Inside:
Homecoming Highlights
New Vision for the Engines Lab
Senior Design Today

University of Minnesota
Driven to Discover SM
Dear Alumni and Friends:

I am pleased to report that matters in the ME department are moving forward both in a positive direction and with encouraging speed.

In recent letters, I informed you about our two major ongoing building projects: The renovation of the old ME building, which dates back to 1948, and the move of the engine lab facilities to a new location. Both projects are on the right track. An architectural and engineering team is currently working on the schematic design for the old ME renovation, for which we expect construction to begin next summer. The design for the engine lab relocation is also progressing quickly, with construction anticipated to start in spring. These two projects will significantly enhance our education and research facilities and we are eagerly looking forward to their completion.

As in previous years, the ME department is conducting searches for several faculty members. The separation of the Industrial and System Engineering program from ME in 2009 had left our department with only 32 faculty members, to be one of the smallest ME departments in the Big Ten. Through our rapid pace of hiring, our faculty has grown back to 39 members. However, this still leaves the department with a significant need to catch up with the increased enrollments in ME.

Talking about enrollments, in the 2011/12 academic year ME graduated more than 200 bachelors for the first time in a decade. The last time that ME graduated more students was in 2000, when the conversion from quarters to semesters caused about 220 students to quickly finish their programs in order not to be caught up in the transition. The 203 bachelors awarded in 2011/12 is an excellent upswing from the 154 degrees conferred in 2006/07. I am equally pleased to report that 15% of the graduates of the Class of 2012 were women. While Minnesota trailed the national average for almost all of the past decade, we may have exceeded the 2011/12 average, which still needs to be officially reported. I sincerely hope that this trend will continue.

With our increase in enrollments, the quality of the student experience is an issue I am particularly interested in. The applications to the College of Science and Engineering as a whole have almost quadrupled over the past decade. We believe that one driving force behind this trend is the overall improved student experience. However, larger enrollments have led to larger class sizes, an issue that the ME faculty are concerned about. Currently, our faculty are deliberating on how to optimally use our available resources to provide the best student experience possible. I hope to have more to report on this topic in one of my next letters.

Finally, let me update you on the impressive growth of our ME Alumni Network (ME-AN). More than 900 alumni have now joined ME-AN’s LinkedIn group to stay connected. ME-AN organized two well-attended networking events this Fall semester. The ME-AN Homecoming Reception and the associated tour of our 4th floor engine lab brought about 70 alumni back to the department; a recent tour of the 3M Innovation Center drew an equal number of alumni. The job listings on the LinkedIn site have become rather lively and present an excellent resource for our alumni to further their
Uwe Kortshagen
Distinguished McKnight University Professor and Head of Mechanical Engineering

Accolades and Awards

**Professor Rajesh Rajamani** has been elected a Fellow of the American Society of Mechanical Engineers (ASME). In August, Professor Rajamani was the keynote speaker at the 14th ASME International Conference on Advanced Vehicle Technologies in Chicago, Illinois.

**Professor Zongxuan Sun** and **Graduate Students, Yu Wang and Hu Zhang** won the best paper award at the 2012 International Conference on Advanced Vehicle Technology and Integration in Changchun, China.

**Professor Jane Davidson** was awarded the Frank Kreith Energy Award from the ASME for her significant contributions to a secure energy future with emphasis on innovations in renewable energy. The award was presented at the International Mechanical Engineering Congress and Exposition in Huston, Texas.

**Professor Jane Davidson and Josh Quinnel, PhD,** received the best paper award in solar heating and cooling at the 2012 ASME Energy Sustainability Conference held in San Diego.

**Professor John Bischof** was awarded the Van C. Mow Medal from the AMSE for significant contributions to the field of bioengineering.

I wish you the very best for the upcoming holiday season and for the year 2013.

Sincerely,

Uwe Kortshagen
Distinguished McKnight University Professor and Head of Mechanical Engineering

I hope that, in the future, you will take the opportunity provided by ME-AN to reconnect with your fellow alumni and the department and to develop your professional and social network. To learn more, visit the ME website at: http://www.me.umn.edu/alumni/index.shtml
A new faculty member brings innovation to the operating room

Richard and Barbara Nelson Assistant Professor Tim Kowalewski joined the department this summer. Born in Poland while it was still behind the “iron curtain” of cold war days, the Kowalewski family escaped to the United States when he was seven years old. His father was an architect for the U.S. Army and they settled in the Seattle area. Kowalewski did his undergraduate and graduate work at the University of Washington - Seattle, obtaining his Ph.D. in Electrical Engineering in 2012.

Early in his undergraduate days he took a thorough look at the fields of medicine and engineering, and realized “I could do a lot more for medicine as an engineer than as a doctor.” His awareness of how much more technology could do for the medical field compelled him to pursue the science and engineering education that set him on this path.

During his undergraduate education he had the opportunity to visit operating rooms and observe surgeries. He began doing research with a urologist, Dr. Rob Sweet (who is now also at the University of Minnesota) developing one of the first virtual reality (VR) simulators. The simulator enabled surgeons to practice in VR and make mistakes in VR, before they went into an actual operating room.

In working with clinicians he found that what can seem obvious to an engineer is not obvious to other people, “even an undergrad has the ability to walk into an operating room and see things to improve, which is something that really excites me about undergraduate engineering education,” he said. “To share these tools with my students, to solve some of the big problems of the world today, that’s really the passion behind it.” He wants to give his students this same kind of exposure to both fields.

In graduate school Kowalewski got involved with surgical technology and surgical robotics, and in “pushing the envelope to see how engineers can influence the future of medicine,” he said. In that pursuit his Medical Robotics and Devices Laboratory is conducting research in four main areas: surgical robotics, smart tools, medical simulation and computational surgery.

In a recent talk, Kowalewski remarked on the high cost of medical errors – as high as $29 billion dollars. Engineering technologies can offer some solutions. Simulation holds much promise, since people learn by doing, and simulation offers hands on experience, with no risk to a patient. Robots are able to perform tasks with greater ease and dexterity that otherwise take surgeons a long time to perfect, like suturing. Smart tools are surgical instruments with tiny sensors attached to them. Such tools can discriminate tissue properties to, for example, localize cancerous regions or detect ischemic tissue. This can provide diagnostic information to clinicians in real time while they operate.

In his computational surgery research, Kowalewski is developing tools to ensure surgical trainees have sufficient skill before they graduate. He has collected a large repository of surgical tool motion data. He uses Hidden Markov Models trained to recognize differences between surgical experts and novices to quantify surgical skill. This provides faculty surgeons with objective, quantitative means of evaluating their trainees, rather than just the subjective and time-consuming approach they have historically used.

Currently, Kowalewski is co-teaching ME 2011 with Professor Will Durfee. This is the introductory engineering course in which students are charged with building a robot that can do something interesting, costing less than $50. It’s the kind of course Kowalewski wished he could have taken as an early undergrad. It has made him think about the metric of research dollars spent versus number of lives saved – “a very hard metric to look at,” he said. But it points to the amazing potential of first year students being able to solve problems.

He started thinking of how to take their creative, problem-solving techniques to create ultra low cost health
simulators for use in underdeveloped countries. The students are using Arduinos – inexpensive, open-source electronic prototyping platforms - that make it really easy to use electronics, and which can make things “a little” intelligent. By using native materials, like home-made bioplastics from starch instead of expensive polymers, you could build a simulator for $10 or less. He envisions a project that students could work on during their undergraduate years, possibly collaborating with Engineers Without Borders.

Kowalewski also has plans for creating an immersion course, in which graduate students, and even some highly motivated undergrads, from diverse backgrounds such as electrical and mechanical engineering, and business, would shadow clinicians in an operating room, or other clinical setting, to see firsthand what is needed, or what could be improved. They would foster relationships with physicians to come up with ten great ideas. The second half of the semester could be devoted to deciding which one to prototype and developing a business plan. They could extend this unto Durfee’s new product design course. This gives students and clinicians a clearer picture of how ideas develop into new technologies and become products.

So how did this electrical engineer come to our Department of Mechanical Engineering? By chance he met Durfee, who was visiting a colleague at Washington, and Durfee told him about our department’s work in medical devices. Then he met Professor Art Erdman, and heard about the incredible strength of the medical device industry here and the close collaborations and partnerships they have with the University. Our department seemed uniquely suited to his research interests – in fact, “a perfect fit,” he said.

And then he learned that the University hospital and medical school are just across the street from the engineering school. Kowalewski remarked on how crucial it is to have clinicians that will collaborate and work closely with engineers long-term, and who are open to engineering and innovation. While there are lots of laboratories that work in engineering for medical technology, few have the proximity found here, where meetings can take place often and easily. These were compelling reasons for Kowalewski to come here.

Kowalewski joins many of his ME colleagues in being an avid bicyclist – commuting to the University along the Mississippi River Boulevard. He is also looking forward to cross-country skiing this winter. Kowalewski is an accomplished musician of several instruments, including the accordion. “An accordion will either attract a crowd or disperse one, but you can’t predict which one,” he said with a laugh.

Since arriving he has found our faculty “very helpful and welcoming.” And because the University is such a large place, he has found many other colleagues doing interesting things – “with all the diverse expertise – in the department, or just outside, you don’t have to go to far to find great collaborators,” he said.
ME celebrated Homecoming 2012 with a number of events for alumni and friends of the department. Department Head Uwe Kortshagen gave an update and news of the department in the opening presentation. This was followed by presentations from Professors David Kittelson and Will Northrop, showcasing the research being done in the Engines Lab, complete with tours of the fourth floor facilities.

A reception sponsored by the Mechanical Engineering Alumni Network (ME-AN) concluded the days events.
A New Vision for the Engines Laboratory

The Engines Laboratory and Center for Diesel Research (CDR) have been operating on the fourth floor of the Mechanical Engineering Building for over sixty years. Professor David Kittelson has been teaching and doing research on engines for more than 40 years. He is often asked, why continue to do research on engines - won’t we be turning to batteries or hydrogen fuel cells soon? He counters that even the most aggressive plan, from the California Air Resources Board, CARB, projects that in 2040 we will have the same number of vehicles with engines as we have today. And the CARB has consistently over predicted the demise of the internal combustion engine. So engines are going to be around for a long time.

The key missions of the Engines Laboratory and CDR are to explore the nature of engine emissions and develop solutions for emissions mitigation; to advance knowledge in engine combustion processes and alternative fuels; to develop advanced strategies for improving efficiency; and most importantly, offering unique educational and research opportunities to our students through classes and outreach opportunities.

Research on diesel emissions measurement has been taking place in this lab for a very long time. “The development of particle filtration systems has actually turned the modern, heavy-duty truck into an air cleaner,” said Kittelson. Work is continuing to measure engine emissions at the nanoscale.

Air Resources Board, CARB, projects that in 2040 we will have the same number of vehicles with engines as we have today. And the CARB has consistently over predicted the demise of the internal combustion engine. So engines are going to be around for a long time.

“Improving fuel economy is the number one way to reduce greenhouse gasses and emissions,” said Kittelson. To really reduce CO₂ emissions, more efficient engines with higher fuel economy are the answer. However, the U.S. has had to meet fuel economy standards at the same time the emissions standards were getting tighter. How is it that the U.S. car industry has made so little gain? The truth is the U.S. has made great fuel economy gains, of 50% or more, but because vehicles have continued to get larger with more performance options, those gains are not felt. There is still room for improvement. One way is to make engines much smaller and turbo-charging them, an idea that a founder of the Engines Laboratory, Professor David Kittelson, has been championing for decades.

Members of the Engines Laboratory on the 4th floor of the old ME building
Lab, Professor Thomas Murphy (ME Faculty 1944 – 94) proposed long ago and is now being implemented by automakers.

Continuing research on low temperature combustion is another goal of the lab. The motivation is to reduce emissions at a reasonable cost while maintaining diesel’s efficiency advantage. With a premixed fuel/air mixture compressed through a diesel-like compression ratio we get diesel-like efficiency. Because the fuel is premixed it produces very low particle emissions (soot) and the peak temperatures are low so that there is very little NOx (nitric oxide and nitrogen dioxide) emissions. The problem is that there is no control over the combustion event, which is one of many challenges to this technology.

Another challenge is that exhaust hydrocarbons and CO emissions tend to be high. Exploring the nature of these emissions is another goal of the lab; for example, whether their condensation makes a particulate that is damaging to human health, and to figure out how they might be cleaned up.

One of the most promising alternative fuels is Dimethyl Ether (DME), a bio-fuel that can be made from a variety of abundant sources, such as biomass, waste from pulp and paper mills, forest products, and agricultural by-products. It is non-toxic and studies have shown it to be an almost carbon-neutral fuel. It burns with virtually no soot, even in conventional diesel modes, and has low NOx emissions as well. “We are studying the particle emissions that do occur because there are other things that make particles – additives in the fuel, or from the engine oil itself - so we want to demonstrate the true emissions of using this fuel,” said Professor Will Northrop. Additionally, they are looking at the economic benefits of producing DME in Minnesota, by using waste energy from Minnesota’s paper mills.

A challenge in using DME is that it is very volatile, like propane. This brings up safety issues that have limited the use of DME in the Engines Laboratory. Current codes and standards do not allow these kinds of flammable fuels to be used in a fourth floor lab. Most engine research facilities around the country are on ground floors. The facility is outdated, and although the University has made a commitment to renovate the older part of the Mechanical Engineering building, renovation cannot address many of the current lab’s defects.

A new facility is necessary; one that is safe, functional, with appropriate infrastructure and that could accommodate future expansion. The University agrees, and has appropriated $5 million dollars toward a new laboratory. Fortunately, an appropriate site and existing building have been identified in the Como area near campus. Part of what is now the ReUse Center will be renovated to house the new Engines Laboratory. Taking up one-sixth of the building, there is room for future expansion, and a pre-design for 6,000 square feet has been completed. The new lab will have three test cells which will accommodate five engines, and will also provide an engine build area, as well as office and storage space. More funding is needed to supply the new lab with state-of-the-art equipment, such as dynometers, controls, and instrumentation, and also staff to man the site. The lab is scheduled to move in about one year.

We want to ensure that the University’s engines laboratory remains a center of excellence in Minnesota, and continues to lead in the areas of emissions, combustion processes and alternative fuels. Professors Kittelson and Northrop envision becoming one of the top three engines research centers in the United States. “The work being done has garnered many supporters and sponsors from industry and shows our relevance to this industry,” said Northrop. “The students are the ‘products’ of what we do in the lab; many have gained crucial information here through our courses and outreach activities.”
The College of Science and Engineering Deans’ Club is a special community of our most generous benefactors who support CSE and the Department of Mechanical Engineering with gifts of $1,000 or more annually.

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Thanks to all our generous donors!
Senior Design course takes students into the real world

Design Projects, often called the capstone course, is indeed the crowning achievement of our undergraduate program. Teams of four to six students work for thirteen weeks (one semester) on an engineering design project, usually sponsored by a local company. The sponsoring companies are an integral part of giving students the real world, work experience. “The projects motivate students to bring together all of the engineering tools they have learned,” said Professor Jim Van de Ven, who is teaching the course this fall. “They see the industry side, what real engineers do in the workplace, and the different demands and requirements that a company has,” he said. The one semester timeline forces the students to focus and maintain a schedule.

Each project has an advisor, usually from the company, who spends one to two hours per week helping the team to accomplish their goal. The companies fund any prototyping done for the projects, and the students work directly for them. This gives companies a first hand look at potential hires, but more importantly, these companies are helping to educate the next generation of engineers.

Two out of thirteen teams, the “wheelchair” team and the “cooler” team, described their projects and how they are meeting the challenges.

The Wheelchair project team is working with the VA Medical Center to produce a research tool for studying arm biomechanics of push wheelchairs. Shoulder stress in wheelchair users is not uncommon, especially after many years in a chair. The suspected cause may be the location of the drive wheel, which is located directly below the person’s center of gravity. They have to reach back to push forward on the wheel, which may be causing extra stress on the shoulders. The team is trying to create a push rim that is separate from the drive wheel, and position it from four to ten inches forward. They need to figure out a way to transfer the power from that pushing motion back to the drive wheel, while keeping the wheelchair light and stable. “We essentially want the wheelchair to feel like home to the user, but with the added adjustability of the pusher,” explained Phil Ebben, a member of the team.

Creating those different positions has been a big challenge. “When you build a chair and it’s a certain length and a certain size, that is a known factor, but now we have to engineer variability,” said Ravinder Diamond, another team member. “It’s kind of an optimization tool for them, so that they can figure out the optimal position, and see how much of a difference it actually makes on the operator. It may be that every user will be different, depending on their arm length. That might be the future of what our design will do. It’s really just a prototype for them to test at this point,” said Diamond.

Each team has to devise a way of dividing the work. “That’s probably the most challenging piece, working with six people, and trying to even out the workload,” said Diamond. Ruben D’sa, another team member, has the design abilities, and being very good at CAD draw-
ings and marking them up, he did most of the design work. By chance, four members of the team are also taking a project management class, so they’ve been able to apply the techniques they are learning in that class to their project. By using responsibility matrices they are better able to divvy up the assignments.

The team credits the strong connection with their advisor for some of their success. They made frequent trips to the VA Hospital and were able to test-drive various wheelchair designs, including some power-assisted chairs, and one that was gear driven with levers. They were surprised at how difficult some of them were to maneuver.

The course is structured to mimic the work world. According to Diamond, who has been working for several years, the course does a good job of that. The need to keep up with paperwork, having team meetings, and taking minutes of those meetings, as well as incorporating changes mandated by the VA, and researching patents to see what other designs have been developed, are common tasks for the working engineer. A big part of the course is learning to work as a team with a common goal, and keeping people accountable.

The course goals may not have changed greatly over time, but the methods for teaching them have. “One thing that is unique is the way we use technology,” said D’sa. Today he can run a full-blown, SolidWorks 3D, CAD program on his laptop, “which you couldn’t do even six years ago,” he said. That combined with advances in additive machining processes, such as 3D printers that can print parts, allows them to quickly create a part and assess it. They are even able to create functional parts and test them.

Team communication is another area that has been greatly enhanced by technology. “Because of the ability to store data on the Cloud and make it accessible to everybody, we are able to have a finalized assembly that is available at any time, and we can see modifications immediately,” said Ebben. “Five years ago we’d be emailing data around, then wondering where the most updated version was. Now it’s all on the Cloud and we all know it is the most updated version,” he added. Data storage
has entered into the several gigabytes range, and become so cheap that we can save complicated assemblies, CAD models, and even CFD, computational fluid dynamics models,” said D’sa. They maintain a website and keep it up to date — from responsibility matrices, to their current mechanical designs, build materials and meeting minutes. This also streamlines communication with their advisor and the company.

Choosing a project can reflect a student’s abilities in one of the areas of mechanical engineering like fluid flow or heat transfer, but it can also have a more personal relevance. For Ebben the choice was very personal. His younger sister was born with spina bifida, a congenital disorder that has left her paralyzed from the waist down. Growing up with a sibling in a wheelchair has made him keenly aware of the user’s needs and preferences. It also provided first hand familiarity with wheelchairs. “Whenever my sister would get a new chair we would all see how long we could do a wheelie in it,” he said. Working on a project that so readily benefits society keeps team members motivated. “It gives you the drive when you are working late at night,” said Ebben.

The Cooler team is working on a heat transfer project for a company called OnFarm Storage. With the growing demand for locally grown produce, for farmers markets and restaurants, there were no commercially viable options for small and medium sized growers to store and keep their harvested products. OnFarm Storage is working with an inventor of a CO2 refrigeration system to meet this demand. The objective given to the team is to design a storage harvest cooler that uses this proprietary CO2 refrigeration system.

Because the CO2 refrigeration system does not need a compressor or condenser, the storage unit can be used in areas with unreliable power grids, so it could also effectively work for growers in India. “We are exhausting the CO2 after it has absorbed the heat from the air in the storage unit,” explained Charles Volhaber, a member of the team. “There are crates of vegetables running parallel to each other with a tarp over the front and top, and a fan on the back forcing the cold air over them,” is how team member Drake Myhrman described it. One requirement from the company is that the unit must cool the produce much more rapidly than traditional refrigeration, so, for example, an 1,800-pound load of carrots could be cooled in six hours.

The company recently completed a full size prototype of the cooler that the team was able to work with in creating their design. They have built a CO2 cooling unit with a chest freezer to run various tests. “One of our main deliverables is to come up with an Ansys model of the air flow and heat transfer within the cooler,” said Alexander Marshall, another team member. “With our CAD model developed we are able to look at the air flow throughout the cooler as it occurs, and the ongoing state of the heat transfer,” he added.

Another task was to research specifications for equipment such as fans and evaporation coils, so that the company can order the most cost effective ones. The Ansys modeling validates that their calculations for the equipment are correct. “We are also comparing the costs of the CO2 cooler compared to standard refrigeration,” said Volhaber. Because this is a new product, with all of the risks associated with something new, cost efficiency is very important.

Team members had interesting reasons for choosing this project: for Rebecca Kinchen it was the desire to work on a project that had an environmental and sustainable focus, for Myhrman it was the thermal science factor, as he wants to pursue an HVAC career. Alexander Marshall liked the idea of working for a start up company that was formed to produce this one, new thing. Matthew Peterson was also interested in working on a new idea, something that nobody had tried before. Volhaber liked the thermal aspect, and he is also planning to go into the HVAC industry. This was his first choice for a project.

The culmination of the course is the Senior Design Show, a public walk-through event, which takes place in Coffman Union Great Hall at the end of the semester in fall and spring. The teams display their projects - with their objectives, results, posters and photos, and sometimes the actual products, available for review by teams of industry and faculty jurors. The event gives the teams a chance to engage with other students, friends, family, and the general public.

If you would like to participate as a judge, or have ideas for a project proposal, please contact Professor Will Durfee, wkdurfee@umn.edu.
Connecting with alumni can be even easier now with these QR symbols. Just scan the image into your phone to be connected to the ME alumni pages of our website, or to the ME-AN LinkedIn Group:

This growing group of alumni meet for fun, networking, and support for the Mechanical Engineering Department. For more information, please contact:

Jim Rutzick (ME ‘66) at alumni@me.umn.edu.

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In Memoriam

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<tr>
<th>Name</th>
<th>Program</th>
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<tr>
<td>Joseph T. Abdo</td>
<td>BME 1943</td>
<td>August 23, 2011</td>
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<td>Richard B. Archie</td>
<td>BME 1953</td>
<td>June 29, 2012</td>
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<td>Philip J. Becker</td>
<td>MSME 1992</td>
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<td>Warren T. Benoy</td>
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<td>August, 2012</td>
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<td>Edwin W. Bernhagen</td>
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<td>July 5, 2012</td>
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<td>Leslie W. Heins</td>
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<td>Thomas G. Herschbach</td>
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<td>Kenneth M. Krali</td>
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<td>William J. Krussow</td>
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<td>Herbert N. Mahle</td>
<td>BME 1940</td>
<td>June 16, 2012</td>
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<td>Karen A. Maki</td>
<td>BME 1965</td>
<td>October 1, 2012</td>
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<td>Ralph J. Muller</td>
<td>BME 1938</td>
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<td>Rodger L. Naeseth</td>
<td>BME 1941</td>
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<td>Timothy P. Sheridan</td>
<td>BME 1981</td>
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<td>George T. Spell</td>
<td>MSIE 1967</td>
<td>July 9, 2012</td>
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<td>Elliott E. Spencer</td>
<td>BME 1950</td>
<td>July 6, 2012</td>
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<td>Donald Stephenson</td>
<td>BME 1950</td>
<td>March 17, 2012</td>
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<td>Robert E. Stoll</td>
<td>BME 1951</td>
<td>September 28, 2012</td>
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<td>Paul Sullivan</td>
<td>PhD 1995</td>
<td>August 13, 2012</td>
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<td>James H. Thoe</td>
<td>BME 1951</td>
<td>September 26, 2012</td>
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<tr>
<td>Bruce W. Wehrle</td>
<td>BME 1966</td>
<td>May 31, 2012</td>
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SAVE the DATE: April 8 - 11, 2013
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The Commons Hotel (formerly the University Hotel)
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