The Director's Report

by David R. Criswell

The Institute for Space Systems Operations (ISSO) is the operating agency for the Houston Partnership for Space Exploration (HPSE) at the University of Houston and the University of Houston-Clear Lake. UH and UHCL are also members of the Texas Space Grant Consortium. ISSO works through TSGC on a statewide level. Dr. David R. Criswell directs ISSO and is responsible for both UH and UHCL activities. In the academic year 2005-06, HPSE continued funding under a State of Texas Line Item for $355,986 that allocated $278,990 to operations at the University of Houston and $76,996 at the University of Houston-Clear Lake. As reported by the faculty in the following research articles, the AY2005 ISSO State of Texas funds were leveraged by a factor of 7.8 to 1.

David R. Criswell

ISSO projects have established solid professional links between NASA, the Johnson Space Center (JSC), the Houston aerospace community, and UH and UHCL. ISSO provides the flexibility and resources for UH and UHCL faculty to fully participate in the rapidly evolving national space program. Since 1991, faculty supported by ISSO research funds have reported obtaining $23,800,000 of external funding and thus leveraged the research funds by 4.7 to 1 over the life of the program.

This report summarizes the 2006 accomplishments by ISSO supported researchers. A short synopsis of each research activity is presented within six study areas. The joint UH/UHCL-NASA JSC Post-Doctoral Aerospace Fellowship projects, approved as of August 31, 2006, are listed in the last section along with a description of a new request for proposals for Space Cluster projects.

Summary of the 2006 Program

The primary activities of ISSO are the unique Post Doctoral Aerospace Fellowship (PDAF) program between UH/UHCL and the NASA-Johnson Space Center seed-level funds awarded to UH and UHCL faculty for development of new aerospace research projects. Prior ISSO reports, available on request as published reports and on the web at http://www.isso.uh.edu, provide detailed descriptions of both programs. The PDAF program started in 1995. It operated through a Memorandum of Understanding between JSC and the university on the main campus and the campus at Clear Lake. The MOU was converted to a Space Act Agreement in early 2006.

In 2006, ISSO provided $308,300 in research funds to 16 UH and UHCL faculty to support nine new seed-grant projects, five PDAF projects, the director's research, and for program documentation. ISSO requires investigators to report results on projects for five years after completion of funding of a given project. In 2006, the prior and currently funded UH and UHCL faculty reported submitting 37 proposals applying for $15,470,000 of external funding. They report obtaining $2,850,000 for these external proposals and proposals submitted the prior year. The 2006 ISSO State of Texas funds were leveraged by a factor of ~8. Leveraging of the 2006 funds will continue to increase as more proposals are submitted based on follow-up results of the 2006 projects.

In 2006, ISSO investigators reported submitting 120 professional papers, delivering 110 professional presentations and interviews. Six undergraduates participated in the research activities. Twenty-nine master's level students and 17 doctoral candidates participated in ISSO research projects along with 14 post-doctoral fellows.

Thirty-five UH System faculty participated in the ISSO research along with eight professors from other universities, nine NASA researchers, and 14 from other non-profit organizations and companies. In addition to JSC, 15 other organizations and/or their employees participated:

- Baylor College of Medicine
- Boeing - Houston
- Centre for European Radiation Nuclear (CERN)
- Harbin Institute of Technology, China
- Lockheed Martin - Houston
- Montreal Bio-Processing Laboratory
- NASA- Langley Research Center
- Prairie View - A&M
- Rice University Electrical and Computer Engineering
- Smalley Inst. For Nanoscale Science and Technology
- Stanford Linear Accelerator Center
- University of Quebec
- University of Singapore
- University of Texas at Dallas
- University of Texas Medical Branch

ISSO maintains a website of all reports and uses that website to announce proposals and fellowship opportunities.

ISSO worked at UH with four colleges and Deans J. Bear (Natural Science & Mathematics), R. Flumerfelt (Engineering), W. E. Fitzgibbon (Technology), and R. K. Wimpelberg (Education) and with Dr. A. Ignatiev (SVEC) and the newly reformed Center for Advanced Materials (CAM). ISSO thanks

them for their support in the research projects. At UHCL, ISSO worked primarily with the School of Science and Computer Engineering. Thanks are sincerely extended to Dean C. McKay (retired) and E. A. Dickerson (interim).

Summary of ISSO Research Projects

Six major themes identify the 14 research projects funded in 2006 and the follow-up results of 42 projects first funded between 2003 and 2005:

Astrobiology and Life Sciences
Space Radiation Modeling
Computer Science and Communications
Physical Sciences, Cosmology, and Defoe
Engineering and Sensors

Post-doctoral Aerospace Fellowship Projects (2006) and Related Follow-up Projects

Professor A. Bensaoula (UH: Center for Advanced Materials), Dr. Pranob Misra (Fellow), and Dr. Andenet Alemu (prior Fellow, now with the UH Advanced Materials Center) and Dr. Bran Mayeaux (JSC: Materials Processing Branch) conducted research on the "Development of Micro Column Arrays (MCA) for Thermal Management Applications" (p. 8) and report both current progress and new results from the initiation of the grant in 2003. They have fabricated and demonstrated micro column arrays exhibiting low reflectance, high emissivity, and large effective surface areas by pulsed laser ablation on several metals, ceramics, and semiconductor materials. In addition to their use for emissive-based thermal management, MCA can produce enhanced bonding and brazing strength when applied to either identical or dissimilar materials. Some of the specific applications that can benefit from this and other aspects of MCA technology are space, defense, avionics, laser systems, and high performance computers.

Professor G. E. Fox (UH: Biology and Biochemistry) and Dr. Duane Pierson (JSC) report on the results of the third and final year of the Post-Doctoral Aerospace Fellowship project concerning the "Effects of Simulated Microgravity on Microbial Gene Expression" (p. 17). Dr. Victor Stepanov completed his PDAF. Dr. Madhan R. Tirumalai is the new Post-Doctoral Aerospace Fellow. Bacteria can leave and thrive in an extremely wide range of environmental conditions. Unusual conditions can lead to unexpected bacterial responses that can not be predicted even if their genetic map is completely described. Wild type *E. coli* MG1655 were grown for 1,000 generations in a rotating environment that simulates zero-gravity. Researchers found that *E. coli* chemotactic and flagellar genes as well as genes involved in the acid tolerance response were up-regulated. Refer to the report for details of the methodology, equipment, and an extended discussion.

Professor G. Fox also provided a follow-up report on his 2004 and 2005 seed-grant projects on early genetic systems: "Early Origins of Genetic Systems" and "Remnants of the RNA World: RNA Structures Associated with Gene Regulation" (p. 79). These two projects focused on different aspects of the hypothesis that DNA-based Earth life arose from an earlier RNA world. A detailed study of the RNAs and proteins associated with the translation machinery was carried out, and many remnants of early evolution were identified.

Professor J. H. Miller (UH: Physics and TCSAM) and Dr. D. S. McKay (JSC: Planetary Sciences) participated with the ISSO Fellow, Dr. David Warmflash, and Prof. J. Wosik (UH: Electrical and Computer Engineering) and Dr. J. A. Jones (JSC: Flight Medicine) to develop electronic means of detecting life on Mars (p. 21). F. Karouia (JSC) is pursuing a doctoral degree on the project in the UH Biology and Biochemistry Department. They have found that dielectric spectroscopy measurements at different temperatures can distinguish live organisms from non-living complex macromolecules and may eventually be suitable for *in situ* astrobiology studies on the surface of Mars or in the liquid ocean beneath the ice of Europa.

Dr. Dickey Arndt (NASA-JSC) and UHCL Post-Doctoral Aerospace Fellow Dr. Jianjun Ni worked with Prof. E. Dickerson (UHCL: Acting Dean of the College of Science and Computer Engineering) on the second and final year of the development and demonstration of an "Ultra-Wideband Two-Cluster Angle-Of-Arrival Tracking System Design for Space Exploration" (p. 11). The system is being studied for use in tracking of Lunar/Mars rovers during early exploration missions when satellite navigation systems (such as GPS) are not available. Field tests were conducted jointly with the SCOUT vehicle at the Meteor Crater in Arizona to test the tracking capability for a moving target. These tests demonstrated that the UWB tracking system can co-exist with other RF communication systems onboard SCOUT, and that a tracking resolution less than one percent of the range (range up to 2000 feet) can be achieved.

Seed Grants (2006) and Follow-up Results (2003)

Astrobiology and Life Sciences

Professor G. Fox (UH: Biology and Biochemistry) investigated the *Bacillus pumilus* SAFR-032 as a model for protecting other planets from contamination by Earth's micro-organisms carried on spacecraft (p. 40). As a first step toward understanding the biology of these strains that are extremely resistant to decontamination procedures, research scientists determined the whole genome sequence of one isolate, *B. pumilus* SAFR-032. Prof. Fox collaborated with the Baylor College of Medicine Human Genome Sequencing Center (HGSC).

Professor Jaroslaw Wosik (UH: Electrical and Computer Engineering) led a 2005 and 2006 seed grant funded collaboration with UH professors J. H. Miller (Physics) and W. Zagozdzon-Wosik (ECE) and Rice University professor J. M. Tour (Mechanical Engineering and Materials and the Smalley Institute For Nanoscale Science and Technology), and four doctoral students and one master's student on "Dielectrophoresis of Biological Cells and Single-walled Carbon Nanotubes" (p. 108). The general goal is to develop miniaturized sensors aimed at cellular analysis and bio-diagnostics. Such sensors are expected to play a very prominent role in space missions. The sensors were used to characterize the electromagnetic properties of biological and solid state materials, as well as electromagnetic properties of neutral (reference) par-

ticles, single-wall nanotubes, and the microorganism *S. Cerevisiae* and *S. pombe*. Results of these preliminary experiments are described.

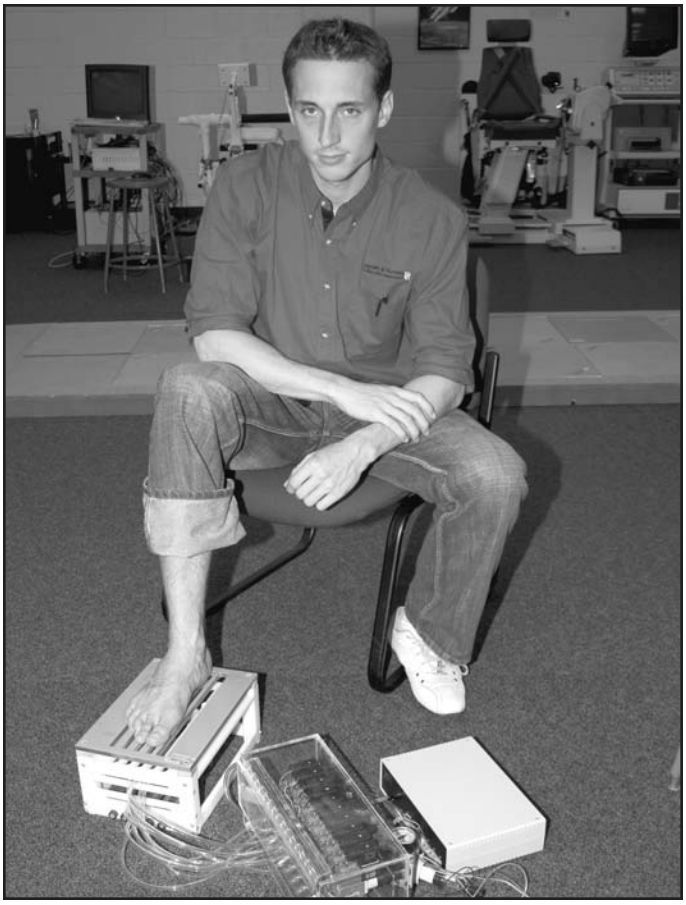
Professor C. Layne (UH: Health and Human Performance, College of Education) completed his Post-Doctoral Fellowship Program in 2003 on "Using Dynamic Foot Pressure as a Countermeasure to Muscle Atrophy" (p. 90). The ISSO Fellow Katharine Forth continues her work as a post-doctoral fellow at UH. Dr. Andrew Abercromby completed his doctoral program and now works for Wyle Life Sciences at NASA-JSC.

Space Radiation Modeling

Professors L. Pinsky and B. Mayers (UH: Physics) participated under ISSO special funding for 2005 in an international "Space Radiation Shielding Modeling Consortium" (p. 96). Two post-doctoral fellows (A. Empl and V. Anderson), three Ph.D. candidates, along with three master's candidates and two undergraduates, also participated. Dr. Tom Wilson (NASA-JSC), Dr. A. Fasso (Stanford Linear Accelerator Consortium), five members of CERN, and six faculty of INFN (Italy) were also members. The objective was to provide a Monte Carlo-based software tool to model the radiation environment in space that will enable the evaluation of radiation shielding materials. In particular, they proposed to cooperate with the other members of the consortium to develop an event generator for Nucleus-Nucleus interactions that is accurate to within 25 percent in any significant channel over energies that are relevant for the evaluation of space radiation shielding issues.

As a result of the efforts of the Houston Group in concert with the FLUKA team at CERN and in the INFN Milan Group, the analysis tool FLUKA now embeds two of the most respected heavy ion event generators in existence, RQMD and DPMJET. The past year has also seen significant progress in the primary effort of the UH Group to enhance the models within FLUKA and the user interfaces to the FLUKA code itself. Please refer to the full report for descriptions of the many other major accomplishments of the consortium.

Space radiation is likely to be the ultimate limiting factor for future human deep space exploration. Prof. Liwen Shih (UHCL: Computer Engineering) worked with seven UHCL master's level students, one Ph.D. candidate (UH: Aerospace Engineering), Dr. Robert Singleterry, Jr. (NASA-Langley), and the JSC MARIE Team via Dr. P. Saganti of Lockheed Martin and Prairie View A&M on the 2006 seed grant "Efficient Space Radiation Computations with Parallel FPGA" (p. 56). The team has identified major bottlenecks that slow down the running of the code HZETRN on several types of parallel computing systems. They are seeking further improvement, semantic application-, methodology- and algorithm-specific thread mapping optimization. Better understanding of the numerical models of nuclear physics theory with the help of LaRC Nuclear physics researchers is needed to further optimize parallel mapping. They note that as Earth's ozone depletion continues, space radiation study could lead to dual-use countermeasures that will, in turn, protect human health from the radiation/aging effect in general, *e.g.*, slowing down cataract development. Other critical



NEW CANDIDATE—Marius Dettmar, a doctoral student from the University of Bochun, Germany, is introduced to equipment designed to prevent muscle atrophy in astronauts who suffer from the loss of muscle tone when assigned for a lengthy period of time in an atmosphere free of gravity. The technology has been applied with success to bedridden and hospitalized patients.

CLUSTER/GRID—Team members focused on high-performance computing (HPC) are (*l. to r.*) Victor Shum, Ph.D. candidate in Aerospace Engineering, Thang Nguyen Toan, M.S. student, Dr. Liwen Shih, UHCL professor of computer engineering, and Susan Strasser, M.S. student in the Computer Engineering Department.

medical cures, *e.g.*, proton cancer radiation treatment, are evolving. Dr. Shih also provides a follow-up on the initial ISSO seed grant "High-Performance Martian Space Radiation Mapping" (p. 104).

Computer Science and Communications

Adaptive optics systems used in surveillance satellites/air/spacecrafts, and astronomical observatories provide high-resolution imaging through Earth's atmosphere. Professor Albert M. K. Cheng (UH: Computer Science) conducted the study "Optimizing Quality-of-Service in Adaptive Optics Systems and Other (m, k)-Firm Real-Time Spacecraft Control Systems" (p. 30). This preliminary study proved that the problem is NP-hard. He proposes a simple heuristic solution. "Greedily" increasing the QoS level of the tasks with the maximal "reward ratio" is possible as long as all the other tasks have their minimum service level. In 2003, 2004, and 2005, Prof. Cheng conducted three successive seed grant projects related to the ultimate goal of building fully-verified space vehicles that are (1) reliable, (2) energy-efficient, and (3) schedule-optimized (p. 74).

Professor H. Al-Mubaid (UHCL: Computer Engineering) provides a combined progress report on two 2005 seed grants (p. 68). The first deals with "Natural Language Interface Models for Fast Responsiveness Applications" such as needed in Virtual Reality (VR) training programs, real-time text messaging applications, and mission-critical systems like aerospace applications. He designed and implemented word disambiguation and prediction techniques to solve the NL ambiguity problem. In "A Text-Mining Technique for Literature Profiling and Information Extraction from Biomedical Literature," methods based on machine learning were used for a word classification task. Feature extraction techniques like MI (mutual information) and X^2 (Chi-square) selected the key features in the contexts of the terms of interest. The methods were evaluated extensively with a large number of experiments.

One of the challenges in data mining is to provide sufficient coverage of the search space in order to produce an acceptable model. Solving large problems using genetic programs (GPs) consumes excessive amounts of computer resources. Professor G. D. Boetticher (UHCL: Computer Science and Engineering) asked the questions, "Does chromosome lineage information provide any insight into the effectiveness of solving problems? If so, how could these insights be utilized to make better breeding decisions?" Experiments reveal that higher pedigree chromosomes can be identified leading to more efficient searches (p. 72). He participated with faculty of Rice University and the University of Texas Medical Branch in proposals to the Department of Defense and to the Severe Asthma Research Program.

More accurate friction models are needed for software that simulates the motion of mechanical systems, such as the remote manipulators of the Space Shuttle or the International Space Station. Prof. LieJune Shiau (UHCL: School of Science and Computer Engineering) worked with Prof. R. Glowinski (UH: Mathematics), and UHCL Research Assistant M. Sheppard in the third seed grant devoted to "Computational Methods in Non-Smooth Mechanics: Applications to Dry Friction Constrained Motions" (p. 53). They formulated a friction-constrained motion model to describe some remote manipulator system simulators with finite numbers of degree of freedom. The formulation addressed the need for computational efficiency required for high degree-of-freedom models. They have published results of low degree-of-freedom. The current study resulted in the new publication of higher degree-of-freedom generalized test systems proposed by NASA engineers.

Professors T. Andrew Yang and S. Davrai (UHCL: Science and Computer Engineering) provide a follow-up on their 2004 ISSO seed-grant "Development of Wireless Stations for Distributed Field Operations" (p. 111). They specifically investigated the security and performance issues of wireless stations in mobile ad hoc networks, with a focus on the public key management system using certificates. One of the main issues to consider in a certificate-based scheme is the secure distribution of the public keys to all the nodes in the network. In addition, they were awarded a two-year Advanced Research Programs (ARP) grant by the Texas Higher Education Coordinating Board for the project "SOCO—Secure and Optimized Communication & Organization for Target Tracking in Wireless Sensor Networks."

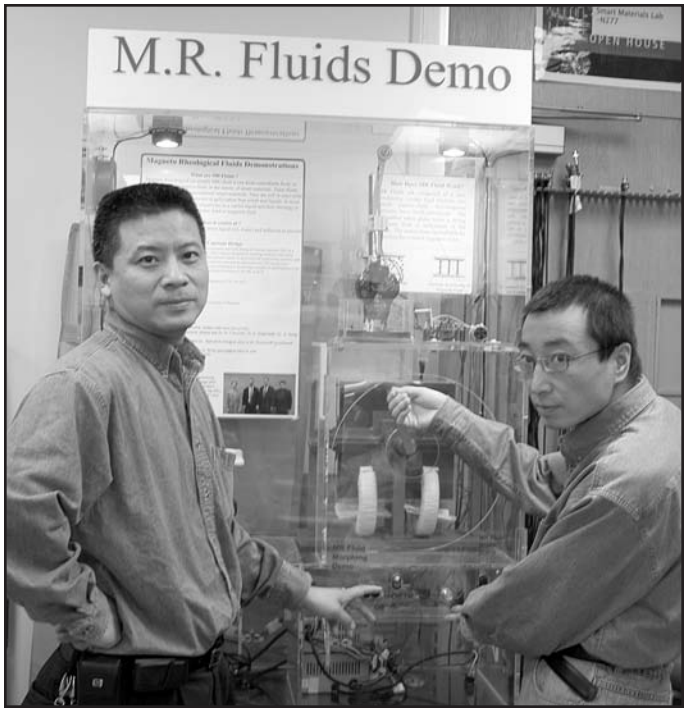
Physical Sciences, Cosmology, and Defoe

Professors J. D. Dabney and T. L. Harman (UHCL: School of Science and Computer Engineering) investigated a "Prototype Micro-Manipulator for Space Robotics Applications" (p. 37). This type of actuator has great potential for space-based robots because of their inherent low mass, simplicity, and immunity from magnetic fields. In this study, a piezoelectric actuator, position sensor, driver, and sensor amplifier were assembled. LabView software was applied to monitor the performance of the system. Dabney and Harman also provide an update (p. 76) of results from their 2003-2005 seed grants for the application of piezoelectric devices to the sensing and control of motion of mechanical systems such as robotic manipulators.

The combustion front of an engine or a gas turbine combustor near its lean burn limit can become unstable to dynamic modes of propagation in which the steady front is replaced by a front that varies in both space and time. Professor M. Gorman (UH: Physics) utilizes "A Unique Camera System To Study the High-Speed Dynamics of Premixed Flames" (p. 81). He presents examples of the greater details visible in the rotating flame fronts in viewing at 60 Hz versus 250 Hz imaging rates.

Professor D. Garrison (UHCL: Physics) is developing mathematical models for the "Origin of Structure in the Early Universe from Gravitational Radiation" (p. 43). Relatively little work has been done within standard cosmology on the impacts of structures in the early universe due to interactions between initial high-energy plasmas and gravitational radiation. The open-source computational tool CACTUS will be applied using the 30 2-GHz Pentium-4 based Linux machines and a small 16-node Beowulf cluster housed at the UHCL computational laboratory. This 2006 seed grant has already resulted in two proposals to NSF.

Professor I. Rothman (UH: English) provides a delightful history of Daniel Defoe's writings opposing the English Schism Act of 1714. He made use of Edward Halley's prediction of the April 22, 1715 eclipse of the sun by the moon over southern England



FLUIDS & MAGNETICS—Dr. Gangbing Song (*l.*) and Dr. L. Huo (*r.*), Post-Doctoral Fellow, are writing a proposal to the National Science Foundation on handling vibration-sensitive instruments in space, utilizing a fluid whose viscosity responds to an applied magnetic field. Instruments are affixed to low-mass truss structures.

and Wales to satirize this act of Parliament (p. 48). Defoe explored the complex interactions between the populace, parliament, predictive astronomy, religion, and a husband and wife.

Engineering and Sensors

Professor A. Bensaoula provided follow-up reports on 2003 and 2005 seed grant projects "Miniature Optical Sensors for Detection of Water and Air-Contaminations" and "Investigation of III-Nitride Materials for Space-Based Solar Cells" (pp. 71, 70). He also provided a report on the 2006 seed-grant project "Micro-Integrated Super Broadband Stellar Simulator Optical Calibration Source" (p. 28).

Thermal radiators are required to let waste heat flow away from operating equipment, such as rovers that are used to explore Mars. Dust suspended in the atmosphere of Mars or churned up by driving across Mars can land on radiators and inhibit the flow of heat from the radiator. Professors K. Hollingsworth and L. C. Witte (UH: Mechanical Engineering) conducted a 2005 seed grant project on "The Effect of Martian Dust on Radiator Performance" (p. 88). This follow-up paper describes their progress implementing an automatic system to conduct long-duration measurements of the temperature and heater voltage of a thermal test station for radiator coupons.

Metal-organic polymers have been found to have wide range of applications such as molecular separation and pollution prevention in air, liquid and water systems, where they can be used as ion exchangers and molecular sieves. Professor J. Y. Lu (UHCL: Chemistry) conducted experiments under a 2006 seed grant to develop "Superior Adsorbents for Aerospace Applications" (p. 46). He also provides a follow-up report on the 2005 seed grant "Contaminant Removal From Fuel Cells for Aerospace Applications" (p. 91). Proposals were submitted in 2006 to the Texas Higher Education Coordinating Board ARP and the Welch Foundation that focused on water quality after a disaster and the adsorption properties of porous compounds. A proposal is planned for fall 2007 to the NSF.

Equipment used to condition electric power onboard spacecraft can be a significant fraction of the mass of the overall electrical power system. The 2004 seed grant research on "An AC-DC-AC Converter with Smaller DC-Link Capacitor for Space Power Distribution Systems" conducted by Professor W. Shireen (UH: Engineering Technology) and graduate research assistant S. Vanapalli (M.S., 2004) continues to yield publications and is supported by an NSF grant through 2007 (p. 106). They demonstrate and test an experimental prototype of an AC-DC-AC converter that consists of a diode rectifier, DC-link, and a PWM inverter used in a closed loop V/Hz motor drive.

Dr. Gangbing Song (UH: Mechanical Engineering) and Dr. L. Huo (UH post-doctoral fellow) conducted the 2006 seed grant "Fault Tolerant Control of a Truss Structure Using MR Dampers" (p. 62). Very low-mass truss structures are used in space to support and position vibration-sensitive instruments such as interferometers, antennas, cameras, or remote devices. This work focuses on techniques to suppress truss vibrations inducted by motions and vibrations of the spacecraft, environmental changes (changing sun angle), or driven motion of the truss or of the devices the truss supports. They examine the use of a magneto-rheological (MR) damper that uses a fluid whose viscosity responds to an applied magnetic field. They have developed mathematical models and applied them to data on a vibrating laboratory 8-bay truss supplied by Prof. Dr. S. Nagarajaiah of the Civil and Environmental Engineering Department at Rice University. They find that the designed fault tolerant controller can achieve a fair vibration reduction ratio, though there are partial faulty signals in the outputs of the sensors. A proposal is being prepared for submission to NSF.

Follow-up reports were not received from:

Prof. M. S. F. Clarke (Health and Human Performance)

2005: Validation of a Novel Micro-capillary Array Fluid Collection Technology for the Determination of Biomarkers of Bone Metabolism in Human Sweat

2004: Development of a Microgravity-Compatible Slide Staining Device

Professors H. Malki (Technology) and K. Grigoriadis (Mechanical Engineering):

2005: PWM Control of Formation Flying Space Vehicle

2004: A Neural-Network-based Approach for Control of Vibration in a Black Hawk Helicopter

These will be provided in future ISSO Annual Reports and on the ISSO website as they are received. Follow-up reports on the following subjects indicate sustained effort: Prof. M. Gorman's study of the dynamics of premixed flames, (p. 81); Prof. G. Gunaratne's study of measures of bone damage, (p. 82); Prof. V. Hadjiev's

"Raman Scattering Test of the Properties of Nanocomposites," (p. 83); Prof. T. Harman's development laser-based biosensor technology, (p. 85); Prof. K. Grigoriadis's approach for collocated structural systems, (p. 92); Prof. J. Miller's studies of molecular motors and Martian soil samples, (p. 95).

Post Doctoral Program for 2006 – 2009

ISSO invited proposals for new two-year duration Post-Doctoral Aerospace Fellowship projects in early 2006. Six proposals were received from UH/UHCL faculty and NASA-JSC co-investigators. Four were accepted:

- Prof. G. E. Fox (UH: Biology and Biochemistry) and Dr. D. Pierson (JSC) – "Bacterial Adaptation to the Space Environment."
- Prof. R. Krishnamoorti (UH: Chemical Engineering) and Dr. L. Yowell (JSC) – "Active Nanocomposites: Multifunctional Aerospace Structures."
- Prof. L. H. Rhode (UHCL: Physics) – "Biological Effects of Shielding Parameters Across the Bragg Curve of Energetic Protons and *Fe* ions."
- Prof. E. A. Bering (UH: Physics) and Dr. D. S. Winter (JSC) – "Study of Mechanics of Plasma Detachment in a Magnetic Nozzle."

Two existing PDAF projects were renewed for their third and final year:

- Prof. A. Bensaoula (UH: Center for Advanced Materials) and Dr. Brian Mayeaux (JSC: Materials Processing Branch) – "Development of Micro Column Arrays (MCA) for Thermal Management Applications."
- Prof. J. H. Miller, Jr. (UH: Physics), Dr. D. S. McKay (JSC: Planetary Sciences), and Dr. J. A. Jones (JSC: Flight Medicine), and Dr. D. Warmflash (UH: PDAF) – "Martian Soil Biosensors Based on Dielectric Spectroscopy."

The ISSO program is evolving in response to the evolving objectives of the University of Houston System. In past years, ISSO has requested mini-grant proposals from UH and UHCL faculty members. Each selected principal investigator received funds for summer research that would enable the professor, sometimes including a co-investigator, and one or more students to prepare better individual proposals to external organizations. In the fall of 2006, Dr. D. L. Birx (Vice Chancellor and Vice President for Research and Intellectual Property) challenged the UH System faculty to form large teams that could more effectively identify and pursue major research programs offered by external government and private organizations.

In the spring of 2007, ISSO is requesting Space Exploration Cluster Pre-proposals from faculty teams of the UH System. Each team pre-proposal must be from a group of faculty committed to working as a team through 2008 to pursue major external funding in the very broad field of space exploration and development. Each pre-proposal must list specific external agencies and funding opportunities that exist as of May 1, 2007. Each proposal should also list highly probable proposing opportunities anticipated during 2007 and early 2008.

Director's Research and Administrative Activities

Dr. D. R. Criswell directs the Institute for Space Systems Operations at the University of Houston and the University of Houston-Clear Lake. His primary research interests are in industrial development of the moon and the economic benefits to Earth of a sustainable global solar power grid.

Dr. Criswell works extensively with Dr. Helen Lane (Director of University Programs at the Johnson Space Center), Dr. Kamlesh P. Lulla (University Program Officer), and Dr. Donn Sickorez (University Affairs Officer) coordinating the ISSO research program with primary program goals of NASA-JSC.

Since April 2006, he has provided interviews to members of the general and aerospace press and one invited editorial on solar power from space. Presentations and papers from September 2005 through March 2006 are listed in the ISSO 2006 *Annual Report*.

Interviews

Interview with Ms. C. Tumiel, *San Antonio Express-News*, "Lunar Solar Power and the Supply of Commercial Power to Earth" (May 23, 2006).

Interview and filming by Mr. Brian Solari (Production Manager), The Future Channel, "Lunar Solar Power" (May 10, 2006).

Interview with Ms. M. Chandler, CBS San Antonio, "Lunar Solar Power" (May 23, 2006).

Interview with Mr. T. Hamilton (Energy Reporter/Tech Columnist), *Toronto Star* (July 6, 2006).

Interview with Mr. N. Davidson, British Broadcasting Company (TV), (July 24, 2006).

Publications

Criswell, D. R. "The Sun, the Moon, and Sustainable Global Prosperity," *Energy Biz Magazine,* July/August 2006, p. 54 (also available online; *invited editorial*).

ISSO Program Documents

Criswell, D. R. (Director), Rothman, I. (Editor), and Bush, D. (Associate Editor) (2006 Spring) Y2005 *Annual Report*, the Institute for Space Systems Operations of the University of Houston and the University of Houston-Clear Lake, 136pp., Houston, TX.

Criswell D.R. (director) and H. Lane (JSC) (2006, 9 May) Peer Review of proposals submitted by University of Houston and University of Houston-Clear Lake faculty to ISSO Post Doctoral Aerospace Fellowship projects by faculty and research staff from UH, UHCL, and NASA-Johnson Space Center.

Criswell, D.R. (2005 August - December) Worked with UH System Office of the General Counsel and NASA-JSC to renew the existing Memorandum of Understanding for the UH/UHCL-JSC Post-Doctoral Aerospace Fellowship Program and then (2006, January - to date) convert it to a Space Act Agreement.

TEAM MEMBERS—Researchers working on micro column arrays (MCA) for thermal management applications (*l. to r.*) Nasr Medelci, Ph.D.; Rajeev Pillai, Ph.D. candidate in electric engineering; Dr. Abdelhak Bensaoula, Ph.D., Principal Investigator; and Sujay Paranjape, master's student in mechanical engineering.