braking force to prevent the slip using controller. (6). I gave my research presentation entitled "Full Spectrum Analysis of Rotating Machinery" in Mechanical Engineering Graduate Seminar ME563.

Publications and other Deliverables (students in bold)

Peer-reviewed journal paper

1. Wu, X., **Sommer, A.,** Meagher, J., 2016, "Spectrum Diagnostics of a Damaged Differential Planetary Gear during Various Operating Conditions", Physical Science International Journal, 9(3): 1-13, 2016, Article no. PSIJ.22868 ISSN: 2348-0130

Miscellaneous presentations / activities

1. Wu, X., **Naugle, C**.. *Full Spectrum Analysis of Rotating Machinery,* Mechanical Engineering Graduate Seminar ME563, Cal Poly. Feb. 2016.
2. Wu, X., *Smart Vehicles*, Munich University of Applied Science, Germany, July 2016.

Student Impact

Supervision of Cal Poly student projects

1. Cameron Naugle (ME, MS research, Fall 2015-present).
2. Lucas Carter (ME, MS research, Fall 2015-present).
3. Pedro Rivera (ME, MS research, Fall 2015-present).
4. Sean Fowler (ME, BS research, Fall 2015-Spring 2016) *Magnetic Bearing for Bently Nevada RK4 Rotor Kits*
5. Garret Olson (ME, BS research, Fall 2015-Spring 2016) *Magnetic Bearing for Bently Nevada RK4 Rotor Kits*

Member of Graduate Student Defense Committees

1. Nar Vang (ME, MS thesis defended on 2015) *A Concept Validation Of A Magnetometry-Based Technology For Detecting Concealed Weapons In Vehicle Door Panels.*
2. Lynda Beatriz Tesillo (ME, MS thesis defended on 2015) *Development Of Electronics, Software, And Graphical User Control Interface For A Wall-Climbing Robot*
3. Deep Pradipkimar Shah (ME, MS thesis defended on 2016) *Design Of A Lift Assist Fall Mitigating Walker*
4. Han Tran (ME, MS thesis defended on 2016)*Fault Diagnosis Of Rotating Machinery Using Wavelet-Based Feature Extraction And Support Vector Machine Classifier*

Proposals and other Leverage

Student Proposal submitted during the period of support

1. **Warren J. Baker Endowment for Excellence in Project-Based Learning Funding**
$5,000 (not funded).
Title: Active Magnetic Bearing & Rotordynamic Research.

FINAL REPORT FOR BENTLY CENTER AWARD (2015-2016)

Awardee

Jesse Maddren, Professor, Mechanical Engineering, jmaddren@calpoly.edu

Award

3 units (Summer 2015)

Summary of Accomplishments

The scope of the proposal was to write a technical paper that would be submitted for consideration at an upcoming ASHRAE conference. The paper was submitted and is currently under review for publication at the 2016 ASHRAE Annual Conference in St. Louis, MO. Final acceptance is not determined until February, 2016.

During the 2011-12 academic year, I had a senior project group working on a study supported by ACCO Engineered Systems, a design/build HVAC company headquartered in Glendale, CA. ACCO was interested in modeling air flow in perforated supply ducting systems. They had engineered some systems previously for sound stage applications where noise was a primary consideration and proper air distribution was also important. Prior to this project, ACCO did some preliminary testing and built the system for the client without any design tools to predict air flow rates in the different sections of the ducting system. Representatives from ACCO approached me with the goal of tasking a senior project group to develop a design tool, preferably Excel based, to model air flow through perforated ducts.

The senior project group was comprised of three students: John Farrell, Alan Fields and Cesar Jarquin. The group designed and built a test apparatus with a fan and perforated duct sections of different diameters that could be tested separately. They measured air flow rates along the length of the duct and from these measurements the outflow through the perforations could also be determined. The senior project group was not able to adequately develop a model for air flow through a perforated duct and so I continued to work on this problem and developed a simple numerical model. The paper documents the results of the experimental measurements and the model.

Publications and other Deliverables (students in bold)

Maddren, J., **Farrell, J., Fields, A. and C. Jarquin**, "Modeling Air Flow Through a Perforated Duct," 2016 ASHRAE Annual Conference in St. Louis, MO (under review).

Student Impact

Bently funding was used to support writing the paper to document the experimental and modeling results. No funding was used while supervising the students. The students that supported the experimental study documented in the paper are: John Farrell (BSME, 2012), Alan Fields (BSME, 2012) and Cesar Jarquin (BSME, 2012).

FINAL REPORT FOR BENTLY CENTER AWARD (2015-2016)

Awardee

Saeed Niku, Professor and Graduate Coordinator, Mechanical Engineering, sniku@calpoly.edu

Award

Total units: 2 (1.6) in 2015 Summer quarter

Summary of Accomplishments

The original proposal was to spend part of my summer to learn about the capabilities of an Adept Motivity Autonomous robot that was donated to the IME department, but was later given to the Robotics Lab on loan, its many different types of sensors (including LiDAR), software, and programming language. The robot was studied for its capabilities and programming. The robot was missing many parts and was not configured correctly. Eventually it was started and studied. In cooperation with the instructor and the students of the RFID class in IME, the robot was also programmed to find its way around the lab and look for RFID tags.

It was discovered that although the robot is fascinating, it is limited in its use. I talked to a number of students, including one who studied the robot's software, for potential use of the robot in a masters thesis. The student eventually decided to do coursework and turned down the offer. At the present, the robot is back at the RFID lab.

Publications and other Deliverables (students in bold)

Peer-reviewed conference papers

There were no articles published.

Peer-reviewed journal papers

There were no journal papers published.

Student Impact

Supervision of student projects

Although I presented the possibility of using the robot in a masters thesis to a number of prospective students, only one showed additional interest. After learning about the capabilities of the robot, and considering that he is a full-time employee at a company in town, he declined to continue and chose the coursework route. No additional students have shown any new interest.

Proposals and other Leverage

None.