The Institute for Systems Research

1997 Annual Report

ISR
INSTITUTE FOR SYSTEMS RESEARCH

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

ISR develops, applies and teaches advanced methodologies of design and analysis to solve complex, hierarchical, heterogeneous and dynamic problems of engineering technology and systems for industry and government.

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From the ISR Director

ISR is the protagonist for cross-disciplinary, systems-directed research at the University of Maryland because of its intellectual leadership and the growing importance of systems engineering.

Fundamental systems problems correctly continue to be thought of in terms of research thrust areas in control, communications and signal processing and systems integration, i.e., the heart of ISR's research program and thrust area organization. To complement this, the investment of research efforts in systems problems organized by their area of application increasingly will drive the major funding opportunities for ISR's research agenda.

ISR's future research agenda will continue to be realized through its evolution into a federation of centers and major research programs under the Institute umbrella and supported by the ISR staff and funding. Currently with six such large activities, ISR is now focusing on how a synergistic relationship can be structured among ISR, its centers and large programs. The arrangement must recognize and support the thematic and structural diversity of the centers as well as the pervasiveness of fundamental systems methodologies throughout the centers.

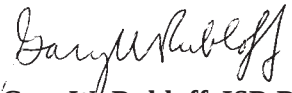
Another aspect of ISR's future concerns its outreach to new areas of opportunity. ISR has achieved excellence and recognition for its contributions and talent in key areas central to systems research. These can leverage additional benefits through new associations with other disciplines and research areas in the College of Engineering, information technology, and a host of external representatives from industry, government, and academia. Examples of such opportunities include reliability and risk assessment, transportation, civil infrastructure systems, economics and finance, environmental systems, and learning systems.

ISR's M.S. in Systems Engineering, as well as the corresponding Professional Master's degree, are already part of the university's degree programs, and dramatic demand for systems engineering education will provide a strong incentive for current efforts to revise, improve, and disseminate these unique programs.

While industry and government increasingly and forcefully underscore the profound needs for both regular academic and continuing education in systems engineering, few opportunities currently exist nationwide. ISR is encouraging and supporting major developments in its systems engineering education programs along several directions, including: construction of modular components accessible over the Internet and usable for customized short courses; increased emphasis on case studies and the application of systems engineering tools; collaboration with industry and government practitioners of systems engineering; and development of a graduate certificate program in systems engineering which would accompany advanced degrees in conventional engineering disciplines.

Similar excitement stems from ISR's Gemstone program at the undergraduate level, which has not only captured tremendous attention across the campus and the nation, but has stimulated thinking in ISR about mechanisms to bring systems educational experiences to a broad spectrum of undergraduates, both in and outside engineering.

The College Park campus provides profound faculty resources to underwrite such initiatives, while research needs assessments and agendas on the national scene highlight directions of high potential. ISR's educational activities will remain a very high priority. With focus on systems research as seen from the perspective of both core systems skills and systems applications, the educational experiences of students and postdocs directly involved in ISR's research programs will continue to deliver substantial and unusual value as these alumni move into careers in industry, government, and academia.



Gary W. Rubloff, ISR Director

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ISR's contributions to systems engineering

In 1985, before the establishment of the Institute for Systems Research, control and systems engineers had few tools with which they could apply advanced methodologies. Traditional control and systems methodologies were applicable to relatively simple systems, so engineers took established (simple) models "over the wall" and used these techniques, possibly after applying straightforward model reduction algorithms. Control design was not at all integrated with other elements of design as an interactive, iterative process.

There was little emphasis on modeling and experimental components in the systems field, particularly in universities. System development was ad-hoc, with little in the way of formal modeling and analysis tools. Developments in computer science and VLSI had little impact on control and communication system design. There was little automated control or communication system design software. The methodology in systems design had not kept pace with the technological developments in microelectronics, computer-aided design (CAD) and artificial intelligence (AI).

Since its inception, ISR has been at the forefront of the progress made in systems research and applications. Methods from computer science have begun to be integrated with those from control and communications and software tools for design have become prevalent. ISR has made great progress in advancing the state of the art in control, communications, and computation, and in the integration of these fields for the design of complex dynamical systems. These advances cover the full spectrum from fundamental research to implementation in hardware and software to the use of these advances in industry. The advances have moved the systems field significantly in the direction of formal modeling, analysis and optimization-based techniques. They represent a real advance in the state of the art.

Intelligent Control. There have been significant advances in the study of linear and nonlinear systems described by differential equation models, including methods for stability analysis, optimization, robust control, adaptive control, stabilization, tracking, and sensitivity minimizing controllers. ISR has been at the forefront of exciting developments in nonlinear control theory and design principles for designing nonlinear control systems.

Little work has been done to extend this significant body of control results to heterogeneous systems. The complexity of systems is increasing faster than our ability to analyze and control them.

Recently ISR has played a major role in a strong effort to model and understand hybrid models for heterogeneous systems involving both numeric and logical variables. Such models arise in many contexts, including multi-mode systems that are reconfigurable or have failure modes, disk drives, robotic systems, and stepper motors. These models involve a close coupling between parts that are governed by differential equations and parts that are governed by models from computer science such as finite state automata. We have developed new analog models for hybrid systems at ISR, as well as a hybrid control formalism based on MDL, our device independent motion description language. Our aim is to develop methodologies based on these advances which will lead to knowledge and tools for the control of heterogeneous systems.

Signal Processing and Communication. Communication and information processing are critical components of system operation. At the same time, the communication infrastructure of a system itself constitutes a subsystem that must be controlled. Although this coupling between control and communications has been widely recognized, there has been little progress in exploiting it to enhance overall performance. In large communication systems such as communication networks, control methodologies have been used to some degree. ISR has been a leader in this effort.

Networking and signal processing aspects of these systems have traditionally been pursued separately, despite the strong interaction between them. ISR has been at the forefront of current trends that have begun to combine signal processing techniques, such as compression, with networking techniques, such as broad band switching, for joint design that integrates across traditionally separate network layers.

ISR has been a leader in the key area of hybrid satellite, terrestrial, and wireless telecommunication networks. There have been significant contributions at ISR to network performance evaluation and design. This effort has led to the establishment of the Center for Satellite and Hybrid Communication Networks (funded by NASA) at ISR and the participation of ISR as a key partner in the Advanced Telecommunications and Information Distribution Research Program (a Federated Laboratory of the Army Research Laboratory).

Furthermore, ISR has initiated the full exploitation of this coupling between communication and control by considering the impact of communication technology on control design. Instances in which the coupling has yet to be fully exploited include the reliance of control strategies on sensor technology and data fusion, the effects of signal compression techniques on servo loop bandwidth, and the use of hierarchical signal representations (such as progres-

sive coding and compression) both for adaptive network flow control and for improved operation of control systems in general.

Systems Integration Methodology. There is a need for a rational methodology for solving problems of systems integration; this was a clear message of ISR's December 1994 Industry Workshop. There is a considerable body of knowledge on object-oriented programming and object-oriented databases, and there has been progress in describing products with higher level codes.

However, no methodologies exist for representing processes in an object-based manner at a higher level of abstraction. These are not just computer science or software issues. They require, for example, a close coupling with research on modeling. ISR has been a leader in the development of fundamentals for heterogeneous databases and deductive databases. Complexity has been studied for some classes of models, but quantitative theories of model complexity for heterogeneous systems do not exist.

The use of feedback to manage system complexity has been studied extensively, but systematic efforts to make quantitative comparisons between architectures for heterogeneous systems have been lacking. ISR has been at the forefront of research on optimization and trade-off analysis based on linear and nonlinear optimization. This has culminated in widely used tools such as CONSOL and FSQP.

Progress has been made at a number of universities on mixed integer-nonlinear programming. However, there is a clear need for tools and methodologies for analyzing tradeoffs between conflicting specifications and performance metrics for complex heterogeneous systems. ISR has been a leader in AI planning (including heterogeneous planning), and is now beginning to combine these methods with optimization-based techniques to perform trade-off analysis for heterogeneous systems.

Impact of ISR research advances on systems engineering

In 1985 ISR's main research theme and vision was the computer-aided design of complex automatic control and communication systems. This was to be accomplished through fundamental research that synergistically combined advances in three types of technology (VLSI, CAD, and AI) with sophisticated control and communication methodologies. The research plan included:

- In-depth investigation of the impact of VLSI, CAD, and AI;
- Fundamental research in modeling, optimization, computational and numerical methods
- Techniques for control systems, communication systems, and computer engineering;
- A set of five application thrust areas, including intelligent CAD of stochastic systems, intelligent servomechanisms, chemical process control, advanced automation and information processing in manufacturing systems, and telecommunication systems.

When ISR was founded, a significant amount of control and communication research was being undertaken in universities, and a significant amount of control and communication practice was occurring in industry, but there was little connection between the two.

There was a clear need for a cross-disciplinary center to bridge this gap. ISR's goal was to change the situation by:

- Bringing experiments and industrial interactions into the university and its education and research programs;
- Educating a new breed of engineer who would have a broad as well as a deep foundation, and an understanding of industrial practice;
- Bridging the gaps between disciplines; and
- Transferring technology to industry.

ISR has been successful in all aspects of its programs: education, cross-disciplinary research and technology transfer and industrial interaction. It has been a major force in changing the paradigm for the way in which systems research and education are carried out. Universities around the world have adopted ISR's approach of combining theory and experiment in communication and control. ISR's focus on integrating control, communication and computation also has been validated and adopted.

ISR's impact on industry

ISR has had a profound influence on industry during a time of two fundamental and important changes.

First, industry has identified and emphasized a growing need for systems engineering due to increased technological complexity, emphasis on competitive manufacturing, and business forces which place a premium on systems-level design, realization, metrics, rapid time to market and quality.

Second, these pressures have driven corporations to transform the character of their investment in university research from relatively open-ended fundamental work to more directed, coherent, strategic initiatives.

Accordingly, ISR began emphasizing sponsored joint research with corporations, as long as that research was consistent with ISR's overall theme. It also began forming research consortia to diffuse the cost of research while at the same time ensuring corporate participation in that research. The NSF core funding, in this regard, has served as an excellent source of "seed money" to encourage industry to join these consortia.

ISR also began forming and joining consortia to pursue third party sources of funding to underwrite the cost of research; these have included funding from federal agencies as well as state programs such as the Maryland Industrial Partnerships (MIPS). As a result, ISR's collaborations with industry have increased and deepened. Particularly notable have been:

- The emergence of consortia that ISR has organized or been involved in (e.g., the Center for Satellite and Hybrid Communication Networks and the Smart Materials Manufacturing consortium);
- A significant increase in the number of joint ISR / industry projects funded by the Maryland Industrial Partnerships program; and
- More aggressive marketing to industry of ISR's systems approach.

ISR and its industrial partners promote the growth of American industrial competitiveness by accelerating the rate at which fundamental engineering advances are applied by industry. ISR achieves this goal by continuously and actively engaging industrial partners in every level of activity in the organization, and, by doing so, promoting the rapid exchange of information between ISR and those industries. During its existence, the number of patents and copyrights issued to ISR has increased, the amount of intellectual property licensed to industry has grown, and the level of industrial participation in ISR activities has expanded significantly.

We present here some examples of the significant impact that ISR has had on industry.

Optimization-based engineering design

ISR has developed two optimization software packages in use at more than 300 sites in 34 countries. CONSOL and FSQP are software packages for interactive optimization-based design of a large class of engineering systems. Each systematizes trade-off analysis in design of dynamical systems, allowing engineers to interactively assess design decisions free from mathematical complexities.

Northrop Grumman has incorporated CONSOL into PROTO-OPT, an advanced graphical optimization-based control system design software. At Northrop Grumman's Electronic Sensors and Systems Division (ESSD), CONSOL is being implemented to design a line-of-site stabilizer for an airborne camera. At General Electric, FSQP is incorporated in Engineous for design optimization and automation, yielding a 10 to 1 productivity savings for the company. Texaco is using FSQP in its process control software, now being commercialized, for nonlinear constraints and feasible iterate.

Next generation network management system

ISR and Hughes Network Systems (HNS) have been participating in a collaborative research and development effort to develop the next generation network management product for satellite and hybrid network configuration management. The project incorporates ergonomically designed graphical user interfaces tailored to the network configuration management function and advanced object-oriented database structures.

The design concept incorporates object-oriented programming methodology to associate data with functions, permit customization and provide an open architecture environment. Hughes Network Systems strongly believes that the resulting network management product will help the company maintain a strong, long-term competitive position relative to foreign competitors, improve its exports and increase its revenues by tens of millions of dollars.

Producability and manufacturability of high power surveillance T/R modules

High Power Surveillance Transmit/Receive modules are an integral part of the latest active aperture surveillance radar antenna arrays being developed and manufactured by Northrop Grumman ESSD. Since 1991 ISR has worked with engineers at ESSD to develop an expert software system to optimize design configuration and manufacturing processes for the production of High Power T/R modules.

Information technology has been used to create a unique concurrent engineering environment for design and manufacturing of electronics products. The developed system consists of an object-oriented database, a cost evaluation module, a quality evaluation module and a process planning module. It is capable of analyzing a given process plan based on the system's knowledge and user input and is able to critique the plan in terms of cost, quality and manufacturability. This computer-based system has been installed at ESSD and is currently being used as a consultation tool to management and engineers seeking the most cost-effective approach to producing T/R modules while maintaining high quality.

Facility design

ISR has developed a master plan for shop layout that is expected to yield $300,000 cost savings during the second phase of implementation at Northrop Grumman ESSD. In the company's manufacture of radar assemblies, over 10,000 parts are produced in a job shop facility that comprises 160 work centers arranged in a functional layout. The shop layout causes high part traffic and, consequently, large production cycle times.

To improve efficiency, ISR researchers adopted a three-stage approach to the redesign:

- Determined a set of manufacturing cells based on the inter-resource traffic; computed the expected savings in material movement; selected the most promising of these cells for implementation;
- Derived a layout that maximized the flow in a common direction for the machines in each of the previously selected cells (a variety of cellular arrangements were examined); and
- Derived a time-phased implementation plan to decide which cells should be implemented, the time at which the implementation will take place and the final layout of machines and cells on the facility shop floor; the goal was to maximize the total benefits over time while keeping machine relocation costs within budget constraints.

A software package that performs all of the above design modules is being developed.

Disk head control

ISR and Digital Equipment Corp. jointly developed a new control algorithm for positioning the read-write head on a high-performance disk storage unit. ISR researchers used a digital controller and a specially parameterized torque profile, chosen to approximate a bandlimited function, to accomplish the positioning operation more rapidly. With present methods for this procedure the control forces applied to the positioner excite vibratory modes in the positioning arm and only when these vibrations die out can the read/write operation be performed. ISR's scheme eliminates higher harmonics from the input and from the resulting motion of the positioning arm, making it unnecessary to allow for a delay while they die out.

Design of a smart tool post for precision machining

Smart materials are critical for the creation of structures that can sense and react to their environment. This project explores the application of smart materials in machine tools for vibration compensation. ISR worked with three industrial partners (Martin Marietta Laboratories, Lockheed and AVX) to design a tool post for precision machining.

In the product design, multi-layer stack-type actuators made of an electrostrictive lead-magnesium-niobate (PMN) ceramic material were used as built-in devices to provide anti-vibration action during machining. A product prototype of the tool post has been fabricated at ISR to demonstrate the systems engineering approach for product development.

In the mechanical design, the principle of vibration absorption was employed and membrane components were used to maximize the authority of the actuators for vibration compensation. In the controller design, the method of self-tuning control has been used to coordinate the actuator excitation based on detected tool vibration. The prototype is now under testing. ISR is now working with its industrial partners for commercialization of the smart tool post product.

ISR's impact on research

The Institute for Systems Research serves as an instrument of change at Maryland, particularly concerning attitudes about cross-disciplinary research, education and interaction with industry. ISR is a new type of institute that stresses truly cross-disciplinary research, working in teams and the importance of working closely with industry.

ISR has been held up as a model for combining cross-disciplinary research, education and public service by the Deans of Engineering and Computer, Mathematical and Physical Sciences, the Provost and the President of the University of Maryland, as well as by the University of Maryland System Blue Ribbon Committee on Research and Public Service.

The value system among faculty (both inside and outside ISR) has been changed as a result of ISR's influence: working with industry and working in cross-disciplinary teams are now regarded as key elements of a faculty member's responsibilities. Indeed, these factors are taken into account in promotion, tenure and merit raise decisions; the ISR director has an official role in these processes for faculty with joint appointments in ISR.

Since ISR's inception, there has been a distinct improvement in the extent to which engineering systems research at Maryland is relevant to industry and in the tendency of faculty and students to work in teams that include industry. Many of ISR's projects now involve faculty from a number of the 12 departments affiliated with ISR. In addition, the choice of research directions has increasingly been influenced by relevance to industrial needs.

Interactions of faculty and students are enhanced by the co-location of the primary offices of most ISR faculty in ISR space and by a student office policy that places students from different departments in the same office. This bringing together of faculty and students from different departments has broken down departmental barriers.

ISR faculty have spun off two centers built on ISR's model of industrial interaction and cross-disciplinary research. These are the Center for Satellite and Hybrid Communication Networks (a NASA Commercial Space Center) and the CALCE Electronic Packaging Research Center (an NSF State / Industry / University Cooperative Research Center). Each includes a consortium of companies; the latter includes other universities as well.

Because of ISR's success and because many of the administrative problems associated with cross-disciplinary research have been worked out between ISR and the departments, there has been an increasing number of cross-disciplinary proposals funded and centers established at the University of Maryland and led by ISR faculty. These include the Center for Auditory and Acoustic Research (funded by the Office of Naval Research), the Center for Dynamics and Control of Smart Structures (funded by the Army Research Office), the National Center of Excellence in Aviation Operations Research (funded by the Federal Aviation Administration), the program in Collaborative Agent Technology Systems (funded by the Army Research Laboratory), the program in Learning and Intelligent Systems (funded by the National Science Foundation), and the program in Operational Methods for Semiconductor Manufacturing (funded by NSF and the Semiconductor Research Corporation).

These programs represent embodiments of integrated systems research approaches, some aligned more toward application areas and others toward advancing fundamentals in systems research. NSF's ERC investment in fundamental systems research themes has thus flourished, leading to a kind of federation of major programs and activities which reflect the initial systems engineering core. At this point, ISR has become a highlight of engineering at the University of Maryland, integrally connected to almost one third of its portfolio of engineering research. Furthermore, ISR is regarded as—and is encouraged to be—the primary leader for cross-disciplinary initiatives in the College of Engineering.

ISR advances, 1996–1997

Year	Type	Advance	Impact	Significance
1996	Knowledge	Foundations of Hybrid Systems	New analog models and methods for analog / digital hybrid systems; device-independent language for motion commands, feedback laws, and execution times; integration of planning and nonholonomic control.	Can provide basis for control and optimization of hybrid systems; basis for portability, reuse and open control software; motion description language (MDL) software tool.
1996	Knowledge	Nonlinear Analysis and Design	New results in modeling and control of interconnected mechanical systems; invention of bifurcation control laws.	Extends control theory to much broader classes of systems arising in applications.
1996	Knowledge	Models and Algorithms for Sound Processing	Models of spatiotemporal response of the auditory system and auditory cortex; new algorithms for speech processing.	Applications to speech analysis and recognition; applications to prediction of faults in mechanical systems and to understanding learning processes in natural and artificial systems.
1996	Knowledge	Foundations for Optimization-Based Engineering Design and Trade-off Analysis	Accommodate challenges of real problems through formulation of multi-objective optimization framework; new optimization algorithms involving feasible iterates, addressing semi-infinite problems.	Provides structured methodology for complex systems optimization problems, where thousands of parameters, objectives, and constraints are involved.
1996	Knowledge	Object-oriented (OO) Systems Modeling and Graphical User Interfaces (GUI)	Methods for incorporating constraints in OO databases; treemap approach for information visualization for hierarchical data; fast queries in OO databases.	The confluence in ISR of leading-edge expertise in database structures and user interface design has led to the development of powerful new tools for network visualization and management, with major implications for telecommunications.
1996	Knowledge	Design and Planning System for Concurrent Engineering	Information technology has been used to create a unique concurrent engineering environment for design and manufacturing of electronics products. The developed system consists of an object-oriented database, a cost evaluation module, a quality evaluation module and a process planning module. It is capable of analyzing a given process plan based on the system's knowledge and user input and is able to critique the plan in terms of cost, quality and manufacturability.	ISR researchers from engineering, computer science, and business have teamed skills to produce a suite of methods for concurrent product design and manufacturing planning. Such advances are increasingly requires for systems integrators, where a premium is placed on rapid design, efficient development processes, and early assessment of manufacturability and cost.
1996	Technology	Producibility and manufacturability of high power surveillance transmit / receive (T / R) modules	High Power Surveillance Transmit / Receive modules are an integral part of the latest active aperture surveillance radar antenna arrays being developed and manufactured by Northrop Grumman ESSD. Since 1991 ISR has worked with engineers at ESSD to develop an expert software system to optimize design configuration and manufacturing processes for the production of High Power T / R modules.	This computer-based system exploits ISR's systems expertise in design and planning for concurrent engineering. It has been installed at ESSD and is currently being used as a consultation tool to management and engineers seeking the most cost-effective approach to producing T / R modules while maintaining high quality.
1996	Technology	Next generation network management system	ISR and Hughes Network Systems (HNS) have been participating in a collaborative research and development effort to develop the next generation network management product for satellite and hybrid network configuration management. The project incorporates ergonomically designed graphical user interfaces tailored to the network configuration management function and advanced object-oriented database structures.	The close collaboration between HNS and ISR, a consequence of ISR's industrial partners program and its initiation of the Center for Satellite and Hybrid Communication Networks, has driven the design concept incorporating object-oriented programming methodology to associate data with functions, permit customization and provide an open architecture environment. Hughes Network Systems strongly believes that the resulting network management product will help the company maintain a strong, long-term position relative to foreign competitors, improve its exports and increase its revenues by tens of millions of dollars. Software tools and graphical widgets for network representation have been productized and licensed.
1996	Technology	Algorithms and Circuits for Sound Processing	Application to sound localization	Patent on cochlear filter bank which processes sound as does mammalian auditory system, with potential implications for sound localization.

Year	Type	Advance	Impact	Significance
1996	Education	Industrial Workshop: Model Based Sensing and Control in Semiconductor Manufacturing	ISR sponsored an industry-university workshop (38 participants) to address available and needed technology and the pathways for implementation of intelligent process control. Participants included Texas Instruments; SEMATECH; Motorola; LAM Research; Sandia National Laboratories; NIST; Air Products and Chemicals, Inc.; Applied Materials; IBM; Integrated Systems, Inc.; NSF; Northrop Grumman and Science Applications International Corp.	The workshop served effectively to educate both ISR and industry people, to bring together ISR's skills in control, modeling, operations, and experiment, and to initiate the substantial ISR research programs now in place for semiconductor manufacturing applications.
1996	Education	Gemstone: Cross-disciplinary undergraduate honors program	The innovative, interdisciplinary Gemstone undergraduate honors program 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. Now entering its third year, the program has attracted 461 students, with average SAT scores of 1440.	Gemstone is a model for interdisciplinary education, bringing together students from all disciplines into teams which address issues with broad social, economic, and political aspects together with strong technological contexts. Gemstone already has gained national attention for the University of Maryland, which increasingly is being seen as a leading innovator in undergraduate education. Because of its leadership and tradition in cross-disciplinary research and education, ISR was the obvious and natural home to make Gemstone a success.
1997	Knowledge	Advanced Systems Approaches for Semiconductor Manufacturing	Critical assessment of transferrability of run-to-run control between process and equipment versions and generations, identifying robustness of control algorithms as critical.	Advanced theoretical control methods provide value in spite of measurement and model error, and collaboration with experimental expertise enables identification of impact in equipment specifications.
1997	Knowledge	Hybrid Shop Layout	ISR has developed a master plan for hybrid shop layout that is expected to yield $300,000 cost savings during the first phase of implementation at Northrop Grumman. In the company's manufacture of radar assemblies, over 10,000 parts are produced in a job shop facility that comprises 160 work centers arranged in a functional layout. The shop layout causes high part traffic and, consequently, large production cycle times.	ISR exploited its skills in logistics and systems to benefit Northrop Grumman, a prime industrial partner. Researchers adopted a three-stage redesign: 1) a set of manufacturing cells was determined based on the inter-resource traffic and the expected savings in material movement was computed; the most promising of these cells was selected for implementation; 2) a layout that maximized the flow in a common direction was derived for the machines in each of the previously selected cells—a variety of cellular arrangements were examined; and 3) a time-phased implementation plan was derived in order to decide which cells should be implemented, the time at which the implementation will take place and the final layout of machines and cells on the facility shop floor; the goal was to maximize the total benefits over time while keeping the machine relocation costs within budget constraints. A software package that performs all of the above design modules is being developed.
1997	Knowledge	Variant and Generative Planning	Theoretical framework for analyzing hierarchical task network planning; formalized techniques for plan reuse.	These methods are attractive and applicable to combine and exploit both existing and new plans for applications including manufacturing and defense.
1997	Technology	Control Designer's Unified Interface (CONDUIT)	CONDUIT is a state-of-the-art designer's assistant for use in the design and evaluation of aircraft control systems. It assists the designer in setting up control system design problems in the computer, in evaluating the controller's performance with respect to the aircraft handling quality-qualities criteria, and in optimizing the design.	CONDUIT is currently being used by U.S. aircraft manufacturers in approximately one half-dozen aircraft control system design projects. It is expected that CONDUIT will be used in the design of virtually all aircraft control systems designed in the United States.
1997	Technology	Wavelet-Based Multiresolution Local Tomography	The algorithm reconstructs the wavelet coefficients of an image from Radon transform data, using the properties of wavelets to localize the Radon transform. It can reconstruct a local region of the cross-section of a body, using almost completely local data which significantly reduces the amount of exposure and computations in X-ray tomography.	Use of the algorithm could significantly reduce the amount of radiation exposure necessary, for example, in mammograms and other x-rays. It allows reconstruction of a local region with only 12.5 percent of full exposure data. Previous attempts reduced exposure only to 40 percent for the same case. The algorithm is considered a novel possible technology when coupled with ISR's new image processing ideas.

ISR's impact on education

The Institute for Systems Research has implemented a comprehensive education program that spans the spectrum from post-doctoral researchers to elementary and middle school students. These programs have had a profound effect on the engineering education provided by the University of Maryland and their influence has spread well beyond those campuses.

From 1988 through August 1997, 238 Ph.D. students and 410 M.S. students from the University of Maryland closely affiliated with ISR have received their graduate degrees. In addition, 129 ISR-affiliated B.S. students at Maryland have graduated.

Students in the broadly-based, cross-disciplinary Master of Science in Systems Engineering (MSSE) program at ISR benefit both academically and professionally by being exposed to a wide range of systems engineering principles; becoming familiar with the financial and management issues associated with complex engineering systems; and acquiring a deep understanding of one particular application area. Designed with substantial industry input, the MSSE curriculum is the University of Maryland's first multi-college graduate degree program involving the A. James Clark School of Engineering.

The ENPM program serves the needs of part-time students who are often employed full-time during their ENPM pursuits. The purpose of both the MSSE and ENPM degrees is to pursue an explicit systems engineering career or to substantively enhance a career in another engineering discipline by acquiring systems engineering expertise.

ISR administers the Gemstone undergraduate honors program, which brings together students from many disciplines, including business, engineering, journalism, the social sciences, agriculture and natural resources, the arts and humanities, computer, mathematical and physical sciences, and the life sciences. As freshman, these students form interdisciplinary teams that spend three years analyzing and investigating important societal problems.

Research Experiences for Undergraduates (REU) Awards give non-University of Maryland undergraduate students the unique opportunity to participate in state-of-the-art research in systems engineering. Exceptional opportunities exist for research in collaboration with leading industrial and government research laboratories. The funds for these awards are provided by the National Science Foundation to encourage students to strive for engineering excellence and to provide opportunities for research participation.

The Young Scholars experience helps students between their junior and senior years of high school who have strong interest and potential to excel in science and mathematics, and who would like to explore academic and professional opportunities in engineering and math-based science. It offers three undergraduate credits for completion of ENES100, "Introduction to Engineering Design." The experience includes daily hands-on work in ISR's state of the art laboratories, substantive seminars and workshops and field trips to manufacturing and consulting firms.

Employment history of ISR graduates in industry

ISR's database includes information on alumni and their current employers. ISR alumni are working in telecommunication, satellite, computer, manufacturing, defense, automotives, consulting, government and military settings.

Employer	No. of ISR graduates
AT&T Bell Labs	7
Bellcore	6
COMSAT	5
Comsearch	4
General Electric	2
General Motors	2
Hughes Network Systems	12
IBM	17
Johns Hopkins Applied Physics Lab	10
Lockheed Martin	3
MITRE	4
Motorola	3
NASA Goddard	4
Naval Research Lab	7
Texas Instruments	3
TRW	3
Westinghouse	4

Faculty Biographies

Up-to-date information about ISR's faculty can be found at the ISR web site, *http://www.isr.umd.edu/ISR/faculty/faculty.html*. The information includes faculty home pages, e-mail addresses, office addresses and phone numbers, department affiliations and associated links.

Eyad H. Abed

Professor, Electrical Engineering and the Institute for Systems Research

Eyad H. Abed received the S.B. degree from the Massachusetts Institute of Technology in 1979 and the M.S. and Ph.D. degrees in 1981 and 1982, respectively, from the University of California at Berkeley, all in Electrical Engineering. He has been with the Department of Electrical Engineering at the University of Maryland since 1983, where he is presently a Professor and holds a joint appointment with the Institute for Systems Research. Dr. Abed is a recipient of the Presidential Young Investigator Award from the National Science Foundation, the O. Hugo Schuck Best Paper award from the American Automatic Control Council, the Outstanding Systems Engineering Faculty Award of the Institute for Systems Research and the Alan Berman Research Publication Award from the Naval Research Laboratory and two teaching awards from the University of Maryland. He serves on the Advisory Editorial Board of *Nonlinear Dynamics*.

Dr. Abed's past research includes contributions on the following subjects: control of nonlinear systems exhibiting bifurcation and chaos; singular perturbation analysis and reduced-order modeling; nonlinear stability and stabilization; linear robust stability; gas turbine jet engine dynamics and control; electric power system dynamics and control; tethered satellite control; aircraft control; and radar system dynamics. He is also investigating the use of nonlinear dynamics in communication systems and signal processing applications.

Raymond A. Adomaitis

Assistant Professor, Chemical Engineering and the Institute for Systems Research

After receiving his Ph.D. from IIT in 1988, Dr. Adomaitis became a postdoctoral research associate in the Chemical Engineering Department of Princeton University.

He accepted a postdoctoral fellowship at the University of Maryland in 1990, joined the research faculty in 1992 and became an Assistant Professor in 1995.

He also has held short-term appointments at Los Alamos National Laboratory and the Institute for Mathematics and Informatics at the Lithuanian Academy of Sciences in Vilnius, Lithuania.

Dr. Adomaitis is a member of the AIChE, AIAA and SIAM. He is one of the organizers of the 1995 workshop "Noninvertible Dynamical Systems: Theory, Computation, Applications," has served as a panel member for the 1994 ARO workshop "Intelligent Turbine Engines for Army Applications," chaired the sessions "Nonlinear Dynamical Problems in Process Control," (1993 ACC), "Rotating Stall II," (1995 SPIE), "Microelectronics and Thermal Process Control," (1995 ACC) and is a referee for numerous journals, one book and several proposals. He is currently serving on a number of University of Maryland academic service committees.

Dr. Adomaitis' research interests include systems modeling methodologies for simulation and control of materials manufacturing processes and aircraft propulsion systems. This research aims to develop a modeling framework which gives reduced order models, suitable for analysis and model-based control, consistent with high-fidelity dynamic simulations. This research encompasses aspects of computational fluid dynamics, bifurcation analysis, parallel computing techniques, nonlinear control and nonlinear signal processing.

David L. Akin

Associate Professor, Aerospace Engineering and the Institute for Systems Research

David L. Akin is an Associate Professor of Aerospace Engineering and of the Institute for Systems Research at the University of Maryland, where he is also the director of the Space Systems Laboratory. He received a B.S. degree in 1974, an M.S. in 1975, and a Ph.D. degree in 1981, all from the Department of Aeronautics and Astronautics at the Massachusetts Institute of Technology.

His current research spans the range of space operations from purely manual activities such as extravehicular activity, through teleoperation and robotics, to space applications of artificial intelligence techniques. He was the Principal Investigator on the Experimental Assembly of Structures in EVA, a flight experiment on board Space Shuttle Mission 61-B. He has also headed the development of seven different full-function telerobot devices used in neutral buoyancy simulations of space operations.

He is a member of the NASA Telerobotics Intercenter Working Group, the NASA EVA Working Group, and the AIAA Automation and Robotics Technical Committee. He has also served on the

NASA Advisory Council on the Role of Humans in Geostationary Orbit. He has written more than 50 papers on EVA, teleoperation, robotics, and space applications of artificial intelligence.

Dr. Akin's research interests include space telerobotics; zero-gravity human anthropometrics, kinematics, and dynamics; neural network applications for closed-loop adaptive control; and artificial intelligence for space station operations.

Mark Austin

Associate Professor, Civil Engineering and the Institute for Systems Research

Dr. Austin received his Master of Science and his Ph.D. degrees in Structural Engineering from the University of California, Berkeley, in 1982 and 1985, respectively. He received his Bachelor of Engineering in 1980 from the University of Canterbury, New Zealand.

Dr. Austin was a Research Assistant at the University of Canterbury, New Zealand, from November 1980 to July 1981. From 1982 through 1985, he was a Research Assistant at the University of California, Berkeley and from 1985 through 1987 he was a Research Engineer at the same institution. He has worked as a faculty member at the University of Maryland since 1987. For the period 1989–1991, Dr. Austin received the NSF Research Initiation Award.

In 1989, Dr. Austin was a member of the ASCE Maryland Section Seismic Provisions Review Committee. He is currently a reviewer for NSF and *ASCE Journal of Structural Engineering*. Dr. Austin is affiliated with the American Society of Civil Engineers, the New Zealand Society of Earthquake Engineering, the Association of Computing Machinery and the American Institute of Aeronautics and Astronautics.

Dr. Austin's research interests are in computer-aided design of civil engineering structures, numerical algorithms for multibody dynamics and control and earthquake engineering.

Michael O. Ball

Professor, College of Business and Management and the Institute for Systems Research

Michael Ball received his BES in Engineering Science and MSE in Operations Research from Johns Hopkins University in 1972 and his Ph.D. degree in Operations Research from Cornell University in 1977.

Dr. Ball joined the University of Maryland faculty in 1979 as an Assistant Professor and in 1984 he became Associate Professor in the College of Business and Management. In 1988, he became a Professor in the College of Business and Management and in 1990 he received a joint appointment with that College and the Systems Research Center. Dr. Ball is a member of the Operations Research Society of America, the Mathematical Programming Society, the Society for Industrial and Applied Mathematics and IEEE. He is associate editor for *Networks and Operations Research Letters* and has been area editor for optimization for the journal *Operations Research* and associate editor for *IEEE Transactions on Reliability*.

Dr. Ball held several industrial positions from 1973 to 1978, at companies including the U.S. Environmental Protection Agency, Network Analysis Corp. and Bell Laboratories. Since 1979 he has consulted with a variety of private companies and government agencies, including the Federal Aviation Administration, Sprint, CACI, Inc., the United States Postal Service, the Military Airlift Command and United Parcel Service.

Dr. Ball's research interests are in network optimization and network reliability analysis, particularly applied to the design of telecommunications networks, transportation systems and manufacturing systems. He has published extensively on these topics in a variety of journals. His research has been funded by the U.S. Department of Transportation, the U.S. Army Research Office, NSF, IBM, United Parcel Service, Westinghouse, Loral and Hughes Network Systems.

John S. Baras

Lockheed Martin Chair in Systems Engineering, Professor, Electrical Engineering and the Institute for Systems Research

John S. Baras received the B.S. in Electrical Engineering from the National Technical University of Athens, Greece, in 1970, and the M.S. and Ph.D. degrees in Applied Math. from Harvard University in 1971 and 1973.

Professor Baras was the founding Director of the ISR from 1985 to 1991. Since August 1973 he has been with the Electrical Engineering Department, and the Applied Mathematics Faculty, at the University of Maryland, where he is currently a Professor holding a permanent joint appointment with the ISR. In February 1990 he was appointed to the Lockheed Martin Chair in Systems Engineering.

Since 1991 Dr. Baras has been the Director of the Center for Hybrid and Satellite Communication

Networks (a NASA Commercial Space Center). Among his awards are: a 1978 Naval Research Laboratory Research Publication Award; the 1980 Outstanding Paper Award of the IEEE Control Systems Society; 1983 and 1993 Alan Berman Research Publication Award from NRL; 1991 Outstanding Invention of the Year Award from the University of Maryland for the invention of a Low Complexity CELP Speech Coder; 1994 Outstanding Invention of the Year Award from the University of Maryland for the invention of "A System Design for a Hybrid Network Data Communications Terminal Using Asymmetric TCP/IP to Support Internet Applications"; November 1995, Outstanding Contributions to Seniors Award, from the Vice President for Student Affairs and the Senior Council; January 1996, Outstanding Paper Award, "ATM in Hybrid Networks," presented at Design SuperCon 1996 Conference, Santa Clara, CA; April 1996, MIPS Research Award of Excellence for Outstanding Contributions in Advancing Maryland Industry for work done with Hughes Network Systems.

Professor Baras is a Fellow of the IEEE. He has consulted extensively with industry and government on various automation and telecommunication problems. He has served in the following: Board of Governors of the IEEE Control Systems Society; IEEE Engineering R&D Committee; Aerospace Industries Association advisory committee on advanced sensors; IEEE Fellow evaluation committee.

He is currently serving on the editorial board of *Mathematics of Control, Signals, and Systems*, the editorial board of *Systems and Control: Foundations and Applications*, the editorial board of *IMA Journal of Mathematical Control and Information*, the editorial board of *Systems Automation-Research and Applications*, and he is the managing editor of the series *Progress in Automation and Information Systems* from Springer-Verlag.

Professor Baras' research interests include stochastic systems, robust control of nonlinear systems, real-time parallel architectures for nonlinear signal processing, integrated network management systems, satellite and hybrid communication networks, intelligent control systems, expert and symbolic systems for control and communication systems synthesis, distributed parameter systems, planning and optimization, real-time architectures for intelligent control, speech and image understanding, intelligent manufacturing of smart materials, integrated product-process design, hybrid and fast Internet over satellite and wireless networks.

Carlos A. Berenstein

Professor, Mathematics and the Institute for Systems Research

Carlos Berenstein received his Licenciado en Matematicas in 1966 from the University of Buenos Aires. In 1969 and 1970 he was awarded his M.S. and Ph.D. degrees from New York University.

Carlos Berenstein was an instructor at the University of Buenos Aires from 1964 to 1965, and a Research Fellow at CNICT (Buenos Aires) in 1966. He worked as an assistant professor at Harvard University from 1970 to 1973, and a research fellow from 1975 to 1976. He served as assistant professor at the University of Maryland from 1973 to 1975, and later as an associate professor from 1976 to 1980. He became full professor at the University of Maryland in 1980 and in 1985 joined ISR (then the Systems Research Center) as a research faculty appointment. Since 1995 he has held a permanent position in ISR, awarded for outstanding contributions to system science.

He has held visiting professor positions at Scuola Normale Superiore (Pisa), Brandeis University, IMPA (Rio de Janeiro), University of Kiel, Université P. et M. Curie (Paris), Université de Paris (Orsay and Paris IV), Ecole Polytechnique, Univ. de Bordeaux, and Bar Ilan University. Dr. Berenstein was the Director of the Center for Applications of Mathematics at George Mason University from 1990 to 1991.

Dr. Berenstein received a Sloan Foundation Graduate Fellowship, from 1967 to 1970 and the Founder's Day Award of New York University in 1971. His research has been supported by grants from ARO, NSF and NSA. The Argonne Universities Association also awarded Dr. Berenstein a Special Year in Complex Analysis grant. In 1989, Dr. Berenstein received a National Academy of Science Travel Award to the Soviet Union, and in 1990, he received the Hironaka Fellowship and was a Visiting Professor at the Research Institute of Mathematical Sciences in Kyoto, Japan from June to July in 1990.

He also has received grants to travel to Israel by the Binational Science Foundation, and in 1995 was the only American in the Annual Taniguchi Conference in Katata, Japan.

Professor Berenstein's research interests lie in the theory and applications of complex variables, convolution equations, complexity, and linear systems. Particularly interesting recent applications are to medical tomography and non-destructive evaluation.

Berenstein has written five books, edited another four, contributed chapters to several, and written more than 150 research articles.

Kyu-Yong Choi

Professor, Chemical Engineering and the Institute for Systems Research

Kyu-Yong Choi received B.S. and M.S. degrees in chemical engineering in 1976 from the Seoul National University in Korea. He received his Ph.D. in chemical engineering in 1984 from the University of Wisconsin-Madison. Dr. Choi joined the University of Maryland as an Assistant Professor of Chemical Engineering in 1984. In 1985, he received his research faculty appointment to the Institute for Systems Research. Dr. Choi received the NSF Presidential Young Investigator Award in 1986. He became an Associate Professor in 1988. In 1993, he was promoted to full professor. Dr. Choi received the Engineering Achievement Award from the Washington Academy of Sciences in 1992.

Dr. Choi's research interests are in polymerization process design and control. He is presently involved in modeling and optimal control of batch, semibatch and continuous polymerization reactors. He has carried out university-industry joint research projects with major U.S. polymer companies in process modeling and analysis for the development of state-of-the-art industrial polymerization processes.

M. Scott Corson

Research Scientist, Center for Space and Hybrid Satellite Communications Networks

Dr. Corson is an expert in distributed communication protocols, having developed distributed algorithms for achieving highly adaptive, multipath routing; medium access for multi-receiver communication systems; reservation-based multicast routing in mobile networks; and self-organizing, scaleable, reliable multicast transport in high-speed networks. Concepts developed from his work on scaleable, reliable multicast are being incorporated into the ARPA-sponsored Real-Time Information Transfer and Networking (RITN) project to support Distributed Interactive Simulation and the STOW '97 demonstration. He is currently working with Hughes Network Systems on a project to extend IP multicast over the asymmetric DBS system for inclusion in the DirecPC product. He is currently a co-chair of the Mobile Mesh Networking BOF group within the Internet Engineering Task Force (IETF). The group's goal will be to standardize an IETF protocol for routing in mobile, multihop packet radio networks.

He is also an expert in object-oriented software and programming. He is currently managing development of an integrated tactical and strategic network simulation and management capability for the Army Research Laboratory, for use in a possible follow-on to the Force XXI effort, as well as developing new routing technologies for possible inclusion in future mobile Army communication networks. The testbed is CORBA-compliant and will consist of an object-oriented hierarchical simulation framework to permit the fast performance evaluation of large communication networks.

Anthony Ephremides

Co-Director, Center for Hybrid and Satellite Communication Networks Professor, Electrical Engineering and the Institute for Systems Research

Anthony Ephremides received his B.S. degree from the National Technical University of Athens (1967) and M.S. (1969) and Ph.D. (1971) degrees from Princeton University, all in Electrical Engineering. He has been at the University of Maryland since 1971 and currently holds a joint appointment as Professor in the Electrical Engineering Department and the Institute of Systems Research. He is co-founder and co-director of the NASA Center for Commercial Development of Space on Hybrid and Satellite Communications Networks, established in 1991 at Maryland as an offshoot of the ISR. He was a Visiting Professor in 1978 at the National Technical University in Athens, Greece and in 1979 at the EECS Department of the University of California, Berkeley.

He is the President of the Board of Governors of the Information Theory Group of the IEEE. He has been an Associate Editor on Estimation of the *IEEE Transactions on Automatic Control* and is now the Associate Editor for *Queueing Networks*. Dr. Ephremides is also the President of Pontos, Inc., a private consulting firm and a Member of the Advisory Scientific Committee of the University of Crete. He was the organizer of the 1983 IEEE Workshop on Multi-User Information Theory and Systems and has taught several short courses on the subject under continuing engineering programs in the United States and abroad.

He was the general chairman of the 1986 IEEE Conference on Decision and Control in Athens, Greece. He also has been the Director of the Fairchild Scholars and Doctoral Fellows Program, an academic and research partnership program in Satellite

Communications between Fairchild Industries and the University of Maryland. He won the IEEE Donald E. Fink Prize Paper Award (1992). He has been the President of the Information Theory of the IEEE (1987) and served on the Board of the IEEE (1989 and 1990).

Dr. Ephremides' interests are in communication theory, communication systems and networks, queueing systems, signal processing and satellite communications.

Christos Faloutsos

Associate Professor, Computer Science and the Institute for Systems Research

Christos Faloutsos received the B.Sc. degree in Electrical Engineering (1981) from the National Technical University of Athens, Greece and the M.Sc. and Ph.D. degrees in Computer Science from the University of Toronto, Canada.

Since 1985 he has been with the department of Computer Science at the University of Maryland, where he is currently an associate professor.

In 1989 he was given the Presidential Young Investigator Award by the National Science Foundation. He has received three awards for teaching excellence from the Department of Computer Science (1987, 1992, 1996). He has also two patent applications pending (with IBM and Lucent), and two 'best paper' awards (SIGMOD 1994 and VLDB 1997).

His research interests include physical database design; searching methods for medical, multimedia and spatial data; data mining and visualization.

Nariman Farvardin

Professor, Electrical Engineering and the Institute for Systems Research

Nariman Farvardin received the B.S., M.S. and Ph.D. degrees in electrical engineering from Rensselaer Polytechnic Institute, Troy, NY, in 1979, 1980 and 1983, respectively. Since January 1984 he has been with the Electrical Engineering Department at the University of Maryland, where he is currently a professor and department chair. He holds a joint appointment with the Institute for Systems Research. He was a visiting professor at Ecole Nationale Superieure des Telecommunications, Paris, France, during the 1990–91 academic year.

Dr. Farvardin was the Associate Editor for *Quantization, Speech/Image Coding* of the I*EEE Transactions on Communications* from 1986–1990 and is currently Associate Editor for Source Coding of the *IEEE Transactions on Information Theory*.

Professor Farvardin was the recipient of the Allen B. Dumont Prize as a graduate student in Electrical, Computer and Systems Engineering at RPI. He received the 1987 George Corcoran Award for outstanding contributions to electrical engineering education at the University of Maryland. In 1987, he received the Presidential Young Investigator Partnerships Award of Excellence (with J. Jájá) and in 1993 he received the Outstanding Systems Engineering Faculty Award from the Institute for Systems Research, University of Maryland.

He was the faculty advisor for a team of students which received the 1996 Texas Instruments DSP Solutions Challenge Award for the American Division.

Dr. Farvardin's research interests include information theory, digital communications and signal processing with application to speech/image coding and transmission, in particular for wireless communication systems.

Michael C. Fu

Associate Professor, Management Science and Statistics and the Institute for Systems Research

Dr. Fu received his Ph.D. and M.S degrees in applied mathematics from Harvard University in 1989 and 1986, respectively. He received S.B. and S.M. degrees in electrical engineering and an S.B. degree in mathematics from the Massachusetts Institute of Technology in 1985. Since 1989, he has been at the University of Maryland in the College of Business and Management.

Dr. Fu is a member of IEEE and the Institute for Operations Research and the Management Sciences (INFORMS). He is an Associate Editor for the *INFORMS Journal on Computing* and *IIE Transactions*. He was on the program committee for the Spring 1996 INFORMS National Meeting, in charge of contributed papers. In 1995 he received the Maryland Business School's annual Allen J. Krowe Award for Teaching Excellence. He is the co-author (with Jian-Qiang Hu) of the book, *Conditional Monte Carlo: Gradient Estimation and Optimization Applications* (1997), and has authored or co-authored more than 40 journal articles and conference proceedings.

Thomas E. Fuja

Associate Professor, Electrical Engineering and the Institute for Systems Research

Thomas Fuja received his undergraduate education at the University of Michigan, graduating with a B.S.E.E. and a B.S.Comp.E. in 1981. He pursued his graduate studies at Cornell University, receiving an M.Eng. and a Ph.D. in 1983 and 1987, respectively.

In 1982–83 Dr. Fuja worked at AT&T Bell Laboratories in Holmdel, N.J.—first in the Satellite Communications Department and later in the Loop Transmission Laboratory. Since August 1987 he has been a member of the faculty at the University of Maryland, where he holds a joint appointment in the Department of Electrical Engineering and the Institute for Systems Research. Dr. Fuja was promoted from Assistant Professor to Associate Professor with tenure effective August 1993.

Dr. Fuja has been very active in the IEEE Information Theory Society, currently serving as an elected member of its Board of Governors.

He has received the National Science Foundation's Presidential Young Investigator award and the University of Maryland's George Corcoran Memorial Award for teaching and educational leadership in electrical engineering. Fuja is spending 1997 in a visiting position as Program Director for Communications Research at the National Science Foundation, where he oversees the Foundation's $5M annual budget in support of physical-layer communication systems.

Dr. Fuja's research interests lie in many different aspects of digital communication systems—particularly in coding theory and applications and information theory. Most recently he has become interested in the channel coding problems associated with transmitting compressed speech and video signals over wireless channels.

Evaggelos Geraniotis

Professor, Electrical Engineering and the Institute for Systems Research

Evaggelos Geraniotis received the Diploma (with highest honors) in Electrical Engineering from the National Technical University of Athens in 1978 and the M.S. and Ph.D. degrees in Electrical Engineering from the University of Illinois at Urbana-Champaign in 1980 and 1983, respectively.

From September 1982 to August 1985 Dr. Geraniotis was an Assistant Professor of Electrical and Computer Engineering at the University of Massachusetts, Amherst. Since September 1985 he has been with the University of Maryland, where he is presently Professor of Electrical Engineering and a joint faculty member of the Institute for Systems Research. Dr. Geraniotis has received several awards including the Ministry of Education of Greece First National Prize in 1973 and an Alan Berman Naval Research Laboratory Publication Award in 1990. He is a Senior Member of the IEEE and has served as officer of the Washington D.C. / Northern Virginia Chapter of the Information Theory Society. From February 1989 to December 1992 he was editor for Spread-Spectrum of the *IEEE Transactions on Communications.*

Dr. Geraniotis' research has been in communication systems and networks with emphasis on the traffic and channel modeling, performance evaluation and design of: multi-access protocols for mobile, satellite, cellular and optical networks; multi-media (video, voice and data) integration schemes for wireless networks, optical networks, high-speed ATM networks and hybrid satellite / terrestrial networks. He also has been conducting research on spread-spectrum and anti-jam communication systems; on schemes for interception, feature-detection and classification of signals; on radar detection and discrimination; and on distributed detection, estimation, multi-sensor correlation and data fusion.

Neil Goldsman

Associate Professor, Electrical Engineering

Neil Goldsman holds a Ph.D. from Cornell University. His research interests are in device physics, electron transport in high-electric fields, microelectronic device reliability and device modeling.

James A. Hendler

Associate Professor, Computer Science and the Institute for Systems Research

James A. Hendler is an Associate Professor at the University of Maryland, in the Department of Computer Science and the Institute for Systems Research. Dr. Hendler heads the Autonomous Mobile Robotics Laboratory, an ISR-affiliated laboratory.

In 1978, Dr. Hendler received his B.S. degree in computer science (specializing in artificial intelligence) from Yale University. Between 1978 and 1983, Hendler worked in artificial intelligence and human factors engineering, first as a research programmer for Yale University's Artificial Intelligence Project

and then as a member of the technical staff at Texas Instruments Incorporated. In addition, he continued his studies, earning two Master's Degrees, one in 1982 from Southern Methodist University's Psychology Department (specializing in experimental psychology) and one in 1983 from Brown University's Computer Science Department. He received his Ph.D. in 1985 working with Dr. Eugene Charniak at Brown University. The Ph.D. work centered on expanding the abilities of AI planning systems.

Dr. Hendler has been a consultant teaching LISP and AI and working in the expert systems area for Smart Systems Technology, Gould Corp., Lisp Machines Incorporated, Symbolics Incorporated, IBM, OAO and ARD Corp. He is the author of the book *Integrating Marker-Passing and Problem Solving: An Activation Spreading Approach to Improved Choice in Planning* (Lawrence Erlbaum Associates), 1987, is the editor of *Expert Systems: The User Interface* (Ablex, 1987), *Readings in Planning* (Morgan-Kaufmann, 1990; with J. Allen and A. Tate) and *Massively Parallel AI* (AAAI/MIT Press, 1994; with H. Kitano). He also serves as the Artificial Intelligence area editor for the international journal *Connection Science* and is an associate editor of the *Journal of Experimental and Theoretical AI.* He is currently writing a textbook entitled *AI Planning Systems* to be published by Morgan-Kaufmann. Dr. Hendler was the recipient of a 1995 Fulbright Foundation Research Fellowship.

Jeffrey W. Herrmann

Assistant Professor, Mechanical Engineering and the Institute for Systems Research

Dr. Herrmann earned his B.S. in applied mathematics from Georgia Institute of Technology and as a National Science Foundation Graduate Research Fellow from 1990 to 1993, he received his Ph.D. in industrial and systems engineering from the University of Florida. His dissertation investigated production scheduling problems motivated by semiconductor manufacturing. He held a post-doctoral research position in the Institute for Systems Research from 1993 to 1995. He has worked on applied research projects with Harris Semiconductor, Westinghouse Electronic Systems Group, Martin-Marietta, Black & Decker and other manufacturers in the state of Maryland.

His publications cover topics in production scheduling, manufacturing facility design and design evaluation and partner selection for agile manufacturing. His current research interests include the design and control of manufacturing systems and the integration of product design and manufacturing system design.

Joseph Jájá

Director, Institute for Advanced Computer Studies and Professor, Electrical Engineering and the Institute for Systems Research

Joseph JáJá received his B.S. degree in Mathematics with high distinction from the American University of Beirut in 1974. He was awarded his M.S. and Ph.D. degrees in Applied Mathematics by Harvard University in 1976 and 1977, respectively.

Dr. JáJá served as an Assistant Professor of Computer Science from 1977-82 and as an Associate Professor of Computer Science from 1982-82 at the Pennsylvania State University. In 1983 he became an Associate Professor of Electrical Engineering at the University of Maryland and joined ISR, then the Systems Research Center, as a research faculty appointment in 1985. He was promoted to full Professor in 1987. He served as the ISR Associate Director for Research from 1988 to 1994. He has been the Director of the Institute for Advanced Computer Studies since July 1994.

Professor JáJá's current research interests are in the areas of high-performance computing and parallel algorithms.

P.S. Krishnaprasad

Professor, Electrical Engineering and the Institute for Systems Research

P.S. Krishnaprasad received his Ph.D. degree from Harvard University in 1977. He was on the faculty of the Systems Engineering Department at Case Western Reserve University from 1977 to 1980. He has been with the University of Maryland since August 1980, where he has held the position of Professor of Electrical Engineering since 1987 and a joint appointment with the Institute for Systems Research since 1988. At Maryland, Krishnaprasad also is a member of the faculty of the Applied Mathematics Program. He has held visiting positions with Erasmus University (Rotterdam); the Department of Mathematics, University of California, Berkeley; the University of Groningen (the Netherlands); the Mathematical Sciences Institute at Cornell University; and the Mechanical and Aerospace Engineering Department at Princeton University.

Dr. Krishnaprasad's research interests lie in the broad area of geometric control theory and its applications. He has contributed to the understanding of parametrization problems in linear systems, the Lie algebraic foundations of certain nonlinear filtering problems pertaining to system identification, the Lie theory and stability of interconnected

mechanical systems (e.g., spacecraft with elastic attachments, spinning rotors and fluid-filled cavities) and symmetry principles in nonlinear control theory.

He also has investigated mathematical problems in the kinematics and control of robot manipulators, the real-time control of flexible robot arms with endpoint sensing, tactile perception and the development of symbolic algebraic tools for design and control. In the last several years, his interests have drawn him to problems of modeling, design, motion planning and control, arising in mobile robotics (legged and wheeled vehicles, autonomous underwater vehicles and autonomous aircraft); geometric methods in nonlinear dynamics; wavelet analysis for signals and systems; intelligent control architectures, in part inspired by biological paradigms such as central patterns generators and neural networks; the technology of smart materials such as piezo-electric and magnetostrictive materials for use in actuation and sensing; problems of integration of actuators and sensors in control networks; and modeling, simulation, monitoring and control in semiconductor manufacturing processes, such as rapid thermal chemical vapor deposition and chemical mechanical polishing / planarization.

A central interest in geometric control theory, geometric mechanics, Lie groups and distributed parameter systems, guides the technical approaches taken to attack problems in the above areas. Additionally, this work is also linked to the experimental efforts in the Intelligent Servosystems Laboratory where the current projects include experiments in positioning, vibration suppression and impact control of a flexible arm; mechanical manipulation with a modular hand; nonholonomic robot design; 3–D solid modeling and graphical animation; a hybrid motor prototype; and motor networks. In the area of semiconductor processing, experimental efforts are being explored with collaborating University and Industry partners.

Dr. Krishnaprasad was on the Editorial Board of *Systems and Control Letters*.

He is a reviewer for IEEE, the National Science Foundation, SIAM journals and others. His professional society memberships include the AIAA and the AMS. He is an Elected Fellow of the IEEE.

P.S. Krishnaprasad was elected a Fellow of the IEEE in 1990 for his contributions to geometric and nonlinear control and engineering education.

Miroslav Krstic

Assistant Professor, Mechanical Engineering and Institute for Systems Research

Miroslav Krstic received a B.S. degree in Electrical Engineering in 1989 from the University of Belgrade, Yugoslavia, and M.S. and Ph.D. degrees in Electrical and Computer Engineering in 1992 and 1994, respectively, from the University of California, Santa Barbara, under Petar Kokotovic. His dissertation received the 1995 Best Dissertation Award at UC Santa Barbara and was a runner-up in the national competition.

He received Best Student Paper Awards at both of the two leading conferences in the area of control: first at the 1993 IEEE Conference on Decision and Control, and then at the 1995 American Control Conference. He also received the O. Hugo Schuck Best Paper Award for 1996 from the American Automatic Control Council.

Dr. Krstic is a recipient of the National Science Foundation CAREER Award. He published the book *Nonlinear and Adaptive Control Design* (Wiley, 1995). He is an Associate Editor for the *International Journal of Adaptive Control and Signal Processing*.

Dr. Krstic's research interests include nonlinear, adaptive, and robust control, with applications to aeropropulsion, flight control, and automotive systems.

William S. Levine

Professor, Electrical Engineering

Dr. Levine is currently Professor of Electrical Engineering at the University of Maryland. He specializes in systems, control and estimation. He is engaged in research on control systems design (including specific applications to fixed-wing aircraft, rotorcraft, and antennas), the analysis and synthesis of biomechanical controls, and signal processing of biomechanical signals.

Dr. Levine received his S.B., S.M. and Ph.D. degrees from MIT in Electrical Engineering. His Ph.D. thesis was entitled "Optimal Output Feedback Controllers for Linear Systems." He is a Fellow of the IEEE, a Distinguished Member of the IEEE Control Systems Society and a Distinguished Lecturer of the IEEE Engineering in Medicine and Biology Society. He is a past president of the IEEE Control Systems Society.

He has been an associate editor of the *IEEE Transactions on Automatic Control*, an editor of *Automatica* for Rapid Publications, program chair-

man of the 1982 IEEE Conference on Decision and Control (CDC), general chairman of the 1987 IEEE CDC, and a member of the board of governors of the IEEE Control Systems Society. Dr. Levine has over 100 publications dealing with control and estimation theory and their application to practical problems. He is the co-author of the book *Using MATLAB to Analyze and Design Control Systems* published by Benjamin/Cummings. He is the editor of *The Control Handbook* published by CRC Press.

One of his papers, "Discrete Time Point Processes in Urban Traffic Queue Estimation" (co-authored with J.S. Baras and T.S. Lin) received a biannual award as the best paper in the *IEEE Transactions on Automatic Control*.

Professor Levine's research interests are primarily in the area of control theory and its applications, with emphasis on computer-aided control system design, and the use of control and estimation theory to biomedical and aerospace problems.

K.J. Ray Liu

Associate Professor, Electrical Engineering and the Institute for Systems Research

Dr. K.J. Ray Liu received his B.S. from the National Taiwan University in 1983 and his Ph.D. from the University of California, Los Angeles, in 1990, both in electrical engineering.

Since 1990 Dr. Liu has been with the Electrical Engineering Department and the Institute for Systems Research at the University of Maryland. He is the director of the Digital Signal Processing Laboratory. During his sabbatical leave in 1996-97, he was a visiting associate professor at Stanford University, and is chief scientist of NeoParadigm Lab.

His research interests span all aspects of signal processing with applications to image/video, communications, networking, and medical and biomedical technology. He has published more than 100 papers in these areas.

His research has been supported by the National Science Foundation, the National Institutes of Health, the Office of Naval Research, the Army Research Laboratory and companies such as Westinghouse, Watkins Johnson, Allied-Signal and Micro Star.

Dr. Liu was the recipient of the 1994 National Science Foundation Young Investigator Award in recognition of being one of the nation's most outstanding and promising young faculty in science and engineering. He was awarded the IEEE Signal Processing Society's 1993 Senior Award for a paper of exceptional merit published in the IEEE Transactions on Signal Processing. Dr. Liu received the George Corcoran Award in 1994 for outstanding contributions to electrical engineering education and the Outstanding Systems Engineering Faculty Award in 1996 in recognition of outstanding contributions in research, both from the University of Maryland.

He also received numerous awards including Finalist for Invention of the Year from the University of Maryland, the Research Initiation Award from the National Science Foundation, the University Fellowship and the Hortense Fishbaugh Memorial Scholarship from UCLA, the President Research Partnership from the University of Michigan, the Achievement Award from the Taiwanese-American Foundation, the Service Award from the Mei-Hwa Chinese School and the Book Coupon Award and Prof. Feng Memorial Scholarship from National Taiwan University.

Dr. Liu is an Associate Editor of *IEEE Transactions on Signal Processing*, an editor of the *Journal of VLSI Signal Processing* and a member of the Design and Implementation of the Signal Processing Systems Technical Committee of the IEEE Signal Processing Society. He has been in program committees and served as session chairman of numerous international conferences and workshops.

Armand M. Makowski

Professor, Electrical Engineering and the Institute for Systems Research

Armand M. Makowski received the Licence en Sciences Mathematiques from the Universite Libre de Bruxelles in 1975, the M.S. degree in Engineering-Systems Science from UCLA in 1976 and the Ph.D. degree in Applied Mathematics from the University of Kentucky in 1981. In August 1981, he joined the faculty of the Electrical Engineering Department at the University of Maryland, where he is presently a full professor.

He has been affiliated with the Institute for Systems Research, one of the NSF Engineering Research Centers, since its establishment in 1985; he is currently its Associate Director for Research. He is also a co-founder of and active participant in the Center for Satellite and Hybrid Communication Networks, a NASA center for the development and commercialization of space.

Over the past few years, he has held visiting positions at the Technion (Israel), INRIA (France), the IBM T.J. Watson Research Center (Hawthorne)

and AT&T Bell Laboratories (Murray Hill). Dr. Makowski was a C.R.B. Graduate Fellow of the Belgian-American Educational Foundation for the academic year 1975–76; he is also a 1984 recipient of the NSF Presidential Young Investigator Award.

Dr. Makowski's research interests broadly lie in applying advanced methods from the theory of stochastic processes to the modeling, design and performance evaluation of a variety of engineering systems, with particular emphasis on communication systems and networks. Recent activities include the use of asymptotic methods for the performance evaluation of switching systems, long-range modeling for multimedia applications in high-speed networks and stochastic control formulation of resource allocation issues in wireless networks (e.g., handoffs and paging). He is also currently involved in several industry-sponsored projects dealing with ATM technology.

Steven I. Marcus

Professor, Electrical Engineering

Steven I. Marcus received his Ph.D. and S.M. from the Massachusetts Institute of Technology in 1975 and 1972, respectively. He received a B.A. from Rice University in 1971. From 1975 to 1991, he was with the Department of Electrical and Computer Engineering at the University of Texas at Austin, where he was the L.B. (Preach) Meaders Professor in Engineering. He was associate chairman of the Department from 1984-89.

In 1991, he joined the University of Maryland, where he was director of the Institute for Systems Research until 1996. He is currently a Professor in the Electrical Engineering Department and the Institute for Systems Research.

Dr. Marcus is a Fellow of the Institute of Electrical and Electronics Engineers and a member of SIAM, AMS, and the Operations Research Society of America. He is an editor of the *SIAM Journal on Control and Optimization*, and associate editor of *Mathematics of Control, Signals, and Systems; Discrete Event Dynamic Systems: Theory and Applications*; and *Acta Applicandae Mathematicae.* He has authored or co-authored more than 250 journal articles, conference proceedings and book chapters.

Dr. Marcus' research interests lie in the areas of stochastic and adaptive systems and control, learning, fault detection, and discrete event systems.

Thomas J. McAvoy

Professor, Chemical Engineering and the Institute for Systems Research

Thomas J. McAvoy received his B.S. in Chemical Engineering from the Brooklyn Polytechnic Institute in 1961. He received M.A. and Ph.D. degrees in Chemical Engineering from Princeton University in 1963 and 1964, respectively.

In 1960 and 1961, Dr. McAvoy worked for the Diamond Alkali Co., Newark and for the M.W. Kellogg Co., New York, in a Computer Applications Group in 1962. In 1964 he worked for Electronics Associates Inc., Computation Center, Princeton.

From 1970 to 1971, Dr. McAvoy served in a research apprenticeship at Delft University of Technology in Delft, Netherlands. He taught from 1964 to 1980 at the University of Massachusetts, Chemical Engineering Department. In 1980 he began teaching at the University of Maryland, Chemical Engineering Department and received his research faculty appointment to ISR (then the Systems Research Center) in 1985.

Professor McAvoy earned the Allied Foundation Award for Excellence in Undergraduate Education in 1982 and received the Donald P. Eckman Education Award in 1987. He was on the Editorial Board for *Instrumentation Technology* from 1983 to 1987, Editorial Board *I&EC Research* from 1989–92, Associate Editor for *Automatica* from 1991–1993, is currently North America Editor for *Automatica* and was a Co-Chairman in 1986 for *Chemical Process Control III*.

Dr. McAvoy's interests are in neural networks, process control, smart sensing and waste water control.

Ioannis Minis

Associate Professor, Mechanical Engineering and the Institute for Systems Research

Dr. Minis received his M.S. in mechanical engineering from Clarkson University (1983) and his Ph.D. in mechanical engineering from the University of Maryland (1988). He received his undergraduate degree in mechanical engineering from the National Technical University of Athens, Greece (1982).

He has been with the University of Maryland for 12 years, most recently in a joint appointment with the Department of Mechanical Engineering and the Institute for Systems Research. From 1988 to 1995, he was an assistant professor in the Department of Mechanical Engineering at the University's Baltimore County and College Park campuses. From 1984

to 1988, he was a research fellow and assistant instructor in the Mechanical Engineering Department at the College Park campus.

Dr. Minis is the 1993 recipient of the Earl E. Walker Outstanding Young Manufacturing Engineer Award of the Society of Manufacturing Engineers. He also received the best paper award in the area of Engineering Database Management: *Use of PDES in Group Technology Applications for Electronics*, at the 1992 ASME International Conference on Computers in Engineering.

Dr. Minis' research interests are in production systems, concurrent engineering and machining dynamics and control.

Prakash Narayan

Professor, Electrical Engineering and the Institute for Systems Research

Dr. Narayan received his M.S. degree in Systems Science and Mathematics and his Ph.D. in Electrical Engineering from Washington University in St. Louis, Mo., in May 1978 and August 1981, respectively. He received his Bachelor of Technology in Electrical Engineering in August 1976 from the Indian Institute of Technology in Madras, India.

He has been with ISR since 1985 and holds a joint appointment with the Institute. Since 1991, Dr. Narayan also has been a member of the Center for Satellite and Hybrid Communication Networks at the University of Maryland. He has held the position of Visiting Professor at the Swiss Federal Institute of Technology (Zurich), the Technion (Haifa, Israel), the University of Bielefeld (Bielefeld, Germany), the Mathematical Institute of the Hungarian Academy of Sciences (Budapest, Hungary), the Laboratory for Dynamical Systems and Bioengineering (Padova, Italy) and the Indian Institute of Science in Bangalore.

Dr. Narayan has served as a consultant to Bell Communications Research, Morristown, N.J. He is a reviewer for several IEEE *Transactions*, NSF and other publications and organizations.

Dr. Narayan's interests are in information theory, communication networks and statistical signal processing.

Dana S. Nau

Professor, Computer Science and the Institute for Systems Research

Dana Nau is a professor at the University of Maryland, in the Department of Computer Science and the Institute for Systems Research (ISR). He is also affiliated with the Institute for Advanced Computer Studies (UMIACS) and the Department of Mechanical Engineering. In ISR, he is co-leader of the EMSYS (Electro-Mechanical Systems Design and Planning) project and co-leader of the Systems Integration research thrust. His research interests include AI planning and searching techniques and computer-integrated design and manufacturing.

Dr. Nau received a B.S. in applied mathematics from the University of Missouri at Rolla in 1974. He received an A.M. (in 1976) and Ph.D. (in 1979) in Computer Science from Duke University, where he was an NSF graduate fellow and a James B. Duke graduate fellow. He has had summer and/or sabbatical appointments at IBM Research, NIST, the University of Rochester and General Motors Research Laboratories. He has been on numerous program committees, review panels and editorial boards and has been the Academic Co-Director for AAAI's Special Interest Group on Automated Manufacturing (SIGMAN). He has co-edited two books and has published more than 150 refereed technical papers. Copies of recent papers and summaries of current research projects are available at *http://www.cs.umd.edu/users/nau*.

Dr. Nau has received a NSF Presidential Young Investigator Award (1984–89), an IBM faculty development award (1984–86), an honorable mention award in the Texas Instruments 1987 call for papers on AI for industrial automation, an honorable mention for AAAI's best paper award (1991), ISR Outstanding Systems Engineering Faculty award (1993–94) and a best-paper award at the ASME 1995 Computers in Engineering Conference. In 1996 he was made a Fellow of the American Association for Artificial Intelligence (AAAI).

Edward Ott

Distinguished University Professor, Electrical Engineering, Physics, the Institute for Systems Research, and the Laboratory for Plasma Research

Edward Ott received his B.S. (1963) in Electrical Engineering from the Cooper Union, and his M.S., (1965) and Ph.D. (1967) in Electrophysics from the Polytechnic Institute of New York in New York City.

He was an NSF Postdoctoral Fellow in the Department of Applied Mathematics and Theoretical Physics at Cambridge University, Cambridge, U.K., from 1967–1968. Following that, he joined the faculty of the Department of Electrical Engineering at Cornell University where he remained until 1979, at which time he accepted a joint appointment in the Department of Electrical Engineering and the

Department of Physics at the University of Maryland at College Park. Dr. Ott has also held visiting appointments at the Naval Research Laboratory (two separate one year stays) and the Center for Theoretical Physics at the University of California at Santa Barbara. Professor Ott is an author of over 250 papers in refereed scientific and engineering journals.

Dr. Ott's early research has been in the theory of plasma physics, charged particle beams and advanced microwave generators. For the last 10 years, his work has concentrated on chaotic dynamics including theory of bifurcations to chaos, ergodic properties, numerical experiments, and applications. An example of the latter is his recent work on control of chaotic dynamical systems using small controls.

Michael Pecht

Director of the CALCE Electronic Products and Systems Center; professor in Mechanical Engineering, Engineering Research, and the Institute for Systems Research

Michael Pecht has a B.S. in Acoustics, an M.S. in Electrical Engineering and an M.S. and Ph.D. in Engineering Mechanics from the University of Wisconsin. He is a Professional Engineer, an IEEE Fellow and an ASME Fellow. He has written 14 books on electronics products development. He served as chief editor of the *IEEE Transactions on Reliability* for eight years and on the advisory board of *IEEE Spectrum*. He is currently the chief editor for *Microelectronics Reliability*, an associate editor for the *IEEE Transactions on Components, Packaging, and Manufacturing Technology*; and on the advisory board of the *Journal of Electronics Manufacturing*. He serves on the board of advisors for various companies and consults for the U.S. government, providing expertise in strategic planning in the area of electronics products development and marketing.

Gary W. Rubloff

Director, Institute for Systems Research; Professor, Department of Materials and Nuclear Engineering

Dr. Rubloff received his B.A. in Physics magna cum laude from Dartmouth College in 1966, his M.S. in 1967 and his Ph.D. in 1971 in Physics from the University of Chicago. He held a postdoctoral position in Physics at Brown University from 1971 to 1973. In 1973 he joined IBM Research, Yorktown Heights, N.Y., as a Research Staff Member in the Physical Sciences Department, were he worked on surface and interface science. In 1984-85 he served as Technical Assistant to the IBM Research Vice-President for Logic and Memory, and from 1985 to 1991 he continued his research while serving in several capacities as Manager of exploratory materials and processing in the Silicon Technology Department.

From 1992-1993 he was Manager of Thin Film Process Modeling in the Manufacturing Research Department, and in 1992 he became Professor Adjunct of Electrical Engineering at Yale University.

From 1993-96 he was Associate Director of the NSF Engineering Research Center for Advanced Electronic Materials Processing and Professor of Electrical and Computer Engineering at North Carolina State University, focusing on real-time process sensing, simulation, optimization, and control. In 1996 he joined the University of Maryland as Director of the Institute for Systems Research and Professor in the Department of Materials and Nuclear Engineering.

Dr. Rubloff has published over 130 papers, holds 15 patents and 6 IBM Invention Achievement Awards, and is a Fellow of APS and AVS. He is the founding and current chairman of the AVS Manufacturing Science and Technology Group, and he currently serves on the Metrology Technical Working Group for the SIAOs National Technology Roadmap for Semiconductors. He has been active in professional society work, including the Board of Directors of the AVS, Executive Committees of the AVS Electronic Materials and Processing Division, the APS Materials Physics Division, and the Editorial Board of the Journal of Vacuum Science and Technology. He has long been active in civic affairs, included 11 years service as an elected Member, Vice-President, and President of a local Board of Education in New York State.

Dr. Rubloff's research has included solid state physics, surface physics and chemistry, interfaces, semiconductor materials and processing science and technology, process diagnostics and modeling, and manufacturing science. His semiconductor process research has emphasized the elucidation of chemical and physical mechanisms involved in surface cleaning, thermal oxidation, chemical vapor deposition, and plasma etching, and for these goals he has pioneered the exploitaiton of ultrahigh vacuum process environments and in-situ surface and interface diagnostics; for this he has won Fellow status in APS and AVS.

More recently he has concentrated on the application of real-time, in-situ sensor techniques and dynamic simulation to such processes, particularly for equipment and process design optimization, environmentally-conscious manufacturing, and process control, areas which led to his interaction with systems engineering.

Nicholas Roussopoulos

Professor, Computer Science and the Institute of Advanced Computer Studies

Dr. Roussopoulos received his B.A. degree in Mathematics from the University of Athens in 1969. He received an M.S. degree and a Ph.D. in Computer Science from the University of Toronto in 1973 and 1977, respectively.

Dr. Roussopoulos served as a lecturer in Mathematics for the Greek Army from 1969–1970. From 1971–1976, he was a Research and Teaching Assistant for the Department of Computer Science, University of Toronto. He became a Researcher for the IBM Research Lab in San Jose, Calif., from 1976–1977. In 1977 he joined the Department of Computer Science, University of Texas as an Assistant Professor. In 1981 he became Assistant Professor at the Department of Computer Science at the University of Maryland, Associate Professor in 1985 and Full Professor in 1991.

He served on the Space Science Board Committee on Data Management and Computation, (CODMAC), from 1985 until 1988. He was the general chairman of the ACM International Conference on Data Management 1986. He has been an elected trustee of the VLDB Endowment since 1990.

He has also organized and chaired a series of Workshops for the VHSIC Engineering Information System program.

He serves on the editorial board of two international journals, *Information Systems* and *Decision Support Systems*.

Dr. Roussopoulos' research is in high-performance database systems, mobile databases, client-server database architectures, distributed database systems, geographic information systems, network management information systems, database design and management, engineering information systems, software engineering databases and artificial intelligence databases.

Dr. Roussopoulos has published over 80 refereed papers in journals and conferences.

Shihab A. Shamma

Professor, Electrical Engineering and the Institute for Systems Research

Shihab Shamma received his B.S. degree in 1976 from Imperial College, in London, U.K. He received his M.S. and Ph.D. degrees in Electrical Engineering and an M.A. in Slavic Languages from Stanford University in 1977 and 1980.

He has been a member of the University of Maryland faculty since 1984 when he started as an Assistant Professor in the Electrical Engineering Department. He became an Associate Professor in 1989 and a Professor in 1995. He has been associated with ISR since its inception in 1985 and received a joint appointment in 1990. Previously, Dr. Shamma worked at the National Institutes of Health and Stanford University.

Dr. Shamma's research interests include biological aspects of sound and speech analysis and computational neuroscience in general.

Mark A. Shayman

Professor, Electrical Engineering and the Institute for Systems Research

Mark Shayman graduated Summa Cum Laude from Yale University with a B.A. in Molecular Biophysics and Biochemistry in 1975. He received his S.M. in Applied Mathematics from Harvard University in 1977 and Ph.D. in Applied Mathematics from Harvard in 1981.

From 1981–1986 he was a faculty member in the Department of Systems Science and Mathematics, Washington University, St. Louis, Missouri. Since 1986, he has had a joint faculty appointment in the Electrical Engineering Department and the Institute for Systems Research (ISR) at the University of Maryland where he currently holds the rank of Professor. Dr. Shayman served as Graduate Director of the M.S. in Systems Engineering program (1994-1996), and is currently Associate Director for Education. He also is a member of the Center for Satellite and Hybrid Communication Networks (CSHCN), a NASA Commercial Space Center.

Dr. Shayman received the Donald P. Eckman Award in 1984 from the American Automatic Control Council (U.S. member organization in International Federation of Automatic Control) for outstanding contribution to the field of control by a young researcher in the United States. He was granted the Presidential Young Investigator Award in 1985 by the National Science Foundation. Dr. Shayman received the George Corcoran Award for contributions to electrical engineering education from the Electrical Engineering Department and the Outstanding Professor Award from the Graduate Student Association of the Electrical Engineering Department of the University of Maryland, both in 1988. He has served as Associate Editor of *IEEE Transactions on Automatic Control* and is currently Chair of the Technical Committee on Control Theory of the IEEE Control Systems Society.

Dr. Shayman's research interests are in the control of discrete event systems, communication network management, and wireless networks.

Ben Shneiderman

Professor, Computer Science and the Institute for Systems Research

Ben Shneiderman received his B.S. from City College of New York in 1968 and his Ph.D. from State University of New York at Stony Brook in 1973. He received an Honorary Doctorate of Science from the University of Guelph, Ontario, Canada in 1996 and was elected a Fellow of the Association for Computing (ACM) in 1997.

He is a professor in the Department of Computer Science, head of the Human-Computer Interaction Laboratory, and member of the Institute for Systems Research, all at the University of Maryland. He has taught previously at the State University of New York and at Indiana University.

He regularly gives conference keynote speeches and public talks on "Human values and the future of technology" and "Relate-create-donate: Applying educational technology for the post-TV generation." Dr. Shneiderman's professional talks and courses cover user interface design, information visualization, and educational technology. He organizes an annual satellite television presentation on "User Interface Strategies" seen by thousands of professionals since 1987.

Dr. Shneiderman is the author of *Software Psychology: Human Factors in Computer and Information Systems* (1980) and *Designing the User Interface: Strategies for Effective Human-Computer Interaction* (1987, second edition 1992, third edition 1997), Addison-Wesley Publishers, Reading, Mass. His 1989 book, co- authored with Greg Kearsley, *Hypertext Hands-On!*, contains a hypertext version on two disks. It was the world's first commercial electronic book and pioneered the highlighted embedded link. This concept was part of the Hyperties hypermedia system, now produced by Cognetics Corp., Princeton Junction, N.J.

Dr. Shneiderman has co-authored two textbooks, edited three technical books, and published more than 180 technical papers and book chapters. His 1993 edited book *Sparks of Innovation in Human-Computer Interaction* collects 25 papers from ten years of research at the University of Maryland. This collection includes Dr. Shneiderman's seminal paper on direct manipulation, a term he coined in 1981 to describe the graphical user interface design principles: visual presentation of objects and actions combined with pointing techniques to accomplish rapid incremental and reversible operations.

Ben Shneiderman has been on the editorial advisory boards of nine journals including the newly formed ACM Transactions on Computer-Human Interaction and the ACM Interactions. He edits the Ablex Publishing Co. book series on "Human-Computer Interaction." He has consulted and lectured for many organizations including Apple, AT&T, Citicorp, GE, Honeywell, IBM, Intel, Library of Congress, NASA, and university research groups.

David B. Stewart

Assistant Professor, Department of Electrical Engineering

David B. Stewart received his M.S. and Ph.D. in Electrical and Computer Engineering from Carnegie Mellon University in 1989 and 1994, respectively. He received a B.Eng., Summa Cum Laude, in Computer Engineering from Concordia University in 1988. In 1991 he was a visiting researcher at the Jet Propulsion Laboratory, California Institute of Technology. He attended the summer session of the International Space University, held in Toronto, Canada, in 1990. He has been with the University of Maryland since August 1994.

He is a recipient of the Natural Sciences and Engineering Research Council of Canada (NSERC) 1967 Science and Engineering Scholarship (1988-1992). He has also been awarded the Canadian Foundation for the International Space University Scholarship, also sponsored by NSERC (1990), the Chait Medal and Computer Engineering Medal from Concordia University (1988), the Prize of Excellence from the Professional Order of Engineer's of Quebec, Canada (1988), twice the NSERC Undergraduate Research Award (1986, 1987), the Myer F. Pollock Scholarship for academic excellence (1986), the Concordia University Entrance Scholarship (1984-1987), the Independent Order of Forester's University Entrance Scholarship (1984-1988), the National Honor Society Scholarship (1982), and the Josten's Foundation Scholarship (1982-1983).

Dr. Stewart is a member of IEEE and ACM.

Dr. Stewart's research interests lie in the area of software engineering for real-time systems, including software design of reconfigurable and reusable software, robotics and multi-sensor systems, real-time systems theory and implementation, fault detection and handling, and automatic systems integration. He has recently created a new "Software Engineering for Real-Time Systems" graduate research laboratory at University of Maryland.

V. S. Subrahmanian

Assistant Professor, Computer Science and the Institute for Systems Research

V.S. Subrahmanian received his M.S. (1987) and Ph.D. (1989) in computer science from Syracuse University where he was a teaching / research assistant during 1985–89. In 1989, he joined the University of Maryland as an Assistant Professor in Computer Science. In 1993, he received NSF's Young Investigator Award.

Dr. Subrahmanian's work is on the declarative, computational and implementation aspects of reasoning with uncertainty, inconsistency, non-monotonicity and numeric computation in logic programming and deductive databases. He is working on the development of a theoretical foundation for a logic programming / deductive database system incorporating these features. The theoretical foundation is based on characterizing the meaning of such programs in terms of model-theoretic semantics and in terms of fixed-point theory. The fixed-point theory is complicated by the fact that the operators being studied are non-monotonic. He is also developing techniques to compute the alternative semantical constructs developed by us. As one of his intended domains of applications is real-time control systems, it is important that these query processing techniques be very fast at run-time and that they be easily "updatable" in the sense that new information reflecting changes in the environment leads to quick re-evaluation of appropriate queries. He has developed fast, incremental computation techniques for query processing under such circumstances.

Leandros Tassiulas

Assistant Professor, Electrical Engineering

Leandros Tassiulas obtained the Diploma in Electrical Engineering from the Aristotelian University of Thessaloniki, Thessaloniki, Greece in 1987 and the M.S. and Ph.D. degrees in Electrical Engineering from the University of Maryland in 1989 and 1991 respectively.

From September 1991 to June 1995 he was an Assistant Professor in the Department of Electrical Engineering, Polytechnic University, Brooklyn, NY.

Since July 1995 he is an Assistant Professor in the Department of Electrical Engineering, University of Maryland.

His research interests are in the field of computer and communication networks with emphasis on wireless communications and high-speed network architectures and management, in control and optimization of stochastic systems and in parallel and distributed processing.

Dr. Tassiulas received an NSF Research Initiation Award, an NSF Faculty Early Career Development Award, and the Office of Naval Research (ONR) Young Investigator Award. In addition, he co-authored a paper that won the INFOCOM '94 best paper award.

André L. Tits

Professor, Electrical Engineering and the Institute for Systems Research

André L. Tits was born in Verviers, Belgium on April 13, 1951. He received the "Inginieur Civil" degree from the University of Liege, Belgium and the M.S. and Ph.D. degrees from the University of California, Berkeley, all in Electrical Engineering, in 1974, 1979 and 1980, respectively.

Since 1981, Dr. Tits has been with the University of Maryland. Currently, he is a Professor of Electrical Engineering and he holds a permanent joint appointment with the Institute for Systems Research. He has held visiting positions at the University of California, Berkeley, at the Lund Institute of Technology, at INRIA, at the Catholic University of Louvain at Louvain-la-Neuve, Belgium and at the Australian National University.

Dr. Tits received a 1985 NSF Presidential Young Investigator Award. He is a member of the Institute of Electrical and Electronics Engineers, of the Mathematical Programming Society, of the Society for Industrial and Applied Mathematics and of the Association des Ingenieurs sortis de l'Institut Montefiore.

Dr. Tits is an Associate Editor of *Automatica* (the IFAC journal) and an Associate Editor at Large of the *IEEE Transactions on Automatic Control*.

Dr. Tits' main research interests lie in various aspects of optimization-based system design and robust control. The former include theoretical questions in numerical methods for optimization, novel ideas and software for interactive optimization-based design and application of the above to the design of electrical, chemical and mechanical systems. Current projects include the development of a fast feasible algorithm for semi-infinite optimization and the development of graphical tools for exploration of design tradeoffs.

Dr. Tits' recent work in robust control has dealt with both parametric and dynamic uncertainty, including contributions to the computation of the structured singular value.

Lung-Wen Tsai

Professor, Mechanical Engineering and the Institute for Systems Research

Dr. Lung-Wen Tsai received his B.S. from the National Taiwan University in 1967, his M.S. from the State University of New York at Buffalo in 1970, and his Ph.D. from Stanford University in 1973.

From 1973 to 1978, he worked for Hewlett-Packard Co. as a research and development engineer leading projects in instrumentation tape recorders and x-y plotters. From 1978 to 1986, he worked for the General Motors Corp. as a senior staff research engineer leading projects in the design of variable-stroke engine mechanisms, variable valve-timing mechanisms, active engine balancing devices, and innovative transmission mechanisms.

Dr. Tsai joined the University of Maryland in 1986. He has established a nationally recognized research and education program in mechanisms and machine design, automotive engineering, robot manipulators, and walking machines.

Dr. Tsai is a well-known researcher in the fields of mechanisms and machine theory, and robotics. He has published over 100 journal and conference proceeding papers, and is the holder of eight U.S. patents. He is the recipient of the following prestigious awards: the 1984 ASME Mechanisms Committee Best Paper Award, the 1985 ASME Melville Medal, the 1986 General Motors John Campbell Award, the 1988 SAE Arch Colwell Award, the 1989 and 1991 AMR Procter & Gamble Awards, the 1991 Lectureship Award of the Taiwan National Science Council, the 1992 Visiting Professorship of the University of Rome, the AMR 1993 South-Pointing-Chariot Rotating Trophy, the 1993 Visiting Professorship of the National Cheng Kung University, and the 1994 Distinguished Lecturer of the National University of Mexico.

Dr. Tsai is a registered professional engineer in California. He is a Fellow of the ASME, a member of the SAE, and an advisory board member of the *Journal of Applied Mechanisms and Robotics*. He served as a member of the ASME Mechanisms Committee from 1991 to 1996, and as an Associate Editor for the *ASME Journal of Mechanical Design* from 1991 to 1993.

Dr. Tsai's research interests include design methodology, design automation, kinematics and dynamics of mechanisms, automotive engineering, robot manipulators, and other intelligent servomechanisms.

Evanghelos Zafiriou

Associate Professor, Chemical Engineering Department and the Institute for Systems Research

Evanghelos Zafiriou received his Diploma in Chemical Engineering from the National Technical University in Athens, Greece, in 1983, where he was the recipient of several awards, including the Technical Chamber of Greece award for having the highest GPA of any NTU student during his senior year. He obtained a Ph.D. degree in Chemical Engineering from the California Institute of Technology, in 1987. He then joined the University of Maryland as Assistant Professor and was promoted to Associate Professor with tenure in 1991. He is the co-director of the Chemical Process Systems Laboratory at ISR.

In 1990 he received the Presidential Young Investigator award from NSF and he has obtained full industrial matching funds.

Dr. Zafiriou has lectured at several short courses for industry nationally and internationally on topics including model predictive control, robust process control and neural networks. In addition to numerous papers, he has co-authored a book on Robust Process Control (Prentice-Hall, 1989). He has organized several sessions and meetings on these topics, including, in June 1994, a Workshop of the Int. Federation of Aut. Control on the Integration of Process Design and Control, for which he served as General Chair and Int. Program Committee Chair, as well as Proceedings Editor.

He is a member of AIChE, IEEE, ACS and SIAM and a panel member and proposal reviewer for five NSF Programs and the ACS. He has served as guest editor for two archival journals and is a reviewer for more than a dozen journals.

Dr. Zafiriou's interests are in robust and nonlinear process control, control-relevant identification and run-to-run and feedback control in semiconductor manufacturing.

Guangming Zhang

Associate Professor, Mechanical Engineering and the Institute for Systems Research

Dr. Zhang received M.S. and Ph.D. degrees in Mechanical Engineering from the University of Illinois at Urbana-Champaign in 1983 and 1986 respectively. He also received a M.S. and B.A. degrees from Tianjin University, The People's Republic of China, in 1981 and 1966 respectively. Dr. Zhang has been on the faculty at the University of Maryland since 1989. From 1988 through 1989, Dr. Zhang was a Visiting Research

Associate at the Knowledge-Based Engineering Systems Research Laboratory in the Department of Mechanical and Industrial Engineering at the University of Illinois at Urbana-Champaign. He was an Associate Professor at the Beijing Institute of Printing in The People's Republic of China from 1986 to 1988.

Dr. Zhang holds memberships in the American Society of Mechanical Engineers and the Society of Manufacturing Engineers. He is a member of the Editorial Board of the *International Journal of Flexible Automation and Integrated Manufacturing.* He received the 1992 ASME Blackall Machine Tool and Gage Award. He was the recipient of the 1993 E. Robert Kent Outstanding Teaching Award from the College of Engineering.

Dr. Zhang's research interests include manufacturing systems, dynamics of mechanical structures, quality engineering, dynamics of machine tools, machining of advanced engineering materials and rapid prototyping.

ISR Management Biographical Sketches

Margaret Brumfield

Assistant Director for Finance and Internal Operations

Margaret Brumfield has been with the Institute since 1987. She plans and manages all financial and internal administrative matters of the institute and its associated Centers (CALCE Electronic Packaging Research Center and Center for Satellite and Hybrid Communication Networks), including its total budget of $12 million from state, government and industry sources. She has organized the financial affairs of the institute through the creation and management of a computer-based parallel accounting system and has overseen the development of a computer-based data management system for payroll, inventory, proposal development and facilities utilization. Additional facets of her work include the management of ISR space and facilities and supervision of six employees who perform accounting, payroll, facilities management, inventory tracking and proposal submission activities.

Ms. Brumfield has over 25 years of professional experience in a variety of positions involving financial and administrative management, budgeting, organization and management analysis, contracting and statistical analysis. Before joining ISR, she was senior business affairs specialist with the Corp. for Public Broadcasting. She has also held positions with the U.S. Department of Commerce Office of International Marketing and the U.S. Department of Labor. Ms. Brumfield is a graduate of the University of Maryland, having received a Master of Public Policy degree in Public Sector Financial Management and a Bachelor of Science degree in Economics.

Jeffrey A. Coriale

Assistant Director for External Affairs

Jeff Coriale is responsible for directing all contacts and activities between the Institute for Systems Research, industry and government. In addition, he oversees ISR's public relations and meetings functions. He has been with ISR since 1996.

He earned a B.S. in Electrical Engineering at the University of Rochester in 1979 and an M.Eng. in Electrical Engineering at the University of Virginia in 1980.

Previous to joining ISR, he was the Industrial Liaison Coordinator for the NSF ERC at North Carolina State University, Raleigh, N.C. He spent 10 years with Harris Semiconductor as a Device Engineer / Staff Engineer / Principal Engineer, and as Resident Program Manager, at the Semiconductor Research Corporation, Research Triangle Park, N.C.. He has also been an R&D Engineer / Process Development, at General Electric, Research Triangle Park, N.C.

Coriale is a Member of Executive Committee of AVS Manufacturing Science and Technology Group; Communications; September 1994-Present. Member of the SRC's Technology Transfer Technical Advisory Board, August 1994-Present. He received eleven Golden Quill Awards from Harris for technical authorship excellence and the Harris Special Recognition Award for outstanding leadership as the SRC Mentor Program Manager, October 1990.

Coriale is a member of Technology Transfer Society; IEEE; AVS; and a member of the Technical Program Committee for 1987 VLSI Technology Symposium

His research interests lie in technology transfer, industrial liaison activities, deep submicron process integration issues, microelectronics process technology, and semiconductor equipment development.

Susan L. Frazier

Assistant Director for Education and Personnel

Sue Frazier's responsibilities include managing faculty, student and staff affairs. She serves as the personnel and equity officer for the Institute, coordinating recruitment efforts for faculty, post-doctoral appointments and visitors and advising the Director on personnel related issues. She also coordinates administrative and technical staff recruitment and search processes, monitors affirmative action activities and develops visa documentation for employees. She manages the ISR education programs, including the Post-Doctoral Fellowship program and graduate, undergraduate and high school student participation in research and education. She supervises development efforts to solicit funds to support the programs and outreach activities to attract women and minority students to the ISR programs.

Ms. Frazier has been with the Institute since April 1986. Prior to that time, she was a Program Analyst in the Office of the Chancellor at the University of Maryland at College Park, where she was employed for 10 years. Ms. Frazier is a graduate of the University of Maryland; she received her Bachelor of Arts degree in Sociology.

Amar Vadlamudi

Assistant Director for Computing and Laboratory Facilities

As Assistant Director for Computing and Laboratory Facilities, Amar Vadlamudi coordinates and manages all of the Institute's computing activities. His objectives in this endeavor are to provide a state of the art computer system for research; to teach faculty, students and staff the use of the systems and supported software; to generate revenue through proposals involving software development and outreach functions; and to present a coherent picture of ISR computing to supporting government agencies and industrial affiliates.

The Assistant Director for Computing and Laboratory Facilities plans and manages administrative support for labs; ensures the development of necessary ISR hardware and software capability; maintains productive relations between ISR and vendors; manages software licensing for ISR; recommends and supervises the procurement of computer equipment and outside computer services; coordinates network planning and development; develops and maintains research software; represents ISR on campus committees; provides leadership in key technologies; interfaces with other units within the University; initiates and manages a software club and bulletin board system; assists in the implementation of an outreach to medium and small companies; and assists in the educational outreach functions of ISR.

Mr. Vadlamudi worked under the direction of Dr. Joseph Jájá in the VLSI Systems Laboratory of ISR in 1992 as part of his master's degree program. He subsequently received a Master of Science degree in Electrical Engineering from the University of Maryland at College Park. In 1993 he joined ISR General Computing Staff as a Computer Systems Specialist and maintained and supported the Institute's UNIX computer networks and software environment. In 1994, he became the Institute's Assistant Director for Computing and his broad knowledge in engineering and computer science, as well as his familiarity with the Institute's research activities, enabled him to manage a highly skilled technical team and to assist faculty with specialized equipment needs for their research.

Mr. Vadlamudi is currently involved with the introduction of technologies such as ATM, multicasting and distributed object databases into ISR computing environment.

Faculty Publications

Eyad H. Abed

Books or chapters in books

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