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Tackling Electrical Engineering's big problems: power, weight, and efficiency

Prof. Ramesh Harjani is the principal investigator (PI) of a new Defense Advanced Research Projects Agency (DARPA) \$5.975 million grant to solve the challenge of wideband signal sensing for dynamic spectrum access—the process of identifying frequency usage and efficiently maneuvering to access unused frequencies. The work is being done under the purview of the DARPA CLASIC (Cognitive radio Low-energy signal Analysis Sensor ICs) program whose goal is to enable highly efficient signal recognition integrated circuits (ICs) for cognitive communications, radar and electronic warfare. Signal parameters of interest to Harjani and his team include spectrum and channel occupation, signal and modulation schemes, and the ability to demodulate these symbols.

Currently, the Federal Communications Commission (FCC) governs radio frequencies from 3KHz to 300GHz and allocates them on a semi-permanent basis to a variety of primary users. Many frequencies are busy most of the time such as those assigned to cell phones, television, and FM radio. Others are used less than 10 percent of the time and could easily be accessed by secondary users. The challenge is doing so without disrupting the intermittent primary use. Fig. 1 (above right) shows the measured spectrum occupancy in Chicago from 30MHz to 3GHz. The figure plots the RF power vs. frequency and time. The areas marked in dark blue show frequencies that are not in use. “If we were able to dynamically and efficiently access those frequencies when they were not in use, we might be able to increase the number of users by 10x,” says Harjani. “The results of this project will allow us to quickly differentiate between occupied and unoccupied spectrum and be able to do so with minimal power.”

For you and I, this means convenience—eventually we would have one electronic device that could open our garage door, start

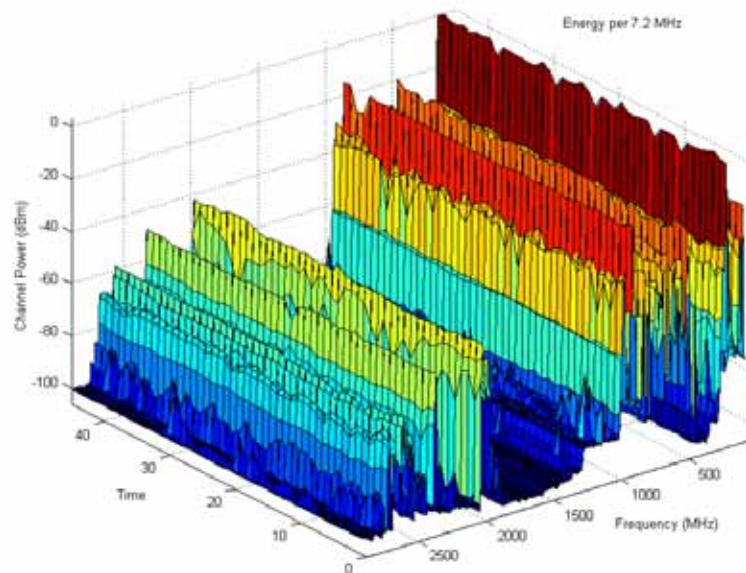


Fig. 1: Spectrum occupancy in Chicago (Shared Spectrum Company)

our car, serve as our cell phone, and access the web. For our military defense personnel, this would mean safety in the form of trouble-free, continuous communications—enemy jammers would be unsuccessful due to the agility available to our service personnel to simply move around the blocked frequencies and continue communications.

A critical challenge is to minimize the power required to operate these ‘cognitive’ devices. Harjani and his team will address this challenge by researching the optimal boundaries between analog and digital computations to reduce power requirements. In other words, less battery means less weight to carry. Less weight to carry could mean the difference between life and death on the battle field.

To overcome this challenge, Harjani and his team will be investigating blind source separation using RF adaptive recursive and transversal filters; analog implementations of fast Fourier and wavelet transforms; and efficient implementations of signal feature extraction and classification algorithms (e.g., cyclostationary signal feature extractors and classifiers, etc.) in analog/neuromorphic processing blocks.

The University of Minnesota will be the lead on this project. The other members of the team include:

- University of California at Los Angeles (UCLA) - teams led by Profs. Danijela Cabric and Dejan Markovic
- Army Research Lab (ARL) - Brian Sadler (Brian was Prof. Georgios Giannakis's graduate student; Prof. Harjani did a sabbatical in 2009 at ARL.)
- Lockheed Martin Co. (Eagan, Minn. and Owego, NY locations)
- Silvus Technologies - a private Los Angeles company founded by UCLA faculty Babak Daneshrad.

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In electronic medical devices, the best is yet to come



Richard Booth (MSEE'98)
Mayo Clinic
Product Manager

Richard C. Booth, (MSEE'98), Mayo Clinic Product Manager, believes the best is yet to come for engineering breakthroughs, especially in electronic medical devices.

“Advances in computer architecture, driven by miniaturization, will lead to enormous capabilities enabled by breakthroughs in the biological to electronic interface,” says Booth. “We are making improvements daily at monitoring human organs with a goal of disease prevention.”

Joining Mayo Clinic in January of this year, Booth is involved with the entire range of research, from basic science research to clinical trials (Mayo has more than 650 active clinical trials) to medical device research.

“My engineering career has offered a continuous stream of opportunities,” he says. “I can list a number of machines I was instrumental in bringing to the marketplace but I hope my greatest work is yet to come. Mayo is an enormously impressive operation with tremendous opportunities. I believe my best work will be with electronic medical device research that will provide major impacts on society.”

Booth's engineering career began in 1974 when he graduated with a Bachelor of Science from the University of Minnesota's Department of Electrical and Computer Engineering. After graduation, he joined IBM in Rochester, Minn., as a server hardware product developer working on microprocessors doing logic design, simulation, testing, and documentation.

“My U of MN engineering education offers a versatile career path,” he says. “One may move vertically and delve deeply into the subject matter, or one may move horizontally pursuing the business and financial side of technology,” he says. “I moved from doing product development to being a research scientist and then to becoming an entrepreneur.”

“I was consumed by technology when I graduated,” he says. “The U of MN provided the technical skills I needed. When I was hired at IBM, having a background in theoretical architecture was a unique skill. I understood and accomplished things others who were being hired were not prepared for—things like Karnaugh maps and state transition diagrams. I was able to design machines with fewer circuits which ultimately provided improved cost performance.”

“I would encourage ECE students to keep focused on building strong technical skills—the basic requirement for entering the job market,” he says. “You will learn continually on the job but you must enter with strong basics skills.”

Booth began taking graduate classes at the U of MN and completed his Masters in EE in 1998. “By this time, I had worked for a while and being back in an academic program helped to refresh my knowledge in theory and architecture and made my skills current.”

In 1999, Booth went to Silicon Valley to pursue his interest in internet protocols, Ethernet, Fibre Channel and InfiniBand at IBM's Almaden Research Center in San Jose, Calif. He also worked with researchers at University of California Berkeley on advanced caching algorithms for cloud computing and system reliability. “I was experiencing a rare event in the history of technology. Brilliant people from all over the world came together in Silicon Valley with a common purpose — a technical vision to improve society with major advances in internet technology.”

Booth went on to become a research scientist joining T.J. Watson Research Center in Yorktown Heights, NY. “I worked in a world class lab focusing on parallel processing architecture and parallel processing algorithms—the precursor to today's supercomputer,” he says.

Among Booth's successes are completing a parallel system prototype which, in part, set the architectural direction for the IBM Blue Gene* system and the parallel architecture for the Watson computer that recently was a successful participant on the game show “Jeopardy.”

Importance of Risk-Taking

While working in Silicon Valley as an entrepreneur, Booth learned to take risks—the environment encouraged it. “We may have had difficulty communicating sometimes, but we could build and accomplish unprecedented, incredible stuff. It was a special place and truly built my appreciation for the power of technology.”

While in Silicon Valley, Booth became the Director of Engineering—Network Physics—in Mountain View, Calif.. The company's core competency was in internet traffic management. Booth invented and brought to market the industry's first one-gigabyte Optical Ethernet Bypass Switch which provided packet routing redundancy. After returning to Minnesota, Booth became the President and CEO of his own business—Midwest Medical Devices. Midwest Medical Devices provides engineering and business services to small businesses interested in the development of electronic medical devices.

“In the Midwest, we are a conservative lot—it's what is expected,” he says. “I had to learn to take risks on the job. I would encourage ECE faculty to instill risk-taking as well as academic competency in students. Risk-taking builds confidence, character and wisdom. My experiences have shown me that taking risks is worth it—the opportunities are tremendous.”

**A prototype of the IBM Blue Gene computer, donated by IBM Rochester to the Department of Electrical and Computer Engineering in 2008, is on display in Keller Hall (formerly Electrical and Computer Engineering Building) lobby on the East Bank campus.*

Student Activities

Innovative Engineers Expands its Focus

“Come as you are; leave as an engineer.”

Innovative Engineers' (IE) new project, called “5-5-1”, consists of developing five wind turbines in five Nicaraguan villages to create one renewable energy community. The project's cost estimate is \$17,000 for wind turbine materials, support tower fabrication, tower components, and half of the travel and lodging for five students. Students will pay half of their own expenses.

“Like a tree, IE is growing its organization slowly and thoughtful to make sure that it has a strong base and limber branches,” says Prof. Paul Imbertson, IE advisor for the on-campus student organization. Through IE experiences, CSE students are learning to be project engineers and team players.

With the help of mentor Don Craighead (University of St. Thomas Emeritus Professor; former Powermation Chairman of the Board; DHC Enterprises; The Works Trustee; University of St. Thomas Industry Liaison; and University of Minnesota alumnus), three IE members faced a task that doesn't involve the lab—seeking outside funding support for their vision.

IE president David Giacomini, IE Global Coordinator Alejandro Ojeda, and IE member Scott Morton, presented IE's plans for expanding the reach of their initial project to an audience of industry leaders that included Harold Kossman – IBM retiree; William Fitzgerald – RobotoGram Productions President and CEO; Christopher Scorcella – Medical Innovation Director, Kablooe Designs; Don Weinkauff – University of St. Thomas School of Engineering Dean; Bonnie Holub – ArcLight Inc., Technology Consultant.

Last year, IE completed a project in La Hermita, Nicaragua, that provided renewable energy via a wind turbine for this village of 120 people. IE participants, local Nicaraguan students and businesses, and La Hermita villagers worked as a team in designing, constructing, and erecting the wind turbine.

“We know the elements of success include cash, connections, and brain power,” says Giacomini. “To date, we have a passionate group of CSE students, a lab in Keller Hall, and the assistance from the ME Machine Shop. We also have the success of our first completed project of establishing a wind turbine in La Hermita, Nicaragua. Now we have to seek financial support for ‘5-5-1.’”

Currently, IE has a financial commitment from Discount Steel for laser cutting of materials and financial assistance from Xcel Energy and Kick Start.

As part of “5-5-1”, IE students will engage and teach the Nicaraguan village communities how the turbines work, how to repair them, and how the five villages as a team can achieve their own success. “Talented, passionate people can make a difference,” says Ojeda. “Collaboration is everything. In a project such as ours, we rely on the collaborations and the trust engendered.



(Above l to r) IE mentor Don Craighead, President and CEO of Robogram Productions William Fitzgerald, (unidentified intern), IE members Alejandro Ojeda, Scott Munson, David Giacomini.



(l to r) IBM executive Harold Jostman; University of St. Thomas Dean of Engineering Don Weinkauff; CSE Senior Development Officer Sally Euson; Medical Innovation Director Christopher Scorcella, M.D.; CSE Director of External Relations Kim Docktor.



Innovative Engineers designed and built a wind turbine in La Hermita, Nicaragua.

In addition to the Nicaraguan project, IE members hosted University of Mexico students for two months this summer while together they worked on a wind turbine project design.

IE activities are carried out by four on-campus project groups: wave energy, wind turbine, blade design, and hydropower. IE has 60 members but hopes to grow the organization to 80 members this fall. Visit their web site at www.innovativeengineers.us/

Dr. David Malah (Ph.D. '71) receives U of MN Outstanding Achievement Award



Prof. David Malah (Ph.D.'71), Technion, Department of Electrical Engineering, Israel Institute of Technology, received the University of Minnesota Outstanding Achievement Award (OAA) on Sept. 8, 2011, presented by U of MN Regent Clyde Allen. The OAA is the highest award presented to a U of MN alumnus.

David Malah (Ph.D.'71) Malah's Time Domain Harmonic Scaling method and signal processing algorithms for noise reduction have had significant impact on digital speech compression and communication. He is the current head of and founder of the Signal and Image Processing Laboratory at Technion in Haifa, Israel, and is considered the father of the signal processing industry in Israel.

"David Malah is a gifted mentor who gave his students the opportunity to explore real industry problems and expand the frontiers

of knowledge in fields of signal and image processing and their applications," says Department of Electrical and Computer Engineering Head and Professor David Lilja. "His students benefited greatly from his guidance and many have become university professors and industry leaders."

Malah was named Life Fellow of the Institute of Electrical and Electronics Engineering (IEEE) in 2009. He also is a member of the European Association for Signal Processing (EURASIP) and International Society for Optical Engineering (SPIE.) He has been an active collaborator with Motorola, Inc. and AT&T Bell Laboratories throughout his career working on digital speech communications, speech compression, speech analysis and coding, image sequence coding for video conferencing, and storage applications.

Malah has been an active presenter at conferences, workshops, and seminars throughout the world, as well as, an organizer and chair of international conferences.

Minnesota Gov. Mark Dayton and the 2011 State Legislature approved \$51.3 million in bonding funds for a new physics and nanotechnology building

As part of the budget negotiations during the 2011 first special session, Minnesota Gov. Mark Dayton and the State Legislature approved \$51.3 million for an Experimental Physics and Nanotechnology Building at the University of Minnesota. The building was part of a larger capital investment bill approved by the governor and legislators in July. Construction on the new building is expected to begin in late fall.

In addition to the \$51.3 million, the U of MN received \$4 million in planning money for the Experimental Physics and Nanotechnology Building during the 2010 Legislative Session. The remainder of the funding for the \$80 million project will be paid by the University and private donations.

"The \$51.3 million for the new Physics and Nanotechnology building is a giant step forward for the state and the University," said University of Minnesota President Eric Kaler. "It will help the University keep pace with the rapid global innovation in these fields and it secures the state of Minnesota's position as a leader in these ever-changing, cutting-edge technologies."

"Seeing this building come to fruition has been a top legislative priority for us," explains Rich Baker, vice president of engineering for MTS Systems Corporation and board chairman for MN Nano—a statewide association working to establish Minnesota's standing as a region of excellence in nanoscience. "We are very pleased legislators and the governor agreed to advance this project now, rather than wait for the 2012 session. This means construction crews can be in the ground soon, putting up a building that will play a critical role in this state's ability to compete for highly-skilled faculty and graduate students."



(Above) Two architectural rendering views of the soon-to-be constructed University of Minnesota Physics and Nanotechnology Building to be completed in 2013. For more details, go to: <http://physicsnano.umn.edu/project.html>

Where are they now?



Ratnanjali Khandwal
(Ph.D. '08)
XKL, LLC
Seattle, Wash.

Ratnanjali Khandwal (Ph.D. '08) had two job offers before she even completed her Ph.D. She credits her success to taking a wide variety of course and lab experiences.

“I went from electromagnetics to semi conductors to fiber optics to pure optics in my coursework,” she says. “I also got as much hands on experience in the labs as I could. My courses, as well as, my research required me to work in industry-standard labs. The University’s Nanofabrications Center (NFC) and Characterization Facility (Char Fac) provided a variety of equipment for me to use including XRD, SEM, photo and e-beam lithography, wet and dry scanning, sputtering equipment, and the scanning microscope.”

Currently, Khandwal works as an optical engineer with XKL, LLC, creator of optical networks in Seattle, Wash. When she graduated with her Ph.D. from the University of Minnesota, she went to work

for a year for Lumera (now called Gig-Optics located in Bothell, Wash.) Now at XKL—a company of about 45 people—she works as part of a team where she tests projects for competence at the system level and then works with the packaging team.

She credits her success to her advisor Prof. Beth Stadler who played a large part in helping Khandwal complete her Ph.D. on time. One of the most helpful experiences she had at the University was Stadler’s monthly member presentations. “We’d make a presentation about our progress on our project,” says Khandwal. “Those meetings helped us all learn to speak to a group and answer questions—we gained confidence.”

She says the classes that helped the most were “Semi Conductors” with Prof. Paul Ruden, “Optics” with Prof. Jim Leger, and “Fiber Optics” with Prof. Anand Gopinath.

“Students need to be more versatile,” she says. “Get a variety in your classes and as much experience as you can in the labs. Balance the theory with the hands-on.”

Khandwal received her undergraduate degree at HNB Garhwal University, Dehradun, India; a master’s degree in Physics at ITT, Roorkee, India, and a master’s degree in Applied Optics at ITT Delhi, India.

Upgrades for ECE Undergraduate Labs provided by Micro Control President

Harold Hamilton (MEE'72), founder and president of Micro Control Company and a long-time supporter of the Department of Electrical and Computer Engineering (ECE), recently gave a gift of \$50,000 to upgrade ECE’s lab equipment to help enhance the student learning experience.

Hamilton’s philanthropic motivation is driven by his interest in education—he also supports his undergraduate alma mater, the University of Nebraska, where he graduated in 1960. “I know that students need help and the Universities need help,” he says. “It’s important to me to provide these Universities with support to become even better places for students to learn.”

“Mr. Hamilton’s gift will help support our senior design projects through enhancement of the lab equipment used for these projects,” says ECE Assistant Head and Prof. William Robbins. “We will add to the capabilities of the senior design lab with purchases of one-of-a-kind higher end equipment such as a higher end oscilloscope, transistor curve tracer, logic analyzer or high arbitrary function generator. This type of equipment normally is not found in an undergraduate lab. Mr. Hamilton’s gift will give us a chance to support our students with more sophisticated equipment.”

To earn his masters degree in electrical engineering, Hamilton spent evenings attending the University of Minnesota and working full time at Memorex during the day. He says it was tough and he was glad when he graduated with his MEE in 1972. Shortly after, Memorex went out of business, so Hamilton started his own company producing manufacturing test equipment for the electron-



Harold Hamilton (MEE'72)
Founder and President of Micro Control Company

ics industry. The company’s microprocessor-controlled test system produced in 1973 was the first in the industry.

Today, Micro Control ships nearly half of its products to global markets. Its tradition of innovation continues with high-power burn-in for memory and logic applications, automatic test equipment, and supplemental equipment testing services. For more information, go to www.microcontrol.com

News Briefs

ECE Students

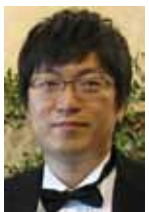


Dr. Hyungsoon Im and colleagues from Prof. Oh's team, in collaboration with Prof. David Norris, have an article in *ACS Nano*, which was highlighted on the Institute of Physics Web site titled "Template stripping produces nanohole arrays." They have shown new methods to synthesize large-area nanohole arrays in ultra-smooth metal films for biosensing." Go to <http://nanotechweb.org/cws/article/tech/46841> (Prof. Sang-Hyun Oh, advisor)



Ranjan Gupta (Ph.D.'10), now with GE (far left) and Ph.D. candidate **Apurva Somani** (left) have been chosen as the recipients of the 2011 Student Best Paper Award for their IEEE – Industrial Electronics Transactions Paper "Direct-Matrix-Converter-Based Drive for a Three-Phase Open-End-Winding AC Machine With Advanced Features," *Trans. IE* vol. 57, Dec 2010.

This honor consists of a cash prize and travel funds to attend the award ceremony in Melbourne, Australia. This paper was co-authored by Dr. Krushna Mohapatra and Prof. Ned Mohan, Gupta's and Somani's advisor.



Ph.D. candidate **Taehyoun Oh** received Best in Session award in Analog, Mixed Signal and RF Circuit Design at Techcon 2011 for his paper "A 11GB/s MIMO Channel Equalization and Crosstalk Cancellation Architecture for High-Speed I/Os" (Prof. Ramesh Harjani, advisor)



Graduate students **Shruti Patil** (far left) and **Pingqiang Zhou** (near left) each received James Zeese Fellowships. (Patil's advisor is Prof. David Lilja; Zhou's advisor is Prof. Sachin Sapatnekar.)



Ph.D. student **Anthony Giacomoni** has received the Best Session Presentation at the 2011 American Controls Conference for his "Reconfigurable Interdependent Infrastructure Systems: Advances in Distributed Sensing, Modeling, and Control." (Profs. Massoud Amin and Bruce Wollenberg, advisors)



Ph.D. student **Todd Klein** received the Department of Defense (DOD) Teal Pre-Doctoral scholarship to fund his work with Prof. Jian-Ping Wang in collaboration with Medical School Profs. Amy Skubitz, Dr. Kristin Boylan and Dr. Levi Downs. The team is researching protein biomarker detection using giant magneto-resistive (GMR) biosensors for early identification of ovarian cancer with funding from a DOD Ovarian Cancer Pilot Award. (Prof. Jian-Ping Wang, advisor)

ECE Faculty



Prof. Massoud Amin was interviewed for an article about Hurricane Irene power outages for the Gigaom. Com Web site "Hurricane Irene highlights need for smarter Grid." Aug. 29; Katie Fehrenbacher <http://gigaom.com/cleantech/hurricane-irene-highlights-need-for-smarter-grid/> Prof. Amin also was interviewed by Thalia Assuras on "energyNow!" about the security issues facing the electrical grid in the United States. <http://www.energynow.com/video/2011/08/12/preview-guarding-grid>.



Prof. Steve Campbell is one of 11 U of MN faculty members to receive a research grant from the funds derived from the University's share of technology commercialization royalties.



Prof. Tryphon Georgiou has been elected as a Foreign Member of the Royal Swedish Academy of Engineering Sciences (IVA). Founded in 1919, IVA awards membership to those who are active in the technological and economic sciences and who have performed outstanding work.



Prof. Georgios Giannakis is ranked in the Top Ten of the world in Thomson ISI Web of Knowledge List of Highly Cited Researchers in Computer Science. His h-index is 90. Giannakis also tops the list from the societies in which he is most involved – Signal Processing, Communications, and Networking.



Prof. Mihailo Jovanovic's work on "Controlling the Onset of Turbulence by Downstream Traveling Waves" was selected as a Minnesota Supercomputing Institute (MSI) Research Spotlight for May, 2011, and featured in the spring 2011 issue of MSI Research Bulletin. (www.msi.umn.edu)



Prof. Mo Li is one of 11 U of MN faculty members to receive a research grant from the funds derived from the University's share of technology commercialization royalties.



Prof. Guillermo Sapiro and graduate student Alexey Castrodad have been selected to present their work on human activity recognition in video as a yearly highlight of the National Geospatial-Intelligence Agency (NGA) basic research. This is the third time in the last four years that Prof. Sapiro's research will be highlighted as one of the success stories at the annual NGA meeting. Alexey Castrodad is a full time NGA employee pursuing his Ph.D. at the U of MN with the support of InnoVision-NGA.

In addition, **Prof. Sapiro** is founding Editor-in-Chief of the *SIAM Journal on Imaging Sciences*, which already is ranked as the journal with the second highest impact factor in the area of Applied Mathematics. In one year, it has become one of the most cited journals in its field.



Prof. Sachin Sapatnekar was presented the IEEE Council on Electronic Design Automation (CEDA) Outstanding Service Contribution Award for his significant service as the general chair of the 47th Design Automation Conference (DAC). The award was presented at the 48th DAC held in San Diego, Calif.



(from left) **Prof. Jian-Ping Wang** (PI), **Chris Kim** (Co-PI) and **Steven Koester** (Co-PI), and Physics Prof. Paul Crowell (Co-PI) have received a National Science Foundation research grant to work on All-Spin Non-Volatile Logic Devices and Circuits. The project will be supported by the Nano-



electronics Research Initiative of the Semiconductor Research Corporation. The project is awarded under the Nanoelectronics for 2020 and Beyond competition. Minnesota is one of only 10 universities to win this NSF NEB award.

Donations

Nvidia provides upgrades for CUDA labs

ECE's Compute Unified Device Architecture (CUDA) Training Center received a donation of 50 Fermi class GeForce GTX480 boards for the CUDA Teaching Center program from Nvidia. Thirty of the boards will be installed for ECE/CS courses and 20 will go to MSI to support their tutorials.

Thank you, Nvidia!



87 Consortium Participants Attend DOE-Sponsored Summer Workshop at ECE

ECE Principal Investigator **Prof. Ned Mohan** and ECE co-principal investigators **Prof. Bruce Wollenberg**, **Prof. William Robbins**, and **Prof. Paul Imbertson**, welcomed 80 members and seven advisory members to the Department of Energy (DOE) Summer 2011 Workshop. The group members lead efforts at their respective colleges and universities to revitalize electric power engineering education by creating state-of-the-art laboratories and new curricula to prepare EE students for the renewable energy source challenges they will face when they graduate.

The summer workshop was designed to prepare faculty to provide the education contained in the new power engineering curriculum. This new educational framework will quickly start producing a large number of graduates with a fundamentals-based education who can meet the multi-disciplinary challenges inherent to our nation's efforts to make the nation's grid cleaner, smarter, and more reliable. It also will be a foundation for graduate education and research in the areas of renewable energy such as wind, solar, storage, and energy conservation.

Total funding for the project is approximately \$4.2 million with DOE providing \$2.5 million and the rest from cost-sharing by the University of Minnesota and the other participating institutions. For a map and information about the members of the consortium, go to: <http://maps.google.com/maps/ms?msid=201201383282471632785.0004a6292d654eb65455c&msa=0>



(l to r) ECE Principal Investigator Prof. Ned Mohan and ECE co-principal investigators Prof. Bruce Wollenberg, Prof. William Robbins, and Prof. Paul Imbertson.

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ECE undergrads design power distribution system and ozone detector experiment for rocket payload



University of Minnesota students participated in the June 23 launch of a sub-orbital sounding rocket from NASA Wallops Flight Facility. This rocket launch is part of the NASA ROCKSAT program which promotes student designed experiments on board sounding rockets.

The University of Minnesota team designed a 20-pound payload which included a variety of experiments. Students from the electrical engineering department designed and built the power distribution system along with an absorption spectrometer for ozone detection. The ECE team included Prof. Ted Higman and students Rebecca Lam, Patrick Plonski, Joshua Flugar, Sean Ding, Cole Anderson, and Carl Johnson.

To watch the launch of the NSA ROCKSAT mission, go to: <http://www.youtube.com/watch?v=eGmV38F1oRw>

Mark Your Calendars

Math & Science Family Fun Fair

Saturday, Nov. 19

10 a.m.-4 p.m.

Coffman Memorial Union

Fall Senior Design Show

Tuesday, Dec. 13

2-4:30 p.m.

Coffman Memorial Union, Great Hall

300 Washington Ave. S.E.

Minneapolis, Minn.

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