The newsletter of the Institute for Systems Research
Volume 13 , No. 1 Fall 1998

Systems Signals

Internet-based display system developed for Black & Decker

ISR Research Engineer Ed Lin demonstrates the display system.

Assistant Professor Jeffrey Herrmann (ME/ISR), Ioannis Minis (formerly affiliated with ISR) and ISR Research Engineer Edward Lin have helped Black & Decker improve one of the most basic factory designs: the assembly line.

The company's factory in Easton, Md., has made the transition from manufacturing primarily consumer products to producing professional products.

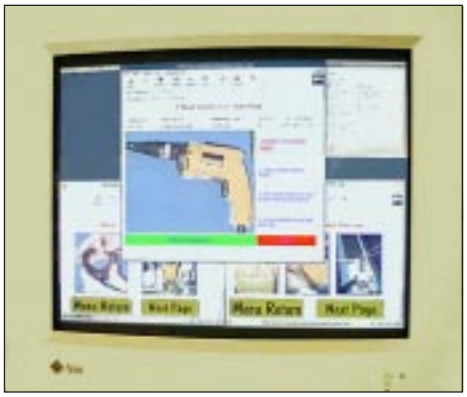
The plant uses a flexible assembly system, manufactured by Prodel, that allows different products to be manufactured simultaneously. Herrmann, Minis and Lin's project introduced computer automation to this system so that operators could read instructions from a computer screen when they receive a new type of product.

Black & Decker's need for a more efficient system is directly related to consumer demand and an increasingly global market, Herrmann says. Consumers want more choices, and different countries have different standards. One consequence of this is that Black & Decker makes hundreds of different drills.

Black & Decker needed an assembly line that could handle all of these products. In a traditional linear assembly line, production temporarily halts before a new tool with different parts is introduced. But when the company switched to the Prodel system, new tools could be introduced at any time and operators could change quickly from one product to another.

The flexible assembly system has 12 stations: four transmission assembly stations, five final assembly stations, two kitting stations and one run-in and test station. Unlike the traditional assembly line, the Prodel system does not individually unload uncompleted tools onto a linear conveyor belt.

Instead, pallets move along a circular track between stations. After a pallet gets components at a kitting station and is programmed with the code for a specific model, it moves to a transmission assembly station. The operator assembles some of the components and



sends the pallet to a final assembly station. After final assembly, the pallet moves to the test station for removal and testing. The empty pallet returns to a kitting station for a new drill.

Herrmann says that one of the distinct advantages of this system is that it can produce different types of drills simultaneously. Moreover, each station contains components common to different models, while the pallet carries the unique components. Thus, changing from one model to another requires little effort. This saves time and money.

Still, operators lost time trying to determine how to make each model.

At the start of the project, the ISR research team noted, "Faced

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What's inside

ISR is a permanent institute of the University of Maryland, within the A. James Clark School of Engineering/ Glenn L. Martin School of Technology. It is a National Science Foundation Engineering Research Center.

Director's Corner

MicroElectroMechanical Systems are an ISR research frontier

We have become accustomed to the rapid shrinking of microelectronic devices, enabling high performance computers with increasing capability of memory, storage, and display resolution. This trend toward miniaturization also is moving full speed ahead in a broader context that promises to profoundly affect our world.

One embodiment of this larger context is the miniaturization of functions beyond electrical manipulation of information, to include such things as physical measurements (e.g., pressure, temperature, stress/strain), chemical analysis (e.g., pollutants, dangerous species), and modification or actuation of physical systems.

While more conventional approaches to the fabrication of miniaturized structures have been useful, the construction of even smaller structures based on silicon technology as practiced for computer chip manufacturing has opened new doors to small structures which combine sensing, actuation, computing, and communication. This approach is often referred to as MEMS, for MicroElectroMechanical Systems.

Fabrication of microstructures and microsystems is based largely on the thin film technology developed for computer chips. It provides mechanical, electrical, chemical, acoustic, electromagnetic, and optical functionality. ISR researchers are already moving to the forefront of this field, as evidenced in work by Don DeVoe (ME/ISR), Tom McAvoy (ChE/ISR), collaborators at NIST, and in the recent DARPA award for three-dimensional MEMS to DeVoe and Lung-Wen Tsai (ME/ISR) described in this issue of *Systems Signals*.

From the start, the move toward broad physical microminiaturization has been motivated and accelerated by the existing power of integrated circuits. This combination integrates physical and information systems and has profound consequences.

First, ISR's expertise and position in the university make it ideally suited for investigating the superb systems research opportunities in engineering these integrated systems for numerous and highly diverse applications.

Second, integrated microsystems represent an ideal educational opportunity to produce a generation of engineers who understand and deeply appreciate not only systems concepts and methods, but also the fundamental connection between the physical and information worlds in systems applications. ISR is closely involved in the growth of this integration within the College of Engineering, supported by the university's Flagship Initiative.

Finally, and most importantly, our society can expect to see integrated microsystems benefiting many aspects of our lives, from new biomedical technologies and environmental management to personal communications and security. ISR will play an important role in this era.

Black and Decker display system

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with increasing product variety, production operators need more accurate information.

"Currently, they waste too much time and energy seeking information that describes the product they are building. Mistakes can occur when the operators cannot access the right information and when they use outdated information.

"Moreover, operators often have difficulty interpreting engineering drawings."

Enter the Internet. The ISR researchers developed hardware and software that displays instructions on computer screens on the production floor. The instructions appear in real time, just as the operator receives the product.

Each assembly station has the Internet-based display system, which reads the information from the pallet, retrieves the instructions and displays them on the screen.

"It works great," says Herrmann. The Internet interface allows Black & Decker to easily standardize software across its facilities.

Now the researchers are looking for other companies that use the Prodel system, hoping to test their program elsewhere.

The Maryland Industrial Partnerships Program (MIPS) and the University of Maryland's Engineering Research Center funded this 1996-1997 project. The resources of the ISR-affiliated Computer Integrated Manufacturing Laboratory were used extensively.

You can download the Technical Report associated with this project at *http://www.isr.umd.edu/TechReports/ISR/1998/TR_98-4/TR_98-4.phtml*. For more information, contact Jeffrey Herrmann at (301) 405-5433, *jwh2.@isr.umd.edu*.

—Jeremy Bond

ISR
INSTITUTE FOR SYSTEMS RESEARCH

The Institute for Systems Research is a permanent state-supported institute of the University of Maryland, within the A. James Clark School of Engineering and the Glenn L. Martin School of Technology. ISR has a continuing affiliation as a National Science Foundation Engineering Research Center.

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Systems Signals is printed on recycled paper.

Robot birds aid zoologist's Ph.D. project

Assistant Professor Greg Walsh (ME/ISR) is known around the world for Maryland's robot grand prix victory in Japan last year. But Walsh's main interest is in control systems-which guide robots, but have many other applications as well.

In one of his most recent projects, Walsh and his students built six mechanized Australian Blue Satin Bower Birds for Maryland Zoology Professor Gerald Borgia and Zoology doctoral candidate Gail Patricelli.

Walsh was intrigued by the question of how much tiny computers could do. Bower birds are about the size of a pigeon, and the machine to control them had to fit inside. His solution was to build a computerized RISC processor "bird brain," with just .5K of memory, which sits on a one-inch by one-inch board.

"We control four motors and monitor a serial communication channel using error correction, all on an 8-pin chip running at 4 MHz," Walsh said. "These are very short programs."

The "brains" are as cheap as they are small, running about $2 each. The switches and dials cost more than the computer chips, the most inexpensive parts. The use of computers in mechanical devices formerly was limited by their prohibitive cost.

The robots are being used in Patricelli's thesis on how bower birds mate. Finding the best way to make them move on command was a challenge. If a wire were attached to the robot, the male might mistake it for a snake. So Walsh provided a serial radio communication link. In the field, Patricelli controlled the birds with a radio transmitter.

Walsh's graduate student David Delalio worked on the mechanical design using the ProEngineer program, and undergraduate Jeff James built the first prototype. Edward Oliver Craft programmed the bird's brain. It was an impressive project for undergraduate students, Walsh said.

Walsh's robots are "animatronic," similar to the dancing animals popular at Disney World. With four degrees of freedom, they can perform simple movements such as tilting their heads and fluffing their feathers.

Walsh said economics have transformed small pieces of technology in countless ways.

"Even though these embedded computers are not very sophisticated, their low cost means they can be used for control in most any mechanical device, anywhere," Walsh said. "You can think of using embedded computers in ways you would have never thought of using them before. You can put intelligence almost anywhere at a very little increase in cost."

A completed robot bird is in the foreground. Behind it, the bird's robot "guts."

For more information, contact Greg Walsh, 301-405-5447, *gwalsh@eng.umd.edu*.

—Jeremy Bond

CSHCN-HNS partnership showcased at summit meeting

Center for Satellite and Hybrid Communication Networks (CSHCN) Director John Baras (EE/ISR) and John Kenyon, senior vice president of engineering at Hughes Network Systems (HNS), told regional business, government and education leaders about their partnership at a summit meeting in March.

The presidents of the University of Maryland, Johns Hopkins University and George Mason University wanted to draw attention to coordinating the Baltimore-Washington-Northern Virginia region's technology and research efforts. They emphasized the need to better compete against places such as Silicon Valley, Boston and Austin, which have powerful links between universities and businesses.

The meeting showcased successful existing partnerships. Baras and Kenyon explained their accomplishments in Direct Broadcast Satellite-based Internet service and hybrid network and information infrastructure deployment.

DirecPC Turbo Internet(TM) was conceived and designed at the University of Maryland, and produced and marketed by Hughes Network Systems, Gaithersburg, Md. Baras and Kenyon explained how DBS-based Internet access provides solutions to performance bottlenecks by allowing larger window sizes, using satellite bandwidth, and avoiding long-delay effects.

Partnership benefits to HNS include exceptional students, many of whom have been subsequently hired; working relationships with faculty and research staff; and the creation of more than 100 new Maryland jobs. The University of Maryland gained international prominence and leadership recognition and has become a driver for educational reforms. Maryland and the surrounding region have been able to retain highly qualified people, attract new and strengthen existing companies.

For information on CSHCN and HNS visit *http://www.isr.umd.edu/CSHCN/projects/hybridnet/hybridnet.html*, or contact CSHCN at 301-405-7900. For information on industrial partnerships, contact Jeff Coriale at 301-405-6604, *coriale@isr.umd.edu*.

Stewart sure makes a mean pinball

Assistant Professor David Stewart (EE and ISR affiliate) is a computer engineer who loves pinball. And he's found a way to merge his passion for it with what he does for a living.

Stewart developed and leads ENME 459B/ENEE 459Q, a course that gives students hands-on experience in building "Comet Commander," a new kind of pinball machine.

In 1997's spring, summer and fall sections, Stewart's cross-disciplinary class attracted 16 mechanical engineering students, nine electrical engineering students and seven computer engineering students. Many of the students participated for two or more semesters.

The students concentrate on the aspect of building the machine that corresponds to their discipline.

Future mechanical engineers, for example, must consider the layout and structure of the playfield. Electrical engineers have to build the power supply, electrical wiring and audio and video circuitry. Computer engineers take care of the computing hardware and software to read sensors and control the actuators of the machine.

As an engineer, Stewart specializes in developing embedded systems: the kinds of computers that are built into something larger, such as CD players or automobile cruise controls. He focuses on lowest-level software, which lends itself perfectly to pinball machines.

Stewart's idea is to build a pinball version of a "redemption" machine. Redemption machines are manufactured by the same companies (such as Bally) that build pinball machines and arcade video games. The lucrative machines dispense tickets that can be redeemed for prizes and are familiar to any parent or child who's been to Chuck E. Cheese.

But the problem with most redemption machines, Stewart said, is that they do not help kids develop any skill that they can use later on. "It's because they don't involve actually playing a game, just losing a quarter."

A pinball redemption machine, on the other hand, would be exciting to play, would still dispense the prize tickets, and could help revive interest in the game.

The students' challenge is to build a game that will work, be fun, and be geared toward children ages 6 to 12.

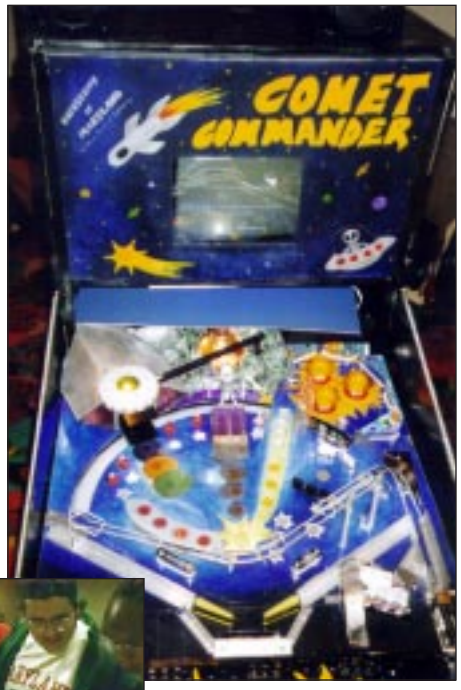
Lockheed Martin is funding Stewart's project; the controls that need to be developed are comparable to flight control systems on airplanes, on a smaller scale.

The pinball machine is purposely powered by an outdated computer because the computing power built into consumer electronics needs to be simple, cheap and reliable, Stewart said. Even braking systems on trains use a slow 9 MHz processor that's comparable to the old Apple IIE computers of a decade ago. In cost-conscious manufacturing industries, the thinking is that the more money you save on computers, the more money can be made on the product.

Stewart said the pinball project has academic significance for the students beyond what they would learn in a textbook. "It's similar to what you'll learn in industry," he said. "Pinball is an engineering marvel."

The work involves mechanical challenges that most pinball players would never think about. One is the friction of the playfield, which determines how fast the ball can travel, which in turn determines how fast the flippers should work.

Students also must consider things like the proper angles at which to place the ramps in the machine, so the ball is able to sustain its momentum. The measurements have to be exact.



Above, *Comet Commander at the World Pinball Championships.*

At left*, students examine the machine's "guts" at a demonstration last fall.*

Stewart unveiled the machine at the February 1998 Pinball World Championships in Las Vegas; *The Chronicle of Higher Education* wrote about this event in its Feb. 27 issue. In the future, one goal is to make Comet Commander capable of playing by itself. Then there could be a competition between a world-champion pinball player and the machine itself-kind of a pinball version of Kasparov vs. Deep Blue.

Other faculty assisting Stewart with the pinball project include Steven Tretter (EE), Linda Schmidt (ME) and ISR-affiliated Greg Walsh (ME).

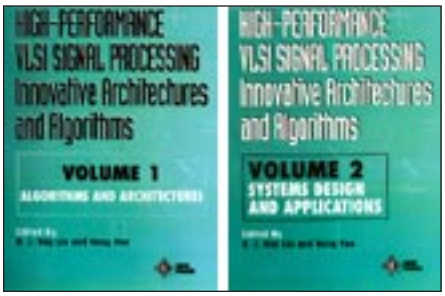
For more information on ENME 459B/ENEE 459Q, visit the class's web site at *http://www.ee.umd.edu/class/enee459q.F97/* or contact David Stewart at 301-405-3658, *dstewart@eng.umd.edu*.

—Jeremy Bond

Faculty news

Professor and Chair of the Electrical Engineering Department **Nariman Farvardin** (EE/ISR) and Professor **André Tits** (EE/ISR) have been elected fellows of the Institute of Electrical and Electronic Engineers.

Associate Professor **Guangming Zhang** (ME/ISR) has written a new book, *Engineering Design and Pro/ENGINEER*, published by College House Enterprises. The book is a comprehensive treatment of engineering design with a focus on solutions based on information technology.



Associate Professor **K.J.R. Liu** (EE/ISR) is co-editor with UCLA's Kung Yao of *High Performance VLSI Signal Processing: Vol. 1-Algorithms and Architectures, and Vol. 2-Systems Design and Applications*, published by IEEE Press and SPIE Optical Engineering Press.

Professor **William Levine** (EE and ISR affiliate) hosted a short course on the use of CONDUIT, a new multidisciplinary integration environment for flight control development at the University of Maryland in February. In addition, CRC Press, publishers of *The Control Handbook*, which Levine edited, has announced that the book soon will be translated and published in India.

Professor **John Baras** (EE/ISR) was a member of an international team of four experts that reviewed the 30 Swedish Industry-University Centers of Competence (NUTEK) in 1997. The centers are the equivalent of the Engineering Research Centers in the United States. After the completion of its work, the team's work was lauded by Swedish academics, industrialists and government managers.

This January Professor **Carlos Berenstein** (Math/ISR) participated in a National Cancer Institute workshop on how to detect lung cancer earlier. The Wavelet-Based Multiresolution Local Tomography invention of Berenstein, D. Walnut, K.J.R. Liu and F. Rashid-Farrokhi is considered a novel possible technology when coupled with new ideas Berenstein has on image processing.

Professor **Lung-Wen Tsai** (ME/ISR) is now the technical editor for the *ASME Journal of Mechanical Design*. In addition, he is the conference chair of the ASME 1998 Mechanisms Conference and the general conference chair for the six ASME 2000 Technical Conferences.

Professor **Thomas McAvoy** (ChE/ISR) gave a lecture in April on "Learning from the Brain: Towards Developing an Artificial Nose" as part of being a 1997-98 Distinguished Scholar-Teacher at the University of Maryland. The program honors a small number of faculty each year who have demonstrated notable success in both scholarship and teaching.

"Perspectives in Control," a scientific conference in honor of the 60th birthday of Professor **Roger Brockett** (Harvard and ISR affiliate) will be held Oct. 23-24 in Cambridge, Mass. Information: *http://eng.bu.edu/Brockettfest/*.

ISR Director **Gary Rubloff** (MNE/ISR) served on the Metrology Technology Working Group constructing the recently released 1997 National Technology Roadmap for Semiconductors. The effort brought together industry and academic leaders to define the technological challenges facing the semiconductor industry in coming years.

The National Science Foundation's November online *Engineering News* newsletter featured a front page story on the world champion Bridge Baron software, Professor **Dana Nau** (CS/ISR) and ISR. Read the story at *http://www.eng.nsf.gov/news/1997_News/erc_work_includes_a_game.htm*.

In December, *USA Today* interviewed Professor **Ben Shneiderman** (CS/ISR), director of the ISR-affiliated Human-Computer Interaction Laboratory, about frustrating computer interface problems.

Michael Pecht (ME/ISR), Director of the CALCE Electronic Packaging Research Center, received the 1997 ISHM/IEPS William D. Ashman Memorial Achievement Award "for his numerous contributions to academia and the electronics packaging industry." Professor Pecht also co-authored the new book, *The Influence of Temperature on Microelectronic Device Reliability*, with P. Lall and E. Hakim. It is published by CRC Press.

Associate Professor **Michael Fu** (BGMT/ISR) received the Institute for Industrial Engineers Transactions Best Paper Award on Operations Engineering during the Industrial Engineering Solutions '98 Conference in Banff, Alberta. The award was for "Optimization of Discrete Event Systems via Simultaneous Perturbation Stochastic Approximation," a paper Fu co-authored with Stacy Hill of the Johns Hopkins Applied Physics Laboratory, and which appeared in *IIE Transactions* in 1997.

The Institute for Scientific Information in Philadelphia ranked Professor **Edward Ott** (EE/Physics/ISR) 67th on a list of the 1,120 most cited physicists from 1981 to 1997. Ott's work was cited 6,705 times in 188 articles during that period.

New faculty member

Professor **Stuart Antman** (Math) was recently named an ISR affiliate faculty

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member. His research involves concrete problems for general classes of constitutive equations.

A number of his current research projects involve magnetostrictive materials. He is affiliated with the Center for Dynamics and Control of Smart Structures.

New staff members

ISR welcomed two new staff members in March. **Dr. Vickie Claflin** (left) is the new assistant director of the Gemstone program.

Lee Harper (right) is the new coordinator of educational programs, with responsibilities including the Master's of Science in Systems Engineering and the Young Scholars program.

Student news

Ph.D. student **Radhakrishnan Haridasan** received a Best Student Paper Award at the Society for Imaging Science and Technology / International Society for Optical Engineering International Conference on Visual Communications and Image Processing 1998. The award was for his paper, "Accurate Segmentation and Estimation of Parametric Motion Fields for Object-Based Video Coding Using Mean Field Theory." His advisor, John Baras, co-authored the paper, which can be downloaded at *http://www.isr.umd.edu/TechReports/ISR/1997/TR_97-82/TR_97-82.phtml*.

Gemstone freshmen test projects in wind tunnel

The incoming class of Gemstone freshman built windmills and tested them in the Glenn L. Martin Wind Tunnel as their final project for the fall semester introduction to engineering design class. The challenge was to see if the creations could actually generate electricity.

Clark School Dean William Destler helps students from his Gemstone engineering design class set up their windmill.

Gemstone is an interdisciplinary honors program that addresses two of the most common criticisms of modern undergraduate education—the lack of an integrative experience to provide a context for learning, and the failure to provide meaningful interactions between students in different disciplines.

The brainchild of William Destler, dean of the A. James Clark School of Engineering, the Gemstone concept is helping the University of Maryland stake out a national presence as an innovator in undergraduate education. Destler took time from his packed schedule to supervise one of the sections of the engineering design class.

Now in its second year, the program has expanded from 114 students in the initial class to 165 in the 1997 freshman class. As a group, Gemstone students have an average SAT score above 1400. ISR is the administrator of the program.

Students were instructed to design their projects in the context of a world energy crisis. Using knowledge from their various majors, the students from each team completed an oral and written report that addressed the history of the problem, current solutions, future worldwide energy requirements, the social impact, resource requirements, costs, business concerns, and prototype concerns.

This project was the freshmen's first taste of what is to come in the Gemstone program. At the end of the spring semester, the students will be divided into interdisciplinary teams that will remain together for the next three years. Each team will work on a major project that begins in their sophomore year and does not end until they graduate. The projects address large-scale problems with both technological and social consequences.

For more information on the program, visit the Gemstone web site at *http://www.isr.umd.edu/gemstone/*, or contact Gemstone Assistant Director Vickie Claflin at 301-405-6564, *vclaflin@isr.umd.edu*.

Progress of the long-term projects chosen by the inaugural class of Gemstone students can be monitored at *http://www.isr.umd.edu/gemstone/teams.htm*.

First-year Gemstone students Sabastian Niles, Melissa Murray, Peggy Wood and Maggie Lassack are four of the University of Maryland's "Top 10 Freshman" according to the national leadership honor society Omicron Delta Kappa.

—Jeremy Bond

Ball updates FAA officials on NEXTOR research

Professor Michael Ball (BMGT/ISR) briefed government and industry officials on the progress of research connected with the National Center of Excellence in Aviation Operations Research (NEXTOR) at Federal Aviation Administration headquarters in November. Ball, associate director of the NEXTOR consortium, leads faculty and students from the University of Maryland and the Massachusetts Institute of Technology working on NEXTOR's collaborative decision making (CDM) project.

CDM will help the FAA and airlines coordinate and manage flight schedules and delays. Its initial focus is on the construction of ground delay programs.

Future CDM uses include the distribution of National Airspace System status information and collaborative routing.

Ball illustrated the need for CDM by explaining current ground delay program guidelines. Today, when an airport is experiencing bad weather, the rate at which aircraft can land is restricted. This restriction is implemented by delaying the departure of certain flights destined for the afflicted airport. Airlines want more control over the allocation of delays to their flights. At the same time, the FAA needs more up-to-date information on the status of flights to make better ground delay decisions. Current operational systems actually provide disincentives for airlines to provide the FAA with more information.

Certain fair allocation principles, agreed upon by all parties, are at the heart of the CDM research. The new systems based on these principles give much greater control over the final landing slots to the airlines and, at the same time, give them strong incentives to provide the FAA with the most current information on the status of their aircraft and their intentions.

NEXTOR's principal CDM research results from the past year are 1) methods for explicitly considering weather uncertainty within the CDM procedures, and 2) an optimization-based model for allocating landing time slots.

Current procedures develop plans based on a single weather forecast.

NEXTOR's new models take into account potential weather variability and plan accordingly. The slot allocation research replaces the current allocation rules and heuristics with a formal model. The challenge of this work involved embedding fair allocation principles within an optimization model.

In the coming year both of these models will be embedded within the Flight Schedule Monitor (the CDM decision support tool) and will undergo testing by the airlines and the FAA.

All of NEXTOR's CDM research undergoes close scrutiny by the airlines and the FAA, Ball noted. NEXTOR faculty and students regularly attend the monthly CDM working meetings, which involve representatives of all the major airlines, the FAA, systems developers and researchers.

"The FAA has agreed to a new way of doing business," Ball said.

"[CDM] is the most exciting thing going on in the FAA," agreed NEXTOR co-director Professor Amadeo Odoni of MIT.

Established in June 1996, NEXTOR is helping the FAA develop advanced operations methodologies that can be validated through full-scale testing.

NEXTOR research is wide-ranging, including airport terminal operations, en-route flight operations, safety and security issues as well as other topics. It involves disciplines ranging from economics to artificial intelligence.

The NEXTOR consortium includes participants from the University of Maryland, MIT, the University of California at Berkeley, and Virginia Polytechnic Institute.

More than 20 industrial participants and 11 affiliated universities also contribute their resources. Other University of Maryland faculty involved in NEXTOR are Associate Professor Michael Fu (BGMT/ISR), ISR-affiliated Professor Paul Schonfeld (CE) and Associate Professor Larry Bodin (BGMT).

Additional participants in the CDM research include University of Maryland students Taryn Butler, Bob Hoffman, Tasha Innis, and Thomas Vossen; MIT faculty Dimitris Bertsimos, Eric Feron and Amadeo Odoni; and MIT students Bill Hall, Ryan Rifkin, and Sarah Stock. Embry-Riddle Aeronautical University and Ohio State University also have contributed research.

For more information, visit *http://www.isr.umd.edu/NEXTOR/* or contact Michael Ball at 301-405-2227, *mball@bmgtmail.umd.edu*.

—Jeremy Bond

Sprag wrench to fly on shuttle

Brian Roberts, an M.S. candidate in the ISR-affiliated Space Systems Lab, recently won a proposal to fly his thesis research project, a sprag wrench, on an upcoming Space Shuttle flight. The experiment will show how well the wrench, a possible replacement for ratchet wrenches, survives continuous use in the orbital space environment.

The sprag wrench will be useful for astronauts working on extravehicular activity (EVA) projects. Astronauts have difficulty using ratchet wrenches under EVA conditions. The 3-D sprag, when used in place of a traditional ratcheting mechanism, will be an essential part of EVA tool evolution.

More information can be found at *http://www.ssl.umd.edu/homepage/Projects/EVAtools/EVAtools.html*.

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Tsai and DeVoe awarded grant for three-dimensional MEMS

Professor Lung-Wen Tsai (ME/ISR) and Assistant Professor Don DeVoe (ME/ISR) have received a three-year funding award of $874,902 from the Defense Advanced Research Projects Agency's Electronic Technology Office for their project to develop three-dimensional micro-electro-mechanical systems (MEMS).

The title of the project is "Parallel Fabrication of 3-D Microstructures." It has two primary goals: the development of three-dimensional micro-mechanisms using novel MEMS fabrication technology, and understanding the fundamental design issues for these micro devices.

Applications which will be investigated include a three degree-of-freedom micro-platform mechanism, and a microfluidic system employing integrated one-way valves and multilevel fluid passageways. The technology allows for the integration of VLSI circuitry and planar MEMS structures on the top level of the three-dimensional mechanisms for the parallel fabrication of true three-dimensional microsystems.

Clark School advances in rankings

The A. James Clark School of Engineering at the University of Maryland is the fastest rising engineering school in the nation, as evidenced by recent rankings in *U.S. News & World Report.* Rated 37th in 1994, the Clark School's graduate programs were ranked 25th in 1995, 18th in 1997 and 13th in 1998 among all institutions, public and private. The Clark School is especially proud of the fact that both its undergraduate and graduate programs are consistently ranked among the top 25 nationally.

New at *www.isr.umd.edu*

Bookmark the ISR **News Archive page** *(http://www.isr.umd.edu/ISR/archivenews/)* in your web browser for easy access to recent ISR news and accomplishments.

Information about ISR's **Industry Fellowship Program** can be found at *http://www.isr.umd.edu/ISR/industry/IndFellowPgm.html.*

The **faculty page** (*http://www.isr.umd.edu/ISR/faculty/faculty.html*) provides home page, e-mail and research interest links, office addresses and phone numbers.

The **research page** (*http://www.isr.umd.edu/ISR/research.html*) ties you into what's going on in ISR centers and labs, lets you search for specific research projects, and links you to various research-related pages on the ISR site.

Pages of current information about ISR can be downloaded from the **overview page** (*http://www.isr.umd.edu/ISR/overview.html*). Categories include general information, faculty, research, centers, labs, major projects, education and patents.

At the **Autonomous Mobile Robotics Laboratory** web site (*http://www.cs.umd.edu/projects/amrl/*) you can download an article written by Julio Rosenblatt (formerly of UMIACS) about his and ISR-affiliated Greg Walsh's (ME) experiences in leading the Maryland students who won the Robot Grand Prix in Japan last summer. The article appeared in the January/February 1998 issue of *IEEE Intelligent Systems*.