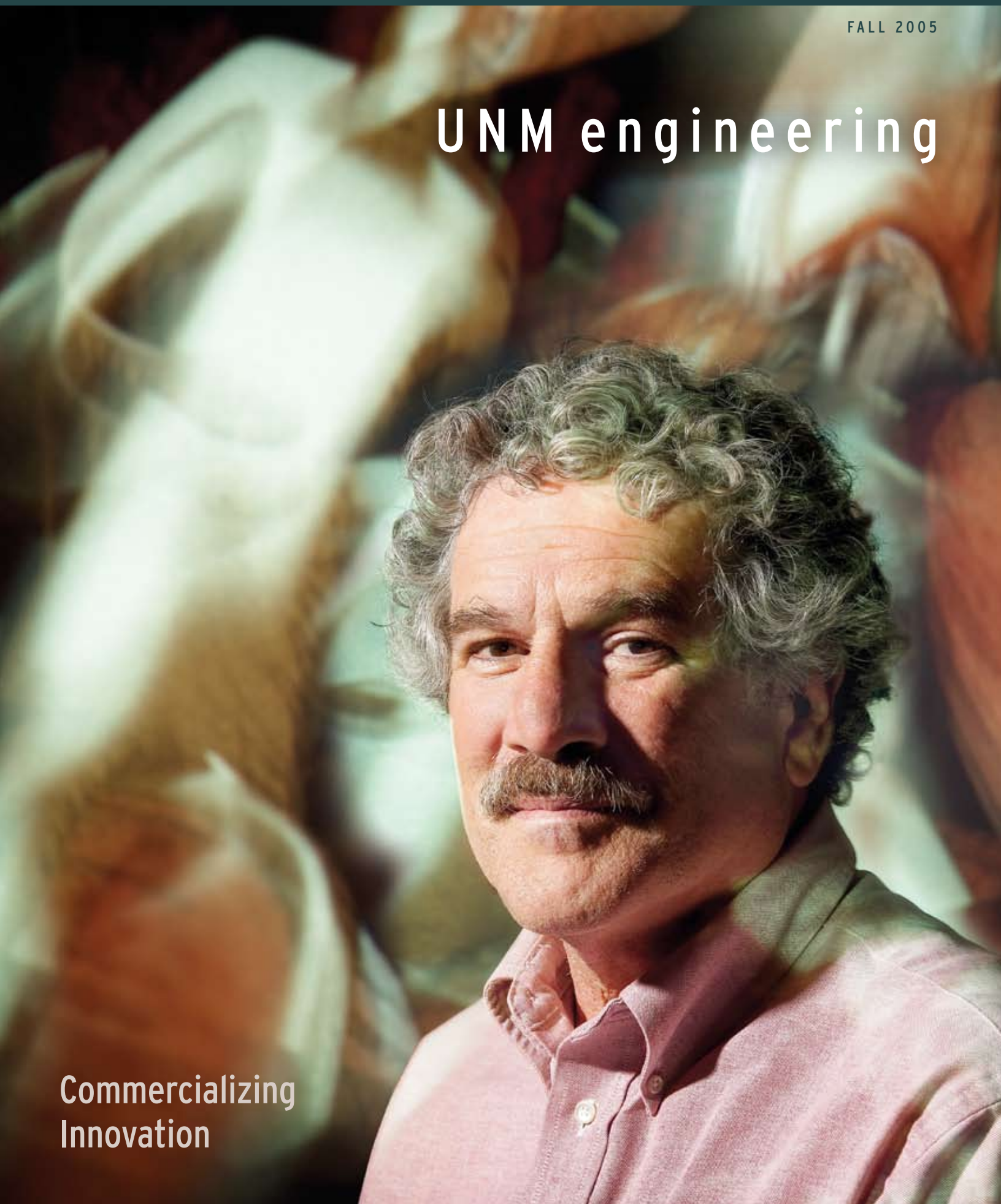
THE UNIVERSITY OF NEW MEXICO SCHOOL OF ENGINEERING

FALL 2005

UNM engineering



Commercializing Innovation

This issue of *UNM Engineering* shows how we're combining engineering and business to commercialize some of our innovations.

From the Dean

I'm not sure why it is such a well-kept secret, but the fact is engineers and computer scientists have fun. I sure did when I drove the Lobo MotorSports Formula Society of Automotive Engineers (FSAE) racecar. With serious performance (0-60 in 3.25 seconds) and great handling (1.2 G's on the skidpad), this was an experience not to be missed. And this year, as you can read about later in this issue, the School of Engineering's car number 22 placed 14th out of approximately 140 in the international competition held in Pontiac, Michigan, in May, and 10th among U.S. entries.

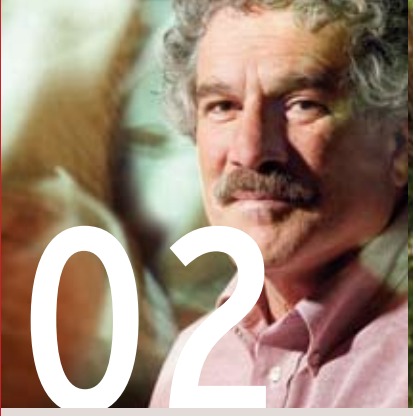
My congratulations to the team for their stellar performance in the competition, exacting teamwork in innovative design, superb execution, and learning a great deal along the way.

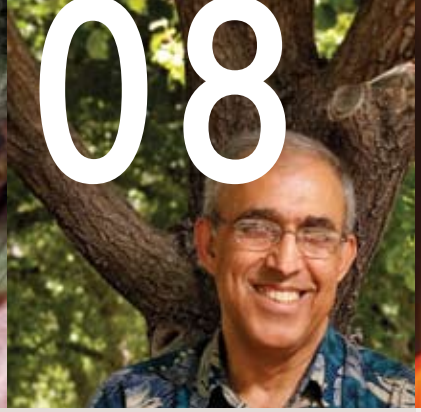
An important part of the FSAE team's success was giving careful attention to the business aspects of producing a winning car. They marketed the project to solicit financial support from UNM and community sponsors, for whom they advertised. They built the car on schedule (so they could be in the competition) and on cost (one of the evaluation factors). The team's efforts underscore the importance of learning in an environment that combines engineering and business.

This issue shows how we're commercializing some of our inventions. We do this in partnership with President and CEO Lisa Kuuttila and her team at the Science and Technology Corporation @ UNM (STC), our technology transfer organization. You will read about one of our inventors, Professor Mo Jamshidi, who brings products to the marketplace. Other articles highlight how Professor John Wood has developed MTTC, a UNM center that brings together academic interests, researchers, and businesses; how Professor Ed Angel has developed the ARTS Lab, a collaboration of arts and sciences with enormous potential for our state; and how Professor Luke Lester and the team at Zia Laser, a UNM spin-off, is commercializing quantum dot technology.

The partnership between the School of Engineering and STC is helping transform UNM into a community that understands and values invention and commercialization as integral and exciting components of our vital academic climate and public responsibility. We're enjoying the ride and hope you do too!

Joseph L. Cecchi
Dean of Engineering





Points of Pride

■ Chemical and Nuclear Engineering Lecturer III **Bob Busch** was given UNM's Adjunct/Lecturer Teacher of the Year Award for 2005. Busch is recognized for being at the top of the "most effective" list, and as a principled, committed, and caring professor. Numerous students say they will graduate or have graduated because of his assistance and advice.

■ The **Civil Engineering** department has created a new Master's of Construction Management program for construction professionals who have a non-engineering degree in a related field. The program is designed specifically for general or specialty contractors, construction suppliers, distributors, and designers, and features courses scheduled late afternoons, weekends, and online.

■ The New Mexico Information Technology Fellowship was recently established to support students pursuing graduate degrees in **Computer Science** at UNM. Funded by the McCune Foundation, the fellowship provides tuition, health benefits, and a monthly stipend to recipients who commit to working in New Mexico upon graduation, and is designed to strengthen New Mexico's technology base by providing fellowships that emphasize research and original thinking.

■ UNM and the University of Campinas, Brazil, have signed an agreement allowing students at either institution to obtain joint master's or Ph.D. degrees. The agreement is currently focused on **Electrical and Computer Engineering,** and it enables UNM students to obtain an advanced degree from the top engineering school in Latin America.

■ **Yu-Lin Shen,** associate professor and director of mechanical engineering graduate programs, was elected a Fellow in the American Society of Mechanical Engineers this summer. Shen has published over one hundred articles in the interdisciplinary areas of materials science and solid mechanics. He is a passionate teacher and a leader in academic excellence and diversity in engineering programs.

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The science of art.

THE AUDIENCE SITS TRANSFIXED…FIRST THE HUGE DOME-SHAPED CEILING ABOVE THEM FILLS WITH OUTSIZED, TRANSLUCENT JELLYFISH THAT FLOAT AND PULSE IN SPACE. THEN MULTICOLORED GRAPHICS OF FRACTALS BLOSSOM LIKE GIANT FLOWERS ABOVE THEIR HEADS. NEXT 20-FOOT TALL PEOPLE GARBED IN BRIGHT COSTUMES SWAY TO THE BEAT OF A DRUM AS THEY SURROUND THE ONLOOKERS AND DANCE ALONG THE ROOF LINE. IS THIS AN OFF-THE-WALL MOVIE? PERFORMANCE ART? SCIENCE? NEW TECHNOLOGY? ACTUALLY, IT'S A LITTLE BIT OF EACH.

The art of science.

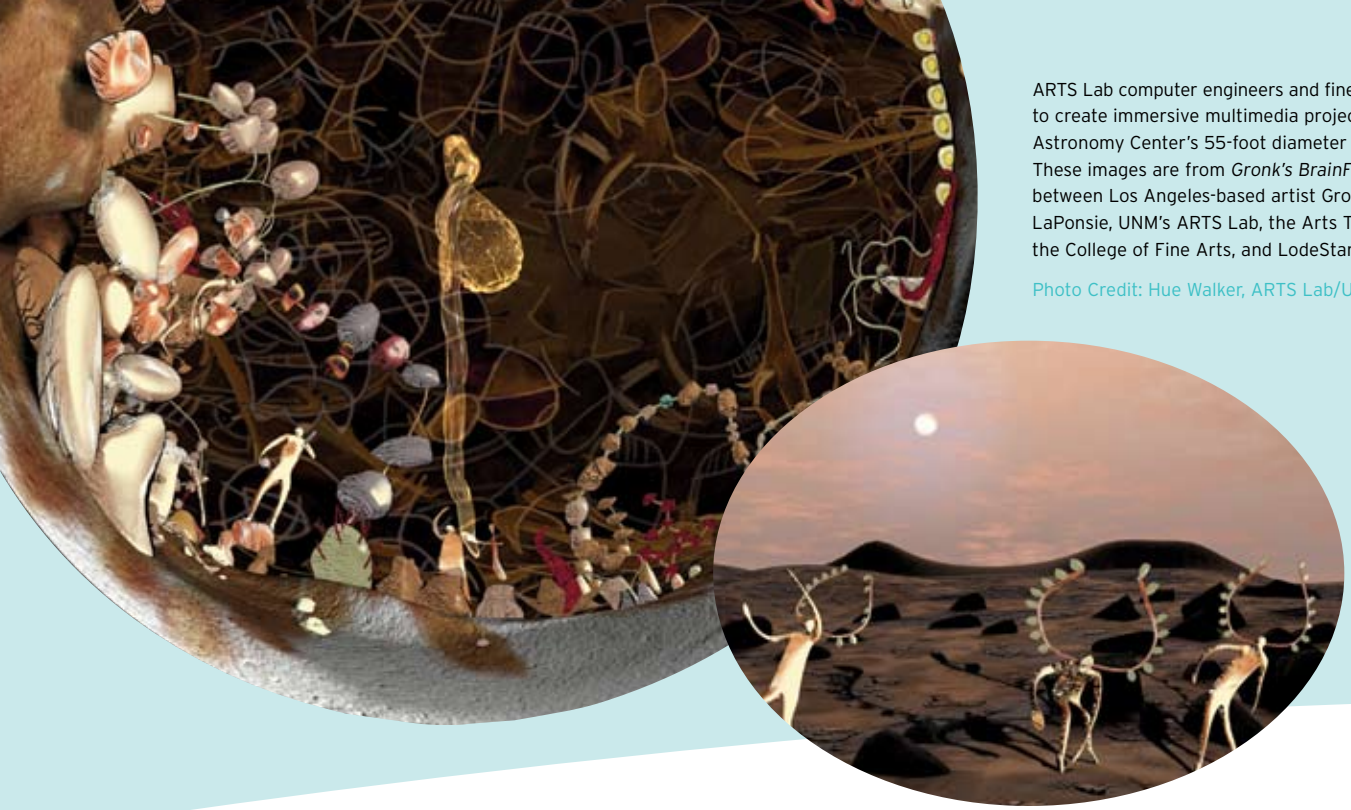
A NEW PROGRAM FOSTERS COLLABORATIONS ACROSS UNM

It's DomeFest, a digital exhibition which brings artists and scientists from around the world together to create content for a planetarium that surrounds the viewer with stunning digital images. DomeFest is produced, hosted, and funded by the LodeStar Astronomy Center, a UNM museum located at the New Mexico Museum of Natural History & Science in Albuquerque. Not only is DomeFest captivating, it's also an example of how the combination of art, science, and technology can generate economic potential, new research, and new frontiers for learning.

Two presentations shown at DomeFest were from a new initiative called the Art, Research, Technology, and Science Laboratory, or ARTS Lab. In 2003, Ed Angel, professor of computer science, electrical and computer engineering, and media arts, gathered a team of UNM faculty, students, administrators, artists, and others to brainstorm how UNM could support the state's burgeoning film and digital media industry. New Mexico's film industry had an $80 million impact on the state in 2003, up from just $8 million the year before. By 2004, the industry had grown to $250 million.

ARTS Lab was one result of the meeting. The program, funded by New Mexico Governor Bill Richardson's Media Industries Strategic Project, is changing the way UNM students and researchers from disparate disciplines work together. The lab, which became official at the beginning of this year, is both a physical place and an innovative interdisciplinary center. There are several locations on and off campus that house equipment used by ARTS Lab participants, and a major expansion of the lab's facilities is underway.

The vision of ARTS Lab is to become a catalyst for education and research that will grow and sustain an advanced media industry in New Mexico. Angel calls ARTS Lab a matchmaking service that brings together students, faculty, and researchers from around the university to collaborate on innovative digital arts and science projects, many



ARTS Lab computer engineers and fine artists work together to create immersive multimedia projects for LodeStar Astronomy Center's 55-foot diameter hemispheric screen. These images are from *Gronk's BrainFlame,* a collaboration between Los Angeles-based artist Gronk, composer Steven LaPonsie, UNM's ARTS Lab, the Arts Technology Center of the College of Fine Arts, and LodeStar.

Photo Credit: Hue Walker, ARTS Lab/UNM

with economic potential. Computer engineers and fine artists work together to create aesthetically pleasing spaces in virtual reality. Doctors, musicians, engineers, and artists develop a virtual patient to train medical students. Media artists and animators turn mathematical equations into beautiful graphics. An electrical engineering graduate teaches Native American children how to use digital media.

A Giant Curved Canvas

The "fulldome" at the LodeStar Astronomy Center is a spectacular canvas for ARTS Lab projects. The dome, 55-feet in diameter, uses six projectors and seven computers to fill the space with millions of pixels and surround viewers with panoramic digital images. By day, LodeStar is a planetarium where museum goers zoom through constellations and experience some of the world's best astronomy and astrophysics educational shows. At night, UNM students, researchers, faculty, and museum employees use the dome as a canvas for their digital films and scientific visualizations. They're also evaluating the dome's potential for supporting research and education in the arts and sciences.

Another ARTS Lab and LodeStar collaboration blends art, education, and economic development. *Arrow to the Sun,* an award-winning children's book about a Native American child's journey to the sun, is being adapted for viewing on the dome. The author, Gerald McDermott, is working with Hue Walker of the ARTS Lab, LodeStar, and school children from the Zuni Pueblo to animate the book and weave science education into the story. UNM School of Engineering graduate Shaun Tsabetsaye is organizing the effort with the pueblo. (See *UNM Engineering,* Spring 2004.) When the project, which is funded in part by the National Science Foundation through the Digital Pueblo Project, is complete, it will be distributed worldwide.

Collaborating to Create New Worlds

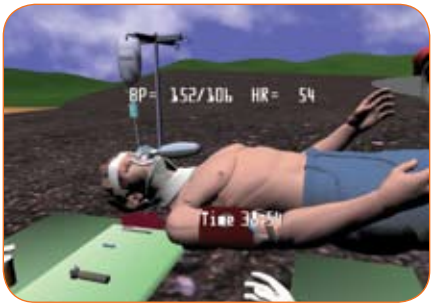
Thomas Preston Caudell, associate professor of electrical and computer engineering, includes in his research program the study of information visualization, research that goes beyond visualizing physical calculations and measurements to include elements that don't have natural interpretations. He's worked with artists and musicians for years because they enhance his research. "We bring artists and their creative palette of tools to the table to help us interpret and represent data in more comprehensive ways. There's no way I could accomplish my long-term scientific goals without their help," he explains.

Caudell says the ARTS Lab is facilitating the way he works. "The ARTS Lab makes it a much easier process. I've seen it already. People are coming together with the common interest of arts, research, science, and technology. We share a common vision of the value of our interdisciplinary work."

Caudell, along with fellow researchers at UNM and the University of Hawaii (UOH) are leading a team of engineers, doctors, medical students, artists,

"The ARTS Lab represents a collaboration of arts and sciences and a whole new way of working at UNM. It has enormous economic development potential for New Mexico."

Professor Ed Angel



Doctors, musicians, engineers, and artists developed "The Touch Project," a fully-immersive virtual patient that helps train medical students.

and musicians on The Touch Project, a patient simulator for the UNM and UOH Schools of Medicine. By combining engineering, medicine, and art, the team created a fully-immersive virtual patient that helps medical students improve their diagnostic skills. Students enter the virtual environment and diagnose a patient who has suffered an accident. An underlying artificial-intelligence system controls the complete simulation, provides the knowledge content, and monitors the efficacy and timeliness of the student's decision-making process.

To create The Touch Project, the team started with Flatland, a program Caudell wrote with his students to create general interactive three-dimensional virtual spaces. Artists applied their talent to help design a lifelike patient and environment. In collaboration with Panaiotis, a research professor in the UNM Music Department, ambient and patient sounds were created to enhance the environment. Then doctors on the team provided the pertinent medical information. It was an effective collaboration. "Medical students who have used the virtual environment in controlled experiments came closer to an expert's knowledge," says Caudell. He and his colleagues are now working with digital gaming companies and federal funding agencies to expand the tool to include other medical scenarios.

The Digital Garage

The potential for more creative ARTS Lab projects will grow exponentially with the opening of The Digital Media Garage later this fall. "The Garage" is a new $2 million, 7,000 sq. ft. facility that will be filled with digital media equipment, including high-performance computers, a blue screen area, a lighting grid, and a black-box studio with a motion capture system. The facility's centerpiece will be a 15-foot diameter dome with a projection system identical to LodeStar's.

Angel says The Garage will be an excellent meeting ground for people interested in digital media. "This is going to involve people in music, theater, dance, engineering, and the High Performance Computing Center. They'll all be working together in a big, collaborative environment where people can talk with each other and experiment," says Angel.

This innovative, synergistic spirit is not just growing the state's film and digital media industry and creating jobs, Angel adds. "The ARTS Lab represents a collaboration of arts and sciences and a whole new way of working at UNM. It has enormous economic development potential for New Mexico." ✦

MTTC's cleanroom (left and right photos) supports UNM researchers, students, and tech start-ups. MTTC tenant Advent Solar (middle photo) uses an MTTC bay and cleanroom to develop its innovative photovoltaic cell technology.



TECH'S FUTURE STARTS HERE

MTTC SERVES AS AN INCUBATOR FOR TECHNOLOGISTS

In a modern building about one mile south of the UNM School of Engineering, students, researchers, and small tech companies work side-by-side turning scientific principles into the next wave of technological, commercialized advancements.

While talented people with big ideas drive the process, it's the building itself that makes it all possible. Since 1998, the UNM Manufacturing Training and Technology Center has been an incubator for the people and the companies exploring the development and application of technology. "Our vision for MTTC was to create a place where we could bring together academic interests, researchers, and businesses," says John Wood, professor of mechanical engineering and director of manufacturing engineering at MTTC. "This is unique within the city and that's why you'll find this gathering of interests here."

Along with plenty of offices, classrooms, and meeting spaces, the 56,000 sq. ft. center features a 1,000 sq. ft. cleanroom stocked with equipment for most processes involved in etching and photolithography. The cleanroom features a modern support infrastructure including air handling units, a deionization/reverse osmosis water system, nitrogen, a scrubber, and acid waste neutralization systems.

Starting Up Start-ups

Walking through the hallways, you pass door after door inscribed with company names that have a high-tech sound: MEMX, Advent Solar, AgilOptics, and Lumidigm. Behind each door is a fledgling company busy converting ideas first generated within UNM or the national labs into products for the commercial market. In many cases, it's the MTTC cleanroom, which opened in 2001, that attracts so many tech start-ups to MTTC. For a nominal fee, companies can use the cleanroom facilities, equipment, and support infrastructure, all of which would be prohibitively expensive for any start-up to construct on its own.

MEMX, a broad based nanotech and micro-electro-mechanical systems (MEMS) company, was the first to utilize the MTTC cleanroom. The company's technical team had worked on MEMS development at Sandia National Laboratory before

Harry Weaver, research professor in Chemical and Nuclear Engineering and director of cleanroom operations (left), talks with School of Engineering Dean Joseph L. Cecchi.

> "This is a good partnership. It's an excellent demonstration of how the university and the business community can work together on something that's very real and very tangible."
>
> Mike Skaggs, president and CEO of Next Generation Economy, Inc.

spinning off to transfer that technology to the commercial sector. "As a start-up, the resources you have are very precious. The great thing about MTTC is that you can access very nice equipment on a pay-as-you-go basis," says MEMX CTO and Founder Paul McWhorter. "That allows us to invest in ideas rather than investing in infrastructure."

McWhorter says that the benefits of working at MTTC go beyond the infrastructure and equipment. "The great thing about having a presence at a university is that you gain access to bright young talent looking for jobs. It's a mutually beneficial situation." MEMX has several UNM graduates on staff and a number of UNM students working part time.

Training Tomorrow's Technologists

Forty percent of MTTC's cleanroom schedule is set aside for businesses. The remainder is allocated to UNM researchers and students. Their work is expected to expand as new facilities are added to the building. "MTTC gives our researchers the materials and equipment they need to pursue their work and prove their theories. It also gives our students the opportunity to see tech start-ups at work and become inspired by the entrepreneurial spirit which is at the heart of this facility," says Joseph L. Cecchi, dean of the School of Engineering.

The facility provides valuable training for UNM students in semiconductor and MEMS manufacturing. "This program gives students hands-on training that they otherwise wouldn't receive in New Mexico," says Wood. "We're closing the loop of training, R&D, and commercialization so that when tech companies come here, they can find a workforce."

An ongoing program between UNM and the Albuquerque Technical Vocational Institute (TVI) helps students from both schools hone their semiconductor and microsystems manufacturing skills. Technicians from TVI and engineers from UNM go through co-training exercises on selected process tools that emulate the types of teamwork and responsibilities they would experience in an actual semiconductor fabrication facility.

Expanded Opportunities

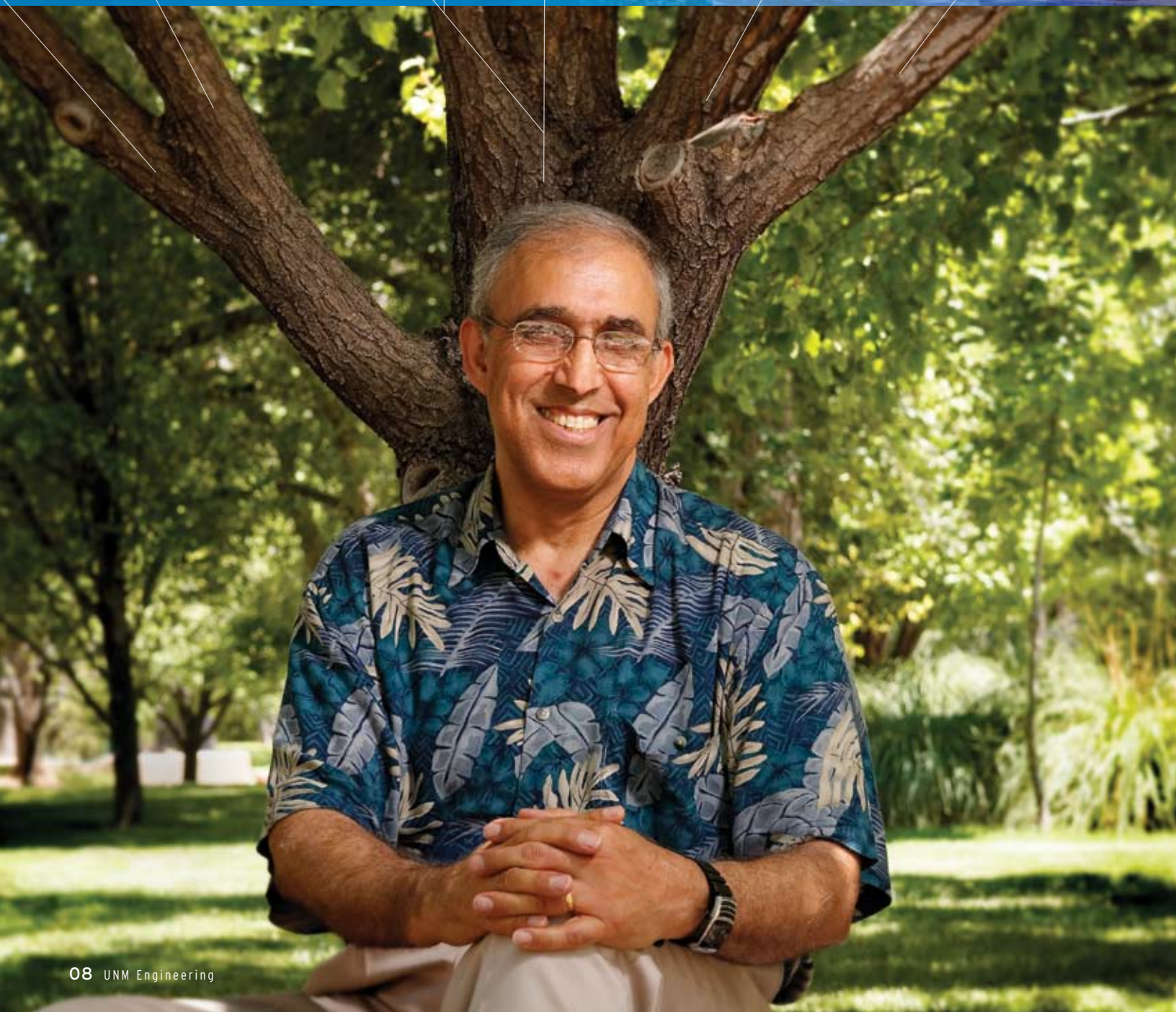
MTTC's successful shared facility concept is about to expand. Last year, Wood secured a $1.3 million federal grant from the Economic Development Administration, matched with state bond funds, that will expand the cleanroom size two-fold to 2,000 sq. ft. Another phase of construction is anticipated. When that construction is complete late next year, the cleanroom will be 3,000 sq. ft. and will include a full-function microelectronic process to make MEMS and BioMEMS. The larger cleanroom will accommodate numerous pieces of fabrication equipment, including tools donated to MTTC from Next Generation Economy, Intel, and Philips Semiconductors.

Intel's most recent equipment donation to MTTC, valued at over $2 million, was negotiated by Next Generation Economy. The Albuquerque-based organization develops public and private partnerships that nurture entrepreneurial endeavors in New Mexico. "This is a good partnership," says Mike Skaggs, president and CEO of Next Generation Economy, Inc. "It's an excellent demonstration of how the university and the business community can work together on something that's very real and very tangible."

Wood agrees, "We have a win-win situation here. Companies give us equipment and we turn it around and use the equipment to generate a workforce they can hire."

"Win-win" is an apt phrase for MTTC. Through visionary thinking and hard work, Wood and everyone involved with MTTC have created new opportunities for UNM and greater economic development potential for the state. The outcome will be far-reaching technological advancements and a New Mexico workforce trained for New Mexico high-tech jobs. ✦

FROM THE SMALL PICTURE TO THE BIG PICTURE



UNM RESEARCHER APPLIES FUZZY LOGIC TO SHARPEN RESEARCH RESULTS

In the future, your family photo album could be filled with pictures that are perfectly lit, crystal clear, and accurately reflect your vacation to Hawaii, with its deep blue water, crashing waves, and vibrant green palm trees. You'll have Mo Jamshidi to thank for that.

And when NASA lands a person on Mars, Mo Jamshidi will deserve some thanks then, too.

That's because as Regents Professor of Electrical and Computer Engineering, AT&T Professor of Manufacturing Engineering, and Director of the NASA-funded Autonomous Control Engineering Center, Mo Jamshidi has conducted research that has literally ranged from looking at the small picture to the big picture. In the process, he has gained international recognition for his research, prolific writing, and leadership in the area of large-scale complex systems.

Some of Jamshidi's hard and fast research has its roots in something decidedly ambiguous called fuzzy logic. Fuzzy logic is a technology that applies human intelligence and reasoning, processes which are inherently imprecise, to machines. The tools apply a mathematical framework to human reasoning, replacing human thinking with "if-then" rules. The result is a decision-making process, or controller, that is then implemented on a chip and put inside a machine.

Fuzzy logic's strength is its ability to tolerate inaccuracies and shades of gray, whereas conventional "hard computing" handles only absolutes.

Fuzzy logic was first created by Jamshidi's longtime friend and mentor, Lofti A. Zadeh, a professor at the University of California at Berkeley, who pioneered the concept with a groundbreaking and seminal paper on fuzzy sets in 1965.

Since then, fuzzy logic has been integrated into a spectrum of products manufactured around the world, but dominated by Japanese corporations, which adopted the concept more readily than American manufacturers. Fuzzy logic is used for the motion stabilizer in a video camera, determines the best air-fuel mixture in car engines, provides a quiet and smooth ride on an elevator, and helps air conditioners run more efficiently. "Fuzzy logic can replace any kind of application where humans are in the loop and they don't need to be," says Jamshidi.

The Small Picture

In the summer of 1992, Jamshidi, along with two UNM colleagues, was teaching a short course on fuzzy logic at MIT Lincoln Laboratory when some engineers from Polaroid Corporation approached him. They wondered whether fuzzy logic could help them solve a dilemma they were having with a video printer. They depended on an expert to fine-tune the tint, color, contrast, and sharpness of a picture before it was printed. But the printed picture wasn't matching the parameters set by the expert. Could fuzzy logic be used to correct the error?

Yes, Jamshidi thought. It was a perfect problem for fuzzy logic, so he secured a $50,000 grant from Polaroid and worked with a team of researchers

"This patent gives outsiders a new perspective on the quality of engineering work that's going on at UNM."

Professor Mohammad "Mo" Jamshidi

BEFORE

AFTER

Jamshidi's patented controller automatically adjusts any digital or analog picture's sharpness, contrast, tint, and color, pixel by pixel.

and students to resolve the problem. The result was a fuzzy logic controller implemented on a micro-controller board. This controller applied "if-then" rules to automatically adjust any digital or analog picture's sharpness, contrast, tint, and color, pixel by pixel, until the print was perfect. UNM's Science and Technology Corporation (STC) patented the Fuzzy Logic Controlled Printer in 1996.

The Future of SmartPhotoLab®

The software by-product of this patent was a C++-based environment called SmartPhotoLab. UNM researchers have used it to refine satellite images for more accurate analysis of vegetation growth and soil erosion. Jamshidi says it could also be used in military applications to refine reconnaissance data or verify nuclear weapons test bans. STC is collaborating with Jamshidi and his students to commercialize SmartPhotoLab. Jamshidi says that while there's even greater commercial potential for SmartPhotoLab than for the printer, that's not what is important to him. "This patent and its by-product give outsiders a new perspective on the quality of the engineering work that's going on at UNM," he said.

The Big Picture

Fuzzy logic is just one tool Jamshidi uses in his major area of research called *large scale systems* or *complex systems.* He's been researching the topic since he was a doctoral student at the University of Illinois in the 1960s, and is now recognized worldwide for his work in the field. In fact, Jamshidi wrote the first textbook on large-scale systems in 1983. The book and its second edition have been translated into five languages and are used at universities around the world.

A system is considered to be *large scale* if its size, design, model, and function are so complex and decentralized that standard analysis, modeling, and computing procedures are ineffective for managing and troubleshooting the system. You'll find large scale systems everywhere—in power grids, hospitals, and economies. Jamshidi's research uses, among other things, fuzzy logic and artificial intelligence to solve problems associated with large-scale systems and help them run more efficiently.

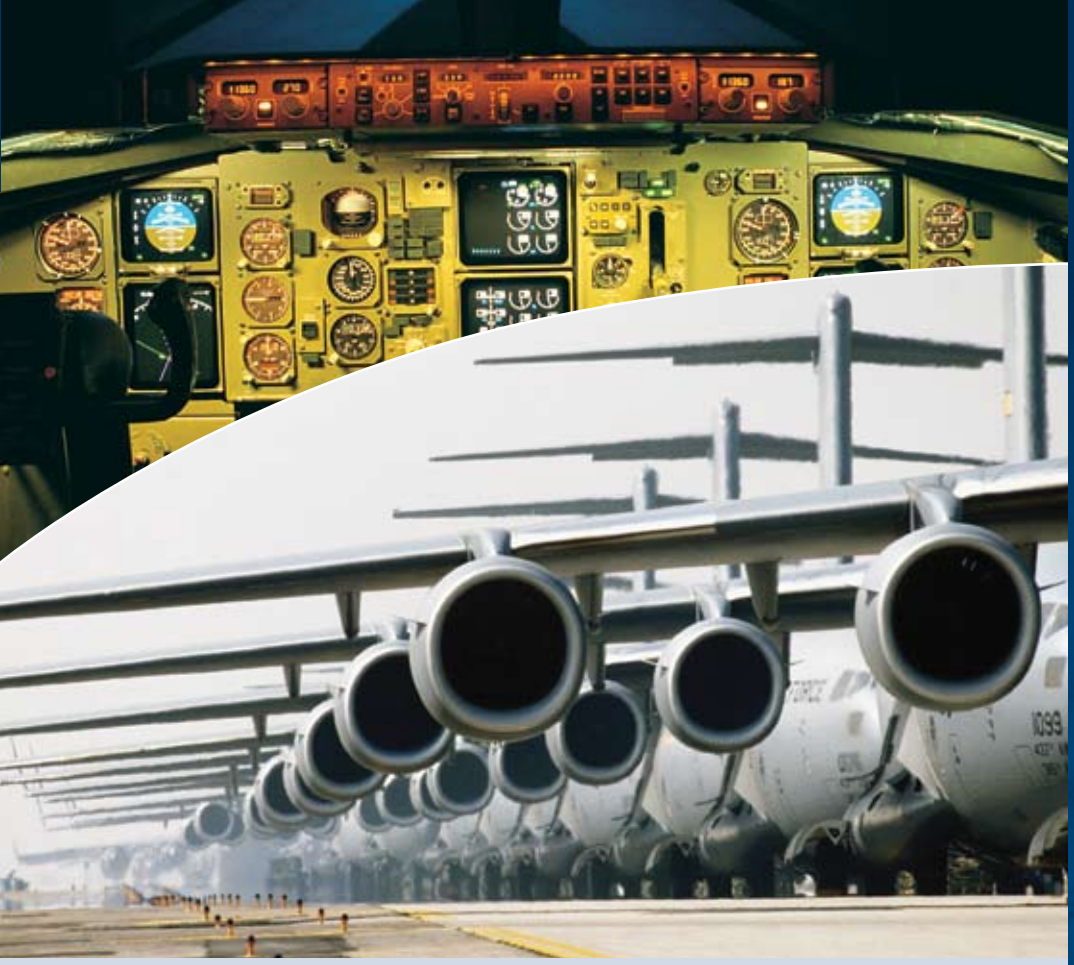
The Biggest Picture

Jamshidi's newest area of study, System of Systems (SoS), is a natural extension of his large-scale systems research. SoS focuses on the integration of multiple large scale systems that operate independently but also work interdependently within a larger system, or metasystem. For example, an airplane with its many automated parts and computer-controlled mechanisms is a system. But an airport with hundreds of airplanes, gates, control towers, and administrative departments is a system of systems. The military, satellite systems, and even large corporations are other metasystems. "Large-scale complex systems are the building blocks of SoS," says Jamshidi.

The challenges that researchers face with large-scale systems grow exponentially with metasystems. "The question is that, even though each system works fine individually, how will all the systems in the system be able to work together with some pre-specified degree of functionality and efficiency?" explains Jamshidi. SoS research looks at the best way to allocate resources correctly and integrate the many individual systems so that the metasystem functions effectively with minimal probability of failure.

Fuzzy logic comes into play in most stages of SoS. The soft computing process—which includes fuzzy logic, neural networks, evolutionary computing, and probabilistic reasoning—is useful in modeling the problem, aiding in information exchange between each system, and in analyzing problems within the system.

SoS was initiated by the Department of Defense and the U.S. aerospace industry prior to 9/11. Since then, the idea has been adopted by all branches of the military, major defense contractors, NASA, and aerospace companies. "SoS has a wide range of applications," says Jamshidi. "I think it's potentially a $2 billion per year opportunity for research and development." In fact



An airplane with its many automated parts and computer-controlled mechanisms is a system. But an airport with hundreds of airplanes, gates, control towers, and administrative departments is a system of systems.

NASA and CalTech's Jet Propulsion Laboratory in Pasadena are using SoS on the Code T Project, President Bush's initiative to send a person to Mars via the moon.

SoS is also being used in Global Earth Observing Systems (GEOS), a 60-nation global effort led by the United States government and the aerospace industry.

While SoS is gradually being adopted, research in the field is just beginning. Jamshidi plans to take the lead at UNM. He taught UNM's first SoS course in the spring of 2005 and is planning to write the first textbook on the topic.

Jamshidi is also organizing the National Consortium on System of Systems, a high-profile think tank of SoS experts from academia, government agencies, national laboratories, and industry. The consortium being planned by Jamshidi will collaborate to solve many of the most challenging problems facing the country and the world community today. Jamshidi plans to hold the first consortium and IEEE conference next spring in Los Angeles. "We are combining talents from different places so that a theory developed at the university level could be implemented for homeland security by a defense contractor. We're all working on pieces of the same puzzle," he said.

In essence, Jamshidi is using a system of systems approach to solve the challenges of system of systems. And based on his track record, the results will be anything but fuzzy. ✦

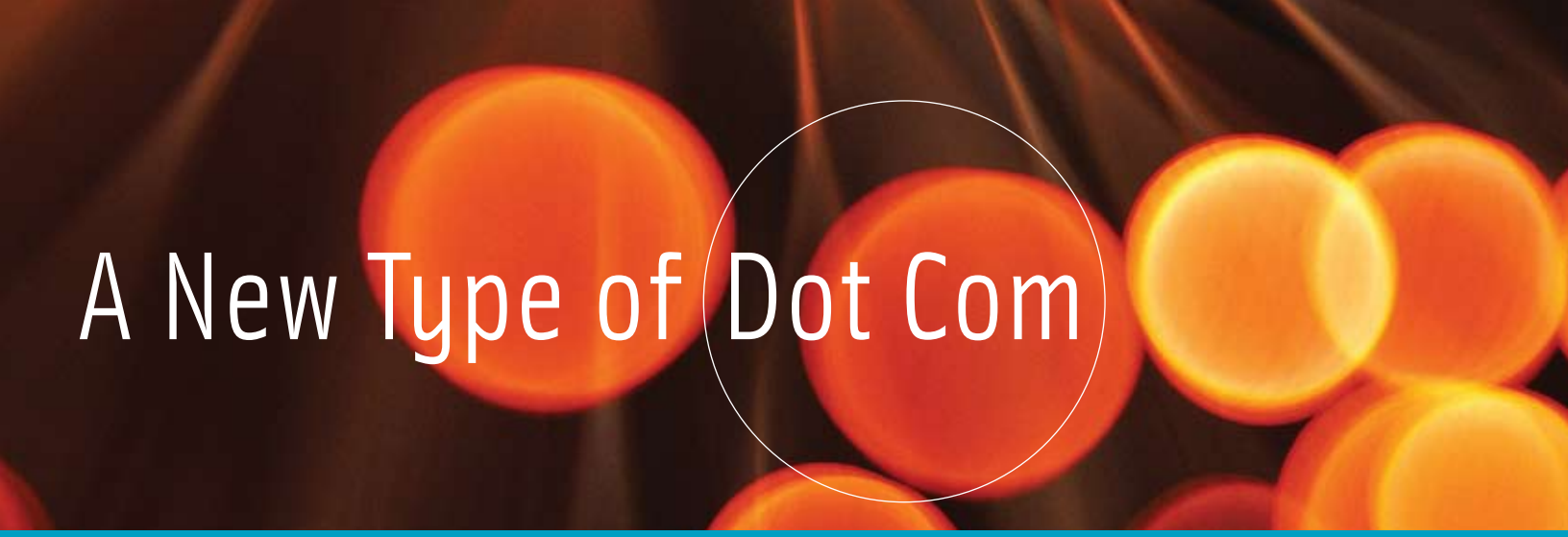
TRANSFORMATION IN PROCESS

Science and Technology Corporation @ UNM (STC) patented Mo Jamshidi's Fuzzy Logic Controlled Printer on behalf of Jamshidi and his Ph.D. candidate Ali Asgharzdeh in 1996. Jamshidi's was one of UNM's first patents.

Since then, STC has been steadily changing the university's culture and enhancing New Mexico's economic development. STC licenses the university's innovative technology, resulting from over $200 million in annual research funding, a wealth of laboratory research facilities, and collaborative ties to nearby national laboratories.

STC CEO and President **Lisa Kuuttila** confirms that engineering is leading the way for inventions at UNM with 10 start-up companies out of a total of 17 to date. A dozen engineering students or student groups have also commercialized their inventions.

STC encourages innovators to consult with them about disclosing their invention as soon as it is clearly conceptualized. This strategy resulted in 79 disclosures for FY '05, up 30 percent from the previous year. STC's mission is being accomplished: it is transforming UNM, one patent at a time.



A New Type of Dot Com

"We wanted to show that we could not only use people and money to make good science and engineering, but that we could take science and engineering and make money and products."

Luke Lester, associate professor of electrical and computer engineering

UNM SPIN-OFF IS COMMERCIALIZING QUANTUM DOT TECHNOLOGY

Zia Laser, an Albuquerque-based nano-tech company, is refining its quantum dot technology into what could be the next generation of microprocessors.

Quantum dots, or tiny dot-like clusters of semiconductor, are just a few nanometers (a billionth of a meter) in height, so small that two million of them lined end to end would be just one centimeter long. By harnessing the power of these dots, Zia Laser is blazing a trail for tech start ups from the University of New Mexico and creating opportunities for students, New Mexico's economy, and the entire semiconductor industry.

Zia Laser spun off from UNM's Center for High Technology Materials (CHTM) in 2001. "Our vision really was to take a technology in its very earliest stages and show that a New Mexico company could be started from UNM technology," says Luke Lester, associate professor of electrical and computer engineering and one of the company's founders. "We wanted to show that we could not only use people and money to make good science and engineering, but that we could take science and engineering and make money and products," adds Lester.

A Better Beam

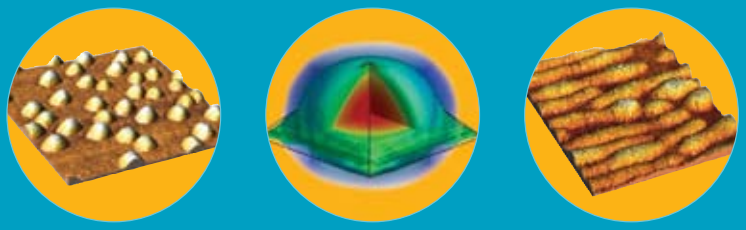
Quantum dots are created using Molecular Beam Epitaxy (MBE). Through MBE the dots self-assemble on a substrate and emit light. By applying electricity to stacks of these substrates, researchers generate laser beams that are used to enhance data transfer rates between integrated circuits. These lasers have the world's lowest threshold current density, a measure of how much current it takes to make the laser turn on. They also behave very differently from other semiconductor lasers and in ways similar to atomic lasers. Zia Laser's quantum dot laser beam has superior performance capabilities in part because it combines the advantages of both semiconductor and atomic lasers. The result is a more efficient device that consumes less power and may be less expensive to manufacture.

Zia Laser founders think their laser could transform the optoelectronics industry. "The issue is moving data on and off microprocessor chips and the bottleneck that creates in the copper wiring. What we're looking at is a way to get around that bottleneck optically," says Lester. He estimates that the company is about two years from production.

Collaboration and Capital

All this cutting-edge technology requires talented engineers and a large infusion of cash. Since the company started in 2000, Zia Laser has generated more than $22 million from investors. "That's money going into high-tech jobs. Ninety percent of that money is spent right here in New Mexico," says Lester.

He points out that the company's flexibility and the technology's broad



(Above) Zia Laser co-founder and CHTM assistant research professor Andreas Stintz readies the Molecular Beam Epitaxy (MBE) machine for producing quantum dots.

(Left) Zia Laser's quantum dots form when the semiconductor indium arsenide (InAs) self-assembles during MBE growth. Each dot is about 15 nm wide and 7 nm tall; one square centimeter contains more than 100 billion dots. (Center) The calculated quantum mechanical wavefunction for an electron inside the dot. The portion of the wave function cloud that extends outside the dot indicates the possibility of quantum mechanical "tunneling." (Right) InAs quantum "dashes" are another key part of the technology licensed by Zia Laser.

application made Zia Laser attractive to investors and kept the company going during the notoriously difficult start-up phase. "The company isn't a one hit wonder. Our quantum dots are core materials technology that has many different applications," says Lester. He adds that Zia Laser employees have been especially supportive during the start-up phase. "They've been through the trenches, and my hat is off to them. They have a lot of true entrepreneurial spirit."

But it took more than talent, money, and patience to get Zia Laser off the ground. To spin off from CHTM, the company needed to collaborate with the Science and Technology Center (STC), a non-profit corporation owned by UNM that assists faculty and researchers with patents and technology transfer.

All of the company founders, including COO Petros Varangis, were either UNM faculty members, researchers at CHTM, or UNM students at the time they started the spin-off process. In fact, Zia Laser was STC's first full-fledged tech spin-off with active faculty members. Between negotiating the license, finding venture capital, and starting the business, both parties say it was a challenging process that had a good end result. "Zia Laser is the first UNM start-up founded by active faculty," says Joe Cecchi, dean of the School of Engineering and chairman of the board of STC. "The company represents an excellent case study in technology transfer. No other UNM spin-off has done as well as Zia Laser has in generating venture capital funding."

Lisa Kuuttila, president of STC, agrees. "Zia Laser has a lot of promise. They've raised a considerable amount of money to get their technology going, and we want to do everything we can to help support them."

The market for Zia Laser's research is growing. Business Communications Company Inc., a technical market research and analysis firm, estimates that the current global market for quantum dot technology is around $10 million. But new technology from companies like Zia Laser could increase the market exponentially to hundreds of millions of dollars in just a few years. Zia Laser's success will also be UNM's. STC holds the license to the core technologies Zia Laser uses, and therefore will receive a percentage of the company's future earnings.

The benefits to the company and the university go beyond the financials. UNM engineering students gain career opportunities from tech start-ups like Zia Laser. In fact, the company now employs several UNM graduates.

It's clear that through innovative technology and smart business collaborations, Zia Laser is proving that its dot com revolution is just getting started. ✦

RACING TO A NEW LEVEL

UNM TEAM GOES FROM 39TH TO 14TH IN INTERNATIONAL RACECAR COMPETITION

The pressure was intense as the UNM student team's formula-style racecar pulled into the pit during the 2005 endurance race. There were only three minutes to stop the car and change drivers. This had been the low point of the competition for the 2004 UNM team; their car had overheated and they could not continue. The endurance race, a test of overall performance, reliability, and fuel economy, is a challenge for most teams: two-thirds of them do not finish it. (See *UNM Engineering*, Fall 2004.)

Mechanical Engineering Professor and Faculty Advisor John J. Russell emphasized it repeatedly: the endurance race was critical. If the team could complete all 22 of the one-kilometer laps, they would have a chance at breaking through to being one of the top 20 finalists worldwide. And here they were—in the pit, changing drivers, at the halfway point of the endurance race.

Each moment seemed to drag on. Now Russell couldn't see the team but he visualized them in the pit, synchronizing their moves, the new driver taking control, starting the car. He held his breath and shut his eyes for a second. Then he heard his wife Pam scream, "Yes!" and suddenly he saw car number 22 burst out of the pit. He counted down the remaining 11 laps and saw his team's car cross the finish line. They did it! The team finished the endurance race and broke through a barrier all previous UNM teams had been unable to overcome.

OPPOSITE LEFT: Evaluating, adjusting, and redesigning were important steps to build reliability and confidence in the car.
OPPOSITE CENTER: The team unveiled the racecar to fellow students, faculty, and staff at the School of Engineering Annual Awards on May 6, 2005.
OPPOSITE RIGHT: UNM's 2005 racecar can go from 0–60 mph in under four seconds and can corner at 1.5 G's in autocross and 1.2 G's in skidpad (compared to .98 G's for a Corvette).

A real-world scenario

UNM's student-built racecar went on to place 14th overall in the 2005 Formula Society of Automotive Engineers (FSAE) competition in Pontiac, Michigan, last May, UNM's best finish ever. The four-day event is the largest international engineering competition in the world.

The premise set up by the FSAE competition is that a manufacturing firm has commissioned each team to produce a prototype open-wheeled, open-cockpit, formula-style racecar for evaluation as a production item for the nonprofessional weekend autocross racer. Approximately 140 teams from around the world compete in seven categories that are judged by hundreds of industry professionals.

To emphasize the real-world scenario, teams are judged on engineering and business outcomes. There are events that measure the car's acceleration, handling, braking, fuel economy, overall performance, and reliability. In addition, it must be easy to maintain, reliable, and affordable. Judges from auto industry management evaluate marketing, design, and manufacturing reports and presentations. The result is an all-encompassing yearlong effort that demands engineering skills, project management, teamwork, and business acumen.

From start to finish

UNM is one of a handful of colleges offering courses designed around the FSAE racecar event. Russell re-designed the courses in 2003. Students on the team begin a three-semester, for-credit course sequence in the spring of their junior year. The first semester is dedicated to the academics of racecar design. In the fall, students build the car, and in the spring, they test it. The class is an alternative to the required senior design project in Mechanical Engineering.

The course sequence is an ideal vehicle for combining engineering, life skills, and experiences that last a lifetime. "The event itself lasts maybe six months in students' minds. The thrill of victory or defeat passes," says Russell. "The total experience lasts forever—the teamwork, the time they put into it, the accomplishments, the experiences they have along the way."

Justin Reddick, a 2005 team member, agrees. "This course changed me. I became much more passionate about engineering," he says. "I was totally immersed in the project from start to finish and there is no better feeling than seeing something that you had a hand in perform so well."

Reliability and continuity

Throughout the course, Russell emphasized the importance of analyzing, preparation, and testing. "Build in reliability, drive the car smartly by not risking the car, and more than anything – remember that better is the enemy of good enough. No last minute untested improvements," he explains.

One of the keys to the success of the course and the competition is continuity from one year's team to the next. Ryan Chefchis, a senior and the project manager for the 2006 team, says, "It's an evolutionary project. We take what works from last year's car and use it. We fine-tune what doesn't work and change it. But racing is racing—anything could happen. We could be in the first place in the last race and blow a tire. We know that preparation is key, and we'll certainly be prepared."

The 275 additional points from the endurance race helped push the 2005 team from the 2004 39th place finish to 14th place internationally, 10th place nationally, and a new level for UNM. Russell says, "I'm most proud of the way the team put it all together. They were organized, prepared, professional, and on-time for each event. Our team demonstrated it has what it takes to win by performing well in all aspects of the competition. They showed they belong with the best in the world." ✦

Chemical and Nuclear Engineering

Heather Canavan, Ph.D., joined the department this fall as an assistant professor specializing in nano and biomaterials. With a research background in bioengineering specializing in the interface between biology and manmade materials, Canavan will be instrumental in helping the department incorporate courses and research in bioengineering. She has presented her work internationally on numerous occasions and was recently published as the cover article in *Langmuir.*

Dimiter Petsev was hired this fall as an assistant professor in chemical engineering. He is currently involved in research on the theoretical modeling of the transport of fluid, current and dissolved analyses in channels of nanometer sizes. Petsev has substantial expertise in emulsions and emulsion stability, and edited a book entitled *Emulsions: Structure, Stability and Interactions,* published in 2004 by Elsevier.

Chair: Julia E. Fulghum
505-277-5431
chne@unm.edu
Faculty: 18
Graduate students: 89
Undergraduate students: 81
Annual research expenditures: $5,200,000

Civil Engineering

Arup Maji has been appointed as the new chairperson for the Department of Civil Engineering. He has been in the department since 1988 and now oversees a department of 140 students and 17 faculty members. Maji's goals for the department are to increase the efficiency of their teaching mission, advance the department's reputation in cutting-edge research, and enhance the department's role in ensuring economic development through greater community involvement.

Maji's research interests encompass experimental mechanics, structural engineering, and composite materials. He served as a Senior Research Scientist with the Air Force Research Laboratory's Space Vehicles Directorate, in Albuquerque, NM, from 1995 to 2005. He is a Fellow of the American Society of Civil Engineers (ASCE), Associate Editor of several international journals, and a past president of the ASCE New Mexico Section.

Deborah J. Fisher, associate professor of civil engineering, has been selected to receive the 2005 Society of Women Engineers Distinguished Engineering Educator Award. Fisher has contributed to engineering research for over 30 years, specializing in computer modeling of constructability and manufacturing applications to improve the construction industry. She has taught for 25 years, first at the University of Houston and then at the UNM School of Engineering since 1994.

Chair: Arup Maji
505-277-2722
civil@unm.edu
Faculty: 16
Graduate students: 68
Undergraduate students: 98
Annual research expenditures: $1,900,000

Computer Science

The Computer Science Graduate Student Organization held the first annual CS UNM Student Conference in spring 2005. The conference included research talks and a poster session. The keynote address was given by Orran Krieger, a leading figure in operating system research, from IBM's T.J. Watson Laboratory in Yorktown, New York. This conference was funded in part by Sandia National Labs.

CS Department undergraduate **Rory McGuire** received Honorable Mention from the Computer Research Association for the 2005 Outstanding Undergraduate Award. UNM students Clint Morgan, Breanne Duncan, Cris Riley Wilson, Scott Carter, and Monica Rogati won this honor in 2004, 2003, 2002, 2001, and 2000, respectively.

Andree Jacobson joins the CS Department in Fall 2005 as a Lecturer. Jacobson earned a master's degree in Computer Science and Engineering from Lulea University of Technology in Sweden as well as a master's degree in Computer Science from the University of Arizona. He will support the department with teaching efforts in undergraduate education in addition to advisement and recruitment in the undergraduate program.

Graduate students **Aaron Clauset** and **Maxwell Young** have written a paper on "Scale Invariance in Global Terrorism" that was discussed in the July 21st issue of *The Economist* and in the German publications *Nature* and *Die Welt.*

Chair: Deepak Kapur
505-277-3112
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Faculty: 16
Graduate students: 242
Undergraduate students: 185
Annual research expenditures: $3,800,000

Note: Faculty and enrollment numbers are from Fall 2004. Annual research expenditures are preliminary figures from FY 2004/2005.

Electrical and Computer Engineering

Chaouki T. Abdallah assumed leadership of the Department of Electrical & Computer Engineering on July 1. His immediate goals for the ECE department include increasing the visibility and reputation of the department locally and globally, strengthening the online ECE program, and encouraging international experience among ECE's undergraduate and graduate students.

Prior to his appointment, Abdallah served as associate chair and director of ECE's graduate program from August 2001 to December 2004, during which time the number of graduate students at ECE increased from 125 to about 300.

He received his Ph.D. in 1988 from Georgia Tech and has been at UNM ever since. Abdallah conducts research and teaches courses in the general area of systems theory with a focus on control and communications systems. His research has been funded by national funding agencies (NSF, AFOSR, NRL), national laboratories (SNL, LANL), and various companies (Boeing, HP).

Electrical engineering major **Frank Hemingway** was selected as a 2005 Goldwater Scholar. He is among 320 recipients in the U.S., all of whom will be juniors or seniors during the 2005-2006 academic year.

Professor **Mark Gilmore** has launched a new plasma experiment, Active Control of Turbulent Transport, to study processes relevant to the goal of realizing fusion energy. The goal of the ACTT experiment is to investigate how active feedback control techniques may adjust plasma flow in order to reduce turbulence and thereby increase the efficiency of the fusion process.

Chair: Chaouki Abdallah
505-277-2436
info@ece.unm.edu
Faculty: 32
Graduate students: 285
Undergraduate students: 260
Annual research expenditures: $11,300,000

Mechanical Engineering

Dr. Herbert Tanner was awarded the NSF Faculty Early Career Development (CAREER) award in the field of Robotics by the Information and Intelligent Systems (IIS) division of the Computer & Information Science & Engineering (CISE) directorate. The CAREER is NSF's most prestigious awards program for junior faculty members. In this field, only three CAREER awards were given nationally in the fiscal year 2005. Tanner's proposed research aims at developing swarms of heterogeneous robots that could automatically plan their cooperative actions toward a common objective. The total amount of his award is $400,000 for five years.

Marwan Al-Haik was hired as assistant professor of mechanical engineering in fall 2005. Al-Haik received his Ph.D. from Florida State University in May 2002. His research interests focus on the processing, characterization and simulation of nano scale materials, polymers and their composites and super alloys. His computational investigations utilize novel techniques such as molecular dynamics simulation and neural networks to capture constitutive behaviors at nano and micro scales.

Kenneth M. Armijo, a 2005 mechanical engineering graduate now at UC Berkeley, was awarded several fellowships, honors, and accolades while at UNM. Most recently, he received the Harriett G. Jenkins Pre-doctoral Fellowship, a GEM Fellowship, and the California/Berkeley Fellowship, totaling over $100,000 in support and financial assistance.

Chair: Juan C. Heinrich
505-277-2761
lsandve@unm.edu
Faculty: 17
Graduate students: 119
Undergraduate students: 189
Annual research expenditures: $1,900,000

Note: Faculty and enrollment numbers are from Fall 2004. Annual research expenditures are preliminary figures from FY 2004/2005.

The University of New Mexico

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